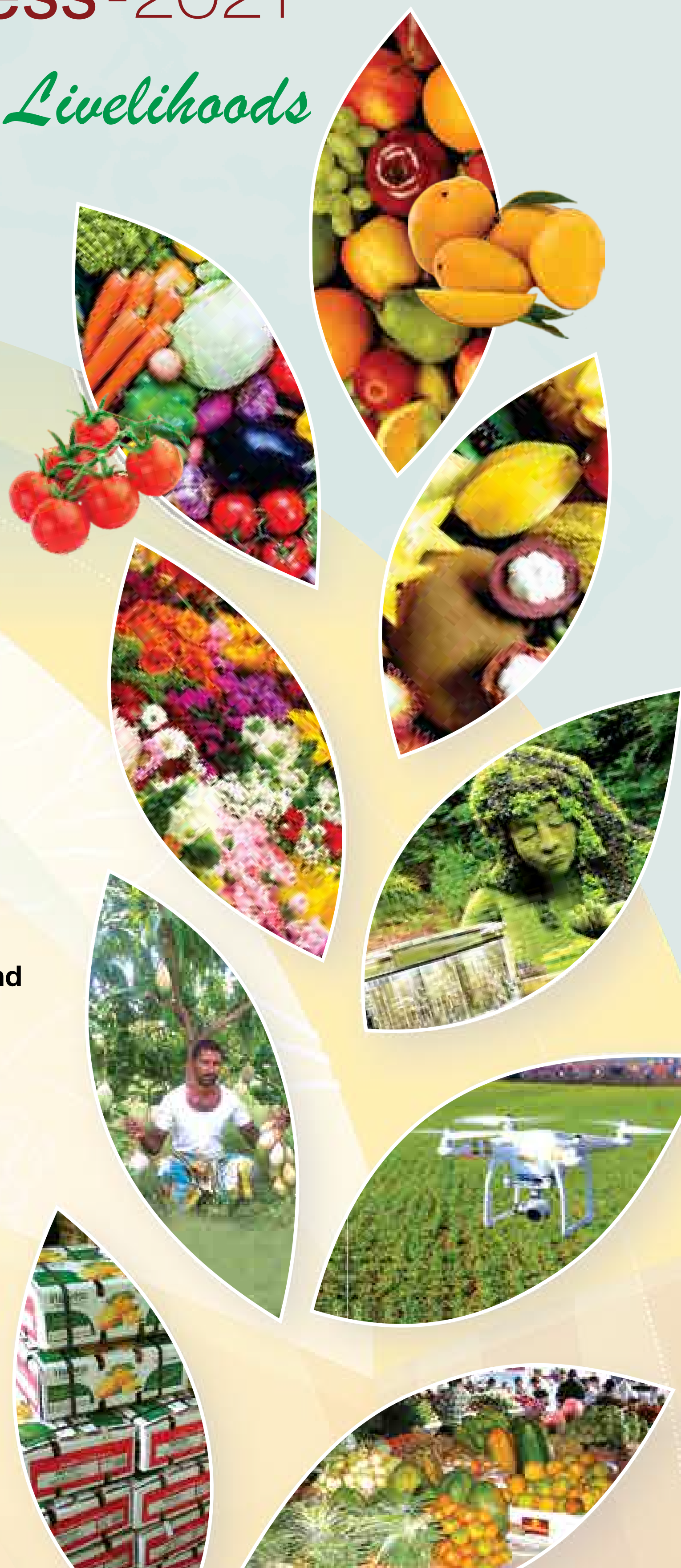
9th Indian Horticulture Congress 2021

9th Indian HortiCulture Congress-2021

INTERNATIONAL YEAR OF
FRUITS AND VEGETABLES
2021

Horticulture for Health, Livelihoods and Economy



Souvenir

cum

Lead Paper Abstracts

Chandra Shekhar Azad University of Agriculture and Technology

Kanpur, Uttar Pradesh

November 18-21, 2021

Organized by

INDIAN ACADEMY OF HORTICULTURAL SCIENCES (IAHS)
भारतीय उद्यान विज्ञान अकादमी

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Address:
F-1, National Societies Block, NASC Complex,
DPS Marg, Pusa, New Delhi - 110 012, India
Phone: 011-25842127
E-mail: hortacademy@gmail.com,
Website: www.iahs.org.in

Editors:
S.K. Singh
D.R. Singh
V.B. Patel

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Dr K.L. Chadha
President, Indian Academy of Horticultural Sciences,
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Pusa, New Delhi - 110 012, India
Phone : 011-25842127; E-mail: hortacademy@gmail.com

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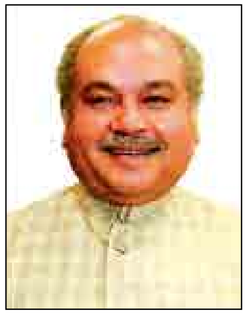
नरेन्द्र सिंह तोमर
NARENDRA SINGH TOMAR

सत्यमेव जयते

कृषि एवं किसान कल्याण मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली
MINISTER OF AGRICULTURE & FARMERS WELFARE
GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI



संदेश

मुझे यह जानकर प्रसन्नता हो रही है कि संयुक्त राष्ट्र के खाद्य एवं कृषि संगठन द्वारा घोषित अंतर्राष्ट्रीय फल एवं सब्जी वर्ष के उपलक्ष्य में इंडियन अकादमी ऑफ हॉर्टीकल्चरल साइन्सिज, नई दिल्ली द्वारा चन्द्र शेखर आजाद कृषि एवं प्रौद्योगिक विश्वविद्यालय, कानपुर, उत्तर प्रदेश में 'स्वास्थ्य, आजीविका एवं अर्थव्यवस्था के लिए बागवानी' विषय पर दिनांक 18-21 नवम्बर, 2021 के दौरान नवीं भारतीय बागवानी कांग्रेस का आयोजन किया जा रहा है।

भारत, विभिन्न कृषि जलवायु परिस्थितियों से समृद्ध है जो कि अनेकानेक बागवानी फसलों का उत्पादन करने हेतु व्यापक क्षमता उपलब्ध कराती हैं। मुझे पूर्ण विश्वास है कि यह सेक्टर ग्रामीण भारत के त्वरित एवं सम्यक प्रगति हासिल करने में एक महत्वूपर्ण भूमिका निभाएगा।

वर्ष 2022 तक किसानों की आय को दोगुना करने और उससे भी अधिक आय हासिल करने संबंधी सरकार के विजन को बागवानी सेक्टर में प्रौद्योगिकी प्रेरित विकास के माध्यम से हासिल किया जा सकता है। इस सेक्टर द्वारा पहले से ही भारत की कृषि जीडीपी में 30 प्रतिशत से अधिक का योगदान दिया जा रहा है। अब किसान समुदाय को अनेक विकास कार्यक्रमों एवं सरकारी पहलों का लाभ मिल रहा है।

किसानों के हितों को ध्यान में रखते हुए तथा पोषण एवं मानव स्वास्थ्य में फलों, सब्जियों व अन्य बागवानी फसलों की भूमिका पर फोकस करते हुए इस बागवानी कांग्रेस में बागवानी विशेषज्ञों, छात्रों, किसानों, निजी सेक्टर, एनजीओ/एफपीओ के कार्मिकों, उद्यमियों तथा अन्य इच्छुक वर्गों के बीच सार्थक विचार-विमर्श करने के लिए एक अनूठा मंच उपलब्ध होगा। मुझे विश्वास है कि हमारे बागवानी उत्पादकों को खेती में उत्कृष्टता हासिल करने की दिशा में उन्नत जानकारी और कौशल प्राप्त होगा। साथ ही उद्यमी वर्ग को लाभकारी व्यवसाय अवसरों के बारे में जानकारी मिल सकेगी।

नवीं भारतीय बागवानी कांग्रेस की सफलता हेतु मेरी शुभकामनाएं।

(नरेन्द्र सिंह तोमर)

Office : Room No. 120, Krishi Bhawan, New Delhi-110 001 Tel.: 23383370, 23782691 Fax : 23384129
Resi. : 3, Krishna Menon Marg, New Delhi-110001, Ph. : 011-23794697 / 98, Fax : 011-23794696

आनंदीबेन पटेल
राज्यपाल, उत्तर प्रदेश

राज भवन
लखनऊ - 226 027

21 अक्टूबर, 2021

सन्देश

मुझे यह जानकर अत्यन्त प्रसन्नता हुई कि भारतीय उद्यान विज्ञान अकादमी, नई दिल्ली एवं चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिक विश्वविद्यालय, कानपुर द्वारा चार दिवसीय "9वीं भारतीय उद्यान कांग्रेस 2021 स्वास्थ्य, आजीविका और अर्थव्यवस्था के लिए बागवानी" का आयोजन 18 से 21 नवम्बर, 2021 तक किया जा रहा है। इस अवसर पर एक स्मारिका भी प्रकाशित की जायेगी।

मुझे उम्मीद है कि 9वीं भारतीय उद्यान कांग्रेस–2021 में प्रतिभाग करने वाले विशेषज्ञों, वैज्ञानिकों, नीति निर्धारकों, उद्योगपतियों, शोध छात्रों एवं कृषकों के आपसी विचार–विनिमय से निश्चय ही ऐसे सार्थक परिणाम सामने आयेंगे, जो प्रदेश एवं देश के लघु एवं सीमान्त कृषकों की आय बढ़ाने में सहायक सिद्ध होंगे।

9वीं भारतीय उद्यान कांग्रेस–2021 के सफल आयोजन हेतु मैं अपनी हार्दिक शुभकामनाएं प्रेषित करती हूँ।

आनंदीबेन
(आनंदीबेन पटेल)

संख्या-G. 368/C.M.-2/2021.

योगी आदित्यनाथ

मुख्य मंत्री
उत्तर प्रदेश

लोक भवन,
लखनऊ - 226001

दिनांक : 28 OCT 2021

<u>संदेश</u>

मुझे यह जानकर अत्यन्त प्रसन्नता की अनुभूति हो रही है कि भारतीय उद्यान विज्ञान अकादमी, नई दिल्ली एवं चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिक विश्वविद्यालय, कानपुर के संयुक्त तत्वावधान में दिनांक 18 से 21 नवम्बर, 2021 तक 9वीं भारतीय उद्यान कांग्रेस–2021 का आयोजन किया जा रहा है। इस अवसर पर एक स्मारिका का प्रकाशन भी किया जाएगा।

9वीं भारतीय उद्यान कांग्रेस–2021 का विषय 'स्वास्थ्य, आजीविका और अर्थव्यवस्था के लिए बागवानी' अत्यन्त प्रासंगिक है। उद्यान एवं शाकभाजी में नए नवाचार विकसित कर देश एवं कृषकों को वास्तविक रूप से समृद्ध किया जा सकता है। इसके दृष्टिगत उत्तर प्रदेश सरकार अनेक योजनाओं का संचालन कर रही है। किसानों को उद्यान एवं शाकभाजी के उत्पादन एवं प्रसंस्करण की नवीनतम तकनीक उपलब्ध कराने में कृषि विश्वविद्यालयों एवं कृषि विज्ञान केन्द्रों का उल्लेखनीय योगदान है। मुझे आशा है कि 9वीं भारतीय उद्यान कांग्रेस–2021 के आयोजन से देश के कृषकों एवं उद्यमियों को बेहतर मार्गदर्शन प्राप्त होगा।

आयोजन की सफलता तथा स्मारिका के उद्देश्यपरक प्रकाशन हेतु मेरी हार्दिक शुभकामनाएं।

(योगी आदित्यनाथ)

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सूर्य प्रताप शाही
मंत्री
कृषि, कृषि शिक्षा एवं
कृषि अनुसंधान विभाग,
उत्तर प्रदेश

मंत्री
उत्तर प्रदेश

कार्यालय, दूरभाष/फैक्स : 2239247
सी.एच. : 2213256
कार्यालय कक्ष संख्या 69-70
मुख्य भवन

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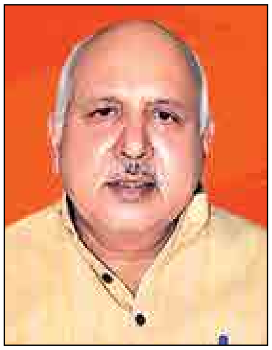

संदेश

मुझे प्रसन्नता है कि भारतीय उद्यान विज्ञान अकादमी, नई दिल्ली एवं चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिक विश्वविद्यालय, कानपुर द्वारा चार दिवसीय **"9वीं भारतीय उद्यान कांग्रेस 2021: स्वास्थ्य, आजीविका और अर्थव्यवस्था के लिए बागवानी"**(**9th Indian Horticulture Congress-2021: Horticulture for Health, Livelihoods and Economy)** विषय पर एक उद्यान कांग्रेस का आयोजन दिनांक 18–21 नवम्बर, 2021 को किया जा रहा है और इस अवसर पर विश्वविद्यालय की ओर से स्मारिका का प्रकाशन भी किया जा रहा है।

मुझे विश्वास है कि इस उद्यान कांग्रेस में उद्यान वैज्ञानिक, विशेषज्ञ, उद्योगपति, शोध छात्र–छात्राएं व प्रगतिशील किसानों के विचार–विमर्श से वर्तमान चुनौतियों को देखते हुये वैज्ञानिक आधारित उद्यान एवं शाकभाजी की बेहतर तकनीक एवं व्यावहारिक उपायों के साथ किसानों व उद्यान एवं शाकभाजी के उद्योग से जुड़े उद्योगपतियों के लिए अपने अनुभवों को साझा करते हुये एक ठोस दिशा में रचनात्मक और गुणात्मक दिशा देगी।

मैं इस 9वीं भारतीय **उद्यान कांग्रेस–2021** के आयोजन एवं स्मारिका के प्रकाशन की सफलता की कामना करता हूँ।

आपका,

(सूर्य प्रताप शाही)

डा0 डी0आर0 सिंह जी,
कुलपति,
चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिकी विश्वविद्यालय,
कानपुर।

त्रिलोचन महापात्र, पीएच.डी.
सचिव, एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE AND FARMERS WELFARE
KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

Message

Horticulture, which includes fruits, vegetables, flowers and ornamental plants, tuber crops, spices, medicinal and aromatic plants, is a priority area for diversification in Indian agriculture and improving economic condition of farmers and entrepreneurs. It is contributing significantly to the national economy. India has marched ahead from food sufficiency to nutritional security, which is visible with rise in production, productivity and availability of an array of horticultural produce / products round the year. This is a welcome sign as it addresses key issues like malnutrition, greening of marginal and arid regions, dwindling rural employment, women empowerment, availability of safe food, post-harvest management and value-addition, enhancing export opportunities etc.

The R&D efforts in Horticulture sector in the country during the last four decades have impacted Indian Agriculture in many ways. The importance of Horticulture is being realized by one and all be it a small farmer, the corporate sector and policy makers. There is now a sound R&D network in Horticulture in the country with several institutions and implementing a number of research and developmental programmes. Horticulture has come out of village confines to the urban areas and the corporate sector as an organized enterprise. Further, it has enormous potential for livelihood security in the rural, urban and peri-urban areas, besides providing better nutrition, environment and economic security compared to conventional agriculture.

I am happy to note that Indian Academy of Horticultural Sciences, New Delhi is organizing the 9th Indian Horticulture Congress on the theme "Horticulture for Health, Livelihood and Economy" from 18-21 November, 2021 in collaboration with Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh to celebrate the International Year of Fruits and Vegetables declared by Food and Agricultural Organization (FAO) of the United Nations.

I am sure, the Congress would give a unique opportunity for the researchers, students, entrepreneurs, NGOs, industry representatives, farmers and other stakeholders to deliberate wide array of issues related to Horticulture R&D in the country, and come up with an action plan.

I congratulate the Indian Academy of Horticultural Sciences, New Delhi and Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh for organizing this mega event. I wish the event all success.

(T. MOHAPATRA)

Dated the 27th October, 2021
New Delhi

डा० देवेश चतुर्वेदी
आई.ए.एस.
अपर मुख्य सचिव

अर्द्धशा. पत्र. सं : 7616/ACS Ag/2021

कृषि, कृषि शिक्षा एवं अनुसंधान, कृषि विपणन,
कृषि विदेश व्यापार एवं निर्यात प्रोत्साहन विभाग,
उत्तर प्रदेश शासन।
25, नवीन भवन, सचिवालय,लखनऊ।
कार्या. : 0522 - 2237617
फैक्स : 0522 - 2235488
Emai : psup.agri@gmail.com

दिनांक 27.10.2021

संदेश

मुझे यह जानकर अपार हर्ष हो रहा है कि भारतीय उद्यान विज्ञान अकादमी, नई दिल्ली एवं चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिक विश्वविद्यालय, कानपुर के तत्वाधान में चार दिवसीय **"9वीं भारतीय उद्यान कांग्रेस 2021: स्वास्थ्य, आजीविका और अर्थव्यवस्था के लिए बागवानी"** (9th Indian Horticulture Congress-2021: Horticulture for Health, Livelihoods and Economy) विषय पर एक उद्यान कांग्रेस का आयोजन दिनांक 18–21 नवम्बर, 2021 को किया जा रहा है। कृषि विश्वविद्यालयों एवं कृषि विज्ञान केन्द्रों का कृषि विकास में सदैव अतुलनीय योगदान रहा है। इस उद्यान कांग्रेस में वैज्ञानिक, विषय विशेषज्ञ, नीति निर्धारक, उद्योगपतियों, शोध छात्र–छात्राओं व प्रगतिशील किसानों के विचार–विमर्श से कृषि क्षेत्र की वर्तमान चुनौतियों के सन्दर्भ में प्रदेश व देश के कृषक लाभान्वित हो सकेंगे तथा उद्योग हेतु नये मार्ग भी प्राप्त होंगे।

मैं इस उद्यान कांग्रेस–2021 के सफल आयोजन एवं इस अवसर पर स्मारिका के प्रकाशन हेतु विश्वविद्यालय परिवार को हार्दिक बधाई एवं शुभकामनाएँ।

27/X/21
(देवेश चतुर्वेदी)

आलोक सिन्हा
आई.ए.एस.
कृषि उत्पादन आयुक्त

अ०शा०प०सं०....मेडी..........
उत्तर प्रदेश शासन
9–10, बहुखण्डी भवन, सचिवालय
लखनऊ–226001
☎ : 0522–2238082, 2238145 (का०)
ई–मेल : apcofficeup@gmail.com

दिनांक :..20-Oct-2021.

संदेश

मुझे यह जानकर अत्यन्त प्रसन्नता की अनुभूति हो रही है कि भारतीय उद्यान विज्ञान अकादमी, नई दिल्ली एवं चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिक विश्वविद्यालय, कानपुर द्वारा दिनांक 18–21 नवम्बर, 2021 को चार दिवसीय **"9वीं भारतीय उद्यान कांग्रेस 2021: स्वास्थ्य, आजीविका और अर्थव्यवस्था के लिए बागवानी"** (9th Indian Horticulture Congress-2021: Horticulture for Health, Livelihoods and Economy) विषय पर उद्यान कांग्रेस का आयोजन किया जा रहा है। जिसमें उद्यान एवं शाकभाजी पर अधारित कृषि विश्वविद्यालयों एवं कृषि विज्ञान केन्द्रों का प्रदेश में ही नहीं अपितु देश के कृषि विकास में महत्वपूर्ण योगदान प्रदान किया गया है।

मैं आशा करता हूँ कि उद्यान कांग्रेस–2021 के आयोजन से देश एवं प्रदेश के उद्यान एवं शाकभाजी के उत्पादन में वृद्धि हेतु ठोस रणनीति तैयार होगी जो किसानों की आर्थिक एवं सामाजिक स्थिति को सुधारने एवं उद्योग जगत में कृषि को नया आयाम मिल सकेगा।

मैं इस उद्यान कांग्रेस–2021 के सफल आयोजन एवं इस अवसर पर स्मारिका के जनउपयोगी एवं उद्देश्यपरक प्रकाशन हेतु हार्दिक बधाई एवं शुभकामनाएँ प्रेषित करता हूँ।

Alok Sinha

(आलोक सिन्हा)

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9^TH^ INDIAN HORTICULTURE CONGRESS - 2021

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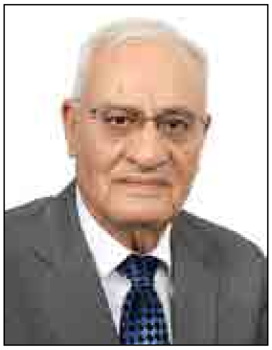
FOREWORD



The Indian Academy of Horticultural Sciences (earlier Horticultural Society of India) is one of the premier horticultural societies in the Indian sub-continent founded on 1st January, 1942 at Lyallpur (Punjab Province) (in undivided India with the objective of promoting the science and practice of Horticulture) and registered on November 6th in 1950. The decision to start the society was taken by four eminent horticulturists of the country at that time, namely, Sardar Bahadur Lal Singh, Shri S.S. Bhat, Shri Aslam Khan and Dr P.K. Sen in a Fruit Committee meeting organized by the then Imperial Council of Agricultural Research at Delhi. Since its inception in 1942, the Indian Academy of Horticultural Sciences has travelled and has the distinction of the premier professional academy and had been leading in organizing several symposia, conferences, seminars, brainstorming sessions, etc. both International and national on topical issues related with Horticulture thus impacting the research and development personnel, students, technocrats, growers, policy makers, entrepreneurs, and industry representatives involved in Horticulture and allied sectors. The earlier path-breaking initiatives of the academy include national seminars on topics like Hi-tech Horticulture, Plant Biotechnology, Organic Farming and Pre & Post-harvest Management in Horticulture. The academy also organized several crop-specific dedicated symposia, *e.g.* sapota, grape, papaya, banana, citrus and temperate fruits. Though the society has held a number of symposia to deliberate and sensitize latest advancements on topical issues, the need for organizing biennial Horticulture Congress on the lines of Indian Science Congress was felt during 2004 when the academy took the initiative to organize the following mega events;

- First Congress on '*Improving Production, Productivity, Quality and Trade of Horticulture Crops*' held at New Delhi in 2004
- Second Congress on '*Opportunities and Linkages for Horticulture Research and Development (Focus: North Eastern Region)*' held at Barapani, Meghalaya in 2007
- Third Congress on '*New R & D Initiatives in Horticulture for Accelerated Growth and Prosperity*' held at Bhubaneswar, Odisha in 2008
- Fourth Congress on '*Horticulture to Horti- Business*' held at New Delhi in 2010
- Fifth Congress on '*Horticulture for Food & Environment Security*' held at Ludhiana, Punjab in 2012
- Sixth Congress on '*Horticulture for Inclusive Growth*' held at Coimbatore, Tamil Nadu in 2014
- Seventh congress on '*Doubling Farmers income Through Horticulture*' at New Delhi in 2016.
- Eight Congress on '*Shaping Future of Indian Horticulture*' at Raipur, Chhattisgarh in 2019.

The Indian Academy of Horticultural Sciences has marched attune with the changing times and has been the true flag bearer in championing the cause of horticulture in the country. Time and again it has served as the source for flagging off R & D issues in Horticulture, which have far reaching influence on setting up of research and development agenda. Since its inception the academy had the patronage of several stalwarts and luminaries in Horticulture who have contributed immensely in shaping this sector in the country from a homestead activity to a full-fledged organized industry.

In 2021, India emerged as a major producer of horticultural crops and emerged as the Horticulture Bowl of the world. The horticulture production is estimated at 329.86 million tonnes, and India ranks second after China. The Horticulture sector *per se* is contributing over 30% share in the agriculture GDP of the country, which is also forming the base for rural entrepreneurship and employment generation. Horticulture signifies diversity in crops ranging from fruit & plantation crops, vegetables, flower and ornamental plants, tuber crops, spices, medicinal and aromatic plants, mushroom, bamboo production, honey production etc. Horticulture in India with its higher annual growth rate has become a major contributor to growth of Indian agriculture. It is, therefore, important that horticultural crop production is given more emphasis so that it could sustain the desired growth rate in agriculture sector and provide job opportunities to the emerging youth force.

Presently, the Horticulture sector contributes around 30% of the GDP and 38% of the total exports of agricultural commodities from about 13.08% of area. During 1070's (VII Five Year Plan) focused attention was given to horticultural research and development, which made India emerge as the as the second largest producer of fruits and vegetables; largest producer and consumer of cashewnut, tea, spices; third largest producer of coconut; fourth largest producer and consumer of rubber and sixth largest producer of coffee in the world. About 10 per cent of the total budget of Indian Council of Agricultural Research (ICAR) and 30 per cent of the total budget of the Department of Agriculture & Cooperation (DAC) is now being earmarked for the Horticulture Sector.

Several new schemes are in operation leading to significant development in area expansion, production, value-addition and exports. Likewise, budgetary and institutional allocations have also increased considerably. Today, as a result of better synergy between research agencies, technological and policy initiatives by different central and state governmental agencies, proactive participation of private sector and higher degree of employment generation diversification to Horticulture, this sector has emerged as a sustainable and viable proposition for even the small and marginal farmers including different stakeholders in the commodity chain. In spite of the remarkable progress made in the Horticulture Sector in India, there is a lot of scope in further consolidating the missing links. This could better happen in a situation where private agencies, which have strong forward linkages and public & private-funded agencies having strong backward linkages join together to harness the potential of this sector to forge towards newer heights in the era of globalization, consumerism, skill development, organized retail and e-trading, better access to market information, micro-finance and crop insurance etc. The time has come for forging rewarding PPP ventures, which would pay rich dividends to all the partners. The challenges are many, namely, nutritional security in diverse agro-climatic zones, threat of climate change, need for new plant genotypes for diversified end uses, efficient management of production deficit and gluts, lack of infrastructure in commodity value-chain, retail chains and organized market systems, establishment of farmer producer companies/ SHGs, Crop clusters and export promotion. It is, therefore, necessary that modern Horticulture sector gears to meet the new challenges and to bring overall change leading to redefining the short and long term goals in research, production system, education and human resource development, public and private sector collaboration, market intelligence and auction system and, refinement & implementation of diligent policies to boost production, productivity, processing and export of fresh and processed horticultural produce and products.

Several states have taken the advantages of the pro-horticulture programmes and policies of both central and state governments and have marched ahead and made remarkable progress in almost all sub-sectors in Horticulture. Several newer issues are however cropping in and the world community is discussing the impact of climate change on crop production and concerns for the depleting biodiversity, which are also affecting horticulture sector too. It is timely that the 9th Indian Horticulture Congress is being organized on the theme Horticulture for Health, Livelihoods and Economy" is being organized from 18-21 November, 2021 at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh to commemorate the International Year of Fruits and Vegetables, declared by Food and Agricultural Organization (FAO). This event will be an occasion to take stock of the current situation of Horticulture and to identify critical gaps in various existing and emerging areas in horticulture. This implies better exchange of scientific and technical information among various stakeholders to achieve the goal of high quality safe production to enhance productivity, quality, profitability, meeting market and consumer requirements, value-addition, export promotion etc. in a sustainable way.

The Indian Academy of Horticultural Sciences has made an effort in this Souvenir to publish the Invited paper abstracts of scheduled to be presented in 12 Technical Sessions. The academy had requested resource persons and organizations of repute to contribute in this Souvenir to bring their experiences to celebrate the International Year of Fruits and Vegetables besides, enable formulation of strategies for the future holistic growth of the sector in the competitive global market. The response received has been quite encouraging. We are indeed indebted to all the contributors who accepted our request and agreed to share their expertise/ views.

On behalf of the Indian Academy of Horticultural Sciences, I take this opportunity to profusely thank the members of National Advisory Committee, Local Organizing Committee, Office Bearers & members of the Executive Committee of the academy; faculty, students and staff members of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, Chairmen/ Coordinators and the team members of different Committees who have toiled hard in organizing the 9th Indian Horticulture Congress-2016 in a befitting manner. I would also like to place on record our gratitude to all the public and private organizations supporting the Congress, namely, Ministry of Agriculture and Farmers Welfare, GoI, Govt. of Uttar Pradesh, Indian Council of Agricultural Research, Agricultural and Processed Food Products Export Development Authority (APEDA), Chandra Shekhar Azad University of Agriculture & Technology, Kanpur; Sevenstar Fruits Ltd., National Horticulture Board, National Horticultural Research and Development Foundation, National Bank for Agriculture and Rural Development, UPCAR and Department of Horticultural & Food Processing, for co-sponsoring the event. I thank profusely, Mahyco Grow, Bayer, Dainik Jagran, Goldee Masale, VNR Seeds, ICSI, IFFCO, Namaste India, Nunhems Seeds and several others for providing the financial support in organizing this Congress.

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Thanks are due to Chairmen, Conveners and members of different Local Organising sub-committees for their whole hearted support in organising this congress. I am equally thankful Chairpersons, Co-Chairpersons and Conveners who have agreed to conduct the Technical Sessions. I am extremely obliged to all the invited speakers and guest contributors who have responded to our request for both participation and presentation. I am sure the Congress would generate meaningful discussions culminating in more relevant recommendations, which can be projected to different agencies for consideration in framing policies and developmental progammes for future improvement of productivity of horticultural crops and income of horticultural farms.

I wish every participant in the congress a very happy stay at Kanpur, participation in fruitful discussions and good luck for their future endeavours. The IAHS family conveys all the delegates a Very Happy and Prosperous New Year-2022.

K.L. Chadha

12th November, 2021

(K.L. Chadha)
President IAHS & Chairman, National Organizing Committee

KNOW YOUR MINOR, UNDERUTILIZED AND EXOTIC FRUITS: NUTRITIONAL AND HEALTH BENEFITS

Sanjay Kumar Singh, V.B. Patel, Jai Prakash, M.K. Verma, Chavlesh Kumar and Satyabrata Pradhan
Division of Fruits and Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012
E-mail: sanjaydr2@gmail.com

Introduction

Horticulture has emerged as the major driver of growth in the Agriculture Sector in India. However, there was a major boost to this sector with higher allocation of funds by the Government of India during the VII FYP, which resulted in development of sound infrastructure for R&D, besides implementation of several programmes and pro-horticulture policies. At present the area under horticulture crops has increased from 1.95 million ha in 1947 to 26.2 million ha in 2019 resulting in cumulative increase of 506 per cent during the last 60 years. During the same period, the total horticulture production has increased from 31.8 million MT in 1961 to 319.5 million MT in 2019-20 a clear cumulative increase of 904 per cent. Recently, in 2020-21, the estimated production is poised at 329.86 million tonnes (second adv. estimates released on 15.07.2021; Source MoAFW, GoI).

India is a paradise for growing large number of fruit crops due to prevailing diverse agro-ecological conditions. About 40 fruits are grown in India of which several are commercial. Besides major fruit crops, there are several minor, underutilized and exotic which are now being grown commercially. Many of these fruit crops were earlier neglected due to various reasons (due to lack of supply chains, poor shelf-life, unknown for their nutraceutical values, etc.). However, these fruit species are well recognized for their tolerance/ resistance to several stresses and resilience to climate change. These minor and underutilized fruits are realized for their high nutraceutical values and their use in traditional foods. These fruits are being well adapted in diverse edaphic and climatic conditions, thus have potential to contribute in food security, nutrition, dietary and health food, culinary use and income generation. As consequences, several neglected fruit crops are now of global significantly, dragon fruit, kiwifruit, blue berries etc.

Malnutrition is one the biggest challenge among the Indian population and India's child malnutrition is still alarming in the world. Subsequently, child and maternal malnutrition are accounting for the 15 percent human diseases and disorders in India. It is estimated that due to the child malnutrition, India losses about its four per cent of the gross domestic product and eight per cent of its productivity. This challenging situation need to be addressed with nutrient rich diversified diet especially the food rich in iron, zinc and vitamins along with several essential bioactive compounds. The diversified diet always needs to be included in the form of fresh and cooked fruits and vegetables owing to their richness in vitamins, minerals and essential bioactive compounds designated as protective food. They are also rich sources of certain soluble dietary fiber which reduces erratic bowel movements, aids in cholesterol and fats reduction from the body and ultimately helps in boosting the body immune system. It is here that role of minor, underutilized and exotic fruits are essential to combat the challenge of malnutrition being the inherent source of micronutrients. In the present note an attempt has been made to compile the information on nutritional and health benefits of some minor, underutilized and exotic fruit crops.

Minor & Underutilized Fruit Crops

Underutilized crops may be termed as the crops that are neither grown on a commercial or large scale nor are traded widely around the world. These crops fall under lesser recognized plant species in terms of research and marketing but are well adapted to the wild and stress like conditions. Neglected and underutilized crops are domesticated plant species that have been used for centuries by locals for their food, fibre, fodder, oil or medicinal properties, but have been reduced in importance due to commercialization of major fruit crops having organized trade. Similarly, these crops are also described as orphan, abandoned, lost, underutilized, local, minor, traditional, alternative, niche, or underdeveloped; recently as neglected, forgotten or smart food. Reductions in use may pertain to, among other things: supply or consumption constraints, poor shelf life, unrecognized nutritional value, poor consumer awareness, and reputational problems.

As the demand for plant and crop attributes changes (reappraisal or discovery of nutritional traits, culinary value, adaptation to climate change, etc.), neglected crops can overcome the constraints to the wider production and use. Although the options for scaling up neglected crops for large-scale cultivation appear to be increasingly limited, many species have the potential to contribute to food security, nutrition, dietary, culinary and processing use, health and income generation. Besides, being environmental friendly are also nutritious, higher medicinal properties and multiple uses. Various underutilized fruit crops available in India included; *Aegle marmelos*, *Annona muricata*, *Artocarpus heterophyllus*, *Averrhoa carambola*, *Bactris gasipaes*, *Canarium indicum*, *Carissa edulis*, *Carya cathayensis*, *Casimiroa edulis*, *Cornus mas*, *Crataegus monogyna*, *Cydonia oblonga, Dimocarpus longan*, *Diospyros kaki*, *Durio zibethinus*, *Emblica officinalis*, *Eriobotrya japonica*, *Garcinia mangostana*, *Hippophae rhamnoides*, *Hovenia dulcis*, *Irvingia gabonensis*, *Juglans regia*, *Lagenaria sphaerica*, *Nephelium lappaceum*, *Passiflora edulis*, *Pistacia lentiscus* etc. During present day wild and underutilized fruits, ethnic fruits are gaining popularity along with the major fruits, and thus diversifying the fruit basket on the dining table.

Arid Region Fruits

Arid zone is characterized by extremes of temperature, low and erratic rainfall, high wind velocity, high evapotranspirational losses of water and light sandy soil with very low water holding capacity and poor fertility status. Hence, the crops suited in the region have xerophytic traits and some do have summer dormancy. Drought-hardy crops especially perennial fruits with deep root systems are capable of surviving extreme radiation and temperatures and provide income security, nutritional security and food security. Some of the fruit crops suited for the region are;

***Aonla* or Indian gooseberry (*Emblica officinalis* Gaertn.):** It belongs to the family Euphorbiaceae, is an ancient, indigenous fruit of India. All parts of the plant including the fruits are medicinally rich and are used in the preparation of various Ayurvedic medicines. Fruits are commercially used for preparation of *Chayanprash* and *triphala*. Being a rich source of vit. C, is helpful in curing scurvy, problems of teeth, gums, eye and stomach. The pellets of dried *aonla* powder is being served to soldiers during war and sea voyage for the treatment of scurvy. Being a nutritious and medicinal, *aonla* proves the proverb, "*an aonla a day keeps the doctor away*". It contains 500-1500 mg vit. C, 0.2 mg nicotinic acid, 1.2 mg iron, 0.5 g protein, 0.l g fat, 0.7 g minerals, 2.0-3.4 g fibre, 14-21.8 g carbohydrates, 0.02 g phosphorus and 0.05 g calcium in 100 g pulp. The total sugars content in *aonla* fruit varies from 7 to 9.6%, reducing sugars from 1.04 to4.09 per cent and non-reducing sugars from 3.05 to 7.23 per cent, among the various varieties. Fresh fruits are also used for the preparation of products such as preserve (*murabba*), pickle, chutney, shreds, etc. The fruits act as diuretic, laxative and useful in anemia, atherosclerosis, hemorrhages, leucorrhea, bronchitis, liver ailment, diarrhea *etc*.

***Bael* (*Aegle marmelos* Corr.):** It is a native of India and belongs to the family Rutaceae. The pulp is mucilaginous. The fruit and leaves are used for curing stomach diseases and to improve digestive system. All parts of the tree *i.e.*, root, bark, leaves, flowers, fruits and seed oil are used in different Ayurvedic medicines. *Bael* fruit contains 31.8 g carbohydrates, 1.8 g protein, 2.9 g fibre, 1.7 g mineral (mainly Ca and Fe), 8-18 mg vitamin C, 0.03 mg riboflavin per 100 g pulp. Fruits can be processed into various beverages and preserves. Its wood is used to prepare agricultural implements, besides the trifoliate leaves is grown in temple premises of Lord Shiva. All the parts of plant are economical and possess different medicinal values, *viz.* leaves, roots, seed, bark and fruit *etc.* contain a large amount of coumarins, alkaloids, sterols and essential oils hence, possess analgesic, anti-inflammatory, antipyretic, anti-microfilaria, antifungal, hypoglycemic, anti-dyslipidemic, immunomodulatory, anti-proliferative, wound healing, anti-fertility, and insecticidal abilities. The fruit is considered as one of the richest source of riboflavin. Marmelosin in fruit has therapeutically active factor which is remedy of the stomach ailments. The fresh leaf juice in doses of 8 to 16 g is given with honey as a mild laxative in fever, catarrh and asthama. Fresh leaves and fruits are used as a remedy for beriberi. It is also used in the treatment of chronic diarrhea, dysentery, and peptic ulcers, as a laxative and to recuperate from respiratory affections.

***Ber* (*Ziziphus mauritiana* Larnk.):** It belongs to the family Rhamnaceae and is indigenous to India. *Ziziphus nummularia* (syn. *Z. rotundifolia* Lamk.), *Z. oenoplia* Mill., *Z. rugosa* Lam.. and *Z. sativa* Gaertn are also native of India and yield edible fruits. *Ziziphus jujuba* Mill. (Chinese jujube) produces large fruits but is not common in India. The fruits of *ber* have been in use in India since ancient times. The fruits are rich in sugars, vitamins C, A and B complex. Fully ripe fruits of *ber* contain 0.8-0.9 g starch, 16-23°Brix TSS, 4.9-12.4 g total sugars, 2.0-5.8 g reducing sugar, 0.1-0.5 per cent acidity apart from 0.3-0.5 g ash, 0.03-0.04 g calcium, 0.01- 0.02 g phosphorus, 0.5-1.0 mg iron and 66-133 mg vitamin C per 100 g of pulp. *Ber* leaves contain 5.6 per cent digestible crude protein and 49.7 per cent total digestible nutrients and are thus a nutritive fodder for animals. The decoction from root and bark is good for dysentery and diarrhea and leaf decoction is useful as gargle in sore throat and in bleeding gums. The powder of roots has medicinal properties for curing ulcer, fever and wounds. It is also rich in carotenes and phenolics. The secondary metabolites were present in ber fruits like flavonoids, glycosides, saponins, lignins, sterols and phenols are very effective function against pathogens. The different parts of plant like root, bark, leaves, flowers, seeds are used for treatment and also used as blood purifier and appetizer.

***Lasora* (*Cordia myxa* Roxb.)**: It is also known as *gonda* or Indian cherry or *leusua* is a drought hardy fruit tree of the family Boraginaceae. Cordia is native of India and occurs throughout the warmer regions of the world. A related species *C. gharaf* Forsk. (*gondi*) is found distributed in arid sub-tropical region. Cordia plants are sensitive to frost but can tolerate the extremely high temperatures. Unripe fruits are used as pickle and vegetable. The ripe fruits are eaten as fresh and are rich in sugar and minerals. It has anthelmintic, diuretic, demulcent and expectorant properties. Other parts of the plant also have medicinal properties. Leaves are used for curing ulcer and headache. The bark is used for the treatment of fevers.

***Karonda* or Christ's thorn (*Carissa carandas* L.):** It belongs to the family Apocynaceae, is a hardy evergreen spiny shrub of Indian origin. It is a multi-branched bushy tree and is generally planted as a hedge. It can tolerate the hot and dry conditions and intense solar radiation in the arid and plateau region. *Karonda* fruits are rich in Fe (39.1%) and also contain 2.2 per cent protein, 96 per cent fat, 2.8 per cent minerals, 0.10 per cent Ca, 0.06 per cent P and 201-555 mg/100 g vit. C. The fruits are astringent, anti-scorbutic and are used as a remedy for biliousness. The major bioactive constituents, which impart medicinal value to the herb, are alkaloids, flavonoids, saponins and large amounts of cardiac glycosides, triterpenoids, phenolic compounds and tannins. Fruits have been reported to contain carisol, β-caryophyllene, carissone, carissic acid, carindone, carinol, ascorbic acid, lupeol, and β-sitosterol. The fruits are traditionally used for medicinal treatments of malaria, epilepsy, nerve disorder, relieve of pain and headache, fever, blood purifier, itches and leprosy. These chemicals are very effective in the treatment of scabies, intestinal worms, pruritus, biliousness and also used as antiscorbutic, anthelmintic.

***Ker* (*Capparis decidua* (Forsk.) Edgew.):** It is a native of India a prominent fruit plant found wild in the desert. It belongs to the family Capparidaceae. Almost all the plant parts have economical and medicinal value. The tender branches and leaves are used as a plaster on fractures and swellings. The foliage and stem are chewed to relieve toothache. The root and root bark are pungent and bitter and are used to treat intermittent fevers and rheumatism. The stem bark is laxative, diaphoretic and anthelmintic and is useful in the treatment of cough, asthma and bronchial inflammation. Immature flower buds, flowers and unripe green, immature acrid fruits are used as vegetable. Unripe fruits contain 14.9 g protein, 7.4 g fat, 59.4 g carbohydrate, 12.3 g fibre, 90 mg calcium, 779 mg phosphorus, 3.5 mg iron, 9000 IU vitamin A and 120.7 mg vitamin C in 100g edible matter. These contents are 17.0 g, 5.0g, 71.0 g, 1.0g, 210 mg, 360 mg, 6.0 mg 35000 IU and 119 mg respectively in ripe fruits. It has numerous medicinal properties as its different plant parts have pharmacological activities like hyper-cholesterolemic, anti-inflamatory and analgesic, anti-diabetic, anti-microbial, anti-plaquer, anti-hypertensive, anti-helmintic and purgative activities.

***Pilu* (*Salvadora oleoides* Decne.)**: It is an underexploited multipurpose tree species. Its bushy trees are tolerant to drought and salinity grows successfully in the ravines and degraded lands. Ripe *pilu* fruits are eaten fresh. The fruits contain 6.0 g protein, 2.0 g fat, 76.0 g carbohydrate, 2.0 g fibre, 630 mg Ca, 167 mg P, 8.0 mg Fe and 2.0 mg ascorbic acid in 100 g pulp and the seeds contain 45-46% fat, 18.9% albuminoides, 28.5% carbohydrates, 5.8% fibre and 3.5% ash. Many chemical constituents such as carbohydrates, alkaloids, steroids, glycosides, saponins, tannins, triterpenes, mucilage, fats and oils have been reported from its leaves and stems extracts. Seeds contain 40-45 per cent non-edible greenish-yellow fat (oil), which is a potential industrial substitute for coconut oil. The fat is rich in lamic and myristic acids and is used in medicines. Because of the presence of these active chemical constituents it possesses anti-inflammatory, analgesic, anti-ulcer, anthelmintic, antibacterial, antifungal and diuretic activities.

Cactus pear (*Opuntia ficus-indica* (L.) Mill.): Commonly known as prickly pear or Opuntia pear, belongs to the family Cactaceae. Being a succulent xerophytic plant, it is ideally suited to arid and semi-arid regions. Cactus pear is cultivated in several countries for fruits, vegetable, and fodder. The plant has thick succulent spiny or spineless pads called ‘cladodes’. The fruit is known as ‘tuna’. These are used fresh and for processing as well. The tender cladodes are used as green vegetable and salad. It is a traditional vegetable in Mexico. It also has medicinal value for the treatment of diabetes and is also used as cattle feed during drought periods. *Opuntia* species have been drawn attention of international scientific community and FAO has promoted its cultivation. It cladodes have been used for the treatment for gastritis, hyperglycaemia, hypercholesterolaemic, arteriosclerosis, diabetes, prostatic hypertrophy and they also have an hypolipidemic action and immune-regulation function in gastro-intestinal tract.

Tropical and sub-tropical Fruits

Custard apple or *sitaphal* (*Annona squamosa* L.): It is a sweet and delicious dessert fruit. It belongs to the family Annonaceae and is native of South America. It has adapted so well in India that a considerable variability is found in Aravali hills in north India and in Telangana & Andhra Pradesh. Some related species such as *A. reticulata* (Ramphal), *A. cherimola* (Laxmanphal), *A. atemoya* (Hanumanphal), *A. glabra* (pond apple) are also important. Custard apple fruits are rich in carbohydrates (23.9%), protein (1.6%), calcium (0.02%), iron (1.0 mg/100 g) and mineral matter (0.7%). The leaves of the plants have been used as insecticide, anti-helmintic and in the healing of bleeding wounds. Unripe and dried fruits are used as anti-dysenteric. Bark act as powerful astringent, anti-dysenteric and vermifuge. Root, bark, leaves and stems are sources of many isoquinoline alkaloids. Annonaceous acetogenins isolated from the seeds were found to possess potent cytotoxicity against different cancer cell lines. The crude extracts as well as isolated compounds from different plant parts exhibited pharmacological activities such as antidiabetic, antimicrobial, antidepressant, anxiolytic, antiviral, antitumor and cytoprotective.

***Chironji* (*Buchanania lanzan* Spreng.)**: It is a tropical evergreen, underutilized nut fruit and is native to India. It is a member of the Anacardiaceae family. *Chironji* plays an important role in lives of tribal people in southern and northern tropical dry deciduous forests in both medicinal and as income generating with fruit kernels for better livelihoods. Fruit kernels are eaten raw or roasted and also used in making dessert, which is rich source of protein, fat, starch, vitamins and minerals and yields sweet oil, which can be used as substitute to olive and almond oil. The tree provides food, fuel, fodder, timber, lac and has medicinal properties. It contains 3.0 g moisture, 19.0 g protein, 59.1 g fat, 3.8 g fibre, 12.1 g carbohydrates, 279 mg Ca, 528.0 mg P, 8.5 mg Fe, 0.69 mg thiamine, 0.53 mg riboflavin, 1.5 mg niacin and 5.0 mg vit. C per 100 g of kernel and provides 656 calories. The polyphenols have been proven for its disease fighting power and possess good antioxidant activities. The fatty acids, polyphenols, phytosterols and stigmasterol in seed extract has both medicinal and nutritional value.

Fig (*Ficus carica* L.): It belongs to the family Moraceae and is closely related with species, *F. glomerata* (gular) is common in deciduous forests in the subtropical region. It is a native of India and is grown in arid and semi-arid tracts since antiquity. Fruits are valued for their laxative and medicinal properties. The fruit contains 11.5 g sugar, 1.5 mg iron, 270 IU vit. A per 100 g pulp. Fig fruits preserved in vinegar are used to cure liver and spleen enlargement in children and are effective in the treatment of chronic cough and piles. Phytochemistry of the fruit revealed the presence of total phenolics, flavonoids, alkaloids and saponins and other secondary metabolites that contribute to its high antioxidant activity which was evident from ABTS and FRAP assays. Volatile components of fig fruit were identified through GC-MS and showed the presence of vit. E, β-amyrin, stigmasterol, campesterol, oleic acid, isoamyl laurate and ϒ tocopherols majorly. The extract was also screened for antibacterial activity and showed zone of inhibition against *Proteus mirabilis* and *Bacillus subtilis*.

Pommelo (*Citrus maxima* (Burm.) Merr. or *Citrus grandis* L.): It is the largest citrus fruit of the family Rutaceae and the ancestor of the grapefruit. It is found growing in all Eastern, north-eastern and southern states. The fruit is large, 15–25 cm in diameter, usually weighing 1–2 kg. It has a thicker rind than a grapefruit, and is divided into 11 to 18 segments. Aril juice has good TSS (8-12%), low acidity (0.2-0.8%), vit. C (41-60 mg/100 g FW), total anthocyanins

(0.011- 0.030 µmol ml^{-1}) with high fibre content. Pummelo contains higher antioxidants thus beneficial for health. It contains several vitamins, minerals, and antioxidants. Pomelo is also rich in potassium, which helps regulate fluid balance and blood pressure. It helps in promote weight loss. Pommelos contain high levels of antioxidants, including vitamin C, naringenin, naringin, and lycopene, which may several health benefits. It has anti-aging and heart-healthy properties, and boosts heart health by reducing levels of cholesterol and triglycerides. Thus, reduce these blood fats by preventing the cholesterol. Extract from pomelo peels and leaves have been shown to kill cancer cells and prevent the spread of cancer**.**

Pomegranate (*Punica granatum* L.): It belongs to the family Punicaceae. It is a delicious table fruit rich in vitamins (0.06 mg thiamine, 0.1 mg riboflavin, 0.3 mg niacin and 16.0 mg vitamin C per 100 g pulp), minerals (10.0 mg calcium, 70 mg phosphorus and 0.3 mg iron per 100 g pulp), carbohydrate (14.5%) and protein (1.6%). The fruit is used as a special diet for sick and aged persons. Several *in vitro* and *in vivo* studies have revealed its beneficial physiological activities, especially its antioxidative, antimicrobial and anti-inflammatory properties. The health-promoting properties of the fruit are considered to mainly be due to the presence of punicalagin and, to a lesser extent, to other metabolites, such as flavonols and anthocyanins. Several studies have brought up the potential contribution of pomegranate in the treatment of cancer, diabetes and heart disease.

Tamarind (*Tamarindus indica* L.): It is an important fruit crop of semi-arid, tropical and subtropical regions experiencing extended spell of dry weather. It is a frost susceptible but drought hardy tree species of the family Fabaceae and can be grown in degraded and problematic soils but performs well in deep, well drained, red loam soils. Tamarind pulp is a good source of calcium, tartaric acid (8-18%), malic acid, protein (3.1%), invert sugar (30-40%), vitamins and other minerals. Young leaves, flowers, seed kernels and bark of the tamarind tree are also used for various purposes. It has various pharmacological activities like hypolipidemic, weight reducing, antimicrobial, hepatoprotective, anthelmintic, antioxidant, analgesic and anti-inflammatory *etc*. Tamarind fruit pulp contain proteins, carbohydrates and minerals especially Na, Zn and Fe and can be eaten as fresh or processed into different food products and also the principal culinary souring agent for dishes, squashes, chutney, beverages, *etc*. The fruit has medicinal value and treated as a number of diseases. Antioxidant activity present in tamarind indicate that fruits contain biologically important mineral elements and have high antioxidant capacity associated with high phenolic content appetizer, stomach ailments, etc.

***Jamun* [*Syzygium cuminii* (L.) Skeels]:** It belongs to family Myrtaceae and is indigenous to India and grows well under humid tropical conditions. It is also found growing in Thailand, Philippines, Myanmar, which are probably the secondary centre of its origin. *Jamun* is also cultivated in drier parts of Israel, Algeria, Malagassy, West Indies and South Africa. In deciduous forests of subtropical region, it sheds leaves during the spring season. Its fruits are nutritious and are rich in minerals, fibre, carbohydrates and vitamins A and C. The fruit also contains 1.0 g iron, 0.02 g calcium, 0.01 g phosphorus, 0.7 g protein, 0.1 g fat, 0.9 g fibre and 19.7 g carbohydrates in 100 g pulp. *Jamun* fruit is rich in anthocyanin pigments. Fruits, seeds and bark have medicinal value. The gallic acid and ellagic acid content present in seed play an important in role in conversion of starch into sugar thus minimizing blood glucose level. It is also effective in the treatment of inflammation, ulcers and diarrhea. Fruit pulp contains very high anthocyanin content and can be a good source of natural food colourants for the food processing industries. The pigment is known for their strong antioxidant capacity and health-protecting effects and reduces the risk of various diseases.

Wood apple (*Feronia limonia* (L.) Swingle): It belongs to the family Rutaceae. It is a native of India and Sri Lanka and is found throughout the tropical and subtropical plains. It grows wild in drier regions of Myanmar and Indochina. Fruits contain 7.3 per cent protein, 15.5 per cent carbohydrates, 170 mg riboflavin, 2 mg vitamin C per 100 g pulp and minerals, especially Ca and P. The fruits are highly acidic and contain 7.6 per cent acid when unripe and 2.3 per cent when ripe. The fruits also contain 3-5 per cent pectin making it suitable for making good quality jelly. The fruits are also used in various ayurvedic preparations for the treatment of diarrhoea, dysentery, gum and throat problems. The fruits contain phytochemicals (polyphenols, phytosterols, saponins, tannins, coumarins, triterpenoids), vitamins, amino acids *etc*. It has curative value for various diseases of bones and joints, bilious diseases, prevention of capillary bleeding, cold, influenza, piles, dysentery, habitual constipation and scurvy. The fruit pulp is used as a liver and cardiac tonic, diarrhoea and dysentery.

***Phalsa* (*Grewia subinaequalis* DC.) syn. *Grewia asiatica* L.)**: It belongs to the family Tiliaceae, is a native of India. It is widely cultivated in tropical and subtropical parts of India, Pakistan, Bangladesh, Thailand and Philippines. Phalsa is a drought hardy fruit and is grown successfully in the hot and dry plains having distinct summer and winter and is, thus, most suited to the arid parts of the country for the production of quality fruits even under extreme summer conditions. Capable of thriving in the humid tracts of coastal India. Its fruit are rich in carbohydrates (14.7), Ca (12.9 mg/100 g), P (39 mg/100 g), Fe (3.1 mg/100 g), b-carotene (419 µg/100 g) and fibre (1.2%). *Phalsa* fruits are cooling aphrodisiac and tonic and alley thirst and burning sensation, remove biliousness, cure inflammation, heart and blood disorders and fever. The extracts from various parts of *phalsa* plants (especially the fruit) possess strong antioxidant, radioprotective, antimicrobial, antidiabetic, anti-inflammatory, anticancer, and cardio-protective properties.

Minor Temperate Fruits

Pistachio (*Pistacia vera* L.): It belongs to family Anacardiaceae. The earliest attempt to cultivate pistachio nut in India was made as early as 1985 at the Regional Horticultural Research Station, Sharbo-Kinnaur of H.P. In India, it is mainly grown in Western Himalayan states like J&K, Himachal Pradesh, Uttarakhand and have potential to grow even in Eastern Himalayas (Arunachal Pradesh). It is a nutrient-dense nut with a heart-healthy fatty-acid profile as well as protein, dietary fibre, potassium, magnesium, vitamin K, γ-tocopherol and a number of phytochemicals. The pistachio's unique green and purple kernel colour is a result of its lutein and anthocyanin contents. Among nuts, pistachios contain the highest levels of potassium, γ-tocopherol, vit. K, phytosterols and xanthophyll carotenoids. It is mainly used as roasted and salted for snacks purpose and rest in the form of flavouring agent in ice-cream, confectionary and non-vegetarian dishes. Exploratory clinical studies suggest that pistachios help maintain healthy antioxidant and anti-inflammatory activity, glycemic control, and endothelial function. Pistachios help in controlling body weight because of their satiety and satiation effects and their reduced net metabolizable energy content.

***Chilgoza* (*Pinus gerardiana* Wallichex. D. Don.)**: It is commonly known as the chilgoza pine. It is a pine native to the north-western Himalayas in eastern Afghanistan, Pakistan, and northwest India, growing at elevations between 1800 and 3350 m. In India, it grows naturally in the inner Himalayan zone comprising Kinnaur and Pangi in H.P and Kishtwar and Astur areas of J&K. The Chilgoza pine is well known for its edible pine nuts, rich in carbohydrates and proteins. The nut is eaten as raw, roasted or used in confectionary. It contains 51.3% fat, 8.7% water, 13.6% protein, 22.5% starch, 0.9% fibre and 3% mineral and ash; it possesses a tremendous wound healing property. The plant shows various biological activities such as antioxidant activity, antithrombotic and anti-platelet activity, antidiabetic activity, anti-inflammatory activity, antifungal activity, antibacterial activity *etc*.

Sea buckthorn [*Elaeagnus rhamnoides* (L.) A. Nelson]: It belongs to family Elaeagnaceae, originated from Eurasia. Commonly, it is also known as seaberry, Leh berry, sand thorn, sallow thorn, wonders berry and Ladakh gold, is one of the most nutritious fruit. The leaf extracts are rich in flavonoids, tannins, and triterpenes like isorhamnetin-3-O-glucoside, kaempferol-3-O-β-D-(6-O-coumaryl) glycoside, 1-feruloyl-β-D-glucopyranoside *etc*. Ripe berries are rich in vitamins (A, C, E, and K), organic acids, carotenoids and flavonoids. Sea buckthorn seed is also a good source of vit. C, vit. E, carotenoids, flavonoids, fatty acids, organic acids, triacylglycerol, phytosterols, pro-anthocyanidins, phenolic compounds etc. Oil extracted from berries is not only rich in monounsaturated fatty acids (MUFA) and tocopherols but also in various vitamins including E and K, carotenoids, β-70 sitosterol and other compounds. Its seed and root extracts have higher antioxidant activities. Gallic acid was observed as the most important antioxidant in sea buckthorn. Sea buckthorn leaves can be used for the treatment of gastrointestinal disorders, diarrhoea and dermatologic diseases. Leaf tea has proven to play a role in reducing the body weight through lowering the cholesterol, also in controlling blood pressure and blood sugar and platelet aggregation. In Indian and Tibetan medicine, fruit pulp extract, pulp and seed oil have been used to treat a number of diseases including skin disorders, gastric ulcers, coronary heart disease, platelet aggregation etc. Apart from this, the seed and fruit oils are also used for curing of lupus erythematosus, inflammatory diseases, trachoma, eczema, chronic wounds, burns etc.

Spondias (*Spondias mombin* L.): Known as hog plum (*S. pinnata*) and great hog plum (*Spondias dulcis*) is an underexploited members of the family Anacardiaceae, are growing widely in India for its edible fruits. These deciduous species are tolerant to drought and growing abundantly as fence side trees in West Bengal. Fruits can be eaten fresh, cooked or made into value-added products. Unripe fruits can be made into jelly, pickle, chutney or relishes or used for flavouring sauces, soups and stews. In some places young leaves are eaten raw or steamed as vegetable for eating with salted fish and rice. Fruits are reported to be rich in vit. A, vit. C and Fe contents. The fruits are used to treat heart ailments and urinary troubles and are used on wounds, sores and burns and for digestion. The bark is considered useful in dysentery and diarrhea and is also given to prevent vomiting. The root is considered useful in menstruation. The plant is reported to have anti-tubercular properties. So, there is great scope of increasing socio-economic status of rural and tribal people by exploiting these two species, *viz*., (hog plum) and *Spondias dulcis* (great hog plum).

Minor Exotic Fruits

Rambutan (*Nephelium lappaceum* L.): It is a native of Malaysian archipelago and belongs to the family Sapindaceae. The attractive colour and hairy fruits attracted the visitors enthusiastic farmers who introduced in Kerala and coastal Karnataka about half a century ago. Chemical composition of the rambutan fruit on the basis of 100 g pulp: water content (83 g), caloric value (63 cal), proteins (0.8 g), carbohydrates (14.5 g), calcium (25 mg), vit. C (20–45 mg) and iron (3 mg). The pulp has antioxidant and anti-inflammatory activities. However, rambutan seed extract has a high content of α-glucosidase inhibitory activity, with an IC_{50} value of 9.92 µg/mL relevant to low hypoglycemic activity (antidiabetic). Apart from the above, its anti-inflammatory, antiproliferative, antibacterial and antioxidant activities are also well proven.

Longan (*Dimocarpus longan*): It is also another member of Sapindaceae family. Longan is originated in the mountainous region from Myanmar to Southern China. Fruits are fleshy, very sweet, translucent, white aril which surrounds a red brown to black seed from which it separates easily. Fruit can be eaten fresh, frozen, canned or dried. There are some reports that it is also found wild form in western Ghats region. Longan contains several vitamins and minerals, including iron, magnesium, phosphorus and potassium and large amounts of vitamins A and C. Its pulp has abundant nutritional phytochemicals such as protein, carbohydrates, polysaccharides, polyphenols, etc. which show multiple biological activities including antioxidant, immunomodulatory and antitumor effects. Pulp pericarp also demonstrates biological activities because of its rich content of polysaccharides and polyphenols. Longan seed extract is known for antioxidative, antiproliferative, anti-inflammatory, hypoglycemic and hypouremic effects. It has been reported to contain gallic acid, corilagin (an ellagitannin), ellagic acid, soyacerebrosides I and II, 1-O-β-D-glucopyranosyl-(2S,3R,4E,8E)-2-(2/-lignoceroyl amino)-4, 8-octadecadiene-1,3-diol(longan cerebroside I) and its 8 Zisomer (longan cerebroside II), momor-cerebroside I and phytolacca cerebroside. The most important benefits of longan are skin care, antiaging, boosts libido, flights anxiety, treats insomnia, it may use for blood tonic, promotes weight loss, increase energy, control blood pressure, strengthens immunity, it may use for neuroprotection, speeds-up healing, prevents chronic diseases, aids in digestion, improves memory, it may use for vision health, treats snake bites, dental care *etc*.

Avocado (*Persia Americana* Mill.): It is a native of Central America from where it reached different parts of the world during the sixteenth century. The nutritional composition of avocado pulp has been reported to have a moisture content ranging from 67 to 78%, lipid content ranging from 12 to 24%, carbohydrate content ranging from 0.8 to 4.8%, protein content ranging from 1.0 to 3.0%, ash content ranging from 0.8 to 1.5%, fibre content ranging from 1.4 to 3.0%, and energy between 140 and 228 kcal per g pulp. It is rich in monounsaturated fatty acids, which are effective in reducing the blood levels of undesirable low-density lipoprotein (LDL) and increasing the levels of the beneficial high-density lipoprotein (HDL). Compared to other vegetable oils, avocado oil is known to contain high levels of monounsaturated fatty acids (oleic and palmitoleic acids), low quantities of polyunsaturated fatty acids (linoleic acid) and a significant quantity of saturated fatty acids (palmitic and stearic acids). Another relevant advantage of avocado is the presence of vitamins, such as β-carotene, vitamin E, retinol, ascorbic acid, thiamine, riboflavin, niacin, pyridoxine and folic acid, which are of great importance for overall health and wellbeing. Larvicidal, antifungal, antimicrobial, antioxidant, antiprotozoal, antidiabetic, antihypertensive, hypocholesterolemic, and antimycobacterial activities as well as inhibition of lipid and protein oxidation are the numerous biological activities reported to be related to avocado fruit. Studies have also reported anticancer activity *via* induction of apoptosis of MDA-MB-231 cells by methanol extracts of avocado seeds. Avocatin B, a lipid derived from avocado fruit, is a novel compound with cytotoxic activity in acute myeloid leukemia and has been shown to inhibit fatty acid oxidation and decrease NADPH levels, resulting in ROS-dependent leukemia cell death.

Malayan apple or red jambo (*Syzygium malaccense*): It is native to Malaysia, Indonesia, Vietnam and Thailand. Malayan apple first came to the shores of Goa by way of the Portuguese and is grown throughout the humid tropical regions of Western Ghats. All portions of *S. malaccense* exhibit significant concentrations of bioactive compounds with biological activity proven to promote human health. The fruit is rich in minerals (Ca, P. & Fe), iron) and vitamins (A & B). The high fiber content allows the fruit to be classified as a food source of these components; this gives it great functional potential, considering the important role of fiber intake, both in aiding digestion and in combating health problems that have emerged among the population, including weight gain and several chronic diseases, such as cardiovascular disease, Type 2 diabetes and some types of cancer. Among the phenolic, anthocyanins are the main pigments responsible for most of the colors of fruits and exhibit anti-inflammatory, antimutagenic and cancer chemo-preventative activities *in vivo*.

Wax apple (*Syzygium samarangense* Blume) Merr. & L.M. Perry): It is a non-climacteric tropical fruit with its origin in the Malay Archipelago. This fruit was introduced in India mainly in the Western Ghats regions of Karnataka, Kerla and Tamil Nadu. The fruit pulp is a rich source of phenolics, flavonoids and several antioxidant compounds. The extracts of wax fruits, flower and bark have potent free radical scavenging, antimutation and anticancer activities. The leaves of wax apple used as tea and is proposed as a possible supplement for type II diabetes patients. Wax apple studied for its numerous pharmacological properties such as antioxidant and antidiabetic properties, anti-inflammation and antinociceptive activity, wound healing activity, antiulcerogenic effect, antibacterial, anticancer and also, it's potential as an uterotonic agent. The fruit can be used to treat high blood pressure and several inflammatory conditions, including sore throat, and can also be used as an antimicrobial, antiscorbutic, carminative, diuretic, and astringent.

Rose apple (*Syzygium jambos* (L.) Alston): It is a native of Malay Archipelago, distributed in south India especially in the Western Ghats. The fruits pall yellow colour. Rose apple has a long history of being used in traditional and folk medicine in various cultures. The fruit and root bark are believed to be of use as a blood coolant. The fruit has been used as a diuretic and as a tonic for better health of the brain and liver. With regard to rose apple, reports showed that the ethanol extract was effective as a free radical scavenger in the 1,1-diphenyl-2-picrylhydrazyl free radical scavenging assay, reducing total phenol capacity, total flavonoid content, and total antioxidant capacity. It health benefits could be antimicrobial, anti-inflammatory, analgesic, antiviral, anti-dermatophytic, anticancer, and hepatoprotective effects.

Durian [*Durio zibethinus* (L.) Murray]: It is a native to Southeast Asia. The unique durian flavour is attributable to the presence of fat, sugar, and volatile compounds such as esters and sulphur-containing compounds such as thioacetals, thioesters, and thiolanes, as well as alcohols. A significant amount of fiber (7.5–9.1 g/100 g DM), carbohydrate (62.9–70.7 g/100 g DM), and sugar (47.9–56.4 g/100 g DM) are found in different varieties. Durian is also rich in polyphenols such as flavonoids (flavanones, flavonols, flavones, flavanols, anthocyanins), phenolic acids (cinnamic acid and hydroxybenzoic acid), tannins, and other bioactive components such as carotenoids and ascorbic acid. Current epidemiological studies have suggested that polyphenols decrease the risk of chronic diseases (*e.g.*, cardiovascular diseases, cancers and diabetes).

Star fruit or carambola (*Averrhoa carambola* L.): It is a native of South Asia and is grown in all parts of India except Arid and temperate regions. There are two distinct classes of star fruit, the smaller, very sour type, richly flavored and the larger, sweet type, mild-flavored, with less acid. The star-fruit is a good source of various minerals and vitamins. Star-fruits are also a rich source of natural antioxidants such as L-ascorbic acid (Vitamin C) and Gallic acid, which aid in scavenging reactive oxidative species (ROS). Star-fruits are a good source of Mg, K, P, as well as β-carotene, and vit. C, which are common antioxidants. The presence of antioxidants like Fe, Zn and Mn in the fruits aid in strengthening the immune system. In addition, the presence of high amounts of fibres in fruits aids in absorbing glucose and retarding the glucose diffusion into the blood stream; thus helps in controlling blood glucose concentration. Its consumption exhibits hypo-cholesterolemic and hypolipidaemic effect as it enhances the removal of cholesterol, lipid, and bile acid through the excrement. It is widely used in Ayurvedic and traditional Chinese Medicine preparations as remedy for fever, sore throat, cough, asthma, chronic headache, and skin inflammations. The phytochemical and pharmacological studies suggest that the extracts of Star-fruit plant leaves, fruits and roots contains saponins, flavonoids, alkaloids and tannins which are known to confer antioxidant and specific healing properties.

Mangosteen (*Garcinia mangostana* L.): It is an ever-green tree of family Clusiaceae and a native of south Eastern Asian countries. The fruit was introduced more than a century ago in India, but currently it is successfully grown only in selected places on slopes of Nilgiris (Tamil Nadu), Malabar and Kanyakumari (Kerala). The natural molecules α-mangostin, xanthones and other bioactive substances are believed to be responsible for its medicinal activities. It is famous for its anti-inflammatory properties and is used in the treatment of skin infections and wounds. Other applications include the therapy of various conditions such as dysentery, different urinary disorders, cystitis and gonorrhoea. Products containing its fruits are now sold widely as 'liquid botanical supplements'. The biological actions of mangosteen are anti-inflammatory, anti-carcinogenic, antioxidant, anti-allergic, antibacterial, antifungal, antiviral, cardioprotective, anti-depression, and anti-deterioration. It is very effective in treating conditions such as obesity, Alzheimer disease, diarrhea, urinary tract infections, gonorrhea, thrush, tuberculosis, and osteoarthritis.

Passion fruit (*Passiflora edulis* Sims.): It belongs to the family Passifloraceae. The edible commercial species of passion fruit originated in the South American rain forests in the Amazon region of Brazil. Passion fruit has two distinct forms, the standard yellow (*Passiflora edulis* f. *flavicarpa* Deg.) and the purple (*Passiflora edulis* f. *edulis*). The yellow is more acidic and less starchy, while the purple is less acidic and starchier. Purple passion fruit (*P. edulis*) and yellow passion fruit (*P. edulis* var. *flavicarpa*) are of commercial importance. Phytochemical analysis of *P. edulis* revealed the presence of carbohydrates, glycosides, flavonoids, resins, alkaloids and phenolic compounds. Tannins were present in the leaf and fruit, saponins were present in the leaf and stem. Organic extract (methanol, ethanol) of *P. edulis* leaves were reported to possess tannins, flavonoids, terpenoid, steroida and saponins. It has anti-inflammatory, anticonvulsant, antimicrobial, anticancer, anti-diabetic, antihypertensive, anti-sedative, antioxidant properties and various remedial measures for treating conditions like osteoarthritis, asthma and act as colon cleanser. Besides, also used for treatment of ulcers, haemorrhoids, as sedatives, remedy for insomnia, digestive stimulant and remedy for gastri carcinoma.

Mulberry (*Morus alba* L.): It has a long history of use as an edible fruit and traditional medicine. A great diversity of nutritive compounds such as fatty acids, amino acids, vitamins, minerals, and bioactive compounds, including anthocyanins, rutin, quercetin, chlorogenic acid, and polysaccharides have been found in mulberry fruit depending on the cultivars and maturity stages. The fruit extracts have demonstrated numerous biological activities, including antioxidant, neuroprotective, antiatherosclerosis, immune modulative, antitumor, antihyperglycemic, and hypolipidemic activities.

Kiwifruit (*Actinidia chinensis* (Planch.): It is member of Family Actinidiaceae) and is derived from a deciduous woody, fruiting vine. It is composed of different species and cultivars that exhibit a variety of characteristics and sensory attributes. In India Kiwi is being cultivated in the sub-Himalayan tracts of Himachal Pradesh, in North Eastern states including Arunachal Pradesh *etc*. Kiwifruit is contains vit. C, actinidin, fiber, vit. E, and for selected cultivars, the persistence of chlorophyll in the mature fruit. Kiwifruit are widely known to contain high concentrations of phytochemicals such as carotenoids, polyphenolics, and fiber that may provide health benefits beyond basic nutrition. A limited number of human intervention trials validate some of these health benefits for kiwifruit in the areas of "natural protection" (protection from oxidative stress and DNA damage associated with mutation and cancer), gut health (laxation and healthy bowel habits), recovery from symptoms of cold and flu, and cardiovascular health (reduction in platelet aggregation). The fruit has low glycemic index which makes it suitable for the individuals with diabetes, while being fibre rich maintains blood sugar levels under control.

***Kokum* (*Garcinia indica* Choisy):** One of the native underexploited tree spices found in Western Ghats of India and some parts of north-eastern India. In spite of its incredible medicinal and nutritive properties, it is generally not cultivated systematically on orchard scale. It is commonly known as *kokum* (Hindi), kokum butter tree, Goa butter tree and mangosteen oil tree. Ripe fruits are harvested during April-May. Fruit rind is widely used in refreshing drinks and curries. The fruit is anti-helminthic, appetizer, cardio-tonic, useful against piles and dysentery. Hydroxyl citric acid (HCA) extracted from kokum is used against obesity, which is available in the form of tablets. The fruit is rich in anti-oxidants that bind with free radicals and prevent oxidative damage to body cells. The anthocyanin pigments obtained from it are used as natural colouring agents for food preservation. Advanced processed products like HCA, garcinol, wine and purified pigments would create more domestic and international demand for *kokum*. Chemical studies have shown that the rind contains protein, tannin, pectin, sugars, fat, organic acids like hydroxycitric acid, hydroxycitric acid lactone and citric acid; the anthocyanins, cyanidin-3-glucoside and cyanidin-3-sambubioside; and the polyisoprenylated phenolics garcinol and isogarcinol. Preclinical studies have shown that *kokum* possess antibacterial, antifungal, anti-ulcerogenic, cardioprotective, anticancer, chemo-preventive, free radical scavenging, antioxidant and anti-obesity effects.

Other Underutilized Fruit crops

Chalta (*Dillenia indica* Linn., Family: Dilleniaceae): It is an evergreen large shrub or small to medium-sized tree that grows all over the NE states, especially Mizoram and Tripura. Named after Johann Jacob Dillenius, a German botanist, *Dillenia* is a genus of about 100 species of flowering plants growing in tropical and subtropical regions. However, up to now, only eight *Dillenia* species have been reported to be used traditionally for different medical purposes including treatment of cancerous growth. Medicinal properties of the fruit juices of *D. indica* are manifold, as a cooling beverage to treat fever and to relieve fatigue. Although mainly a source of food for elephants and monkeys, the ripped fruits are taken orally to increase appetite and overcome weakness, as laxative and medication for abdominal pain. Native communities used the fruits as a remedy for jaundice. All the plant parts viz., leaves, bark, fruit, fruit peel, etc. all have proven medicinal properties against most of the common ailments including anti-cancer and anti-microbial properties. Some of the major compounds with medicinal and nutritive value are lupeol, betulinaldehyde, betulinic acid and stigmasterol.

Indian olive [*Elaeagnus rhamnoides* (L.) A. Nelson]: It is one of the minor crops grown in *terai* region of West Bengal. Fruits are the good source of vitamins and minerals. Fruit had the total soluble solids of 9.98 °Brix, ascorbic acid of 50 mg/ 100 g pulp, food energy value of 97.23 kcal /g, Zn of 46.31 μg/g DM, Mn of 53.86 μg/ g DM, and Cu of 7.82 μg/ g DM.

***Kendu* (*Diospyros melanoxylon* Roxb.):** It is an underexploited fruit species, is grown as natural wild in the forests and marginal lands of West Bengal, Odisha, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh and Andhra Pradesh. Fruits are a good source of carbohydrates, Ca, P and carotene and can prevent malnutrition. Dried powdered fruit is used as carminative and dried flowers are reported to be useful in urinary, skin and blood diseases. Seeds are prescribed for curing mental disorders, palpitation of heart and nervous breakdown.

Wild edible fruits of North-East India

The northeastern region of India, contains more than one third of the country's total fruit diversity. In addition to commercial fruits, the region is also known for its rich genetic resources of underutilized and underexploited fruits. These fruits are neither grown commercially on large scale nor traded widely. They are scattered only in wild forest or semi-wild in homestead gardens and remained uncared for albeit with large variability and are traded and consumed locally. Considerable diversity exists among these species in plant type, morphological and physiological characteristics, adaptability and distribution. They can be grown under stress and adverse conditions and are also known for their medicinal, therapeutic and nutritive values. These fruits, from time immemorial are known to play an important role in food and nutritional supplement of rural community. Most of them are very rich sources of vitamins, minerals along with carbohydrates, proteins and fats. This region harbors a good number of underutilized and under exploited species, *viz*., *Aegle marmelos*, *Artocarpus heterophyllus*, *Artocarpus lackoocha*, *Averrhoea carambola*, *Citrus medica*, *C. macroptera*, *C. grandis*, *Dillenia indica*, *Elaegnus latifolia*, *Emblica officinalis*, *Garcinia cowa*, *Passiflora edulis*, *Phylanthus acidus*, *Spondias pinnata*, *Syzigium jambos*, *Tamarindus indica*, *Terminalia chebula* and many more. The Nutritional and health benefits of some of these fruits have been discussed under the previous heads and sub-heads.

Sohiong [*Prunus nepalensis* Ser. (Steud)]: belongs to the family Rosaceae, is an important underutilized fruit of the tribal population in Meghalaya. The study was conducted to investigate the physical and biochemical contents of two different genotypes of *Sohiong* fruits. Result indicated that the big fruit size type had higher values for various physic-chemical characters except for pulp recovery (74.71%), pulp: stone ratio (2.95) and dry recovery (34.72%), TSS (20.15%), β-carotene (2.76 mg/100 g), anthocyanin (358.86 mg/100 g) and fibre (2.5%). Similarly, the mineral contents of big-sized fruits were comparatively higher than the small fruit type except for potassium and ash content (1.51%). The study indicated that the availability of *sohiong* fruit ranging from August to November. In addition, fruits are rich in vitamin, minerals and bio-chemical properties.

Conclusion

India enjoys a prominent position in under-exploited fruit crops of the world. The varied geographical and suitable environment conditions favor growing a wide variety of fruit crops. These fruits are available in abundance and also in different seasons. Most of the minor and underutilized fruits are often available only in the local markets. A large number of these fruits can grow under adverse conditions and are also known for their therapeutic and nutritive value and possess demands of the health-conscious consumers. However, some of these fruits are not acceptable in the market in fresh form due to their acidic/ astringent taste. Hence, there is a need to diversify and popularize of such underutilized fruit crops.

Since ages, several minor and underutilized fruit crops having medicinal properties are utilized in various indigenous medicinal systems like Ayurveda, Unani, and Homoeopathy. Most of these fruit crops are a rich source of vitamin C, which has been proved as a boon in enhancing immunity in this COVID-19 pandemic times. These crops can even cure insomnia, scurvy, constipation hemorrhage, leucorrhea, anemia, stomach ache, and can be used as a cooling agent to reduce sun strokes ill effects. There is large variability of underutilized and wild fruits present in the entire Western Ghats, western and eastern sub-Himalayan tracts. Similarly, there are several exotic fruits which have acclimatized in the region and acquire good variability due to cross-pollination. A good number of germplasms of underutilized fruits have been collected but most of the species yet to be characterized and conserved. Apart from these, there is a need to develop high yielding varieties, production and plant protection technologies, and post-harvest management practices for these crops. Better coordination among all the agencies involved in research, development, and promotion will help to popularize these fruit crops.

BIOFORTIFICATION OF HORTICULTURAL CROPS FOR NUTRITION AND HEALTH

Tusar Kanti Behera
ICAR-Indian Institute of Vegetable Research, Varanasi-221305, Uttar Pradesh
E-mail: tusar@rediffmail.com

Nutrient deficiency leads to poor health, mental impairment, low productivity, and even death. Its adverse effects on child health and survival are devastating, particularly the first 1,000 days of a child's life, from conception to the age of two, resulting in serious consequences such as morbidity, mortality, physical, and mental defects. Childhood stunting and wasting rate is highest in India due to chronicity of energy-protein malnutrition, occurring in approximately one-third of all children of the world. As per the National Health and Family Survey (2015-16) by the Indian Government, in rural India about 27% women and 23% men are malnourished (Verma and Kumar, 2019). Comprehensive National Nutrition Survey (2016-18) data showed 34.7% of children under 5 years of age are still low height for age (stunted growth) and 33.4% are low weight for age (underweight) (Kumar and Kumar, 2020). The subsequent health and productivity costs of hidden hunger in the adult population also result in severe economic losses; the economic cost of micronutrient deficiency in India is ~2.4% of GDP which is equivalent to $15–46 billion (Ricthie et al., 2018).

Fruits and vegetables are a natural source of micronutrients essential for the human body and horticultural production has the potential for attaining nutritional security. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions. Developing nutrient dense horticultural crops can be achieved by biofortification (through agronomic and breeding practices, transgenic and genome editing approach). Now a days plant breeding programmes primarily focused on high agronomic yields and conventional efforts like diet diversification, supplementation, and industrial fortification are not enough to alleviate the situation. An efficient and complete food system is necessary to deliver all basic nutritional requirements.

Biofortification through Agronomic practices

The agronomic biofortification of vegetables is one of the simplest and easy methods of biofortification. However, this strategy requires a long period and adequate funds, and this technique is useful in the countries where the genetic engineering method of biofortification is not well accepted. In this approach, generally, fertilizer is used either in the form of spray on leaves or the application of fertilizer in soil (Weng et al. 2008b). The biofortification of Fe and Zn was reported to be successful where the foliar application was used to enhance these nutrients in plant tissue and edible part. The agronomic approach for biofortification also includes management practices during the crop growing season. The package and practices like tillage, water management, and nutrient interaction are involved in enhancing micronutrient. Foliar application is the better option for agronomic biofortification, which requires less amount of Fe and Zn fertilizer as compared to soil application.

In agronomic biofortification, application of potassium (K) influences quality of fruit and yield of *C. melo*. Soil application of 11 mM K increased phenol content and antioxidant capacity of C. melo to 213.10 μM equivalent Trolox/100 g fresh base compared to treatment at 7 mM K, respectively, which produced 162.90 μM (Preciado-Rangel et al., 2018). This is an advantage since fruit with extensive phytonutrients are associated with lower risk of chronic diseases and cancers (Linnewiel-Hermoni et al., 2015). Foliar application of silicon at 100 and 200 mg·L−1 increased ascorbic acid (Vitamin C) content of C. sativus (AbdAlkarim et al., 2017). Vitamin C helps the body defense system, and boosts immunity, and cell functions in humans (Linnewiel-Hermoni et al., 2015). Besides that, in biofortified pumpkin varieties Oleshkivskyi and Sviten, treated with Riverm fertilizer, which contains organic materials, microorganisms, enzymes and growth substances, caused protein to increase by 16.8 and 15.4%, respectively, compared to nontreated plants (Deinychenko and Yudicheva, 2016). The result indicated that the application of fertilizer could improves the protein content in pumpkin varieties, thus, improves the quality of the fruits produced.

Biofortification through Breeding and transgenic approaches

Biofortification is a practice of adding nutrition value to the crop by breeding, improved agronomy and microbiological interventions, improving micronutrient uptakes and their proper distribution in the edible part, genetic engineering/ transgenic approach etc. Biofortification of crop plants have potential to reduce the gap between micronutrient requirements and intake by increasing the proportion of dietary vitamins, iron, zinc and selenium - essential micronutrients of health significance. In developing countries, more than 20 million people are now growing and consuming biofortified crops. Considering the nutritional impact, biofortification program have been carried out in many horticultural crops like Potato, Orange sweet potato, Cow pea, Beans, Pumpkin, Bananas, Cassava, etc. These are joint efforts of national and international organizations by conventional and transgenic / genome editing approaches (Prasad et al., 2015).

Breeding approaches

To overcome the malnutrition/hidden hunger, biofortification of vegetable crops can be a feasible and economical approach. Vegetable crops are important part of the daily diet in developing countries of the world. Vegetable crops are often deficient in some of mineral elements. Thus, by increasing the bio available concentration of micronutrients in vegetable crops via biofortification is a promising strategy in modern agriculture, providing more nutritious foods, to more people, with the use of fewer lands and can effectively contribute in alleviating the micronutrient deficiency. Biofortification of vegetable crops is under the process of development in many parts of the world.

i) Selection and hybridisation

The International Centre for Potato (CIP) developed iron rich potato by conventional biofortification method having 11-30 ppm iron with low phenolic compounds and hence have better bioavailability of iron to the human body. CIP in South Africa, Uganda (Harvest Plus) and National Agriculture Research and Extension System (NARES) jointly developed and released provitamin A biofortified orange sweet potato in 2002. The biofortified orange sweet potato has upto7.4 mg/100g fresh weight β-carotene. Donald Danforth Plant Science Center, Nigeria has developed high β-carotene cassava (7.6 ppm) by hybridization and selective breeding methods to fight against vitamin A malnutrition in Nigeria and Kenya as Bio Cassava. International Centre for Tropical Agriculture (CIAT), Colombia developed high iron and zinc biofortified beans. Usually, iron content in common bean is about 50 ppm and biofortified beans developed with 83 ppm iron and 44 ppm zinc, released in the year 2012 and 2014. In India, G.B. Pant University of Agriculture and Technology, Pantnagar, developed two early maturing high iron and zinc fortified varieties namely Pant Lobia-1 (82 ppm Fe and 40 ppm Zn), Pant Lobia-2 (100 ppm Fe and 37 ppm Zn) by conventional plant breeding and released in 2008 and 2010. Pant Lobia-3 (67 ppm Fe and 38 ppm Zn), Pant Lobia-4 (51ppm Fe and 36 ppm Zn). Indian Agricultural research Institute, New Delhi, India has developed biofortified β-carotene rich cauliflower (Pusa Beta Kesari 1: 1000 μg/100g β-carotene). Its curds are yellow/orange coloured and compact with average marketable curd weight is 1.250 Kg and 42.0 to 46.0 t/ha yield. Biofortified crops can have a significant impact on the lives and health of millions of people, especially for micronutrient deficient population, the effectiveness of the biofortification program depends on the farmers' and consumers' acceptance and future policy interventions.

ii) Mutation breeding

Out of 3000 mutant varieties developed globally, 776 have been induced for nutritional quality (Jain and Suprasanna, 2007). In a simple way, mutation is a random or directed change in the structure of DNA or the chromosome which often result in a visible or detectable chance in specific or trait. Relatively minor genomic changes (point mutations, single gene insertions) are regularly observed following metabolomic analysis, leading to significant changes in biochemical composition and antioxidants (anthocyanin, lycopene) in the tomato cv. Moneymaker (Giliberto et al. 2005).In self-pollinated crops, it is well known whereas in cross pollinated crops its application is more difficult and identification of the origin of the desirable genotypes is difficult. Both physical (X-ray, UV) and chemical (Ethyl Ethane Sulphonete, Ethyl Methane Sulphonate, 5-bromouracil) mutagens cause macro-mutation (major, mono or oligogenic qualitative mutation) and /or micro-mutation (minor, polygenic or quantitative changes) in the genotypes under treatment. Sapir et al. (2008) reported in tomato that high pigment-1 (hp-1) mutation known to increase flavonoids content in fruits. Spontaneous mutation such as 'orange' cauliflower (Li et al. 2001) and in sweet potato orange mutants are rich in beta-carotene (30–100 ppm) than white fleshed (2 ppm) and some of the common orange fleshed mutant varieties are Nancy Gold and Murff Bush Porto Rico (LaBonte and Don, 2012).

iii) Polyploidy breeding

Polyploid can be induced due to aberration in cell division. This may occur both in the mitosis as well as in meiosis. This method can be used successfully in vegetable breeding as a means of enhancing nutraceuticals and colours in vegetables. Tetraploids in radish, pumpkin, muskmelon and watermelon are highly productive and have improved quality. Zhang et al. (2010) developed tetraploid muskmelon which is rich in soluble solid, soluble sugar and vitamin C contents and distinctly higher than those in the diploid fruit. Liu et al. (2010) reported that the range of lycopene content among diploid watermelon fruit was from 33.2 to 54.8 mg/kg" and in triploid it was ranged from 41.2 to 61.8 mg/kg. The range of lycopene content among tetraploid was from 38.1 to 59.8 mg/kg. They also reported that the lycopene content in the triploid and tetraploid was higher than that of diploid however, ploidy did not affect lycopene content in variety Fan Zu No.2. Marzougui et al. (2009) induced polyploidy in *Trigonella foenum-graecum* L. using a 0.5% colchicine solution and reported that the autotetraploid cultivar has larger leaf area and larger productivity compared to the diploids concerning seed number, pod number and branch number. Its leaves are richer in potassium, sodium, calcium and phosphorus.

iv) Marker assisted Breeding

Zhang et al. (2008) found SCAR markers linked to "*or*" gene inducing β-carotene accumulation in Chinese cabbage. Ripley and Roslinsky (2005) identified an ISSR Marker for 2-propenyl glucosinolate content in Brassica. The orange cauliflower was first discovered in Bradford Marsh, Ontario, Canada in 1970. The orange cauliflower resulted from a spontaneous mutation of a single dominant gene designated as '*Or*' for orange gene (Dickson et al., 1988). This *Or* mutant was originally found in white curded autumn crop cv. extra early snowball. This trait is absent in Indian cauliflower where large population is suffering from carotene deficiency. IARI, New Delhi designed and led the biofortification of Indian cauliflower with β-carotene enhancing native '*Or*' gene following marker assisted breeding.

Quantitative traits due to genetic variation can be regulated by combining effects of genes, known as quantitative trait loci (QTLs) (Sehgal et al., 2016). The QTL analyzed using statistical methodology links phenotypic and genotypic data to genetically explain variation in complex traits. Marker assisted breeding can be used to develop gene mapping of carotene content and control of flesh color. The 4 QTL mapping for total carotenoid content, based on phenotypic data in *C. moschata* with phenotypic variance, explained (PVE) 13.2 to 28.6%, has been demonstrated with genetic position at 7.12–7.64 cM, respectively (Zhong et al., 2017). This will serve as a basis for map-based gene cloning, draft genome assembling and molecular breeding. In *C. lanatus* one QTL at LCYB4.1 (lycopene β-cyclase) occurs with a high value of trait variation (83.50%) related to lycopene content and mapped on Chromosome 4 between CAPS markers WII04E07-33 and WII04E07-40, respectively (Liu et al., 2015). The QTLs can facilitate study on determining lycopene content related genes and cloning watermelon genes. Other examples for marker-assisted breeding was in *C. sativus* with yellow flesh that contain more β-carotene than those with green and white flesh (Lu et al., 2015).

This is because yellow fruit flesh of C. sativus inbred line PI200815 was controlled by a single recessive gene, yf, and mapped at Chromosome 7 linked by markers yf SSR108 and yf Indel29, at 92.3 and 84.6%, respectively (Lu et al., 2015)

Transgenic approach

Biofortification in fruit crops gain very limited success. Bananas (*Musa* spp.) are economically important fruit crops grown throughout tropical and sub-tropical regions of the world where Vitamin A deficiency is most prevalent. Some banana genotypes are rich in provitamin-A carotenoids, providing an opportunity to use bananas as a readily available vehicle for provitamin A delivery. Queensland University of Technology, Australia, developed provitamin-A (β-carotene), alfa-tocopherol and iron rich varieties of banana by transgenic approach as Super banana. The biofortified banana has up to 20 ppm beta carotene, 2.6mg/100 gm iron and higher alfa-tocopherol content.

Three genes, encoding phytoene synthase (*CrtB*), phytoene desaturase (*CrtI*) and lycopene beta-cyclase (*CrtY*) from Erwinia have been introduced in potato to produce beta carotene. Romer et al. (2000) developed transgenic tomato to enhance the carotenoid content and profile of tomato fruit, we have produced transgenic lines containing a bacterial carotenoid gene (crtI) encoding the enzyme phytoene desaturase which converts phytoene into lycopene. Gerjets and Sandmann (2006) developed genetically engineered potato for the production of commercially important keto-carotenoids including astaxanthin (3, 3′-dihydroxy 4, 4′-diketo-β-carotene). Lu et al. (2006) suggested that transgenic cauliflower with *Or* transgenesis associated with a cellular process that triggers the differentiation of proplastids or other non-coloured plastids into chromoplasts for carotenoids accumulation and also reported Or gene can be used as a novel genetic tool to induce carotenoid accumulation in a major staple food crop. The post-transcriptional gene silencing is also used for change in nutrient biosynthesis pathways which improve the nutrient contents.

Another big health challenge is folate deficiency which causes neural tube defects and other human diseases. Folates are synthesized from pteridine, p-aminobenzoate (PABA), and glutamate precursor. Díaz de la Garza et al. (2007) engineered tomatoes by fruit- specific over-expression of GTP cyclohydrolase I that catalyzes first step of pteridine synthesis, and ami-nodeoxychorismate synthase that catalyzes the first step of PABA synthesis. Vine-ripened fruits contained on average 25-fold more folate than controls by combining PABA- and pteridine overproduction traits through crossbreeding of transgenic tomato plants. This research programme showed way for biofortification of folate in other vegetables for millions of people deprived of adequate folate in their regular diets however adequate attention is required on safety issues.

Biofortification through Genome Editing

CRISPR/Cas (Clustered regularly interspersed short palindromic repeats/ CRISPR—associated proteins) is one of the most promising genome editing tool emerging as a revolutionary technology in diverse plant species because of its easy manipulation, high efficiency and its wide application in functional studies of genes and genetic crop improvement (Thakare et al. 2019). CRISPR/Cas9 tool contains a non-specific Cas9 nuclease and a single guide RNAwhich is specific to target gene directs Cas9 to the specific genomic location creating double-strand breaks and subsequent repair process creates insertion or deletion mutations. This is currently the widely adopted tool for reverse genetics, and crop improvement in large number of agricultural crops. Among horticultural crops, 42% genome editing studies were on tomato crops, targeting development related gene edited to manipulate flowering patterns and fruit development and 13% genome editing work was carried out in potato. Among horticultural crops, 72% genome editing was performed in vegetable crops, some medicinal and flowering plants.

Genome editing

Most of the CRISPR/Cas9 experiments of horticultural crops were done in tomato where 18 different genes have been edited independently. The first CRISPR/Cas9-mediated genome editing in vegetable crops was reported in tomato in 2014, where ARGONAUTE7 (SlAGO7) gene involved in leaf development was targeted (Brooks et al., 2014). Later on, other genes such as*Anthocyanin 1 (ANT1)* gene of anthocyanin biosynthetic pathways in tomato (Cermak et al., 2015), *Phytoene desaturase (SlPDS), Phytochrome interacting factor (SlPIF4)* (Pan et al., 2016), and *Phytoene synthase (PSY1)* (Hayut et al., 2017) functioning in carotenoid biosynthesis were mutated by CRISPR/Cas9.

Potato starch quality is an important factor for food as well as many commercial product developments. The "waxy genotype" of potato, producing only amylopectin containing starch was developed by mutating granule bound starch synthase (*GBSS*) gene using CRSIPR/Cas9 (Andersson et al., 2017). The starch characterization of genome-edited lines produced only amylopectin and completely lacking amylose confirming the knock-out of all the four alleles of *GBSS* gene.

Parthenocarpy in horticultural crop plants is an important trait having huge demand in processing industry as well as for direct eating quality. Development of parthenocarpic fruits is considered as an important goal especially for maintaining sustainable agriculture in the face of global warming. Keeping these facts in view, Ueta et. al. 2017 have successfully introduced mutations in *SlIAA9*- a key gene controlling parthenocarpy and their results showed that, regenerated mutants exhibited seedless fruit; a characteristic of parthenocarpic tomato. Klap et al. (2017) developed parthenocarpic tomato through CRISPR/Cas9 gene - SlAGAMOUS-LIKE 6 (SlAGL6) knockout and confirmed that a mutation in *SlAGL6* was responsible for the parthenocarpic phenotype.

Genome editing in fruit crops

CRISPR/Cas9 applications in fruit crops are still at preliminary level but in view of the potential of this technology, and very few reports have appeared so far due to its perennial nature, and mutation was done mostly for carotenoid biosynthesis pathway genes. Jia and Wang, 2014 reported editing in citrus by mutating *Phytoene desaturase* (*CsPDS*) gene of carotenoid biosynthesis pathway. Other than citrus, genome editing by CRISPR/Cas9 has also been reported in watermelon (Tian et al., 2017) and grape (Nakajima et al., 2017) by targeting *Phytoene desaturase* gene in both the crops.

Traditional agricultural practices can partly enhance the nutritional content in plant foods but biofortification is a practice of nutrient fortification into food crops using agronomic, conventional and transgenic breeding methods to provide a sustainable and long term strategy to address vitamin and nutrient deficiencies.

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UNDEREXPLOITED ARID FRUITS AND VEGETABLES AND THEIR ROLE IN HUMAN NUTRITION

P. L. Saroj, R. Kumar and B. R. Choudhary
ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner 334 006, Rajasthan
E-mail: plsaroj@yahoo.co.in

Introduction

Underexploited arid fruit crops such as bael (*Aegle marmelos*), phalsa (*Grewia subinaequalis*), wood apple (*Feronia limonia*), karonda (*Carissa carandus* L.), fig (*Ficus carica* L.), tamarind (*Tamarindus indica*), mulberry (*Morus sp.*), kair (*Capparis deciduas*), pilu (*Salvadora oleoides*), lasoda (*Cordia myxa*) etc. and in arid and semi-arid vegetables such as kachri (*Cucumis callosus*), snap melon (*Cucumis melo var. momordica*), round melon (*Citrullus vulgaris* var. *fistulolus*), arya (*Cucumis melo* var. *chate*), jhar karela (*Momordica balsamina*), bitter apple (*Citrullus colocynthis*), cluster bean (*Cyamopsis tetragonoloba*), phog (*Calligonum polygonoides*), khimp (*Leptadenia pyrotechnica*), khejri (*Prosopis cineraria*) etc. are rich sources of energy and nutrients particularly micronutrients (like iron and calcium) and vitamins (like vitamin B, C, folic acid, and carotenoids) along with phytochemicals (anthocyanins, carotenoids, phenols and flavonoids) and dietary fibers. Some horticultural crops such as water melon and cucumber provide very low calories, whereas some others such as date palm are rich in starch which provides energy in good amount. Therefore, vegetables and fruits can be used to increase or decrease calories in our diet for malnutrition alleviation and obesity management. Fruits and vegetables can be categorized in two groups on basis of their commercial cultivation and utilization (Table 1).

Table 1. Fruits and vegetables of arid regions

Commercial fruit and vegetable crops				
Common name	**Scientific name**	**Family**	**Chromo-some no. (2n)**	**Origin**
Date palm	*Phoenix dactylifera*	Palmaeae	36	Persian Gulf, Iraq
Pomegranate	*Punica granatum* L.	Punicaceae	16, 18	Iran
Ber	*Ziziphus mauritiana*	Rhamnaceae	24	Indian Sub-continent
Aonla	*Emblica officinalis*	Euphorbaceae	18, 28	Peninsular India
Kinnow	Hybrid of ‘King’ (*Citrus nobilis*) × ‘Willow Leaf’ (*Citrus deliciosa*)	Rutacae	18	-
Sweet orange	*Citrus sinensis*	Rutaceae	18	South East Asia
Guava	*Psidium guajava* L.	Myrtaceae	22, 33	Brazil
Custard apple	*Annona Squamosa* L.	Annonaceae	14	Tropical America - Peru

Common name	Scientific name	Family	Chromo-some no. (2n)	Origin
Tomato	*Solanum lycopersicum* L.	Solanaceae	24	South America
Brinjal	*Solanum melangena*	Solanaceae	24	Southern India
Chilli	*Capsicum annuum* L.	Solanaceae	24, 26	Central and South America
Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	22	Sub-Saharan Africa
Cucumber	*Cucumis sativus* L.	Cucurbitaceae	14	India
Water melon	*Citrullus lanatus*	Cucurbitaceae	22	Africa and India
Peas	*Pisum sativum*	Leguminosae	14	Southern Europe & Western Asia
Onion	*Allium cepa* L.	Alliaceae	16	South East Asia
Underexploited fruit and vegetable crops				
Bael	*Aegle marmelos* L.	Rutaceae	36	Northern India
Jamun	*Syzygium cumini*	Myrtaceae	40	Indian Sub-continent
Tamarind	*Tamarindus indica*	Leguminosae	24	Tropical Africa
Wood apple	*Feronia limonia*	Rutaceae	18	India, Sri Lanka
Phalsa	*Grewia subinaequalis*	Tiliaceae	36	India
Mulberry	*Morus alba* L.	Moraceae	308	Northern China
Karonda	*Carissa carandus* L.	Apocynaceae	12	India
Fig	*Ficus carica* L.	Moraceae	26	South East-Asia
Lasoda	Cordia myxa	Boraginaceae	48	India
Chironji	*Buchanania lanzan*	Anacardiaceae	22	Western Peninsula
Kair	*Capparis decidua*	Capparidaceae	14, 16	Arid region of India
Pilu	*Salvadora oleoides*	Salvadoraceae	24	India/Tropical Africa
Khejri	*Prosopis cineraria*	Leguminosae	28	Thar desert of India
Kachri	*Cucumis callosus*	Cucurbitaceae	14	Thar desert of India
Snapmelon	*Cucumis melo* var. *momordica*	Cucurbitaceae	- 24	Tropical regions of Africa and Asia
Mateera	*Citrullus lanatus*	Cucurbitaceae	22	Thar desert of India
Bitter apple	*Citrullus colocynthis*	Cucurbitaceae	22	Thar desert of India
Arya	*Cucumis melo* var. *chate*	Cucurbitaceae	24	Thar desert of India
Round melon	*Citrullus vulgaris* var. *fistulolus*	Cucurbitaceae	24	India
Spine gourd	*Momordica dioica*	Cucurbitaceae	28	India
Jhaar karela	*Momordica balsamina*	Cucurbitaceae	22	Africa
Cluster bean	*Cyamopsis tetragonoloba*	Fabaceae	14	India
Moth bean	*Vigna aconitifolia*	Fabaceae	22	India, Pakistan and Myanmar

Common name	Scientific name	Family	Chromosome no. (2n)	Origin
Phog	*Calligonum polygonoides*	Polygonaceae	54	Indian Thar desert
Khimp	*Leptadenia pyrotechnica*	Apocynaceae	22	Africa, Indian Thar desert

Role of fruits and vegetables in human health

According to the *Food and Agriculture Organization*, 'Food Security' refers to a situation that 'all people have physical, social and economic access to sufficient, safe and nutritious food at all times to meet their dietary and food requirements for an active and healthy life' (World Food Summit 1996). The International Food Policy Research Institute defined 'Nutrition Security' as 'adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times'. Therefore, nutrition security is broader term than food security since it encompasses biological utilization by human body to ingest and metabolize food which promote health and prevent disease. Underexploited fruits and vegetable crops plays important role in nutritional security as they provides micronutrients (minerals and vitamins) along with macro nutrients with high biological utilization efficiency. Underexploited arid fruits and vegetable crops are rich in phytochemicals such as anthocyanins, carotenoids, phenols and flavonoids, which provides protection against reactive oxygen species and act as health promoter.

A balanced diet provides all the required nutrients in appropriate amounts and proportions which can be achieved through a blend of the four basic food groups i.e. carbohydrates, proteins, fat and micro nutrients (vitamins and minerals). The quantities of foods needed to meet the nutrient requirements vary with age, gender, physiological status and physical activity. A balanced diet should provide 50-60% of total calories from carbohydrates, possible from complex carbohydrates, about 10-15% from proteins and 20-30% from both visible and invisible fat. In addition, a balanced diet should provide other non-nutrients for example dietary fiber, antioxidants (vitamins C and E, beta-carotene, riboflavin and selenium) and phytochemicals (anthocyanins, carotenoids, phenols and flavonoids) which protect the human body from free radical damage. The *Indian Council of Medical Research* recommended 300 g of vegetables (green leafy vegetable 50 g, other vegetables 200 g and roots & tubers 50 g) and 100 g fresh fruits per day for a balanced diet (Anonymous, 2011).

It is estimated that per capita availability of fruits and vegetable in India is 126 and 286 g per day, respectively after 30% loss, 5% exports and processing deduction which is far below the recommended quantity. This may be attributable to low production of affordable food, supply limitation, poor purchasing power, lack of awareness, uneven consumption, or a combination of these factors. Fruit and vegetable are rich in micro and phytonutrients which play important role in preventing micronutrient deficiencies and non-communicable diseases. The contribution of underexploited arid fruits and vegetable crops to the vitamin, mineral and fiber content in a balanced diet and their role is shown in Table 2.

Table 2. Nutrient rich underexploited fruits and vegetables for arid and semi arid region

Crop	Nutrients status (per 100 g)
Bael	Water 61.06 g, crude protein 3.64 g, fat 0.43 g, ash 2.85 g, potassium 603 mg, calcium 78 mg, and phosphorous 51.60 mg
Ber	Moisture 82 g, protein 0.8 g, fat 0.07 g, fiber 0.60 g, carbohydrates 17.0 g, total sugars 10.5 g, ash 0.4 g, calcium 25 mg, phosphorus 26 mg, iron 1.2 mg, carotene 0.021 mg, thiamine 0.021 mg, riboflavin 0.02 mg, miacin 0.7 mg, citric acid 0.6 mg, ascorbic acid 65 mg, fluoride 0.1 ppm, pectin 2.2-3.4 % on dry basis.
Jamun	Moisture 82.10%, fat 0.31%, crude fibre 0.25%, total ash 0.36%, vitamin C 19.4 mg, total sugars 12.6%, reducing sugars 8.9%, non-reducing sugars 3.7%, anthocyanins 157 mg, antioxidant activity 415 mg GAE of total phenolics.
Tamarind	Moisture 35.29 g, carbohydrates 50.07 g, dietary fiber 4.13 g, titratable acidity 18.52 g tartaric acid, soluble solids 44.00 °Brix, vitamin C 4.79 mg, folates 59.35 µg, vitamin E 108.78 µg.
Wood apple	Water 64.06 g, carbohydrates 18 g, protein 7 g, fat 4 g, fibre g, calcium 130 mg, and phosphorous 110 mg,
Phalsa	Juice contain protein 1.57 g, dietry, fiber 5.50 g, carbohydrates 21.0 g, phosphorus 24 mg, iron 1.08 mg, potassium 372 mg, sodium 17.3 mg, vitamin A 16.11 ug, , thiamine 0.02 mg, riboflavin 0.22 mg, vitamin C 4.38 mg
Mulberry	Moisture 78 g, total soluble solids 28 g, total sugar 17 , sucrose 4.2 g, reducing sugar 15 g, protein 0.8 g, ash 2.6 g, pH, titratable acidity 5.7 g, vitamin C 68 mg, total phenolic 21.50 mg, antioxidant activity 19.24 µg gallic acid equivalent/mg.
Karonda	TSS 7.8%, acidity 3.94%,, ascorbic acid 6.98 mg, total sugars 5.28 %, reducing sugars 4.15%, protein 2.96 %, iron 6.88 mg, calcium 16.33 mg and phosphorus 24 mg.
Fig	Moisture 67.82 %, ash 0.89 %, fibers 2.88 %, protein 2.17 %, lipids 1.12 %, total carbohydrate, sodium 17.33 mg, potassium 208.67 mg, calcium 65.00 mg, magnesium 37.67 mg, iron 3.13 mg, zinc 0.14 mg, copper 0.37 mg and phosphorus 32.76 mg.
Lasoda	Ash 6.7 g, crude protein 8.32 g, lipid 2.2 g, crude fibre 25.7 g, carbohydrates 57.08 g, ascorbic acid 40 mg of dry weigh basis.
Chironji	Moisture 3.0 g, protein 19.0 g, fat 59.1 g, carbohydrate 12.1 g, calcium 279 mg, phosphorus 528.0 mg , iron 8.5 mg , thiamine 0.69 mg, riboflavin 0.53 mg and niacin 1.5 mg .
Kachri	Moisture 88.2%, fibre 1.21%, copper 0.0046 mg, carbohydrate 7.45%, calcium 0.09 mg, zinc 0.052 mg, protein 0.28%, phosphorus 0.0029 mg, manganese 0.058 mg, fat 1.28%, iron 0.182 mg, vitamin C, 29.81 mg.
Snapmelon	Moisture 95.7%, fat 0.1%, carbohydrate 3.0%, vitamin A 265 IU, protein 0.3% and minerals 0.4%.

Crop	Nutrients status (per 100 g)
Round melon	Protein 1.4%, fat 1.4%, carbohydrates 3.4%, fibre 1%, minerals 0.5%, carotene 13 mg and vitamin C 18 mg.
Spine gourd	Moisture 84.1 g, phosphorus 42 mg, protein 3.1 g, carotene 2700 IU, carbohydrate 7.7 g, thiamine 45.2 µg, fibre 2.97 g, riboflavin 176.1 µg, iron 4.6 g, niacin 0.59 mg, calcium 33 mg and ascorbic acid 275.1 mg.
Cluster bean	Moisture 81.0 g, phosphorus 50.0 mg, protein 3.2 g, carotene 198 mg, Carbohydrate 10.8 g, thiamine 0.09 mg, fibre 3.2 g, riboflavin 0.03 mg, iron 1.08 mg, niacin 0.60 mg, calcium 130 mg, ascorbic acid and 49.0 mg.
Moth bean	Moisture 9.7 g, protein 22.9 g, fat 1.6 g, carbohydrate 61.5 g, calcium 150 mg, magnesium 381 mg, phosphorus 489 mg, iron 10.9 mg, zinc 1.9 mg, vitamin A 32 IU, thiamin 0.56 mg, riboflavin 0.09 mg, niacin 2.8 mg, vitamin B_6 0.37 mg, folate 649 µg, and ascorbic acid 4.0 mg.
Phog	Moisture 59.7 g, ash 11.14 %, dietary fibre 44.98 %, fat 1.27 %, sugar 9.75%, protein 8.02 % and vitamin C 66.88 mg/100g.
Ivy gourd	Moisture 93.5 g, thiamine 0.07 mg, protein 1.2 g, calcium 40 mg, riboflavin 0.08 mg, fat 0.1 g, phosphorus 30 mg, niacin 0.7 mg, mineral 0.5 g iron 0.38 mg, folic acid 18 µg, carbohydrate 3.1 g carotene 156 µmg and vitamin C 15 mg
Khejri	Protein 23 g, carbohydrate 55.5 g, fat 2 g, fibre 20 %, ascorbic acid 532.0 mg, calcium 414 mg, phosphorus 400 mg and iron 19 mg.

Health promoting phytochemicals in underexploited fruit and vegetable crops

Phytochemicals are naturally occurring chemicals other than nutrients found in fruits and vegetables, which play important role in the human metabolism leading to improvement in human health. Fruits and vegetables have functional food properties to develop nutritional ingredients or supplements. The perception of underexploited fruit and vegetable crops as food is now shifting to nutritious food. The horticultural crops are gaining importance for their metabolite capabilities (Table 3) in preventive health care (Khanuja and Shukla, 2011).

Table 3. Health promoting phytochemicals in fruits and vegetables crops

Crop	Phytochemicals	Function
Karonda and phalsa	Anthocyanin	Antioxidant activity
Bael	Marmelosin	Antihelminthic and antibacterial activity, gastric ulcer treatment
Jamun	Jambolin	Diabetes treatment
Pumpkin and winter squash	Beta carotene	Anti-ageing, anti-cancer, help in diabetes and lung problem

Crop	Phytochemicals	Function
Mustard green	Glutathione	Antioxidant
Turnip	Ferulic acid	Antioxidant
Bitter apple	Citrullin, citrullene and citrullnic acid, cucurbitacin B and cucurbitacin I.	traditional medicines and biopesticide formulations
Indian aloe	Alloin	Antioxidant and medicinal properties
Phog	Furan-2,5-dimethyl, 2,3-dihydro-3, 5-dihydroxy-6-methyl-4H-Pyran-4-one, dehydromevalonic lactone, quinic acid, lauric acid, linolenic acid and squalene	Anti-microbial, anti-inflammatory, anticancer, anti-diabetic, hepatoprotective, cardiovascular, antioxidant, and anti-mutagenic.
Kair	Glucocapparin, methyl isothiocyanate	Antibacterial properties
Jhar karela	Saponins and *Momordin*	Anti-diabetic activity biopharmaceuticals and neutraceuticals properties

(Source: Rai, 2012)

Enhanced consumption of carotenoids containing fruits and vegetables was useful than carotenoids dietary supplements in enhancing LDL oxidation resistance, reducing DNA damage, and inducing higher repair activity in human (Southon 2000). Antioxidant (vitamins A, C and E) dietary supplements into the diet of cancer patients, who were eating a balanced diet of fruits and vegetables, negatively impacted their radio and chemotherapies (Seifried *et al.* 2003). Presently, food security mission include not only the problems of physical availability of food but also nutritional status of food with biological absorption. During green revolution stress was given on production exclusively and not on nutritional security, which is the ultimate goal addressed through fruits and vegetables. Preference should also be given to nutritious underexploited fruits and vegetables. For the same, high-yielding varieties of these crops are being developed by ICAR institutes and SAUs and made available to farmers. Each fruit and vegetable crop contains a distinctive combination of phytochemicals, minerals and vitamins which offers a unique health benefit. More than 3,000 phytochemicals have been identified in fruits and vegetables. Besides health benefits, fruits and vegetables growing play an important role in meeting nutritional security, and ensuring socio-economic development of farmers with environmental protection.

Important underexploited fruits

***Ber* (*Zyziphus mauritiana*):** It belongs to the family Rhamnaceae. It is an ideal fruit tree for arid and semi-arid regions in tropical and subtropical climate where most of the fruit crops cannot be grown. It has a high amount of vitamin C. More vitamin C was found in the fruit flesh near the seed rather than near the skin of the fruit. It is also a rich source of vitamin A and B complex. The fruits can also be used for making several products like chutney, dried ber, murabba, jelly, etc. Wines can also be prepared from the fruits. The decoction from root and bark is good for dysentery and diarrhoea and leaf decoction is useful as gargle in sore throat and in bleeding gums. The seed kernels are aphrodisiac. The powder of ber roots has medicinal properties for curing ulcer, fever and wounds.

Wood apple (*Feronia limonia*): It is originated in India and belongs to the family Rutaceae. It is a hardy upright tree, producing nutritive acidic fruit and the pulp is eaten raw with or without sugar. The pulp is a rich source of calcium, phosphorus, iron and vitamins like carotene, riboflavin, niacin, thiamine and vitamin C. The fruit is used as a liver and cardiac tonic, and when unripe, for easing diarrhoea and dysentery. Wood apple can be converted into value added products like jam and fruit bar in order to avoid glut and utilize the surplus during the season. Wood apple juice when mixed with other fruits can serve as an excellent beverage.

***Bael* (*Aegle marmelos*):** It is one of the oldest cultivated fruits in India which is native to India and spread throughout South-East Asia. The leaves are used for worshiping Lord Shiva. This fruit is also commonly found in the hilly regions of India. The fruit is used as ayurvedic remedy against diarrhea, dryness of the eye and common cold. It is also useful in preventing scurvy and strengthens the stomach and promotes its actions. It can be used for jam, jelly, juice, murbba squashes and other beverages.

Jamun (*Syzygium cumini*): It is an important indigenous fruit belongs to the family Myrtaceae. The tree is ideally suited for windbreak and roadside plantations. It is taken as a dessert fruit and is also used in making beverages, squash, jam, jelly and wine. It is used in blood purification, diabetes, diarrhoea, eczema and as an antidote for strychnine poisoning. It is stomachic, carminative and diuretic and lowers the blood pressure. The jamun seed powder reduces the sugar content in urine.

***Karonda* (*Carissa carandas*):** It is a hardy, evergreen, spiny and indigenous shrub which thrives well as rainfed crop. The fruit belongs to the family Apocynaceae. Fruits, sour and astringent in taste, are a very rich in iron contains a good amount of vitamin C. They also contains protein, carbohydrates, fat, fibre and calcium. The ripened fruits may be eaten as dessert or used for the preparation of jelly, sauce, cream or jellied salad. Unripe fruits are used for making vegetable, pickles, sauces and chutney. The dried fruits may act as a substitute for raisins. The wine prepared from ripe fruits contains about 14.5 to 15% alcohol and is very much liked by wine fanciers. Fruits can also be used in dyeing and tanning industries. Karonda fruit is considered to be antiscorbutic and is also very useful in curing anaemia, stomach ache and is anthelmintic. Root extracts are used in lumbago, chest complains and venereal diseases.

Lasoda (*Cordia myxa* L.): It belongs to family of Boraginaceae. It is a perennial, medium sized tree with crooked stem. Lasoda bears small sized fruits in bunches, used as traditional vegetable and pickles. Fruits are good sources of protein, carbohydrates, K and Na, fiber ascorbic acid and vitamins, which gives essential nutrients for the human health. Unripe green fruits are mostly used as vegetable and pickles. Sometime fruits are dehydrated after blanching for used as vegetable during off season. The sticky pulp from ripe fruits is commonly used to make glue.

Fig (*Ficus carica*): Fig was an important food crop in ancient civilization. It is a highly nutritious fruit. The fruit contains protein, calcium, iron, vitamin A and thiamine at varying concentrations. Figs are consumed as fresh or dried, preserved, candied or canned. Fresh figs are nutritious and used as dessert or for making jam, jelly, pudding, cakes, etc. The fruit is valued for its laxative property. It is applied for boils and other skin infection. The latex is used to coagulate milk and leaves are used medicinally as diuretic, demulcent, emollient and anthelmintic properties.

Tamarind (*Tamarindus indica*): It is native to Tropical Africa and belongs to the family Fabaceae. Tree is large sized, long-lived evergreen tall with a spreading crown. It is an excellent tree for social forestry and agro forestry. This crop is highly suitable for wastelands due to its multi ferrous uses and capacity to withstand adverse agro-climatic conditions. It also acts as a good wind break. Almost every part of the tree finds some uses but fruit is the most useful which contains the sweet acidic pulp. The pulp has low water content and high levels of proteins, carbohydrates and minerals. The pulp is also the principal souring agent for squashes, chutney, beverages, etc. The fruits are used in the medicine as a refrigerant, carminative, antiscorbutic and laxative. The active constituents present are furunone, phenyl acetaldehyde and tartaric acid. The products of the seeds are used mostly for manufacture of sizing powders. Tamarind kernel powder is extensively used for starching of cotton yarns, jute and woolen fabrics.

Phalsa (*Grewia subinaequalis*): *Phalsa* belongs to family of Tiliaceae. It is a shrub or small tree of Indian origin. The ripe fruits are consumed fresh or processed into refreshing fruit and soft drinks during summer. Phalsa fruit has a short shelf life suitable for only local marketing. It is grown in the northern and the western states of India. Phalsa is found wildly growing in UP, Rajasthan, Punjab, Haryana, MP, West Bengal and many parts of south India. The cultivation of phalsa is limited to very small scale in Punjab, Haryana, Rajasthan, Gujarat and Uttar Pradesh. The fruits are good sources of citric acid, vitamins A, minerals, flavonoids, carotenoids and anthocyanins. The phalsa fruits are potential sources of potassium which plays crucial important role in energy metabolism and normalizing blood pressure.

***Chironji* (*Buchanania lanzan*):** It belong to family of Anacardiaceae. Nutritional composition of the seeds shows that it as a potential source of protein, fat, dietary fiber, and energy. It is very good source of phosphorus, calcium, magnesium and iron. The fruit has high socio-economic value providing livelihood to rural population. Chironji is low in calories but extremely such in protein and dietary fibre. The fruit is juicy and sweet in taste and used for preparation of various value added products like squash, ready to serve drinks and nectar after juice extraction.

Important underexploited vegetables

***Kachri* (*Cucumis callosus*):** *Kachri* is a drought hardy and high temperature tolerant crop (up to 46°C), found in the arid zones during rainy season. Unripe fruits are bitter in taste but at ripening they become edible. The mature fruits are usually cooked with various vegetable preparations, *chutney*, pickles and are also used for garnishing the vegetables or as salad. *Kachri* is one of the components of the delicious vegetable popularly known as *Panchkuta* in the desert districts of north-western India (Pareek and Samadia, 1998). Unripe fruits are bitter in taste but at ripening they become edible (Samadia, 2007). *Kachri* can be cultivated successfully both during rainy and spring-summer season. It requires warm and dry weather with plenty of sunshine for growth and production.

Snap melon (*Cucumis melo* var. *momordica*): Snap melon is commonly grown as inter crop in maize. Its immature fruits are used as salad, vegetables and other culinary preparations. Fruits at ripening stage develop suture. Its fruits are generally less sweet as compared to muskmelon; hence it is much liked by the people who are suffering sugar related disorders. Snap melon pulp is suitable for preparation of jam by adding equal quantity of sugar to pulp. Good quality wine with excellent aroma and taste can be prepared with its pulp. Snap melon is originated in the tropical regions of Africa and Asia. It is a very popular vegetable of arid zone. It is commonly grown as a rainfed crop in Rajasthan and Gujarat. A great extent of genetic variability exists in India with respect to vegetative growth, quality attributes and resistance to biotic and abiotic stresses.

***Mateera* (*Citrullus lanatus*):** *Mateera* is generally known as the poor man's vegetable and the common man's fruit in the desert. It is an indigenous type of drought hardy watermelon and extensively grown on barren sand dunes of western Rajasthan. Watermelon is indigenous to Tropical Africa where wild forms are still available. The immature green fruits at the tender stage are rich in protein, carbohydrate, crude fibre, calcium and phosphorus. The mateera fruits are sweet with refreshing edible flesh and consumed fresh as dessert and have juicy properties. Besides, the tender fruits (*Loiya*) weighing 80-150 g are used extensively as fresh vegetable for making *rayta* and curries. The seeds are protein rich (25-32%) and are roasted and eaten as snacks.

Bitter apple (*Citrullus colocynthis*): Bitter apple is the probable ancestor of watermelon which is bitter in taste and also known as *Tumba* or 'bitter apple'. It resembles a common watermelon vine, but bears small, hard fruits with a bitter pulp. Fruit contains 15% pulp, 62% seed and 23% rind. The mesocarp contains glucose (1.3% on flesh basis). The processed mesocarp may be good sources of pectin. The juice of the fruit contains citrullin, citrullene and citrullnic acid. The fruits of bitter apple also contain cucurbitacin B and its glycoside, cucurbitacin I. The peel free flesh of ripe fruits contains yellow bitter oil. The seeds are used for edible purposes as well as to extract oil. Seeds contain 16.7% yellow coloured semi-dry oil rich in linoleic acid. It is one of the most drought cucurbit showing maximum diversity in Thar Desert. The fruits are widely used in traditional medicines and preparation of biopesticide formulations.

***Arya* (*Cucumis melo* var. *chate*):** *Arya* is an annual plant and monoecious. Tender fruits are generally used as salad and harvested before maturity. The fruit is climacteric. It is propagated by seeds. Fruit shape is long, skin colour light to dark green and smooth at tender stage. Fruit flesh is light orange at ripening without sugar and aroma. It is cultivated in several parts of arid zone. Fruits are rich in vitamins, minerals and phytochemicals.

Roundmelon (*Citrullus vulgaris* var. *fistulolus*): Roundmelon is also known as round gourd, Indian squash, squash melon and *Tinda*. It is grown for small, tender fruits that are roughly spherical and about 5-8 cm in diameter. The fruits at cooking stage contain 1.4% protein, 1.4% fat, 3.4% carbohydrates 1% fibre, 0.5% minerals, 13 mg carotene and 18 mg vitamin C/ 100 g of fresh weight. *Tinda* is extensively cultivated in North India, especially in Punjab, Uttar Pradesh and Rajasthan. It is believed to have originated in India and several landraces are prevalent in arid zone.

Spine gourd (*Momordica dioica*): Spine gourd or *kartoli* is a perennial climbing plant. The spiny fruits are used as vegetable in all regions of India. They are quite palatable, rather sweet and entirely free from bitterness. Fruits are good source of protein and iron. It is also rich in ascorbic acid content (275.10mg/100g). It also contains iodine (0.7µg/100g). Fruits, leaves and tuberous roots are used as a folk remedy for diabetes. It has small leaves and small yellow flowers. Fruits are small, dark green, round or oval with spines. Fruits are available from July to October in North India. Momodicausenal (a pentacyclic triterpene) was isolated from the seed (Ali and Srivastava, 1998). Spine gourd is dioecious and propagated by underground tubers and stem cuttings. Wide genetic variability exists in arid zone of Rajasthan particularly in natural habitats.

***Jhaar karela* (*Momordica balsamina*):** *Jhaar karela* is a wild climber containing wide spectrum of medicinal and nutritional value. The fruits are harvested from waste land from July to October in arid zone. It is monoecious and propagated through seeds. Fruits are small and used as vegetable. The leaves, fruits, seeds and bark of the plant contain resins, alkaloids, flavonoids, glycosides, steroids, terpenes, cardiac glycoside, saponins having various medicinal importance. The therapeutic agent is '*Momordin'* which possess very good anti-diabetic activity. The commercial exploitation for biopharmaceuticals and neutraceuticals are some of the prospective future potential of *Jhaar karela*. It is found in natural habitats of arid zone particularly neglected places. It possesses resistance against biotic and abiotic stresses which may prove worth in utilizing in the breeding programmes.

Cluster bean (*Cyamopsis tetragonoloba*) : Cluster bean commonly known as *Guar* is one of the most drought hardy legume vegetable. Its immature pods are primarily used as vegetable. It is also dehydrated and stored for future use as vegetable. Cluster bean possesses several medicinal properties. Being a legume crop it is much preferred for forage. It fixes nitrogen in soil and preferred in crop rotation cycle in arid zone. It is relatively tolerant to salt and water stress and give high yield under adverse conditions and need less fertilizer. It is very good source of protein and dietary fibers.

Moth bean (*Vigna aconitifolia*): Moth bean is an important crop of arid and semi-arid regions. It has higher adaptability to uncongenial ecological environments makes it a perfect choice for areas receiving lesser rainfall. Moth bean seeds are a good and potential reservoir of proteins and other essential minerals and vitamins. The green pods are eaten as a vegetable and the ripe seeds, whole or split, are eaten cooked. Dry seeds of moth bean offers a variety of edible products-vegetable, fodder for animals, whole seed, *Papad, Bhujia, Dal, Mangori, Vada*, *etc*. It is also assimilated as a flour to prepare south Indian food delights like *Idli* and *Dosa*. India being the origin place has numerous landraces and cultivars of moth bean are available in arid zone.

***Phog* (*Calligonum polygonoides*):** *Phog* is an endemic and threatened species reported from Thar Desert. It belongs to the family Polygonaceae and commonly grows on dry sandy soils and sand dunes. Its native habitat is hot arid region of Thar Desert of India. *Phog* is a perennial shrub, usually 4-6 feet in height but occasionally may reach even 15 feet height. It is drought hardy and capable of growing under adverse conditions of soil and moisture. It is not affected by frost. *Phog* has high economic values as its all plant parts are useful in one or other way. Its abortive flowers and succulent fruits are the most important source of food for sustenance during frequently occurring famines and also valued for medicinal properties. Dried tender flower buds are known as *phogla* in Rajasthan and used to prepare *rayta*. The wood is used as raw materials in building huts/ shelter and scaffolding of wells and other structures. The aqueous paste of plant acts as an antidote against snake bite. It is used for curing typhoid, asthma, cough and cold.

***Khimp* (*Leptadenia pyrotechnica*):** *Khimp* is a amazing desert plant belongs to the Apocynaceae family. It is leafless, erect, evergreen perennial shrub and widespread in arid zone of India. Being highly drought resistant, it played an important role in afforestation of desert. Roots have a strong soil binding capacity and used in sand dune fixation. *Khimp* possesses antifungal, antibacterial, anticancer, antioxidant, wound healing, anthelmintic, antiatheroscloretic, hypolipidemic, antdiabetic and hepatoprotective activities coupled with other multifarious uses. Almost all plant parts are used in the traditional medicinal system to treat various disorders. It's flowering and fruiting time is August to January. The pods are known as *khimpoli* which ripe in the month of March. Pods are cooked as vegetable and used possess medicinal value. The plant is used in thatching of huts and plant fiber for making ropes.

Ivy gourd (*Coccinia grandis* syn. *C. indica*) : Ivy gourd or *kundru* is perennial climber and dioecious plant. Being perennial in nature it continues up to 2-3 years in same field. It is native of India. Fruits are smooth, small (5-6 cm long) and cooked as vegetable. It is propagated through stem cuttings. Parthenocarpic germplasm is also found in nature which does not require pollination for fruit set. It is rich source of vitamins and minerals.

Indian aloe (*Aloe barbadensis*): Indian aloe or *Guarpatha* is a small, succulent, stemless, herbaceous perennial plant (60-100 cm height) with shallow root system. It contains alloin, a yellow coloured liquid and colourless aloe gel. It is rich in vitamin C (53 mg/ 100g edible part) with antioxidant and medicinal properties. The tender aloe, free from bitter content, is commonly used for vegetable purpose. The aloe vera is widely used for preparation of juice, vegetable and cosmetic purpose.

***Khejri* (*Prosopis cineraria*) :** *Khejri* is a drought hardy perennial plant belonging to family Leguminosae. It is called as *Kalpvriksh* of Thar Desert. It grows luxuriantly under the extremely adverse agroclimate in hot arid regions without much care. *Khejri* have multiple uses *viz*., nutritious rich pods, fodder and fuel, besides its favourable effects on ecology and soil fertility. It not only tolerates the extreme edapho-climatic conditions of Thar Desert but also has plentiful foliage, bears flowers and fruits during the dry period. Being leguminous species, it is compatible to almost all companion crops grown under the traditional cropping systems. The immature pods called as *sangri* are used as vegetable. It is a major source of leaf fodder (*loong*) in arid zone of country. The pods and fodder is nutritious and high valued. About 10-15 kg tender pods and 25-30 kg *loong* can be harvested annually from a 20 years old tree.

Improved varieties of underexploited fruit and vegetable crops

The climatic conditions of arid region are very adverse for growth and production of a crop therefore; selection of a variety/crop for this region is highly important for economic production. The selected crop/variety should complete their vegetative and reproductive phase during maximum moisture availability period. The underexploited arid fruits and vegetables crops meet this requirement. The genetic resource of underexploited arid fruits and vegetables crops are being conserved and maintained in field repository at ICAR-CIAH, Bikaner and its regional station CHES, Godhara, Gujarat. The collected germplasm has been evaluated and characterized for utilization in improvement programmes. The ICAR-Central Institute for Arid Horticulture, Bikaner has released numbers of varieties of arid fruits and vegetable crops (Table 4). A number of varieties have been developed and released through AICRP on Arid Zone Fruits. Bael can be grown successfully in semiarid and arid regions and varieties NB-5 and NB-9 doing well under irrigated hot arid conditions. Goma Yashi bael variety developed by ICAR-CIAH, Bikaner is well accepted among farmers under semi-arid conditions due to optimum fruit size, high yield and quality (Singh *et al.,* 2011). Similarly improved varieties of arid vegetables like *khejri, kachri*, snap melon, Indian bean and clusterbean have been released for cultivation. AHK-200 and AHK-119 variety of Kachri and Thar Manak of mateera are becoming popular in arid region.

Table 4. Underexploited fruits and vegetable varieties released by ICAR-CIAH, Bikaner

Fruit(s)		Vegetable(s)	
Bael	Goma Yashi, Thar Divya, Thar Neelkanth, Thar Shristi	Khejri	Thar Shobha
Jamun	Goma Priyanka, Thar Kranti	Bottle guard	Thar Samridhi
Lasoda	Thar Bold	Mateera	AHW-19, AHW- 65, Thar Manak

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Fruit(s)		Vegetable(s)	
Phalsa	Thar Pragati	Kachri	AHK-119, AHK-200
Karonda	Thar Kamal	Snap melon	AHS-10, AHS-82
Mulberry	Thar Lohit, Thar Harit	Kakri	AHC-2, AHC-13
Mahua	Thar Madhu	Sword bean	Thar Mahi
Tamarind	Goma Prateek	Indian bean	Thar Kartiki, Thar Maghi
Chironji	Thar Priya	Ridge gourd	Thar Karni
Khirni	Thar Rituraj	Clusterbean	Goma Manjri, Thar Bhadvi
Ber	Goma Kirti, Thar Sevika, Thar Bhivraj, Thar Malti	Sponge gourd	Thar Tapis

After evaluation of germplasm by AICRPs, ICAR institutes and SAUs, a number of varieties of arid fruits and vegetable crops have been recommended for cultivation in arid and semi regions for income and nutritional security (Table 5).

Table 5. Promising varieties of arid fruit and vegetable crops

	Fruit crops
Ber	Gola, Seb, Mudia, Kaithli, Banarsi Karaka, Umran, Ilaichi, Rashmi
Bael	NB-5, NB 9, NB-16, NB-17, Pant Aparna, Pant Sujata, Pant Shivani, CISH Bael-1, CISH Bael-2
Fig	Poona Fig, Dinkar, Conadria, Excel, Dianna, Brown Turkey
Tamarind	PKM 1, Pratisthan, Yogeshwari, Goma Prateek
Aonla	NA 6, NA 7, NA 10, Kanchan, Krishna, Banarasi, Chakiya, Lakshi 52, BSR 1, Anand 1, Anand 2.
Custard apple	Balanagar, Arka Sahan, Phule Janki, Washington, Pink's Mammoth.
Pomegranate	Ganesh, G 137, Jalore Seedless, Mridula, Ruby, Arakta, Bhagwa, Phule Super Bhagawa, Solapur Lal, CAZRI, Vishal
	Vegetables
Cowpea	Pusa Dofasali, Pusa Phalguni, Pusa Barsati, Pusa Rituraj, Pusa komal, Kashi Nidhi,
Cluster bean	Pusa Sadabahar, Pusa Mausami, Pusa Navbahar, Durga Bahar, AHG-13
Amaranth	CO-1, CO-2, CO-3, Chhoti Chauali, Badi Chaulai

Conclusion

Underexploited fruits and vegetables are well accepted and more sustainable source of minerals, vitamin phytochemicals and antioxidant for nutritional security along with socio-economic development and environment protection. Integration of fruits and vegetables in daily diet not only supply nutrients and vitamins but they also improve nutrient absorption and impart unique flavors and taste of food too. Underexploited fruits and vegetables are cheapest and effective sources of vitamin and dietary fiber. Under exploited fruit and vegetable crops have adaptability to diverse agro-climatic condition and ability to survive in degraded lands. The area and production of underexploited fruits and vegetables crops are increasing fast because of the development of new varieties and agro-techniques for arid and semi-arid regions. However, there is a need for germplasm conservation, evaluation, standardization of region specific technologies, infrastructure development in form of market, storage and processing for sustainable development of under exploited arid fruits and vegetable crops.

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Day 1, November 18, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session I

THEMATIC SESSION ON INTERNATIONAL YEAR OF FRUITS AND VEGETABLES WITH FOCUS ON NUTRITION AND HEALTH

Chair : Dr S.K. Malhotra

Co-chair : Dr Balraj Singh

Brief Bio-data

Dr S.K. Malhotra

Dr. Suresh Malhotra, Agriculture and Horticulture Commissioner in the Ministry of Agriculture & Farmer's Welfare has more than 31 years of experience in Research & Development in Agriculture. He is providing leadership in development of agriculture in the country through policy planning, program development, coordination, execution, supervision of R&D multidisciplinary activities. He looks after National Food Security Mission program which ensures food security of the country. His concerted efforts as a team made India self-sufficient in pulses production. As a Chairman of more that 30 high powered committees, task forces he has been guiding & providing solutions to emerging problems in agriculture.

He is the architect of Per Drop More Crop program under PMKSY, High value agriculture, National Saffron Mission, National Pulses Mission, National Millets Mission and National Bee and Honey Mission programs. He has served as Assistant Director General (Hort. Sci.) with ICAR and provided leadership to 23 horticulture research institutes & 14 AICRP projects. As a scientist, his research contributions to the agriculture science are development of 15 high yielding varieties and technologies of seed spices, which are now basis of cultivation in the rainfed farming system.

There are 240 publications to his credit. His outstanding contribution in agriculture has earned him 12 awards and 7 fellowships. He is a widely travelled and represented India in more than 17 international programs of FAO, CODEX, G20, SAARC, WHO, UNECE, CGIAR, ADB, BRICS, G4, SCO, CGIAR institutes (CIMMYT, ICRISAT, ICARDA, CIPA, Bioversity International, AVRDC).

GLOBAL AND NATIONAL HORTICULTURE SCENARIO INCLUDING HORTICULTURE DEVELOPMENT PROGRAMME AND THEIR IMPLICATIONS ON HEALTH AND NUTRITIONAL SECURITY

S.K. Malhotra
Ministry of Agriculture & Farmers Welfare, Government of India, Krishi Bhawan, New Delhi – 110007
E-mail: agricommissioner@gmail.com; malhotraskraj@yahoo.com

ABSTRACT

A variety of fruits, vegetables, tuber crops, root crops, plantation crops, spices, medicinal and aromatic and ornamental crops, represent core of strategy towards food, nutrition, health and income security.

The last decade has seen technological infusion i.e. precision farming, micro-irrigation and micro sprinklers, *in vitro*-propagation and hi-tech nurseries, protected cultivation, improved integrated cold chain system, have impacted the development. Investments made in past two decades in R&D have been rewarding in terms of increased production, productivity and export of horticultural produce. India has emerged as the largest producer of mango, cashew, banana and second largest producer of fruits and vegetables in the world. Despite of the fact that the country is second largest producer of fruits and vegetables; the availability of fruits and vegetables still continues to be below the actual dietary requirements. The big challenge being faced is how the production could become competitive both in terms of quality and value. Therefore, existing potentialities need to be harnessed and gains have to be sustained. Technology-led development, therefore, has to be in focus. Evolvement of region-specific new cultivars with specialty characters of nutrition, *i.e.* biofortification, productivity, inbuilt resistance to diseases, pests and environmental stresses are in priority. It is important that technologies improve the efficiency of inputs, water, nutrients, quality yield and low postharvest losses of fruits and vegetables.

The Government of India has addressed many of these constraints in production and consumption chain in regionally-differentiated manner through Mission for Integrated Development of Horticulture (MIDH). This programme would help to achieve economic development and address the issues of income security, nutritional adequacy, employment and environment concerns. It is clearly evident from the record output of 331 million tons horticulture produce achieved during 2021, 2nd estimates efforts.

In order to ensure holistic growth of horticulture, Government of India has very recently launched the Horticulture Cluster Development Programme (HCDP), will be implemented in 12 horticulture clusters in first phase out of the total 53 clusters selected for the programme. This central sector programme is implemented by the National Horticulture Board (NHB) for growing and developing identified horticulture clusters to make them globally competitive. HCDP will address all major issues related to the Indian horticulture sector.

Brief Bio-data

Dr. Tusar Kanti Behera

Born at village Brahmapur, Dist. Balasore, Odisha Dr. Tusar Kanti Behera graduated from OUAT, Bhubaneswar, Odisha, Ph.D. from Indian Agricultural Research Institute, New Delhi and Post-Doctoral Fellowship programme at University of Wisconsin, USA. He is presently the Director, ICAR-Indian Institute of Vegetable Research, Varanasi. Before joining as Director, he worked as Scientist to Principal Scientist at the Division of Vegetable Science, ICAR-IARI, New Delhi. He also served as the Professor in the Discipline of Vegetable Science, P G School, IARI and Nodal Officer, IARI-Jharkhand, Hazaribag.

Dr Behera, was associated in breeding 23 varieties and hybrids in brinjal, cucumber and gourds those are released and notified through CVRC and State Seed Sub-committee; besides some were licensed to Pvt. seed companies. He isolated gynoecious lines in bitter gourd from its feral form, *Momordica charantia* var *muricata* and introgressed *gy-1* gene into commercial bitter gourd cultivars which are now licensed to Pvt. Seed companies. He also introgressed gynoecious trait in Indian cucumber using marker-assisted back cross breeding (MABC). A bitter gourd variety, Pusa Rasdar developed by him is exclusively suitable for protected cultivation. He guided 12 Ph.D. and 2 M.Sc. students at IARI, New Delhi. He published 125 peer reviewed research papers, edited 3 Book and written 15 book chapters and 7 training manuals. He was deputed to USA, Australia, France, Russia, Thailand, and Libya on different academic assignments. He was the member on the XI Five Year plan for Horticulture, Plantation Crops and Organic Farming, member on RAC (ICAR-DMR, Solan & BAU, Bhagalpur) and IMC (ICAR-IIHR, Bengaluru, ICAR- CCARI, Goa, ICAR-CIAH, Bikaner and ICAR-DOGR, Pune). He also served as FAO International Consultant in Vegetable Breeding at Libya 2010.

Dr Behera is Fellow of National Academy of Agricultural Sciences (NAAS), Indian Society of Plant Breeding and Genetics (ISGPB), Indian Academy of Horticultural Science (IAHS) and Indian Society of Vegetable Science (ISVS). He has been bestowed with several reputed awards, namely, IARI Hari Krishna Shastri Memorial Award (2019), ICAR Best Teacher Award for Higher Education (2018), ISVS Dr Biswajit Choudhury Memorial Award (2018), IAHS Dr Kirti Singh Gold Medal (2016), Fulbright-Nehru Academic and Professional Excellence Fellowship (2015), IARI Hooker Award (2010), DBT Associateship (2006) and ISVS Dwarka Nath Memorial Medal (2000). He is presently the Secretary of Indian Society of Vegetable Science (ISVS) and earlier served as Editor of IJH (2011-19), Agricultural Research Journal (from 2016) and Indian Society of Agricultural Sciences (2012-16), Assistant Editor of CGCR, USA (from 2008) and Treasurer of IAHS (2015-18).

BIOFORTIFICATION OF HORTICULTURAL CROPS FOR NUTRITION AND HEALTH

Tusar Kanti Behera
ICAR-Indian Institute of Vegetable Research, Varanasi 221305, Uttar Pradesh
E-mail: tusar@rediffmail.com

ABSTRACT

Comprehensive National Nutrition Survey (2016-18) data showed 34.7% of children under 5 years of age are still low height for age (stunted growth) and 33.4% are low weight for age (underweight). Fruits and vegetables are a natural source of micronutrients essential for the human body and horticultural production has the potential for attaining nutritional security. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions. Developing nutrient dense horticultural crops can be achieved by biofortification (through agronomic and breeding practices, transgenic and genome editing approach). The agronomic biofortification of vegetables is one of the simplest and easy methods of biofortification. In this approach, generally, fertilizer is used either in the form of spray on leaves or the application of fertilizer in soil. Biofortification through Breeding and transgenic approaches are the potential approach to reduce the gap between micronutrient requirements and intake by increasing the proportion of dietary vitamins, iron, zinc and selenium-essential micronutrients of health significance. Considering the nutritional impact, biofortification program has been carried out in many horticultural crops like potato, orange, sweet potato, cow pea, beans, pumpkin, bananas, cassava, etc. Through transgenic some banana genotypes were developed which are rich in provitamin-A carotenoids. Queensland University of Technology, Australia, developed provitamin-A (β-carotene), alfa-tocopherol and iron rich varieties of banana by transgenic approach as Super banana. Three genes, encoding phytoene synthase (*CrtB*), phytoene desaturase (*CrtI*) and lycopene beta-cyclase (*CrtY*) from *Erwinia* have been introduced in potato and tomato to produce beta-carotene. Transgenic cauliflower with *Or* transgenesis associated with a cellular process that triggers the differentiation of proplastids or other non-coloured plastids into chromoplasts for carotenoids accumulation and also reported *Or* gene can be used as a novel genetic tool to induce carotenoid accumulation in a major staple food crop. The post-transcriptional gene silencing is also used for change in nutrient biosynthesis pathways which improve the nutrient contents.

Presently, Genome editing through CRISPR/Cas is one of the most promising genome editing tools owing to its easy manipulation, high efficiency and its wide application in functional studies of genes and genetic crop improvement.

Dr M.N. Sheela

After graduation in Agriculture took MSc(Ag) and PhD in Plant Breeding and Genetics from Kerala Agricultural University. Joined Agricultural research service in 1991 and presently working as Director(A), ICAR-Central Tuber Crops Research Institute Thiruvananthapuram. Handled four International projects with agencies viz. CIAT, CIRAD and ETH and more than 25 institute and external aided projects. Developed and released 20 high yielding varieties in Tuber Crops viz. cassava, greater yam, white yam and elephant foot yam. Developed high yielding cassava mosaic disease resistant varieties, dwarf white yam variety and biofortified greater yam variety. Published 51 research papers, 12 book chapters, 15 technical bulletins, two catalogues and 23 popular articles. Presented more than 120 papers in International and National symposiums. Developed DUS test guidelines of cassava, sweet potato, greater yam and yam bean. Guided 30 MSc students and two PhD students. Recipient of the International Pat Coursey Award for the best Yam rsearcher of the world in 2006. Visited the countries viz. USA, Brazil, Columbia, Belgium, Switzerland, France, China, Ghana, Uganda, Laos, Thailand, Cambodia and Australia in connection with tuber crops research programmes

TUBER CROPS FOR NUTRITION AND HEALTH

Sheela,M.N. and A.V.V.Koundinya
Central Tuber Crops Research Institute, Sreekariyam P.O., Thiruvananthapuram – 695017, Kerala
E-mail: director.ctcri@icar.gov.in

ABSTRACT

Tropical tuber crops are a unique group of vegetables that can be grown on a wide range of soils from slightly acidic to saline and in climatic conditions from tropical to subtropical regions with limited inputs. These crops produce high energy as their economic plant parts are reservoirs of carbohydrates thereby meeting the energy requirement of people living in rural, tribal and other marginal areas. These crops provide 6 % of the world's dietary energy (300 to 600 KJ/100g) and are good sources of dietary fibre (1.19 to 1.64%) and ash (0.3 to 2.1%). They have low protein content up to 3.0%. Tropical tubers have low or no fat content which implies that their consumption reduces the chance of cardiovascular diseases. They are also a good source of minerals. For instance, taro corms have high phosphorous (1500 to 4500 ppm), potassium (10000 to 17000 ppm), magnesium (650 to 3800 ppm), calcium (400 to 1200 ppm), iron (15 to 55 ppm), zinc (40 to 120 ppm) and copper (6.5 to 8.0 ppm) content. Tropical tuber crops are also proven rich sources of β-carotene, antioxidants, flavonoids, mucilage, omega 3 fatty acids, minerals, nutraceuticals and resistant starch which can play an important role in mitigating hidden hunger through diet diversification. Tropical tuber crops such as sweet potato and yams offer immense scope as health protectants, therapeutics and bicolours because of the presence of compounds like carotenes and flavonoids. The orange flesh sweet potato varieties *Sree Kanaka, Bhu Sona, Bhu Kanti* and *Bhu Ja* have β-carotene content from 5.8 to 14.4 3 g/100g. The purple flesh sweet potato variety *Bhu Krishna* is having high anthocyanin content (85 to 80 mg/100g). The greater yam variety *Sree Neelima* is also rich in anthocyanin, protein and minerals. One cassava breeding line 17S325 has high β-carotene content (6.10 mg/100g). These crop varieties are expected to combat vitamin-A deficiency and provide a high nutraceutical rich diet thereby reducing the risk of cancer and other related ailments. The alkaloids from these crops have immense medicinal value. Diosgenin from *Dioscorea* species is widely used in the preparation of oral contraceptive pills. Elephant foot yam is commonly used in Ayurveda medicine as an anti-inflammatory agent and also for treating diseases like haemorrhoids. Despite these health and nutritional benefits, these crops have remained as the food of rural and tribal people. Hence, these crops are made as ingredients in the preparation of traditional and modern foods to increase their scope of consumption by all age groups of humans, especially by the youth. Few products developed and popularized by ICAR-CTCRI are anthocyanin and β-carotene-rich pasta and noodles, functional sago with high antioxidant potential, vacuum fried orange/purple-fleshed sweet potato chips, ready to eat energy-dense Nutri-bars, sweet potato flour-based gluten-free cookies and extruded products from purple-fleshed sweet potato flour. There is a necessity to promote tropical tuber crops as '*nutrition & health crops'* owing to their strength in eliminating malnutrition, overcoming hidden hunger and providing a balanced diet. Their availability at cheaper rates will make this possible to make a healthy nation.

Brief Bio-data

Gyan Prakash Mishra

While working in different institutions of repute like DRDO-DIHAR (Leh), ICAR-DGR (Junagadh), ICAR-IIVR (Varanasi), and ICAR-IARI, New Delhi; Dr G.P. Mishra has made significant contributions in the area of crop improvement, using conventional and biotechnological tools. He has developed four lentil varieties (L4727, L4729, PDL-1, PSL-9), one mungbean variety (Pusa 1641), two okra varieties (Kashi Chaman & Kashi Lalima) and an okra hybrid (Kashi Srishti). Eight okra genotypes including varieties and advanced breeding lines were licensed to various seed companies for Rs. 15.85 lakh. Kashi Lalima has the distinction of first red colored okra variety. Identified and registered unique multi-flowering genotypes in lentil and garden pea, and a lentil genotype having extended funiculus. Developed and commercialized a microgreens kit named '*TinyFields*'. In rice, he has identified a 5-methylcytosine DNA glycosylase/lyase which demethylates the retrotransposon *Tos17* and promotes its transposition. Developed double mutant lines for *ahFAD* genes, for high O/L ratio using MABC and MAS. Also, developed five transgenics viz. *defensin, mtlD, atDREB1A, CP&NC protein*- Peanut; and Bt-potato. Established a prototype of Permafrost based Germplasm storage facility at Chang-La, Ladakh (17,586 feet amsl) for the conservation of important germplasm as safety duplicate. He is the recipient of various prestigious awards including NAAS Associate, NASI-Membership, Fellow- BOYSCAST & ISGPB, IARI-Merit Medal and Best Student Award, ISCA-Pran Vohra Award, DRDO-National Science day Award, ICAR-Dr Rajendra Prasad Award, etc.

MICRO-GREENS: EMERGING SUPER FOOD FOR HEALTH AND WELLBEING

Gyan Prakash Mishra
Principal Scientist, Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi 110 012
E-mail: gyan.gene@gmail.com

ABSTRACT

Microgreens are obtained from certain crop species and are harvested at first true leaves stage (7-21 days old seedling). They are harvested by cutting the seedlings 5-10 mm above the soil or grow-media surface. These are classified as a high-value functional foods sice these contain very high contents of a number of antioxidants and certain minerals. These have gained a lot of popularity during last a few years as a functional food mainly due to their unique nutritional composition along with flavor, color and texture. A number of studies have revealed the superiority of micorgreens over their mature greens, especially for certain vitamins, antioxidants, etc. Nutraceutical effects of the microgreens like reduced risk of cardiovascular disease, oxidative stress and chronic diseases; have microgreens more popular, especially among the health cautious populations. Compared to the western countries, the microgreens market in the developing countries are not that organized. However, countries like India and China is considered as the future microgreens market. We have studied the mungbean and lentils microgreens due to the ease of their growth and relatively cheaper seed cost. The 20 diverse genotypes each of mungbean and lentil microgreens were grown under plain-altitude (Delhi) and high-altitude (Leh) conditions, which showed significant genotypic variations for various antioxidants and micronutrients. Interestingly, for most of the studied parameters, Leh grown microgreens were found superior to the Delhi grown microgreens, which could be due to unique environmental conditions of Leh, especially wide temperature amplitude, PAR, and UV-B content. Success of this novel technology is mainly dependent on the collaborative e□orts from the industry and researchers. In this manuscript we have comprehensively covered various aspects of a number of microgreens which are popularly being grown and consumed across the globe.

Brief Bio-data

Dr S.K. Malik

Born on June 16, 1962 at Rohtak, Haryana, Dr S.K. Malik obtained his B.Sc., M.Sc. and Ph.D. in Botany degrees from University of Rajasthan, Jaipur. Dr Malik started his career from ICAR-National Bureau of Plant Genetic Resources, New Delhi where he worked in various capacities and rose up to the level of Principal Scientist. Later he joined the Office of Secretary DARE and DG ICAR and presently continuing as Principal Scientist in this office. Dr Malik contributed significantly in the management of genetic resources of horticultural crops. He developed technologies for cryopreservation of Citrus and several underutilized fruits. Establishment of National Base Collection of Citrus and other indigenous fruit genetic resources in Cryogenebank at ICAR-NBPGR, New Delhi. He handled several national and international projects on agro-biodiversity and coordinated international and national trainings on in vitro conservation and cryopreservation. Dr Malik published more than 160 research articles and book chapters besides 11 books and manuals. He has visited USA, Australia, France, Belgium, Netherland, Switzerland, Portugal, Japan etc. for different official assignments.

CONSERVING DIVERSITY OF UNDERUTILIZED FRUITS FOR HEALTH AND NUTRITION THROUGH COMMUNITY PARTICIPATION: A DYNAMIC APPROACH

S.K. Malik and J.C. Rana*
ICAR-National Bureau of Plant Genetic Resources, Alliance Bioversity-CIAT*
Pusa Campus, New Delhi-110 012
E-mail: skm1909@gmail.com

ABSTRACT

Indigenous diversity of tropical underutilized fruits is facing an immense threat of extinction in India due to various biotic and abiotic factors. Changing dietary patterns amongst the younger generation, large scale urbanization, easy access to so called elite fruits and expansion of irrigation facilities has further affected utilization and natural sustenance of these indigenous fruits. Most of these fruits are directly harvested from trees or shrubs growing wild or semi-wild in forests, marginal forest lands and homestead gardens by local people. Bulk of this produce is used by the family or community itself and in case of surplus, it is sold in the local markets with not much of commercial gains. These species are being used by local people as minor fruits or vegetables as well as for various medicinal purposes. Fruit species like *khirni* (*Manilkara hexanda*) fulfill the vitamin A requirement of tribal women and children in the tribal dominated districts of Gujarat, Madhaya Pradesh, Rajasthan and Maharashtra. *Amla* (*Emblica officinalis*), *bael* (*Aegle marmelos*.), *chironji* (*Buchanania lanzan*), *karonda* (*Carissa congesta*), *ker* (*Capparis decidua)*, *lasora* (*Cordia myxa*), phalsa (*Grewia asiatica*), *pilu* (*Salvadora oleoides*), *jamun* (*Syzygium cuminii*), custard apple (*Annona squamosa*), tamarind (*Tamarindus indica*) etc. have tremendous health and nutritious value and form the small but special part of diet of local inhabitants. Genetic resources of these minor tropical fruits have not been given desired attention due to their less commercial importance and limited research on genetic improvement of cultivars. There is an urgent need to realize socio-economic value of these fruits in view of their nutritional, cultural, religious and economic values for the local communities and excellent adaptive capabilities of plants to changing climate. Most of these tropical fruit species are providing ecosystem sustainability being fully adapted to harsh and stressed arid and semi-arid fragile habitats the most vulnerable to the climate change scenario. It is, therefore, advocated to encourage participation of farmers and tribal communities in the promotion, value addition and conservation effort of these fruits by providing them good planting material, training them in better cultivation practices, motivating communities to protect and use their own plant species, facilitating value addition and marketing options and empowering them with available public support systems. Such community-based participation would encourage farmers to protect, grow and promote indigenous diversity of these species in their own farmlands, backyards, community lands etc. for harvesting fruits and using wood and shade. Encouragement to such farmers recently defined as the "Custodian farmers", would be ensuring maintenance, adoption and protection of the valuable indigenous agrobiodiversity and indigenous knowledge attached to these species. Comprehensive efforts made would serve dynamic *in-situ* conservation of these species and support livelihood of small, marginal and tribal farmers.

Oral Paper

POTATOES FOR FOOD AND NUTRITION

Brajesh Singh[1]*, Pinky Raigond[1], Som Dutt[1], Milan K. Lal[1], Arvind Jaiswal[2], Sushil S. Changan[1], Bandana Koundal[3] & N.K. Pandey

[1]ICAR-Central Potato Research Institute, Shimla, India

[2] ICAR-Central Potato Research Institute Regional Station, Jalandhar, India

[3] ICAR-Central Potato Research Institute Regional Station, Meerut, India

E-mail: birju16@gmail.com

ABSTRACT

Potatoes have been consumed since ages, however, efforts to popularize its nutritional significance have increased its importance as alternative for food and nutritional security. Accelerated growth of potato in developing world including Asia and Africa can help to substantiate the food and nutritional requirements of the undernourished in these regions. Potato can be a perfect replacement for other cereals due to its high nutritional value and high production and productivity. Potato is a nutritious and wholesome food. It's low energy density is beneficial when eaten without much added fat. Potatoes contain high quality protein rich in essential amino acids. It is a rich source of vitamin C and is far superior in this respect to most other vegetables and cereals. Substantial quantities of some of the B group vitamins are also present in potato. Potatoes contain many minerals and trace elements and concurrently are low in fats. Moreover, among the major food crops, bioavailability of minerals is potentially high in potatoes because of the presence of high concentrations micronutrient absorption enhancers such as ascorbate. Also, low content of absorption inhibitors such as phytate and oxalate further improve the bioavailability of minerals from potato. Hence, potato as such is a nourishing food and anyone can live by eating potatoes alone. With ever increasing population, potatoes are destined to be very crucial for providing food and nutritional security to populations in the developing countries including Indian masses.

POSSIBILITIES FOR DEVELOPING BIOACTIVE-COMPOUND RICH MANGO CULTIVARS

Ashish Yadav, Anshuman Singh, Vishambhar Dayal, A. K. Bhattacharjee and Shailendra Rajan
ICAR-Central Institute for Subtropical Horticulture, Rehmankhera P.O. Kakori, Lucknow – 227107, Uttar Pradesh
E-mail: 2005ash@gmail.com

ABSTRACT

The taste, aroma, eating quality, appearance, and content of neutraceuticals Indian mango varieties vary greatly. Mango is now widely acknowledged as a health-fruit, comprising multiple bioactive components with a variety of health advantages, establishing mango as an economical functional fruit. Aside from vital nutrients, organic acids, dietary fibre, vitamins, and minerals, Indian mango varieties also contain significant amounts of non-essential phytochemicals. Recent research has revealed that Indian mangoes are high in two bioactive compounds with high pharmacological value: mangiferin and lupeol. Earlier research at the data suggests that the fruits of the mango cultivars Bombay Green and Dashehari had much higher levels of mangiferin (0.25 and 0.22 mg/100 g, respectively) than Langra (0.07 mg/100 g) and Chausa (0.08 mg/100 g). Dashehari is also higher in lupeol (0.18 mg/100 g) than other cultivars (0.01-0.04 mg/100 g). Ambika and Arunika mango hybrids were discovered to be extremely high in mangiferin (35.1 µg/g) and lupeol (135.1 µg/g), respectively. The study has shown that bioactive substances in Indian mango varieties varies greatly, with the most notable being mangiferin, lupeol, carotenoids, gallotannins, and phenolic acids. The results indicate that rich genetic diversity for total antioxidants, carotenoids, flavonoids and phenolics in Indian mango varieties and hybrids is existing. Numerous factors are known to influence the level and composition of bioactive compounds in mango; however, genotype has a strong influence on bioactive compound profiles, implying the need for screening diverse mango germplasm for promising cultivars/accessions for potential industrial and genetic improvement applications

PHENOLIC RROFILING OF *PHALSA* (*GREWIA ASIATICA* L.) USING A HIGH-RESOLUTION QUADRUPOLE –TIME OF FLIGHT LCMS

Tanmay Kumar Koley, Kaushik Banerjee, Zareen Khan. DasharathOulkar and Raju Singh

ICAR Research Complex for Eastern Region, ICAR Parisar, P.O.: Bihar Veterinary College, Patna-800 014, Bihar

E-mail: tanmay.iari@gmail.com

ABSTRACT

Phalsa (*Grewia asiatica* L) from the family Tiliaceae is known for its therapeutic properties. Although various pharmacological researchers have established its medicinal properties, a detailed report on its phenolic metabolites is still lacking. In our experiment, a total of 64 compounds, including 28 flavonols, 4 dihydroflavonols, 10 flavones, 3 flavanols, 8 anthocyanins, 4 isoflavonoids, 2 phenolic acids, 2 flavanones, and 3 other phenolics was putatively identified in phalsa fruit by using liquid chromatography (LC) electrospray ionization high-resolution mass spectrometry analysis. As a methodology, the chemical structures of the constituents were elucidated by collision-induced mass fragmentation. The identification of each compound was based on the accurate mass of the parent ion, and at least on one confirmatory ion, each with less than 5 ppm of mass accuracy. In this study, 57 compounds were reported for the first time. Our results revealed that flavonols were found to be the predominant group of compounds, representing around 52.59 % of the total phenolics. Additionally, we noted that flavones and anthocyanins were identified as the two crucial groups in the phalsa fruits. When measured by four in vitro methods, the fruit showed strong antioxidant potentiality

FRUITS IN HUMAN NUTRITION AND HEALTH

Amit K. Goswami, Sanjay Kumar Singh, V.B. Patel and Suneha Goswami
Division of Fruits and Horticultural Technology, ICAR-IARI, New Delhi
E-mail: amit.tkg@gmail.com

ABSTRACT

Fruits and vegetables are an essential source of human nutrition and health. They are a good source of bioactive nutrient molecules such as dietary fibre, vitamins and minerals, and non-nutritive phytochemicals such as phenolic compounds, flavonoids and various bioactive peptides. Fruits and vegetables are low in salt, sugar and fat. Their intake has a positive effect in terms of weight management and obesity prevention. The abundance of diverse phytochemicals and secondary metabolites in these plant-based food plays a significant role in biological activities, modulating critical cellular pathways. Regular consumption of fruits and vegetables may be associated with decreased incidence of mortality of a variety of chronic diseases and prevent several non-communicable diseases such as cancer, cardiovascular, cognitive, skin, eyes, lung and, bone diseases, and provide a healthy and active healthy life. The phytochemicals available in fruits and vegetables have a strong antioxidant capacity, which modifies the metabolic activation and detoxification/ disposition of carcinogens and may even regulate tumour cell proliferation. It is recommended to consume various seasonal, fresh and locally available fruits rather than limiting consumption to a few. Indian Council of Medical Research (ICMR) guidelines suggest consuming up to 300 g of vegetables and 100g of fresh fruits daily for better health.

Oral Paper

PROMOTING FRUITS, VEGETABLE AND HUMAN HEALTH

Dr. Abha Singh, Shaurya Singh*
Department of psychology,P.P.N. College, Kanpur
Sam Higginbottom University of Agriculture Technology and Sciences

ABSTRACT

From ancient times it has been said that "jaisa hoga ann vaisa hoga mann". Several nutrients obtained from fruits and vegetables have been identified to have effects on cognitive abilities. Vitamins and minerals can affect multiple brain processes by regulating neurotransmitter pathways and plasticity. Undoubtedly food, fruits and vegetables are directly related to our health. We become what we eat. Nowadays every person is busy trying to attain worldly power. People are facing many health issues. Almost all families of the generation before ours had small kitchen gardens. People used to grow their vegetables and fruits in their own gardens. In this paper, I would like to mention that there is a very close relationship between fruits , vegetables and our health. Nutrients and their metabolites not only serve as building blocks of cellular structures and as energy sources, but also serve as direct modifiers of protein function, potent signaling molecules as well as inducers and repressors of gene expression. Therefore, Fresh fruits and vegetables are excellent performance enhancers. Health means not only physical but mental. The dietary consumption pattern of the general population in many countries reflects that they are often deficient in several nutrients, especially essential vitamins, minerals, and omega-3 fatty acids. Ultimately every person needs happiness and well-being. Thus discussion on this topic is inevitable on this platform.

Keywords: Promoting fruits and vegetables, Health, Nutrients, Mental health, Diet.

DEVELOPMENT OF NUTRIENT RICH CAULIFLOWER FOR BETTER PUBLIC HEALTH AND NUTRITION

Shrawan Singh
Division of Vegetable Sciences, ICAR-Indian Agricultural Research Institute,
New Delhi -110012
E-mail: singhshrawan@rediffmail.com

ABSTRACT

<p>Cauliflower is an important vegetable crop in India and grown on 450000 ha area with annual production of 8900000 tonnes (NHB Database, 2017). It has widespread reach to consumers and also available year round due to development of tropical varieties. But, the most common type is white curd (bleached) cauliflower which devoid of major nutraceuticals except glucosinolates. However, now-a-days, a range of colours are available in cauliflower which is sometimes considered as ‘speciality cauliflowers’ or ‘rainbow cauliflowers’ or ‘colourful cauliflowers’ which add splash of colours hence, nutrients and antioxidants to the food. In cauliflower, purple and orange curds are due to two different semi-dominant genes namely Pr and Or genes,which imparts anthocyanin and beta-carotene. The introgression of these two genes in tropical cauliflower was initiated at IARI, New Delhi and developed an anthocyanin rich genotype ‘PC-1’ (using Sicilian Purple) and ‘Pusa KeshriVitA-1 (using an orange line 1227) of mid maturity group cauliflower by recurrent selection. Further, the genetic study was done which showed influence of modifiers, however, their number could not be investigated so far. Further, the introgression of Pr gene from a recently identified variety Pusa Snowball Purple Cauliflower-1 into Indian or tropical cauliflower. The attempt will be useful for bringing the seeds of diverse coloured nutrient rich cauliflower to the common farmer and consumer at affordable prices and also at extended period. Also, these new programme in Indian cauliflower for anthocyanin as well as beta-carotene will be useful for health of consumers and increase growers’ earnings.</p>

Oral Paper

CAN THE BANANAS (BANANA & PLANTAIN) BE THE PANACEA FOR INDIA'S HIDDEN HUNGER?

Ramajayam Devarajan, Jeyabaskaran K J, Sivasankarai R, Suresh Kumar P, Thirugnanavel A, Pitchai Muthu R, Kalpana S, Ranjani M, Arjun Singh, Saraswathi MS, Uma S
ICAR-National Research Centre on Banana, Thogamalai Road, Thayanur Post, Tiruchirapalli - 620 102, Tamil Nadu
E-mail: ramajayamd@gmail.com

ABSTRACT

Among the fruits, bananas are the highest produced fruits in the world (158 million tons) as well as in India (32.6 million tons). Cultivation of micronutrient-rich banana varieties has the potential to significantly reduce micronutrient deficiencies especially the women and preschool children in most countries of Africa and Asia who are vulnerable to this 'hidden-hunger'. Insufficient intake of fruits and vegetables is estimated to cause around 14% of deaths from gastro-intestinal cancer worldwide. In India, over 99.4% of bananas are consumed locally with the percapita consumption rate of over 23 kg/head/year, contributing considerably to the food & nutritional security.

We analyzed the fresh fruit pulp sample of 450 bunches belongs to 121 commercially cultivated banana cultivars of India to quantify nine different mineral contents using ICP-OES. We have also estimated the mineral contents in the edible flower parts of 14 banana cultivars and total carotenoid contents (9 cultivars). The total carotenoid contents (µg/100 g) in the ripe pulps ranged from 230 in Grand Naine to 1369 in Nendran. ANOVA revealed highly significant cultivar differences for all the minerals. Observed below 10-fold variability for K & Mg to more than 100-fold for Na and Ca. Iron and Zn recorded 35- & 45-fold variability, respectively. The descending order of mean fruit pulp mineral content (mg/Kg) was K (626.1) > Ca (548.4) > Mg (321.9) > Na (196.3) > Fe (7.9) > Mn (4.6) > B (3.5) > P (3.2). Significant positive correlation was observed for all minerals with highest correlation value of 0.677 between Mg & Zn. Correlation value >0.5 were also observed between Mg-Ca, Mg-Fe, Mg-Na and Mg-Mn. Similarly, the highest loading value of 0.5 was recorded for Mg followed by 0.4 for Mn, Zn, Na & Fe in the first principal component. The cumulative proportion of three principal component explained 64.7% of variance with >1 Eigen values. Both principal component analysis and cluster analysis failed to group the banana cultivars according to their ploidy (3)/genome (6)/subgroups (15). Consumption of 100 g of banana pulp fairly contributes to the percent RDA (Recommended dietary allowances)/AI (Adequate intake) requirement of the Indian adult men in the descending order of Mn (11.5) > Mg (9.5) > Ca (9.1) > Fe (4.7) > K (1.7) > Na (0.9) > P (0.05). Besides Ca and Mg, commercially grown banana cultivars of India possess higher micronutrients than the banana cultivars grown in other countries.

Day 1, November 18, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session II

MANAGEMENT OF BIOTIC AND ABIOTIC STRESSES

Chairman : Dr A.N. Mukhopadhyay

Co-Chair : Dr D.K. Ghosh

Bio-data

Dr S. Uma

Dr. Uma Subbaraya, completed her Graduation, Postgraduation and Ph.D from the University of Agricultural Sciences (UAS), Bengaluru, during 1979-1990. Presently, serving as the Director, ICAR – National Research Centre for Banana, Trichy since 2016 and has expertise of 31 years as Researcher, Research Coordinator and Research Administrator.

Her research extends on conservation of traditional bananas, *in-vitro* conservation and cryo-banking with release of 7 climate resilient banana varieties. She has developed very high throughput tissue culture technologies, appreciated globally and patent is filed. Now, leading a project on genetically fortified bananas with iron and Vitamin-A to combat deficiency. She led her team for developing a low cost Sea-Protocol for export of traditional Indian bananas.

She is also elected as the Chair of Banana Network for Pacific Asia (BAPNET*)* as representative in MusaNet Expert Committee and Member of World Banana Forum. Served as FAO consultant for 3 years.

As Director, ICAR- NRCB, she led her team to be awarded with prestigious Sardar Patel Outstanding ICAR Institute Award for 2021. She is the recipient of International awards - Pisang Raja Award (2007), Banana Conservator Award (2009) of Bioversity International, France. She is also the recipient of National Awards, Punjabrao Deshmukh Best woman Agricultural Scientist Award (2008) from ICAR ; Dr. M.H. Marigowda *National Endowment Award (2020)*, Kalayya Krisnamurthny Award (2020) for best research in Agriculture, both from UAS, Bangalore and elected as NAAS Fellow and awarded Dr.(Ms) Prem Dureja Endowment Award of NAAS in 2020 for the contribution in the field of Horticulture.

She has served as Scientific Member of many International Conferences and delivered more than 30 keynote and lead lectures visiting 18 countries. Transferred 10 technologies to stakeholders, guided 5 Ph.D. students and published >100 research papers in refereed journals.

RECENT DEVELOPMENT FOR MANAGEMENT OF *FUSARIUM* WILT IN BANANA WITH REFERENCE TO TR-4

S. Uma and R. Thangavelu
ICAR - National Research Centre for Banana, Thayanur Post, Thogamalai Road, Trichy-620017, Tamil Nadu
E-mail: umabinit@yahoo.co.in

India is the largest producer of banana and contributing21% of global production. Fusarium wilt is one of the major constraints of banana production. but the recent invasion of the new strain tropical race 4 (TR 4) has become a major threat both at national and global fronts. The situation that *Foc* R4 is destroying the Cavendish clones and other commercial clones in the tropics has created a dent in production and exports prospects to the West. Management strategies are very important to save the banana industry.

The recent spread of Foc TR4 which was restricted to East and parts of Southeast Asia into other countries and continents including Latin America has become a major threat both at national and global fronts. Disease epidemiology is less understood leading to gaps in developing effective management models, including resistant varieties and soil management approaches. There is a critical need for better understandings of cultivar and host specificity in this pathogen. There is no satisfactory method to control *Fusarium* wilt. Chemical control, flood fallowing, crop rotation and the use of organic amendments have been advocated but with limited success.

This paper reviews the work done from various perspectives to manage the Fusarium wilt disease with specific emphasis on TR4. The effort of ICAR-NRCB on hot spot screening of banana germplasm resulted in identification of resistant or moderately resistant accessions/ varieties, more specifically among Cavendish clones with a potential to replace Grand Naine. Boosting tolerance through biopriming of disease free tissue culture plants, change in cropping patterns varietal diversification strategies, crop holidays etc are being discussed. The resistant polleniferous diploid accessions are being included in the breeding program to improve resistance in the background of many commercial varieties which are under pre evaluation. Identification of trait specific genes, application of Omics and potential of gene editing technologies are being discussed in this paper. Public sensitization, involvement and state developmental agencies in managing the disease are largely encouraged. This paper largely covers the national strategies for management of the *FoC* TR4.

Dr Jyotsna Sharma

Born on October 24, 1961, Dr. (Mrs.) Jyotsana Sharma completed under graduation from Govt. Degree College, Solan (HP), M.Sc. (Honours) in Plant Pathology from HPKVV, Palampur, Solan campus in 1984, and Ph.D. in Plant Pathology from IARI, in 1989. She joined ICAR as Scientist in June 1989 with first posting at Central Potato Research Station Jalandhar (ICAR-CPRI, Shimla). Thereafter, she joined ICAR- National Research Centre on Pomegranate at Solapur, Mahrashtra, on April 24, 2006. Dr. (Mrs.) Jyotsana Sharma is presently the Principal Scientist (Plant Pathology) and Former Director (Acting), ICAR-NRC on Pomegranate, Solapur. Dr Sharma's research contribution pertaines to production of disease free nucleus seed of potato; soil solarisation promising technology for potato production and integrated management of pomegranate bacterial blight and other diseases. She has to her credit several research publications and technical /Extension bulletins, brochures and videos for the benefit of farmers in English, Marathi, Hindi

Dr Jyotsana Sharma is the recipient of 'Dalimb Ratna Award-2016' conferred by Akhil Maharashtra Pomegranate Growers Research Association for valuable contributions in development of model for management of bacterial blight disease (Telya) plant health management systems in pomegranate. She received Narinder Nath Mohan Memorial Gold Medal for her MSc; Dr S Ramanujam Memorial Certificate of Appreciation 2003-04, by ICAR-CPRI, Shimla. She obtained patent for 'A Process for Preparing a biofertilizer cum biofungicidal composition with *Aspergillus niger* strain AN27'.sewh also Notified in 'The Gazette of India', November 29, 2003.

LATEST DEVELOPMENTS IN BACTERIAL BLIGHT AND WILT MANAGEMENT IN POMEGRANATE

Jyotsana Sharma
ICAR-National Research Centre on Pomegranate, Solapur??? , Maharashtra
E-mail: jyotisharma128@yahoo.com

ABSTRACT

More than 55 pathogens cause around 37 different diseases on pomegranate (Sharma et al., 2021), however, bacterial blight and wilt are most important in India. Bacterial blight caused by *X. axanopodis* pv. *punicae* affects above ground parts of pomegranate and fruits are most vulnerable to blight infection. Among the seedling population of more than 100 IC accessions screened, two seedlings one each of IC 318766, IC 318776 were found resistant, and many were tolerant, further work is in progress. Research on genetic mapping of bacterial blight and fruit quality traits in pomegranate is in progress. In a study on genetic diversity and association mapping, marker PGCT001 associated with both fruit weight and bacterial blight has been identified. Relation between DRIS /CND nutrient imbalance index and blight disease severity has been established.

Integrated disease, insect pest and nutrient management schedule developed and demonstrated in different states, resulted in >80-100% blight control. The latest blight management schedule using stem solarization in hottest months – is ecofriendly, economical and effective with 100% blight control even in rainy season crop. Two endophytes –TC310 and TC137- have consistently proved superior to other.

Pomegranate wilt/ decline/ dieback is prevalent in several pomegranate growing regions across the globe with crop losses ranging from 30-90%. Successful wilt management requires an integrated approach right from planting; among which pathogen-free planting material and use of organic fertilizers as well as efficient biologicals in the rhizosphere for bio-hardening are important prophylactic measures. Soil solarization in the hottest months of the region is recommended before new plantation. Application of well decomposed organic manures and beneficial microorganisms, intercropping with green manure crops-sun hemp and *Sesbania* sp. and proper disposal of wilt infected plants is very important. Application of bio-formulations *Aspergillus niger* and *Rhizophagus irregularis* along with recommended organic fertilizers have effectively checked the wilt due to *C. fimbriata* and root knot nematode *M. incognita*.

Brief Bio-data

Dr P.K. Shukla

Dr Prabhat Kumar Shukla is presently working as Principal Scientist (Plant Pathology) in the Division of Crop Protection, ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow. He was born in Etawah district of Uttar Pradesh on 05 July 1966 and got educated at 10th and 12th standard from SRV Inter College, Phaphund during 1978-1982; completed graduation and post graduation in Plant Pathology from C.S. Azad University of Agriculture & Technology, Kanpur during 1982-1989. He has worked at CSIR-CIMAP, Lucknow for Ph.D. with registration in CSSJM University, Kanpur. Dr Shukla has worked as Assistant Professor in N.D. University of Agriculture & Technology, Kumarganj, Ayodhya before joining ICAR-CISH, Lucknow as Senior Scientist. He has published 86 research papers, 21 book chapters, 2 manuals, 2 bulletins, 42 popular articles and 18 extension folders. He has also attended 78 symposia and workshops. His total citation index is 399, h-index- 11 and i-10 index, 15. He has also received several awards including Young Scientist Award of BRS, Allahabad; Pathology Ratan Award of IPS, New Delhi and Best Scientist Award of AAUEBS, Lucknow. He has also been recognized as examiner of several agriculture and traditional universities; and also contributed as reviewer of Springer, APS, SIS, etc.

RISK TO MANGO PRODUCTION FROM NEWLY EMERGING DISEASES

P.K. Shukla, Tahseen Fatima, Savita Varma, Nidhi Kumari and Gundappa Baradevanal
Division of Crop Protection, ICAR-Central Institute for Subtropical Horticulture,
Rehmankhera, Lucknow-226101, Uttar Pradesh
E-mail: Prabhat.Shukla@icar.org.in

ABSTRACT

Mango production has recently been put at risk due to the emergence of new diseases (wilt, decline, root rot, twig/branch drying, sooty blotch, and shoulder browning). Extensive investigations into the causal agents, symptoms, factors influencing disease development, disease distribution, the extent of losses, and management have been conducted and are currently in progress. During the last 5-10 years, gradual increase in the incidence of wilt/decline and twig/branch drying/ dieback diseases has been observed. Out of 15 major mango growing states surveyed, the distribution of wilt/decline and twig/branch drying disease has been recorded in 14 and 9 states, respectively. *Ceratocystis fimbriata*, which causes wilt and decline, and *Berkeleyomyces basicola*, which causes root rot, are two new pathogens that have recently been reported. It has been confirmed that the Scolytid beetle is associated with *Ceratocystis* wilt. Specific symptoms have been documented to avoid confusion in the diagnosis of emerging diseases. Excessive intercultural operations that cause root injury, flood irrigation and intercropping have all been identified as major factors contributing to the development of root rot, wilt, and decline diseases, while, an increase in the number of unseasonal rainy days during the fruiting period has been identified as a major cause of sooty blotch and shoulder browning diseases. Sooty blotch and shoulder browning are common during the fruiting season wherever there is heavy rainfall; severe cases have been reported in states such as Bihar, Himachal Pradesh, Jharkhand, Odisha, Uttar Pradesh, and others. The management practices for wilt, decline, root rot, sooty blotch and shoulder browning have already been developed however for twig drying/decline, it is yet to be standardized. Minimizing tillage to prevent root injuries, avoiding flood irrigation to contain pathogens, soil drenching with thiophanate methyl (50-150 g with 200-500 l water) to fight infection, and aerial spraying with propiconazole (0.1%) can all help to reduce the occurrence of wilt, decline, and root rot. Sooty blotch and shoulder browning can be reduced by bagging fruits or spraying with difenoconazole (0.05%). The efforts have been made to transfer the knowledge generated in relation to newly emerged diseases through research publications, extension folders, training programmes, seminars, print, electronic and social media; and agro-advisory service of the ICAR-CISH, Lucknow. Many farmers throughout the country have received a correct diagnosis and proper advice by searching the name of the expert and mobile number from the Institute Website, followed by sending photographs of diseased plants. Many farmers, however, continue to rely on the lateral expansion of technologies. The late manifestation of disease symptoms, when protection of trees becomes almost impossible, is a major constraint in the management of diseases such as wilt and decline. As a result, efforts have been initiated to develop primers for the early detection of pathogens in orchard soil to avoid severe losses. Future research should be done to refine wilt, decline, and root rot management technology by getting additional effective treatments while reducing input costs. Efforts are also being made to develop a cost-effective solution for twig drying disease.

Brief Bio-data

Dr P. Bora

Dr Popy Bora is currently working as Scientist (Plant Pathology) at Department of Plant Pathology, Assam Agricultural University, Jorhat and associated with ICAR-AICRP on Fruits. Dr Bora has made significant contribution in developing some microbial biopesticides and identification of pesticide degrading microbes. Many of the technologies are being effectively used in farmers' field and included in the package of practices of the university. Her current research interests include: screening of endophytes for developing microbial bioformulations against diseases, microbial bioremediation of contaminated soils *etc.* Dr Bora is engaged in teaching (Plant Pathology) at undergraduate and post-graduate levels. She is credited as many 59 publications. She is associated with seven academic societies as Life Member and Zonal Coordinator of East Zone, AAPMHE, IIHR-Bengaluru.

Recipient of Young Scientist Award (2018-19) from Society for Horticultural Research and Development (Uttar Pradesh, India) and Young Woman Scientist Award (2019-20) from Agricultural Education and Technology Development Society, AEDTS (Uttarakhand , India) for outstanding plant protection research by AEDTS (Uttarakhand, India). Dr Bora has coordinated two national webinars on *Recent Advances in disease and Pest Management for Sustainable Banana Industry* on July 4, 2020 and *Microbial Biopesticides: Next Generation Preparedness* on July 2, 2021 as Organising Secretary. She is currently coordinating the biopesticides research and development in entire northeast India through DBT- North East Centre for Agril. Biotechnology. She is presently handling three research projects as Principal Investigator.

MICROBES MEDIATED PLANT HEALTH CARE IN HORTICULTURAL CROPS: NEW PARADIGMS

Popy Bora
Department of Plant Pathology, Assam Agricultural University, Jorhat 785013, Assam
E-mail: pbora.sonitpur10@gmail.com

ABSTRACT

Plant diseases are the major biotic stress constantly posing threat to horticultural crops with rapid evolution in pathogenic ability and parallel increase in host range by many phytopathogens. The microbial communities coevolved with plants also offer different microbes complementing horticultural crops with disease suppression through direct antagonism, modulation of host defense response and enhancement of plant growth. Successful management of crown gall pathogen, *grobacteriu tumifaciens* through microbial intervention is a classical success story where excellent control of bacterial crown gall disease of grapevine, pome and stone fruits have been achieved worldwide by using strain of *Agrobacterium radibacter.* Various fungal antagonists such as *Chaetomium* spp., *Aureobasidium* spp and *Phoma* spp. inhibited the growth of the apple scab fungus, while other antagonists such as *Bacillus subtilis* and *Trichoderma* spp. have been so effective in controlling apple canker. Microbial antagonists are more suited for control of soil borne pathogenic genera represented by *Pythium*, *Phytophthora*, *Rhizoctonia*, *Fusarium* and *Sclerotium*, where microbial antagonists such as *Trichoderma* spp., *Gliocladium* spp., *Bacillus subtilis*, and *Pseudomonas* spp. proved their worth. Bacterial wilt, fungal wilt, damping off and root rot, anthacnose etc. are few examples of diseases of many fruits and vegetable crops successfully managed through microbial antagonists under field conditions. Successful management of the most feared Tropical Race 4 of banana *Fusarium* wilt (*F. oxysporum* f. sp. *cubense*) through *T. reesei* based biofungicide ICAR-Fusicont in recent time. Our experiences in northeast India with plant microbioota have contributed towards Organic Horticulture through development of an array of bioformulations, *viz*., Bioveer , Biofor Pf2 , Biozin PTB, Biotime , Biozium Biogreen-5 exploring different antagonists, *viz.*, *T. viride, T. harzianum, P. fluorescens* and entomopthogens *viz.*, *Metarhizium anisopliae*, *Beauveria bassiana* singly and in different combinations have been found extremely successful in managing diseases through large scale field studies in crops like citrus, banana, tea, turmeric, ginger, capsicum, tomato, chilli, lettuce and patchouli using microbial antagonists, preferably in a consortia mode.

Value-addition of microbial bioformulations through nano-technology as new normals of green biopesticides is another cutting edge research to fit into chemical-free options of plant health care.

Oral Paper

BANANA FUSARIUM WILT TROPICAL RACE 4 MANAGEMENT IN THE SUBTROPICS

T. Damodaran and *Shailendra Rajan
ICAR – Central Soil Salinity Research Institute, Regional Research Station, Lucknow
*ICAR – Central Institute for Subtropical Horticulture, Lucknow
E-mail: damhort73@gmail.com

ABSTRACT

Fusarium wilt, caused by Fusarium oxysporum f. sp. cubense Tropical Race 4 (FOC TR4), is one of the most devastating complex diseases affecting banana production globally. The pathogen is well-known for its rapid spread and devastation of plantations, resulting in significant economic loss. The epidemic outbreak in India was severe and spread quickly, affecting 12000 ha and costing 34.75 crores in Uttar Pradesh and Bihar. Controlling the disease has so far proven to be a significant challenge for researchers all over the world. The management and control of FOC TR4 is a major concern. Different research groups have attempted, with limited success, various approaches such as chemical and biological control, manipulation of cultural practises, and resistance breeding. Furthermore, chemical control measures such as corm injection and soil drenching with carbendazim fungicide failed to provide sustainable disease management. Some of the standard management strategies include the selection of resistant varieties and the identification of suitable biological control agents. Because of the disease's complexity, an integrated approach to disease management is recommended. The persistence of effective biological control is dependent on the induction of host plant tolerance via the expression of antifungal genes that regulate the suppression of fungal toxins such as Fusaric acid, Enniatin, etc. The ICAR Central Soil Salinity Research Institute, RRS, Lucknow, and the ICAR-Central Institute of Subtropical Horticulture collaborated to develop ICAR FUSICONT, a bio-fungicide based on a novel strain of Trichoderma reesei. A bio-dynamic media was used to produce biofungicide, which effectively controlled the disease in hotspot regions to an extent of about 85 to 90 percent. When the pathogen mutates as a result of the constant application, the efficacy of the bio-efficacy is severely harmed. A novel approach was used to improve the efficacy of the FUSICONT and to infuse host tolerance in tissue culture plantlets. It contained bioactive identified lipopolypeptides in the form of a BIO-IMMUNE formulation in the process of organogenesis in-vitro mass multiplication. The technology has been found to be promising in terms of producing healthy plantlets that are resistant to biotic and abiotic stress. Extensive testing of the technology in hotspot regions of Uttar Pradesh and Bihar in approximately 22000 plantlets resulted in disease control of 90 to 95 %. Furthermore, after a short period of hardening, the plantlets produced by the immunisation protocol developed robust roots. The addition of the ICAR FUSICONT technology with only two applications instead of the usual 4-5 applications and the use of bio-immunized plantlets were found to have a synergistic effect in the effective management of the disease in hotspots.

SUCCESSFUL BIO-CONTROL OF COCONUT SLUG CATERPILLAR (MACROPLECTRA NARARIA) WITH POTENTIAL PARASITOID PEDIOBIUS IMBRUES (HYMENOPTERA: EULOPHIDAE) IN ANDHRA PRADESH

Chalapathi Rao, Balusu Bhagawan, Damarasinghu Devika Rani, RVSK Reddy
Dr YSR Horticultural University, Horticultural Research Station, Ambajipeta 533 214 East Godavari, Andhra Pradesh
E-mail: chalapathirao73@gmail.com

ABSTRACT

The coconut slug caterpillar *Macroplectra nararia* Moore earlier considered as sporadic pest is off late becoming a regular pest in plantation crops in East and West Godavari district causing serious loss coconut and oil palm . Feeding by the *M. nararia* early instar caterpillars cause leaf spots and grown up caterpillars eat away entire laminar portion of the leaf leaving the mid ribs leaving a scorched / burnt appearance of leaves. Though many parasitoids were identified against *M. nararia* none were amenable for laboratory rearing .

The *Pediobius imbreus* a potential parasitoid on slug caterpillar was identified in ٢٠١٨ in West Godavari district of AP and timely release of this parasitoid gave impetus to biological control based IPM of slug caterpillar . The mass production procedure and release rates of this parasitoid were standardized for the first time and experimentation results revealed that when the pest is in early larval stage (first to third instar), the release of parasitoids @ 60 per palm at fortnight intervals on ten per cent of total palms in the garden (@ 600 number per acre) resulted in successful high parasitisation of slug caterpillar ranging from 30.33 ± 2.28 to 50.23 ± 1.87 per cent within 30 days after release. Integrating biological control with physical control *ie.*, installation of 200 Watts incandescent light traps installed @ 5 per hectare, at 1 ½ feet above the ground level and water pan kept below the light trap from 9 pm to 12.00 midnight effectively attracted the highly phototropic moths providing successful management of this pest .

SCREENING OF GENOTYPES OF MAKHANA (*EURYALE FEROX* SALISB.) AGAINST INSECT AND GASTROPOD PESTS AND YIELD POTENTIAL

Nath[1], Anil Kumar[1],Pankaj Kumar Yadav[1],Shambhu Nath[1], Rajesh Kumar, V. B. Patel[3]
Bihar Agricultural University, Sabour -BPS Agricultural College, Purnea-854302, Bihar
[2]Bihar Agricultural University Sabour-813210, Bhagalpur
[3]ICAR-Indian Agricultural Research Institute, New Delhi
E-mail: parasbpsac@gmail.com

ABSTRACT

Makhana is grown world wide as an aquatic fruit crop. In India, it is cultivated in an area of 20,000 ha, out of which 80% area is in Bihar. The average production and productivity of makhana crop in Bihar is 3,18,750 q and 21.25 q/ha, respectively. At present, 40-45 % of makhana crop is cultivated in field condition, due to the increase in area of makhana crop in field condition, the insect and gastropod pests are now emerging as major constraints in getting maximum production and productivity from existing traditional land races of the makhana crops. The present investigations on evaluation of promising genotypes of makhana against insect and gastropod pest as well as for maximum yield were done at BPSAC, Purnea farm during the crop season 2014 and 2015 for selecting genotypes having field resistance and maximum yield potential. A total of 7 genotypes including one variety, *Swarna vaidehi* were tested in Random block design with four replications at a plot size of 1000 Sq.m each. The crop was maintained as per the makhana production technology except for plant protection measures. The data revealed that the significantly lowest infestation of insect pest viz. *E. depunctalis* (1.17/leaf), *E. Crisonalis* (1.98/leaf), *Chironomous* Spp.(2.21/leaf), *R. nymphaeae* (9.51/10 leaves) with highest yield (33.38 q/ha) was found in accession No. BR Makh-07 compared to other genotypes including released variety, *Swarna vaidehi*. Further, the mediocre genotypes having low incidence of insect pest and higher yield (30.44 q/ha) was found in BR-Makh-09 compared to release variety *Swarna vaidehi*. No significant difference was observed in gastropod pest (7.56-8.0/leaf) across the genotypes and the released variety. It concluded that BR-Makh-07 with highest yield and lowest incidence of important insect pest was found promising genotypes and it was released as Sabour Makhana-1 (IC 620551) by CVRC in Gazette of Government of India vide notification No. 3841 dated 26-11-2019.

CASHEW PROTECT: AN ARTIFICIAL INTELLIGENCE (AI) BASED WEBSITE AND APP FOR IDENTIFICATION OF PESTS, DISEASES AND NUTRIENT DEFICIENCIES IN CASHEW

GS, Vanitha K, Rajashekara H, Shamsudheen M
ICAR- Directorate of Cashew Research, Puttur - 574 202, Dakshina Kannada, Karnataka
E-mail: mohangs2007@gmail.com

ABSTRACT

Cashew farmers often need expert advice for proper management of pests and diseases in addition to nutrient deficiencies. However, due to remote nature of villages and farms, advice is not easily available when it is most required. Recent advances in mobile technologies can help to a greater extent in this connection. Apps and websites based on technologies such as artificial intelligence, visual recognition and deep learning are being developed worldwide for identification of plants/animals/insects including pests/diseases/nutrient deficiencies. These tools have been found very useful and are regularly used by farmers in different parts of the world.

ICAR- Directorate of Cashew Research has developed the Cashew Protect website and app for identification of pests and diseases of cashew along with nutrient deficiencies. This can diagnose about 60 pests, 20 diseases and 10 nutrient deficiencies instantly from the uploaded images. Artificial Intelligence (AI) and computer vision based techniques are deployed in this website/app. This is available in 10 languages i.e. English, Hindi, Kannada, Gujarathi, Marathi, Malayalam, Tamil, Telugu, Bengali, Odiya. The website/app is constantly being trained with additional data and gets more accurate with time.

Most interestingly, it is possible to capture data via users on number and type of pests, diseases and nutrient deficiencies observed in different country/region/district/taluks during different time periods. This will eventually help in early forecasting of these problems and alert farmers in time. Further, it also helps to channelize efforts and inputs required for management by the concerned agencies in an area/region of the country.

Oral Paper

SCREENING AND VALIDATION FOR TOMATO LEAF CURL NEW DELHI VIRUS (TOLCNDV) RESISTANCE IN BITTER GOURD (*MOMORDICA CHARANTIA* L.) GERMPLASM

G. S. Jat, T. K. Behera, Amalendu Ghosh*, A. D. Munshi, J. K. Ranjan, Sachin Kumar and B. S. Tomar

Division of Vegetable Science, ICAR-IARI, New Delhi

*Division of Plant Pathology, ICAR-IARI, New Delhi

E-mail: singhgograj@gmail.com

ABSTRACT

Tomato Leaf Curl New Delhi Virus (ToLCNDV), a monopartite begomovirus transmitted by the whitefly *Bemisia tabaci*, has emerged as a major deterrent in bitter gourd production during *kharif* under North Indian plains. Resistance breeding program relies on identification of stable resistant sources free from disease under field followed by artificial screening for further confirmation of their resistance level. In the present study, identification of resistance source against ToLCNDV under field and glass house condition was carried out, wherein a total of 106 bitter gourd germplasm were evaluated during 2018-19, 2019-20 and 2020-21 *kharif* season in a randomized block design with three replications each. Field evaluation was carried out using 0-4 disease rating scale. Of the 106 bitter gourd germplasm, four germplasm lines (DBGS-2, Andhra Collection, DBGS74 and EC795797) and a wild relative, *Momordica balsamina* showed highly resistant (HR) reaction against ToLCNDV during both the crop seasons. While three germplasm EC795800, EC796546 and NEH-4 showed moderately resistant reaction against ToLCNDV under field condition. The genotypes Pusa Purvi, Pusa Vishesh, DBGS-52 and PVGy-201 showed highly susceptible (HS) reaction under field condition. In glass house evaluation of 4 selected resistant and 4 susceptible germplasm lines using pure culture of ToLCNDV, DBGS-2 showed resistant reaction where as Andhra Collection and DBGS74 showed MR reaction while, the rest of the genotypes showed HS reaction against ToLCNDV. The resistant and susceptibility of the genotypes were confirmed using ToLCNDV and common begomovirus primers. The resistant genotype, DBGS-2 and moderately resistant genotypes (Andhra Collection and DBGS74) could be utilised to develop mapping population to map the genomic regions conferring the resistance to ToLCNDV in bitter gourd and also to develop the resistant varieties/lines with desirable fruit quality traits under North Indian plains.

GENETIC AND TRANSCRIPTOME-BASED STUDY FOR IMPROVEMENT OF OKRA (*ABELMOSCHUS ESCULENTUS* L.) AGAINST BHINDI YELLOW VEIN MOSAIC VIRUS (BYVMV)

R. K. Yadav*, Puneeth P. V, Suman Lata, B. S. Tomar and Anjan Das
Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi-110012.
*E-mail-rkyadavneh@gmail.com

Okra (*Abelmoschus esculentus* L.) is an orphan crop where very limited genetic and genomic studies are reported. The genetic analysis of allelic polymorphism and population structure analysis of okra germplasm is crucial for its genetic enhancement. We have analyzed the molecular variation of a set of 96 okra genotypes using 65 pairs of simple sequence repeats (SSR) markers. Among them 50 primers were found to be polymorphic with mean polymorphic information content (PIC) of 0.38. The maximum PIC value obtained was 0.71 and number of alleles per locus varied from 2 to 7 with a mean of 3.34 alleles per locus. We also used a novel promoter-targeted marker, CAAT box-derived polymorphism (CBDP) and Start codon targeted (SCoT) polymorphisms based on the short conserved region in plant genes surrounding the ATG translation start (or initiation) codon in a set of eighty-nine cultivars of okra. Polymorphic information content (PIC) for CBDP and SCOT primers ranged from 0.11 to 0.49 and 0.13–0.29 with marker index (MI) ranging from 1.5 to 165.8 and 1.3 to 58.6 respectively. CBDP markers were shown to be more useful in analysing genetic variation among okra throughout this study.

Bhindi yellow vein mosaic disease (BYVMD) caused by Bhindi yellow vein mosaic virus (BYVMV) of genus Begomovirus possess a serious threat to okra cultivation. To identify genes/transcripts and markers related to BYVMD in okra we have performed comparative transcriptome sequencing of two okra varieties i.e. Pusa Bhindi-5 (BYVMV resistance) and Pusa Sawani (BYVMV susceptible). *de novo* transcriptome assembly was generated for control and infected samples of Pusa Bhindi-5 and Pusa Sawani. A total of 8710 unique differentially expressed genes (DEGs) were obtained from the four comparison sets of resistance and susceptible. Based on the *de novo* assembled transcripts, a total of 1,06,224 putative SSRs were identified along with variants like SNPs and InDels in two contrasting varieties i.e. resistant and susceptible. SSR markers and transcripts generated from the differential transcriptome data will be used to identify the markers and putative candidate genes/transcripts for BYVMD in okra.

BIO-EFFICACY OF GRANULAR INSECTICIDES AGAINST WHITE GRUB (HOLOTRICHIA SPP.) IN TULIP (*TULIPA GESNERIANA* L.) UNDER TEMPERATE CONDITION OF KASHMIR

Abu Manzar, Jamal Ahmad, Imtiyaz T Nazki, Abu Manzar
Sher-e-Kashmir University of Agricultural Sciences and Technology -Kashmir, Shalimar Campus, Srinagar -190025, Jammu and Kashmir
E-mail: abumanzar@rediffmail.com

ABSTRACT

Field efficacy of four different insecticides were evaluated against the grubs of *Holotrichia* spp. in tulip (*Tulipa gesneriana* L) at Urban Technology Park, Habak, Sher-e- Kashmir University of Agril. Sci. and Tech.- Kashmir, Srinagar (Jammu and Kashmir) during 2018-19 and 2020-21. The required amount of insecticides was applied in furrows by incorporating with pulverized soil before sowing of the tulip bulbs. Experimental results indicated that all the insecticidal treatments were significantly superior in respect of *per cent* reduction of bulb damage in both weight and number basis as well as reducing the number of grubs per square meter over the untreated control. However, the plots treated with Imidacloprid + Fipronil 80% WDG @ 300 g a.i./ha recorded lowest *per cent* of tuber damage (6.64 and 4.78 % both in weight and number basis) as well as least number of grubs (0.96 per square meter) resulting in a marked increase in bulb yield of 220.78kg/500m . On the other hand, untreated control recorded lowest bulb yield (125.50kg/500m^2) with a very high levels of infestation (73.74% and 67.43% based on weight and number, respectively) of bulb caused by the grubs of *Holotrichia* spp. The economics of various treatments revealed that the height net gain was procured in Imidacloprid + Fipronil 80 % WDG @ 300 g a.i./ha that registered maximum B.C. ratio (1.57) followed by Imidacloprid 70 % WG @ 300 g a.i./ha (1.42). On the basis of efficacy of various treatments and net gain Imidacloprid + Fipronil 80 % WDG @ 300 g a.i./ha was considered superior for effective and economical management of white grub in tulip crop.

PREFERENCE OF FRUIT FLIES, BACTROCERA SPP. IN RELATION TO SIZE AND RIPENESS OF INTACT AND FALLEN MANGO FRUITS

Chandrasekaran M
Horticultural College and Research Institute for Women, Tamil Nadu Agricultural University
E-mail: chantrue2020@gmail.com

ABSTRACT

The productivity of the mango fruit is mainly determined by the fruit flies, *Bactrocera* spp. and found to be the major devastating insect pest that causes extensive damage. Fruit flies cause direct damage to fruit by oviposition punctures followed with the feeding of maggots. The greatest threat influenced by the fruit flies is the rejection of harvested fruits in markets and exporters especially in case of mango due to the presence of maggots, it leads fruit becoming unfit for marketing and consumption. To overcome this problem basic knowledge on the scientific reasons behind the preference towards the mango fruits exerted by the fruit flies to be ascertained. The ovipositional preference of the fruit flies may vary depends upon the fruit phenology *viz.,* size, ripeness, odor and thickness of pericarp etc., Thus, the present investigation on preference of fruit flies in relation to fruit size and ripeness in mango was carried out by sampling and assessment of maggot population, pupal percentage, adult emergence and sex ratio in intact and fallen fruits. The diversity of species registered in mango ecosystem is *viz., Bactrocera dorsalis* (Hendel) *B. caryeae* (Kapoor), and *B. correcta* (Bezzi). The prevalence of *B.correcta* both in rumani and PKM 1 varieties is comparatively less when compared with the *B.dorsalis* and *B. caryeae*. The overall sampling study revealed that the maggot population was more in large sized fruits *i.e.,* 50 – 60 per fruit in fallen condition and 20 – 40 in intact fruits and the adult emergence was also more in the large sized fruits (> 60%) when compared with the small and medium sized fruits. Comparing the intact and fallen fruits, the fallen fruit shows the higher population (40 - 45/fruit) and intact fruits shown comparatively less population (20 - 22/fruit). The infestation of *B.dorsalis* was higher than the *B. caryeae* and *B. correcta* in mango ecosystem. The sex ratio recorded shows the male population is more in *B.dorsalis* whereas the male and female seems to be present in equal ratio in case of *B. caryeae.*

SEASONAL INCIDENCE OF LEAF MITE, *PANONYCHUS CITRI* M. ON CITRUS, *CITRUS AURANTIFOLIA C*.

Soundararajan R P, Chandrasekaran M, Jegadeeswari V, Paramaguru P
Horticultural College and Research Institute for Women (TNAU), Navalur Kuttapattu, Trichy - 620 027, Tamil Nadu
E-mail: soundarrajan.rp@tnau.ac.in

ABSTRACT

Citrus mite, *Panonychus citri* (McGregor) (Acari: Tetranychidae) is an important non-insect pest has a worldwide distribution on citrus species. The nymphs and adults feeds on leaves and fruit, occasionally on green twigs, causing a bronzing or silvering effect. Severe infestations may cause a partial defoliation of trees which leads to considerable yield losses. *The mite species has* strong reproductive ability, can infest the whole plant in a short time from one infested leaf, depending on their dispersal behavior which often leads to the population outbreak. The data on level of incidence at different seasons will provide a base for developing pest management strategies in citrus. Field experiment was laid out at Horticultural College farm, Trichy, India (GPS co-ordinates: 10Â°45'N; 78Â°36'E) during 2019-20. The citrus plants are five years old and maintained unprotected without any chemicals during the period of study. Seasonal incidence of leaf mite was recorded in 10 plants and randomly in 10 leaves of each plant at fortnightly interval and mean was worked out. The number of mites present in lower as well as upper surface was recorded. The population was recorded from August first fortnight to March second fortnight. The population ranged from 5 to 59 no./ 10 leaves in the upper surface. The maximum incidence was recorded during March II fortnight. At lower surface the population was ranged from 0.5 to 13.10 nos./ 10 leaves. The incidence was slowly build from December month and peaked during summer. Mostly leaf mites were observed in lower surface but in upper surface also few mites were noticed. Correlation studies were made with major weather parameters and the mite incidence.

EVALUATION OF IPM MODULES FOR MANAGEMENT OF FRUIT FLY IN BITTER GOURD

Arundhati Sasmal, C M Khanda
RRTTS (Coastal Zone), OUAT Bhubaneswar, Odisha
E-mail: sasmalarundhati@gmail.com

ABSTRACT

<p>Evaluation of IPM modules for management of fruit fly in bitter gourd</p><p>Arundhati Sasmal, C M Khanda and P K Sarangi </p><p>RRTTS, CZ, Bhubaneswar</p><p>Odisha University of Agriculture and Technology </p><p> </p><p>Bitter gourd (Momordica charantia) is one important cucurbitaceous vegetable crop. Fruit fly is a quarantine pest and is considered as the major insect-pest of bitter gourd causes up to 80% yield loss. The adult fly lays eggs in the fruit and the maggots, make tunnel inside the fruit, induces secondary infection and causes fruit rotting.</p><p>One field experiment was conducted at Regional Research and Technology Transfer Station, Coastal Zone, Bhubaneswar, OUAT during Rabi, 2019-20 and Rabi, 2020-21 to evaluate different IPM modules for management of fruit flies in bitter gourd. The experiment constituted six IPM modules, replicated four times in RBD and hybrid; BG 55 was the test variety.</p><p>The results revealed that, IPM module constituting ‘Soil application of carbofuran 3G @30kg/ha; para pheromone trap with Cue-lure @10 traps/ha; alternate spray of diafenthiuron 50WP @600g/ ha and neem oil (1500ppm) @1.5 l/ ha at 15 days interval’ resulted highest reduction in fruit damage (85.8%) and yield improvement (74.8%) over untreated control with maximum incremental net profit (Rs 1,10,320/-). The granular insecticide carbofuran restricted the pupation in the soil; neem oil could reduce the oviposition; Cue-lure attracted and killed the male fruit flies and diafenthiuron, applied as a cover spray could reduce the fruit fly damage. This IPM module can be advocated for management of fruit fly in bittergourd.</p><p>E-mail: sasmalarundhati@gmail.com</p><p> </p>

IDENTIFICATION OF HOST-PLANT RESISTANCE AND GENETICS OF FUSARIUM WILT (*FW)* GENE IN WILD PEA (*PISUM SATIVUM* SSP. *ELATIUS*)

Brij Bihari Sharma[1]*, Gowthami, Shri Dhar[1], B.S. Tomar[1], Gyan Prakash Mishra[2], and Malkhan Singh Gurjar[3]

[1]Division of Vegetable Science, IARI, New Delhi, [2]Division of Genetics, IARI, New Delhi
[3]Division of Plant Pathology, IARI, New Delhi-110012
E-mail: brij9851@gmail.com

ABSTRACT

Garden pea (*Pisum sativum* var. *hortense*) is an important legume vegetable grown predominantly during *Rabi* with limited hills during summer and *Kharif* crop in India. It is highly nutritive and rich in protein (7.2 g) and also used as in soup, canned frozen or dehydration. In India, garden pea is producing in approximately 5.63 million hectares with 5.70 million tons of annual production and 10.12 tones/ ha of productivity (NHB, 2019-20). The crop is normally sown in the field during mid-October to November in northern plains of the country, however, earliest sown crop fetches more profit but at the risks of *Fusarium* wilt. Fusarium wilt of peas is a devastating disease that has appeared in all pea growing regions in the India as world over caused by *Fusarium oxysporum* fsp. *pisi* (*Fop*). *Fusarium oxysporum* can survive in field soil as thick-walled spores for more than 10 yr.

This study was carried out at research farm of Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi during 2019-2020 and 2020-21 with the major objectives to study the host plant resistance against *Fusarium* wilt in *Pisum* species, regarding this 50 genotypes (36 genotypes of *Pisum sativum* var. *hortense*, 10 genotypes of *Pisum sativum* ssp. *elatius*, 4 genotypes of *Pisum fulvum*) were screened in artificially created wilt sick pots under natural conditions. Among the 36 genotypes of *Pisum sativum* var. *hortense* 5 genotypes namely G-2, G-12, G-15, G-17 and G-27 were recorded as resistant to *Fusarium* wilt, two genotypes *Pisum fulvum* G-46, G-49 were showed good resistance and G-37, G-38, G-39, G-40, G-41, G-43, G-44, G-45 of *Pisum sativum* ssp. *elatius* were also noted as resistant to *Fusarium* wilt.

Genetics of *Fusarium* wilt resistance in *Pisum sativum* ssp. *elatius* 'N-8' using F_2 (VRP-6 × N-8) and its derived BC_1 population and disease reaction data were analysed using chi square test. In backcross population thirty-four plants that are screened as susceptible to the wilt disease are phenotypically expressed complete wilt symptoms, the forty resistant plants showed light symptoms like yellowing of basal older leaves due to resistant mechanism in the plants, these are segregated in 1:1 expected ratio. In F_2 population 36 plants were exhibited full symptoms of fusarium wilt, the remaining 124 plants are screened as resistant. Due to resistant mechanism, these plants expressed less symptoms of wilt disease with normal growth and development. These F_2 population for disease resistance segregated in 3:1 expected ratio. Single dominant gene (*Fw*) governing resistance against *Fusarium oxysporum* f. sp. *pisi* in wild pea N-8 is found against fop-1. This study reports new sources of resistance in garden pea including its wild species and a single dominant gene (*Fw*) was also reported in wild pea (*Pisum sativum ssp. elatius* 'N-8'). This will pave the new horizons to transfer *Fw* gene from wild pea to susceptible varieties of early garden pea.

IDENTIFICATION OF NOVEL SOURCE FOR FUSARIUM WILT RESISTANCE IN BRINJAL AND GENETIC ANALYSIS OF RESISTANCE

Partha Saha, Bhoopal Singh Tomar, Chandrika Ghoshal, YA Lyngdoh, Anilabha Das Munshi, Shanmugam V
ICAR-Indian Agricultural Research Institute New Delhi 110012
E-mail: partha.saha@icar.gov.in

ABSTRACT

Brinjal is one of the most popular warm season vegetable crops in India. Fusarium wilt, a soil borne fungal disease has become a major threat for brinjal cultivation causing complete defoliation and death of the plants. The identification of resistance source and development of resistant varieties is the most priority area to overcome this problem. The present study was carried out at Division of Vegetable Science, ICAR-IARI, New Delhi to identify novel source of resistance and to study the genetics of resistance. A total of 75 brinjal lines including cultivated varieties, landraces, advanced breeding lines and wild species were screened in sick plot for three years. Among these, DBR-160-2-3-1-3, DBR-40-7-10-5, *S. sysimbrifolium* (EC-390352), *S. macrocarpon* (874750022 and EC790354) and *S. torvum* were found highly resistant. The lines Pusa Hara Baingan 1, Pusa Uttam, DBL-186, DBL-129-5 were found highly susceptible. The identified resistant and susceptible lines were genotypes by previously identified SCAR markers. The markers could not validate all the resistant lines showing specific resistant loci. A total of 210 F2 plants derived from cross of Pusa Uttam and DBR-160-2-3-1-3 were phenotyped and the plants segregated in 3: 1 (164 R: 46 S) Mendelian ratio with $\chi 2$ value of 1.073 (P=0.03) suggesting role of single dominant gene governing resistance. The finding was also confirmed by the result of backcross population. This study will be very useful to transfer resistant gene into susceptible variety through marker assisted backcross breeding.

EFFECT OF *TRICHODERMA SPP*. ON GROWTH PROMOTION YIELD AND STORABILITY OF ONION

Ram Dutta, Vishal Gurav, MN Sharath, Ram Bomble, Satwant Patel and Major Singh
ICAR-Directorate of Onion and Garlic Research, Pune-410505
E-mail:rdutta.icar@gmail.com

ABSTRACT

Onion (*Allium cepa L.*) is an important vegetable crop in India and globally, due to its diverse culinary and health properties. It can be cultivated in three seasons i.e., *kharif,* late *kharif* and *rabi* seasons. *Rabi* season onions could be stored for six months to achieve availability of onion to consumers however, storage losses occur to the tune of 40-70% depending upon the storage conditions and varieties. Trichoderma has properties of colonizing roots, additionally it can attack, parasitize and gain nutrition from other fungi. In order to evaluate the effect of 6 *Trichoderma* spp. for growth promotion, yield and manage diseases, an experiment was initiated at ICAR-DOGR experimental field during *rabi* 2020-21. Bhima Shakti variety, which is recommended for *late kharif* and *rabi* was selected which also has good storability. Observations revealed that all Trichoderma species enhanced the growth of onion, yield and storability. All 6 species/isolates performed well in enhancing the growth of onion plants as well as bulb yield. Forth leaf diameter was increased from 18-22%, length from 22-24%. Number of leaves per plant were increased from 18-20%, plant height from 21-23%, pseudostem diameter from 31-34%, pseudostem length from 21-24% over control. Bulb yield being key factor was also enhanced ranging from 17 to 28% over control. The maximum yield of 33.82 t/ha was received from Trichoderma T-354, being minimum (26.36 t/ha) from control. Further, the produce from this experiment was stored at normal storage condition after curing. The observations revealed that the produce from Trichoderma T-354 had comparatively lesser loss *i.e.* 36% as compared to control (46% losses) in the preliminary studies. It was attributed that Trichoderma T-354 was promising for onion crop to be used in Modules for growth promotion, enhancing yield and management of fungal diseases.

MORPHO-ANATOMICAL AND BIOCHEMICAL ASSAY OF ONION CULTIVARS IN RELATION TO THRIPS TABACI LINDEMAN INFESTATION

Rabiya Basri and M Shafiq Ansari
ITM University, Gwalior
E-mail:rbsiddique21@gmail.com

ABSTRACT

Onion thrips, *Thrips tabaci* is a key pest of onion crop worldwide. It is also a potential vector of Iris yellow spot virus reported to cause heavy losses in onion yield. Aim of study was to assess the morpho-anatomical and biochemical attributes of four onion cultivars as resistance against *T. tabaci*. Results revealed highly significant difference in the *T. tabaci* incidence on onion cultivars (P= <.0001). Highest population was observed on OW followed by PRD, NR-53 and least on OG. The larval stage of onion thrips found to be abundant in the collar region due to its cryptic habit. The wider central angle helps the cultivar to show resistance towards onion thrips infestation. Results revealed that wider angle between the central leaves of onion plant negatively correlated with the thrips population. Number and size of stomata, cuticle thickness, cell wall thickness, and surface wax were studied with the help of SEM as morpho-anatomical characteristics of cultivars. Moreover, quantitative and qualitative analysis were also carried out to estimate epicuticular wax and other biochemical components through GC-MS. Dense and sharp crystals of epicuticular wax were found to positively affecting the colonization of onion thrips. Whereas blunt crystals and no crystals were supported the establishment of thrips population up to an extent. Studied parameters are playing an important role in influencing the resistance of onion cultivars against *T. tabaci.* Introducing these traits in the onion cultivars through plant breeding would definitely add value to pest management from the perspective of sustainable agriculture.

Day 2, November 19, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session III

GENETIC ENHANCEMENT AND NEXT GENERATION BREEDING STRATEGIES

Chairman : Dr C. Kole

Co-chair : Dr T.K. Behera

Brief Bio-data

Dr Nagendra Kumar Singh

Dr Nagendra Kumar Singh is presently the National Professor (Dr. B.P.Pal Chair) under ICAR at National Institute for Plant Biotechnology, IARI, New Delhi, where he aslo served as Director & Principal Scientist (Plant Biotechnology). Born on October 15, 1958 at the village Rajapur, Mau district of Uttar Pradesh. Dr Singh did his B.Sc.(Ag.) 1978 and M.Sc. (Ag.) in Genetics and Plant Breeding in 1980 from Instt. of Agril. Sciences, BHU, Varanasi with Gold medals. He did his Ph.D. from a University of Adelaide in 1985 and received the Dr K.P. Barley Prize best post graduate student prize.

He started his career at University of Adelaide, Australia and later joined GBPUA&T, Pantnagar in the Deptt. of Plant Biotechnology. His areas of research are Plant genomics, Gene discovery, marker development and Molecular Plant Breeding. He is working on different aspects of structural, functional and comparative genomics with special emphasis on rice, wheat, pigeonpea, tomato and mango. His group has successfully completed the sequencing rice chromosome No. 11, tomato chromosome No. 5 and complete genome of pigeon pea. He has mapped genes for yield and quality traits in rice, wheat and pigeon pea. He is also working on high resolution mapping of salinity tolerance and grain characteristics in rice and development of high density reference map in pigeon pea.

Dr Singh has over 300 research publications in high impact journals with high citations and has handled several national and international external funded projects individually and in consortia mode. Besides he has guided over 20 PG students for their degrees and played a major role creating human resource in high-end areas of genomics and molecular breeding.

He has received several awards and recognitions for his contributions, which also include ICAR-Norman Borlaug Award (2015), Dr K. Ramiah Memorial Award (2014) of NAAS; Dr. Rafi Ahmad Kidwai Award (2007) of ICAR; National Bioscience Award for Career Development 2002 of DBT; National Research Fellowship-Queen Elizabeth II Award 1988 of the Department of Employment Education and Training, Govt. of Australia and and CSIRO Postdoctoral Award, Australia 1986; Commonwealth Scientific and Industrial Organization, Australia; INSA (2010) and NAAS Fellowship in 2007.

GENE DISCOVERY AND ITS APPLICATION IN GENOMICS-ASSISTED BREEDING IN HORTICULTURAL CROPS

Nagendra Kumar Singh
ICAR-National Institute for Plant Biotechnology, New Delhi 110012, India
Email: nksingh4@gmail.com

ABSTRACT

During the last two decades the genome sequencing technology as advanced leaps and bounce thus lowering the cost of genome sequencing by more than hundred times. Rice was the first domesticated plant to be fully sequenced with a gold standard reference quality genome published in the year 2005 describing 37,544 genes with the help of *in silico* gene prediction software. Tomato (*Solanum lycopersicum*) is a major vegetable crop and a model system for fruit development with reference genome published in 2012. Several other fruit and vegetable plants have been decoded including apple, citrus, banana, cocoa, potato, cucumber, spinach have been sequenced.

The genome size of mango (*Mangifera indica* L.) estimated by flow cytometry is 402±10 Mbp ($2n$ = 40). The global efforts for sequencing of mango genome and transcriptome studies for the analysis of trait-related differential gene expression. High heterozygosity of about 2.5% made it difficult to assemble the genome of mango using Illumina short sequence reads of 100-150 bp because it did not permit the assembly of its maternal and paternal genomes into an integrated mosaic genome assembly. The problem was overcome by using PacBio SMRT long sequence reads for genome assembly using long overlaps of 500 bp and high mismatch of 15% to take care of the heterozygosity, resulting in the first draft genome assembly of 323 Mb of mango variety ‘Amrapali’ (NCBI Acc. No. LMWC00000000 v.1). The draft genome assembly was updated to a reference quality assembly of 403 Mbp with 4312 scaffolds anchored to 20 chromosome pseudomolecules (LMWC01000000 v.2). The latest v.3 Amrapali assembly, assisted by BioNano optical fingerprinting and HiC conformation capture sequencing, has 2314 scaffolds with a high N50 value of 11.78 Mpb. Mapping sequence reads from18 different transcriptome studies showed average 96% coverage of the gene space, and BUSCO analysis of 1440 genes showed 93.4% coverage of the conserved eukaryote orthologs. A total 46,395 protein-coding genes have been predicted showing maximum homology with *Citrus sinensis*. The Amrapali genome has 45% repeats and large segmental duplications, indicating at least one recent (15.87-31.74 Mya) and one ancient (253.96-269.84 Mya) whole genome duplication. Recently, two more mosaic genome assemblies of mango varieties ‘Hong Jian Ha’ and ‘Alphonso’ have been reported. The reference genome will help accelerate breeding of dwarf, stress tolerant and high-quality mango varieties. We have developed fully bin separated genome assemblies of maternal ‘Dashehari’ and paternal ‘Neelam’ haplotypes revealing substantial gain in the total mummer of genes in their hybrid Amrapali. This provides a novel insight in the theory of heterosis and inbreeding depression in plants. Further we developed a high-density 80K SNP genotyping chip has of mango and produced high-density DNA fingerprints of 384 varieties of mango revealing their origin and identified genomic regions associated with fruit acidity, TSS, polyembryony, fruit size, pulp percentage and alternate bearing in mango. This will lead to gene discovery and molecular breeding for improvement of these traits.

Brief Bio-data

Dr C.S. Prakash

Dr. Channa S. Prakash, Dean of the College of Arts and Sciences (CAS) at Tuskegee University (USA) where he has served on faculty since 1989, is professor of crop genetics, biotechnology. Dr. Prakash's research expertise is on genetic improvement research on food crops of importance to developing countries. His lab was among the first to develop transgenic sweet potato and peanut plants and conduct pioneering genomic studies on the peanut.

Dr Prakash has been a global leader in enhancing the societal awareness of crop and food biotechnology issues around the world for nearly three decades. Dr. Prakash was recognized for his outstanding work on agricultural biotechnology outeach with the award of the prestigious 2015 Borlaug CAST Communication Award, by the Council of Agricultural Science and Technology which credited him as "*arguably done more than anyone else in academia or industry to promote agricultural technologies that can help feed the world's growing population*." He was also recognized by *Huffington Post* as among the Top 30 social influencers in biopharma and biotech. He has an active presence in the social media, impacting close to 2 million readers per month on Twitter (@agbioworld) and is globally ranked as number #1 influencer on 'agricultural biotechnology' issues. He also serves as Co-Editor-in-chief of a highly respected journal *GM Crops* & Food. In 2006, he was named one of the 'Top Personalities Who have made the Most Significant Contribution to Biotech' by *Nature Biotechnology*: Who's who in biotech - Some of biotech's most remarkable and influential personalities from the past 10 years. In 2005, he was named one of the 100 Top Living Contributors to Biotechnology by *The Scientist* (chosen by peers *via* polling).

GENETIC MANIPULATION USING GENE EDITING TECHNIQUES AND THEIR ROLE IN PRECISION BREEDING OF HORTICULTURAL CROPS IN INDIA

Channa S. Prakash
Dean, College of Arts & Sciences, Tuskegee University, USA
E-mail: cprakash@tuskegee.edu

ABSTRACT

Gene editing technology holds considerable potential in advancing the sustainable farming of horticultural crops in India. CRISPR is among the most promising of such gene editing tools, which can be employed to develop nutritionally-rich crops with reduced toxins, enhanced tolerance to diseases and pests, and increased climate resilience. Gene editing is especially relevant to those horticultural crops with long generation cycles which are vegetively propagated. Unlike genetically modified crops, gene-edited crops do not entail a transfer of foreign genes and thus carry a low regulatory footprint, and hopefully, greater public acceptance. Nevertheless, for India to benefit from gene editing tech in horticulture, the regulation of field testing and approval of such crops must be streamlined. Policymaker engagement and public education are critical for fostering this tech in India. Here, we can draw from our experience dealing with GMO controversy for the past three decades and ensure that we do not make some of the same mistakes as with GM crops. The Indian scientific community, especially in the public sector such as agricultural universities and ICAR, must proactively engage the stakeholders and be very transparent in addressing their concerns about the new technology. It is vital that the science community interacts with the media, consumers, and policymakers and share this technology's benefits and safety aspects. The Indian scientific community must also make creative use of innovative information and communications technology tools, primarily social media, to enhance greater societal understanding and acceptance of novel crop varieties developed through new breeding techniques.

Brief Bio-data

Dr Ajit Kumar Shasany

Dr Ajit Kumar Shasany is presently the Director, ICAR-National Instiute for Plant Biotechnology, New Delhi. Earlier, he served as Chief Scientist, Biotechnology Division, Head, Plant Biotechnology Department and International Scientific Collaboration, Convener, IORA-RCSTT Coordination Centre on Medicinal Plants, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow. His research interest includes, plant diversity, metabolic engineering in medicinal and aromatic plants and bioprospection for human health. Isolation of novel genes for phenylpropanoid, terpenoid pathways for aroma. His group submitted the Complete genome and transcriptome sequencing of “Holy basil” *Ocimum sanctum.* Being a graduate in Agriculture, he is vividly engaged in dissemination of technology to farmers for income enhancement and livelihood upliftment though scientific cultivation of mint (Uttar Pradesh), geranium Uttarakhand), artemisia (Uttar Pradesh), and other aromatic plant technology (Odisha). He could help in establishing 22 clusters of Aromatic Plants in 16 districts of Odisha under “Aroma Mission” and trained several start-up Entrepreneurs.

Dr Shasney has about 132 (International: 91) publications in high impact journals; has been granted 109 patents, varieties developed: 45. He has guided 14 Ph.D. students and was involved in 30 external projects of which he was PI in 16 projects.

Dr Sashany is Fellow of NASI, Allahabad and NAAS, New Delhi. Besides he is the recipient of Samanta Chandra Sekhara Award 2012, Odisha Bigyan Academy, CSIR Technology prize for Biological Sciences and Technology (1999) for development of early maturing disease and pest resistant menthol mint, CSIR-Technology Awards 2012 in Biological Sciences, Development and commercialization of anti-malarial drug plant *Artemisia annua* technology package, CSIR Technology Award 2018 (Certificate of Merit) in Biological sciences on *Ocimum*, CSIR Young Scientist Award in Biological Sciences (2000) for mint research, Prof. Umakant Sinha Memorial award (Indian Science Congress Association) 2003, Som Award for developing high yielding *Mentha arvensis*, Kosi by Essential oil Association of India-(2005). DBT Associateship and Visiting Scholar to Purdue University, USA, IARI Merit Medal for Outstanding Academic performance.

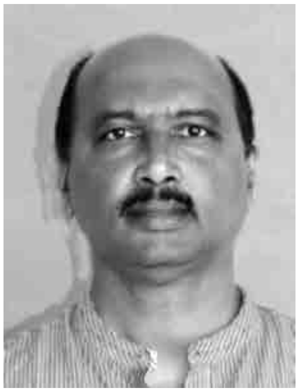
AROMA BIOLOGY AND LIVELIHOOD SECURITY

Ajit Kumar Shasany
ICAR-National Institute of Plant Biotechnology, Pusa campus, New Delhi 110 012
E-mail: akshasany@yahoo.com

There is a huge demand for essential oil-based plants in the world market. Policymakers and researchers are constantly involved in encouraging the value addition of essential oil to get higher economic returns. Several approaches like conventional breeding and metabolic engineering are taken forward by the breeders and researchersfor increasing the concentration of essential oils in plants. In this regard, CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP) has been actively involved in spreading the cultivation of high herb and essential oil yielding improved genotype of holy basil, mentha, patchouli, rose scented geranium etc. Besides, the institute has sequenced a whole genome of holy basil that has opened an avenue for prospecting the genes of terpene synthases responsible to produce economically important terpenes present in low concentration. Also, we have generated a transgenic plant of menthe for the over production of Viridiflorol content (market value Rs. 24,131.40 per 10 mg) compared to transformed the wild type plants. In addition to this, our lab at CSIR-CIMAP is constantly working on increasing the concentration of several terpenes such as Mentha furan, Cubenol *etc.* using transgenic approach.

But the scientific knowledge should reach common man to improve their livelihood. In this context the Aroma mission of CSIR is emphasizing on the cultivation and processing of about 20 aromatic crops in the farmers field. The quality planting material is supplied for growing and framing is improved for distillation. In addition market linkage is established to generate farmer entrepreneurs for enhancing income.

Brief Bio-data



Dr K. Ravishankar

Principal Scientist, Indian Institute of Horticultural Research, Bangalore, Our current research interests are focused on molecular biology, genomics and marker assisted breeding in horticultural crops. Our lab works mainly on tomato, cucumber, okra, mango, banana and guava crops. Using molecular breeding and genomics approaches, we are studying genetics of disease resistance and identification of QTLs/markers linked to it. Our aim is to develop virus resistant tomatoes (ToLDV and GBNV) and YVMV resistant okra. Using marker assisted selection and we have pyramided major genes against highly diverse begomoviruses and late blight in India to different genetic background in tomato. Our lab also has developed microsatellite markers to various horticultural species like garcinia, mango, banana, custard apple, jamun, jackfruit and sapota. Presently, we are employing GBS and microsatellite markers to identify markers linked to different traits in banana, mango and guava. We are also examining molecular and physiological mechanisms involved, to understand disease resistance mechanism and abiotic stress tolerance in these crops through RNA-seq, biochemical and physiological analysis.

BIOTECHNOLOGICAL AND GENOMIC ADVANCEMENTS IN THE IMPROVEMENT OF FRUIT CROPS

Malarvizhi M, and Ravishankar KV
Division of Basic Sciences, ICAR Indian Institute of Horticultural Research, Hessaraghatta lake post, Bengaluru 560089, India
Email: ravishankar.kv@icar.gov.in

ABSTRACT

Crop improvement strategies in fruit crops are faced with challenges due to their heterozygous nature, long juvenile phase, polyploidy and parthenocarpy. The application of genomic approaches can mitigate the problems and expedite the conventional breeding methods. At present, fruit crop research is progressing towards a new era due to the availability of sequence information of various model and non-model crops like apple, mango, banana, citrus, papaya etc. Molecular markers have aided in diversity analysis of germplasms and screening of mapping populations for fruit quality traits with commercial importance. With the advance of next generation sequencing technologies like GBS and RNA Seq helped the construction of high-density linkage maps and identification of QTLs and crop specific SNP and SSR markers linked to important quantitative traits in fruit crops. These predictive markers for fruit traits have augmented the breeding efforts through Marker- Assisted Selection (MAS) of progenies at seedling stage, Marker-Assisted Backcrossing (MAB) and Marker-Assisted Introgression (MAI) of desired traits in fruit species. Integration of 'omics' approaches like genomics, transcriptomics, metabolomics, proteomics and phenomics can be informative and assist in understanding the molecular mechanisms underlying fruit quality traits, bearing nature, shelf life, biotic and abiotic stress tolerance in fruit crops. Further, identification of Single Nucleotide Polymorphisms have led to successful application of genomic assisted breeding strategy like Genome Wide Association Studies (GWAS) and model based predictions like Genomic Selection (GS) in model crops like apple, peach and banana etc. In addition, CRISPR/Cas based genetic modification is gaining more significance in fruit crops with the success of various studies in banana, apple and papayas a proof of concept. Improvement in tissue culture techniques for fruit crops can ensure the success of these transgenic and genomic modification efforts. Some of the new sequencing innovations like pan-genomes, pan-transcriptomes, super pan-genomes and single cell transcriptomics can exploit the potential of the vast genetic diversity of fruit crops. Overall, the advancements and success of genomic assisted breeding strategies can help improve the fruit quality traits, reduce the time and need for vast orchards and mapping populations.

Brief Bio-data

Dr D. Prasath

Born in Udumalpet, District Coimbatore, Tamil Nadu on 30 May 1973. Educated at Tamil Nadu Agricultural University, B.Sc. 1994, M.Sc. 1997, and Ph.D. in 2005. Dr D. Prasath is presently working as Principal Scientist (Horticulture) at the ICAR-Indian Institute of Spices Research, Kozhikode, Kerala.

Dr D. Prasath focused his research on improvement of spices through conventional and molecular approaches. He made significant contributions in the field of spices genetic resources, breeding, and applied genomics. He was involved in release of five high yielding, disease resistant varieties and registration of four unique germplasm accessions in spices. He was also, involved in identification of promising ginger genotypes with high yield, oil, and low fibre. The heterosis and inheritance of cardamom mosaic virus (CdMV) resistance in cardamom was reported for the first time. He has also identified basal defence mechanisms against bacterial wilt resistance in mango ginger, which will be helpful in the development of wilt resistant varieties. He has also standardized two technologies for quality planting material production in spices. The results of these crop improvement studies have immense potential to improve the productivity of horticultural crops. He has published over 50 research papers in highly rated journals. He did his post-doctoral research at University of Guelph, Canada under prestigious BOYSCAST fellowship of DST, Govt. of India. He is also a recipient of Endeavour Research Fellow 2017, Government of Australia and his post-doc research at University of Queensland, Brisbane, Australia.

He is therecipient of National Academy of Biological Sciences Best Research Paper Award, 2013, D.P. Ghosh Young Scientist Award, Indian Academy of Horticultural Sciences, 2017; ICAR-Fakhruddin Ali Ahmed award, 2019; and Fellow, National Academy of Agricultural Sciences (NAAS) and Indian Academy of Horticultural Sciences (IAHS).

BREEDING NEXT GENERATION SPICES FOR INDUSTRIAL USE AND NUTRACEUTICALS

D. Prasath, M.S. Shivakumar, R. Sivaranjani, and S. Aarthi
ICAR-Indian Institute of Spices Research, Kozhikode, Kerala
E-mail: dprasath@gmail.com

ABSTRACT

Unlike other sectors of horticulture, the spices face highly dynamic situations arising from requirements of nutraceutical industries for high quality spices varieties. The proactive nature of response to this factor will translate to the release of new cultivars meeting the requirements of spiceceuticals. Development of improved cultivars by spice crop breeders may require many breeding cycles and dozens of years because of perennial nature, polyploidy, incompatibility, and sterility. The scientific and technological progresses are undoubtedly key factors to obtain quality improved spices derived from the new plant breeding technologies, which have remarkable potentialities.

Spices are high value and low volume, export-oriented commodities, commonly used for flavouring and seasoning of food and beverages. India is the world's largest producer, consumer, and exporter of spices; the country produces about 75 of the 109 varieties listed by the International Organization for Standardization (ISO) and accounts for half of the global trading in spices. Growing demand from the emerging segment of nutraceuticals is driving the global consumption of Indian spices further at a time when the country is straining to meet the needs of the traditional food sector. Non-traditional use of spices including nutraceuticals now accounts for nearly 15% of spice production in India, estimated at 50 lakh tonne a year. The spice nutraceutical sector growth rate is projected as 10%-12% per year. Also, the demand of spice oils and oleoresins is increasing mostly due to enhanced use in food and beverage industries.

Curcumin, in turmeric; capsaicin, in red pepper; piperine, in black pepper; [6]-gingerol, in ginger, saponin in fenugreek are immensely valuable in health care with their multiple physiological effects. Since these parameters are genetically controlled, genotypes can be successfully improved through breeding techniques. Classical breeding techniques along with recent biotechnological intervention can facilitate the improvement in quality parameters in spices. It requires a continuous flow of genes and allelic diversity into different crop gene pool. The primary, secondary gene pool and pre-breeding plays a vital role. The vast chemo-diversity available in India can be exploited for the understanding of biosynthetic pathway modifications or activity of different isoforms of enzymes which leads to accumulation of secondary metabolites of interest. Also, development of mapping population and extensive genotyping and phenotyping is very crucial to identify genomic regions controlling neutracitical components. The NGS based whole genome and transcriptome approaches have clearly demonstrated their advantages over previously developed methods and are becoming the new standard for NGS studies in spices. The functional genomics/ metabolomics approach help to elucidate the biochemical pathways and key genes underlying specific neutracitical compounds. The collaborations between public spices research institutions and human health research centers, with spices-based industries would play a key role in the success of this endeavour.

Brief Bio-data

Dr M.K. Rajesh

Dr M.K. Rajesh is serving as Principal Scientist (Biotechnology) in the Division of Crop Improvement, ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI), Kasaragod, Kerala, India. He has obtained his Bachelor's degree in Agriculture, and Master's and Doctoral degrees in Biotechnology from Tamil Nadu Agricultural University (TNAU), Coimbatore, India. Dr. M.K. Rajesh has made significant contributions to the field of molecular biology and biotechnology with particular reference to coconut and arecanut, in the areas of tissue culture, application of molecular markers, genomics and transcriptomics. He was involved in the development of tissue culture protocols in coconut from plumular explants. He has identified molecular markers linked to tall/dwarf trait in coconut and arecanut and has developed molecular marker panels for hybrid purity assessment in these two crops. Dr. Rajesh has undertaken sequencing, assembly and analysis of the nuclear and organellar genomes of Chowghat Green Dwarf (CGD) cultivar of coconut, possessing enhanced disease resistance, and categorized the repertoire of resistance gene analogues (RGAs) in the CGD nuclear genome. Using transcriptomics approaches, he has categorized genes induced during somatic embryogenesis and host-pathogen interactions [root (wilt) disease and bud rot disease] in coconut. He has identified non-coding RNAs, especially microRNAs (miRNAs) and long non-coding RNAs (lncRNAs), and has examined their expression patterns during coconut somatic embryogenesis. In addition, he has designed novel simple sequence repeat (SSR) markers from these (*viz*., miRNA-SSRs and lncRNA-SSRs) and demonstrated the utility of these markers in the assessment of genetic diversity and population structure of coconut germplasm. Dr. Rajesh was also part of the team involved in the development of '*Kalpasree*' variety of coconut [possessing enhanced resistance to root (wilt) disease], identification of markers linked to sex determination in palmyrah, development and validation of EST-SSR markers in coconut and cocoa, development of 'Coconut Artificial Pollination Management System', development of *in vitro* inoculation assays for studying the interactions of coconut and arecanut with *Phytophthora* spp. and standardization of pollen cryopreservation protocols in coconut and arecanut. He has published more than 100 research papers in peer-reviewed journals, written over 30 chapters, and edited five books. He is currently serving as Member of Editorial Board of BMC Plant Biology and is the Editor of Journal of Plantation Crops, published by the Indian Society of Plantation Crops (ISPC).

BIOTECHNOLOGICAL ADVANCEMENTS IN THE IMPROVEMENT OF COCONUT AND ARECANUT

M.K. Rajesh
ICAR-Central Plantation Crops Research Institute, Kasaragod-671124, Kerala
E-mail addresses: rajesh.mk@icar.gov.in

ABSTRACT

Coconut and arecanut are principal plantation crops cultivated in the tropics for their multitude of economic uses. Coconut and arecanut are particularly susceptible to a number of biotic and abiotic stressors that significantly limit their productivity potential. The demand for high-yielding varieties of coconut and arecanut, along with enhanced resistance to biotic stresses, has been on the rise. Further, it is anticipated that the palms have to be adapted to climate-change induced vagaries. Nonetheless, conventional breeding-based crop improvement programs of coconut and arecanut have largely been ineffective due to various reasons such as their perennial nature, long juvenile period and genetic heterozygosity, among others. Advancements in the field of biotechnology have enabled palm researchers to adopt and apply these techniques in the improvement of perennial crops. For instance, coconut embryo culture has been a boon for unhindered international germplasm collection and exchange. The coconut accessions that do not germinate naturally and sterile inter-specific hybrids of arecanut have been regenerated by applying embryo rescue techniques with relative ease. *In-vitro* culture based multiplication of elite accessions is a major goal in palm tissue culture. Despite the rapid strides in tissue culture of palms, success in direct or callus-mediated regeneration in coconut has remained elusive. On the other, arecanut has witnessed large-scale regeneration of elite genotypes using immature inflorescence tissues as explants. Standardization and application of efficient cryopreservation techniques for somatic, zygotic embryos and pollens of coconut and arecanut have made safe and long term conservation of genetic resources a practically viable approach. Diverse molecular markers technologies have been utilized to decipher the genetic diversity of coconut and arecanut accessions. Further, the application of molecular markers has greatly aided in decoding the QTLomics of coconut, especially in developing linkage maps for QTLs governing yield and yield attributing traits. Recent advancements in genomics and the availability of whole-genome sequence information are anticipated to further unlock the genomic potential of these crops, especially in the field of breeding and development of economically important cultivars. In addition, the adoption of genomic selection (GS) would contribute towards accelerating genetic gain in these two palms.

Brief Bio-data

Dr Bal Krishna

Dr Bal Krishna is working as Sr. Vice President, Agri Biotech R&D, at Jain Irrigation Systems Ltd., Jalgaon, Maharashtra, India. He has been working in this organization since March 2004 and is involved in various Research and Development activities related to Horticulture and Biotechnology. He has obtained his basic degrees in B.Sc., Agri. & A.H, M. Sc. Horticulture and Ph.D. Horticulture with specializations in Plant Breeding & Biotechnology from G.B.P.U.A&T, Pantnagar. He has also obtained advanced training in plant molecular biology from Umea Plant Science Centre, Umea, Sweden. His research interest includes ultra high density planting in mango and high density planting in sweet orange. His group is involved in study flowering biology of mango, banana, pomegranate and onion. In addition, his is also working on understanding drought and heat stress in banana. His expertise also includes growing crops controlled environment for experimental and commercial purpose. He has published more than 30 research papers in various peer reviewed journals. Four students completed their Ph.D. under his supervsion and two are pursuing. He has travelled to more than 25 countries for various business and scientific meetings. He is a member of professional societies like International Society for Horticulture Science, Indian Academy of Horticulture Sciences, Association of Official Analytical Chemists.

MOLECULAR CONTROL OF FLOWERING REGULATION IN MANGO

Bal Krishna, S.N. Vyavahare, S.I. Patil and P.V. Sane
Molecular Biology Lab, Jain R&D, Jain Hills, Agri Park, Shirsoli Road, Jalgaon 425001, Maharashtra
E-mail: balkrishna.yadav@jains.com

ABSTRACT

Mango is one of the most important crops of tropical and subtropical world and India is the largest producer of mango. Flowering is an important aspect of plant biology and in mango it is one of the most crucial events for commercial success of crop. Flowering behaviour of many choice mango cultivars is irregular or alternate year flowering. Number of factors are responsible to induce flowering in mango which includes horticultural, environmental, biochemical and genetic. Most of the genetic factors operate through an intricate network of genes. The network of these genes has been studied well in model plant and several flowering pathways have been identified. These include photoperiod pathway, vernalization pathway, autonomous pathway, gibberellins (GA) pathway and newly identified age pathway.

In the past few years our group has been involved in characterization and expression studies of genes of flowering pathways in mango. Gene homologues were identified, cloned, sequenced and their expressions were studied at different phenological stages in various plant tissues.

The florigen or flowering factor known for a long time is now identified as *FLOWERING LOCUS T (FT)* gene in model plant. Homologue of *FT* gene is also functional in mango and plays a central role in flowering regulation, It has atleast three copies in mango genome *(MiFT1, MiFT2 and MiFT3)*. Structurally a close relative of FT, flowering repressor *TERMINAL FLOWER LIKE 1* (*TFL1), MiTFL1 and MiTFL1a* are also involved in regulation of flowering specially maintaining vegetative phase in mango. The *FLOWERING LOCUS D (FD)* which interacts with *FT* has also been identified by us in mango and is involved in regulation of flowering. Another important group of genes regulating flowering in mango are those regulated through circadian rhythm. These are *GIGENTIA (GI), FLAVIN BINDING KELCH REPEAT F BOX 1, CYCLIC DOF FACTOR 1 LIKE (CDF1)* and *CONSTANS (CO). GI-FKF1-CDF1-CO* work as a module and seems to be working in mango although it is a day neutral crop. The presence of temperature sensitive elements in the promoter region of GI may be the key to the temperature dependent flowering regulation in mango. Other genes involved in regulation of mango flowering are *SUPRESSOR OF OVEREXPRESSION OF CONSTANS1 (SOC1), SHORT VEGETATIVE PHASE (SVP)* and *APETALA 2.* A group of micro RNAs has been also identified in mango, which are involved in regulation of flowering in model plants. The micro RNA 172 (miR172) is a positive regulator and micro RNA 156 (miR156) is a negative regulator of flowering in mango.

The interaction of above positive (*MiCO1, MiCO2, MiFT1, MiFT2 and MiFT3, MiFD, MiGI2, MiSOC1 and MiCDF1)* and suppressors (*MiTFL1, MiTFL1a, MiSVP and MiAP2)* leads to expression of meristem identity genes *APETALA 1* (*MiAP1-1* and *MiAP1-2*) and *LEAFY (MiLFY)* which regulate the development of floral organs. This presentation will try to give a comprehensive understanding on regulation of flowering in mango in view of the current knowledge of molecular biology.

Dr Jai Prakash

Dr Jai Prakash, born on 5th May, 1976 at Sultanpur, Uttar Pradesh. Graduation from ANDUAT, Ayodhya in 1998; M. Sc.(Ag) Horticulture in 2000 from CSAUAT, Kanpur through ICAR JRF; and Ph.D. in Horticulture from Banaras Hindu University, Varanasi in 2003. He joined Agricultural Research Services (ARS) in April 2003 at ICAR, NEH region, Barapani, and posted its regional station Lembucherra, Tripura. He was selected as Senior Scientist in IARI, New Delhi in 2012 and became Principal Scientist in July, 2016.

He has developed and one variety each in pineapple (PQM-I) and papaya RCTP-1(Tripura Papita) which were released from SVRC, Tripura. At IARI, he Identified 5 superior gynodioecious papaya lines P-7-9, P-7-2, P-9-5, P-9-12 and P-7-15 with moderately tolerant to PRSV at field conditions. He was also associated with development and release of four grape varieties namely, Pusa Aditi, Pusa Swarnika, Pusa Trishar and two mango hybrids Pusa Manohari and pusa Deepshikha. He has contributed significantly in mango genome assembly based on hybrid Amrapali and its parents. Presently he is working on papaya and mango rootstock improvement.

Dr Prakash has published more than 72 research papers in National and International journals and author for 4 books, 10 technical bulletin and 18 book chapter on various topics of Horticulture-Fruit Science. Awardee of HSI-DP Ghosh Young Scientist Award 2018 and RASSA Yashasvi Samman 2018. He has also guided 5 M.Sc. students. He is the Fellow of the Indian Academy of Horticultural Sciences and International Society of Noni Science.

PAPAYA BREEDING-CURRENT STRATEGIES AND OPPORTUNITIES

Jai Prakash
Division of Fruits and Horticultural Technology, ICAR-IARI, New Delhi -110 012
E-mail: singhjai2001@rediffmail.com

ABSTRACT

The papaya (*Carica papaya* L.) is among the most important fruit crops of India and commercially cultivated in the tropical and subtropical regions of the World. India is leading in global papaya production since last one decade with a production of 6.011 Mt from 0.142 million hectare area during 2019-20. Papaya has several industrial uses based primarily on its proteolytic enzyme, papain, a major component of the mixture of enzymes extracted from the latex of green, unripe fruit. In papaya, the genetics of the sex form is one of the most important aspects to the breeders for its genetic improvement to provide stable variety to the growers to harvest higher productivity. Being a polygamous plant, it has three types of sex forms, *viz.* male, female and hermaphrodite. Among these forms only the female ones are stable in flowering, fruiting and fruit production under both tropical and sub-tropical climatic conditions. The genomic information generated after sequenced genome of papaya had yielded vital information on sex determination, ripening genes and it will help further to the researchers to explore its medicinal and nutritional applications, and enhance the value of papaya to both growers and consumers.

Disease resistance in papaya has been a major challenge to the researchers and that could be solved by unravelling its genetics and genomics. The susceptibility of papaya to several biotic (virus, fungus, mycoplasma and nematode) stresses might be attributed to its narrow genetic base. Therefore, develop resistant varieties against virulent pathogens, sources of resistance needs to be explored further within *Carica* and its related Caricaceae genera. Refinement of the techniques for inter-generic hybridization and embryo rescue will further facilitate to the breeder for introgression of the desirable traits and genetic diversity into *C. papaya*. Varieties resistant to biotic stresses like 'PRSV' and which can tolerate high temperature as well as tolerant to frost need to be developed so that cultivation can be taken up in other regions as well. Introgression of desirable genes from *Jarilla* and *Horovitzia* needs to be explored in the light of new facts under genomic resources to make papaya cultivation more remunerative and sustainable for the growers.

Dr Ram Pal

Dr Ram Pal graduated from Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, in 1989 and did postgraduate studies at Indian Agricultural Research Institute (IARI), New Delhi, in 1992. He earned his doctorate from Babasaheb Bhimrao Ambedkar University, Lucknow. He joined the Agricultural Research Services in April 1997 at ICAR NRC for Orchids, Sikkim. A year after the establishment of NRC for Orchids, Sikkim, he was given the responsibility of setting up a new centre for temperate orchids in Darjeeling. From 1998 to 2020, he worked at the centre in Darjeeling and since March 2020, he has been the Acting Director of the National Research Centre for Orchids, Sikkim. Dr Ram Pal has been associated with the Centre throughout his career. His research interest is in conservation, in vitro propagation and breeding of orchids. He has conserved 171 species of temperate orchids and developed protocols for mass propagation of several threatened and commercially important orchids. He has registered two Cymbidium hybrids, Darjeeling Nymph and Darjeeling's Delight, with the International Orchid Registration Authority, Royal Horticulture Society, London. Besides, about 100 orchid hybrids developed by him are in various stages of development. He has published 45 research papers, 12 technical bulletins and 15 book chapters in national and international publications. He is involved in several inter-institutional projects with TERI, NBPGR, IBSD.

INDIAN ORCHID GERMPLASM: CONSERVATION AND SUSTAINABLE UTILIZATION

Ram Pal
ICAR-National Research Centre for Orchids, Pakyong-737106, East Sikkim, Sikkim
Email: rampal_nrco@yahoo.com

ABSTRACT

Orchidaceae is the second largest family of flowering plants and is valued for its ornamental and therapeutic importance. A number of species in this family are threatened with extinction due to their specialized life cycle and diverse mode of living. Conservation of orchid germplasm has traditionally been carried out by private nurseries for the sale and cultivation of orchids. The publicly funded organisation also conserves orchid germplasm for botanical and educational interests. ICAR- National Research Centre for Orchids, Sikkim, was established in 1996 to provide research support to orchid growers in India. In collaboration with the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, the centre is engaged in conservation and sustainable use of orchid biodiversity. Conservation of orchid germplasm is a challenge; however, concerted scientific efforts will ensure future conservation and sustainable use of orchid germplasm. There are several challenges in germplasm collection, conservation methodologies, gene pool creation, gene banking procedures and adherence to national and international laws, treaties and conventions for germplasm collection, conservation and sustainable use. ICAR-NRC for Orchids, Sikkim, collected and conserved 3150 accessions of 352 native orchid species. Global and regional networking is required for sustainable collection, conservation and exchange of orchid germplasm.

Orchids are one of the most important groups of flowering plants for evolutionary studies, and the vast amounts of DNA data now accumulating are revolutionizing our ideas about these beautiful plants. Strengthening conservation practices through in situ/ex situ or on-farm conservation involving local communities will help conserve these valuable genetic resources. Therefore, under acceptable policies and guidelines, these resources can be used more effectively for horticultural crop improvement programmes, sustainable use and conservation strategies. Special incentives to farmers/rural people for cultivation of difficult or uneconomic material on private land or in home gardens will help conserve wild relatives. Village communities can benefit through watershed management, wildlife habitats and environmental stabilization. Scientists, individuals, agencies and institutions, especially the State Agricultural Board and the State Biodiversity Board, should work to protect these natural resources.

Oral Paper

ADVANCES IN BANANA BREEDING

S.Backiyarani, S.Uma, M.S.Saraswathi, C.Anuradha, D. Ramajayam, D K. Agarwal, P.Durai and V.Selvaraj
Crop Improvement Division, ICAR- National Research Centre for Banana,
Trichy 620102, India
Email: backiyarani@gmail.com

Improvement of banana through conventional breeding approach is the Himalayan task owing to its recalcitrant nature for seed set. Historically, exploitation of the somaclonal variation has been the successful breeding approach resulting in varieties of commercial importance. Next, exchange of germplasm across the countries favour choosing of desirable accessions with improved traits. Similarly, some success could be attained in creating variability for resistance among some of the commercial cultivars and even dwarf mutants. Many obstacles in successful seed set have been partially overcome by use of synthetic tetraploids and polleniferous improved diploids in the crop improvement programmes. The advent of advance technologies such as embryo culture, embryo rescue, multiple shoots in embryo culture, trait specific markers, easy access to molecular and breeding databases as well as aided capacity in the form of breeding tracker system has hastened up the conventional breeding programmes and has resulted in release of many varieties for commercial exploitation. Apart from these, efforts are being taken up to create variability and develop tetraploids through somatic fusion of male and female sterile accessions which will lead to the creation of commercial triploids. Now with the joint collaboration of all the banana breeders, steps are being taken to develop a genomic prediction model by phenotyping and genotyping of the germplasm and breeding lines available at global level. This will facilitate the breeder to accurately select parents and their hybrids with desired traits at the DNA level itself. The success of these efforts would enable us dream tailoring the banana varieties with all desirable traits to satisfy the need of the end users in a short period.

RADIATION INDUCED MUTATION TO DEVELOP DWARF AND PRECOCIOUS LINES OF PAPAYA (*CARICA PAPAYA* L.)

K. Singh, Jai Prakash, A. K. Goswami and S. K. Singh
Division of Fruits and Horticultural Technology, ICAR-Indian Agricultural Research Institute
New Delhi 110012
E-mail: ksinghiari@yahoo.co.in

Mutation breeding is the most appropriate for improving one or two easily identifiable traits in an otherwise well accepted breeding lines or commercial variety. As regards mutation breeding in papaya, very little work has been done in India. Only one variety Pusa Nanha has been developed through mutation breeding by treating the seed of papaya strain Pusa 1-15 with 15Kr gamma rays. Dwarfness and earliness in flowering are important traits in high density planting as breeding objective for improving papaya varieties for high yield with medium size fruits and good fruit quality. With these objectives, seeds of the gynodioecious papaya line P 7-2 were treated with gamma rays 0.1, 0.15, 0.2, 0.25 and 0.3 kGy. Two mutants viz. PM 04 and PM 28 were selected from two lower doses 0.10 kGy and 0.15 kGy which were particularly outstanding in vigour having dwarf stature and bearing height in M6 population were selected and evaluated in M7 generation. Minimum height (102.44 cm), plant height at flower initiation (70.34 cm), plant girth at first fruiting (64.25 mm), nodes to first flowering (52.44), days to flower initiation (84.52), length of middle internode (4.6 cm), length of petiole (74.24 cm) and minimum plant spread in east-west direction (132.4 cm) was noted in PM 04 and minimum plant spread in north-south direction (135.6 cm) was recorded in PM 28 followed by PM4 (146.4 cm) while maximum height (132.64 cm), plant height at flower initiation (92.24 cm), plant girth (74.36 mm), nodes to first flowering (64.2), days to flower initiation (98.44), length of middle internode (7.2 cm), length of petiole (94.25 cm) and plant spread in east-west direction (148.2 cm) and north-south direction (152.2 cm) was found in control (P 7-2). Maximum number of fruits (42.4) and width of fruit (12.22 cm) was recorded in PM 04 while maximum fruiting length (96.4 cm), weight of fruit (0.980 kg) and length of fruit (21.84 cm) was recorded in control (P 7-2). Minimum length of fruit cavity (14.24 cm) and width of fruit cavity (4.22 cm) and maximum pulp thickness (3.44 cm) and TSS (10.22^{o} Brix) was recorded in PM 04 while minimum pulp thickness (2.52 cm) and TSS (8.44^{o} Brix) was recorded in control (P 7-2).

BREEDING FOR NOVEL TRAITS IN CASHEW FOR ENHANCING FARM INCOME

J. Dinakara Adiga, G.S. Mohana, Muralidhara, B.M., Eradasappa, E. and Siddanna,S.
ICAR-Directorate of Cashew Research, Puttur-574202, Karnataka, India.
Email: dinakara.adiga@gmail.com; jd.adiga@icar.gov.in

ABSTRACT

Being an introduced crop from Brazil, the diversity in India is limited with respect to cashew (*Anacardium occidentale* L.). The cashew breeders in India are confronted with the constraint of this limited diversity for improving the available germplasm through conventional breeding approaches. The germplasm lacks the traits related to bigger nut size, dwarf growth habit, resistance to biotic stress, etc. Although the breeding efforts led to the development of about 45 varieties, most of the varieties have medium nut size (around 7g nut weight) with vigorous stature. Development of a variety which can fulfill an ideotype will be the dream of any breeder and cashew is not an exception to this. Hence, any variety/hybrid with a bigger nut, cluster bearing habit, lower plant height and tolerance to biotic stress without compromising with yield level can be termed as a novel one. Such attempts done at ICAR-Directorate of Cashew Research to incorporate novel traits in cashew are highlighted hereunder. The process of harvesting through picking of fallen nuts accounts to major share of expenditure to the tune of nearly 40 per cent in cashew cultivation. As most of the released cashew varieties are of medium(7g) to small nut(around 5 to 6g) type with a few exception of bold nut types weighing around 8 to 9 gm, developing jumbo nut varieties would significantly reduce the man power requirement for harvesting of nuts apart from fetching premium price from processors as it would lead to production of premium sized kernels with higher market price. As a result of massive hybridization, two jumbo nut hybrids were identified with superior traits for both yield and quality and released as H-130 and Nethra Jumbo-1. Nethra Jumbo-1 can save about Rs. 16,000 on labour cost(50% saving on man days) and fetch a premium of Rs.10,000 for bigger size per ton of nut yield, giving an additional revenue of Rs. 26,000 for farmers on every ton of nut yield which can substantially make cashew cultivation a profitable venture under rain fed horticulture. The efforts were also made to transfer dwarf and compact canopy traits from dwarf, low yielding cashew germplasm into high yielding cashew cultivars viz. Bhaskara, Ullal-3,Vengurla-4, Priyanka, Dhana and Madakkathara-2 resulting in few promising semi dwarf hybrids. As a result of wide hybridization to develop Tea Mosquito Bug tolerance, an interspecific hybrid was found to exhibit tolerance to TMB.

GENOME-WIDE IDENTIFICATION AND CHARACTERIZATION OF MICRORNAS FOR LOW NITROGEN STRESS IN POTATO (*SOLANUM TUBEROSUM* L.)

Jagesh Kumar Tiwari*, Tanuja Buckseth, Rasna Zinta, Rajesh Kumar Singh, Vinay Bhardwaj, Manoj Kumar and NK Pandey
ICAR-Central Potato Research Institute, Shimla – 171 001, Himachal Pradesh
E-mail: jageshtiwari@gmail.com

ABSTRACT

Nitrogen is an important nutrient for plant growth and tuber quality of potato. Since potato crop requires high dose of N, improving nitrogen use efficiency (NUE) of plant is an inevitable approach to minimize N fertilization. The aim of this study was to identify and characterize microRNAs (miRNAs) by small RNA sequencing in potato plants grown in aeroponic under two contrasting N (high and low) regimes. A total of 119 conserved miRNAs belonging to 41 miRNAs families, and 1002 putative novel miRNAs were identified. From total, 52 and 54 conserved miRNAs, and 404 and 628 putative novel miRNAs were differentially expressed in roots and shoots, respectively under low N stress. Of total 34,135 predicted targets, the gene ontology (GO) analysis indicated that maximum targets belong to biological process followed by molecular function and cellular component. Eexpression levels of the selected miRNAs and targets were validated by real time-quantitative polymerase chain reaction (RT-qPCR) analysis. Two predicted targets of potential miRNAs (miR397 and miR398) were validated by 5' RLM-RACE (RNA ligase mediated rapid amplification of cDNA ends). In general, predicted targets are associated with stress-related, kinase, transporters and transcription factors such as universal stress protein, heat shock protein, salttolerance protein, calmodulin binding protein, serine-threonine protein kinsae, Cdk10/11-cyclin dependent kinase, amino acid transporter, nitrate transporter, sugar transporter, transcription factor, F-box family protein, and zinc finger protein etc. Our study highlights that miR397 and miR398 play crucial role in potato during low N stress management. Moreover, study provides insights to modulate miRNAs and their predicted targets to develop N-use efficient potato using transgenic/genome-editing tools in future.

DNA BARCODING AND RNA SECONDARY STRUCTURE PREDICTIONS IN BRINJAL AND ITS WILD RELATIVES

Manas R Sahoo[1], Gobinda Ch Acharya[1], Latika Sahu[1], Bandana Mishra[1], Ponnam Naresh[2], Satyapriya Singh[2], Arup Sarkar[3]
[1]Central Horticultural Experiment Station, ICAR-IIHR, Bhubaneswar
[2]ICAR-IIHR
[3]Trident Academy of Creative Technology
E-mail: gobinda.acharya@icar.gov.in

ABSTRACT

Brinjal (*Solanum melongena* L.) is the second most important *Solanaceous* crop cultivated worldwide. The genus *Solanum* can be divided into 13 major clades with about 1400 species distributed worldwide. Identification and understanding relationship of the genera and taxa is more important to judge the gene pool concept in wild relatives of brinjal. In the present study we have performed morphological discriminations, DNA barcoding and RNA secondary structure predictions in thirteen wild and cultivated brinjal genotypes. Plant morphological characterization was undertaken following the distinctness, uniformity and stability (DUS) guidelines as recommended by protection of plant variety and farmers' rights authority (PPV&FRA) for brinjal. DNA barcode primers showed that all the samples have 78% to 99% similarity with *Solanum* spp. Alignment of DNA sequences from KimmatK and ITS2 in combination grouped the genotypes into ten clusters. Analysis of the chloroplast genome sequences such as KimmatKand ITS2 can be a valuable tool in establishing the phylogenetic analysis and variability of brinjal and its wild relatives. RNA secondary structure prediction grouped the genotypes into 13 different clusters. The structures displayed six helix universal features which was a typical secondary structure of cultivated brinjal. However, wild brinjal genotypes represented five to ten helix universal features. The present study would be helpful in genetic discrimination and germplam conservation of wild brinjal for augmenting breeding strategies for biotic and abiotic stresses.

GENETIC IMPROVEMENT OF CHILLI FOR IMPROVED YIELD REALIZATION AND CONSUMER PREFERENCE

Rajesh Kumar*, Indivar Prasad, K. Nagendran, Achiut K. Singh, P.M. Singh and T. K. Behera
ICAR-Indian Institute of Vegetable Research
PB No. 01, P.O. – Jakhini (Shahanshahpur), Varanasi 221 305
*rajes74@gmail.com

Chilli (*Capsicum annuum* L.) is one of the most important vegetable crops of India and diverse varieties are cultivated for varied uses like vegetables, spices, pickles and condiments. India being the world's largest producer, consumer and exporter of chillies has the largest area under it in the world. Indian chilli is considered to be world famous for two important commercial qualities- its colour and pungency levels. As per latest estimates of National Horticulture Board, green chilli was grown in 3.64 lakh ha with the production of 38.51 lakh metric tonnes. Chilli breeding programme was started at IIVR in early 2000 with the objective of developing high yielding, disease resistant and superior quality varieties/ hybrids of chillies. Germplasm pool of chilli has been enhanced through explorations, active collaborations and exchange from both international as well as national partners. As a result, Institute is currently maintaining large active collection (approx. 400) of chilli germplasm including wild/weedy relatives which are proving highly useful for breeding varieties for specific traits. Apart from own uses, the Institute is also supporting breeding programmes of several SAUs and Institutes through germplasm exchange activities. So far, Institute has developed 4 OP varieties (Kashi Anmol, Kashi Gaurav, Kashi Abha and Paprika chilli -Kashi Sinduri) and three hybrids (Kashi Surkh, Kashi Tej and Kashi Ratna) for cultivation in different agro-climatical zones of the country. They offer diverse choices to chilli growers owing to their unique morpho-horticultural traits and fruit quality attributes. These varieties/ hybrids are quite popular among the chilli farmers which is evident from quantum jump in seed sale as well as commercial licensing to private companies for better outreach of these varieties/hybrids to farmers in last five years. Institute has aggressively utilized CGMS system for hybrid production as it is cost effective and easy to integrate in both breeding and seed production programmes. Breeding for Chilli leaf curl virus (ChiLCV) has been focused area of research for development of resistant varieties/hybrid in chilli. Protocol for artificial inoculation and screening technique for ChiLCV disease has been standardized and has been found effective, reproducible and cost effective. Diversification of existing CMS source in local germplasm, development of ChiLCV resistant variety, utilization of genomic resources and tools for deciphering mechanism underlying key traits are current research priorities in chilli

GENETIC ANALYSIS AND IDENTIFICATION OF SSR MARKERS ASSOCIATED WITH POWDERY MILDEW RESISTANCE IN BITTER GOURD (MOMORDICA CHARANTIA L.)

Prasanth K, Sriram S, Lakshmana Reddy D.C., Venugopalan R, Pitchaimuthu M, Hima Bindu K Varalakshmi B
ICAR-Indian Institute of Horticultural Research
E-mail: prasanth.k@kau.in

ABSTRACT

Bitter gourd (*Momordica charantia* L.) is one of the most popular vegetables cultivated throughout India. However, the production is limited by various diseases, of which powdery mildew is a major fungal disease in most of the production areas. An experiment was designed to identify resistant source for powdery mildew, to study the inheritance pattern of resistance and to identify a molecular marker linked to powdery mildew resistance gene. The experiments were carried out in the Division of Vegetable Crops, ICAR- Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru, Karnataka, India. Out of 31 genotypes screened,two genotypes *viz*.,IIHR-80-1-2 and IIHR-80-1-3 were immune to the disease, and the genotypeIIHR-144-1 was recordedhighly resistant reaction to powdery mildew.The six generation analysis (P1, P2, F1, F2, B1 and B2) of two cross combinations (Arka Harit × IIHR-144-1 and IIHR Sel-5-8 × IIHR-144-1) indicated that resistance in both crosses was controlled by interaction of two pairs of dominant and recessive genes (dominant inhibitory epistasis, 13:3). Quantitative analysis confirmed that epistatic interaction was of greater magnitude than main gene effects in both the crosses.A total of 300 SSR markers were employed to identify polymorphic primers using 193 F2 populations of Arka Harit × IIHR-144-1 to identify linked marker for powdery mildew resistance through BSA. The primer McSSR 57 produced a polymorphic DNA fragment that co-segregated with disease reaction. PCR amplification of all the 193 plants of F2 population using McSSR 57 gave a recombinant frequency of 18.13 % which indicates that the marker is linked to the gene for resistance at 18.13 cM distance. Considering the cross compatibility between *Momordica charantia* L. and *M. charantia* var. *muricata* (IIHR-144-1) the resistance trait can be easily transferred to cultivated species through hybridization and selection for the trait has to be delayed until later generations. Marker assisted selection (MAS) can be employed for early generation selection of powdery mildew resistance in bitter gourd.

OPTIMISING PROTOCOL FOR SUCCESSFUL INDUCTION OF HAPLOIDS IN AFRICAN MARIGOLD (*TAGETES ERECTA* L.) USING *IN VITRO* GYNOGENESIS APPROACH

Reeta Bhatia*, Kavita Dubey, Kanwar Pal Singh and Sapna Panwar
Division of Floriculture and landscaping, ICAR-IARI, New Delhi

ABSTRACT

*Corresponding author's Email: reetaiari@yahoo.com

In recent years, the F_1 hybrids of marigold are gaining popularity in India and other countries. Homozygous parental lines are indispensable for commercial hybrid seed production in any crop. However, the development of homozygous parental lines through conventional method requires several generations of selfing and practically impossible in a highly heterozygous and self-incompatible crop like marigold. The gametic embryogenesis is an effective approach for single-step development of complete homozygous lines from heterozygous parents in shortest period of time (~1 year). Most of the commercial hybrids of African marigold ((*Tagetes erecta*. L.) are doubled-flower type (Petaloid) and sterile in nature. Hence, among the various approaches, *in vitro* gynogenesis (*in vitro* ovule/ovary culture) along with parthenogenesis (induction of egg cell by pollination with irradiated pollen followed by *in vitro* haploid embryo rescue) is the only viable option for efficient induction of haploids and doubled haploids from the petaloid-types male sterile hybrids/lines. The effects of genotypes, culture media and shock pre-treatments were studied for the high frequency embryogenesis in petaloid-types male sterile lines/ hybrids of African marigold. Significant genotypic differences for *in vitro* gynogenic response were noticed among the marigold genotypes. Among the different genotypes, the best *in vitro* response was observed in Arka Bangara -2 (53.9%) followed by BM-2 (48.5%). The addition of growth regulators into the induction media improved the regeneration response from unfertilized ovary culture. Among the different media tested, the best *in vitro* response was obtained on modified MS* medium supplemented with 0.5 mgl^{-1} TDZ. Among the two bioregulators, it was observed that TDZ was more effective in inducing direct embryogenesis from unfertilized ovule culture. Exposing the flower buds to cold pretreatment significantly improved the percentage of the ovaries inducing direct regeneration. While, indirect regeneration was noticed in the absence of the cold pretreatment. Among the three genotypes, the best *in vitro* response was observed in Arka Bangara-2 (73.7%) followed by BM-2 (65.8%) when the cultures were pretreated at 9°C for 4 days. The shoots induced through *in vitro* gynogenesis were successfully proliferated and maintained on basal MS medium supplemented with 125 mgl^{-1} PVP, 0.25 mgl^{-1} BAP, 0.1 mgl^{-1} GA_3, 0.1 mgl^{-1} NAA and 20 g l^{-1} sucrose. The gynogenetically induced shoots were characterised using morphological and cytological approaches for the detection of the ploidy levels.

Oral Paper

DEVELOPMENT OF SHRUNKEN2 AND SUGARY1-BASED SWEET CORN THROUGH GENOMICS-ASSISTED BREEDING

Rashmi Chhabra, Firoz Hossain, Vignesh Muthusamy, Aanchal Baveja, Nisrita Gain, Ashvinkumar Katral, Brijesh Mehta, Nitish Ranjan Prakash and Rajkumar Uttamrao Zunjare

Maize Genetics Unit, Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi-110012

E-mail: reshu0428@rediffmail.com

ABSTRACT

Sweet corn consumed as fresh vegetable has emerged as a popular horticultural commodity. Two recessive genes, *shrunken2* (*sh2*) and *sugary1* (*su1*) have been extensively used in sweet corn.The present study was aimed at molecular characterization of *sh2* and *su1* genes for their utilization in molecular breeding. Sequence analysis of ٧,٣kb and ١١,٧kb regions revealed the presence of ٤٧ and ٤٤ haplotypes for *sh2* and *su1*, respectively. While *sh2* orthologue of *Oryza sativa* was similar to maize;orthologues of *Panicum hallii, Sorghumbicolor* and *Eragrostis tef* were closer to *su1* of maize. In *sh2* gene, three SNPs viz., SNP٥٨٣ and SNP٧٥٥ in ٥'UTR, and SNP٥١٢٢ in intron١٢- were exploited to develop markers. In *Su1*, InDels of 6bp and 36bp in intron-10 and promoter, respectively, and one SNP in exon-2 were selected to develop markers. Breeder-friendly markers for *sh2* and *su1*genes were validated in five F2 populations and 230 diverse inbreds. Gene-based markers developed here were used in stacking of *sh2* and *su1* into genetic background of four parental inbreds (PMI-SWT١٦-, PMI-SWT١٧-, PMI-SWT١٩- and PMI-SWT٢٠-) of two released hybrids (Pusa Super Sweet Corn١- and Pusa Super Sweet Corn٢-). BC١F١, BC٢F١ and BC٢F٢ populations were successfully genotyped using developed markers. This has led to development of novel sweet corn inbreds with *su1* and *sh2* genes. The newly derived sweet corn genotypes (*su1su1/sh2sh2*) possess higher kernel sweetness than the individual mutants. This is the first report of comprehensive characterization, marker development and stacking of *sh2* and *su1* genes using genomics-assisted breeding approach.

GENETIC IMPROVEMENT IN CHINA ASTER [*CALLISTEPHUS CHINENSIS* (L.) NEES]

Rajiv Kumar[1*], T. Manjunatha Rao[1], T. Usha Bharathi[1], V. Bhargav[2] and Pratiksha Kumari[3]
[1]Division of Flower & Medicinal Crops,
ICAR-Indian Institute of Horticultural Research, Hesaraghatta Lake Post,
Bengaluru 560089, Karnataka, India
[2]Central Agricultural University, Nakhu Nachibon, Arunachal Pradesh, India
[3]Horticulture Division 1, South Avenue, New Delhi, India
*E mail of the presenting author: Rajiv.Kumar11@icar.gov.in

ABSTRACT

China aster, herbaceous plant of Asteraceae family with diploid chromosome number (2n=2x=18), is one of the most popular flowering annuals grown throughout the world mainly for loose flower, cut flower, bedding and pot culture. Several countries produce its seeds in large quantities due to its wide popularity. ICAR-IIHR, Bengaluru have conducted extensive work on collection, evaluation, hybridization and mutation, which lead to the development and release of nine improved varieties with unique traits. In recent decade, large number of collections were made, characterized and evaluated for quantitative and qualitative traits. The stabilized genotypes were DNA fingerprinted using SSR markers. Genetic studies were carried out to ascertain the desirable traits on which selection can be made. The traits such as flower diameter, flower stalk length, number of branches/plant, weight of flower/plant, days to flowering, plant height, ray and disc florets/head, flowers/plant were found to be highly heritable. The yield parameter *viz.*, weight of flowers/plant was positively correlated with plant height, branches/plant, days to flowering, flower diameter, stalk length and flowers/plant. The genotypes namely Matsumoto White and Matsumoto Scarlet, Phule Ganesh Violet, IIHRJ3-2 and IIHRG13 were found to be best general combiner for most of the economic traits. The cross combination Matsumoto Red x IIHRJ3-2, Matsumoto Scarlet x Phule Ganesh Violet, Matsumoto Scarlet x IIHRG13, Matsumoto White x Phule Ganesh Violet and Matsumoto White x Local White were found to be best for flower stalk length, flower head diameter, 100 flower weight and vase life in terms of specific combining ability and for exploitation of heterosis. Induction of mutation resulted in identification of putative mutants with remarkably different plant type, flower colour and forms. Recently, two unique pseudo ray florets mutants *viz.*, Arka Advika and Arka Nirali, and one pure line IIHRJ3-2 as Arka Shubhi for long stalk, more number of flowers/plant and prolonged vase life, have been identified for release. Six genetic stocks with unique traits have been registered with NBPGR, New Delhi. Variation in flower colour was identified among the varieties and the lines with highest anthocyanin can be exploited commercially for bio-color synthesis.

GENETIC DIVERSITY ANALYSIS AND POPULATION STRUCTURE IN OIL PALM GERMPLASM BY MOLECULAR CHARACTERIZATION USING SSR MARKERS

Bhagya, H.P., Kalyana Babu, B., Mathur, R.K., Ravichandran G and Anitha P.
ICAR-Indian Institute of Oil Palm Research, Pedavegi, West Godhavari District, Andhra Pradesh-534
E-mail: bhagya509@gmail.com

ABSTRACT

Oil palm (*Elaeis guineensis* Jacq.) is a perennial crop, which is a major source of vegetable oils and belongs to the family Arecaceae. Now there is lot of demand and more scope to obtain self-sustainability in edible oil requirement in the country and to make Athmanirbhar Bharath, for this genetic resources play an important role to improve the yield of oil palm and development of hybrids. In this background, we have evaluated oil palm germplasm available at field gene bank of ICAR-IIOPR, Pedavegi. Fifty-four SSR loci were used for amplification of 150 oil palm genotype for genetic diversity and population structure analysis. The PIC values of all the polymorphic loci across the oil palm genotypes varied from 0.19 to 0.78 at an average of 0.44. mEgCIR0246, mEgCIR3358, mEgCIR0782 and mEgCIR0779 markers found to have higher level of polymorphism. The unweighted pair-group method with arithmetic averaging cluster analysis (UPGMA) grouped 150 genotypes into two main clusters and two populations based on the results from the structure analysis. These results demonstrated that the oil palm germplasm lines obtained from two different sources. The SSR protocol was most reliable for evaluating knowledge of the genetic diversity and population structure and this will be crucial for management genetic resources and can remove duplications in field gene bank and can incorporate further collection of germplasm material in this place.

PRIORITY TRAITS IDENTIFICATION AND UTILIZATION TO DEVELOP NEXT GENERATION PLANTING MATERIAL IN OIL PALM (*ELAEIS GUINEENSIS* JACQ.)

Anitha Pedapati*, Mathur RK, Ravichandran G, Kalyana Babu B, Somasundaram G and Bhagya HP

ICAR-Indian Institute of Oil Palm Research, Pedavegi-534450, West Godavari Dt., Andhra Pradesh New Delhi-110012, India

*anita.pedapati@gmail.com

The oil palm (*Elaeis guineensis* Jacq.) is a monoecious crop with male and female flowers in separate inflorescences in an alternating cycle of variable duration depending on genetic factors, age and particularly abiotic factors. Till date, very few promising hybrids have been developed in oil palm due to existing narrow genetic base and its improper utilization. It is very essential to select suitable parents for developing trait specific hybrids of high yield potential. For selecting individual palms, it is necessary to analyze the yield components contributing towards bunch and oil production. The other important traits like compact type, high oil quality, more Iodine value, free fatty acid, disease resistant, increased water use efficiency/ drought tolerance and longer bunch stalk. The evaluation and characterization of existing oil palm germplasm have resulted in identification of genetically diverse trait-specific germplasm lines meeting the needs of oil palm breeders for use in developing high yielding cultivars with a broad genetic base. At Indian Indian Institute of Oil Palm Research, Pedavegi, fourteen mother palms were selected based on its high bunch yield (180-221 kg/palm/year) and its low height increment (18-30 cm). These selected mother palms were utilized in hybrid seed production by crossing with promising male parent to produce elite progeny. The third generation materials produced from selected mother were planted in field for further evaluation and characterization.

PLOIDY MANIPULATION: AN INTEGRAL PART FOR THE GENETIC ENHANCEMENT IN CITRUS

Awtar Singh*, L.S. Sisodia, O. P. Awasthi and S. K. Singh
Division of Fruits and Horticultural Technology, ICAR- Indian Agricultural Research Institute, Pusa Campus, New Delhi-110012
E-mail: awtar_saini@yahoo.co.in

ABSTRACT

Plant breeding is expensive and long term process, especially in case of perennial fruits like citrus. Ploidy manipulation is particularly interesting in citrus scion improvement and opens the possibility of producing tetraploid breeding parents that can be used in inter-ploid crosses to generate seedless triploid cultivars. Moreover, production of triploid citrus fruits can lead to fresh as well as processed fruit quality improvement because of their possession of distinctive commercial benefits. Tetraploids are a preliminary requirement for developing triploid cultivars in citrus and only a few tetraploids are available that can be utilized for their genetic enhancement. Mutation polyploidy possesses great prospective to bring about sudden changes in genotypes as well as phenotypes. Kinnow mandarin, Mosambi sweet orange are commercially cultivated citrus crops in the northern India and the pummelo can be utilized for their genetic enhancement because of its possession of many desirable attributes and zygotic monoembryony that can be utilized for triploid citrus breeding without involving the process of embryo rescue. Induction of tetraploidy has been initiated and tetraploids have been produced in these citrus crops through colchicine treatment and confirmed by morpho-physiological, cytological and molecular characterization as well as flow cytometry. The tetraploids grew more slowly had compact growth habit and yielded less than diploids of the same cultivar. Leaves of tetraploids were broader, thicker and darker in color compared to the diploids. Increased ploidy level resulted in increased cell size, which caused thicker, broader leaves and larger flowers and fruits. Shoots were thicker and had shortened internodes. Stimulatory as well as inhibitory effects of colchicine were observed among the progeny for the gas exchange parameters. The autotetraploid possessed doubled chromosome number, which was evident by cytological and flow cytometry studies. The frequency of stomata reduced but the dimensions increased in tetraploids compared to diploids. Molecular characterization resulted in the identification of some colchi-mutants. The identified tetraploids were crossed with their diploids for the production of triploids and further studies are in progress.

CONSTRUCTION OF GENETIC LINKAGE MAP USING BI-PARENTAL PROGENY POPULATION OF AMRAPALI AND SENSATION

Manish Srivastav[1], Nidhi Radadiya[1], Pawan Jayswal[2], Sangeeta Singh[3], Sridhar Ramachandra[1], Ankit Singh[1], Rajani Devi[1], Geetanjali Tandon[4], Nisha Singh[2], Ajay Kumar Mahato[3], H. R. Meena[1], Mir Asif Iquebal[4], Rakesh Singh[5], Sanjay Kumar Singh[1], and Nagendra Kumar Singh[2]

[1]Division of Fruits and Horticultural Technology, ICAR- Indian Agricultural Research Institute, New Delhi- 110 012, India

[2] ICAR- National Institute of Plant Biotechnology, New Delhi- 110 012, India

[3]National Institute of Plant genome Research, New Delhi 110 067, India

[4]ICAR- Indian Agricultural Statistics Research Institute, New Delhi -110012, India

[4]Division of Plant Genomic Resources, ICAR- National Bureau of Plant Genetic Resources, New Delhi -110012, India

Email: msrivastav@iari.res.in; manishfht@gmail.com

Mango breeding is tedious and time consuming owing to highly heterozygous nature of this perennial fruit crop, coupled with relatively long juvenile period. The poor understanding about genetics of important horticultural traits makes the breeder's job more difficult. The speed and precision of mango breeding can be improved by developing high density genetic linkage maps, thus facilitating the development of diagnostic markers for polygenic traits and identification of genes controlling complex phenotypes.

Bi-parental progenies obtained by crossing contrasting parents Amrapali and Sensation were genotyped using 80K SNP AffymetrixAxiom(®) array. All 96 samples passed with average DQC (0.97) and call rate (96.89). Out of yielded 80821 SNP markers, 67188 markers were selected for further linkage analysis after excluding 5% missing call. Among them 7718 markers showed 1:2:1 Mendelian segregation ratio. These markers again mapped on physical map of Dashahri genome that yielded 3134 and 5112 SNPs having one SNP per gene and all SNP per all genes respectively, after allowing 100% base call rate. SNP markers (3134) markers were selected for the linkage map analysis with population type F_2 by JoinMap 4.1. Significant deviation from expected Mendelian genotypic frequencies (1:2:1 genotypic ratio for F_2 population) was tested using chi-square tests ($p<0.005$). 2624 SNPs were successfully mapped on 20 linkage groups (LG) and spanned 5931.85 cM with a mean distance of 2.78 cM between markers. Among 20 LGs, LG 10 has shortest length (190.47 cM) with 139 SNPs, whereas, LG 11 has highest length (382.10 cM) with only 55 SNP markers. The length of other LGs were ranging from 223.31 to 373.07cM. The observed map length (Go) and observed map coverage (Co) were 5931.85 and 98.13%, respectively.

The construction of high-resolution genetic linkage map and identification of QTL(s) for important horticultural trait(s) is under way. These resources will fast track the mango varietal improvement for superior end use quality.

Oral Paper

GENETIC AND GENOMIC RESOURCES FOR CUCURBIT IMPROVEMENT

Dr Manjusha Verma
ICAR-National Bureau of Plant Genetic Resources, New Delhi 110 012
Email: dinakara.adiga@gmail.com; jd.adiga@icar.gov.in

ABSTRACT

Cucurbits are economically important vegetable and fruit crops that are valued for their nutritional and health benefits. They comprise major cucurbits growing globally— cucumber, melon, watermelon and squash/pumpkin and others—bitter gourd, bottle gourd and luffa popular in many Asian and African countries. These crops are nutrient-rich and traditionally grown and consumed by subsistence farmers in Asia and Africa. They are increasingly vulnerable to various biotic and abiotic stresses, due to which the genetic and genomic resources are key for improvement of the crops. Currently, sizable-untapped genetic resources of cucurbit crops are present that offer promise for improvement for stresses as well as nutritionally superior varieties. Also, the potential of cucurbit genomic resources, such as molecular markers, genetic maps, and DNA sequences is manifold for the efficient and accelerated delivery of the climate-smart and nutritionally rich varieties. The last decade has witnessed a rapid development of genetic and genomics resources including draft genome assemblies, chromosome level assemblies and high-density genetic maps in several cucurbit crops, creating opportunities for accelerated research for cucurbit improvement. Here, we highlight the achievements and future directions in cucurbit research and present a variety of topics ranging from development and improvement of the cucurbit genome assemblies to identification and molecular mapping of horticulturally important QTLs/genes and their utilization in marker-assisted selection for cucurbit improvement. Despite several developments from limited genetic resources, these crops have endured diminutive systematic research. This presents a dual challenge and an opportunity, to tap the genetic resources from hotspots of biodiversity and endow unique alleles for cucurbit improvement. The rationale of this assessment, first, is to highlight the nutritional and nutraceutical traits of cucurbit species that hold potential for selection and improvement of genetic resources and genomics research. Additionally, the evaluation will note current trends and gaps in the literature and make recommendations on conservation and utilization of cucurbit diversity to accelerate crop improvement for subsistence farmers in Asia and Africa.

COMPARISON OF FLOW CYTOMETRY, STOMATAL TRAITS, AND MORPHO-TAXONOMICAL CHARACTERS FOR DIFFERENTIATING NEYPOOVAN DIPLOID FROM ITS AUTOTETRAPLOIDS

Arjun Singh, D. Ramajayam, S. Kalpana, Dinesh Kumar Agarwal, M Ranjani, R. Sivasankari, R. Jayaprakash, S. Uma
ICAR-NRCB
E-mail: arjunsiari@gmail.com

ABSTRACT

Banana is an important fruit crop of India. It has a wide diversity of ploidies largely derived from *Musa acuminata* and *M. balbisiana*. Knowledge of ploidy level in *Musa* accessions is vital crop improvement. Inexpensive and accurate method for the determination of ploidy is of utmost importance for breeding next-generation plants. Although protocols for root-tip chromosome counting or flow cytometry analysis are in vogue in banana, these techniques are expensive and skilled. Therefore, this study aimed to identify, compare and standardise new, economical, easy to carry out methods for ploidy determination.

In the present investigation, 3rd leaf parameters of 6 diploid (2n) and 30 autotetraploid (4n) plants of Neypoovan cultivar of banana were used. Morpho-taxonomical parameters (height of petiole (Hp), petiole-leaf blade junction (HLBPJ), leaf tip (HLT)) and derived parameters like the ratio of HLT/Hp, HLT/HLBPJ, leaf and petiole parameters (length, width, and weight) beside leaf drooping angle (Tanθ) were recorded and analysed. The ratio of HLT/Hp, HLT/HLBPJ, was 0.76, 1.72, and 0.68, 1.41 for 4n and 2n respectively, found significantly different. Similarly, Tanθ was 48.61 and 78.96 for 4n and 2n, respectively. Leaf length (219.36cm, 173.50cm), petiole length (75.36, 53.25cm), fresh weight of petiole (0.37, 0.15kg) and leaf blade (0.58, 0.31 kg) were found significantly different for 4n and 2n. The correlation coefficient of flow cytometry with Tanθ (-0.71), HLT/Hp (0.61), and HLT/HLBPJ (-0.59) was found to have strong correlation. Based on results, morpho-taxonomical parameters like leaf drooping angle (Tanθ), HLT/Hp, and HLT/HLBPJ can be used to differentiate Neypoovan autotetraploid from its diploid.

Oral Paper

DE NOVO TRANSCRIPTOME ANALYSIS OF ROOTS OF GRAPE ROOTSTOCK 110R IN RESPONSE TO SALT STRESS

Anuradha Upadhyay, Manisha Shinde and Ajay Kumar Upadhyay
ICAR-National Research Centre for Grapes
E-mail: anuradha.upadhyay@icar.gov.in

ABSTRACT

Grape (*Vitis vinifera* L) is an economically important fruit crop worldwide. In India, grape is mainly grown in semi-arid regions of Maharashtra, which accounts for about 70% grape cultivation in India. During its life cycle, grapevine experiences several biotic and abiotic stresses. Among the different abiotic stresses, salt stress has significant effect on the growth and yield of grapevine. Therefore most of the commercial varieties are grafted on tolerant rootstocks. Rootstock 110R has salt exclusion properties and is recommendation for grape cultivation under saline conditions of soil and irrigation water. RNA seq based *de novo* transcriptome analysis of roots of 110R was performed at three time points to understand response of rootstocks at molecular level. A total of 4227 transcripts were differentially expressed in salt stressed samples across three time points. The number of DETs in salt stressed roots at 6h, 24h and 7 days were 1965, 1669 and 820 respectively. At 6h, 836 transcripts were downregulated whereas 1129 were upregulated. The number of downregulated and upregulated transcripts at 24 h was 1081 and 588 respectively and 254 and 564 respectively at 7 days. Most of the DEGs were stage specific and only a few were common at two time points. Only 33 transcripts were common among three time points. Gene ontology analysis revealed modulation of genes involved in protein metabolism defence response, DNA binding and hydrolases. Several ion transporter genes were also modulated in response to salt stress. This information will help understand the mechanism of salt stress tolerance in 110R and identify the key genes involved in tolerance mechanism.

EVALUATION AND IDENTIFICATION OF PROMISING GENOTYPES FOR IMPORTANT FRUIT CHARACTERS IN POMEGRANATE

Shilpa Parashuram, Dhinesh Babu, N V Singh, P G Patil, Roopa Sowjanya P, Rahul A Kade, Dipali C Jadhav, Tukaram H Daphale, R A Marathe
ICAR-National Research Centre On Pomegranate, Solapur
E-mail:

ABSTRACT

Pomegranate (*Punica granatum* L.) is an important commercial dry land crop of India, which is widely consumed as fresh fruit and also in processed forms. Development of new varieties is need of the hour in pomegranate to overcome the menace of mono-varietal ("Bhagawa") cultivation in large areas. In this context a preliminary evaluationof 28 pomegranate genotypes for 10 important fruit characteristics was carried out during 2020-21. The statistical analysis (R package v. 0.1.0 & 1.0.1) has showed the presence of significant variation for Fruit Weight(g), Fruit Volume(cc), Fruit length(mm), Fruit Diameter(mm), Aril Weight(g), 100 Aril Weight(g), Aril Width(mm) ranged from 144.21(NRCPS-19) to 382.18(NRCPS-23)g; 120.08(NRCPS-22) to 359.33(NRCPS-23) cc; 64.61(NRCPS-19) to 85.35(NRCPS-23)mm; 64.67(NRCPS-19) to 86.12(NRCPS-23)mm; 75.63 (NRCPS-19) to 238.07(NRCPS-23)g; 19.9(NRCPS-13) to 46.24(NRCPS-23)g; 4.95(NRCPS-13) to 7.14(NRCPS-7) mm among genotypes, respectively. Considerable variation was also recorded for fruit rind colour (Yellow-red tinge to red) to aril colour (Light yellow to dark red). Based on the least significant difference test, three genotypes (NRCPS-7, NRCPS-8 and NRCPS-23) were found promising with better fruit weight (290.35g, 279.74g, 382.18g), 100 aril weight (39.47g, 34.05g, 46.24g), aril length (10.81mm, 10.42mm, 11.18mm), aril width (7.14mm, 6.72mm, 6.92mm), total soluble solids (16.50Brix, 16.440Brix, 17.510Brix) and acidity (0.26%, 0.25%, 0.25 %) content than the check varieties *viz*. 'Bhagawa' (268.59; 31.35g; 10.35mm; 6.55mm; 15.520Brix; 0.29%) and 'Ganesh' (338.22g; 34.53g; 10.69mm; 6.77mm; 16.370Brix; 0.31%). Further confirmation with replicated trial is needed to utilize these identified promising genotypes as potential varieties for commercial cultivation or as important genetic resource for future use in pomegranate improvement programmes.

Oral Paper

MOLECULAR MARKERS LINKED TO BACTERIAL WILT (RALSTONIA SOLANACEARUM) RESISTANCE GENE LOCI IN EGGPLANT (*SOLANUM MELONGENA* L.)

Pandiyaraj P, Lakshmana Reddy D C, T H Singh
Indian Institute of Horticultural Research
E-mail: pandiyaraj.p7@gmail.com

ABSTRACT

Bacterial wilt (BW) (Caused by *Ralstonia solanacearum*) is the most devastative soil-borne disease in eggplant, causing sudden wilting of the plants before flowering, followed by yellowing of leaves and stunted growth. The molecular marker linked to BW resistance loci will help in the selection and development of elite eggplant resistant cultivars. Bulked segregant analysis (BSA) was performed in two segregating F2 populations with BW resistance. These populations were derived from the cross between resistant cultivars CARI–1 and IIHR–7 and susceptible cultivars Rampur Local and Arka Kushmakar (IIHR–108). The present inheritance studies indicated that the eggplant BW resistance is governed by single dominant gene. A total of 390 single sequence repeat (SSR) markers were used in the survey of parental polymorphism, and 42 SSRs were found to be polymorphic. The SSR markers, emb01D10, emh11I06, emh02E08, and SSR–46 co–segregate with resistant and susceptible genotypes of the two F2 populations and linked to BW resistance loci. These four SSR markers are followed mendelian genetics for subsequent generations. In addition, they are useful in marker-assisted selection and eggplant breeding effectively. This is the first report describing the association of SSR markers with BW resistance loci in eggplant.

STUDIES ON GROWTH ANALYSIS TRAITS AND ACFT GENE EXPRESSION FOR BULB YIELD IN KHARIF ONION

Sabina Islam, Jayanth K,B. S. Tomar,Manisha Mangal,Shrawan Singh, V. K. Verma[2]
[1]ICAR-IARI, New Delhi
[2]ICAR Research Complex for NEH region
E-mail: tokumkum1@gmail.com

ABSTRACT

The present study was carried out in 34 *kharif* onion genotypes and 11 morphological traits were studied at 60, 90 and 120 days after planting (DAP) to analyze 8 growth analysis traits. The bulb yield and total yield were measured to estimate harvest index. The bulb yield varied from 1.92 - 30.65 t/ha while biomass yield ranged from 6.27 - 54.1 t/ha. Leaf area index (LAI) at 60 DAP ranged from 0.11 - 1.09 which increased to 0.36 - 2.19 at 120 DAP. The differences in leaf area ratio (LAR) at 60 DAP between highest and lowest genotype was 5.39 fold which increased to 6.94 fold at 120 DAP. High leaf weight ratio (LWR) at early growth stage and low value at harvesting is desired for onion and the genotypes exhibited significant difference for this trait. The high yielding genotypes (>25.0 t/ha) followed this trend and lowest LWR (0.09 gg-1) at 120 DAP was recorded in PKO 1964 (29.35 t/ha). The specific leaf area (SLA) which corresponds to photosynthesizing area ranged from 63.67 - 142.53 cm2 g-1 at 60 DAP and changed to 74.81 - 131.57 cm2 g-1 at 120 DAP. The specific leaf weight (SLW) gives an idea of biomass production and ranged from 0.07 - 0.16 at 60 DAP and the value ranged from 0.08 - 0.13 at 120 DAP. High crop growth rate (CGR) (12.22 g m-2d-1)was observed at 90 - 60 days interval compared to 120 -90 days (4.73 m-2d-1). Similar to CGR, absolute growth rate (AGR) was high at 90-60 days interval (0.48 cm d-1) compared to 120 - 90 days interval (0.10 cm d-1). Harvest index (HI) ranged from 6.27 - 80.28. The lowest HI was observed in lowest yielding genotype PKO 1908. However, the highest HI was observed in PKO 1923 (12.05 t/ha). The HI of highest yielding genotype was 57.96. The association analysis revealed that LAI at 60 DAP exhibited highly significant positive correlation (0.59) with yield, however, the associations were found non-significant at later growth stages. LAR and LWR at 120 DAP exhibited highly significant negative association with yield (-0.44 and -0.51, respectively). SLA at 60 DAP exhibited highly significant negative association (-0.45) while SLW exhibited significant positive association (0.38) with yield. The CGR exhibited non-significant association with yield at both the intervals (90-60 days and 120-90 days). Absolute growth rate between 90 - 60 days interval exhibited significant negative correlation with yield while the association was found non-significant at 120 - 90 days interval. Leaf area duration at 90 - 60 days interval exhibited highly significant positive association with yield and exhibited non-significant negative association at 120 - 90 days interval. Harvest index exhibited highly significant positive association with marketable bulb yield. The role of *AcFT* genes in bulbing were studied in three genotypes having three levels of bulb development.

FROM GERMPLASM CHARACTERIZATION TO FUNCTIONAL GENOMICS-A HOLISTIC APPROACH FOR TROPICAL CARROT (*DAUCUS CAROTA* SUBSPP *SATIVUS*) IMPROVEMENT

Sarvamangala Cholin[1], Chaitra Kulkarni[1], Chaitra Poleshi[1], Manikanta DS[1], Akhilesh Bajpai[2], Fakrudin B[1]

[1]University of Horticultural Sciences Bagalkot,

[2]Shodhaka Life Sciences

E-mail: sarugpb@gmail.com

ABSTRACT

A research was initiated with germplasm characterization of around 150 diverse Indian germplasm collections comprising of vast adaptable and multi-colored types by phenotyping for root and floral characters and genome wide molecular markers as well. From the population structure analysis and genetic diversity assessment, presence of wide genetic diversity with the moderate genetic differentiation among the subpopulations was understood. Later, promising genotypes that were maintained by sib-pollination were subjected to modified Marker-assisted recurrent selection program for carrot tropical carrot population improvement using gene specific markers targeting higher carotenoid, nematode resistance and higher sugar content. After three successful recurrent selections involving combined phenotyping (traits without markers) and genotyping (for trait linked with markers), two populations with higher beta carotenoid content (>7.0 mg/100 g) than the parents and also superior in terms of root yield and internal and external root uniformity were successfully improved. The populations are under farm trial. Further, in order to understand the secondary storage root development and flowering biology of domesticated temperate adapted European carrots with the tropical adapted Asiatic carrots, two economically important tissues such as matured tap root and floral primordia were subjected to RNASeq in triplicates by next generation sequencing platform. Both reference based and *de novo* based assembly of root and flower transcriptome produced high quality assembly. A total of 2239 and 789 differentially expressed genes (DEG), along with 477 and 1234 genes encoding for transcriptional factors (TF) were respectively identified in root and flower transcriptome. Gene regulatory network (GRN) analysis of root transcriptome also confirmed the co-expression of photosynthesis and vascular cambium related genes in association with biotic and abiotic stress responsive genes in Western and Asiatic orange cultivars and are considered as key factors that distinguish these two contrasting cultivar types of carrot for storage root development. GRN for flowering related genes showed key regulatory network involved in floral transition and floral morphogenesis that are distinct to each of the cultivar types were identified.

INNATE DEFENCE MECHANISM AGAINST CHILLI LEAF CURL DISEASE IN RESISTANT HOT PEPPERS

Manisha Mangal*[1], Arpita Srivastava[1], Khushboo Singh[1], P.K. Jain[2], K.Gaikwad[2] and Bikash Mandal[3]

[1]Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi, India
[2] ICAR-National Institute for Plant Biotechnology, New Delhi, India
[3]Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi, India
E-mail: manishamangal@rediffmail.com

Hot pepper (*Capsicum annuum* L.) is an important crop grown worldwide for vegetable, spice, ornamental, medicinal and lachrymatory uses and is an important dietary source of vitamins A, B-complex, C, E and minerals like molybdenum, manganese, folate, potassium and thiamine. Enormous economic losses are caused to this crop due to the infection by viruses of the genus *Begomovirus* (family *Geminiviridae*) which cause leaf curl disease. This group of viruses have circular single-stranded (ss) DNA genomes, that are encapsidated in distinctive twinned icosahedral (geminate) particles and are transmitted exclusively by the whitefly *Bemisia tabaci*. In some parts of India the farmers have abandoned cultivation of crop in *Kharif* due to the devastation caused by the disease. Therefore searching the sources of resistance to this disease and understanding the mechanism of resistance in the resistant sources is the need of the hour. In our endeavor to achieve this objective DLS-sel-10 a tolerant source to ChiLCV was identified at ICAR-IARI, New Delhi. Transcriptome of the resistant host DLS-Sel-10 was compared with the susceptible Phule Mukta following challenge infection with the virus. The study led to the identification of a number of differentially expressing transcription factors (TFS), mi RNA of host and the virus (ChiLCV) as well as host targets of the differentially expressing ChiLCV miRNA. In addition role of post transcritptional gene silencing in resistance to ChiLCV was also investigated. The study provided an important insight for understanding the mechanism of resistance in tolerant hosts against chill leaf curl disease.

DEGREE OF GENETIC DETERMINATION AND EXPECTED GENETIC GAIN FOR QUANTITATIVE TRAITS IN LUFFA GOURD (*LUFFA CYLINDRICA* L.) GENETIC RESOURCES OF ASSAM

Ira Sarma, Deepa Borbora Phookan, Akashi Sarma, Rupam Borgohain, Luchon Saikia, Jumi Saikia, Prakash Kalita
Assam Agricultural University
E-mail: ira.sarma@aau.ac.in

ABSTRACT

Luffa gourd or sponge gourd is an important and popular vegetable crop in Assam, North east and entire India. There are lots of germplasm of luffa gourd in Assam varying in fruit length, fruit girth, fruit weight, fruit skin type and other various morphological traits including fruit yield. The literature on studies regarding estimation of genetic variability and diversity of luffa genetic resources of Assam is not available. Thirty-three germplasm of luffa gourd were collected from across the places of state of Assam including one germplasm from Nagaland and an improved variety Pusa Sneha. Genetic variation was studied among the various germplasm of this crop for important metric traits and components of genetic variation was estimated in the study.The collected germplasm were evaluated in randomised block design during kharif 2017. Analysis of variation for various quantitative traits were performed using standard procedures. The genetic parameters, viz. genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), degree of genetic determination (h^2) and expected genetic gain as per cent of mean (GAM) were estimated for various quantitative traits as per the methods reported in Singh and Chaudhary (1985).The characters namely, primary branches per plant, internode length, fruit length, fruits per plant and marketable fruit yield per plant had high (>20%) estimates of both PCV and GCV. These results indicated that considerable improvment on luffa gourd could be made through selection of individuals for these traits in desired direction. Both PCV (38.60%) and GCV (36.40%) were had the largest values for marketable fruit yield per plant. High estimate of both the degree of genetic determination (> 60%) and expected genetic gain as per cent of mean (> 20%) were observed for all the traits except vine length. Traits with both high degree of genetic determination and high expected genetic gain as per cent of mean indicated that they were mostly under the control of genes with addtive gene action.

Day 2, November 19, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session IV

CROPS FOR ROUND THE YEAR PRODUCTION

Chairman	:	Dr Brijendra Singh
Co-Chair	:	Dr B.S. Tomar

Brief Bio-Data

Dr Bhoopal Singh Tomar

Born on 1st Dec. 1963 at Bagpat, U.P. Dr Bhoopal Singh Tomar obtained his B.Sc. Ag. and M.Sc. Agricultural Botany degree from Meerut University and Ph.D. degree in (Hort.) Vegetable Crops from ICAR-IARI, New Delhi. He is the recipient of Jawaharlal Nehru Award for Ph.D.

Dr Tomar has started his career Research Assistant from Division of Vegetable Science in and continued till 1996, later joined Agricultural Research Service in Seed Technology in 1996 and rose to the level of Principal Scientist, Seed Technology. Dr Tomar has joined as Head, Division of Vegetable Science, ICAR-IARI, New Delhi in 2016 and continued till date. He also working as Professor, Vegetable Science as well as Joint Director (Extn.), IARI since March 2021.

He have been associated in the development of 24 vegetable crop varieties/ hybrids and signed 15 MoUs with seed companies and generated revenue of Rs. 28 lakhs. He has guided 17 M.Sc. & Ph.D. students. He has organised production of breeder & IARI seed of more than Rs. 75 lakh. He has delivered > 500 All India Radio and Doordarshan.

Dr Tomar has published 98 research papers comprising 79 research papers > 6 NAAS rating including 10 in repute foreign journals. He also published 10 bulletins, 2 practical manuals, 150 popular articles & edited 3 books. Dr Tomar received IARI Best Teachers Award in 2014, Fellow of IAHS, ISVS, ISST & ISSS and Executive Councilor member in IAHS & ISVS. He is member Scientific Advisory Committee, NHRDF and member of Editorial Board of Indian Horticulture and Editor, Current Horticulture. He has also served as TCDC consultant in FAO in Uzbekistan during 2009.

TECHNOLOGICAL INTERVENTION FOR YEAR-ROUND PRODUCTION OF VEGETABLE CROPS

B.S. Tomar*, S.S. Dey, and Partha Saha
Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi 110012
E-mail: bst_spu_iari@rediffmail.com

ABSTRACT

In the recent past, significant improvement in transportation facilities and consumer preference for wide variety of vegetable crops facilitated year-round production of several vegetables. Genetic diversity and architecture for climatic adaptation in different crops like cole groups of vegetables, root crops, bulb vegetables and leafy vegetables are a key factor in their availability in different seasons in spite of photo-thermo sensitive in nature. Cauliflower is a classical example with evolution of different maturity groups which are suitable for cultivation under different temperature condition varied from 10^{o} up to 40^{o}C. However, selection of suitable cultivar and F_1 hybrids from different climatic regions is the key for their successful cultivation. Similarly, in onion development of cultivars for *Kharif* season made it possible to harvest onions from November onwards till March when the onions produced and stored under low temperature are not available. Sufficient genetic variation is also available in crops like tomato, brinjal, carrot, radish, French bean, important leafy vegetables like palak and amaranthus for their successful cultivation in different seasons. In case of brinjal the high temperature tolerant local accessions like Bijnour Local and Panipat Gol are cultivated in different parts of North India during the extreme summer condition either as single cropping or mixed cropping system. Therefore, thermo and photo sensitive crops like carrots, cauliflower, broccoli and cabbage can be cultivated even during the summer seasons in high altitude hilly regions where suitable conditions are available. Themo-pohoto insensitive crops like tomato, brinjal, okra, chilli, melons are cultivated different regions almost in all seasons under moderate temperature condition. Fresh garden peas are also available during the summer seasons from July onwards supplied from temperate districts of Himachal Pradesh like Lahaul Spiti. Manipulation in climatic condition through protected structures are instrumental in off season and safe cultivation of key vegetable crops like tomato, cucumber, capsicum, chilli, brinjal, coriander, bitter gourd and melons. Availability of micro-climate under inter-cropping systems with sugarcane and maize also facilitated cultivation of beans, cucumber, long melon, round melon and snap melon during the summer seasons.

Convergence of the improved agro-techniques, reducing post-harvest loss through suitable storage and modern breeding techniques can do wonder in cultivation and availability of diverse vegetables crops year-round to meet the challenges of nutritional security and to enhance farm income.

Dr P.K. Gupta

Dr Gupta born on 11th February, 1971 in Gazhipur district in U.P. He has done graduation in Agriculture in 1993 from Kanpur University, Kanpur with 1st position in the college. He has done post-graduation in Ag. Bio-chemistry and Horticulture in 1st Division and scored 1st position in the University of Allahabad. He did his Ph.D. from the University of Allahabad.

He has started his career in August, 2001 as a Technical Officer in Karnataka Agro-Chemicals, Bengaluru. He joined Amity University, Uttar Pradesh, Noida on 1st August, 2005 as a Senior Lecturer. During his service period he taught horticultural subjects to graduate and post-graduate students of different disciplines. He was a Project Coordinator of "Promotion of Organic Farming" from the Ministry of Agriculture, Govt. of India. He has joined National Horticultural Research and Development Foundation as a Joint Director on 7th June, 2011 at its H.O. at Nashik and presently he is Director (Acting), NHRDF, and Sr. Scientist & Head, KVK, New Delhi from 1st March, 2017.

During his 20 years' service, he received one Gold Medal from the Academy of Plant Sciences of India and Young Scientists' Award from Bioved Research Society, Allahabad in 2002 and 2003 respectively. He got a Fellowship from Bioved Research and Communication Center, Allahabad in 2010. He was conferred with the Honorary Fellow -2017 from Society of Horticulture Research and Development, Fellow of CHAI-2017. He is received appreciation certificate from Directorate of Agriculture, Govt. of Sri Lanka for Contribution in onion in the Asian countries in 2018. He also received the APSI Fellow-2018, IVSI Fellow-2019 and JISL-CHAI Fellowship 2020 for providing quality service to uplift the livelihood of horticultural growers.

He published different 85 research papers in National and International Journals and abstracts / popular articles and news clips etc. During his service tenure in NHRDF, 4 varieties of garlic and 2 varieties of onion were notified by the Ministry of Agriculture & Farmers Welfare, Govt. of India.

MANAGEMENT OF SURPLUS AND SCARCITY OF ONION IN THE COUNTRY

P.K. Gupta*, P. Bhaskar, S. Singh** and S.K. Tiwari***
*National Horticultural Research & Development Foundation, New Delhi
** National Horticultural Research & Development Foundation, Nasik
E-mail: drpkgupta11@gmail.com

ABSTRACT

Onion is one of the major bulbus crops in India, which is presently attracting consumers throughout the year. India has been traditional producer of onion and securing 2nd position in the world after China. In the country during the year 2019-20 total production of onion is 26.95 million tons from 16.53 million hectare area. In India onion is growing in three seasons of short day varieties and the share of these 3 seasons in production is 60-65% in *rabi,* 20-25% in *kharif* and 10-15% in late *kharif.* Onion price is increasing gradually in the month of September to till November and gradually decreasing after arrival of fresh onion in November last week to January and stabilized till June every year. Uncertainty of onion production in the wake of damage of standing *kharif* crop in onion producing state due to climate vagaries. After a huge spike in onion price government banned onion export or imposes MEP to stabilized onion price in the country time to time. The scarcity of onion in past two decades was happen in 1998, 2010, 2013, 2015, 2019 and 2020. The glut situation was happen during the year 2009, 2011, 2014 and 2018.

As onion crop is sensitive to weather vagaries and productivity depends on prevailing weather conditions the production trends are seen much fluctuating. There is need to reassess the requirement of onion for domestic and export market and plan for seed, bulb production and storage etc. Accordingly to ensure better returns to the farmers and to make onion available to the consumers at affordable prices;improved marketing network, providing cheaper transport facilities and incentives for export and marketing of onions by onion grower's associations can help to manage glut as well as crisis of onion. The weather prediction is also plays the major role to minimize the glut and scarcity of onion in the country. Processed production of onion needs to be popularized in domestic use and contract production for export and processing must be encouraged.

Brief Bio-data

Dr Pritam Kalia

Born on January 14, 1955, Dr Pritam Kalia obtained B. Sc. (Agri.), M. Sc. (Vegetable Science) degrees from HPU, Shimla and Ph. D. (Vegetable Science) from Himachal Pradesh Krishi Vishvavidyalaya, Palampur, HP. He did his post doctorate on Commonwealth Scholarship of the Great Britain from The Horticultural Research International, Wellesbourne (UK).

Dr Kalia started his career from HP Krishi Vishvavidyalaya, Palampur where he rose to the level of Professor before joining as Principal Scientist at ICAR-IARI, New Delhi in 2002. He took over as Head of Vegetable Science Division, ICAR-IARI, New Delhi in 2010 and served for more than six years. Dr Kalia served as ICAR-Emeritus Scientist at ICAR-IARI, New Delhi for three years.

He was awarded Dr. Kirti Singh Gold Medal, Himotkarsh Himachal Shri and Himachal Gaurav awards. For his outstanding contribution to Vegetable Science, he was awarded VASVIK Award, IAHS Shivshakthi Lifetime Achievement Award and Rafi Ahmed Kidwai Award of the ICAR.

During his career spanning over nearly 37 years, Dr Kalia developed 33 varieties of different vegetable crops. Registered genetic stocks 2 of CMS cauliflower, 4 of CMS tropical carrot, 1 resistant to each of black rot and downy mildew diseases of cauliflower with NBPGR. His major contributions are in exotic vegetables, nutraceutical and resistance breeding and genetic mechanisms facilitating hybrid breeding in cauliflower and carrot. Dr. Kalia contributed significantly in disease resistance etc. powdery mildew resistant garden pea variety Palam Priya, black rot and downy mildew resistant cauliflower varieties Pusa Paushja and Pusa Shukti. He established genetic mechanism cytoplasmic male sterility in tropical carrot and Indian cauliflower. He identified genes (*Xca1bo & Xca1bc*) which impart resistance to black rot disease in cauliflower, which are being bred into commercial varieties through marker assisted breeding. Dr. Kalia has introgressed betacarotene enhancing *Or* gene in Indian cauliflower.

Dr. Kalia has published more than 110 research papers in journals of repute. He has guided 5 M.Sc. and 6 Ph.D. students. He is Fellow of National Academy of Agricultural Sciences (NAAS), Indian Society of Vegetable Science (ISVS) and Indian Academy of Horticulture Sciences (IAHS).

ROUND THE YEAR PRODUCTION OF COLE AND ROOT VEGETABLE CROPS

Pritam Kalia and Shrawan Singh
Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi-110012
E-mail: pritam.kalia@gmail.com

ABSTRACT

The present paper highlights the efforts made in research and developments for year round production of cole and root vegetable crops. The varietal development efforts in cole vegetable crops led to breed a range of month specific varieties which can be grown from May to March months. These are broadly grouped into Extra-early or Early-I (temperature for curding: 25-30°C; maturity: September end – mid October), Early-II (20-25°C; mid October – mid November), Mid-early (16-20°C; mid November – mid December), Mid-late (12-16°C; mid December – mid January), late or snowball (10-16°C; February - March). On the basis of month of sowing, the available cauliflower varieties from public sector are: Pusa Meghna (May-June), Pusa Kartik Sankar and Kashi Aghani (June- July), Pusa Ashwini and Pusa Kartiki (June end to July end), Pusa Sharad (August), Pusa Paushja and Pusa Shukti (September- mid October), Pusa Snowball K-1, Kt-25, Pusa Snowball Hybrid-1, Pusa Cauliflower Hybrid -301 (October – November) and Pusa Snowball Cauliflower-2 (November). In case of cabbage, Pusa Ageti was developed to grow cabbage for early harvest, *i.e.* November month. Similarly in Broccoli, a range of varieties were developed which can be grown for harvesting in the months of November –January (Palam Samridhi, Pusa KTS-1) to February-March months (Palam Haritika, Palam Vichitra, Palam Kanchan).

With the development of heat tolerant Pusa Chetki variety that it became possible to grow radish from early April – mid August, and other varieties which followed are Pusa Desi (mid-August to mid-October), Pusa Reshmi (mid-September to mid –November), Japanese White and Pusa Shweta (mid-October to mid-December), while European types Pusa Himani (mid-December to mid-February) and White Icicle and Rapid Red White Tipped (second fortnight of October to February end) are suitable for respective months.

In carrot, development of heat tolerant Pusa Vrishti variety has facilitated growing of red carrot during August – November in North India, while for main season (i.e. September – October) sowing Pusa Rudhira is a leading variety. Orange carrot varieties, namely Pusa Meghali (tropical) suitable for October sowing and Nantes, Pusa Yamdagini and Pusa Nayanjyoti (temperate) can be sown from October – January months for harvest from January – April months. Heat tolerant tropical red carrot variety Pusa Vrishti can also be sown during March-April months for fresh harvest during May-June. In turnip, heat tolerant tropical variety Pusa Sweti is suitable for early season (August –November), whereas temperate types (Pusa Chandrima, Pusa Swarnima and Purple Top White Globe) are suitable for October-November sowing in North Indian plains.

However, there are certain concerns for growing year round vegetables particularly Cole vegetables such as that of insect pest evolution, pesticide usage, resurgence of insect pests, pathogen survival and disease incidences, and excessive water requirement during summers etc.

Oral Paper

RIVERBED CULTIVATION FOR OFF-SEASON VEGETABLE PRODUCTION

Sudhakar Pandey
ICAR-Indian Institute of Vegetable Research, PO Jakhani, Shanshahpur 221 305,Varanasi
E-mail: sudhakariivr@gmail.com

ABSTRACT

Diara land is the land which is subjected to the diluvion or alluvion as well as a result of flooding or an account of any change in the course of river. Generally in these areas amount of water starts to collect from the end of July and continues up to end of September. Riverbeds in the region are annually flooded during the extreme events, that's why, hardly used for agriculture and mostly left uncultivated. Therefore, during September to mid-May, this land may be utilized for cultivation of cucurbitaceous vegetable crops, when level of water flow in the river goes down. Fresh silt relay deposition is a normal feature which makes these lands suitable for cultivation of vegetable crops particularly cucurbits. Most of the diara land farming is practiced by the landless and poor farmers living near by the river bank for their alternative form of livelihood, which has helped them in income generation, sustain family nutrition, and as well as for food security. According to survey report, 50-60% of total cucurbit cropped area of the country falls under river beds. In India, cultivation of cucurbits like watermelon, muskmelon, long melon, pumpkin, ridge gourd, smooth gourd, snake gourd, bitter gourd, bottle gourd, pointed gourd and snap melon mostly in North, Central & eastern India, bitter gourd, snake gourd etc. in Kerala, pointed gourd and watermelon in Bihar and West Bengal is more common under river bed condition. Presently not only in India, but in other South East Asian countries also, cucurbits are commercially cultivated in the river bed areas. In survey it is observed that out of total area under cucurbits cultivation ~50% area is under river bed cultivation and during summer season around 55-60% of total cucurbits production is being produced in *diara* land area, which is available in the market from last week of January to June. At the time when there is increasing pressure of population and demand of land resources, the focus is now to exploit those areas which have not been properly attended till date. One of such tracts of land is *diara* land or river bed which is extensively available in Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh and some part of Rajasthan can be exploited with scientific interference to grow cucurbits to supplement the total production of vegetables in India. Besides, this type of farming has great scope to uplift the livelihood of the farmers as crops are come early to the market (off-season) as compare to their normal growing season and fetches higher market price of their produces. Riverbed cultivation also provide opportunity to grow vegetable organically as these land are marginally exploited for crop cultivation. The research in the area of diara-land has been initiated and through proper intervention the productivity and profitability has been improved to promote, protect and uplift *diara* land farming in India.

GENETIC DIVERSITY AND IMPROVEMENT IN ONION FOR WIDE ADAPTABILITY

Amar Jeet Gupta, Vijay Mahajan, Major Singh
ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune-410505 (MS)
E-mail: guptaaj75@yahoo.co.in

ABSTRACT

Onion (*Allium cepa* L.) is highly cross pollinated important spice as well as vegetable crop grown throughout the world. Diverse genetic materials are required to meet the ever changing demands of plant improvement. Diversity in onion species occurs in the form of land races, traditional varieties, wild edible forms and related non-edible wild and weedy species. ICAR-DOGR has been identified as a National Active Germplasm Site for onion and garlic germplasm collection and conservation in the country. Extensive germplasm surveys have been done from 16 states of the country in collaboration with ICAR-NBPGR as well as several lines of onion have been introduced from different countries through ICAR-NBPGR. A genepool of dark red, light red, white and yellow onion types has been collected. A total of 1259 germplasm accessions are being maintained at ICAR-DOGR consisting of 225 (dark red), 372 (light red), 309 (white), 35 (yellow), 8 (rose type), 61 (multiplier type), 139 (lines of 28 *Allium* species) and 82 (exotic). One dark red onion unique line 'DOGR-1203-DR' has been registered as genetic stock for very early maturity and uniform neck-fall with ICAR-NBPGR whereas, one pink multiplier onion unique line "DOGR-1549-Agg" has been registered as genetic stock for earliness and suitable for both *rabi* and *kharif* season. Based on genetic improvement and selection in the germplasm, ten onion varieties have been released at national level. Among these Bhima Super, Bhima Red, Bhima Raj, Bhima Dark Red, Bhima Shubhra, and Bhima Safed are suitable for *kharif* season whereas, Bhima Shakti, Bhima Kiran, Bhima Light Red and Bhima Shweta are suitable for *rabi* season. Bhima Shakti, Bhima Super, Bhima Red, Bhima Raj and Bhima Shubhra are also suitable for *late kharif* which indicates that these varieties have wide adaptability in changing climate. All the ten onion verities have been notified by CVRC.

STUDY OF PHOTOSENSITIVITY AND PHOTOSYNTHETIC EFFICIENCY IN ONION VARIETIES FOR CULTIVATING ROUND THE YEAR UNDER CLIMATE CHANGE SCENARIO

Kiran P. Bhagat[1], A.J. Gupta[2], K.V. Jawalekar[3], A.K. Upadhyay[3], Vijay Mahajan[2], Major Singh[2]

[1]ICAR-Directorate of Floricultural Research Pune

[2]ICAR-Directorate of Onion and Garlic Research Pune

[3]ICAR-National Research Centre for Grapes

E-mail: kiranbhagat.iari@gmail.com

ABSTRACT

Photosynthesis is one of the important factors which significantly attributes to the yield potential of any plant. Photosensitivity and photosynthetic efficiency of onion varieties depends on many factors, especially response of plants to photosynthetically active radiation (PAR) and ambient CO2 concentration. The availability of PAR is a dynamic phenomenon which fluctuates round the year due to earth revolution and the influence of climate change scenario. Therefore, an experiment was conducted to study the photosensitivity and photosynthetic efficiency of all the ICAR-DOGR released onion varieties (10 in numbers) during *Rabi* season, 2019-20 at Manjri Farm, Pune. The photosynthesis and related parameters were measured with the help of Advanced Photosynthetic System (Model No. GFS-3000). The results were recorded by providing constant 1000 µmol of photosynthetically active radiation (PAR) within the leaf chamber and found that Bhima Shakti performed better photosynthesis (9.876 µmol m-2 sec-1), followed by Bhima Kiran (9.624 µmol m-2 sec-1) and Bhima Shubhra (9.548 µmol m-2 sec-1), whereas Bhima Safed (6.630 µmol m-2 sec-1), followed by Bhima Dark Red (6.848 µmol m-2 sec-1) and Bhima Super (7.535 µmol m-2 sec-1) was recorded lower photosynthetic rate. The transpiration rate, the intercellular CO2 concentration and various physiological parameters were investigated, and found significant differences among the onion varieties. Further, among the varieties, light saturation points shown significant variations in response to the net photosynthetic rate. It was also observed that the transpiration rate is directly proportional to the photosynthetic rate and whereas, the vapour pressure deficit is inversely proportional to the relative humidity. In conclusion, the results of photosensitivity and photosynthetic efficiency in studied onion varieties at different light saturation points will help to select the varieties for production throughout the year.

Day 2, November 19, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session V

UNEXPLOITED/ UNDEREXPLOITED CROPS

Chair	**:**	Dr B.M.C. Reddy
Co-chair	**:**	Dr Prakash Patil

Brief Bio-data

Prof. (Dr.) P.L. Saroj

Prof. P. L. Saroj, born on 7th January, 1965 in Jaunpur district of Uttar Pradesh. He is ARS Scientist of 1991 batch. Prof. Saroj obtained his B.Sc. Ag., M.Sc. and Ph.D. degree in Horticulture (Pomology) from Narendra Dev University of Agriculture and Technology, Ayodhya. He is recipient of University Gold Medal and ICAR JRF and SRF for his Post Graduate Studies.

Prof. Saroj started his career as Asstt. Prof. in CCS University, Meerut in 1990 before joining as ARS Scientist in 1991. As Scientist, he served at ICAR-IIHR, Bangalore and ICAR-IISWC, Dehradun. In 1999, he was selected as Sr. Scientist at CIAH, Bikaner. In 2005, selected as Prof. & Head, Horticulture at SVPUAT, Meerut and also worked as Dean Student Welfare. In 2009, he joined ICAR HQ, New Delhi as Pr. Scientist & also served as ADG (H-I). In 2012, selected as Director, Directorate of Cashew Research, Puttur (Karnataka) & PC, AICRP-Cashew. From 2016 onwards, he is working as Director, Central Institute for Arid Horticulture, Bikaner (Rajasthan) & PC, AICRP-Arid Zone Fruits.

Prof. Saroj has versatile experiences over 30 years. Specialized in pomology, standardized anatomical indices for predicting plant vigour in clonal rootstocks of *Psidium* species, production technologies including use of rootstocks in guava and grapes; training systems in grape and *ber*, vegetative propagation techniques in guava, *aonla*, *ber*, *bael*, *lasoda* and tamarind, fruit-based cropping systems in mango, peach, *ber* and *aonla* and canopy architecture management in *ber*. Developed 16 varieties of fruits, plantation crop and vegetables.

Currently, Prof. Saroj is President, Indian Society for Arid Horticulture; besides Life Member of 12 professional societies. Worked as Visiting Scientist in World Agroforestry Centre, Kenya in 2004 and also led Indian delegation to Sri Lanka in 2011 for formulation of project on “Underutilized fruits and vegetables in SAARC countries”. He also visited USA, Kenya, Uganda, Tanzania, Nepal and Sri Lanka under various official assignments. He is currently Visitor’s nominee, BHU Varanasi and Member of Board of Studies, SKRAU, Bikaner.

Prof. Saroj has published 110 research papers, 07 books, 54 book chapters, 13 bulletins, 91 popular articles, 26 lead papers/ key note addresses. He is recipient of Young Scientist Award-1991; Bhartiya Vikas Ratna Award-2005; Dr BP Pal Scientist of the Year-2009, Scientist of the Year-2011, Life Time Achievement Awards in 2018 & 2019 and Sh. Girdhari Lal Chadha Gold Medal in Fruit Science in 2020 from professional societies. He is fellow of IAHS; ISHRD; CHAI and ISNS.

UNDEREXPLOITED ARID FRUITS AND VEGETABLES AND THEIR ROLE IN HUMAN NUTRITION

P.L. Saroj, R. Kumar and B. R. Choudhary
ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner 334 006, Rajasthan
E-mail: plsaroj@yahoo.co.in

ABSTRACT

Fruits and vegetables play important role in nutritional security by providing nutrients, vitamins and minerals through balanced human diet. This impressive growth in fruits and vegetable production has increased the availability of nutritive food and this was possible due to development of improved varieties and production technologies coupled with large scale adoption by the farmers. However, this remarkable production was contributed by only few major fruit and vegetable crops. The fruit and vegetable crops which are not grown commercially on large scale are termed as underexploited crops. The possible reasons for the low utilization of underexploited fruits and vegetables, in spite of their well known significance are owing to lack of availability of planting material, lack of awareness on nutritional and medicinal aspects and lack of information on production technologies of these crops. Underexploited arid fruit crops such as bael, phalsa, wood apple, fig, tamarind, mulberry, lasoda, kair and in arid vegetables such as kacri, mateera, bitter apple, arya, round melon, spine gourd, jhar karela, cluster bean, moth bean, phog, khimp, ivy gourd, Indian aloe and khejri are rich sources of energy and nutrients particularly micronutrients and vitamins. The micronutrients present are minerals (like iron and calcium) and vitamins (like vitamin B complex, C, folic acid, and carotenoids) while, the macronutrients present are complex carbohydrates/fiber. They contain plentiful amounts of iron, calcium, vitamin C, folic acid, carotenoids (vitamin A precursors) and phytochemicals. In this perspective, there is an imperative need to take up programme on genetic resources exploration, conservation, utilization and improvement of underexploited fruit and vegetable crops to provide nutritional security. The agro-climatic conditions of India are favourable for the production of various underexploited fruits and vegetables. Therefore, the underexploited fruits and vegetables production will meet the shortage of per capita availability of fruits and vegetables and also provide economic security to the rural populations.

Dr B.N. Hazarika

Prof. B N Hazarika, Dean, College of Horticulture and Forestry, and College of Agriculture, Pasighat, Arunachal Pradesh, also Officer in charge of MTTC&VTC, Nafra and KVK, East Siang under the CAU, Imphal. He served in CAU, Imphal, AAU, Jorhat, and ICAR Research Complex, Umiam, Meghalaya for last two decades. He guided a number of PG & Ph D students, handled several externally funded research projects and organized a number of state/national levels seminar/ Agri/ Horti expo and one International Symposium at College of Horticulture and Forestry,Pasighat as organizing secretary. His significant contribution is reflected with securing highest number of ICAR-JRF from the College and also country topper in Horticulture and Forestry from the College of Horticulture and Forestry, Pasighat. He has made significant contribution in the field of horticulture includes collection, morphological and molecular characterization of diverse genotype of various fruit crops, standardized production technology of virus free planting material of Khasi Mandarin, standardized good agricultural practices for some major fruit crops; introduced new fruit crops in the region; He was awarded with prestigious H K Jain Gold Medal with 1.0 lakh cash prize by CAU, Imphal besides a number of other awards including two Life Time Achievement Award.

POTENTIAL UNEXPLOITED FRUITS FOR MALNUTRITION FROM NORTH EASTERN REGION

B.N. Hazarika
Central Agricultural University, College of Horticulture and Forestry, Pasighat -791102, Arunachal Pradesh
E-mail: bnhazarika13@yahoo.co.in

ABSTRACT

The North-East India is a part of both Himalaya as well as Indo-Myanmar biodiversity hotspots in the world. It has the richest reservoir of plant diversity in India and is one of the 'biodiversity hotspots' of the world supporting about 50% of India's biodiversity. North Eastern region occupy 7.7% of total geographical area of country and harbours 50% of Indian flora (8,000 species) of which about 4% is endemic (2,526 species). The distinct tribes in the region have rich indigenous knowledge system on the use of components of biodiversity for their daily sustenance like food, fodder, shelter and healthcare. The region has several unique features such as fertile land, abundant water resources, evergreen dense forests of about 66%, high rainfall, and agriculture-friendly climate. Its unique phyto-geographical positions, topography and high degree of precipitation are some of the important factors which are mainly responsible for its enormous biological diversity. As a result, an array of unexplored plants are grown across the region ranging from tropical to alpine. A large number of diversity in fruits belonging to the genera *Artocarpus*, *Annona*, *Averrhoa*, *Garcinia*, *Musa*, *Passiflora*, *Phyllanthus*, etc. are reported from the region besides diverse vegetables, and spices with some unique quality because of their locational advantage. The region has a great ethno-cultural diversity with major and sub-tribes, which explains the wealth of traditional ecological knowledge among farmers. People of region have their own culture, tradition and medicinal system of treatment and knowledge acquired through close observation of nature. Its ethnic people living in the remote forest areas still depend to a greater extent on the forest ecosystems for their livelihood and avoid malnutrition. They collect different wild fruit plants along with other medicinal plants and use them in traditional ways to cure their health related forms. The minor and wild fruits are mostly used to cure various gastrointestinal disorders, respiratory problems, cardiovascular compliance, muscular illness, bone diseases, gynaecological problem, cancers, snake bite, allergy, malaria etc. by local people of the region besides their use as fruit. These lesser known fruits are rich in minerals like Ca, Fe, P, Mn, organic acid, vitamins and other nutrients like carbohydrates, proteins, and fats. Tribal people used to take lesser known fruits either raw or in the form of beverages, pickles or cooked / boiled with some other diets. This indigenous system of treatment based on such fruits is still an important part in social life and culture of the tribal people. Malnutrition affects badly in countries like India. The hidden potential of these novel fruits need to expore to strengthen the nutritional security. Even though, works on underutilized fruits are done, yet a large number of species being endemic remained underexplored. Hence, cultivation, promotion and conservation of these underexploited are very important.

This paper provides the information on some of the wonder underutilized fruit plants of the region and their ethno-medicinal as well as uses in overcoming malnutrition by the tribes of the region.

Brief Biodata

Dr G. Karunakaran

Dr G. Karunakaran, Principal Scientist (Fruit Science) at ICAR-Indian Institute of Horticultural Research, Bengaluru. His significant research contributions includes formulation of Road Map for the promotion of Dragon fruit in India and represented India to present the country report on "*Dragon Fruit Cultivation*" in DFNET Workshop in 2019 at Vietnam. He has developed and released: varieties in rambutan (Arka Coorg Arun & Arka Coorg Pitab), and one each in avocado (Arka Supreme), and bell pepper (Arka Coorg Excel). He developed the innovative model of linking biodiversity with livelihood security by identifying and releasing several farmer's varieties like jack fruit with coppery red flakes (Siddu, Shankara & Shree Halusu) and a tamarind with high pulp recovery and broader pulp thickness (Lakhsmana). He has developed high-yielding banana hybrids resistant against nematodes, evolved stable hermaphrodite genotypes in Coorg Honey Dew and developed Shoot Tip Grafting (STG) protocol to produce virus-free plants in Coorg mandarin.

Dr Karunakaran has published 15 research papers, 8 book chapters, 14 popular articles and 12 technical bulletins. He is a recipient of H.S. Mehta Memorial Best Young Scientist Award, 2017 and also received Best Ph.D. Dissertation Award for the year 2010.

EMERGING POTENTIAL NEW GENERATION FRUIT CROPS- ASSOCIATED CHALLENGES AND PERSPECTIVES

G. Karunakaran*, M. Arivalagan, T. Sakthivel and P.C. Tripathi
ICAR-Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Karnataka
IIHR-Central Horticultural Experiment Station, Hirehalli 572104, Karnataka
E-mail: karanstg@gmail.com

ABSTRACT

India is bestowed with diverse agro-climatic conditions that could favour the production of a wide range of exotic fruit crops having national importance in view of their yield and market potential. Many of these exotic fruits got introduced in to India through the travellers and migrant settlers from the South East Asian countries. Among them, Dragon fruit (*Hylocereus* spp.), avocado (*Persea americana* Mill.), Rambutan (*Nephelium lappaceum* L.), Mangosteen (*Garcinia mangostana* L.), passion fruit (*Passiflora edulis* Sims), durian (*Durio zibethinus* L.) and longan (*Dimocarpus longan* Lour.) were primarily introduced and raised in quite a few homesteads in India. Although precise documentary information is not available, all these introductions are of seedling origin to a great extent. Even though they got adapted gradually to the tropical humid western peninsular India, in majority, sexual propagation practiced by the growers has led to development of some amount of genetic diversity through gene flow, genetic introgression and probably some extent of genetic consolidation which has not been exploited to their full potential despite for their novelty, niche markets and economic value. Systematic work on the exotic fruit crops started at ICAR-IIHR, Bengaluru during the year 2000s by collecting and assembling the prevailing genetic diversity from their respective growing areas. Dragon fruit (Kamalam fruit) was introduced in India and presently the area under its cultivation is gradually increasing over the past 3-5 years. It can grow in a wide range of agro-climates regions of Southern, Western, and North-Eastern Indian states, which are dry and frost-free are highly suitable. Avocado is the most nutritive fruit and is regarded as one of the most important contribution of new World to human diet and due to its market value it is named as “Green Gold”. In recent time farmers from Tamil Nadu, Karnataka, Kerala, Maharashtra, south-central India and eastern Himalayan state of Sikkim establishing avocado orchards. Acreage under Rambutan reportedly has increased appreciably to about 1000 acres in Kerala, Karnataka and Tamil Nadu, where it is grown commercially in small Further, several other edible tropical fruits such as mangosteen, durian, longan, and passion fruit could also hold a promise to be potential exotic crops.

Empirical appraisal of agro-climatic requirements for these crops, profiling of potential tropical humid areas in parts of India through advanced tools for area expansion needs consideration. Such efforts need to be appropriately backed up by introduction of elite genetic resources already available with other countries. Undertaking awareness programme among the growers, consumers and entrepreneurs regarding the potential of these fruits in the local and export markets, development of trait-specific superior types, optimization of plant propagation techniques for rapid and large scale multiplication of quality planting materials, crop husbandry practices including pests and diseases management, post-harvest management and value-addition protocols are the critical needs for promoting these crops for diversification and sustainable livelihoods of the growers.

Brief Bio-data

Dr M.K. Verma

Dr M.K. Verma is presently working as Principal Scientist (Horticulture-Fruit Science) at Div. Fruits & Hort. Tech., ICAR-IARI, New Delhi. He received his Ph.D. in Horticulture (Fruit Science) in 1998. He is the recipient of JRF & SRF from ICAR. He is 1995 batch ARS scientist and joined ICAR services in 1998. He has successfully completed 14- externally funded projects funded by NATP, MoA, DST and DBT. Served 12 years at ICAR-Central Institute of Temperate Horticulture, Srinagar (J&K) and worked extensively on improvement of temperate fruits and nut crops. While serving in ICAR-CITH (1998-2009), he has developed internationally reputed varieties of walnut (10), apricot (3), sweet cherry (2) and apple (1) and production technologies on high density orcharding in almond, apple, apricot and saffron.

Since 2009, he is serving at ICAR-IARI, New Delhi and engaged in research, teaching and extension activities. He is working on grape breeding and quality improvement of grape and Kinnow. While working at ICAR-IARI, he has developed 4- hybrids of grape, 2- varieties of sweet orange and 2- varieties of acid lime. He published 86- research papers in peer reviewed journals, 4- books, 95- book chapters, 34- bulletins/folders and 10- popular articles. He is recipient of 'GL Chadha Gold Medal' in Fruit Science (2019) from IAHS and Young Scientist Award (2010) from BRIAT for his outstanding contribution in the field of fruit science. He is the fellow of nationally important professional societies like, Indian Academy of Horticultural Sciences (2013), ISNS (2017), ISHSD (2019) and SHRD (2020). He had served as Editor for Indian Journal Horticulture (2010-13); Asian Journal Horticulture; Journal of Agriculture for Sustainable Development and Agriways. He was the member of RAC and IMC of ICAR-CITH, Srinagar. Dr Verma also worked in the international laboratories at University of Castila-La Mancha, Spain and Horticulture Research Centre, Cairo, Egypt. He even represented as the member of Indian Delegation for finalization of apple maturity indices, held at Mexico City, Mexico.

POTENTIAL UN/UNDEREXPLOITED HORTICULTURAL CROPS FOR TEMPERATE REGION

M.K. Verma*, V.B. Patel, S.K. Singh and Chavlesh Kumar
Division of Fruits and Horticultural Technology, ICAR- Indian Agricultural Research Institute, New Delhi 110 012
*E-mail: mahenicar10@gamil.com

ABSTRACT

A wide range of wild temperate fruits occurs in the Indian Himalayas categorized under the category of unexploited and underutilized fruit crops. The agro-ecological niches and variation in altitude in North-Western Himalaya are suitable for adaptation of unexploited and underutilized temperate fruits having minor importance like *Rubus, Ribes*, *Viburnum*, *Pyrus* and *Prunus*. Species of pome fruits, in addition to cultivated fruits like apple and pear, *viz. Malus*, *Pyrus*, *Sorbus*, *Cydonia*, *Cotoneaster*, *Crataegus*, *Pyracantha*, *Diospyrus* and *Docynia* are also prevalent. Several other species that are indigenous to India are also available in these hilly areas. These minor crops can assure yield, tolerance to biotic and abiotic stress and low input. Very little attention has been paid by the researchers in case of minor temperate fruit crops for its exploitation at commercial scale. Moreover, the size of the fruit, less pulp-to-seed ratio, undesirable sugar-to-acid ratio, perishable nature of the fruit, less productivity, presence of protective structures (spines, prickles), long juvenile period and lack of awareness about their potentiality are the major limiting factor for its popularization. There is also a need to investigate value-addition useful for product and processing, medicinal, ornamental and other potential applications.

In last century, several wild species have emerged as potential fruit crops for commercial exploitation due to their higher yield potential, nutritionally rich fruits, tolerant to biotic/ abiotic stresses and adaptability to the varied temperate ecological regions. Some notable success stories are associated with kiwifruit, avocado, blueberries, pistachio and macadamia nut, and many others. Currently there are a number of species in the process of being domesticated for horticulture. The sequence of events involved in developing a wild species to the point of commercial production is in most cases similar. It involves making an extensive germplasm collection to establish whether there are genotypes suitable for direct utilisation. Studies of the floral biology of the species are required to bring about regular cropping, in new environments. Attention must be paid to fruit quality as quite subtle differences in acid, sugar and flavour levels can affect the palatability of fruit. Postharvest aspects are most important as for commercial production with extended shelf life are required. Subsequent steps involve developing methods of clonal propagation so that superior genotypes can be multiplied by rooting cuttings or by budding or grafting them to rootstocks. With most species plant breeding is used to combine into potential cultivars the desirable characteristics of different genotypes. It is essential with new crops to develop methods to control both insect pests and micro-organism infections. With new species with new flavours, textures and appearances, market acceptability trials can be unrewarding. There is a requirement to have growers, processors, and enthusiastic consumers who have faith in the crop and are prepared to promote its use over a long period of time to obtain market penetration.

Dr T. Stobdan

Dr Tsering Stobdan, Scientist 'F' is the Head of Horticulture Division at Defence Institute of High Altitude Research (DRDO), Leh. He received his B.Sc. in Horticulture from University of Horticulture & Forestry, Solan; Masters in Molecular Biology & Biotechnology from G B Pant University of Agriculture & Technology, Pantnagar; and Ph.D. in Molecular Biology & Biotechnology from Indian Agricultural Research Institute, New Delhi. He has published over 70 research articles on topics related to horticulture and protected cultivation in Ladakh. Seven Research Fellows have been awarded Ph.D. degree under his supervision.

Dr Stobdan has made several outstanding research and extensions in Ladakh. He identified native apricots (*Raktsey Karpo*) as the world's unique and sweetest apricots resulting in fetching premium price to the farmers. Based on his report, Seabuckthorn is included as an activity under the MIDH scheme of GoI. He introduced watermelon as a new cash crop in Ladakh. He developed passive solar greenhouses wherein he demonstrated growing of warm season crops in sub-zero temperatures.

Dr Stobdan has been awarded the prestigious 'Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems-2018' by Indian Council of Agricultural Research (ICAR). Dr Stobdan has also been honoured with 'Young Scientist Award-2015' by Seabuckthorn Association of India; and National Science Day Medal-2015 & National Technology Day Medal-2016 by DRDO. Dr Stobdan is the Fellow of Indian Academy of Horticultural Sciences (IAHS) and Indian Society of Horticultural Research and Development.

POTENTIAL UN/UNDEREXPLOITED HORTICULTURAL CROPS FOR COLD-ARID REGION

Tsering Stobdan[1*], Deldan Namgial[2], O.P. Chaurasia[1], Mushtaq Wani[3], Tsewang Phunchok[4] and Mohmad Zaffar[5]

[1]Defence Institute of High Altitude Research, Defence R & D Organisation, Leh-Ladakh-194101, India

[2]High Mountain Arid Agriculture Research Institute, SKUAST-K, Stakna, Leh Ladakh, India

[3]Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, India

[4]Horticulture Department, Leh Ladakh-194101, Union Territory of Ladakh, India

[5]Horticulture Department, Kargil Ladakh, Union Territory of Ladakh, India

ABSTRACT

Ladakh is the biggest apricot producer in India. The total fruit production is 15,789 MT (Leh: 5,133; Kargil:10,656 MT). The fruit crop is a major source of livelihood and is also deeply associated with the tradition and culture of the region. The major part of apricot produced is consumed locally. The fruit is being sold in various forms, *viz.* fresh, dried, kernels, oils etc. Historically, the premium quality dried apricots, locally known as *Phating*, with high sugar and dry matter content, were one of the main trading commodities. *Raktsey Karpo*, apricots with white seed coat, is unique to Ladakh. It is the sweetest apricot and has been ranked as the most preferred cultivar for fresh consumption. However, of today, the popularity of Ladakhi apricots remains restricted to the region due to limited production, incidence of codling moth (*Cydia pomonella*), and lack of organized marketing system. The efforts to organize apricot marketing and drying have not been initiated in the region, and thus there is a need to organise fruit collection, processing, value-addition and marketing. The disorganized nature of the sector and adherence to certain inefficient production and processing techniques implies that 40-50 percent of the apricot production is wasted. Critical areas that need focused attention include promotion of premium quality cultivars, plantation in orchard system, adoption of standard cultural practices, conservation of the rich genetic resource, organic certification, adoption of integrated post-harvest management, management of insect-pests, and establishment of marketing infrastructure. In view of the uniqueness and premium quality of apricots of Ladakh there is immense scope for Ladakh to emerge on the world map for apricot production. Export of Ladakh fresh apricots started in year 2021.

Oral Paper

NUTRACEUTICAL: PRESENT STATUS AND PROSPECTS OF UNDERUTILIZED CITRUS FRUITS

Dinesh Kumar
ICAR-CCRI, Nagpur, Maharashtra
E-mail: dineshscn@gmail.com

ABSTRACT

Citrus fruits occupy better position in the world. In India, its production ranks third after mango and banana. However, the underutilized citrus species of Indian Wild orange (*Citrus indica*), Khasi Papeda (*Citrus latipes*), Citron (*Citrus medica*) remain neglected without any commercial importance. These varieties are among the largest citrus fruit most popular due to its phytochemical content and medicinal properties. There is need to create public awareness on the importance of citrus fruit which is relatively cheap and with high nutritional value. Our country is still importing the food supplements for having the nutritional security. There is an increased global interest due to the recognition that nutraceuticals play an important role in health enhancement and there is great awareness among the people for the beneficial effect of nutraceuticals in day to day life. Citrus phytochemicals possess biological activities and can be used as pharmaceutical, nutraceutical products. Underutilized citrus fruits have their own, unique active ingredients with tremendous nutraceutical significances yet to be explored. This study aims to draw attention to the possible utilization of underutilized citrus fruits like Indian wild orange, Khasi papeda and Citron with the added advantage of providing novel sources of bioactive compounds which can provide desirable health benefits and prevent disease. A plethora of bio-active compounds has been revealed in the varieties assessed. The limonin content in Indian wild orange and Khasi papeda juice was 11.38ppm and 7.54ppm while it was 15.85ppm in Citron juice. The ascorbic acid quantified was 17.68mg/100ml, 28.67mg/100ml and 23.98mg/100ml in Indian wild orange, Khasi papeda and Citron species. The total polyphenols was 6.07mg GAE L-1 (Indian wild orange), 7.84mg GAE L-1 (Citron) and 15.41mg GAE L-1 (Khasi papeda) respectively. The total flavonoids and carotenoids content were found higher in peels in comparison to juice when analyzed. Due to the presence of various bio-active and nutritional compounds, which impart nutraceutical properties these underutilized varieties can hold tremendous potential in food, pharmaceutical and nutraceutical industries. Further, results of this study will provide information necessary to meet standards requirements while efficiently providing juices and other citrus products that are safe for consumption. Nutraceuticals are supposed to hold the key to a healthy society in the coming future.

POTENTIAL OF BLUE BERRIES IN INDIA

N.D. Negi
Department of Horticulture & Agroforestry, Chaudhary Sarwan Kumar Himachal Pradesh Agriculture University, Palampur, Kangra-176062, Himachal Pradesh
E-mail: nanak_negi@yahoo.co.in

ABSTRACT

Blueberries are grown extensively in the USA, Europe, New Zealand and Australia and presently, the United States of America is leading in its production with 3, 08,760.00 MT followed by Canada, Peru, France and Poland. Traditionally, blueberries have been grown in cooler northern hemisphere; however, with the development of new southern highbush cultivars with low chilling requirements have made it possible to be grown in southern parts of the globe as well. Apart from some parts of Russian federation, Japan, China and Korean Republic are major Asian countries where it is also grown as commercial crop. However, in India, its commercial cultivation has not been reported yet but in Himachal Pradesh, few Southern Highbush and Rabbiteye cultivars have acclimatized well to prevailing conditions and now bearing commercial fruits. Owing to numerous health benefits and increased awareness among the consumers, at present India is importing about 130 MT of fresh blueberries annually and it has huge potential in Indian markets especially in the metro cities. According to Highbush Blueberry Council (USHBC), a body that represents blueberry farmers and exporters in the USA, this trade is growing at a rate of around 30 per cent per annum and expected to grow in near future. From the investigations carried out at CSKHPKV, Palampur (HP) it can be summarized that the low chilling Southern Highbush and Rabbiteye blueberries have great potential in India especially North-Western Himalayan region, North Eastern states and Nilgiri hills in south.

UNDEREXPLOITED HORTICULTURAL CROPS OF NORTH-EAST INDIA: ISSUES, CONCERNS AND FUTURE PROSPECTIVE

T. K. Hazarika

Professor and Head, Dept. of Horticulture, Aromatic and Medicinal Plants, School of earth Sciences and natural Resources management, Mizoram University, Aizawl, MIZORAM

Email: tridip28@gmail.com

ABSTRACT

The North eastern region of India, being one of the mega hot spots of plant biodiversity in the world is considered as one of the richest reservoir of various horticultural crops. In addition to commercial crops, the region is also known for underutilized and under exploited crops. These crops are scattered only in wild forest or semi wild in homestead gardens and are neither grown commercially on large scale. Considerable diversity exists among them in morphological and physiological characteristics, adaptability and distribution. Most of them are very rich sources of vitamins, minerals along with carbohydrates, proteins and fats and play an important role in food and nutritional supplement of rural community. Despite rich diversity of these horticultural resources in this region, erosion of genetic resources is taking place in the natural habitat. The loss of genetic diversity is mainly due to large-scale deforestation, shifting cultivation, rapid urbanization and other developmental activities. To safeguard the existing diversity of underutilized crops, systematic exploitation, collection, characterization, multiplication, and conservation of these valuable resources are urgently needed to ensure food and nutritional security of rural population and to achieve sustainable development of NE region of India. E*x situ* and *in situ* conservation of rare and endangered species should urgently be undertaken to ensure safe storage of germplasm for dynamic conservation and sustainable use of genetic resources of all available germplasm.

GENETIC DIVERSITY STUDIES IN AVOCADO (*PERSEA AMERICANA* M.) ACCESSIONS OF SOUTH INDIA FOR MORPHOLOGICAL AND BIOCHEMICAL CHARACTERS

Muralidhara B M[1], Sakthivel T[1], Shivashankara K.S[1], Venugopalan. R[1], Karunakaran G[1], Honnabyraiah M.K[1], Karthik Nayak V.S[2], Siddanna Savadi[3], Venkatravanappa V[2], Divya Vani Vaka[2], Lakshmana Reddy D.C[2]

[1]ICAR-Indian Institute of Horticultural Research

[2]ICAR-IIHR

[3]ICAR-DCR

E-mail: Murlidhara.M@icar.gov.in

ABSTRACT

The avocado is an important emerging exotic fruit crop of India which belongs to the family of Lauraceae. Three races of horticultural importance viz. Guatemalan, Mexican and West Indian races exist in avocados. Avocadoes are the good source of bioactive compounds and also known as ideal food for diabetic patients due to the presence of high energy with low sugars. These are also widely used in the cosmetic and food industries due the presence of high oil content. Avocado was introduced to India during early decades of 19th century and distributed to different parts of India viz. Tamil Nadu, Kerala, Karnataka, Maharashtra, Sikkim, Uttarakhand and Himachal Pradesh. Due to cross pollinations and sexual mode of propagation the wide variability is created in avocado accessions for morphological and biochemical traits. An understanding of the diversity existing in a crop species is prerequisite for collection, conservation and utilization in crop improvement. The information on diversity existing in Indian avocado genotypes or accessions is lacking. Therefore, the intensive survey was carried out in avocado growing belts of South India. As a result 83 different avocado accessions were identified and characterized for different fruit morphological and biochemical traits. The results showed a wide variability for fruit characters such as fruit weight (75.88-934.12 g), pulp weight (48.08-736.19 g), peel weight (9.75-73.47 g), peel thickness (0.23-2.23 mm) and seed weight (18.05-150.67 g). The variability was also noticed in avocado accessions for biochemical traits such as FRAP activity (27.65-119.81 mg AEAC/100g), total phenols (23.65-148.26 mg GAE/100g), total carotenoids (0.96-7.17 mg/100g) and oil content (4.91-25.49 %). The fatty acids composition of some important avocado accessions was also studied using GC-MS. The five to six compounds were identified in all the selected accessions. The high average values were reported for oleic acid (44.22%) followed palmitic acid (33.62 %), linoleic acid (11.31 %), palmetoleic acid (8.06 %), stearic acid (1.64 %) and linolenic acid (1.15 %). In conclusion, the wide variability exists in South Indian avocado accessions for morphological and biochemical traits which is useful for utilization of these germplasm accessions in crop improvement.</p>

Oral Paper

ENHANCING THE WETLAND PRODUCTIVITY THROUGH EXPLOITING GENETIC DIVERSITY IN MAKHANA (EURYALE FEROX SALISB.)

Anil Kumar[1], Pankaj Kumar Yadav[1],Paras Nath[1],Gopal Lal Choudhary[1],Taapan Gorai[1],S. K. Yadav[2],V. B. Patel[3], I. S. Singh[4]
[1]Bihar Agricultural University, Sabour -BPS Agricultural College, Purnea-854302
[2]ICAR-NBPGR,
[3]ICAR-Indian Agricultural Research Institute
[4]ICAR-RCER- Research Centre for Makhana
E-mail: makhanaanil@gmail.com

ABSTRACT

Foxnut (*Euryale ferox* Salisb.) grows well in chaur land or oxbow lakes or lowland or waterlogged areas. It belongs to Nymphaeaceae family. Makhana is considered a potential aquatic cash crop in India, especially in Bihar. Commercially, it is grown in the Mithilanchal districts of Bihar (Madhubani, Darbhanga, Sitamarhi, Purnea, Katihar, Kishanganj, Araria, Saharsa, Madhepura and Supaul etc.). Geographically North Bihar in India is the heaven for Makhana production. It is considered one of the most nutritious dry fruits due to its low-fat content, high content of carbohydrates, proteins and minerals, and has been compared to other dry fruits such as almonds, walnuts, cashews, and coconuts. The calorific value of raw seeds lies close to staple foods like wheat, rice, other cereals, and some aquatic plants like Nelumbo and Trapa. *E. ferox* has medicinal uses in the Indian system of medicine and is recommended for the treatment of many diseases especially rheumatic disorders and bile disorders. *E. ferox* is used as a tonic and for the treatment of leucorrhoea and good immunostimulant. The seeds, which may be of the size of a pea or a cherry, are black in colour and eaten raw or roasted. The average yield of *E. ferox* is estimated to be 20-22 quintals/hectare. Unfortunately, our knowledge of the genetic diversity and population genetic structure of *E. ferox* is still limited, and therefore, insufficient to contribute towards varietal development. Keeping in view, the potential of this minor fruit crop in our country especially for wetland areas and to develop genetic resource of *E. ferox,* an exploration trip was conducted in Northern districts of West Bengal. The samples were collected from 10 m MSL to 45 m MSL particularly in the *E. ferox* growing regions of Cooch Behar, Islampur and Malda. The detailed paper discusses the diversity of *E. ferox* available in the explored region. It concluded that BR-Makh-07 with highest yield and lowest incidence of important insect pest was found promising genotypes and it was released as Sabour Makhana-1 (IC 620551) by CVRC in Gazette of Government of India vide notification No. 3841 dated 26-11-2019.

STUDY ON MORPHOMETRIC TRAITS AND GENETIC BARCODING OF VELVET BEAN (*MUCUNA PRURIENS* (L.) DC. *VAR*. PRURIENS

J. Shankaraswamy and Rudra Vinayak
Sri Konda Laxman Telangana State Horticultural University, Mojerla-509382, Telangana
E-mail: shankara.swamy@gmail.com

ABSTRACT

Velvet bean is an economically cultivated green vegetable crop due to its nutraceutical and pharmaceutical properties. The seeds of Mucuna pruriens are a major source for L-DOPA a precursor of dopamine which is used in the treatment of Parkinson's disease and also the seed is reported to possess high crude protein. Even though the crop possesses highly valuable nutrients the genus Mucuna is greatly hampered owing to the unavailability of information on intraspecies diversity for crop improvement. In the present study, we explored modern tools such as matK loci DNA barcoding marker suitable to resolve closely related mucuna species and based on phylogenetic trees and genetic distance in the selected wild species determined as mucuna pruriens var. pruriens and the mucuna poggei is the immediate perennial ancestor to annual varieties of M. pruriens. In collected plant under study for L-DOPA quantification study revealed that 9.966 micrograms per milliliters. From morphology and the anatomical study revealed that *Mucuna pruriens var*. pruriens differs from other species in presence of thin leaf lamina and Druce type solitary calcium oxalate crystals. In conclusion, the application of genetic barcoding technology provides much faster with higher taxonomic resolution than the morphological determination method to compare species inter-and intra-detailed discrimination for an accurate species and varieties identification as well as L-DOPA biochemical profiling information provides new opportunities in crop improvement for improved food and feed value.

Oral Paper

IMPACT OF DIFFERENT SPACING ON PRODUCTION OF POLE TYPE LIMA BEAN (PHASEOLUS LUNATUS L.) WITH INTERCROPPING OF BRINJAL CROP

Sanjay Kumar; Abhimannu; R.N. Singh3 and A.K. Singh,
KVK, Farrukhabad
E-mail: sanjaykvkcsa@gmail.com

ABSTRACT

Lima beans are very nutritious underutilized legume crops. It is two types; bush type and pole type or vine varieties. Pole lima beans are grown for their distinctive flavor prized by local cooks (Namkeen) and high value as a fresh market crop in the district Farrukhabad. The pods are picked when they semi mature and seed sold for namkeen making. The experiment consisted three plant spacing (T1 S-1x1m Farmers practice without trellis, T2 S-2x2m+trellis, T3 S-3x3 m+trellis) and that effect on growth, yield and quality of lima bean and additional crop of brinjal as an intercrop at initial stage of lima beans. Flowering parameters Days to first flowering Significantly earliest flowering was observed in the treatment T3 (S-3.0m x 3.0m + trellis), with minimum days for first flowering (72.50) and 50% flowering (92.50) at days after sowing. The number of pods per cluster (7.20) was found to be superior among all the treatment in spacing T3 followed by T2 and minimum in T1. Green Seed yield per hectare (q) as influenced by different spacing was found to be significant. The green seed yield per hectare (185q) was found significantly superior in the treatment T3 followed by (178q) in T2 and minimum (129q) in T1. The economics of the lima bean and intercrop of brinjal was found superior in treatment T3 with highest BC ratio.

EVALUATION OF HELICONIA GENOTYPES FOR COMMERCIAL EXPLOITATION IN HUMID TROPICS OF ANDAMAN ISLAND

Baskaran Vbaskaran[1], Abirami K[1], Jerard B. A[1], Venkatesan K[1], Singh D. R[2],
[1]ICAR- Central Island Agricultural Institute (CIARI)
[2]Chandra Shekhar Azad University Of Agriculture & Technology
E-mail: vbaski01@gmail.com

ABSTRACT

The family Heliconiaceae comprised of a single genus *Heliconia* with distribution of about 250-300 species worldwide. Heliconias are rhizomatous, herbaceous perennials which have attracted much attention in recent years owing to their variability in shapes, colour of bracts, orientation and longivity of spikes. The humid tropical zone of Andaman Island favours the growth and flowering of these exotic *Heliconia* genotypes for their commercial exploitation. About 42 different genotypes introduced into the Island were evaluated for their growth and flowering behavior. Coefficient of variation (%) among genotypes ranged from 5.6 for number days to 1st flowering to 20.9 for number of flowering shoots clump-1 and was followed by number of spike length clump-1 year-1 (17.7). *H. psittacorum* cv Golden Torch could be a elite genotype for commercial exploitation owing to its higher number of shoots clump-1 (62.7), number of flowering shoots clump-1 (23.0) with early flowering (115 days) when compared to other genotypes. Genotype *H. psittacorum* cv Lady Di showed maximum number of spikes plant-1 year-1 (31.7), whereas genotype *H. chartacea* cv Sexy Pink showed for spike length (92.3 cm) and stalk length (128.7 cm). Number of open bracts were maximum in *H, rostrata* cv Parrot beak (18.7). Genotype *H. collinsiana* showed maximum plant height (3.4m), whereas maximum plant spread (3.0m) was observed in *H. wagneriana* cv Rainbow. On basis of growth and flowering behaviour, these 42 genotypes were categorized for various commercial uses like cut flower standards, pot plant cultivation and landscape gardening purpose in the humid tropical environment of Andaman Islands.

APPROACHES FOR ENHANCING YIELD AND QUALITY OF DRAGON FRUIT IN EASTERN TROPICAL REGION OF INDIA

Kundan Kishore[1], G. Sangeetha[1], Deepa Samant[1], Ankita Sahu[2]
[1]ICAR-IIHR, Central Horticultural Experiment Station, Bhubhaneswar
[2]ICAR-CIWA, Bhubaneswar
E-mail: kkhort12@gmail.com

ABSTRACT

Dragon fruit (*Selenicereus*spp.) is a promising exotic fruit of tropical America and Southeast Asian countries due to its nutritional value and market potential. In recent years, the cultivation of dragon fruit has also started in tropical regions of India. It is commonly known as pitaya or pitahaya, however in India it is known as *'Kamalam'*. *S. undatus* (white pulp)*S. monacanthus (*red pulp*), S. costaricencis* (crimson pulp) and S*. megalanthus (*white pulp) are commercial species cultivated globally. In spite of expansion of dragoon fruit with fairly Rapid pace, its potential yet to be harnessed fully. Selection of varieties, optimization of growing environment, training system, nutrient use efficiency, pollination, fruit regulation, diseases management and fruit quality are vital issues associated with the potential of dragon fruit in India. Among different species *S. monacanthus (*red pulp*)* is most promising species of dragon fruit due to its prolific bearing habit, high fruit set and fruit quality. Moreover this species is autogamous. Single post is the preferred training system in dragon fruit with the planting density of 1333 hills/hectare. In eastern tropical region, crop should preferably be cultivated with the shade intensity of 50% during summer (March to mid-June), as high temperature and exposure to direct sunlight not only reduces flowering but also increases disease incidence and sun scalding. Nutrient use efficiency can be enhanced with the use of mycorrhiza. Application of boron (400 mg/L) on flower buds enhances pollen germination and fruit quality. However optimized number of fruits improves fruit quality. The advanced ripening stage (28 DAA) is considered as an ideal harvest stage on the basis of fruit quality attributes. The *redness* (*a**) and *chroma (C*)* coordinates were important colour coordinates to define ripening of dragon fruit. Management of anthracnose, soft rot, shoot canker and shot blight are important for sustaining yield in dragon fruit.

EFFECT OF ARTIFICIAL POLLINATION IN FRUITING OF DRAGON FRUIT (HYLOCEREUS SP) UNDER TROPICAL ISLAND CONDITION

Abirami K, Baskaran V, Jerard B A, Singh P K, Venkatesan K
ICAR- Central Island Agricultural Research Institute (CIARI)
E-mail: abirami78@gmail.com

ABSTRACT

Dragon fruit (*Hylocereus sp*) is an exotic tropical climbing cactus (family Cactaceae) identified as a potential future crop for Andaman and Nicobar Islands to attain nutritional and livelihood security owing to its rich essential nutrients such as vitamins, minerals, complex carbohydrates, dietary fibres, betalains and antioxidants. Four genotypes oftwo different *Hylocereus*species(*H. costariscensis*and*H. undatus*) grown at ICAR-CIARI, Port Blair were observed in the year 2021 for effect of artificial pollination with same genotype/ cross combinations among four genotypes in fruit setting and yield along with natural pollination as control.Fruit setting from artificial hand pollinationwith cross combinations, same genotype and bynatural pollination ranged as 86.7 to 100.0, 63.0 to 75.0 and 19.4 to 32.5, respectively. Hand pollination done in different cross combinations showed significantly higher average fruit setting (94.2%) compare to hand pollination with same genotype (68.3) and by natural pollination (24.2). Low fruit setting and yield were observed from natural pollination, which might be due to various factors like self-incompatibility, nocturnal flowering and pollinator behaviour. Suitable timing of artificial hand pollination for better fruit setting and yield could be 8.30 pmto 9.30 pmon same day of anthesis at Andaman conditions. Maximum fruit size (13.5 cm length and 30.5 cm breadth) and weight (678.4 g)observed in the cross combination DGF 2 (Pink pulp) x DGF 5 (white pulp with pink tinge). This study shows that artificial pollination will help in increased fruit set and yield in dragon fruit. Hence, it is advisable to grow mixed genotypes of dragon fruit with hand pollination in different cross combinations for commercial production.

Oral Paper

INFLUENCE OF POTASSIUM ON MINERAL ACQUISITION, FRUIT QUALITY AND ENZYMATIC ACTIVITY IN DRAGON FRUIT (*SELENICEREUS MONACANTHUS*)

Ankita Sahu[1], Kundan Kishore[2], Subhashree Barik
[1]ICAR-Central Institute for women in Agriculture
[2]Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar
E-mail: sahuankita29@gmail.com

ABSTRACT

Dragon fruit, an exotic fruit crop, has gained significance in India due to its market potential and nutritional value. The crop is characterized by its wider adaptability and high yield potential attributed to multiple flushes (5-6) from May to October. Quality fruit production has paramount significance in attracting consumers' attention and in gathering maximal market preferences. Potassium is known for its significance in improving fruit quality in multitude ways. The present study aimed at assessing the role of varying levels of potassium nutrition on dragon fruit under eastern tropical conditions of India. The treatment comprised of soil application of five levels of potassium *viz.,* 0, 25, 50, 75, 100 % RDF each with full doses of nitrogen and phosphorus. The levels of N, P, Ca, Mg, S, Fe, B, Mn, Zn and Cu were enhanced both in shoot and fruit pulp with increasing levels of potassium nutrition, however highest mineral content was attained with application of full dose of potassium. Application of full dose of K also manifested an improvement in fruit size (~ 38% increase), fruit firmness (2.8 ± 0.5 N/mm), TSS (19.1 ± 1.3 °B), reducing sugar (17.3 ± 1.5 %), total carbohydrate (17.04 ± 1.8%) and citric acid content (0.45 ± 0.1 %). However, protein and betacyanin content were unaffected with potassium nutrition. The fruit bio-active compounds and anti-oxidant capacity manifested an increasing trend with increasing levels of potassium, with maximal values attained with application of 100% potassium which was evident with the increase in total phenol (~ 19% increment), flavonoid (~ 1.75 times more) and FRAP activity. Potassium tended to increase the activity of α-amylase and decreased the activity of sucrose synthase (SuSy), pectin methyl esterase (PME), cellulase, polygalacturonase (PG), poly phenol oxidase (PPO). The study clearly indicated that K plays an important role in influencing mineral acquisition and fruit quality in terms of size, sweetness, firmness, anti-oxidative property and enzymatic activities.

MORPHOLOGICAL AND BIOCHEMICAL CHARACTERIZATION OF GARCINIA FRUITS OF ASSAM

Bornali Gogoi, Rajendra Pransad Das, Utpal Barua, Purnima Pathak, Himadri Shekhar Dutta
Assam Agricultural University
E-mail: bornali.gogoi@aau.ac.in

ABSTRACT

An investigation was carried out in Department of Horticulture, Assam Agricultural University,Jorhat-13 to study the “Morphological and biochemical characterization of *Garcinia* species of Assam” *viz.,Garcinia pedunculata* Roxb, *Garcinia cowa* Roxb, *Garcinia lanceaefolia* Roxb and *Garcinia xanthochymus* Hook.f. Garcinia fruits were collected from healthy trees of uniform age from five locations of Jorhat district *viz.,* Bahek gaon (L1), Charaibahi (L2), Atila gaon (L3), Chotai (L4) and Borbheta (L5). Wide variations were observed in fruit weight and volume. The *G. pedunculata* showed highest (620.80 g) fruit weight whereas *G. lanceaefolia* showed lowest (22.51 g) fruit weight. The moisture content was found highest (92.91%) in *G. cowa* and ascorbic acid content ranges from 35.37mg/100 g to 88.92 mg/100g. The total phenol content was highest (3.68%) in *G.xanthochymus*. Total ash content was found highest (2.18%) in *G. lanceaefolia*. Total antioxidant activity was found highest in *G. xanthochymus* (9.45%) and the lowest (5.22%) in *G. lanceaefolia*. However, HCA content was highest in *G. cowa* (1.48%). From the study it was noted that *Garcinia* fruits is an important food that can supply good nutrition to diet and make our lives healthy and also maintain biodiversity.

BOON FOR WASTELANDS: HENNA (*LAWSONIA INERMIS* L.) A POTENTIAL CROP FOR ARID ZONE

Dheeraj Singh, Mahendra Choudhary, Chandan Kumar, Aishwarya Dudi
ICAR CAZRI KVK
E-mail: dheerajthakurala@yahoo.com

ABSTRACT

Henna (*Lawsonia inermis* L.), is a small and hardy shrub dominating the agro-ecosystem of Pali district of Rajasthan, India which is known for its leaves which have colouring compound. Presently henna cultivation in the region is under 41,000 hectares which is the largest area under this rainfed crop in the world at single location. It is dryland shrub which can tolerate extreme dry and high temperature conditions and survives well on problematic soils with high pH and saline water where other crops cannot be grown. The development of henna cultivation and processing in Pali, Rajasthan is a blend of indigenous knowledge and people's innovations. In this crop generally, no fertilizers and plant protection measures are used and a single leaf cutting is taken every year under the rainfed conditions and two cuttings where water is available. Under rainfed conditions for dense planting the dried leaf yield in the first year is about 250 kg/ha and it keeps on increasing with timespan to 2000 kg/year. By following these measures, on an average they produce 15-20 quintal dry henna leaves per hectare from their barren fields. It is a labour-intensive crop and its cultivation is dominated by women in every operation. The financial analysis indicated that henna farming due to its high quality at Pali is a profitable and attractive option for farmers livelihoods. Sustainable income from henna benefits the farmers of the district as it can tolerate high salinity, drought and incidences of pest and diseases.

TROPICAL TUBER VEGETABLES IN INDIA AND THEIR COMMERCIAL PROPAGATION TECHNIQUES

Mangaldeep Sarkar, Nitesh Jadav, Bhavesh Chaudhari, Sandeep Aklade
Navsari Agricultural University
E-mail: msarkar@nau.in

ABSTRACT

Underground modified stem and root tuber vegetables are major components of subsistence agriculture in many parts of this world including India. They are treated as underexploited vegetable crops and not included as major commodity in agricultural trades worldwide. Africa, Asia, and Southern America are the reservoir for the diversity of tuberous vegetables and supply this crop to whole world. India is home for many of these tropical vegetable crops from ancient time. Cassava, sweet potato, elephant foot yam, colocasia, alocasia, tannia, greater yam, lesser yam, white Guinea yam, bitter yam, aerial yam, and yellow yam are the crops which are grown in tropical tracts of this country and found wild in nature too. Comparatively tuber vegetables provide high energy and nutrition per unit area and time, require less-intensive management systems even under climatically marginal and risky conditions, and can be processed into a variety of food, feed, and industrial products. These facts are the reasons behind the shifting of its subsistence cultivation to commercialization. Every crop is commercially propagated by vegetative means. Proper planting material, propagation technique and planting method directly effect the yield and quality of harvest. Cassava is propagated by mature stem cutting from old mother plant. All the yams including elephant foot yam are commercially propagated by underground corm or cormel. Sweet potato is chiefly propagated by vine cutting. Colocasia, alocasia and tannia are propagated by headsett, corm, cormel and sucker. Minisett technology for quality planting material production in greater yam and elephant foot yam is very popular in India.

STUDIES ON SMALL FRUITED BITTER GOURD, MOMORDICA CHARANTIA L. VAR. MURICATA (WILLD.) CHAKRAV. FOR ANTI-DIABETIC ACTIVITY

Neelavathi R[1], Indu Rani C[2]
[1]ICAR KVK, TNAU, Tindivanam, Villupuram
[2]HCRI, Tamil Nadu Agricultural University
E-mail: neelapht@gmail.com

ABSTRACT

The research experiment was carried out at Horticultural College and Research Institute for Women, Tiruchirappalli, Tamil Nadu during 2018-20. Fifty genotypes of small fruited bitter gourd (*Momordica charantia* L. var. *muricata*) were collected from different districts of Tamil Nadu. The experiment was laid out in Randomized Block design with three replications. The days to opening of first male and female flower in accession, MCM 25 was 33.81 and 38.67 days respectively. The significantly higher number of fruits per plant was recorded in MCM 1 (44.59) followed by MCM 16 (44.37). The individual fruit weight was higher in accession, MCM 45 (9.70 g). The highest number of seeds/fruit was recorded in accession, MCM 47 (13.74). The anti-diabetic compounds *viz*.,stigmasterol and ß-sitosterol were identified using GC-MS. The highest inhibition of DPPH radical scavenging activity was bitter gourd recorded in MCM 10 with IC50 of 77.84 µg/ml followed by MCM 39 with IC50 of 86.53 µg/ml. The highest inhibition of α-glucosidase was recorded in bitter gourd accession MCM 43 with IC50 of 55.25 µg/ml followed by MCM 50 with IC50 of 56.25µg/ml.

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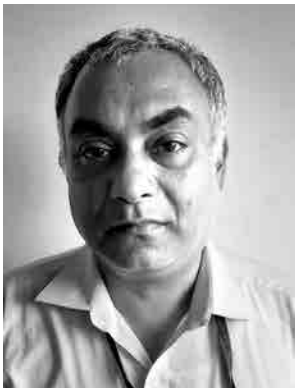
Kanpur, Uttar Pradesh

Session VI

IMPROVING LIVELIHOODS THROUGH TECHNOLOGICAL INTERVENTIONS/ PRODUCTION TECHNOLOGIES IN HORTICULTURE

Chairman : Dr S.G. Sawant

Co-Chair : Dr R.A. Marathe



Dr Bikash Das

Dr Bikash Das is presently working as Principal Scientist (Horticulture), ICAR RCER Farming System Research Centre for Hill and Plateau Region, Ranchi, Jharkhand. He has made several outstanding research and extensions in Eastern Plateau and Hill region. His major research contribution include release of two varieties of Jackfruit; Identification of suitable genotypes of different fruits for Eastern plateau and hill region; Development of fruit-based multitier systems and High density orcharding for rainfed uplands; Rainwater harvesting for orchard establishment in rainfed uplands; Understanding of host-pest interaction and dynamics in mango under climate change scenario. His present area of research include “Management of orchard soil fertility through nutrient recycling from plant biomass”.

He has published 68 research papers in peer reviewed journals, five books and 12 technical bulletins. He is a recipient of prestigious Fakhruddin Ali Ahmed Award of ICAR, 2014 for Outstanding Research in Tribal Farming Systems. He has visited Johannesburg, South Africa in 2013 as a member of Indian delegation to attend BRICS seminar on Agriculture and Climate Change. He has also visited INRA Regional Agricultural Research Centre of Meknes, Morocco in 2018 for a study visit on “Canopy management in apple: Efficient plant architecture for high quality and yield in apple”.

SOIL NUTRIENT ENRICHMENT IN FRUIT ORCHARDS THROUGH RECYCLING OF BIOMASS: IMPACTS ON PLANT NUTRITION AND PRODUCTIVITY

Bikash Das, Mahesh Kumar Dhakar, Sushanta Kumar Naik and Ali, A.
ICAR Research Complex for Eastern Region, Research centre, Ranchi-834010, Jharkhand
E-mail: bikash41271@gmail.com

ABSTRACT

Increasing demand for organic produce as well as increasing cost of manure and fertilizers warrant alternative cheaper options on sustainable nutrient management. Growing of biomass yielding plants in the alley area of orchards and recycling of harvested biomass in the plant basin of fruit trees have been found to improve soil fertility and plant growth of number of fruit trees. Although, species Subabul (*Leucaena leucocephala*) has been found very effective around the world for harvesting biomass and improving soil fertility, the difficulties associated with its eradication from an established area due to its deep root system and high seed dispersal rate is a major deterrent in its popularization. In a study conducted under rainfed conditions of Eastern Plateau and Hill Region, integration of biomass yielding leguminous plant, *Tephrosia candida* in the alley area of *bael* orchard was found to be an effective option in improving the soil fertility and plant growth of bael. *Tephrosia candida* (Roxb.) is native to the tropical foothills of the Himalayas in India and is cultivated and naturalised throughout South–East Asia. The species is a promising for agroforestry in the Tropics due to its high biomass yield, dense vegetative cover, deep root system and its nitrogen fixation ability. The superiority of *Tephrosia candida* over the popularly grown biomass yielding plant, *subabul* (*Leucaena leucocephala*) for integration in the alley area was mainly due to its short life span under normal pruning conditions (5 to 6 years) in contrast to the difficult-to-eradicate *subabul* plants. Based on the nutrient content in tissue, the amount of nutrients that can be recycled during the initial three years through *Tephrosia* plants to the root zone of *bael* plants were 1.17 t/ha nitrogen, 0.06 t/ha phosphorus and 0.42 t/ha potassium. In monetary terms, the cost of nitrogen, phosphorus and potassium that can be recycled through the biomass of Bhoomi Shudha during the initial three years can be calculated as Rs 23,400/-, Rs 3,600/- and Rs 25,200/- per ha, respectively. However, the study also indicated need for supplementation of phosphorus requirement of bearing *bael* plants from other sources under the present planting model. Based on the learnings from *bael* plants, other studies were undertaken to quantify the benefits of mulching of *Tephrosia* biomass in mango and guava orchards. Biomass mulching of *Tephrosia candida* resulted in nearly 40 and 28% increase in the yield of mango cv Amrapali (10-year-old, spacing 2.5 m × 2.5 m) and guava cv. Allahabad Safeda (10-year-old, spacing 1 m × 2 m), respectively. The technology on biological nutrient recycling in fruit orchards through *Tephrosia candida* can help immensely in improving the soil fertility at lower cost and ensuring higher productivity of fruits growing in low fertility regions.

Brief Bio-data

Dr Sushil Kumar Shukla

Dr Sushil Kumar Shukla is working as Principal Scientist (Horticulture) at ICAR-Central Institute for Subtropical Horticulture, Lucknow. He started his career as Scientist (Horticulture) at NRC for Agroforestry, Jhansi where he was actively associated with the research on fruit based agroforestry systems and minor subtropical under-utilized fruit crops. He later published a book on "Under-utilized Subtropical Fruits" He has also worked as Senior Scientist at Zonal Coordination Unit (ICAR), Transfer of Technology Projects, Zone-I at Ludhiana for coordination and monitoring of various extension projects in ICAR institutes and SAUs in Zone-I covering Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir and Delhi.

As he has been associated with dissemination of horticulture technologies, he has composed various poems like *Aam Dohavali, Amrood Chaleesa, Litchi Dohavali, Bael par Dohe* to popularize various technologies among farmers. He has handled NAIP project on "Value chain management of mango and guava" and was instrumental in strengthening the farmer links with various stakeholders and markets. As a

He has published 33 research papers in various national and international journals of repute. Besides, he published three books, 34 book chapters, 3 technical bulletins and 105 technical articles in various magazines. He has presented 76 papers in various national and international symposia/conferences

REFINING MANGO REJUVENATION TECHNOLOGY FOR ENHANCED SUCCESS AND PROFITABILITY

Sushil Kumar Shukla*, G. Pandey and A.K. Trivedi
ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, Kakori, Lucknow-226101
(Email of presenting author: skshuklacish@gmail.com)

ABSTRACT

Old and unproductive orchards with huge tree size and without proper canopy management is the major reason responsible for poor mango productivity and quality. Such orchards account for 35-40% of total area under mango. Mango rejuvenation technology developed by ICAR-CISH, Lucknow was disseminated widely but tree mortality rates up to 40-50% have been reported due to heavy infestation of stem borers. Keeping this in view, an experiment was initiated in Dec 2015. The treatments included old technology (T1-Control) where in trees are headed back at a height of 2.5-3.5 m besides T-2 (Central leader upto 4-4.5m with side branches headed back to 2.5-3 m height, T-3 (Central leader restricted to 2.5-3 m with side branches upto 1.5-2 m height), T-4 (open-vase system with central leader restricted to 2.5-3 m height with side branches at 4-4.5 m). In case of T-5 and T-6, after thinning out of central leader, two branches/year and one branch/year were headed back to complete the process in 3 and 5 years, respectively.

The results indicated maximum mortality (50%) of plants in T-3 followed by T-1 and T-4 (20% in both). In the first year and second year, fruit yields from 50 to 100 kg/tree in T-5 and 100-150 kg/tree in case of T-6 were obtained from the un-pruned branches. Fruit size was far better in case T-5 as compared to T-6 due to lesser no of branches and fruits. During 2020, four years after cutting, maximum tree height (5.45 m) was recorded in T-5 followed by T-4 (5.07 m). Minimum height was recorded in T-3 (4.25 m). Canopy spread in North –South direction. It was maximum in T-5 5.49 m) followed by T-4 (5.47 m) and minimum in T-3 (3.8m). Canopy spread in East-West direction was maximum in T-4 (5.8m) followed by T-5 (5.04 m). Maximum death of primary branches and minimum number of secondary branches/limb were also recorded in T-3. Best canopy development was noticed in T-5 with an average of 6 secondary branches/primary limb. Fruit yield ranged from 8.7 k to 23.7 kg/tree in various treatments. It was highest in case of T-5 (23.7 kg/tree) compared to T-3 (8.7 kg/tree). Average fruit weight ranged from 193.6 g to 238 g/fruit. TSS ranged in between14-17^{0}B, while acidity was in between0.17 to 0.25%. The treatment T-5 was found the best.

Dr S.N.S. Chaurasia

Dr S.N.S. Chourasia is presently the Principal Scientist and Former Head, Division of Vegetable Productionat ICAR-IIVR, Varanasi and was also In-charge at ICAR-IIVR, Regional Research Station, Sargatia, Kushinagar. Dr Chourasia has handled more than two dozens of In-house and externally funded projects funded by ICAR, UPCAR, NHRDF, AVRDC and Taiwan. He has developed about 36 production technologies/ AICRP recommendations on Nursery Raising, IPNM, Organic Farming, Irrigation, Protected cultivation *etc*. Developed 3 vegetable varieties, a number of pre-breeding and advance lines. He has published more than 63 research papers in national and international journals, authored 5 books, 51 book chapters, 6 technical bulletins, 5 mannuals, 20 extension folders and published 207 popular articles. He has supervised 7 Ph.D. and 9 M.Sc. thesis. Dr Chourasia has delivered 60 Radio talks, 65 Stories on DD-1 (Krishi Darshan) and 210 stories on ETV (Annadata) and 14 stories on Zee-Hindustan. He has participated in more than 35 National and International conferences, presented research papers, received several Awards and honors.

Dr S.N.S. Chourasia is Fellow of ISVS, IAHS and ISNS. He was Treasurer, Indian Society of Vegetable Science, Varanasi, Joint Secretary for Association for Promotion of Innovations in Vegetables (APIV), Varanasi, and life member of 10 different scientific societies. He has delivered more than 300 lectures in different training programmes to State Govt. Officials, extension workers, students and Farmers.

IMPROVED PRODUCTION TECHNOLOGIES IN VEGETABLE CROPS

S.N.S. Chaurasia, Anant Bahadur, Swati Sharma and Jagdish Singh
ICAR-Indian Institute of Vegetable Research, Jakkhini, Shahanshahpur, Varanasi-221305, Uttar Pradesh
E-mail: chaurasiaiivr@gmail.com

ABSTRACT

The traditional method of raising vegetable nursery without seed and soil treatment and without considering crop and season, transplanting of ready seedlings without seedling root treatments, imbalance and excess use of chemical fertilizers without soil test, exposure to unfavorable soil and environmental conditions, thermal stress (high and low temperatures), water stress (drought and flooding), salinity and pollutants etc. are the major causes for low productivity of vegetables under present scenario. To overcome these problems various improved production technologies are being promoted worldwide for enhancing the vegetable production like improved nursery raising techniques in potting trays, crop and season based method of seed sowing and planting, application of appropriate amount of organic manures and chemical fertilizer application based on soil test, application of grafting technology for increasing nutrients absorption, doubling production and to overcome abiotic stresses, soil less and vertical farming, hydroponic technology for growing vegetables with or without soil to get maximum production from limited space round the year.

Raising vegetable seedlings under open field conditions is a very old practice still being used by the growers and is uneconomical. Rains for several days and/or fluctuations in temperature ranging from too low and high are major impediments in growing nursery under open conditions. To reduce cost of production, early establishment in the field and round the year production, the seedlings are now a day's being grown in trays under controlled conditions. These seedlings in trays are called 'transplants'. Growing media for raising the seedlings are designed to achieve high porosity and water retention while providing adequate aeration. Nutrient management is the key factor for all farming systems. Excess and indiscriminate/imbalanced use of inorganic fertilizer and agrochemicals has deteriorated soil health badly with simultaneously deficiency of secondary and micronutrient. Depleting soil organic carbon status, decreasing soil fertility and reduced factor productivity and deteriorating environmental quality are other issues of concern. Organic farming practices and regular addition of organic fertilizer improves the soil quality. Protected cultivation offers several advantages to produce vegetables of high quality and yields-particularly during the off-season when prices are higher, thus using the land and other resources more efficiently during off-season. This technology is more relevant to vegetable growers in India who have land holding smaller than one hectare. The expansion of grafting is likely due to its ability to provide tolerance to biotic stress, such as soil borne pathogens, and abiotic stresses, such as cold, salinity, drought, and heavy metal toxicity, due to the resistance found in the root stock. Newer grafting technologies like Pomato, Brimato and different inter-specific cucurbitaceous rootstocks grafting are the options for getting higher productivity of vegetable crops with better quality.

Brief Bio-data

Dr Manoj Kumar

Dr. Manoj Kumar, Joint Director, ICAR-Central Potato Research Institute, supmaC, Modipuram, since August 2016, had acting charge of Director, ICAR-Central Potato Research Institute, Shimla from April 2020 to August 2021. Earlier he served as Head, ICAR-CPRI, Regional Station, Patna since July 2011 to August 2016. He is associated with potato research and development since 2003. Before that, he worked for nearly 7 years (1996-2003) at NRC on Rapeseed and Mustard. He obtained M.Sc (1990) and Ph.D. (1995) degrees in Soil Science & Agricultural Chemistry from ICAR-IARI, New Delhi. He worked in potato research in the area of integrated nutrient management in potato-based inter and sequential cropping systems, developed methodology for early estimation of potato acreage through remote sensing and GIS, developed variety-specific and growth duration specific nitrogen requirement, precise real time N management in potato, developed techniques for mapping spatial variability of available nutrients in potato growing pockets using GIS, developed and identified nutrient use efficient lines of potato and standardized aeroponic minituber production technology in Bihar and Uttar Pradesh. He has over 200 publications including research papers national and international peer-reviewed journals, popular articles, books and book chapters, bulletins, etc. and received awards/recognitions from several professional societies and institutes. He is Fellow of Indian Potato Association, Shimla.

RECENT ADVANCES IN POTATO PRODUCTION TECHNOLOGY

Manoj Kumar, Pooja Chaukhande, Mehi Lal, S.K.Luthra and Sanjay Rawal
ICAR-Central Potato Research Institute, Regional Station Modipuram, Meerut - 250 110, Uttar Pradesh
E-mail: manojkumar0105@gmail.com

ABSTRACT

Potato is third most important food crop in terms of production. As per the second advance estimate of DAC&FW, GoI, potato production during 2020-21 was 53.68 m t from 2.25 m ha area. The phenomenal growth of potato area (0.23 to 2.25 mha), production (1.54 to 53.68 mt) and productivity (6.6 to 23.86 t/ha) during last seven decades has been contributed by research led advancements in technologies of seed production, development of high yielding indigenous varieties, production & protection technologies, post-harvest and processing technologies.

ICAR-CPRI has developed 67 high yielding varieties and one TPS population suitable for different areas like plains, hills and plateau *etc.* and having resistance/tolerance to biotic and abiotic stresses. Kufri Bahar, Kufri Jyoti and Kufri Pukhraj are leading potato varieties cultivated in India. Potato varieties for processing (Kufri Chiposna-1, Kufri Frysona, Kufri FryOm, Kufri Sangam etc), high yield (Kufri Khyati, Kufri Mohan and Kufri Ganga), late blight resistance (Kufri Karn), heat tolerance (Kufri Surya, Kufri Lima, Kufri Kiran), water stress tolerance (Kufri Thar-1, 2 and 3), nutritional superiority (Kufri Manik and Kufri Neelkanth) are important milestone.

Good Agricultural Practices and package & practices for production of organic potatoes, Decision Support System, expert systems, mobile apps, etc. for nutrient recommendation has become very handy for making smart decision and increased precision in potato cultivation. Technology for water management through micro-irrigation as well as fertigation has increased the water and nutrient efficiencies but also improved the quality of produce. CPRI-VEGFAST has been developed for rooftops/ terrace vegetable production.

Disease and pest management has progressed towards more eco-friendly and cost effective management. The use of resistant varieties coupled with late bight forecasting Indoblightcast pan India model and better used of new molecules has almost mastered the late blight disease in Indian plains. Integrated packages have been developed for managing soil and tuber borne diseases. The development of virus resistant varieties and use of dipsticks along with study of vector dynamic and vector management has minimized the virus incidences. Use of drones for timely, precise and more effective application of herbicides, fungicides, insecticides etc. will add new dimension in potato production and protection.

Brief Bio-data

Dr K.V. Prasad

Born in 1966 in Andhra Pradesh, Dr K.V. Prasad, completed his graduation and post- graduation from Andhra Pradesh Agricultural University and Doctorate in Horticulture from the IARI,, New Delhi. He started his career in the ICAR-IIHR, Bengalurui and worked there for 6 years. He moved to IARI as a Senior Scientist, Principal Scientist and as the first Professor of Discipline Floriculture and Landscaping. He is presently serving as the Director, ICAR-Directorate of Floricultural Research (DFR), Pune since October, 2015. Under his leadership new research initiatives in the area of nutraceuticals, virus diagnostics, molecular characterization, gadgets and tools for floricultural crops, vertical farming, new potting media have been initiated.

He is instrumental in developing seven chrysanthemum varieties, six rose varieties at IARI and a unique fragrant anthurium, while serving at IIHR. He had developed DUS guidelines for rose and chrysanthemum. He has developed technology for *in vitro* direct regeneration from ray florets of 18 novel chrysanthemum and annual mutants and their molecular characterization. He is involved in the development of protocols for the induction of *in vitro* nutraceutical anthocyanin pigments from rose, chrysanthemum and carotenoid pigments from calendula.

He had developed three new courses and was involved in the development of curriculum for 2 more courses. He had developed two menu driven e-manuals on Breeding of Ornamental Plants and Plant Tissue Culture. He has guided 4 M.Sc. and 7 Ph.D. students. He has prepared EFC Memo of the Directorate of Floricultural Research, Pune and Detailed Project Report for the establishment of IARI-Jharkhand. He contributed significantly as the Member Secretary of sub-group on Floriculture and Medicinal Aromatic Crops for preparing the XI Five Year Plan (2007-2012).

Dr Prasad is the recipient of several prestigious awards like Dr B.P. Pal Gold Medal for the year 2009 from IARI. He is also a recipient of Gold Medal in Floriculture from Indain Academy of Horticultural Sciences in 2012 and Lotus Puraskar from Indian Society of Ornamental Horticulture besides he got 5 Best Research Paper Awards. He is a Fellow of the IAHS, ISOH and CHAI. He is Fellow of a member of editorial board of important publications.

FLORICULTURE DEVELOPMENT: THE FUTURE PATHWAY

K.V. Prasad
ICAR-Directorate of Floricultural Research, Pune
E-mail: director.dfr@icar.gov.in

ABSTRACT

The main stay of Indian floriculture is growing of traditional flowers in open field conditions which is mostly in the hands of small and marginal farmers. From 3.40 lakh hectares of land, India produces about 19 lakh MT of loose flowers and 8.90 lakh MT of cut flowers per annum contributing significant revenue to the exchequer. The domestic trade from loose and cut flowers is estimated to be around Rs.19,000 cr which is poised to grow to Rs 55,000 cr by 2025. The export of floricultural produce is hovering around Rs. 500 cr during last 5 years. The domestic trade is mostly unorganised while the export trade is better organised.

India has a sizeable domestic trade of foliage and flowering ornamental plants, landscaping plants, lawn grass, trees, palms, dry flowers, and value-added products. The trade in these commodities is a silent contributor to the economy and is not captured in the overall trade. India also exports some of the above commodities albeit in low volumes. India is the sixth largest exporter of essential oils, which is not accounted for under Floriculture Sector although majority are extracted from flower crops. Considerable trade is on the anvil in nutraceutical pigments derived from flowers both in domestic and export markets through Contract Farming of marigold.

Owing to the favourable agroclimatic conditions, adequate natural resources in terms of land, water, diverse soils and other inputs India has enormous potential to become a leader in floriculture. In spite of these strengths, India imports some of the exotic floricultural produce from different countries to a tune of Rs. 110-120 cr per annum.

However to attain the leadership position there is need to develop forward and backward linkages for domestic and export markets, value chain for each commodity and link the same to the One District One Crop (ODOC), encourage start-ups and FPOs.

A national policy on floriculture needs to be put in place to address various issues like support for R&D, import substitution, subsidies for domestic and export commodities, custom hiring, crop insurance, post harvest infrastructure including cold chain, integrated flower auction centres dedicated to flowers, skilling the stakeholders and capturing the data of those commodities that are not crystallised at present. This calls for integrating the initiatives with the national programmes/ priorities/ Missions like Per Drop More Crop (PMSKY), Crop insurance (PMFBY), StartUp India, Green India Mission (GIM), National Biodiversity Mission, National Mission on Waste to Wealth and Skill India etc. This paper dwells in detail on steps already taken and those that needs to be taken to create a roadmap for a vibrant Floriculture sector.

Brief Bio-data

Dr A.K. Srivastava

Dr A.K. Srivastava, Ph.D. in Soil Science from Banaras Hindu University. He has handled 30 projects, credited with 161 peer reviewed publications, life member of 33 academic societies, fellow of 11 academic societies, and associated with editorial board of ten high SCI journals, including Associate Editor of Frontiers in Plant Science. He has authored books like Citrus: Soil and Climate, Citrus Nutrition , Advances in Citrus Nutrition and Fruit Crops: Diagnosis and Management of Nutrient Constraints from publisher like Springer and Elseviers. He is the Adjunct Faculty at three universities in India. He is visiting professor at HZAU and Yangtze University, China and AREEO, Iran.

Dr Srivastava has been extensively working on issues like nutrient constraints analysis of citrus orchards by developing DRIS-based soil-plant nutrient diagnostics, orchard efficiency modelling, targeted yield-based site-specific nutrient management exploiting spatial variability in soil fertility, citrus rhizosphere specific microbial consortium and soil carbon loading, INM module, fertigation scheduling, nutrient mapping using geospatial tools, nutrient dynamic studies, transformation of soil microbial biomass nutrients within citrus rhizosphere and soil fertility map as decision support tool for fertilizer recommendation. He is the recipient of number of prestigious awards including International Plant Nutrition award, Ranade Micronutrient Research award , FAI Silver Jubillee awards *etc*.

ADDRESSING SOIL FERTILITY AND PLANT NUTRITION IN HORTICULTURAL CROPS: PARADIGM SHIFTS

A.K. Srivastava
ICAR-Central Citrus Research Institute, Nagpur 440033, Maharashtra
E-mail: aksrivas2007@gmail.com

ABSTRACT

In recent past, intensive growing of horticultural crops under high density and ultra-high density plant population has further put an additional pressure on soil fertility conservation alongwith economized water use, throwing up new challenges with regard to sustainable management of soil fertility constraints and balanced plant nutrition. Climate change-induced growing concerns have diverted all the attention towards mitigating the soil fertility constraints in a more holistic way. Identifying soil fertility constraint(s) as early as possible in the standing crop (more so in perennial crops) has constituted foremost important aspect of soil fertility management. Therefore, crop/specific soil test ratings are mandatory with regard to precise diagnosis of soil fertility constraints (horticultural crop-based soil health card is still far from reality). With precise diagnosis of soil fertility constrains, we could still notice undesired fertilizer-and water-use-efficiency due to non-redressal of spatial variability in soil fertility due to absolute absence of soil test or leaf test-crop response-based fertilizer prediction models for periodical declaration of crop nutrient holiday. Emergence of plant nutrient uptake-based site-specific nutrient management exploiting the spatial variability in soil fertility has started sensitizing the researchers to tailor fertilizer requirement using variable rate application as per crop phenophase demand.

Rhizosphere properties *vis-à-vis* microbial and nutrient dynamics has dictated soil fertility management options in recent past, especially in many of the perennial fruit crops badly suffering through recurrent replant failures. Identification, isolation and characterization of rhizosphere-specific microbes and later their up-scaling in consortium mode has given some definite edge. The microbial consortium when tested in integrated nutrient management mode expanded the functional corridor of plant nutrition *vis-à-vis* improved fertilizer-use-efficiency. Sensor-based technology has further added a new dimension in providing the nutrient supply as per canopy size in time domain manner using programmable multi-channel fertigation, using micorbes and nano-fertilizers based biofertigation as further top-up of fertigation. In years to come, more concerted efforts would be needed to dwell upon the concept of rhizosphere hybridization triggering the nutrient dynamics where microbiological pool of rhizosphere would be effectively exploited to tailor the crop nutrient requirement and at the same time, provide a sustainable safeguard against any possible nutrient mining with back up support of 4R and 4W principles. Unfortunately , these premises for most of the horticultural crops are yet to be systematically addressed to put nutrient dense crops.

Brief Bio-data

Dr H.P. Maheshwarappa

Dr Maheswarappa H.P. is presently the Director of Research, University of Horticultural Sciences, Udyanagiri, Bagalkot, Karnataka. He started his career as ARS Scientist in ICAR in 1991. He has three decades of professional experience (9 and half years as Project Coordinator, 13 years as Principal Scientist). Have 28 years of experience in the field of plantation crops Management. Involved in the development of improved technologies in the areas of water management, integrated nutrient management with emphasis on organic nutrient aspects, palm-based cropping/farming system research, location-specific technologies for palms and palm-based cropping systems.

Dr Maheswarappa is the recipient of several awards and recognition, which include Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2014, Sardar Patel Outstanding ICAR Institute Award by CPCRI during 2002, Best Publications award “Krishi Sahithya Sree Prashasthi” for the book ‘Dryland Horticulture’ from UAS, Dharwad, several Best Research Paper Awards. He is Fellow of Indian Society of Agronomy, New Delhi, Indian Society for Plantation Crops, CPCRI, Kasaragod, Confederation of Horticulture Associations of India, New Delhi and Society for Horticultural Research and Development, Ghaziabad. He had an Overseas training on Climate Change and Carbon Sequestration at ‘Carbon Management and Sequestration Centre’, Ohio State University, Columbus (USA) during 2010. He has published 153 research papers, 188 popular articles, 6 authored books, 16 bulletins, 42 presentations in Symposia/Conferences and several compiled documents.

COCONUT BASED FARMING/ CROPPING SYSTEMS: RECENT DEVELOPMENTS IN SYSTEM PRODUCTIVITY AND CARBON SEQUESTRATION

H.P. Maheswarappa[1] and S. Sumitha[2]
[1]University of Horticultural Sciences, Bagalkote-587104 (Karnataka), India
[2]ICAR- AICRP on Palms, ICAR-CPCRI, Kasaragod-671 124 (Kerala), India
E-mail: maheshcpcri@gmail.com

ABSTRACT

In the present scenario of fluctuation of coconut price and high production cost, increasing incidence of pests and diseases in addition to low and erratic rainfall, the pure crop of coconut is no more economical. India is a country where agriculture is the mainstay of our economy, whereas intervention can help a poor farmer earn much more than what he does by making the most optimum use of available limited natural resources. This era has seen a dynamic shift from sustenance production to commercial production**.** Coconut, being a perennial oil yielding crop with more than 50-60 years of economic life span, has a potential to act as a carbon sink. Recently, the studies on intercropping of medicinal and aromatic plants, commercial flower crops in coconut garden conducted at different parts of India have resulted in higher net income. Carbon sequestration contribution will be even higher when the crops are grown as mixed cropping or in high density planting system, owing to high density of vegetation per unit area. Higher biomass production in plantation based ecosystems would enhance returns to soil through leaf litter, crop debris, root exudates *etc* thereby enhancing soil carbon pools. Coconut-based cropping systems can improve the microclimatic condition by influencing air temperature, soil temperature, vapour pressure deficit and soil moisture content of plantations. Sustainability can be in built in the coconut system by introducing compatible crops as component crops and promoting positive interferences by judicious application of inputs especially fertilizers. Integrated nutrient management under HDMSCS has resulted in judicious use of input and improvement in soil propertied. All of these have a significant impact on modifying the reproductive and yield performance, soil and water conservation, nutrient status, and carbon sequestration potential of the systems and subsequently, a sustainable growth and productivity making coconut crops more resilient to climate change impacts.

RAISED BED PLANTING SYSTEM IN CITRUS - A NEW CONCEPT

R.K. Sonkar*, M.S. Ladaniya, A.D. Das, A. Thirugnanavel, Anjitha George, G.T. Behere, P. Thakare, and S. Khaire
ICAR-Central Citrus Research Institute, Nagpur-440 033
E-mail: sonkarrk@yahoo.com

ABSTRACT

Raised bed system is a form of orcharding in which the soil is formed in 1-2 m wide beds, which can be of any length as per the land shape. The main advantage of raised bed plantation is the greater accumulation of rain water within the furrow due to the retention of potential runoff.Earlier crops, Weed control, reduced evaporation, reduced fertilizer leaching andcleaner product during fruiting.It improves soil fertility and quality, soil physical, chemical, and biological properties, reduced salinity problems, Improved water management, better infiltration, storage, and less evaporation and reduced wind/water erosion. A trial was conducted with different Citrus spp. on raised bed at 6x3m spacing. In Nagpur mandarin on Alemow rootstock fruit quality data was recorded maximum with respect to average fruit weight (178.98 g), juice content (57.85^{0}B), TSS (8.46%) was found with maximum fruit yield was 12.64 t/ha during its initial phase. The exotic mandarin varieties budded on rough lemon rootstock was planted on raised bed. Average fruit weight (229.20 g) and TSS (9.20%) was recorded maximum in Daisy followed by Pearl tangelo with highest yield(8.71t/ha)and showing promising performance. Among sweet orange cultivars, Pineapple has shown maximum plant height (3.73m) as compared to other cvs. Canopy volume (19.96m3) and juice content (47.58%) was highest in Blood red. Maximum acidity (0.19%) and vit. C (48.02 mg/100mg) content recorded in Pineapple and Jaffa respectively while minimum was noted in mosambi. The TSS content (9.38%) was found to be maximum in Katol Gold followed by Mosambi (9.30%). The maximum fruit yield (14.22 t/ha) was recorded in Blood red followed by Jaffa (11.67 t/ha). With respect to the growth of grapefruit, the highest plant height (4.28m) and canopy volume(27.63m3) was recorded in Marsh seedless with maximum average fruit weight (461.26gm). While highest (51.71%) juice content and TSS (8.19%) was noted in Red blush. Average fruit weight (296.33 g), acidity (1.28%), TSS 8.30% and juice content 56.64% was recorded in NRCC grapefruit 6. US Pummelo-145 and NRCC Pummelo-5 also recorded good fruit quality results. The lemon cultivar, Assam lemon recorded maximum average fruit weight (170.60 g) and highest acidity (6.40%). While maximum fruit yield (31.07 kg/plant) and Productivity (17.24 t/ha) was maximum in Assam lemon. Seedless lemon *i.e.* Lemino also recorded good result on raised bed planting system. In lime varieties, NRCC-8 recorded maximum juice content (69.09%) followed by PKM-1 (68.10%). Highest fruit yield was recorded in PKM-1 i.e. 10.37 t/ha and observed promising variety on raised bed.

INNOVATIVE ENERGY AND WATER HARVESTING MODEL FOR ENHANCING WATER PRODUCTIVITY OF POMEGRANATE IN ARID REGIONS

Akath Singh, Priyabrata Santra, P. R. Meghwal
ICAR-CAZRI
E-mail: Akath.Singh@icar.gov.in

ABSTRACT

The returns from investment on rain water harvesting are less in prevailing conditions of arid region because it is difficult to maintain stored water after January onward while the popular annual crops of the region require irrigation up to April leading to water scarcity at pod grain filling stage and hence low productivity. However, the availability of stored water in farm pond matches the irrigation period and water requirement of pomegranate (September to January) - a highly remunerative and popular crop of the region. An innovative energy and water harvesting model with solar PV based ferti-drip system was developed for small and marginal resource poor farmer to enhance economic return. The one acre model of Bhagwa variety was developed with a provision to harvest rain water of pomegranate field in low cost HDPE lined farm pond having storage capacity of 2.5 lakh litre. For enhancing run off, proper field levelling at around 1 percent slope followed by mulching of row and inter rows with plastic mulch. Anti evaporative material (Thermocol balls of two different size) spread on pond water surface and reduced around 50% water loss from farm pond through evaporation. Harvested rain water is applied through ferti-drip system operated by 3HP solar PV pumping system with regulated deficit irrigation at ETc on daily basis. Sixty percent requirement of major nutrient is supplying through fertigation using water soluble fertizers. Individual plant or rows of plants are covered with non-woven polypropylene sheet (17gsm) to reduce transpiration loss from plant and also to create favorable micro-climate. This system are able to harvest about 2.25 lakh liter of water sufficient to irrigate around 220 pomegranate plant with 30% higher water productivity without affecting crop productivity. Best quality pomegranate fruits with minimum agrochemical residue are being harvested which enhanced marketable yield. The system proved its potential in non traditional areas where ground water quantity and quality are not much suitable for cultivation of pomegranate. This model may also provide opportunities to resource poor farmers of water scarce areas in cultivating high value crops for enhancing their livelihood and net returns

FERTIGATION SCHEDULING BASED ON PHENOPHASES FOR PRODUCTIVITY AND QUALITY OF HDP MANGO

Dinesh Kumar, G Pandey, K K Srivastava
ICAR-Central Institute for Subtropical Horticulture
E-mail: dkches@rediffmail.com

ABSTRACT

Mango (*Mangifera indica* L.) is an important and commercial fruit crop of tropical and subtropical regions of India. It is cultivated over an area of 2.26 mha with annual production of 21.82 mt and productivity 9.7 t/ha. The success of mango production under high density planting depends upon proper nutrient and water management Application of nutrient doses and scheduling play an important role for improving productivity and quality of mango besides saving of input cost. Nutrient scheduling as per the phenological stage (after harvest, before flowering, flowering to fruit set and fruit development) are split into six at each stage and applied at weekly intervals. Under drip irrigation, only a portion of soil volume around each plant is wetted and thus traditional methods for fertilizers application are less effective. The major advantages of fertigation is that it permits timely application of small quantity with frequent intervals of nutrient directly to root zone, which reduces leaching losses, and increases the nutrient use efficiency. Therefore, the present investigations were under taken to increase productivity and quality of HDP mango through nutrient scheduling based on phenophase under subtropical conditions. The experiment have been initiated at ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow during 2015-2020. There were five treatments replicated four times under RBD. Long term experimental data indicated that fruit yield, quality and productivity efficiency were maximum with the application of 90% RDF through fertifgation in mango cv. Dashehari at 5x5m spacing under subtropical conditions.

ENHANCING YIELD AND QUALITY IN APPLE THROUGH TALL SPINDLE CANOPY ARCHITECTURAL SYSTEM UNDER HIGH DENSITY PLANTATION

Javid Mir, Om Chand Sharma, Wasim Raja, Sajad Un Nabi, G S Madhu, . Syed Sami Ullah, Tariq Bhat, Muneer Sheikh

ICAR-CITH, Srinagar

E-mail: javidiqbal1234@gmail.com

ABSTRACT

High Density Plantation in apple is highly remunerative owing to enhancement in yield and quality of apple produce. Tall Spindle system of canopy management is most suitable because this system allows the canopy to spread vertically up-to 14 feet with multiple scaffolds in downward direction.In present study four apple cultivars viz Gala Redlum, Super Chief, Red Velox and Golden Delicious Reinders were evaluated under this system to decipher its potential with respect to yield and quality. These varieties grafted on M-9 clonal rootstock (M9-T337) were planted at spacing of 3.0 m x 1.5 m supplemented with drip irrigation system.Three years data revealed that this system has potential for enhancing yield up-to 50-60 t/ha against 10-15 t/ha under traditional system. Maximum yield was attained in cultivar Gala Redlum (50 t/ha) followed by Golden Delicious Reinders (45 t/ha). Tall Spindle System allows maximum penetration and diffusion of PAR as revealed by highest PPFD percentage inside the canopy (80-90 %), leading to better color development and secondary metabolite production. Better and uniform fruit size and shape was obtained under this system with minimum fruit drop in comparison to other systems like Espalier, Single Axis, Spindle bush, Head & Spread, Open Centre System and Central Leader System.High Density Plantation with Tall Spindle canopy management system supplemented with drip irrigation is recommended for enhancing fruit quality and yield to maximize returns per unit area of land.

TREE PHYSIOLOGY AND FRUITING OF LITCHI CV. CHINA AFFECTED BY BEARING REGULATED CHEMICALS AND GIRDLING

Sanjay Kumar Singh[1], Pragya Kumari[2], Vishal Nath[3], Sheshdhar Pandey[4]
[1]ICAR-National Research Centre on Litchi, Muzaffarpur
[2]Govt. Holkar Science College,
[3]IARI-Jharkhnad
[4]Mushahari
E-mail: sanjay.singh3@icar.gov.in

ABSTRACT

The present study was conducted to evaluate the effect of bearing regulated chemicals (paclobutrazol, KNO3, Pro-hexadione Ca, salicylic acid, KH2PO4, and spermidine) and girdling on tree physiology, endogenous hormonal content, fruit yield and quality in litchi cv. China. Experimental results revealed that the treated trees had increased leaf relative water content (RWC) by 20-50 % over control trees. After paclobutrazol (PBZ) application and a spray of KH2PO4, the stomatal conductance (*gs*) and transpiration rate (E) was highest at flower bud differentiation (FBD) stage. The untreated trees had lower *gs*, transpiration rate (*E*), and lower internal CO2 concentration (*Ci*). The *E* was observed to be higher during the flowering stage than the FBD stage. PBZ application caused the highest leaf free proline and total phenol contents than the control trees. The water use efficiency (WUE), mesophyll efficiency (ME), and carboxylation efficiency (CE) were found to be higher during flowering and reduced during the FBD stage. The Pro-Ca showed the maximum WUE followed by the application of KNO3.

The tree sprayed with KNO3 recorded the highest GA3 followed by girdling in floral shoots. In the non-floral shoot, the GA3 was found to be maximum in trees sprayed with pro-Ca followed by KNO3, while minimum GA3 was recorded with the tree sprayed with KH2PO4 followed by SA. The IAA was estimated to be highest with KNO3 treated tree followed by spermidine. The maximum ABA was estimated after spray of pro-Ca followed by PBZ. The minimum ABA content was recorded with untreated tree (42.43µg-1FW) followed by girdling (58.36µg-1FW). Among non-floral shoots, the tree sprayed with spermidine recorded the highest ABA followed by KH2PO4, the control trees recorded the least ABA contents. In general, the floral shoots had a higher content of cytokinins than the non-floral shoots, and application of PBZ caused the highest content of zeatin (Z) and zeatin riboside (ZR) in floral shoots.

The highest number of flower panicle-1 (3656) and highest yield in terms of number of fruits per tree (2,427.67) (yield as 55.42 kg per tree) were recorded with the spray of KNO3 followed by girdling. The colour intensity of fruits was improved a lot in terms of hue, value and chroma

IMPACT OF INM IN COCONUT BASED HIGH DENSITY CROPPING SYSTEM IN EAST COAST REGION OF ANDHRA PRADESH

B.V.K. Bhagavan[1], E. Padma[2], A. Kireeti[1], N.B.V. Chalapathi Rao[1], H.P. Maheswarappa[3], R.V. S. K. Reddy[1]
[1]Horticultural Research Station, Dr. YSRHU
[2]College of Horticulture, Dr YSRHU
[3]AICRP-Palms, CPCRI
E-mail: hrs-ambj@drysrhu.edu.in

ABSTRACT

Coconut (*Cocos nucifera L.*) is one of the most important tropical humid crop cultivated predominantly under irrigated conditions as Mono-cropping in east coast region of Andhra Pradesh, whereas earlier studies revealed that intercrops like cocoa, banana, pineapple, elephant foot yam and heliconia in coconut has great potential in improving the productivity of nuts. The study on impact of Integrated Nutrient Management (INM) on soil fertility and plant nutrient content and economics in coconut based cropping system (CBCS) was conducted at HRS, Ambajipeta during 2014-20 with four treatments *viz.,* T1 – 75 % of Recommended NPK + Organic recycling with vermicompost, T2 - 50 % of Recommended NPK + Organic recycling, T3 - Fully organic, T4 - Mono block of coconut. The treatment T1 (75 % of Recommended NPK + Organic recycling with vermi-compost) recorded maximum nut yield with 157.34 nuts per palm and 27848 nuts per ha. Further the highest yield of all intercrops *viz.,* cocoa (2.6 kg/plant, 652.60 kg/ha), pine apple (902.66 g/plant, 1918.15 kg/ha), banana (12.68 kg/plant, 10.09 t/ha), elephant foot yam (2.48 kg/plant, 2646.75 kg/ha) and heliconia (13 spikes/plant, 12253 spikes/ha) was recorded in T1. The INM improved the earth warm and microbial population in the soil which improved the soil health and highest cost benefit ratio (3.22) also showed that T1 is more profitable when compared to other treatments. So, Integrated Nutrient Management based coconut high density cropping system will not only improves the coconut but also intercrops yields and improves soil fertility status.

SELF-SUSTAINABLE, ECO-CONSCIOUS, AND LOW-COST STRAWBERRY (FRAGARIA X ANANASSA) FARMING MODEL USING LOCAL RESOURCES FOR SMALL AND MARGINAL FARMERS IN THE MID-HILLS OF MEGHALAYA

Mayengbam Premi Devi, Umakanta Behera
College of Agriculture (Central Agricultural University-Imphal), Kyrdemkulai, Meghalaya
E-mail: mpdhort69@gmail.com

ABSTRACT

Strawberry (*Fragaria* x *ananassa*) is a booming high-value crop in the North-Eastern states like Mizoram and Meghalaya, which are the second and third highest strawberry producers after Haryana in the country. Many progressive farmers of Meghalaya have taken up strawberry cultivation due to its profitability. However, capital intensive commercial strawberry cultivation system is not feasible for the marginal farmers who desire to grow strawberries for additional farm income. Taking this scenario under consideration, a local resource and traditional technology-based strawberry cultivation model with zero external inputs was designed for benefitting local marginal farmers of the region.Naturally decomposed forest litters and sawdust in combination with organic nutrients like vermicompost, poultry manure, fish emulsion, organic waste emulsion, eggshell powder were tried as nutrient sources. Instead of the externally dependent drip irrigation system, an age-old traditional technology of bamboo drip irrigation system was designed for strawberry cultivation to fulfill a similar purpose. Locally available materials like paddy straw, pine needles, tea waste, forest litter were tried for mulching.Decomposed forest litters and sawdust in combination with vermicompost and eggshell powder resulted in perfect growing conditions for strawberries. A maximum yield of 516.90 g/plant was obtained from strawberries treated with vermicompost with organic waste emulsion. Among the mulching materials used, pine needles served as the best alternative material which is a readily available forest bi-product.Self-reliant local-based strawberry cultivation system will give better feasibility with good yield and quality, contributing towards nutrient and livelihood security of small and marginal farmers in the mid-hills of Meghalaya.

SOME HORTICULTURAL TECHNOLOGIES FOR IMPROVING FARM PRODUCTIVITY AND PROFIT EARNING OF SMALL AND MARGINAL FARMERS UNDER SUBTROPICAL AREA

Naresh Babu, Tarun Adak and Arvind Kumar
ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101, Uttar Pradesh, India
E-mail: naresh.babu@icar.gov.in

Advancements of horticultural technologies are in need for enhancing productivity scenario of subtropical farms and to make more profit of growers. It was observed that interventions of nutrient and water saving technologies at ground level of small and marginal farmers bear fruitful outcomes. Planting materials of kinnow and mandarin was distributed among the farmers. Pruning was demonstrated and control measures of insect and diseases were disseminated as well. Cultivation of brinjal was advocated in fruit belt areas and demonstration at farmers' field was successfully done. Scientific cultivation of high value vegetables in fruit belts areas was encouraged for profit earning. Cucumber, green pea, onion, tomato, cauliflower, cabbage etc. were promoted and farmers were received net income of Rs. 233000/ha with B:C ratio of 3.01:1. Gladiolus and marigold cultivation are being successfully promoted and adopted by the farmers of Kakori block of Lucknow and obtaining seasonal income of Rs. 204000/ ha with B: C ratio of 2.55:1; Legume intercropping for improving soil fertility and turmeric as intercrops as profitable venture from per unit area of field. Awareness programmes were conducted for inclusion of vermicompost unit in mango orchard for improving soil fertility. Farmers were motivated for crop diversification and adoption of good agricultural practices (GAP) in orchards for enhancing quality fruits production and marketing. Sensitization workshops paid beneficial outcome to growers for off-seasons vegetables production to secure nutrition of villagers. All these scientific efforts were put together to improve the livelihood condition of farmers involved in horticulture sector.

Oral Paper

IMPACT OF BEE POLLINATION IN MANGO UNDER LOW HILL CONDITIONS OF NAGALAND

Avinash Chauhan
SASRD Nagaland University
E-mail:

ABSTRACT

Pollination is an important component in sustenance of agro-ecosystems. Wild and managed bees has been reported by many researchers as inseparable part of crop systems, especially horticulture crops. Keeping in view the abundance of different insect visitors on mango, an experiment was laid with 4 different pollination treatments i.e. Stingless bee (*Tetragonula iridipennis*) pollination, *Apis cerana* pollination, Open pollination and pollinaor exclusion (Control) to know the role of these visitors on production (per cent fruit set, deformed fruits, fruit weight and fruit yield) and quality (fruit length, fruit width, TSS, dry matter, ash content and moisture) in mango. Mango trees were caged with insect proof nylon nets for pollination treatments. A total of 27 major insect visitors/ pollinators' fauna species were recorded foraging on mango blooms under open field conditions. The Shannon-Wiener diversity Index of mango's insect pollinator revealed higher diversity. Pollination Efficiency Index for pollinators was also calculated. The maximum diurnal abundance of pollinators recorded between 0800-1200 h and the maximum foraging rate was found with syrphid flies and stingless bees. Floral biology showed that stigma remained receptive for more than 72 hours after anthesis. Yield and quality parameters under different modes of pollination revealed bee pollination was significantly superior over open pollination and withoutpollination. In open conditions for adequate pollination of mango, Diptera fauna should be conserved along with non *Apis* bees. Without pollinationthe yields and quality were too less in mango. The flies of Syrphidae and bees belongs to genus Apidae were major pollinators of mango.

EFFECT OF FLOWER REGULATION ON BIOTIC AND ABIOTIC STRESS MANAGEMENT IN POMEGRANATE (PUNICA GRANATUM L.) UNDER HOT ARID CLIMATE

Ramesh Kumar, J.S. Gora, M.K. Berwal
ICAR-Central Institute for Arid Horticulture, Bikaner
E-mail:

ABSTRACT

Pomegranate is an emerging fruit crop of hot arid regions of India. The fruit cracking, mite and fungal spot are major challenges in pomegranate cultivation under hot arid climate of Rajasthan. Therefore, the present study was carried out for management of abiotic stress (fruit cracking) and biotic stresses (mite and fungal spot) in pomegranate by flower regulation through water stress, pruning and ethrel application. The results revealed that horticultural interventions, chemical treatments and their interactions significantly minimized mite, fungal spot and fruit cracking incidence in pomegranate. In different treatment combinations of horticultural interventions and chemicals, minimum mite incidence (4.80 and 4.65%) and fungal spot incidence (9.17 and 7.83%) were recorded in withholding irrigation during June + pruning + thinning with ethrel 2 ml/l treatment as compared to maximum mite (31.95 and 27.51%) and fungal spot (35.78 and 32.58%) recorded in control natural flowering without chemicals during the years 2017-18 and 2018-19, respectively. Lower fruit cracking incidence i.e. <2.0 kg/plant was observed in withholding of irrigation during June + pruning + thinning with ethrel applications in both years. The maximum fruit cracking (2.51 and 3.24 kg/plant) was recorded in withholding of irrigation during March without chemicals treatment during 2017-18 and 2018-19, respectively. Therefore, it can be concluded that withholding irrigation during June + pruning + thinning with ethrel 2 ml/l treatment reduced mite and fungal spot incidence and fruit cracking through induction of flowering and fruit growth during optimal climatic conditions and enhanced management.

Oral Paper

DIVERSIFIED FARMING ENTERPRISES: A STRATEGY FOR ENHANCED INCOME, EMPLOYMENT AND LIVELIHOOD SECURITY OF MANGO FARMERS IN UTTAR PRADESH

Ravi S C, Maneesh Mishra, Rohit Jaiswal, Anil Kumar Verma, Ram R A, Prabhat Kumar Shukla, Shailendra Rajan
ICAR-Central Institute for Subtropical Horticulture, Lucknow
E-mail: avisc3@gmail.com

ABSTRACT

The Malihabad region of Lucknow district is well-known for its cultivation of the world-famous Dashehari mango, which is a major source of income for many smallholders. Perennial nature of crop, mono cropping, changing pest and disease dynamics, lack of organized marketing channels, massive post-harvest losses, and climate change have all posed a threat to the livelihood of small and marginal mango farmers. Diversification has become a norm among farm business due to persistent problems and low farm income. ICAR-CISH through its Farmer FIRST programme has demonstrated the economic benefits of diversified enterprises within mango orchards. Interventions like adoption of GAP and linking farmers to consumers have resulted in reduced use of chemicals besides enhancing the quality, quantity of the produce and increased producers share in consumers' rupee. Use of mango harvesters have reduced the post harvest loess of the fruits and helped in fetching higher prices for their produce. Integration of rural poultry birds in mango orchards have enhanced the BC ratio to 1.97 against 1.66 in sole mango cultivation. Mushroom cultivation in the mango orchard has increased the employment opportunity of the farmers by 25-30 per cent. Farm level processing of mangoes have enhanced the income of farm women vis-à-vis empowering them. In order to have sustainable livelihood options, institute helped in formation of community based organizations – Awadh Aam Utpadan Evam Bagwani Samiti which linked mango growers to distant markets. Self help groups such as Sahbhagita was established to sustain mango orchard based poultry farming and Swavlamban – a women SHG to augment income of rural women through on farm value addition. Thus improved technology adoption, diversified enterprises and institutions have resulted in the sustained livelihood of the farmers.

TECHNOLOGY OF GROWTH STAGE BASED FERTIGATION AND CROP GEOMETRY IN CUCURBITACEOUS CROPS FOR ENHANCING YIELD AND WATER PRODUCTIVITY IN EASTERN HILL AND PLATEAU REGION OF INDIA

Bal Krishna Jha, S S Mali, S K Naik, A K Singh, Ujjwal Kumar
ICAR-RCER, Farming System Research Centre for Hill & Plateau Region, Ranchi, Jharkhand
E-mail: bkjhaicar@gmail.com

ABSTRACT

A field experiment was conducted to investigate the efficacy of growth stage linked fertigation patterns and different crop geometry in cucurbitaceous crop, *viz*., cucumber, bottle gourd and bitter gourd under drip irrigation with 50 micron ultra violet sterilized bicolor polyethylene mulch. The three fertigation patterns *viz*., uniform dose applied every fertigation event (FP1), higher dose during crop development stage (FP2) and higher dose during mid-stage (FP3) in combination with four planting geometries of plant to plant & row to row spacing *i.e*., S1 (80 cm x 80 cm), S2 (120 cm x 90 cm), S3 (160 cm x 100 cm) & S4 (200 cm x 110 cm) comprising of plant population 15,625, 9,259, 6250 and 4545 plants/ha, respectively. The study revealed in cucumber, the highest per hectare fruit yield of 342.0 q/ha, water productivity 26.1 kg/m^3 and maximum economic water productivity of 260.6 Rs/m^3 was observed in the square planting geometry with one row per lateral of spacing of 80 x 80 cm (15,625 plants/ha) in combination with fertigation pattern FP1 in which uniform dose applied at every fertigation event of nutrients in the initial, development stage, mid stage and towards the end stage of cropping season. In bottle gourd also, the fertigation pattern FP1 & planting geometry S1 showed highest cumulative yield of 172.40 q/ha, maximum water productivity of 13.10 kg/m^3 and economic water productivity of 131.4 Rs/m^3. Similarly, higher bitter gourd yields of 148.9 q/ha recorded with uniform fertilizer dose throughout the different stages of crop (FP1) and planted with plant to plant and row to row spacing of 80 x 80 cm (S1). The highest water productivity of 10.3 kg/m^3, economic returns to the tune of 154.1 Rs/m^3 found with fertigation pattern FP1 and planting geometry of S1. High market price and comparatively lower water requirement resulted in higher economic water productivity in cucumber.

Thus, closely spaced square planting geometry (S1) with row to row and plant to plant spacing of 80 x 80 cm (15,625 plants/ ha) and uniform dose of fertigation (FP1) resulted in higher yield, water productivity and economic water productivity of cucurbitaceous crops under drip irrigation. The application of uniform fertilizer dose (80:40:40 kg NPK) in 16 to18 splits is recommended.

STANDARDIZATION OF PRUNING INTENSITY FOR CROP REGULATION IN POMEGRANATE

K. Dhinesh Babu, N.V. Singh, A Maity, P.G. Patil, Shilpa P, R Damale, J Sharma, R A Marathe, B V Naikwadi
ICAR-NRC on Pomegranate, Solapur
E-mail: ckdhinesh36@gmail.com

ABSTRACT

Pomegranate (*Punica granatum* L.), the fruit crop of arid and semiarid regions of the world, is basically deciduous in nature. It behaves as evergreen, partially deciduous and deciduous under tropical, subtropical and temperate regions respectively. This characteristic feature makes it highly amenable for crop regulation during ambia, mrig and hasth bahar. This paves the way for availability of pomegranate fruits throughout the year, enabling enhanced yield of about 30.3 lakh ton from 2.62 lakh ha in 2018-19 and an edge for export to the tune of about 80,000 tonnes/annum. India is the only country in the world where pomegranates are available throughout the year. For crop regulation, pruning of plants is a pre-requisite after rest period and stress period. Hence, an experiment was carried out in pomegranate variety Bhagawa during mrig bahar of 2018-19 and 2019-20 to standardize the pruning intensity. There are 7 treatments covering 3 levels of pruning viz., light pruning (removal of6''shoots from the tip), mediumpruning (12" shoots) and heavy pruning (18'' shoots) individually and combined with removal of tertiary shoots which was compared with a control. Pruning of pomegranate had a significant role on flowering, fruitset, yield and quality parameters. Light pruning resulted in highest fruitset (51.96%), no. of fruits (105.4/tree), mean fruit weight (259.5g), yield (27.46 kg/tree). Control (unpruned trees) registered the lowest value for fruitset (48.7%), number of fruits (99.4/tree) and yield (19.34 kg/tree). Hence, light pruning is essential for crop regulation in pomegranate to ensure better productivity and quality.

INFLUENCE OF CANE LENGTH AND FRUIT THINNING ON THE GROWTH, YIELD AND FRUIT QUALITY PERFORMANCE OF KIWIFRUIT

Vishal Singh Rana, Vikrant Patiyal,Sunny Sharma,Vijay Kumar
Dr. YSP University of Horticulture And Forestry
E-mail: drvishaluhf@gmail.com

ABSTRACT

The kiwifruit has got tremendous potential for commercial cultivation in mid Himalayans due to its wider adaptability and diversification. The market of kiwifruit depends upon on its size and quality. Therefore, proper canopy management and orchard practices are the vital aspects of cultivation. More specifically, pruning and hand thinning have been found to enhance the fruit size and quality. In kiwifruit, fruiting occurs only on current season's growth, which arises from previous year node, and pruning is essential every year to regulate vegetative growth and fruiting. In India previously, pruning by retaining shorter canes having 6-12 nodes/cane coupled with 4 fruits/shoot was followed. But, the emerging concept is to retain loads up to 20 nodes/cane along with 6 fruits/ shoot. Keeping in view above the facts, a study was conducted to elucidate the influence of variable cane length and fruit thinning on the fruit yield and quality performance of kiwifruit in experimental block of Department of Fruit Science, Dr YSP University of Horticulture and Forestry, Nauni, Solan (HP) during the year 2019-20. The results revealed that pruning up to 12 nodes/cane coupled with retention of 6 fruits/fruiting shoot resulted in maximum growth, fruit yield, highest proportion of 'A' grade fruit & quality with better C:N ratio. This treatment also gave maximum net return on per hectare basis, hence was found to be most profitable for the farmers.

POLLINATOR'S DIVERSITY: IMPORTANCE, CHALLENGES AND RESEARCHABLE ISSUE IN INDIA

Balraj singh, Kumaranag. K. M., Ankush Kumar, Gagan Vir
AICRP Honey bees and Pollinators, IARI, New Delhi, India
E-mail: drbsingh2000@gmail.com

ABSTRACT

Various crop plants have different pollination requirements and high diversity of pollinators ensures that the demand is efficiently and timely met. Pollinator species differ in their environmental adaptation so to ensure their diversity to ensure pollination under different conditions. Richness and abundance of pollinator species is a very important factor for effective and stable crop pollination across time and space and this way it ensures enhanced quantity and quality of crop yields.Pollinator diversity studies in agricultural crops from various parts of the country have shown that the crops are dependent on the wide spectrum of insect pollinators for pollination service. Role of insect pollination in enhancing the different yield traits has been quantified in various agricultural crops. Although information on bee colonies required per hectare to achieve optimum pollination and economic benefit have been made. But there are several researchable issues to be addressed in the area of honeybees and pollinators are in India:- Monitoring system for different pollinators, Creation of knowledge hub, Economic value of different pollinators in different agriculture crops, Pollination management under protected conditions, Improvement of bee species through inter and intra specific hybridization, Use of pollen insert in hybrid seed production, Storage of pollens of different parental lines of and *In situ* conservation of pollinators through habitat engineering and their artificial rearing protocols.

CLASSIFICATION OF BIOTIC AND ABIOTIC STRESSES ON GRAPE BERRIES USING TRANSFER LEARNING

Deependra Singh Yadav, Ambarish Gurjar, Ajay Kumar Upadhyay, Sujoy Saha
ICAR-National Research Centre for Grapes
E-mail: deependra.yadav@icar.gov.in

ABSTRACT

Grape farming is one of the most lucrative agricultural enterprises in India. There are several biotic and abiotic stress conditions that may adversely affect the yield if not tackled at the right time. It is crucial that the farmer is able to correctly identify and monitor the type of stress so that steps can be taken to prevent undesirable outcomes. We have gathered a dataset of these stress conditions on grape berries and categorized them into eight classes, necrosis, shriveling, honeydew by mealybug, mealybug incidence, spray injury, thrips scarring, pink berry and powdery mildew. Transfer learning was used to test the performance of six major deep learning image classification architectures (namely MobileNet-v2, Inception-v3, Inception-ResNet-v2, ResNet-v2, NASNet, and PNASNet) with variations in training conditions and hyperparameters. The results were compared in order to determine the most feasible and accurate deep learning architecture and its hyperparameters for the given problem statement. The experiment shows that Inception-ResNet-v2 obtained maximum classification accuracy of 88.75% when learning rate of 0.035 and minibatch size of 10 were applied using 8000 training steps. This result will act as a pre-requisite for the development of an application for mapping vineyard stress conditions on berries and give automated advisory.

BUNCH IMPROVEMENT IN BANANA THROUGH DE HANDING AND SPRAY

Nazimuddin Badruddin Shaikh, Mrs. VedantikaRajenimbalkar and Anjali Mendhe,
Mahatma Phule Krishi Vidyapeeth Rahuri
E-mail: nazem1224@gmail.com

ABSTRACT

With a view to improve the weight and size of fingers of banana for domestic as well as export market, the present investigation entitled, "Bunch Improvement by de-handing and spraying of chemicals in Banana" was conducted at AICRP on Banana Jalgaon under the Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2014 - 2017.The treatments under 'dehanding' were no-dehanding, dehanding at 10th hand and 8th hand while treatments under bunch sprays were water spraying (control), 0.5 % Potassium dihydrogen phosphate (KH2 PO4) + 1 % Urea, 2 % Potassium silicate (SOP) and 1% 19:19:19. The de-handing treatments were applied immediately after opening of all hands in a bunch while under the spraying treatments, first spray was taken immediately after all hands were opened and de-handed while second spray 15 days after 1st spray.It is revealed that dehanding of bunch after 8th hand has recorded significantly maximum finger length (23.70 cm), finger girth (13.58 cm), finger weight (188.72 g), bunch weight (26.36 kg) and yield (117.14 mt/ha). Under spraying treatments significantly maximum finger length (22.98 cm), finger girth (13.26 cm),finger weight (175.22 g) bunch weight (26.76 kg) and yield (118.92 t/ha) were found under 0.5 % KH2PO4 + 1% urea spray.

The pooled results of interaction under dehanding after 8th hands + spraying 0.5% KH2PO4 + 1% urea showed significantly maximum girth (13.77cm) finger weight (194.0 g) and bunch weight (26.96 kg) and it was followed by dehanding after 8th hands + Spray of 0.5 % KH2PO4 + 1% urea (26.91 kg). The yield tons per ha was significantly maximum (119.79) under no dehanding + spray 0.5% KH2PO4 + 1% urea combination which was at par with dehanding after 8th hands + 0.5 % KH2PO4 + 1% urea combinations (119.58).The treatment combination dehanding after 8th hands with spraying 0.5% KH2PO4 + 1% urea gave the best results in respect of yield traits, B:C ratio, sustainable yield index and sustainable value index after three series of trial.

AUTUMN HARVESTING OF MANGO CV. AMRAPALI AND ITS PROXIMATE ANALYSIS IN THE MID HILLS OF WEST KAMENG DISTRICT IN ARUNACHAL PRADESH

Anurag Bajpay, Ajitabh Bora
Defence Research Laboratory RDC Salari,DRDO, West Kameng, Arunachal Pradesh
E-mail: anuragbajpai850@gmail.com

ABSTRACT

The study was carried out to evaluate morphological characters, fruits yield and physiochemical properties of Mango cv. Amrapali which has been observed to be ready for Autumn harvesting (September-October) in the mid hills of West Kameng district in Arunachal Pradesh. The ripening and harvesting time of Mango crop in North India is June to August, while that in South India, it is April to June. However, ripening of Mango crop in West Kameng District of Arunachal Pradesh has been observed during September to October in DRL RDC Salari located at an altitude of 3000 feet above msl. For the study, 6 years old plants of Mango cv Amrapali were selected to evaluate morphological, yield and physiochemical traits following standard procedures. The average Plant height was recorded to be 2.09m, Plant canopy (East west and North south) 2.15x2.28m, Number of branches 3.75, Size of leaves 24x5.14cm, Number of fruits per plant 53.2, Weight of fruits 291g, Length of fruits 10.7cm, Diameter of fruits 7.30cm, Fruits volume 251.6ml and Self life of fruits at room temperature 15 days. The proximate composition of fruits i.e. Pulp yield (72.95 ±1.04%), Moisture (80.23 ±0.11%), Ash % (0.68 ± 0.06), TSS (20.6 ± 0.02º Brix) pH (4.86 ± 0.01), Titrable acidity (0.42± 0.04% citric acid), Vitamin C (31.97± 0.12mg/100g) and Crude fat (0.29± 0.05%) were estimated. However, fruiting and ripening in other local varieties during September to October was also observed in this region. The study indicates distinctness in mango ripening season, which can play a revolutionary role in mango export market, postharvest industries and can uplift the livelihood of tribal farmers in this region.

Oral Paper

ROLE OF CROP AND STAGE SPECIFIC CUSTOMIZATION OF NUTRIENTS IN HORTICULTURAL CROPS

Murlee Yadav
Deepak Fertilizers & Petrochemicals Ltd.,Pune
murlee.yadav@dfpcl.com

ABSTRACT

Effective nutrient management plays an important role in improving the productivity and quality of the produce. Improving the nutrient use efficiency and balancing the nutrient as per the crop and their stages is one of the major challenge due to that reason productivity & quality of the crops lower. Horticultural crops like Grapes, Tomato, Banana, Pomegranate are very responsive towards the nutrients. Grapes are grown in 1.41Mha area in India but productivity is 23 MT/Ha only which is much lower than other countries. India is exporting only 2.26% of total grape production and most of export is happening in gulf countries not in European countries and it is because of poor quality. The same case in tomato also. But, It has been proven that customization of nutrients as per the crops and their stages increased the use efficiency by using the nutrient 20:80 principle (Soil vs fertigation). There is increase in 20-25 % increase in yield along with exportable quality. Keeping in view study was started on development of Crop & stage specific customized water-soluble grades along with complete package in the principle of 20: 80 ratio (Soil vs. Fertigation) for Grapes and Tomato. It was observed that yield increase was 25-30 along with exportable quality in Grapes and 20-25 % increase in yield along with improved quality in tomato by doing multilocation trial in Maharashtra and Karnataka in both the crops for 3 years (2018-21). Hence, there is need to give more focus on customization of nutrients study for all the horticultural crops to increase the productivity as well as quality.

PRECISION CITRICULTURE THROUGH VARIABLE FERTIGATION RATE IN NAGPUR MANDARIN (*CITRUS RETICULATA* BLANCO)

D. T. Meshram[a], A. K. Srivastava[b], P. S. Shigure[c], A. D. Huchche[d], and C. S. Pangul[e]

[b, c & e]Department of Land and Water Management Engineering, [a]Department of Soil Science; [d]Department of Fruit Science, ICAR-Central Citrus Research Institute, Nagpur, Maharashtra, 440 033, India

dtmeshram8@gmail.com

ABSTRACT

An experiment using the principles of advance production was carried out during 2019-2020 on 12 year old age Nagpur Mandarin (*Citrus reticulata* Blanco) (budded on *Citrus jumbhiri* Lush) orchard established on black clay soil (Typic Ustochrept). Three production management zones were delineated using soil fertility and tree canopy volume based variograms using geo-referenced 144 sampling points. Using, these three production management zones (High, Medium and Low) and three variable rates (100, 90 and 80%) of irrigation quantity. The quantity of irrigation during non-rainy days and production period was computed to be 46.67, 52.51, 58.34 $Lday^{-1}tree^{-1}$ and 15,298, 17,210, 19,322 $Lyear^{-1}tree^{-1}$ in High, Medium and Low production zones, respectively. Data analysis showed that, the variation in canopy volume of the Nagpur Mandarin as 8.32, 6.90 and 5.61 m^3 and fruit yield of 9.85, 8.31 and 7.47 tha^{-1} under high, medium and low production zones, respectively. The variation in tree volume and fruit yield corroborated with soil fertility variations across high production management zone (168.4 mg/kg $KMnO_4$-N, 12.8 mg/kg Olsen-P, 186.4 mg/kg NH_4OAc-K, 15.4 mg/kg DTPA-Fe, 11.8 mg/kg DTPA-Mn, 1.18 mg/kg DTPA-Zn and 1.40 mg/kg DTPA-Cu), medium production management zone (169.3 mg/kg $KMnO_4$-N, 10.1 mg/kg Olsen-P, 180.4 mg/kg NH_4OAc-K, 13.4 mg/kg DTPA-Fe, 10.8 mg/kg DTPA-Mn, 0.90 mg/kg DTPA-Zn and 1.04 mg/kg DTPA-Cu) and low production management zone (142.6 mg/kg $KMnO_4$-N, 9.8 mg/kg Olsen-P, 158.3 mg/kg NH_4OAc-K, 11.2 mg/kg DTPA-Fe, 9.6 mg/kg DTPA-Mn, 0.88 mg/kg DTPA-Zn and DTPA-Cu 1.02 mg/kg). Likewise data on fruit quality parameters responded significantly across high production management zone (43.6% juice, 10.3 ^oBrix TSS and 0.64% acidity), medium production management zone (42.1% juice, 9.8 ^oBrix TSS and 0.69% acidity) and low production management zone (42.0% juice, 9.6 ^oBrix TSS and 0.75% acidity). The coefficient of variation across these three production management zones continued to reduce for each of the three soil-plant health, fruit yield and fruit quality parameters kept under investigation, thereby, facilitating the development of an advanced production system in years to come.

Keywords : Citriculture; Nagpur mandarin; nutrients uptake; precision farming; variable rate; water-nutrient use efficiency; fruit quality and yield.

SOIL NUTRIENT INDEX: AN INDEX FOR CHARACTERIZING THE UNBALANCING OF ORCHARD NUTRITION

Tarun Adak and Vinod Kumar Singh
ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101, Uttar Pradesh, India.
Email: Tarun.Adak@icar.gov.in

Indexing of orchards based on soil nutrients is crucial for optimizing soil and tree nutrition *vis-à-vis* productivity. In this direction, recently soil nutrient index was developed in twenty two mango orchards of Lucknow region. Percent soil samples falls under low, medium and high category and SNI values of each mango orchard was calculated. Characterization of all these orchards was done using SNI values. Analysis showed 82% mango orchards had low soil organic carbon; 18% had in medium range. In case of P, 5% orchard had in low rank whereas 95% in medium ranks. Forty one percent orchards falls in low category; in contrast 59% had medium K. Hundred percent mango orchards had low nitrogen and copper contents. Further, it was recorded that only 9% orchard showed high and low Zn content; 82% in medium ranks. Mn and Fe had 100% medium categories. Mango orchards of Kanar Fixed II (M), Malihabad fixed II (M), Ulrapur fixed II (M) and Navipanah fixed I (M) had SNI values of 1.75 to 2.0; others indicated as 1 to 1.5. Only one orchard of Metheynagar Fixed I (L) had 1.25 SNI values; other orchard showed 1.75 to 2.0. Mango orchards of Metheynagar Fixed I, Allupur fixed II, Hafizkhera fixed II, NBD fixed I, Ulrapur fixed I, Allupur fixed I, Metheynagar Fixed II, CISH block II and Kanar Fixed II had low potassium contents. Interestingly orchards of CISH block II and Hafizkhera fixed I had high Zn content. Data linked to productivity for showing orchard status.

STUDIES ON THE RESPONSE OF DIFFERENT GUAVA (PSIDIUM GUAJAVA L.) VARIETIES TO DIFFERENT MULCHES AND PRUNING TIMES FOR QUALITY PARAMETERS UNDER ULTRA HIGH DENSITY PLANTING SYSTEM

Ghanshyam Sahu, Sarita Painkra, Ghanshyam Sahu
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur-492012 (C.G.)
E-mail: sahugd_7@yahoo.com

ABSTRACT

The experiment entitled "Studies on the response of different guava (*Psidium guajava* L.) varieties to different mulches and pruning times for growth, yield and fruit quality under Ultra High Density Planting System" was carried out during the year of 2019 and 2020 at Research Farm of Precision Farming Development Centre (PFDC), College of Agriculture, IGKV, Raipur (C.G.). The experiment was conducted under factorial randomized block design (FRBD) with three replications. The treatment comprising of 18 treatment combinations viz. three level of mulching *i.e.* M1- Control (Non mulch), M2- Poly mulch and M3- Paddy straw, three varieties *i.e.* V1- Allahabad Safeda, V2- Lalit and V3- Lucknow-49 and two pruning months *i.e.* P1- February, P2- June.The quality parameters of guava in terms of total soluble solids, TSS: acid ratio, ascorbic acid, total sugar and non-reducing sugar was proved to be highest with the treatment M2- Poly mulch, V2- Lalit and June pruning while, reducing sugar was maximum under paddy straw and V3- Lucknow-49 during both the year 2019 and 2020 moreover. The acidity of guava fruit recorded lowest by the application of same treatment.

CLIMATE CHANGE RISKS AND RESILIENCE STRATEGIES IN CITRUS

A.D. Huchche
ICAR-Central Citrus Research Institute, Nagpur-440033, Maharashtra
Email : ambadas.huchche@gmail.com

ABSTRACT

Although Citrus trees are evergreen, subtropical plants, they are highly acclimatized to the tropical and semitropical climates the world over. There is considerable variation in productivity depending on orchard management and weather conditions prevailing at crucial periods. With projected productivity of 16 tonnes/ha by the year 2025, the per capita availability of citrus fruit is expected to be 6.88 kg/year as compared to 3.10 kg/year at present. To achieve this goal, it is estimated that the minimum annual growth of 5-6 % will have to be achieved in next two decades so as to meet the domestic demand and enter in exports. This growth can be achieved by evolving strategies to mitigate the challenges imposed by global warming effects in the form of climate change.

Developing agro-techniques to offset the ill-effects of climate change (untimely or delayed rains, scanty rains, inordinately longer dry spells, hailstorms, extended winters, temperature aberrations etc.) using integrated multidisciplinary approaches involving soil and water conservation techniques, horticultural manipulations and plant protection measures is the need of the hour. One of the prominent effects of climate change in citrus that has direct bearing on the economy of the orchardists is the flowering and fruiting. Vagaries of weathers have a telling effect on the cropping pattern in citrus. Temperature, rainfall and humidity are the weather factors that affects flowering fruit sets, fruit retention and fruit harvest. Delay in monsoon, dry spells of rains, untimely rains during water stress period, supra-optimal temperatures during flowering and fruit growth, hailstorms are some of the most commonly encountered experienced by the citrus growers over the past decade or so. The ICAR-Central Citrus Research Institute, Nagpur has devised recommendations to mitigate the ill effects of these adversities. A successful citrus crop insurance model is developed and implemented in the state of Maharashtra which should prove to be a torch bearer for the rest of the citrus growing states of India.

CANOPY ARCHITECTURE MANAGEMENT IN YOUNG MANGO ORCHARDS FOR QUALITY FRUIT PRODUCTION

Pranananath Barman, Dinesh Kumar
ICAR-Central Institute for Subtropical Horticulture, Rehmankhera
E-mail: prananath.barman@icar.gov.in

ABSTRACT

Canopy management refers an interpretation of physiology of light penetration inside tree canopy which is a critical component of overall tree productivity. In mango, there is much necessity for standardizing canopy management technology during initial year of planting for optimised light distribution within canopy for maximizing photosynthesis, flower bud formation, fruit growth and colour development in mango. Therefore, an experiment was laid out in randomized block design with five treatments having four replications during 2015 at ICAR-CISH, Lucknow. Mango cv. Dashehari was tipped off at 70-72 cm during planting at 5 m x 5 m spacing to emerge primary branches. Primary branches were tipped off at 60 cm growth for emergence of secondary branches, which were again tipped off at 60 cm growth for emergence of tertiary branches. Treatments were comprised of P3S2 (3 Primary branches and 2 secondary branches), P4S2 (4 Primary branches and 2 secondary branches), P3S3 (3 Primary branches and 3 secondary branches), P4S3 (4 Primary branches and 3 secondary branches) and without canopy management as control. Results revealed significantly maximum canopy spread, number of panicles per tree, number of grade A fruits (≥ 250 g), fruit yield as well as yield efficiency in P3S3 (55.31, 171.66, 84.53, 122.78 and 70.27% more than control, respectively). Pulp percentage and pulp-stone ratio was found respectively 37.55 and 152.55 per cent more in P3S2 over control. Total soluble solids and ascorbic acid content in fruits were significantly highest while titratable acidity was lowest in P3S3 and P3S2.

STUDIES ON MORPHOLOGICAL CHARACTERIZATION, FLOWERING AND POLLINATION BEHAVIOUR FOR HIGHER SEED YIELD AND QUALITY IN CMS BASED CAULIFLOWER (*BRASSICA OLERACEA* L. VAR. *BOTRYTIS* L.) HYBRIDS

Sudipta Basu, Mohammad Athar, Sandeep K Lal, Debjani Dey, S.K. Chakrabarty, Shrawan Singh[2] and Pritam Kalia[2]

Division of Seed Sci & Technology, [2]Division of Veg. Sci., ICAR-IARI, New Delhi 110012

E-mail: sudipta_basu@yahoo.com

ABSTRACT

Cauliflower is an important vegetable crop of India. The present study was undertaken for standardization of seed production technology in CMS based early and mid maturity group of cauliflower hybrids. The results indicated that the parental lines showed distinctiveness for leaf shape and flower morphology. Flowering in CMS and male fertile parents ranged from 25-30 and 30-35 days, respectively. Among row ratios (2:1, 3:1, 4:1) compared for hybrid seed production, 3:1 (Female : Male) ratio was found optimum for higher seed yield. The non-synchronisation of flowering (10-12 days) among parental lines could be bridged by application of GA3 @ 100 ppm and IAA @ 50 ppm sprayed thrice at 7 days interval to the late parent. Pollen viability and stigma receptivity was highest on the day of anthesis. Being an insect pollinated crop, parental lines were visited by *Apis florae* Fabr., *Apis dorsata, Apis mellifera, Campsomeris* sp., dipterans and syrphid flies; among which honey bees (*Apis mellifera* Linn.*)* were most effective. The pollinators showed diurnal variations for time and duration of bee visit. Pod setting was highest in CMS parents closest to pollen parent which declined with increase in distance from the pollen parent. Seed quality (germination above 95%) and storability (upto one year) was high in all the CMS and male fertile parents. The study showed the feasibility of successful and economical hybrid seed production of CMS based cauliflower hybrids under North Indian conditions.

EFFECT OF VARIOUS CONCENTRATIONS OF BORON ON GROWTH AND CORM YIELD IN GLADIOLUS

Anil Kumar Singh, Anchal Somkuwar, Anjana Sisodia and Thupten Tsomu
Institute of Agricultural Sciences, Banaras Hindu University
E-mail: anilksingh_hort@rediffmail.com

ABSTRACT

A field trial was conducted at Floriculture field of Horticultural Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. to observe the effect of boron supplementation of varied doses on growth and corm yield of gladiolus cv. Malaviya Shatabdi. The treatments were as follows: Control (distilled water), 0.1% boron, 0.2% boron, 0.3% boron, 0.4% boron, 0.5% boron, 0.6% boron, 0.7% boron, 0.8% boron, 0.9% boron and 1.0% boron. The statistical analysis shows promising results obtained due to boron on growth and yield parameters. The growth parameters *viz*., maximum no. of plants/hill was observed at 0.4% B (2.56), maximum leaf length was observed at 0.3% B (61.66 cm), maximum plant height was observed at 0.3% B (64.94 cm). Different B doses had a significant influence on yield parameters as well. Maximum no. of corms/plant was resulted with 0.1% B (2.56), maximum no. of cormels/plant was detected in 0.5% B (11.00), maximum weight of corms/plant was detected in 0.5% B (53.21 g). However, maximum diameter of corm was observed at 0.3% B (45.58 mm).

Day 2, November 19, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session VII

WASTELAND UTILIZATION THROUGH HORTICULTURE

Chairman : Dr D.R. Singh

Co-Chair : Dr B.D. Sharma

Dr M. Madhu

Dr Madegowda is the Director of The Indian Institute of Soil and Water Conservation (ICAR-IISWC). He has been working at the Institute since 1993 in various capacities as Scientist and Head of the Research Centre. Previously, he had worked in the offices of the Institute in Dehradun; Udhagamandalam, Tamil Nādu; and Koraput, Odisha. While he is specialized in Conservation Agronomy, his expertise and knowledge goes beyond diverse fields of Natural Resource Management (NRM), Integrated Watershed Management (IWM), Soil and Water Conservation, integrated and improved farming and social sciences acquired over 25 years of experience and service in different agro-ecological regions of the country. His service innovatively contributed to the farm research and farming communities prominently. Many national and international awards and high-impact research publications stand testimony to his contribution. Dr Madhu is a recipient of the prestigious USDA Global Research Alliance (GRA) Fellowship Programme-2011, Vasantrao Naik Award-2013, IASWC Gold Medal-2010, IASWC-Fellow-2014, ICAR-Team Research Award-2017, Dr KG Tejwani Award 2016-17, University of Agricultural Sciences Gold Medal and Dr HR Arakeri Gold Medal. He has more than 200 high impact research publications on diverse fields of farming and resource conservation.

EXPLOITATION OF WASTE LAND FOR HORTICULTURAL CROPS IN INDIA

M. Madhu*, A. C. Rathore and Charan Singh
ICAR-Indian Institute of Soil & Water Conservation, 218 Kaulagarh Road, Dehradun, 248195, Uttarakhand (India). E-Mail: rathoreac@gmail.com

ABSTRACT

Land, a non-renewable natural resource, is the central resource for all production systems, which has suffered from different types of degradations over the years leads to land degradation which is caused by biotic and abiotic pressures. An ever increasing population places enormous demands on land resources. This is particularly acute in India, which has only 2.4 per cent of the world's geographical area but supports over 16 per cent of the world's population. It has 0.5 per cent of the world's grazing area but has over 18 per cent of world's cattle population. These pressures have led to drastic changes in the proportion of land utilised for agricultural activities, urbanisation and industrial development. Approximately 36.70% (120.72 million ha area) of total geographical area in India is under various kinds of land degradation due to water, wind, salt, etc spread all over country. Degraded lands have poor soil depth, presence of high per cent of gravels, boulders, poor water holding capacity, loss of top fertile soil (soil erosion), etc limits its utilization for shallow rooted annual crops, which compels for cultivation of deep rooted hardy fruit species with suitable soil and water conservation techniques like assured input supply, watering, organic manuring, micro-site improvements, micro water harvesting structure, use of liquid fertilizers, etc for assuring optimum productivity of horticultural crops. Hilly regions are more vulnerable to soil erosion than the other states of India due to undulated topography, medium to very steep slopes and poor soil depth. On an average basis, the total soil erosion from the terrestrial land surface of India is estimated at 4.87 billion Mg yr^{-1}. It has been reported that 5334 million tonnes of productive soil is lost every year, out of which major portion is lost from about 80 million hectares of cultivated land in India. In India, average productivity of fruits and vegetables is 13.83 t ha^{-1} which is much lower than average productivity of USA (28.17 tha^{-1}), Spain (28.0) and Turkey (24.60 tha^{-1}). The average productivity of fruits and vegetables in the country can be enhanced from 13.83 to 27.0 t ha^{-1} yr^{-1} by adopting soil and water conservation practices for utilization of waste lands / degraded lands. It has been proved that such a system can reduce soil erosion from 42 to 1.5 tonne ha^{-1} and can save soil and essential plant nutrients. Water harvesting can be harnessed both for irrigation to fruit plants at critical stages as well as for other purposes. Fruit trees with vegetables as a part of fruit based land uses provide subsidiary sources of income through livestock rearing and have great scope for the degraded lands or waste lands of India.

Brief Bio-data

Dr O.P. Aiswath

Dr O.P. Aishwath has been successful in his pioneering work on nutrient requirement, translocation, re-translocation, phyto-mobilization and nutrient influx for their management in field crops, medicinal & aromatic plants and seed spices. He developed a user friendly model for calculating translocation and re-translocation rate of nutrients so as to overcome the limitation of nutrient influx model for precise nutrient management. He removed many myths and misconceptions in organic farming. He has also been working on climate resilient agriculture (using simple technique without Phytotron facility), edaphoclimatic stress, soil and biological Carbon Sequestration. He has been contributed to manage degraded soils and water using niche diversification of crops and their Autecology and Synecology. First time, he identified and characterized the lime induced chlorosis in 19 medicinal plants, 8 aromatic plants, 5 spices 5 vegetables, legumes and fruit crops. This work brought the boon for the farmer community of Gujarat, Rajasthan and M.P. The technology equally effective in Egypt also. The other breaking through in research are to discover the cause of seedling mortality in *Withania* and cumin is a physiological rather pathogenic and managed accordingly. Nitrogen management using leaf chlorophyll content and leaf angle for precision farming are farmer friendly technologies.

He conducted his research work at ICAR-DMAPR, Anand and ICAR-NRCSS, Ajmer as Senior and Principal Scientist. He is recipient of 12 Awards including Gold medal and Seven Societal fellowships, one international fellowship and 12 Best Research Paper Presentation Awards.

DEGRADED AND WASTE LAND UTILIZATION THROUGH HORTICULTURE CROPS

O.P. Aishwath
ICAR-National Research Centre on Seed Spices, Tabiji-305 206, Ajmer, Rajasthan
E-mail: aishwath1@yahoo.com

ABSTRACT

Land resource, in recent years, are under tremendous pressure with highly competing and conflicting demands of rising population. Not only the demands on food, fodder and fuel have largely upsurge but also claims on land for settlement, urban growth, industrial expansion, roads, railways and other usage are on progressive rise. Land use can create diverse cultural landscapes of outstanding aesthetic, economic and ecological value, but it may equally result in land degradation. Accelerated land degradation limiting crop production over extensive areas has become a subject of serious global concern in recent years. A complex paradoxical situation is confronted today in which more production is required from the scare natural base to meet the multiple demands of the fast exploding population for food, fuel, fibre, fertilizer, timber and other products on one hand, while on the other hand vast areas are either going out of cultivation or show a declining productivity due to degradation of various kinds at an unacceptable rate. Land degradation refers to a decrease in soil productivity including its present as well as potential capabilities for general crops. Horticultural crops are versatile in nature, as these are annuals, perennials, trees, bushes, herbs, shrubs, creepers, climbers etc resultant bears wide adaptability. Some of the crops have inherent capability for absorbing noxious and greenhouse gasses, mobilization and utilization of nutrients, arresting of nutrients to check the runoff. Thus, reclaiming degraded soils can also increase terrestrial C pools, which could off-set some of the anthropogenic emissions. For example- Physically degraded land; *Khirni*, *custard apple*, Drumstick, sponge gourd, betel nut, orchids, cashew, *Aonla*, bajra, *danti*, Indian bdellium, *kalihari, musli*, *tulsi* etc. are plastic for water eroded land and soil; *ber*, *ker*, *khejri*, *kachri*, tumba, *Periwinkle,* neem, *bael*, aswagandh, *isabgol*, beet, vetiver etc. for wind eroded land and soils of various rainfall areas; apricot, *karonda*, *phalsa*, aloe, cowpea, amaranthus, *portulaca*, *ajwain*, cumin, fenugreek *kalmegh*, *senna* etc. for nutritionally eroded soil; Annonas, cashew, pomegranate, fennel, kaner, *gonkhru,* senna etc. for compacted and rocky land; chironji, custer bean, jojoba, fig, sweet potato, *henbane,* lemon, colocasia, patchouli, lemon grass etc. for various rainfall situations of undulated lands. For chemically degraded land and soil- Date palm, sugar beet, *karonda*, *mahua*, *phalsa*, turnip, *bael*, cumin, dill etc for saline soil; *Aegle mamelos,* Date palm, sugar beet, *karonda*, *mahua*, *phalsa*, turnip, *bael*, fennel etc. for saline sodic soils; Date palm, *jamun*, olive, amaranthus, Indian spinach, *guggal*, *isabgol*, dill, lemongrass, vetiver etc. for alkali and sodic soils; Carambola, pineapple, drumstick, sweet potato, carnation, cinchona etc for acidic soil; *Rauvolfia, Rosa, Salvia, Rhus* etc. for metal contaminated soil. Besides the efficient utilization of degraded land and soils through horticultural crops, these could be remedies for those problems and improve environment quality, resulted economic development is inevitable.

Dr R.A. Marathe

Dr Rajiv Arvind Marathe was born and brought up in Sakhardoh, Akola. Maharashtra. He did his B.Sc. (Agri.), M.Sc. (Agril. Chemistry & Soil Science) and Ph.D. (Soil Science) from Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) with first division and distinction.

He started his career from ICAR-NBSS & LUP (ICAR), Jorhat, Assam during 1989 and conducted soil survey and mapping work in remote and backward areas of NEH states. He worked in various fruits (ICAR-CCRI, Nagpur and ICAR-NRC on Pomegranate, Solapur) and soil (NBSS & LUP, Nagpur) institutes of ICAR located in different agro-climatic regions.

His area of specialization includes soil survey, mapping, soil characterization, soil suitability, nutrient and water management, abiotic stress management, high density planting and canopy management and containerized nursery management aspects in citrus and pomegranate fruit crops.

He is awarded with Fellowship in Fruit Science – 2020 by IAHS, New Delhi and by SARP, Solapur. He is Member of Executive Council of VNMKV, Parbhani and got Appreciation Award by Raman Science Centre and Planetarium, Nagpur and State Level ''Rajarshi Chatrapati Shahu Maharaj Krishi Jivan Gaurav Puraskar'' 2017. He worked as technical advisor and expert on different committees and projects of CSIR, NITI Aayog World Bank, NHB, Govt. of MP, Vidarbha Development Board, Maharashtra State Growers Research Association, Pune as well as nodal officer of Soil Health cards and TSP projects.

At present he is working as Director, ICAR-NRC on Pomegranate, Solapur, Maharashstra.

OPPORTUNITIES FOR EXPORTING POMEGRANATE CULTIVATION IN WASTELAND

R.A. Marathe and N.V. Singh
ICAR-NRC on Pomegranate, Kegaon, Solapur 413255, Maharashtra
E-mail: ramarathe28@gmail.com

ABSTRACT

In India, over 32 million ha comes under hot and arid region. Soils of these undulating topographies are characterized by shallow depth and sandy texture with low organic matter emanating poor fertility status. Thus, it is restricting the choice of crops for cultivation. However, by adopting different soil management practices, the drought tolerant pomegranate could be effectively cultivated on these marginal lands. The vast expansion of area (0.283 million ha) under pomegranate cultivation in India has been done on such marginal soils. The hot and dry climate of semi-arid regions favours the pomegranate crop growth but majority of the soils in these areas are on undulating lands having shallow depth, high gravel percent, sandy texture, low organic matter, and low fertility status. It has been observed under field conditions that pomegranate plants raised under poor soils produced lower yield, poor quality fruits and were more susceptible to pests and diseases. On the basis of the investigations related soil management in pomegranate, it can be concluded that, pomegranate can be successfully grown on extremely shallow, rocky soils by digging wide size pits and re-filling it with clay textured soil, provided the filling depth doesn't exceed 60 cm. The performance was equally well on loamy (generally pond soil) soil. If the filling material is of clay texture, then care should be taken towards the supply of sufficient quantity of micro-nutrient, while in case of light soils, application of macro-nutrients should be monitored. For improvement of drainage conditions in clayey soils, use of river sand to the extent of 25 percent is preferred, above which there was drastic reduction in nutrient availability and uptake by the plants, adversely affecting the growth and yield of pomegranate. Incidence and severity of wilt and bacterial blight disease was higher in the plants grown on clayey soils compared to light soils. It is also recommended to plant the pomegranate orchards on trapezoid shaped raised beds of 2 m width and 0.45 m height with sloping sides down on both ends. The standardized and recommended integrated nutrient management practices based on soil fertility status, leaf nutrient analysis and site specific soil related issues need to be adopted at large scale for sustainable pomegranate production on marginal lands.

Dr S.S. Sindhu

Dr S.S. Sindhu is presently the Head, Division of Floriculture and Landscaping & Coordinator, School of Horticultural Sciences, ICAR-IARI, New Delhi. He has over 30 years of professional experience in Horticultural sciences. His area of expertise include commercial agriculture/ horticulture, landscaping, greenhouse to enhance farmer incomes through floriculture; Commercial & Protected Cultivation of Horticultural Crops, Bulbous Ornamental Crops, Landscape Gardening, Fruit Orchard, Vegetable Production, Parks, Gardens Development, Development through Integrated Supply Chain, FPOs, SHGs *etc*. He has developed 16 flower varieties and 25 technologies. He has guided 15 PG students, 150 publications. He is recipient of Anna Saheb P. Shinde National Leaders Freedom Fighters Memorial Award (2009), DAHS Gold Medal (2009), LOTUS Puruskar of ISOH (2017), Dr. H. B. Singh Award for Popularizing & Improvement of Bougainvillea (2010). He is Fellow of India Academy of Horticultural Sciences.

URBAN TREE PLANTATION IN DEGRADABLE LAND FOR SUSTAINABLE ECO-SYSTEM

S.S. Sindhu
Division of Floriculture & Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi-110012
E-mail: sssindhuiaru@gmail.com

ABSTRACT

Nearly 30 per cent of India is degraded or facing desertification whereas 40-70% was reported in eight States encompassing Rajasthan, Delhi, Goa, Maharashtra, Jharkhand, Nagaland, Tripura, Himachal Pradesh and Leh & Ladhakh put together has degraded due to deforestation, over-cultivation, soil erosion, soil salinity, depletion of wetlands and glacial land. The National Wasteland Development Board (NWDB) estimated an area of 123 M ha under wastelands. The effort to increase tree cover up to 33% sits within the National Mission for a Green India (GIM), one of eight Missions under the National Action Plan on Climate Change (NAPCC) as well as earlier national forest policy goals. The GIM plans to increase three to five million hectares of degraded or marginal agricultural land being converted to forest or agro-forestry.

Plants which are growing along roadsides are exposed to many pollutants emitted from motor vehicles such as suspended particulate matters, NO_2, SO_2, CO, heavy metals, benzene, smoke, dust particles *etc*. With rapid industrialization and random urbanization environmental pollution has become a serious problem.Based on the various studies made, air pollution tolerance index (APTI) values calculated from polluted and non-polluted sites, it was observed that *Ficus elastica*, *Cinnamomum camphora*, *Ficus religiosa*, *Ficus benghalensis*, *Ficus auriculata*, *Madhuca longifolia* and *Grevillea robusta* are the most tolerant tree species. Furthermore, based on APTI values concluded tree species such as *Phyllanthus emblic, Tecoma grandis, Thevatia peruviana* and *Schima wallichii* are highly sensitive to air pollution and can be used as bio-indicator of air pollution. Hence, these tolerant plant species mentioned above can be suggested for green belt development in urban areas. Air pollution tolerance index (APTI) is best tool for expected performance of Trees (EPI).

Legume trees can grow well on degraded land because their roots can be a symbiotic host for rhizobium bacteria which produce nitrogen fertilizer. *Acacia benthamii, Acacia lenticularis, prosopis rutiflora, Albizia lebbek, broadleaved trees, Cassia glauca, Cassia obtusifolia, Cassia siamea, Pangomia, Butea monosperma thespasia populnea, Alianthus exselsa, Cassia tora etc.* can be used in degraded land. Certain green belt of degradable land can be developed into fruits plantation like citrus, guava, anola, *Punica granatum* and even dwarf mangos. Such concern authority and land owners can bring such land under tree plantation in PPP mode or through CSR fund to improve carbon foot print and to create better environment for our generations.

Oral Paper

TAMARIND - A GAME CHANGER IN WASTELANDS OF SOUTH INDIA

Vimala Bathineni, Deepthi P, Srinivasulu B
Horticulture Research Station, Anantapuramu, Dr YSRHU
E-mail: vimalabathineni@gmail.com

ABSTRACT

Climate change and the lack of labor have led many farmers to turn to low-maintenance crops that can be grown on any type of soil with limited water availability, especially in south India. Tamarind ranks first among them due to its low maintenance and longer life expectancy than other crops. Additionally, it can thrive in difficult soil conditions or hostile climatic conditions, that has the potential to be cultivated as a fruit or condiment and can be grown commercially in agroforestry groups to meet local demands as well as to provide livelihoods for destitute individuals in the country. However, farmers in general have resisted growing the crop due to its prolonged juvenile age at the seedling stage. The Anantha Rudhira (Redpulp) and Thettu Amalika tamarind varieties released at the Horticulture Research Station, Anantapuramu address this issue, and show great results in dry tracts with a low water availability. The distribution of clonally propagated plants of these varieties made it easier to plant tamarind in arid terrains with limited water availability. These two tamarind varieties may be game changers for India's rural development as demand, price, and export value rise for tamarind.

DEVELOPING SALT TOLERANT ROOTSTOCKS IN FRUIT CROPS FOR WATSE LAND UTILISATION

Anshuman Singh, Shailendra Rajan, Vishambhar Dayal, Ashish Yadav
ICAR-CISH, Lucknow
E-mail: anshumaniari@gmail.com

ABSTRACT

Use of salt tolerant rootstocks in grafting is considered to be a feasible and reliable means to alleviate salt injury in perennial tree fruits. Based on empirical insights from crops such as *bael*, citrus, guava, Indian jujube, *jamun* and mango, evidence is presented that salt-excluding rootstocks not only minimize the accumulation of toxic ions (Na+ and Cl-) in the actively photosynthesizing leaves and shoots, but also regulate scion shoot response in ways that allow normal plant metabolism. The role of stionic interactions in maintaining leaf water relations, osmotic adjustment and tissue tolerance to excess salt in the scion leaves is highlighted. In spite of these benefits, the success in developing easily propagable salt tolerant rootstocks through conventional breeding approaches is rather limited; given complex polygenic inheritance of salt tolerance alongside a long gestation period, complex floral biology and a poor understanding of physiological and genetic traits underpinning salt tolerance in fruit crops. Available evidence also suggests that prolonged exposure to salt may even debilitate the scions on rootstocks with a fairly high salt tolerance, e.g., in grapevines on ‘Dog Ridge’ rootstock. This clearly reflects the need for further improving salt tolerance of some of the commonly used rootstocks by harnessing the emerging genetic improvement tools like association mapping, genome sequencing, marker-assisted breeding, genetic transformation and the omics approaches. Prebreeding activities *viz*. wild and exotic introductions, mutagenesis and intra- and inter-specific hybridization and subsequent selection remain a prerequisite to widening the genetic base in rootstock development programs. Bottlenecks limiting the use of salt tolerant polyembryonic rootstocks in crops like mango need to be identified and dealt with.

Day 3, November 20, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session VIII

ROOTSTOCKS AND PLANTING MATERIAL

Chair	**:**	Dr T. Janakiram, Vice Chancellor, Dr YSRHU, Venkataramanngudem, Andhra Pradesh
Co-chair	**:**	Dr P.L. Saroj, Director, ICAR- CIAH, Bikaner, Rajasthan

Sh. Rajendra Barwale

Sh. Raju Barwale, born on December 12, 1955 in Khamgaon, Buldana, in Maharashtra in India is presently the Chied Chiarman of Mahyco . He obtained his B.Sc. (Hons) Ag. & AH, from G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand in 1976. Thereafter he underwent Agribusiness program at Harvard Business School Executive Education, in 1993.

Sh. Barwale has been associated with Mahyco in various capacities. He was appointed as Managing Director of Mahyco in 1989. His main emphasis was on Human Resource Development which has helped Mahyco to sustain and grow in these changing times. He was instrumental in foraging collaborations with Monsanto, obtaining Regulatory approvals particularly for the *Bt* cotton, which paved the way for the launch of *Bt* cotton varieties in the country. He served as member of the Joint Apex Committee of the Indo-Swiss Collaboration on Biotechnology, Protection of Plant Varieties and Farmers' Right Authority (PPV & FRA), GoI, NAIP, New Delhi.

He served as the President of Industry Associations of India, Biotech Consortium of India Ltd., he is Director of ISF Executive Committee as India's representative. He served as member on Oil Seeds & Fibre Committee of ISF. He is on the Board of Directors of several Companies, Trusts etc. He has travelled extensively across the globe. He is an active Rotarian and has held many positions in the Rotary Club of India.

His foundation Dr B.R. Barwale Foundation has initiated several Awards and Fellowships to boost excellence in research and academics in different Academies and Societies of the country.

AN OPPORTUNITY TO REVOLUTIONIZE FRUIT PRODUCTION IN INDIA

Rajendra Barwale
Mahyco Grow, Jalna, Maharashtra
E-mail:

ABSTRACT

The importance of fruits & vegetables in our daily diet cannot be over emphasized, particularly after the once a life time experience of COVID-19 Pandemic where the immunity enhancement with the balanced diet became paramount. With the increasing awareness about the healthy living, and the better economic status of our population, the demand for fruits & vegetables will continue to grow in India for next few decades. India, although ranked as the number one producer of fruits globally, is seeing a growing demand for imported fruits like apple, date, Kiwi fruit, guava, orange, pear, plums, peaches, cherry, avocado etc. in the recent years largely due to better consumer perceptions of quality, appearance, juiciness, crispiness, etc. compared to locally available fruits.

Fruits being high value crops, generally give the farmers a much greater income than most field crops. We are also fortunate to be endowed with varying agro-climatic conditions, enabling the production of a variety of tropical and temperate fruits. We also have a situation where our productivity of fruit crops is significantly lower than fruit crop productivity in the leading fruit growing countries. Bridging the yield and quality gaps require introduction of new genetics,suitable agronomy package including high density planting, etc. with modern post harvest management and marketing. It is in this context that we have a golden opportunity to usher in revolution in fruit production and thereby improving the income of our farmers, and at the same time expanding the availability of quality fruits to consumers.

High density planting (HDP) with better genetics and agronomic practices would substantially improve productivity and quality of fruits in some of the crops like apple, guava, custard apple, mango, and avocado. A recent research report published in the Asian Journal of Agriculture and Rural Development on economic analysis of HDP scheme in J&K documented two to five times increase in productivity observed in HDP apple. M/s Seven Star Fruits Pvt Ltd, a Mahyco Grow company is working to bring in this concept in India since 2017.

M/s Sevenstar Fruits Pvt Ltd, will be offering high quality planting material of improved rootstocks which support the new agronomic practices to realize higher productivity. True-to-the-type, virus-free, vigorous, elite planting material for rootstocks and scion varieties would be offered by Seven Star Fruits soon for apple and other fruit crops.

A stable policy environment incorporating elements of improved intellectual property protection and market based pricing approach would encourage private sector to invest in such technologies which have the potential to revolutionize the fruit production in our country.

Brief Bio-data

Shri Sudhir Chadha

Sh. Sudhir Chadha is actively engaged in sustainable development of Horticulture in Uttarakhand. He is owner of M/s Chadha Seed Farm & Proprietors of M/s Chadha Farm Agro Exports, Himgiri Blooms & many others. He is also associated with rural development though “Uttaranchal Utthan Parishad” and president of Uttanchal Agri Exporters Association. Sh. Chadha has developed innovative technologies like introduction of dwarf high yielding varieties of papaya, introduction of solar operated system of greenhouses, new varieties of gerbera, standardization of model system of organic farming of low cost model for vermi-composting. His contribution towards economic and rural development of Uttarakhand through various activities is exemplary. He has vast experience in floriculture and fruit productions. He is Director of M/s Indo-Dutch Horticulture technologies (P) Ltd, a project established to substitute Import of Flowers bulb & fruit Trees in India.

Sh. Chadha is Member of Board of Management of GB Pant University of Agriculture & Technology, Pantnagar. He is recipient of “National Most Innovative Farmers Award in 1991 by the then prime minster. He had travelled to Netherlands, Taiwan, Belgium for different assignments including training and studies. There are various achievements to his credit like production of 100 kg papaya per plant, production of one lac gladiolus spikes/acre, production of 1600 kg tomato from 1000 sq. ft greenhouse, production of 700 tonnes of fruits from 25 acre area of farm every year. He is Honaray Fellow of the Indian Academy of Horticultural Sciences in 2015.

REVOLUTIONIZING TEMPERATE FRUIT CULTIVATION THROUGH THE USE OF ROOTSTOCKS

Sudhir Chadha
Director – Indo Dutch Horticulture Technologies (P) Ltd, Bhimtal, Uttarakhand
E-mail: sudhirchadha56@gmail.com

ABSTRACT

The traditional seedling-based orchard the production we can get yield approx. 4 to 5 tons per acre, while in the UHDP system we can achieve up to 20 to 30 tons per acer, which is very high. Secondly, in UHDP because of the dwarfing nature of the plants, we have more fruits, better coloration, and early fruiting. Also, with new improved varieties both under Red. Delicious & Gala group we get better taste, more dark coloration & size of the fruit with less chilling hours required, which makes them possible to grow in lower elevation starting from just 1200+ m from sea level, compared with traditional seedling-based rootstocks. All these new varieties are developed based on the consumer/marker demand having with better taste & Colour are the upcoming future for the Indian market, benefiting the Lower hill farmers of India. Thirds befit we noticed, is the Prices which is almost double if the quality of products is equivalent to the imported fruits, the fourth benefit, we see is the Maintenance & Harvesting cost which is less than as the fruit can be handpicked and other processes like pruning, thinning, spray, fertigation via drip, irrigation. etc. gave more yield & return per given unit area. Therefore, we can say, that with use of dwarfing rootstock & the adoption of UHDP technology in Apple, will help farmers to achieve easily 6-7 times returns, and it's like a cash crop, with commercial harvest just from the second year of production.

I would like to share that our company Indo-Dutch Horticulture is seriously working on all the scientific-based development of plant-material, and in the recent year, we have completed almost 500 to 600 orchards in Kashmir, Jammu & Uttarakhand region. Major credit goes to project Unnati-apple which is a joint initiative of our company IndoDutch Horticulture & Coca-Cola India, with straightforward agenda to enhance the production and income of the farmers by 10-fold in coming years, and the change is visible across Uttarakhand. From 2004 onwards we are working in the field of Research & development and after testing for nearly 10 years, and now we are on the pathway for commercial mass production of quality plant material on various rootstock & varieties for the farmers, together with the transfer of know-how in easy language to the farmers for better and quick adoption by offering monthly advisory and online/offline classes to farmers.

We recommended more financial support to the farmers should be given by the government & universities to expedite the rootstock development program and the fast adoption of the technology by the farmers, so that we become net export of fruits.

Brief Bio-data

Dr Shailendra Rajan

Born on November 15, 1959 at Varanasi, in Uttar Pradesh, Dr Shailendra Rajan received his M.Sc.(Ag.) degree from G.B.PUA&T (1983) and Ph.D. from IARI, New Delhi (1987). He started his career as a Scientist at CISH in 1986, worked as Head, Division of Crop Improvement and Biotechnology till 2014 and presently working as Director of the Institute. His research contributions include development of guava varieties like Lalit, Dhawal, Shweta and Lalima with a widespread cultivation in Andhra Pradesh, Maharashtra, Karnataka, Haryana, Punjab. He has also developed and released mango varieties like Ambika and Arunika. Dr. Rajan has contributed outstandingly in genetic resource management of mango and guava, augmented and maintained one of the largest field genebanks of the world, developed inter-specific (*Psidium mole* x *P. guajava*) wilt resistant rootstock, rejuvenation and propagation techniques in mango and guava.

He has been instrumental in organizing International Conferences and National Conferences. Besides have about 150 research publications, edited 5 books and 30 bulletins. He is widely travelled in mango growing areas of India and abroad e.g. China, Thailand, Malaysia, Philippines, Oman and Nepal.

Dr Rajan served as IPGRI Consultant for “Status Report on Genetic Resources of mango in Asia-Pacific Region in 2000”; Coordinator for the development of web site on “Asian Fruit Genetic Resources Network” for 10 countries; Resource Person for “Information documentation of tropical fruit genetic resources and use of GIS technology”; Member of different Task Force for DUS guidelines for fruit crops; Nodal Person for DUS testing of mango; He was instrumental in developing community based organizations like Society for Conservation of Mango Diversity in Malihabad, Avadh Aam Utpadak Bagwani Samiti deal with the problems of local mango farmers. He was instrumental in developing guava orchards in Arunachal Pradesh at the height of 5,500 feet. He was also instrumental in development of Uttar Pradesh Kela Utpadan Sangh which has managed *Fusarium* TR-4 epidemics.

Dr Rajan is Fellow of five professional societies including IAHS, CHAI, SADH, ISHRD; President of Society of Advancement of Subtropical Horticulture. He is recipient of Shri Giridhari Lal Chadha Award, Life-Time Achievement Award-2019 and Dr R.S. Paroda Award.

MANGO AND GUAVA ROOTSTOCKS: CURRENT STATUS AND FUTURE NEEDS

Shailendra Rajan[1]* and T Damodaran[2]
[1]ICAR-Central Institute for Subtropical Horticulture, PO Kakori, Rehmankhera, Lucknow-226101. [2]ICAR-Central Soil Salinity Research Institute, RRS, Lucknow-226002.
*Email: srajanlko@gmail.com

ABSTRACT

Except in a few South East Asian countries, where polyembryonic seedlings as rootstock are abundant, monoembryonic seedlings are used as rootstock. Farmers identify some roostocks based on their observations on vigour and Fe-chlorosis modulation under different soil conditions and ago ecologies. Apart from compatibility with grafted cultivars, two appealing mango rootstock characteristics are salt tolerance and dwarfism. Other desirable key features include adaptation to difficult soils and deep-rooting condition, shortening of the juvenile phase, and resistance to internal fruit breakdown. Furthermore, no single rootstock possesses both the required salt tolerance and dwarfing effect for the mango industry. There are reports of polyembryonic salt resistant rootstocks ‘13/1’ from Israel, ‘Gomera 1’ from the Canary Islands, ‘Olour’ from India, and ‘Sukkary’ from Egypt. However, very meagre information is available about commercial evaluations of cultivars on reported rootstocks. Only 13/1 has been evaluated commercially in various parts of the world. Studies revealed that adopting interstock may dwarf scion varieties, particularly in dense plantings. Several rootstocks are thought to be drought or flood tolerant, but only the Colombian rootstock ‘Hilacha’ has been reported to be better suited to flood and salty soil environments. Turpentine and 13/1, on the other hand, are better suited to harsh soil conditions, particularly high pH and alkaline soils. The rootstock 13/1 has the most desired rootstock properties, such as salt tolerance, adaptability to harsh soil conditions, and nutrient absorption capabilities. However, given the apparent rootstock/cultivar/environment interaction demonstrated in numerous experiments, as well as the good yields obtained with other rootstocks around the world, no firm conclusions can be drawn. In the absence of obvious indications, future research and collaborative initiatives are warranted for trials on rootstocks and cultivars in diverse edapho-climatic. The fact that mango rootstocks can influence three major aspects of mango behaviour: salt resistance, dwarfing, and effect on increasing output, is undoubtedly a motivating factor for future research and development of rootstock research programmes. Aside from salt tolerance, *Ceratocystis fimbriata*, a soilborne pathogen that causes a lethal wilt disease in various parts of the world, may necessitate increased rootstock research. For decades, the guava sector has struggled with fungus-caused wilt, but in recent years, *Meloidogyne enterolobii*-caused wilt has made guava orcharding problematic in many countries The most essential control method for this melody appears to be interspecific rootstocks produced from wild *Psidium* species. Another research priority is the development of a commercial tissue culture multiplication technique for interspecific rootstocks. In the future, dwarfing will be a secondary goal of rootstock development in mango and guava, with the primary focus being on wilt disease resistance through tolerant rootstocks.

Dr D.K. Ghosh

Dr Dilip K. Ghosh, Director, ICAR- Central Citrus Research Institute, Nagpur, Maharashtra obtained his MSc and PhD degree in Plant Pathology specializing in Plant Virology from ICAR- Indian Agricultural Research Institute, New Delhi in 1994 and subsequently joined this institute as Scientist. Since then Dr Ghosh has made valuable contributions by developing molecular disease diagnostic tools for citrus viruses and greening disease that has been used to implement citrus budwood certification programme. So far, more than 45 lakhs disease-free certified planting material of different citrus cultivars has been developed at the institute.

Dr Ghosh was involved for the release of five citrus varieties, *viz.* Cutter Valencia, US Pumelo-145, Flame grape fruit, Nagpur Mandarin Seedless-4 and NRCC Pumelo-5, developed LAMP-based Rapid Diagnostic Kits for citrus greening and citrus tristeza virus and first time reported infection of *Candidatus Phytoplasma cynodontis* (WBDL) and Hop stunt viroid in citrus. He worked as a visiting scientist at University of Florida (USA) during the year 2000 and 2010, officially visited other citrus growing countries like Brazil, China, Vietnam and Thailand to deliver lectures at various international fora. As an International FAO Consultant, Dr Ghosh worked in Nepal and Bhutan; organized three international training programs for the participants from Oman, Bhutan and Nepal. In collaboration with IIT-Roorkee and UCF-Florida (USA), he has identified and demonstrated the efficacy of mixture of 2S Albumin protein (obtained from Pumpkin seeds) and nano-ZnO to inhibit citrus greening disease and jointly published one US patent (US20200237677A1). Dr Ghosh is the recipient of prestigious J F Dastur Memorial Award (2019), Indian Phytopathological Society; Outstanding Plant Virologist Award at Asian Plant Science Congress (Nepal), and presently working as an Editor of the journal 'Plant Pathology' (UK). He is bestowed with the award of Fellow from four different scientific societies of India. He also worked as a distinguished member of various important committees like MISA, University of Central Florida, USA; Mashalkar Committee of Biotechnology (Govt. of Maharashtra) etc. and reviewer of many internationally reputed scientific journals. Dr Ghosh has worked on different externally funded projects of ICAR, DST, DBT, NHM etc, guided six PhD students, evaluated more than 15 PhD thesis, published more than fifty five research articles in reputed international and national journals and edited two books.

RECENT DEVELOPMENTS IN CITRUS ROOTSTOCKS AND PRODUCTION OF DISEASE-FREE QUALITY PLANTING MATERIAL

Dilip K. Ghosh
Director, ICAR-Central Citrus Research Institute, Nagpur, Maharshtra
E-mail: director.ccri@icar.gov.in

ABSTRACT

Citrus is the third most important fruit crop in India next to mango and banana and cultivated in an area of about 1.003 million ha with the production of 12.54 million tonne and the productivity of 12.5 t/ha (NHB, 2018). However, the productivity is far behind when compared with Brazil, USA, Spain and China. Abiotic stresses like salinity, drought, and extreme temperatures and biotic stresses like *Phyotphthora*, citrus greening (*Candidatus Liberibacter asiaticus*), and citrus tristeza virus (CTV) hampers the citrus production and productivity. Rootstocks played a crucial role in area expansion, production, and productivity of Indian citriculture. Rough lemon (*C. jambhiri*) and Rangpur lime (*C. limonia*) are the two predominant rootstocks having wide adaptability and extensively used for mandarins and sweet oranges across the country. Rangpur lime has deep root system, produces medium to high quality fruit, tolerant to drought and acidic soils. It provides good compatibility for sweet oranges (Mosambi and Sathgudi) and Coorg mandarin. Rough lemon is vigorous, produce high yield, tolerant to Tristeza and Exocortis and tolerant to high pH. It is widely used for Nagpur and Kinnow mandarins.

Rough lemon and Rangpur lime are susceptible to *Phytophthora* root rot diseases, greening and nematodes and also to sodium salts. Combining the different traits for providing resistance to varied stresses, either through conventional breeding or biotechnological approaches may provide solution for the present challenges. Some promising rootstock hybrids were developed through conventional breeding. ICAR-IIHR (Bengaluru) developed several CRH series of rootstock hybrids, *viz*., CRH-12, CRH-47, and CRH-57 that were reported resistant to nematodes and tolerant to *Phytophthora*. Similarly, ICAR-CCRI (Nagpur) developed several rootstocks, among which NRCC rootstock 1, 2, and 4 are tolerant to *P. palmivora*; NRCC rootstock 3 and 5 are tolerant to both *P. palmivora* and *P. nicotianae* and NRCC rootstock 6 is highly tolerant to *P. nicotianae*. Further, ICAR-CCRI has identified Alemow (*C. macrophylla*) as a promising rootstock for Nagpur mandarin and acid lime.

Citrus is highly susceptible to number of highly destructive and graft transmissible virus and virus-like pathogens which are primarily spread through infected planting material in nursery. Nationally accepted guidelines are urgently needed to ensure production and supply of certified QPM of high value fruits crops. ICAR- CCRI has successfully demonstrated and implemented citrus budwood certification program and till date nearly fifty lakhs disease-free planting material has been distributed to the citrus growers of the country.

Brief Bio-data

Dr R.G. Somkunwar

Dr R.G. Somkuwar received his Ph.D. in Horticulture from Indian Agricultural Research Institute (IARI), New Delhi in 1992 and serving ICAR-NRC Grapes since its inception. Dr Somkuwar has significantly contributed in the development of different technologies like planting material mass multiplication, rootstock identification, standardization of bunch load for grape grown under tropical conditions of Maharashtra. He developed the protocol for quality planting material production in grape using wedge grafting to surmount the water and salinity stress. He identified the promising rootstocks for grape varieties under tropical conditions. He has developed nine crop varieties and released at state and central level. He has been working with the farmers and grape growers for resolving their technical problems associated with abiotic stresses like salinity, water scarcity, heavy rainfall, hailstorms. He has published 118 research papers in national & international journals, 7 books, 11 technical bulletins, more than 700 popular articles. His work has been recognised by several reputed organisations such as Doordarshan Sahyadri Krushi sanman Puraskar: 2010 Doordarshan, Mumbai (Govt. of India), Scientist of the year: 2005 National Environmental Science Academy, Fellowship of the IAHS 2017, Krushiratna Dr. Panjabrao Deshmukh Memorial Krushi Puraskar (2009), ISHRD Fellowship (2016), Bhaskar Award (2007), Abhinav Gaurav (2006), Vidharbh Bushan (2012), Maharashtra Bhushan (2012) etc .

FUTURE OPPORTUNITIES FOR EXPLOITING NEW GRAPE ROOTSTOCKS IN INDIA

R.G. Somkuwar
ICAR-National Research Centre for Grapes, Pune
director.nrcg@icar.gov.in

ABSTRACT

Grape cultivation in India is concentrated mostly in semiarid regions where soil moisture and salinity stresses are prevalent concurrently. The own rooted grape orchards cannot withstand these stresses. Hence, three decades back the grape cultivation was shifted from own-rooted to rootstock grafted vines. The grape rootstocks like *Vitis berlandieri, V. rupestris, V. champinii, V. rotundifolia, V. canadicans* helps in mitigating abiotic stresses like soil salinity, acidity, nutrient imbalances and water scarcity. The rootstocks derived from *V. berlandieri x V. rupestris* like 110R, 140Ru and 1103P can survive the harshest conditions of meagre soil moisture and high salt content. Whereas, the selections from *V. champinii (V. canadicans x V. rupestris) viz.,* Dogridge, Ramsey (Salt Creek), Freedom and Harmony shows drought tolerance traits. Dogridge is widely grown rootstock in the country as it performs better in respect of drought tolerance, graft success, yield and fruit quality parameters. But its monoculture can be risky under changing climate scenario. This situation can be addressed by genetically combining salt tolerant genepool like 110R, 140Ru, 1103P with water efficient genotypes like Dogridge and Salt Creek to develop new rootstocks with dual resistance to drought and salinity stresses.

Incidences of unseasonal heavy rain, flooding, high day temperature, frost incidence, hail storm, typhoons etc. are now very common rendering grape farming a tricky business. Development of a single grape rootstock suitable for all conditions is not possible because different viticulture sites have different horticultural demands. Keeping this in mind, Indian viticulture now needs a set of new rootstocks which will perform better under environmental stresses (drought and salinity in particular) besides supporting quality grape production.

Beief Bio-data

Prof. K. Gopal

of Dr. K. Gopal, Registrar, Dr.YSR Horticultural University, Venkataramannagudem, West Godavari district, Andhra Pradesh

Prof. K. Gopal, Born on 7th August 1963 in Peddahothur, Kurnool District of Andhra Pradesh, earned his B.Sc (Ag) and M.Sc (Ag) from Acharya N.G Ranga Agricultural University (ANGRAU) and Ph.D from UAS, Bangalore. He worked in UAS-Dharwad (1988-1993), ANGRAU(1993-2007). Worked at different capacities in Dr.YSRHU and presently working as Registrar, Dr.YSR Horticultural University, Venkataramannagudem, West Godavari District Andhra Pradesh, since 2019. He is member of UG, PG faculty boards, Academic council and REA Council of Dr. Y.S.R. Horticultural University. He was a President of Indian Society of Plant Pathologists, Ludhiana (2015-17).

on crop protection, crop improvement and biotechnological aspects of citrus, oilseed and legume crops for 28 years. He developed 5 crop varieties and IDM technology for many diseases in Horticultural and Agricultural crops, and teaching Plant pathology courses to UG and PG students. Dr. Gopal has worked on preventive and control measures for dry root rot, stem end rot and bacterial canker.

Dr. Gopal was involved in development of two groundnut varieties **KRG 2** and **KRG 3**, multiple disease tolerant **Sweta Til** *Sesamum* variety, canker resistant acid lime variety **"Balaji".** He established Molecular Diagnosis Laboratory for citrus virus indexing.

Dr. Gopal has published 118 research papers, 19 popular articles and 10 bulletins. He presented 95 papers in conferences. Dr. Gopal received **Dr. Shyam Singh Best Scientist Award** (2010), **Sri Veerapaneni Narasimham Gold Medal** (1998); **A.V. Krishnaiah Memorial Prize** (2006); **Andhra Pradesh Scientist Award** for his outstanding contributions in Agricultural Sciences, APCOST, Hyderabad (2006); **Prof. HC Dube Outstanding Young Scientist Award** (2006); **Talented Scientist award** (2008); **Sardar Vallabhbhai Patel International Award** (2012); **Shri V.P. Gokhale Prize (2013)** for his excellent contributions in Agricultural sciences and Citrus industry in AP; **Paramount Achievement All India Award (2018); Dr.B.Vasantharaj David Award-(2020)** for his outstanding research contributions in Groundnut disease management and Molecular plant pathology.

He is a life member in 13 scientific societies and admitted as **Fellow of Indian Society of Mycology and Plant Pathology, Udaipur; Fellow of Society of Plant Protection Sciences,** New Delhi; **Fellow of Indian Society of Plant Pathologists,** Ludhiana. He guided 14 PG and 5 Ph.D.

HIGH-VOLUME VIRUS-FREE CERTIFIED PLANTING MATERIAL PRODUCTION IN CITRUS: A SUCCESS STORY OF ANDHRA PRADESH

Dr.K.Gopal
Registrar, Dr.YSR Horticultural University, Venkataramannagudem-534101, West Godavari District, A.P.
email: gopalkurubatpt@gmail.com

ABSTRACT

Sweet orange is one of the chief commercial fruits grown in Andhra Pradesh. Decline of sweet orange trees should be of significant concern to growers in the state. The factors responsible for this problem is attributed to bud wood transmitted diseases like Huang longbing, citrus tristeza virus and citrus yellow mosaic virus. The average life span ofthe trees is reduced in the state which leads to decrease inproduction and productivity of orchards. Once the plants get infected with these diseases there will be no cure as the bud wood transmissible diseases were present systemically in plant tissue. Hence, using of indexed virus free bud wood material is the only option for checking the spread of these diseases. Keeping this in view bud wood certification programme started at centre and elite clones were selected from nucellar trees and maintained in screen house. Biological, serological and molecular protocols were standardised for indexing major bud wood transmitted diseases in the state. “Andhra Pradesh Registration of Horticulture Nurseries (Regulation) Act 2010” was enacted in Andhra Pradesh to restrict the uncertified bud wood material use in the nurseries. The facilities like screen houses and Laboratory strengthened at centre for augmenting indexing, production and supply of disease-free sweet orange cv. Sathgudi. The project has supplied about 3.72 million virus-free Sathgudi buds and 1.1 million virus-free budlings to the registered nurserymen, Government and voluntary agencies. An amount of Rs.5 crores was realised from the sale of diseased free buds and planting material and responsible for establishment of more than 3980 hectares of healthy orchards in the farmer’s field predominately in Southern India which is paving the way for sustainable production of sweet oranges. It indicated that bud wood certification in a boon to Sweet orange growers in the state and enhancing improving the living standards of the orchardists in the state.

QUALITY PLANTING MATERIAL PRODUCTION IN RECALCITRANT BANANA VARIETIES THROUGH DIRECT REGENERATION USING IMMATURE MALE FLOWER BUD EXPLANTS

M.S Saraswathi, Murugesan Umabharathi, Chinnadurai Karthi, Murugesan Bathrinath, G. Kannan, Jayakumar Mahendran, Natesan Kavitha, S. Uma
ICAR-National Research Centre for Banana
E-mail: saraswathimse@gmail.com

ABSTRACT

Banana and plantains which are perennial monocotyledonous herbs belongs to the family Musaceae and it is one of the most important fruit crops of the tropics. They are vegetatively propagated through suckers. Non-availability of quality suckers in adequate numbers for shoot tip extraction stimulated the search for other potential explants for *in vitro* culture. This unveiled the potential of male flower bud explants in place of shoot tips that can be regenerated directly through organogenesis. A diploid cv. Rose and a commercially cultivated triploid cv. Red banana are the two recalcitrant banana varieties used in the present study. This study also aimed to determine the effect of ploidy, position of male floral hands and plant growth regulators on conversion of floral into shoot meristem and their shoot proliferation. The regenerated shoots were rooted successfully on MS medium fortified with 1mg/l each of IBA and NAA. Plantlets were successfully acclimatized with a survival rate of 90 as against 100 per cent in case of shoot tip explants. Results suggested that male flower bud explants could be used to replace the shoot tips for large scale commercial multiplication.

PRODUCTION OF TRIPLOIDS AND TETRAPLOIDS IN COMMERCIAL CITRUS SCIONS AND ROOTSTOCKS BY INNOVATIVE *IN VITRO* AND *EX VITRO* PROPAGATION TECHNIQUES

Mrs. Vijayakumari Narukulla, Yogesh Lahane, Shashi Pandey, Priya Uge and Krutika Fiske
ICAR-Central Citrus Research Institute
E-mail:narukullav@gmail.com

ABSTRACT

Production of seedless citrus fruits is required for the fresh fruit market. Development of new seedless commercial varieties has a high priority for many citrus industries world wide. Ploidy manipulation in citrus is a major issue for current breeding programs aiming to develop triploids and tetraploids to address consumer needs for seedless cultivars and improved tree size controlling rootstocks, suiting to the advanced citrus production systems. At CCRI, we explored innovative propagation approaches for creation of tripods and tetraploids in commercial citrus cultivars followed by flow cytometry. Complete plantlet regeneration obtained from hybrid endosperm rescue via somatic embryogenesis of Nagpur mandarin and sweet orange. Regenerated shoots were successfully transferred from lab to land by minigrafting on rough lemon rootstock. Further described novel methodology of production of tetraploids based on *in vitro* colchicine treatment of microbudded plants and germinating seeds of the four commercial citrus scions viz., Nagpur mandarin, sweet orange, USA-145 and Pummelo-5 and three commercial rootstocks (Alemow, Rangpur lime and Rough lemon).

Successfully surviving plantlets of stable triploids from endosperm rescue and autotetraploids with colchicine treatment via microbudding and meristematically active seeds of commercial citrus scions and rootstocks were tested for ploidy by flow cytometry and cytogenetic techniques. The tetraploids produced by the above mentioned two innovative approaches can act as potential parents in interploid hybridization of elite scions for triploid breeding. The tetraploid rootstocks so developed can be explored in advanced citrus production systems for sustainable citriculture, which is first of its kind in the field of citrus polyploid breeding in India & can overcome the barriers to sexual hybridization towards breeding seedless citrus cultivars and improved rootstocks.

VEGETABLE ROOTSTOCKS FOR MANAGING BIOTIC AND ABIOTIC STRESSES

Pradeep Kumar[1*] and P.S. Khapte[2]
ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra
Correspondence: pradeep.kumar4@icar.gov.in

ABSTRACT

Grafting in vegetables is increasingly gaining momentum owing to its efficiency to rapidly increase vigour, yield and stress tolerance by utilization of resistant root genotypes belonging to same or different species or genera, even wild relatives. Although grafting originated in East Asian countries (Japan and Korea) a century ago and has spread over >30 countries, getting greater rates of adoption in Europe, its application in India is still in infancy. Scion-rootstock interaction known to influence graft success, but overall success greatly relies on the efficiency of the rootstocks to interact the given soil environments. Our efforts were to select rootstocks by screening a large number of genotypes of different species and genera of solanaceous and cucurbitaceous species for grafting tomato and cucumber, respectively, to increase yield and resource use efficiency, besides alleviating tolerance to different stresses. In grafting technique, we standardized the box-grafting technique and achieved greater success rates both in tomato (92-94%, splice and cleft) and cucumber (89-92%, single cotyledon and cleft) at room normal temperature range (25 to 30°C and 85 to 95% RH) for small scale grafting. In production terms, grafting tomato onto wild tomato (*S. pimpinellifolium*) increased yield under normal and moderate water stress, while grafting onto Arka Vikas and RF4A under severe water deficit condition were more promising. Further, tomato rootstock RF4A tested under controlled watering has shown the higher water use index by better stomatal regulation and maintaining plant water status under severe water stress. Eggplant rootstocks (cultivated or wild) were not found promising for tomato grafting under normal as well as water stress conditions. Whereas, eggplant rootstock has shown beneficial effects on increasing heat tolerance in tomato up to some extent. Similarly, grafting mini-cucumber onto interspecific *Cucurbita* rootstocks (NS 55) imparted good vigour and yield both under normal as well as stressful conditions of water, and soil-borne diseases. The above findings reveal that grafting can effectively be utilized to increase yield under challenging environmental conditions.

EFFECT OF INTER-SPECIFIC GRAFTING IN SOLANACEOUS VEGETABLES ON YIELD AND QUALITY PARAMETERS

Anant Bahadur, Anish Singh, Hare Krishna, Jagdish Singh, Tusar Behera
Indian Institute of Vegetable Research Varanasi
E-mail: singhab98@gmail.com

ABSTRACT

Grafting of vegetables is a unique horticultural tool to enhance yield and quality of vegetables. At ICAR-IIVR, Varanasi, grafting studies have been carried out in different Solanaceous vegetables using various inter-specific rootstocks. Grafting of tomato (Kashi Aman, Kashi Chayan, Kashi Adarsh) on brinjal rootstocks (IC-111056, IC-354557 and Surya) revealed that the maximum fruit yield of 2.055 kg/plant was registered in Kashi Aman grafted over Surya followed by Kashi Adarsh on IC-111056 (1.965 kg) and on IC-354557 (1.888 kg). TSS content in fruit was unaffected in both Kashi Aman and Kashi Adarsh tomato cultivars, but with use of IC-111056 rootstock TSS content was enhanced by 11-36% over ungrafted control. Ascorbic acid content was ranged from 22.17 to 27.23 kg/100 g. Grafting studies in brinjal during 2016-2020 concluded that maximum fruit yields of 333.52 and 306.90 q/ha were reported when Kashi Sandesh brinjal was grafted on IC 354557 and IC 111056, respectively. Field study on grafted pomato revealed that potato tuber production ranged between 505 to 745.67 g, while tomato production in the range of 826-3090 g from a single pomato plant. Dual grafting of brinjal and tomato (brimato) was also successfully demonstrated under field condition during 2020-21. Experimental findings on brimato revealed that about 2.38 kg yields were obtained in tomato, while in brinjal 2.68 kg yields were harvested from each brimato plant. In nutshell, grafting is an effective means to improve yield in vegetables by utilizing the efficient root system of rootstocks

Oral Paper

IMPACT OF ROOTSTOCKS ON QUALITY AND NUTRIENT STATUS OF EXOTIC APPLE VARIETIES UNDER HIGH DENSITY PLANTATION

Aroosa Khalil
SKUAST K Shalimar
E-mail: aroosakhalil11@gmail.com

ABSTRACT

The present investigation entitled 'Impact of rootstocks on quality and nutrient status of exotic apple varieties under high density plantation was undertaken at experimental field of Division of Fruit Science, SKUAST-K. In Jammu and Kashmir, apple acreage is dominated by major proportion of Red Delicious variety on seedling rootstock. In spite of consistent increase in area under apple, the production has not proportionally increased. The need of the hour is to upgrade the varietal status of apple through the use of spur varieties and colour mutants on clonal rootstocks for better productivity. .An investigation was therefore undertaken to assess the potential of semi-dwarf MM-106, M-4 and dwarfing M-9 clonal rootstocks for quality and nutrient status of Vance Delicious and Silver Spur apple varieties. The experiment was laid down in RCBD (factorial) having four replications. Results revealed that Silver Spur performed better in terms of yield efficiency, quality parameters (fruit length, diameter and weight, total soluble solids and total sugars) in comparison to Vance Delicious. Among the rootstocks studied it was the dwarfing rootstock M-9 which showed best result in terms of photosynthetic attributes(chlorophyll content), quality parameters (fruit length, diameter, weight) and nutrient uptake (nitrogen, calcium and magnesium) as compared to MM-106 and M-4. Hence it can be concluded that performance of Silver spur on M-9 rootstock was best in terms of quality and nutrient status and thus can be recommended to the farmers for better returns.

CITRUS ROOTSTOCK IDENTIFICATION BY DNA-FINGERPRINTING WITH INDELS

Ashutosh Murkute, Prasanth Tej Kumar Jagannadham, hirugnanavel A
ICAR - Central Citrus Research Institute, Amravati Road, Nagpur 440033
E-mail: ashutoshmurkute@gmail.com

ABSTRACT

High quality rootstocks and scions are the foundation of citrus industry across the world. Out of which a rootstock is primarily responsible for nutrient and water supply for fencing biotic and abiotic stresses. Rangpur lime (*Citruslimonia*) and Rough lemon (*Citrusjambhiri*) are the recommended citrus rootstock genotypes and used by citrus growers in India. Farmers solely rely on buying budlings of Nagpur mandarin and sweet orange from large distant nurseries for commercial plantation. However, due to increasing demand and non-maintenance of mother blocks of recommended rootstock genotypes, many commercial nurseries import seeds from outside sources. Rootstock seeds, which are randomly collected from different sources mostly contain Galgal (*Citrus psuedolimon*) seeds along with other undesired admixtures. Budding on such non-recommended rootstocks severely compromise the yield, quality and longevity. Therefore, the present study study was designed to identify and differentiate rootstocks using InDel markers. A total of eleven prominent rootstocks including Rough lemon, rangpur lime, Alemow, Galgal etc. were selected for the present study. A total of 45 InDel markers were amplified in the selected rootstock genotypes. Among the 45 InDel markers, 20 were observed to be polymorphic. It was necessary to use a multiplex approach to uniquely identify each rootstock. Based on the patterns of amplified DNA fragments, combinations of different InDel markers was identified to screen and differentiate the selected rootstock genotypes.

Oral Paper

IN VITRO MASS MULTIPLICATION THROUGH ORGANOGENESIS AND SOMATIC EMBRYOGENESIS OF PINEAPPLE (ANANAS COMOSUS L.) FOR ITS AREA EXPANSION IN BIHAR

Hidayatullah Mir, Shaheena Perveen, Tushar Ranjan, Manoj Kundu, A.K Pal, Sanjay Sahay
Bihar Agricultural University, Sabour
E-mail: hidayatmay14@yahoo.co.in

ABSTRACT

Pineapple is one of the important fruit crops of Bihar mainly grown in Kishanganj and adjoining districts and has the potential for large area expansion in the state. Lack of availability of quality planting material of improved varieties is one of the major constraints faced by the pineapple growers. Except pineapple, all other fruit crops registered growth in production in the last three years (Bihar Economic survey, 2019-20). As an alternative, *in vitro* procedures were developed to improve upon the multiplication rate of this crop. Our work concerned several experiments aimed at developing an efficient regeneration protocols through somatic embryogenesis and organogenesis in pineapple. Suckers were used as an explant for Organogenesis. MS media added with BAP and NAA alone and in combination at different concentration (0.0, 1.0, 2.5, 5.0 mg/l) were used as medium. Maximum number of shoots regenerated per explant (6.40 ± 0.58) and maximum regeneration percentage (57.26 ± 3.89) were observed in the media having 1.0 mg/l NAA and 5.0 mg/l BAP. MS media having NAA 1.0 mg/l + BAP 2.5 mg/l recorded minimum number of days (13.80 ±1.85) required for shoot initiation. The longest shoot (4.80 ± 0.02 cm) and maximum number of leaves (8.80±0.06) were achieved with BAP 5.0 mg/l alone. In our study we also developed the efficient protocol through somatic embryogenesis with higher multiplication rate. *In vitro* regenerated plantlets were successfully hardened and planted in the field conditions. These protocols will prove to be very effective for its area expansion in Bihar.

PERFORMANCE OF CULTIVATED AND WILD SPECIES OF BRINJAL AS ROOTSTOCK AGAINST BACTERIAL WILT AND EFFECT OF GRAFTING ON YIELD ATTRIBUTES

Sunidhi Mishra, Jitendra Singh, Versha Kumari, Dhananjay Sharma
Indira Gandhi Krishi Vishwavidyalaya
E-mail: sunidhi.agri@gmail.com

ABSTRACT

Brinjal is among the most extensively grown vegetable crops in India and adds substantially to the income of small and marginal farmers. However, brinjal cultivation is affected due to the infestation of bacterial wilt disease caused by *Ralstonia solanacearum* Smith in certain regions. The need to combine the two desirable traits *viz*., high yield and disease resistance into one cultivar can be achieved by employing the technique of vegetable grafting which confers the resistance toward soil borne diseases along with augmenting the plant vigour. Seventeen brinjal genotypes were included in the study, among which fourteen genotypes (EBV-1, EBV-2, EBV-3, EBV-4, EBV-5, Utkal Keshari, Utkal Madhuri, Utkal Tarini, Utkal Jyoti, LBV-1, LBV-2, LBV-3, *Solanum torvum* and *Solanum viarum*) were taken as rootstock and three commercial cultivars *viz*., VNR-212, Kashi Taru and Kashi Uttam as scions. *Solanum torvum* was found highly resistance towards bacterial wilt followed by EBV- 3, EBV-4, Utkal Madhuri. The grafted plants had same disease reaction as that of rootstock used *ie*., the plants of susceptible scion cultivars showed resistance towards bacterial wilt when grafted on resistant rootstock. There was significant effect of grafting on different growth and yield related characters of the grafted plants in comparison to non grafted controls. For VNR-212 and Kashi Taru, grafting on Utkal Keshari resulted in maximum fruit yield of 3.94 kg per plant and 2.59 kg per plant, respectively. In case of Kashi Uttam, grafting on the rootstock Utkal Madhuri gave significantly higher fruit yield of 3.95 kg per plant than other graft combinations. Our results show that grafting on highly vigorous rootstocks showing disease resistance can contribute to significant improvements in the production of brinjal cultivars.

Oral Paper

STANDARDIZATION OF IN VITRO COMMERCIAL MULTIPLICATION OF IVY GOURD (*COCCINIA INDICA*)

Ravindra Kumar Kurimella, Gouri Sankar T, Ramanandam G, Mamatha K, Naga Lakshmi R, Snehalatharani A, Kishore Kumar Ch S

Dr.YSRHU

E-mail: ravikhorti@gmail.com

ABSTRACT

Coccinia is a perennial, tendril climber commonly known as little gourd belongs to Cucurbitaceous family. It is a commercially important vegetable throughout the India and other tropical countries. Shortage of quality, disease free seedling material from cuttings of mature stems is the major hindrance for its commercial cultivation. The emergence of new strains of ToLCNDV resulting from recombination enables this virus to infect new hosts, resulting in huge economic losses. In this case, an attempt for the replenishment of this valuable genotype is deemed imperative. Keeping in this view, present investigation on developing an efficient and true to type micro-propagation system using nodal segments was carried out at TC Laboratory, HRS, Kovvur, Dr YSRHU during the period from 2018-2021. Highest explant survival (56.9%) with lowest chemical toxicity (4.4%) was achieved by treating the nodal segments with Carbandazim (0.1%) + Mancozeb & Metalaxyl (0.1%) + 200 ppm 8 HQ for 60 min. followed by surface sterilized with 0.1% HgCl2for 4 minutes. Among the different hormonal combinations tested for shoot bud induction, highest shoot response (60.38 %), maximum number of shoots per explant (1.58), longest shoots (4.97 cm) was recorded in shortest period of time (14.5 days) in MS medium supplemented with 2.0 mg L-1 BAP + 0.1 mg L-1 NAA. Among the different shoot multiplication mediums tested, shoots cultured in MS medium supplemented with 2.0 mg L-1 BAP + 1.0 mg L-1 Kinetin + 0.5 mg L-1 GA3 yielded highest micro-shoots per shoot (12.9) with highest (1.88) shoot multiplication ratio. Significantly highest (93.5%) in vitro rooting was recorded in half MS media supplemented with 0.1 mg/l IBA in a shortest period of time (10.8 days) followed by 0.1 mg/l NAA and both are on par with each other. The rooted plantlets were successfully hardened in disposable paper cups containing 1:1:1 ration of red earth, sand and cocopeat media. This protocol enables the commercial scale production of quality, disease free tissue culture plants of *Coccinia*.

Day 3, November 20, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session IX

EXPLOITING ALTERNATE PRODUCTION SYSTEMS FOR PROFITABILITY

Chairman : Dr S.K. Chakraborty, VC, UBKVV

Co-chair : Dr Neelam Patel, Sr Advisor Niti Aayog, New Delhi

Brief Bio-data

Prof Balraj Singh

Prof. Balraj Singh is working as Project Coordinator, ICAR-AICRP on Honey Bees and Pollinators IARI, New Delhi for the last two & half years. Before joining as Project Coordinator, he successfully completed his three-year term as Vice-Chancellor, Agricultural University, Jodhpur on 25th March, 2019. He also served ICAR-National Research Centre on Seed Spices, Ajmer as Director for three years & seven months. He is doctorate in Vegetable Science and well known scientist in the field of Vegetable Science and Protected Cultivation Nationally and Internationally. During his 32 years of professional carrier, he has acquired valuable experience in research, teaching, HRD and extension in field of vegetable crops and protected cultivation of horticultural crops. He was the member of the pioneer team that implemented Protected Cultivation Technology in India under the Indo-Israel collaborative project established in the year 1999. He has standardized numerous low cost and energy efficient protected cultivation technologies suitable for different agro-climatic conditions for Indian farmers to bring up vegetable production at new heights. He has vast research experience on hi-tech horticulture by handling many in-house, externally funded and inter-institutional projects. He was also Consortia Principal Investigator of NAIP project of around 1.0 million USD funded by World Bank on 'Protected Cultivation of High Quality Vegetables and Cut Flowers: He is the founder Secretary of the Indian Society for Protected Cultivation and he is also the Vice President of Indian Academy of Horticultural Sciences (IAHS). He is Fellow member of Academy of Sciences, Engineering and Technology; Indian Society of Seed Technology; Indian Academy of Horticultural Sciences (IAHS) , Indian Society of Seed Spices and presently he is President of the Society for Horticulture Research and Development (SHRD) & Society for Integrated Development of Agriculture, AU, Jodhpur. He has guided several post graduate and Ph. D. students at Indian Agricultural Research Institute, Pusa-New Delhi and he has also published more than 155 research papers in national and international referred journals of repute and more than 50 book chapters published nationally and internationally. He has been awarded with Dr. Kirti Singh Gold Medal for the year 2015 by the Indian Academy of Horticultural Sciences India for his outstanding contributions in the field of horticulture (Vegetable Sciences).

RECENT ADVANCE IN PROTECTED CULTIVATION IN HORTICULTURE

Balraj Singh
Project Coordinator, ICAR-IARI, New Delhi-12
drbsingh2000@ghmail.com

ABSTRACT

Recently, there has been demand, acceptance and interest by consumers in alternative crops species having unique visual appearance, tastes as well as source of biochemical compounds for increasing their immunity across the world. To meet out this demand of high quality produce area under protected cultivation across the world has increased many folds in the last two decades and is presently estimated more than 5.0 million hectares. As a result of significant research work carried out in the area of protected cultivation several advancements have been made & several innovative technologies have been developed in India and other countries in different areas viz.; greenhouse structures, cladding material, energy saving, automation, greenhouse environment control, precision input control technology, soilless cultivation, fertigation, vertical farming, development of new varieties/ hybrids, grafting technology, identification of new crops, biological management of biotic stresses, pollination management, abiotic stress management, use of bio stimulants, mechanization & use of robotics, nursery production systems, on farm value addition and marketing of the produce. In India varieties and hybrids mainly in vegetables viz; Standard Tomato, Parthenocarpic Cucumber, Cherry Tomato, Muskmelon, Summer Squash, Bitter gourd have been developed and released for protected cultivation. Some of these important crops and varieties are, Cherry tomato (Pusa cherry tomato-1), standard tomato (Pusa Rakshit), Parthenocarpic cucumber (Pusa Seedless Cucumber-6), Melon (Pusa Sunheri) from Indian Agricultural Research Institute, New Delhi. Similarly other institutions like GBPUA&T, Pant Nagar, KAU, Kerala, IIHR Banglore, IIVR, Varanasi have also developed. New design of greenhouses have been developed at CPCT, IARI in which the side ventilated has been increased from 3.0 to 5.0 meters and ventilations through roof ventilators has been increased from 1.0 to 1.8 meter.

Low pressure drip irrigation systems has been designed and installed for small protected structures having small area (up to 1000-2000 sq. meters). Good Agricultural Practices (GAP) for protected cultivation of Tomato; Capsicum and Partheonocarpic Cucumber crops have been standardized for their use during greenhouses cultivation. Battery operated opening and closing of the shade net inside the greenhouses have been developed for its operation during the non availability period of electricity during day time for summer seasons. For semi-arid and arid regions, greenhouse designs have been developed where sprinklers are installed on the roof gutters for their use during peak summer period for cooling down the inside temperature of the greenhouses. Self driven trolleys for greenhouses operators like trellising, training and pruning have been developed, which can be easily operated and used by a single worker. Indigenous bumble bees have been collected and being reared for pollination of greenhouses tomato crops, on the other hand stingless bees and carpenter bees have been found effective pollinators for small protected structures for crops like Cucurbits, Sweet pepper and Chillies.

Prof. R.K. Pathak

Born on August 3, 1943, village, District, Jaunpur, Uttar Pradesh, Dr Pathak obtained M.Sc. Ag. Agra University and Ph.D. in Horticulture from IARI, New Delhi. His major contribution is as teacher at ND University of Agriculture & Technology from 1977 to 1996, during which number of students bagged ICAR Fellowships, selected through ASRB and many universities. He was instrumental in identification of 4 varieties of aonla and bael, standardization of their propagation techniques and cultivation practices in marginal lands. Recipient Rajendra Prasad, Girdhari Lal Gold Medal, Dhatri Shree, Wasvik, Rafi Ahmad Kidwai, Hindu Ratna" award for his contribution on organic farming and IAHS -Shivshakti Life time Achievement Award for the year 2017.

For past two decades, he got interested to conceive technology for sustainable horticulture and nutritional security which he is trying to promote as "Innovative Technology: A Ray of Hope for Sustainable Horticulture and Nutrition Security".

COSMIC FARMING IN HORTICULTURAL CROPS: A RAY OF HOPE FOR NUTRITION & HEALTH BENEFITS

R.K. Pathak
Homa Teacher, Fivefold Path Mission, Former -Director, ICAR- CISH, Lucknow
E-mail:pathakramkripal@gmail.com

ABSTRACT

Soil fertility and environmental quality are critical and crucial for survival of humanity at the planet earth. Agrochemicals based farming over 5-6 decades has badly affected the soil biology and environmental ecology in many regions of the world. Ultimately the three basic elements of Nature *i.e.,* soil; water and air have been polluted beyond imagination. It is well established that any amounts of agrochemicals pumped in cannot restore soil fertility as well as sustainable agriculture production. It is only possible by mediating everlasting sources of energy. Cosmic farming, being promoted by us is based on systematic and synergistic mediating of everlasting source of energy by few simple techniques. Since human body is a mini replica of cosmos, hence food produced and consumed in consonance of natures' gesture without use of agrochemicals will be *Sattvic,* full of nutrition and therapeutic values. Horticultural crops are well suited for cosmic production and consumption. The same technique is equally effective for all crops and in each ecological situation. Looking the current plight of small and marginal farmers and pathetic situation of indigenous cow, both can be addressed with assertive promotion of cosmic farming in even in remote villages with enormous implications.

Dr N. Ravisankar

Dr N. Ravisankar, Principal Scientist (Agronomy) is working at ICAR-Indian Institute of Farming Systems Research, Modipuram from 2011. Having 22 years of research experience in the coastal and other regions, presently involved in coordination of integrated farming systems and organic farming activities at National level as In-charge, Project Coordinator, AICRP on IFS and looking after the national level research work of All India Network Programme on Organic Farming as National Principal Investigator. He has published 73 research papers and 9 review papers in National Academy of Agricultural Sciences (NAAS) rated journals out of which 30 are in more than 6 NAAS rating. In addition to this, publications, and extension materials such as 20 research papers in non-NAAS rated journals, 35 popular articles, 10 books, 52 book chapters, 12 technical bulletins, 25 research folders, 13 Training Manuals, 2 Video films and 50 TV/Radio broad casting have been made by him. Based on the farmer participatory research, 81 geo-referenced farming systems success stories have been documented by involving 23 State Agricultural Universities. As a National Principal Investigator of All India Network Programme on Organic Farming (NPOF), detailed package of practices for organic production of crops in cropping systems perspective have been prepared for 79 cropping systems suitable to 14 states of India and published as *"Organic Farming: Crop Production Guide"*. Dr N. Ravisankar has received 3 National awards, 8 Institutional awards and 6 Academic Societies awards. He also visited Bhutan, The Netherlands and Mexico in connection with organic and integrated farming systems research collaboration and linkage.

RESEARCH STRATEGIES AND FUTURE CHALLENGES IN ORGANIC HORTICULTURE

N. Ravisankar
ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh-250 110
Email: n.ravisankar@icar.gov.in

India is ninth largest in terms of total arable land under organic farming and largest in terms of total number of organic producers in the world. Third party certified and in conversion cultivated area under organic farming reached to 2.66 million ha by March 2021 (APEDA, 2021) while around 0.73 m ha is brought under participatory Guarentee System (PGS). Therefore, currently around 2.4% of net cultivated area is either under certified or in conversion process of organic farming. Government of India has set a target of bringing minimum of 4% net cultivated area under organic farming by March 2026. In this, horticulture sector comprising of vegetables, fruits, plantations, spices, seed spices, medicinal and aromatic plants are going to play vital role. However, organic farming promotion is constrained due to limitations in terms of yield, availability of inputs for nutrient, weed, insect and disease management among other factors.

The major components of organic production technologies in horticultural crops include use of improved and high yielding varieties, cultural practices, nutrient management combining tradition, science and innovations, water and weed management besides post-harvest processing and handling. Research strategies adopted till date include the identification of suitable varieties, rotational and reduced manuring practices, fixed and flexible reduction of manures under towards organic approach, integrated and holistic management of pests including weeds. Further, the systems approach of Integrated Organic Farming Systems is found to be successful in reducing the cost under organic farming and maintaining the biodiversity with sustainability. A long-term experiment on comparative evaluation of organic, integrated crop management (ICM; also referred as towards organic approach) and inorganic was initiated during 2004-05 at 13 locations under All India Network Programme on Organic Farming. Various cropping systems including the vegetables, seed spices, tubers were evaluated over a period of time under three management practices such as organic (supply of 100 % N to each of the crop through organic fertilizers and management as per NPOP standards), towards organic (supply of 50 % N through organic and remaining 50 % through inorganic sources with integrated insect-disease-weed management practices) and inorganic (supply of 100 % of RDF to each crop in the system with chemical based insect, disease and weed management) approaches. Analysis of yield, net returns and soil organic carbon indicates that with proper management practices, organic farming in these crops can be productive as well as profitable.

Oral Paper

PLANT GROWTH PROMOTING, BIOCHEMICAL AND ANTIMICROBIAL PROPERTIES OF MICROBES ISOLATED FROM VARIOUS BIO- FORMULATIONS

R. A. Ram[1], Govind Kumar[2], Israr Ahmad[3], Shailendra Maurya[4] and S Rajan[5]
[1]Principal Scientist (Horticulture), [2] Scientist, (Soil Microbiology), [3] Senior Scientist (Agril. Biotechnology) [4] Junior Research Fellow and [5]Director, ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, P.O. Kakori, Lucknow-226 101, Uttar Pradesh
E-mail: ra.ram@icar.gov.in

ABSTRACT

Bio-enhancers are organic preparations, obtained by active fermentation of animal & plant residues over specific duration. These are rich source of diverse micro organisms, macro, micronutrients and plant growth promoting substances. In general these are utilized to treat seeds/ seedlings, enhance decomposition of organic materials thereby enrich soil and induce better plant vigour. In this study, various formulations, *viz.*; BD-500, 501, cow pat pit (CPP), Panchagavya, Amritpani, jeevamrita, Beejamrita, and biodynamic liquid manure/pesticides (BDLP) were produced at the farm and evaluated for microbial dynamics. Based on observations, maximum microbial population observed in CPP, BD-502-07 and BDLP as compared to BD-500 and BD-501. From CPP total 17 microbes were isolated while 9 from BD-500, 3 from BD-501, 4 from BD-502-07 and BDLP respectively. All isolated microbes were tested for plant growth promotory properties and bio-control action. Based on experimental observations, it was revealed that, microbes from vermiwash (V10, V11 and V12), PG (P8) and CPP (CPP2, CPP7, CPP8 and CPP14) were performed dominantly among all in terms of PGP properties, biochemical tests and biocontrol action against all four pathogens (*Ceratocystis fimbriata*, *Pythium*, *Colletotrichum* & *Fusarium*) Microbial dynamics in on-farm produced bio-formulations (bio-enhancers) such as Cow Pat Pit (CPP), *Panchagavya* (PG), and Vermiwash (VW) was studied. In Vermiwash, maximum number of fungus (58 x 10^6 CFUmL^{-1}), P-solubilising microbes (26.4 x 10^6 CFU ml^{-1}), bacteria (22 x 10^6 CFUmL^{-1}) and *Azotobacter* (22 x 10^6 CFUmL^{-1}) were enumerated. In CPP, maximum number of actinomycetes (96 x 10^6 CFUmL^{-1}) and *Pseudomonas* population was observed whereas PG contained maximum number of *Azotobacter* (20.8 x 10^6 CFUmL^{-1}). Based on bacterial dynamics total 6 bacterial strains including *Bacillus cereus* CISH-CPP2 (MT043902), *Pseudomonas aeruginosa* CISH-CPP14 (MT043911), and *Pseudomonas* spp. CISH C-8 (MT043908) were identified from CPP, while *Bacillus amyloliquefaciens* CISH-P8 (MT043909) from PG and *Pseudomonas aeruginosa* CISH-V10 (MT043903), *Bacillus cereus* CISH-V12 (MT043910) were identified from VW. All test strains were tested positive for plant growth promotory properties like P, Zn, K solubilization, IAA & siderophore production and also showed biocontrol action. Based on all biochemical, molecular and PGPR properties and compatibility of all microbes isolated and identified from various bioenhancers, ICAR-CISH Bio-enhancer (consortium) was prepared and tested in laboratory and field scale application and finally distributed among the farmers for further validation.

STANDARDIZATION OF ORGANIC MANURES FOR DRAGON FRUIT IN CENTRAL DRY ZONE OF KARNATAKA

Hemla Naik B[1], Rashmi P[2], Kantharaj Y[2], Prakash Kerur[3], Shivakumar B S[2], Thippeshappa G N[4]

[1]Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga

[2]College of Horticulture

[3]KVK Hiriyur

[4]College of Agriculture

E-mail: hemlanaikbuahs@gmail.com

ABSTRACT

A field experiment was conducted to study the effect of organic manures on the growth, flowering, yield, quality, and economics of dragon fruit cultivation in the farmer's field of Bhuttanatti village, Hiriyur taluk of Chitradurga district of Karnataka during 2018-19. The experiment was laid out in Randomized Complete Block Design with 02 factors and 27 treatments involving different combinations of organic manures with three replications. The treatment consist of Farmyard manure (0, 15, 30 kg/pillar), Vermicompost (0, 2, 4 kg/pillar) and Poultry manure (0, 250, 500 g/pillar) at three levels each. Among the different combinations studied, 30 kg FYM + 4 kg of vermicompost and 500 g poultry manure per pillar positively affected the growth, flowering, yield, and quality parameters. Significantly maximum plant canopy spread (7.55 m2), chlorophyll a (1.78 mg/g), chlorophyll b (0.12 mg/g), total chlorophyll (1.90 mg/g), number of fruits (23.20/pillar), fruit length (12.36 cm), pulp weight (321.00 g), peel thickness (1.75 mm), fruit yield (10.04 kg/pillar), fruit yield per hectare (11.04 t) and ascorbic acid content (7.70 mg/100 g). Further, the above combination obtained the highest net return of Rs. 8 88,276 per hectare and BCR (5.12) under the Central Dry Zone of Karnataka.

EFFECT OF DIFFERENT ORGANIC SOURCES OF NUTRIENTS ON YIELD AND QUALITY OF CASHEW (*ANACARDIUM OCCIDENTALE* L.) CV.BPP-8

P. K .Panda*, R.K. Pattnaik and K. Sethi
All India Co-ordinated Research Project on Cashew, Odisha University of Agriculture and Technology, Bhubaneswar-751003,Odisha, India
*E-mail: pkpandaouat@gmail.com

ABSTRACT

Cashew is a highly commercial crop and an export oriented trade item contributes a major share to the Indian economy . Looking to the prospects for organic products in international market, demand for organic cashew nut and its by-product is increasing day by day as cashew is an export oriented cash crop. Since India is the major player in the world cashew scenario, organic cashew could be one of India's best options for competing in the world market for increasing the export earnings and it could fetch a better price in the world market. For this, thorough understanding and implementation of organic cashew cultivation is very important. Therefore, the present investigation entitled "Effect of different organic sources of nutrients on yield and quality of cashew (*Anacardium occidentale* L.) cv. BPP-8" was carried out at Cashew Research Station, All India Coordinated Research Project on Cashew, Bhubaneswar under Odisha University of Agriculture and Technology during the year 2018 19. The objective of the investigation was to study the effect of different organic sources of nutrients on cashew with respect to vegetative growth, nut yield and yield attributes, quality of cashew nut and apple, post harvest soil fertility status and estimation of economics at 10th harvest. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments including different organic sources along with control i.e. T_1: 100% N as FYM, T_2: 100% N as FYM + Biofertilizer consortia (200g/plant), T_3: 50% N as FYM + Biofertilizer consortia (200g/plant), T_4: 100% N as Vermicompost + Biofertilizer consortia (200g/plant), T_5: Recycling of organic residue with the addition of 20% cow dung slurry, T_6: *In situ* green manuring / green leaf manuring to meet 100% N, T_7: 25% N as FYM + recycling of organic residue + *in situ* green manuring /green leaf manuring + Biofertilizer consortia (200g/plant), T_8: Recommended doses of fertilizer + 10 kg FYM, T_9: Farmers' practice (Control).

The result revealed significantly positive effect of organic source of nutrients on cashew. The treatment T_8 recorded maximum plant height (6.18 m), no. of flowering laterals/m^2 (23.60), sex ratio(0.19), nut weight (8.40g), kernel weight (2.16g), shelling percentage (29.86) and annual nut yield/plant (9.11 kg/tree). Highest total sugar (10.88 %), reducing sugar (10.16%) and ascorbic acid (5.22 mg/100g) were observed in cashew apple in the treatment T_7. Regarding post-harvest soil status, the maximum available nitrogen (330.67 kg/ha) in treatment T_7, available phosphorous (23.37 kg/ha) in treatment T_3 and available potassium (199.67 kg/ha) in treatment T_4 were found.

The maximum B:C ratio (3.44) was recorded in treatment T_8 followed by T_7 (3.06). The overall results observed during 10th harvest revealed the superiority of T_7 (25% N as FYM + Recycling of organic residue + *in situ* green manuring /green leaf manuring + Biofertilizer consortia 200gm/plant) among the different organic sources towards cashew production.

FLOWER AND FRUIT DROP IN SIKKIM MANDARIN AND THEIR ORGANIC MANAGEMENT PRACTICES

Sudip Kumar Dutta, Shaon Kumar Das
ICAR Research Complex for NEH region
E-mail: sudipiari@rediffmail.com

ABSTRACT

Citrus is one of the most prominent and important fruit crops of North-East India in general and Sikkim in particular. Flower and fruit drop are the two major concerns bothering citrus farmers the most in recent times. Due to climate change and other abiotic/biotic factors, citrus production is facing decline in the state of Sikkim; farmers are reporting the problem of post-bloom drop and pre harvest drop with the intensity of considerable economic losses. We studied the phenology of Sikkim Mandarin flower and fruit development. Flower initiation starts from end of January and lasts upto early March. Mid February to early April is the peak time of flowering and pollination. Fertilization and fruit set extends upto mid April to early May. Early flower and fruit drop takes place upto mid May. Fruit development is the longest period which extends upto early January (nearly ten months). Pre-harvest fruit drop causes the most economic damage and it occurs just prior to harvesting during November to January. We recorded variation in flower and fruit drop of citrus in spatio-temporal context. For Sikkim mandarin, under ICAR-NOFRI, Gangtok condition we recorded 63.88 ± 2.36 % of fruit set. Maximum drop was during the final stages of fruit development. Similarly, under South Sikkim (Village: *Lingee Payong*) condition we recorded 52.1 ± 1.28 % fruit set. Here also maximum drop was during the final stages of fruit development. Majority of fruit drop in all the location was due to fruit fly infestation followed by *Fusarium Sp*. Intensity of flower and fruit drop (%) in different aged plantations of Sikkim Mandarin was studied. It was observed that palnts of <5 years age showed less fruit drop compared to 5-10 years , followed by 10-15 years and maximum drop was exhibited by plants of >15 years age.

AEROPONICS TECHNOLOGY APPLICATION FOR RAISING NURSERIES OF HORTICULTURE CROPS THROUGH AYURVET PRO GREEN HYDROPONIC SYSTEM

***Deepti Rai, Abha Saxena, Anup Kalra and Mohan Ji Saxena**
Ayurvet Research Foundation, Kaushambi, Ghaziabad- 201010 (U.P.)
*Email id : drai@arfmail.in (Corresponding author)

ABSTRACT

Water is a precious natural resource. Approximately 70 per cent fresh water is consumed in Agriculture. In order to address the constraints of water availability & reducing land, Climate- change, Ayurvet (formely Dabur Ayurvet) developed Ayurvet Pro Green Hydroponics Technology. This is India's first hydroponic Machine, patented, Commercially tested and Approved by Ministry of Agriculture, Government of India.

The journey stated from production of green fodder from 50 kg-2000 kg/ day to raising nurseries of paddy to horticultural crops. Since the horticulture crop roots system is different from fodder and cereal crop like wheat, paddy, modification is done. The horticultural nurseries were grown using Aeroponics. In this technique, plants are grown with fine drops (mist) of nutrient solution. The plants are suspended in air and the roots are sprayed with a nutrient-rich mist.

Experiments were conducted to grow spinach, coriander, fenugreek, mint, radish, ashwgandha, kalmegh and dill by using the Aeroponics technology and standardise their growth conditions. Temperature, humidity, aeration were maintained by the Ayurvet Pro Green Hydroponics machine/system.

Crop-specific Nutrient solutions were formulated based on the basic idea of the needs of particular plants and its effects were studied.

The root zone of plants developed amazingly fast as compared to the conventionally grown plants. Coriander, garlic, mint and radish showed spurious growth, healthy root system and shoot formation and true leaf stage was attained comparatively early as in case of soil. Whereas, fenugreek, spinach and dill showed a little slow growth, healthy root system and early true leaf formation. The application of red and blue LED light reduced the time of emergence of true leaf by 20-25% in comparison to control.

TECHNOLOGY FOR THE VERTICAL EXPANSION OF NURSERY UNDER PROTECTED CONDITIONS USING THE SOILLESS ROOTING MEDIUM FOR INCREASING THE NUMBER OF ROOTSTOCKS PER UNIT AREA

Wasim Hassan Raja, Om Chand Sharma, Javid Iqbal Mir, Sajad Un Nabi, Mohd Abbas Shah, Muneer A Shiekh

ICAR-Central institute of Temperate Horticulture Srinagar

E-mail: wasimiari@gmail.com

ABSTRACT

The experiment on the vertical expansion of the nursery was started during the year 2019, to utilize the available space in the greenhouse and to exploit the vertical growth of plants. Success was achieved only in the case of apple clonal rootstock MM-106. During the year 2020, the trial on air layering has been attempted in other clonal rootstocks including (M9, Pajam, T337, T339, MB-9, P-22, M-27) buy using the same technique. Those plants having a diameter of (5 mm and above) at 30 cm (1.0 ft) above ground level were selected and wounding/incision has been given by sharp knife/blade and rooting hormones IBA (2500 ppm) was applied to the wounded portion. The wounding was done to the targeted region to expose the inner stem for applying the rooting compound. The treatment was started from the second week of June till the 2nd week of September. Small polybags filled with rooting medium have been fastened at the points where rooting needs to be initiated. A lightweight substrate (Cocopeat) having high water holding capacity was used. Staking was done with the help of bamboo sticks to hold the bags in a proper position. Watering at regular intervals was done to keep the rooting media moist. Sufficient rooting has been recorded in all the rootstocks. From the data, was revealed that the maximum plant height (134.3cm) was recorded in rootstock MM-106 and minimum (89.17cm) in rootstock M9-Pajam. Maximum plant dia (8.77mm) was recorded in rootstock in MM-106 and minimum (6.49mm) in rootstock P- 22. The highest no. of plants per rootstock (3.9) were harvested in MM-106 whereas the minimum no. of plants per stock (2.1) was recorded in rootstock M-27. Maximum root length (15.83cm) was recorded in rootstock M9-Pajam and minimum (9.67cm) in rootstock M9-T339. Maximum root dia (2.39mm) was recorded in rootstock MM-106 and minimum (1.10mm) in rootstock B-9. The highest no. of adventitious roots (5.9) per plant was recorded in rootstock MM-106 whereas the lowest no. of adventitious roots (2.1) was recorded in rootstock P-22. The highest root fresh weight (4.0g) was recorded rootstock M-106 and the lowest (2.1g) in rootstock M-27. Maximum root dry weight (3.70g) in treatment in rootstock MM-106 and minimum (1.80g) in rootstock B-9. This technology will be very useful in promoting the vertical expansion of the nursery in greenhouse conditions and no. of plants per unit area can be increased 3-4 times without utilizing any extra inputs. One more additional benefit of this technology is that under greenhouse conditions a plant is attained a sufficient girth, above (5mm) and all the daughter plants are suitable for budding operation. The budding has been done to about 45% of daughter plants with an almost 95% success rate. This technology not only produced the additional 2-4 plants per stock but also the budded plants which added the further advantage to this technology, that budded plants with well-developed root systems are produced in one year of the nursery cycle.

NET HOUSE CULTIVATION OF PAPAYA

Sharath Kumar Reddy Reddy, Sreedhar Devarakonda, Nagalakshmi Thota
Dr. Y. S. R. Horticultural University
E-mail: sharath2006ag@gmail.com

ABSTRACT

Papaya (*Carica papaya* L) is cultivated primarily in tropical and sub tropical regions. For several decades the global production of papaya has been threatened by papaya ring spot disease (PRSV). Protected cultivation of papaya in a sub tropical region may provide optimal environment for its growth and productivity with avoidance of PRSV. Growth and flowering benefits from the climate within the protected chambers results in improved yields, both in fruit quality and quantity with the critical additional benefit of the exclusion of Ring spot virus. In this context, to access the growth and incidence of PRSV under net house condition the present study was conducted at Horticultural Research station, Anantharajupeta, Dr. Y S R Horticultural University. The study revealed that growing of papaya under net house condition (40x60 mesh insect proof net) from seedling to harvest can completely (100%) control Papaya ring spot virus (PRSV) and Papaya leaf spot virus (PLCV) incidence by preventing the entry of aphids and whiteflies and also recorded the highest fruit weight (1.10 kg), marketable yield (46.25 kg/plant/year) and yield(142.72 t/ha) along with highest fruit quality attributes TSS(12.54oB) and pulp thickness (3.22cm).

STUDIES ON PERFORMANCE OF CHRYSANTHEMUM (CHRYSANTHEMUM MORIFOLIUM RAMAT.) CULTIVARS GROWN UNDER GREENHOUSE IN THE SOIL AMENDED WITH DIFFERENT CYNOBACTERIAL FORMULATIONS

M.C. Singh, Radha Prasanna, Kanchan A, Simranjit K, Ranjan K, Murtaza Hasan and Y S Shivay
CPCT, ICAR-IARI, Pusa Campus
drmamchandsingh@gmail.com

ABSTRACT

An experiment was undertaken with two varieties of cut chrysanthemum (cv White Star and Zembla) inoculated with cyanobacterial formulations at field and nursery stage at the Centre of Protected cultivation Technology (CPCT), ICAR- IARI, Delhi. The experiment was conducted under controlled conditions maintaining a temperature and humidity in a range of 18 to 21°C and 62 to 75%, respectively. Drip fertigation was applied @ 2-3 cubic litres of water in an 1000 m2 area per application supported by 16:2:30 twin-drip laterals per bed. Application of nutrients (NPK) was maintained from urea phosphate (17:44:0), potassium nitrate (13:0:46) and potassium sulphate (0:0:50). To improve the soil health, Anabaena torulosa and filamentous fungus Trichoderma viride have been explored as matrices for agriculturally important rhizospheric bacteria and fungi, to develop laboratory constructed novel multi-functional and two-membered biofilms. IN the present study the different biofilms developed were washed to remove adhering media components and mixed with the carrier (paddy straw compost: vermiculite; 1:1), at the rate of 5 ug chlorophyll /g carrier. The colony counts of Azotobacter sp., B. subtilis and T. viride in the formulations prepared were 107, 108 and 104 cfu/g respectively. The drench/foliar spray were prepared by adding 300 g of the different formulations in 6 litres of water, which was incubated for a week, at room temperature (23 ± 3?C) and shaken manually after every 24 h. The formulations were added adjacent to the roots in powder at the rate of 2 g per plant at the time of transplanting of the plugs in field/nursery and 30 days self-rooted plugs were transplanted and performance in terms of per cent increase in plant height (30%), biomass (18%), dry weight accumulation (22%) and flower size (15%) were significantly influenced by soil drench followed by spray as compared the powder applied in the root-zone. Zembla could produce significantly longer (95 cm) stems as compared to the White Star (67 cm) which was significantly higher than those growth with inoculation (55 cm and 37 cm, respectively.

ENHANCING CLIMATE RESILIENCE OF GRAPEVINES

Ajay Kumar Upadhyay, Deependra Singh Yadav,, Sujoy Saha, Anuradha Upadhyay, R G Somkuwar
ICAR-National Research Centre for Grapes
E-mail: Ajay.Upadhyay@icar.gov.in

ABSTRACT

Changing climatic conditions pose an immense challenge to profitable grape cultivation. The decade 2010-2020 is testimony to recurring droughts, uneven rain pattern and extreme weather events leading to unseasonal rains, hails, frost and temperature stress in grape growing areas. The occurrence of the event and phenological stage determines the extent of crop loss. ICAR-NRC Grapes has quantified the extent of loss due to water scarcity at different phenological stages. The Centre has also standardised irrigation schedule for commercial grape varieties. Further, subsurface irrigation, mulch + antitranspirant and partial rootzone drying techniques were approaches used to for efficient use of irrigation water. The demonstration of these techniques showed the possibility of saving irrigation water in farmer's field upto 46.8%. Molecular analysis revealed that subsurface irrigation minimized the adverse effects of stress through modulation of genes involved in cell homeostasis.

Plastic cover is one such technology suited to extreme weather conditions. It increased the vineyard productivity and reduced irrigation water requirement, downy mildew incidence and insect pest damage compared to grapevines under open conditions.

Among pest and diseases, there have been change in species complex and the nature and intensity of the damage. *Dervishiya cadambae* and *Stromatium barbatum* have become major pests and bacterial spot and leaf blight caused by *Xanthomonas campestris* pv. *viticola* and *Alternaria* species have gained economic importance. *Spodoptera litura*, which was earlier causing damage to leaves, have now started damaging the newly sprouting buds causing severe yield losses. *Scelodonta strigicolis*, which caused major damage mainly to sprouting buds, has now started damaging bunches also. *Scirtohrips dorsalis* has become major thrips species damaging grapes and *Rhipiphorothrips cruentatus* has become less important. Downy mildew earlier prevalent only in the temperature range 28-30°C, are even reported in areas with higher temperature. Thus, there are more fungicide sprays, and early development of fungicide resistance. Location and farm specific weather forecast based biointensive management strategies with need based use of pesticides provided effective management of diseases and pests with MRL compliant quality grapes production.

ENHANCING STRAWBERRY PRODUCTIVITY, IMPROVING FRUIT QUALITY AND SUSTAINABLE MANAGEMENT OF LAND UNDER PROTECTED CONDITION ADOPTING VERTICAL PRODUCTION TECHNOLOGY

Subhrajyoti Mishra, K.M. Karetha, H.L. Sakarvadia, D.R. Kanzaria, D.K. Varu, M.S. Shitap
Junagadh Agricultural University
E-mail: subhrajyoti.ss235@gmail.com

ABSTRACT

Vertical farming, popularly known as sky farming, is a recently emerging technology for cultivating many herbacious crops.As the world's population increases exponentially, arable land is diminishing. The vertical farm concept was developed to remedy the spatial land utilization crisis.An experiment was carried out at Hi-tech Horticulture Park, J. A. U., Junagadh, during 2019-20 and 2020-21 to study the comparative behaviour of strawberry crop under vertical and horizontal production system. The experiment was laid out in Completely Randomized Design, consisting four treatments each replicated four times. The treatment comprised of four different production systems *viz*., single layer system (T1), double layer system (T2), triple layer system (T3) and four layer system (T4). The result revealed critical disparity among the treatments for different characters. With regards to fruit morphometric parameters, the T1 exhibited maximum yield per plant (286.13 g), in contrast, the T4 has shown maximum yield per plot (5.50 kg). The T1 exhibited significantly maximum TSS (9.82 ºBrix). The minimum percent acidity in fruit (0.82%) was produced by the T3. Likewise, the better performance with regards to TSS: acidity ratio (11.72), ascorbic acid content (92.81 mg/100 g), total sugar (4.91%), sugar: acid ratio (6.19) and anthocyanin content (55.16 mg/100 g pulp) was observed in the T3. The T3 was proved to be economically best among the treatments providing a maximum net realization of Rs. 8,68,158.80 and B:C ratio of 0.98. Based on the results obtained from the present investigation, it can be comprehended that the triple layer system (T3) of the vertical garden could be considered for adaptation under the protected structure harnessing greater productivity, fruit quality and profitability in strawberry cv. Winter Down.

CONTAINERIZED FRUIT CULTURE FOR NUTRITION AND INCOME GENERATION

K.K. Srivastava, Dinesh Kumar S.R. Singh and N.K. Sharma
ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, P.O. - Kakori, Lucknow 227 101 kanchanpom@gmail.com
E-mail: kanchanpom@gmail.com

ABSTRACT

As per estimate substantial area in the cities are available for growing fruits, vegetables and medicinal and aromatic plants, however, limitation on land availability pose problems for the growing of plants for aesthetic as well as economic purpose. Further problem of malnutrition among the city dwellers pose the serious health issues. Migration of labors during 'Covid era' lead the problem of the employment. The aforementioned problem can be addressed by containerized fruit culture up to some extent. Growing fruits (perennial plants) in the container always were a challenging task, accordingly ICAR-CISH, Lucknow, initiated research on standardization of container size, growing media, and type of fruit plant and their varieties for successful containerized fruity culture. It can be helpful for fruits growing on the roof top. The results obtained from the experiment conducted at ICAR-CISH, Lucknow revealed that canopy spread (60-75 cm) recorded in different containerized fruit plants with canopy height (70-125 cm). In guava 0.14-0.52 m3, pomegranate 0.15-0.51 m3 and in citrus 0.21-0.42m3 canopy volumes recorded after 3 years. Higher canopy growth recorded in larger containers; however, yield and quality attributes did not vary in different container sizes. In Citrus, 'Kagazilime' variety 'Sriganganagar Lime-1', Jaffa (Sweet orange) and Navel Orange (Sweet orange) and 'Kinnow' performed best in container. Maximum canopy spread (79.30 cm) was noted in Sriganganagar Lime-1 grown in 30x45 cm container which was on par to 45x60 cm, 45x45 cm container size. Pomegranate variety Mridula was found most suitable for growing in the container. In case of guava 'Shweta', 'Lalit' cultivars were found most suitable for container farming. Maximum canopy volume recorded in 'Lalit' variety grown in 45x60 cm container size with average canopy spread 64.48 cm. Growing substrate or media (M1) which comprise equal volume of soil, sand, FYM and vermicompost found suitable for all the crops. Phenological parameters show that different fruits grown in container have 4-7 days' advance in flowering and fruit maturity than field condition. In guava, 4-5 kg fruits, pomegranate 2-3 kg and in citrus group fruit 3-4 kg fruits per containerized plants were harvested in 3rd years. Water requirements vary according to season, containers size and type of fruit plants. Maximum ET and water requirement was recorded in guava, followed by pomegranate and citrus. During summer approximately 1.80-3.50 liter water/ container/day needed in guava while during winter 0.30-0.60 Liter / container/day water required in guava, citrus and pomegranate. The B:C ratio for production of fruited containerized plants is 4:1

EVALUATION OF SUITABILITY OF SOILLESS POTTING MEDIA CONTAINING FLY ASH AND PRESS MUD FOR INDOOR FOLIAGE PLANTS

Shilpa Shree KG
ICAR-DFR
E-mail: shilpa.kgs@gmail.com

ABSTRACT

Foliage plant nurseries have high value per square foot because of their intensive production systems. In nursery industry, selection of a suitable potting media is very important as it influences frequency and rate of watering and fertilization. An experiment was conducted during 2019-20 at ICAR-Directorate of Floricultural Research, Pune to evaluate the suitability of fly ash and press mud as potting media components to grow indoor foliage plants viz., *Epipremnum aureum* and *Dracaena*. The experiment was laid out in randomized block design with 11 treatments and three replications. Different combinations of fly ash, pressmud, vermicompost and cocopeat were tested in comparison to control (cocopeat: vermiculite: perlite (33.3:33.3:33.3). Growth of*Epipremnumaureum* was significantly higher in potting media combination Fly ash+Vermicompost+Cocopeat (20:30:50) when compared to control. Maximum plant height (16.7, 39.9 and 148.4 cm), no. of leaves (7.9, 53.3 and 91.9), leaf length (10.3, 10.4 and 12. cm), leaf width (5.9, 6.3 and 7.7 cm) and petiole length (5.0, 5.8 and 6.6 cm) were recorded in potting media Fly ash+Vermicompost+Cocopeat (20:30:50) at 3, 6 and 9 months after planting respectively. Growth of *Dracaena* was better in potting medium Cocopeat+Vermiculite+Perlite (33.3:33.3:33.3) and it was statistically on par with Fly ash+Vermicompost+Cocopeat (15:35:50). Macro and micro nutrients concentration of the leaf samples of *Epipremnumaureum* and *Dracaena* were observed to be in accordance with the growth trend. Based on the growth observations and cost of potting media, it was found that Fly ash+Vermicompost+Cocopeat at the proportions 20:30:50 and 15:35:50 were most suited and economical potting media for *Epipremnumaureum* and *Dracaena* respectively.

GOAT BASED INTEGRATED FARMING SYSTEM TO ENHANCE THE PRODUCTIVITY AND PROFITABILITY IN COCONUT ECOSYSTEM

Sudhalakshmi C, Rani S., Praneetha S.
Tamil Nadu Agricultural University
E-mail: soilsudha@yahoo.co.in

ABSTRACT

Coconut plantations hold great promise on the rural economy of many countries across the globe. More than 98 % of the coconut holdings in the country is less than 2.0 ha in size and more than 90 % of them are lesser than 1.0 ha. An experiment was initiated during 2015 – 16 at Coconut Research Station, Aliyarnagar over an area of 0.40 ha to study the effect of integration of livestock component (Goat) on soil fertility, system productivity and economics of coconut. The treatments include T1 – Coconut + Fodder trees (*Sesbania grandiflora* (Agathi), *Leucaena leucocephala* (Subabul), Glyricidia) + Pasture Crops (Cumbu Napier Hybrid, Desmanthus) + Goat (Telicherry Breed) and T2 – Monocrop of coconut. Nut yield accrued during 2020 was 17,200 no.s in T2 as against 16950 numbers in T1. Pasture production was 10,700 kgs and goat manure obtained was 6600 kgs. Incremental income of Rs.1,28,200 per ha was accrued in T1 compared to T2. Contribution of N, P and K from 6600 kgs of goat manure is 178.8 kgs, 41.6 kgs and 79.2 kgs respectively. Chemical fertilizer equivalent is 387.9 kgs of urea, 260 kgs of single super phosphate and 126.7 kgs of muriate of potash. Using NUTMON (Nutrient Monitoring) tool box, it was found that negative balance of N, P and K was -54.2 kgs, -0.6 kgs and -114.9 kgs respectively. Employment generation was 225 man days per ha per year in IFS system as against 165 man days per ha per year in coconut monoculture.

Day 3, November 20, 2021

Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session X

POST-HARVEST MANAGEMENT AND VALUE ADDITION

Chairman : Dr B.C. Deka

Co-chair : Dr WS Dhillon

Dr Ram Asrey

Dr Ram Asrey earned his Ph.D. from C.S. Azad University of Agriculture & Technology, Kanpur and started his professional career from Central Institute of Post Harvest Engineering & Technology (CIPHET), Abohar as a Scientist. Presently Dr Asrey is working as principal scientist at Food Science &Postharvest Technology Division ICAR- Indian Agricultural Research Institute New Delhi. Dr Asrey has made significant contributions in the field of pre and postharvest management of horticultural crops. His major work include postharvest handling protocols for strawberry packaging and transportation, pomegranate fruit bagging, low-cost de-sapping sanitizers for mango fruits ,standardization of ethylene doses for Dashehari, Langra and Chausa mango varieties. His work has culminated into development of eco-friendly postharvest technologies. By virtue of their demonstrated ability and adoptability, his research outcomes has disseminated amongst the stakeholders. His work on tree age and postharvest fruit quality has got wider acceptability among the peer group. Dr. Asrey has published more than 75 high impact research articles in international and national journals of repute .He has authored two textbooks on postharvest management of horticultural crops. He has been a recipient of ICAR-IARI best teacher award besides several other awards and honours.

PRE-HARVEST BAGGING FOR ENHANCED POSTHARVEST QUALITY OF COMMERCIALLY IMPORTANT FRUITS

Ram Asrey and V.R. Sagar
Food Science & Postharvest Technology Division, ICAR-Indian Agricultural Research Institute, New Delhi-110 012
E-mail: ramasrey@iari.res.in

ABSTRACT

Pre-harvest fruit bagging is one of the best alternative technique to enhance postharvest quality and commercial value of the fruit. Bag provides protection to the fruits from the insect, pest and diseases, sunburn, scold and scratches caused by the strong winds. It is commercially used in Europe, Australia, Japan, China and Thailand, Taiwan and Malaysia. In India, adoption of fruit bagging by the growers is increasing with a very fast pace in pomegranate, apple, litchi, banana mango and citrus fruit. On-tree pomegranate fruit bagging 70-80 days before harvesting enhances juice content and anthocyanin recovery and minimize the incidence of fruit fly, sun burn, fruit cracking, internal breakdown and bacterial spot. Early stage fruit bagging in apple (4-6 weeks after petal fall) favors higher phenolics, anthocyanin content and minimizes occurrence of cork pit and brown core. In litchi, fruit bagging 30-40 days before harvesting increases fruit retention, peel color intensity and reduce fruit cracking. Bagging after bunch formation in banana lowers the incidence of fruit speckling, peel bruising, anthracnose and cigar-end-rot. Incidence of soft nose, jelly seed disorders, stem end rot and anthracnose get minimized by practicing fruit bagging 60-80 days before harvesting. Timing of fruit bagging and selection of suitable bagging material is crucial for obtaining better results.

Dr B.V.C. Mahajan

Dr B.V.C Mahajan, joined as Director, Punjab Horticultural Postharvest Technology Centre, P.A.U. Ludhiana in November, 2016. Dr Mahajan obtained his M.Sc. (Horticulture) and Ph.D. (Horticulture with specialization in Postharvest Technology) degrees from Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan. Dr Mahajan is recipient of UNDP Fellowship in M.Sc. degree and University Merit Fellowship in Ph.D. degree.

Dr BVC Mahajan has 30 years experience in research, extension and teaching. He has developed several protocols in postharvest handling and export marketing of horticultural crops. He has published 120 research papers in peer reviewed journals of national and international repute, 65 outreach articles, 13 book chapters and authored one training manual. Dr Mahajan has organized numerous hands-on-training programmes for farmers, traders, extension specialists and scientists on postharvest management and marketing of horticulture crops.

He also attended advance training on Information Services about Storage and Distribution of Vegetables and Fruits in Holland. He has also visited Bangladesh to explore the possibility of export of Kinnow fruits from Punjab.

Dr Mahajan has been nominated as Chairman of Cold Chain Committee of Punjab State. He is actively involved in the establishment of commercial postharvest and cold chain infrastructure in various fruit and vegetable market of Punjab, Citrus Estates, and Centre of Excellence for fruits and vegetable in Punjab.

Dr Mahajan was awarded Dr J.C. Anand Gold Medal for his contributions in the field of Horticulture (Postharvest Technology) and also selected as Fellow by Horticultural Society of India, New Delhi.

UV-C TREATMENT FOR SAFE HANDLING OF FRUITS AND VEGETABLES

B.V.C. Mahajan and Pooja
Punjab Horticultural Postharvest Technology Centre, Punjab Agricultural University, Ludhiana-141004, Punjab
E-mail:

ABSTRACT

India enjoys diverse agro-climatic conditions and produce wide variety of fruits and vegetables. However these are highly perishable in nature and therefore, require utmost care during postharvest operation to maintain their shelf life and quality. Developing newer technologies to improve postharvest longevity of horticultural crops has always been a challenge to researchers. A surface treatment that activates mechanisms that reduce microbial burden on fruits and vegetables could be a valuable way for preserving fresh produce. However, a number of chemical approaches that are practical to apply, such as traditional treatments using bactericidal and fungicidal agents are of concern because they pose a harm to human health, prompting research into the identification and development of alternatives. Emerging technologies to reduce proliferation of diseases of produce includes antagonistic organisms, natural antifungal substances and natural defense mechanism such as ultraviolet-C (UV-C) light. Treatments with UV-C light (200-280 nm range) potentially present several advantages to the produce industry as it does not leave a residue, have no legal restrictions, does not require complex equipment, requires no subsequent removal of moisture warranting more in depth analyses for its use in the whole and fresh-cut produce industry. UV-C is non-ionizing radiation that does not penetrate beyond surfaces and is generally regarded as a contact germicide. However, UV-C may induce resistance to various stress factors in tissue via hormesis (initiation of a positive reaction by a low dose of radiation). Recent research suggests that UV-C can modify the nutritional makeup of various fruits and vegetables, indicating that it has the potential to be used to develop fresh functional foods. Treatments that include UV-C in combination with other sanitizing agents appear to be particularly effective in reducing populations of human pathogens, but little is known about the effects of hurdle sanitizing systems on other aspects of the product's quality including nutrient content. UV light used during postharvest on fruits and vegetables can have a variety of effects depending on the dose, preceding conditions/treatments, and/or the surface irradiated. Furthermore, the impact of UV radiation on the possible creation of chemical compounds in foods that may pose a health risk should be assessed to check whether there are any toxicological or chemical safety problems related with UV-treated products. Closer examination of UV light potential to destroy undesirable compounds or pollutants also deserves more attention. Due to low penetration of UV light, the combinations with other post-harvest technologies (ozone, ultrasound, modified packaging atmosphere, sanitizing and anti-browning agents) might be attractive for processors and more efficient. Overall, UV is a promising technology for postharvest disease control and microbial population reduction in some operations; provided that economically feasible means of irradiating fruits and vegetables on a large scale are identified.

Brief-Bio-data

Dr Sunil Pareek

Dr Sunil Pareek is a Professor of Horticulture Postharvest Technology and Head, Department of Agriculture & Environmental Sciences at National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Kundli, India. He is also Adjunct Faculty at Maharana Pratap Horticulture University, Karnal and Director (IQAC), NIFTEM. He obtained Ph.D. in Horticulture (PHT). Dr. Pareek has authored or coauthored 80 research papers, 50 book chapters, 10 books, and 50 popular articles. He is editor of book series 'Innovations in Postharvest Technology' publishing from CRC Press, Taylor and Francis, US. His research focused on the shelf-life extension of fresh and fresh-cut fruits and vegetables. He is on the board of many policy forming bodies. He contributed to technical and scientific meetings with more than 200 invited presentations. He has served in the scientific or organizing committee of 25 international conferences, served on evaluation committees for research grants and on editorial board of many journals including Scientific Reports (Springer Nature) and Journal of Food Quality (Wiley). Dr Pareek is a nominated Director on Board of Directors of National Horticulture Board; Technical Advisory Member of Central Institute of Horticulture, Nagaland; Steering Committee member of GAP, Quality Council of India *etc*. He has been awarded with several prestigious awards.

PHYSIOLOGY, QUALITY AND SAFETY OF FRESH-CUT FRUITS AND VEGETABLES

Sunil Pareek
Department of Agriculture & Environmental Sciences, National Institute of Food Technology Entrepreneurship & Management, Kundli, Sonepat 131028, Haryana
E-mail: sunil_ciah@yahoo.co.in

ABSTRACT

Fresh-cut in reference to fruits and vegetables refers to ready-to-eat or ready-to-cook raw products that have been sliced, cut, shredded, peeled or a braided, while the tissues are maintained in a living respiring state. The portions are completely edible. These products are part of the trend of the food industry to provide convenient items that are consumed directly. Fresh-cut plant produces are currently one of the hottest commodities in the food market of industrialized countries. The products are usually in portion-controlled sizes and are very useful for small households. The fresh-cut sector at present is a dynamic component of the food processing industry and in the United States represent about 10% of fruit and vegetable sales, however, it is in nascent stage in India. The specialized industry is continuously growing, being more and better organized, incorporating the technological advances occurred mainly in the last decade. The main purpose of this talk is to facilitate knowledge transfer and provide helpful guidelines to the industry for minimizing deterioration and keeping overall quality while lengthening the shelf-life.

The technology, physiology, quality and safety of fresh-cut fruit and vegetables must be carefully addressed. There are over 100 different vegetable and fruits that can be prepared as fresh-cut. Popular fresh-cut product includes many types of salad, sliced fruit such as pineapple and various melons, baby carrots and mushrooms. Some of the products are performed in store but many others are produced in pack houses. However, the technology can be complex for longer stored items because in most cases the protective epidermal layers are gone, and wounded making the product more susceptible to microbial decay. Fresh-cut products are alive and hence require very specialized knowledge to maintain appearance, flavour, nutritional quality and safety. Furthermore, there are many interacting technologies that must be employed including raw production selection, temperature and humidity management, gas exchange in films, packing manipulation of respiratory gases, heat and misting application, and chemical treatment to control microbes, oxidation reactions, and textural changes.

Evidently, an integrated and inter-disciplinary approach is needed for accomplishing these challenges, where raw materials, handling, minimal processing, packaging, commercial distribution and retail sale must be well managed. Improving minimal processing is essential for a global market with increased healthier people and ecosystem demands.

Brief Bio-data

Dr Surajit Mitra

Dr Surajit Mitra is a Professor and Former Head of the Department of Post Harvest Technology under the Faculty of Horticulture at Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. Prof. Mitra was awarded several National and International Fellowships for participation in International Training Courses on Postharvest Technology at Kasetsart University, Thailand; PEF, USA; ARO, Israel; and Wageningen University, Netherlands. He also attended and presented several research papers in International Conferences in England, Sri Lanka, Bangladesh and Germany. He delivered a Keynote speech and chaired a Technical Session in the 17th World Congress on Nutrition and Food Chemistry in 2018 at London, UK. Prof. Mitra has published 67 research papers in peer reviewed national and international journals, authored 18 book chapters and 4 books on postharvest technology of horticultural crops. Among various recognitions, Best AICRP Centre Award, Chaudhary Debi Lal Outstanding AICRP Award as a team member; Best Paper Award by ISHS for a collaborative research work with colleagues in Venezuela; Outstanding Scientist Award-2015 from VIF, Chennai; Achiever Award-2015 from SADHNA, HP, and Eminent Scientist Award-2016 from SVWS, Lucknow are noteworthy. Prof. Mitra has developed two varieties of sweet potato including an orange-fleshed type and one variety each of taro, elephant foot yam and swamp taro.

NEW DEVELOPMENT IN PROLONGING STORAGE OF FRUITS AND VEGETABLES

Surajit Mitra
Department of Post Harvest Technology, Bidhan Chandra Krishi, Mohanpur-741252, Nadia, West Bengal
E-mail: drsurajitmitra@yahoo.co.in

ABSTRACT

Desirable dietary intake of nutrients as per the requirement is imperative to maintain good health. Both the macronutrients like carbohydrates, proteins and fats, and micronutrients like vitamins and minerals along with some phytochemicals are required for formulating a balanced diet to lead a healthy and active life. Some of the fruits and vegetables rich in protein, vitamins, minerals and anti-oxidants, and low in carbohydrates, fats and anti-nutrients seem to help in reducing detrimental effects of high fat and high sugar diets to the hippocampus, a major component of the brain. Being protective food, different fruits and vegetables are gaining popularity in almost all over the world as nutrition-security crop to fight oxidative stress, improve general cognition, reduce cholesterol levels and help in maintaining healthy blood pressure levels. The plant foods including fruits and vegetables are only source of dietary fibre, which is essential for bowel movement, growth of gut bacteria and for controlling blood sugar and lipids. Fruits and vegetables having high β-carotene and anthocyanins are also gaining importance as antioxidant foods to tackle the problem of vitamin A deficiency, improving visual acuity and liver function, and to prevent the obesity, heart disease and diabetes. But high moisture content and continuation of metabolic activities as living commodities even after harvest cause huge postharvest losses of fruits and vegetables. In spite of huge production of about 300 million tonnes of fruits and vegetables in India, there is a deficit of 20-25 per cent in per capita availability due to postharvest losses from farm to fork. Globally, about one-third of all food that is produced each year is still wasted, and approximately, 45 per cent of all fruits and vegetables grown are not consumed, causing loss of billions of dollars mainly due to inefficient value chains in developing countries. In this paper, an attempt has been made to discuss a brief account of various modern postharvest management systems including typical value chains for perishables, measures to address the inevitable problem from the base, handling operations starting from harvesting to consumption taking pre-harvest factors into account, use of postharvest tools, nanoparticles, active packaging, improved storage techniques, non-thermal innovative processing technologies including cold plasma technology for microbial decontamination without affecting nutritional and sensory characteristics of foods, pulsed electric fields, ultrasonication and high pressure processing for prolonging shelf life of fruits and vegetables to reduce the loss of harvested produce and thereby to boost farmers' income for lifting rural economy, and to increase the affordability of fruits and vegetables for alleviating global malnutrition. Gene editing to extend shelf-life without loss of quality can also be a promising new avenue for reducing postharvest loss of nutrient-dense fruits and vegetables. Extending storage life of fruits and vegetables with the implementation of improved postharvest technologies and proper monitoring will not only help in cutting food waste and loss, but will be helpful in preventing wastage of natural resources used by the harvested produce, and also in reversing global warming by reducing greenhouse gas emissions due to decomposition of lost and wasted food.

Breif Bio-data

Dr Madhav Naidu

Dr M. Madhava Naidu, Head & Chief Scientist, Spices and Flavour Science (SFS) Department, CSIR-Central Food Technological Research Institute, Mysuru. He studied M.Sc Botany from Gulbarga University, Gulbarga and subsequently obtained Doctoral degree from the same university. He is engaged in various research activities in the core areas of Food Science and Technology. Prior to joining to CSIR, he worked in advanced areas of Coffee-biotechnology at Central Coffee Research Institute, Balehonnur, Karnataka (1990-1999). His contributions to Science & Technology as evidenced from the R & D outcome resulted in more than 65 research articles, two reviews, one book (Cocoa processing) and six book chapters. In addition, 21 PDRU know-how process were developed by him and many of them have been transferred to small and medium scale industries. To his credit 13 patents were already granted and another 14 more have been filed. Three students worked under his guidance were awarded Ph.D degree and at present two more are working under AcSIR programme.

Dr Naidu is Member on several QC bodies like ISO, BIS and Codex since 2014. He is a recipient of prestigious DBT National Associateship Award (1993-94), Best Scientist award (2010-11), Best Technology Transferred Award (2017), Highest ECF Generated Award (2018) from CSIR-CFTRI. He was bestowed with Fellow of Society for Plantation Crops 2017 from Indian Society for Plantation Crops (ISPC), ICAR-CPCRI, Kerala, Life time Achievement Award (2019) from International Society for Horticulture, Agriculture and Plant Sciences, New Delhi.

He is serving as faculty member of the post graduate programmes in CSIR-CFTRI and is in the Editorial Board of Journal of Food Science and Technology (Springer) during 2015-17.

NEW TRENDS IN PRODUCT DEVELOPMENT AND VALUE ADDITION

Sudharani and Madhava Naidu
Department of Spices and Flavour Sciences, CSIR-Central Food Technological Research Institute, Mysore-570020, Karnataka
E-mail: mmnaidu@cftri.res.in

ABSTRACT

Capsicum species are used as a vegetable, spice, and in many traditional medicines due to the presence of bioactive compounds such as capsaicin, carotenoids, and vitamins. Byadagi chilli, a variety grown in Karnataka, India, is famous for its intense colour due to its high carotenoid content. In the present review, we have discussed that Byadagi chilli, which is rich in carotenoids, can be a potential source and can be harnessed for various applications. The main application of carotenoid is in the field of medicine as it possesses antioxidant, anti-inflammatory, anti-carcinogenic and cardioprotective properties. Byadagi chilli can be utilized to obtain carotenoid, which can act as a promising molecule in treating various diseases. Further work is required to isolate and identify different carotenoids present in Byadagi chilli and evaluate their therapeutic properties and further utilization of this potent molecule in treating various diseases.

Dr Brijesh Srivastava

Currently, he is working as a Professor in the Department of Food Engineering & Technology; Tezpur University, India. He has experience of teaching and research for more than 20 years and Industry experience of 02 Years. His research area involves Emerging Non-Thermal Processing, Process & Food Engineering, Food, Rheology; Fruits & Vegetable Processing and Machineries, Hurdle Technology. Currently, he is handling 02 projects with a total money inflow of Rs 2 Crore. He has already published more than 20 peer-reviewed National and International publications and 02 book chapters. He also has been granted an Indian patent on microwave-assisted turmeric processing. He has also delivered invited talks and presented papers at various National and International events. He has guided 03 Doctoral; 20 M. Tech and more than 15 B. Tech. Projects. He is also a member of 06 National and International professional bodies.

ELECTRICAL FIELD-BASED NON-THERMAL AND THERMAL PROCESSING TO EXTEND THE SHELF-LIFE OF FRUITS

Amardeep Kumar and Brijesh Srivastava*
Department of Food Engineering & Technology, Tezpur University, Napaam, Tezpur-784028, Assam
E-mail:

ABSTRACT

India produced 99.07 and 191.77 million metric tonnes of fruits and vegetables, respectively, as per the data published by National Horticulture Board (2019-20) and stood second in the world. These products are highly perishables and easily damaged during post-harvest operations. As per the ICAR (2016) report, there was a loss of 5.8-18.1% fruits and 6.9-13% vegetables during harvesting till storage operations, and also 40% of the produce goes unsell as per Committee on Double Farmer's Income (2019) report.

Conventional processing mainly uses thermal energy for enzyme and microbial inactivation. Energy is produced externally and transmitted to foods through conduction, convection, or radiation which ultimately causes the more significant temperature difference between the innermost and outer surface and results in uneven processing of the final products. The electric field-based novel thermal and non-thermal technologies include ohmic heating (OH), cold plasma (CP), pulsed electric field (PEF), and pulsed light (PL), in which OH is combined electric-field and thermal. The principle behind OH is that it utilizes the internal resistance of the food samples for heating when any electric current is passed through it. Thus, uniform and rapid heating are achieved. PEF, CP, and PL are non-thermal technology used for surface disinfection and sterilization. CP uses energetic, reactive gases to inactivate pathogenic and spoilage microorganisms pertinent to food. It is generated by passing an inert gas through an electric field under applied voltage at room temperature. The electro-permeabilization mechanism of PEF results in the inactivation of microorganisms and permeabilization of the cells without thermal effects. A series of short and high-voltage (10-80 kV) pulses for a few micro- to milliseconds break the cell membranes of vegetative microorganisms in liquid media by electroporation. The US FDA (2015) approved Pulsed light for food treatment at a maximum dose of 12 J cm^{-2}. It uses a high-intensity short burst of broad-spectrum light (pulses) ranging in wavelength from 200 to 1100 nm and inactivates the microorganisms by photochemical, photothermal, and photophysical mechanisms. PL is also effective in reducing allergens, maintaining the nutritional value and texture of food, and extending the shelf-life of certain foods both alone and in combination with other technologies.

The primary focus of these innovations is to increase the production and process efficiency with minimal or no changes to nutritional properties of foods, decrease energy consumption and reduce food wastage by improving shelf life.

Dr Kaushik Banerjee

Dr Kaushik Banerjee is a Principal Scientist from ICAR-National Research Centre for Grapes, Pune. He was largely instrumental in establishing the National Referral Laboratory (NRL) at ICAR-NRC Grapes, Pune, which is acclaimed globally for its contribution to food safety research over the past 17+ years. His area of research focuses on the development of efficient analysis methods for the sensitive and confirmatory estimation of pesticide residues and mycotoxins in agricultural and food matrices, and risk assessment studies for fixation of crop-specific maximum residue levels (MRL). Being a member of the Scientific Panels and Working Groups of Food Safety Standards Authority of India (FSSAI), he regularly contributes to the development and implementation of the food safety standards in India, including MRLs and standard residue analysis methods, for the official control of contaminant residues in food. Dr Banerjee's extensive contributions to science and community have earned him numerous national and international laurels. He received the prestigious Harvey W. Wiley Award of AOAC INTERNATIONAL in 2017, and the Recognition Award of National Academy of Agricultural Sciences (NAAS) in 2019. Earlier, he was named as a Fellow by the Royal Society of Chemistry (FRSC), National Fellow-Indian Council of Agricultural Research and Fellow-NAAS.

STATUS OF REFERRAL LABS FOR CERTIFICATION IN HORTICULTURAL PRODUCE: ISSUES AND STRATEGIES

Kaushik Banerjee
National Referral Laboratory, ICAR-National Research Centre for Grapes, P.O. Manjri Farm, Pune 412 307, Maharashtra
E-mail: kaushik.banerjee@icar.gov.in

ABSTRACT

The referral laboratories play a significant role in managing the quality and food safety of horticultural commodities. The cultivation of horticultural crops receives frequent applications of pesticides and plant growth regulators (PGR) field-applied agrochemicals remain accumulated in the final produce at the stage of harvest, which might create health hazards and non-compliances to the trade standards. In addition to pesticide residues, the horticultural commodities might also get contaminated with mycotoxins and heavy metals, which require a regular-basis monitoring at pre- and post-harvest processing stages, and adoption of mitigation practices. A referral laboratory sets up the guidance documents for appropriate monitoring of these contaminant residues and helps implementing the best practices of residue management through a network of laboratories/ organizations under the Government and private sector leaderships. A referral laboratory also refers to the quality standards (*e.g.* by Codex, Agmark) and defines the guidelines how to comply with those standards.

In 2003-2004, ICAR-NRC Grapes was designated as the National Referral Laboratory (NRL) for controlling the pesticide residues in table grapes to facilitate export to the European Union countries. Over the past 17 years, this laboratory has developed excellent infrastructure through the funding supports received from APEDA, ICAR and FSSAI. It has implemented large-scale residue analysis methods the scope of which covers almost all the pesticides that are currently registered with the Central Insecticides Board and Registration Committee of Government of India. Following the success story of residue management in grapes, the scope of this NRL has been expanded to cover all other fruits and vegetables, especially those which have high export potential (e.g. pomegranate, okra, green chilli, etc.).

These protocols are also optimized to reduce sample-to-sample and lab-to-lab variations in residue test results. For example, the NRL at ICAR-NRC Grapes has contributed several novel residue analysis methods, In a similar line, the Food Safety Referral Laboratory of ICAR-IIHR undertakes analytical services for testing the horticultural produce samples for presence of food contaminants. In each case, the referral laboratories organize the programs for capacity building of the scientific and technical personnel for food analysis through trainings on a frequent basis. These also include the trainers' training courses, which are specially designed to cover food safety regulations, and the techniques of sampling and residue analysis of food contaminants.

STUDIES ON EFFECT OF DIFFERENT PACKAGING MATERIALS ON BIOCHEMICAL CHANGES OF FIG (*FICUS CARICA* L.) CV. BROWN TURKEY DURING STORAGE

A.R. Kurubar, Neeta, Ashok Hugar, Shekharagouda S. Patil and Udaykumar Nidoni
Department of Horticulture, University of Agricultural Sciences, Raichur- 584104
E-mail: amayogikurubar@rediffmail.com

ABSTRACT

A laboratory experiment was conducted during 2019-20 to study the effect of different packaging materials on biochemical changes of fig (*Ficus carica* L.) Cv. Brown turkey during storage. Freshly harvested, well matured fruits were subjected to different packaging viz., crate without newspaper (P1), crate with newspaper layers (P2), honey Comb paper (P3), 1 Kg CFB (P4), punnet box (P5), punnet box with antimicrobial film (P6) and 1 Kg CFB with antimicrobial film (P7) with four replications in CRD design and stored in room condition. Observations were recorded on TSS (Â°Brix), titratable acidity (%), TSS: Acid ratio (%), pH, reducing sugar (%), total sugar (%), phenol content in peel and pulp (mg/g), Ascorbic acid (mg/100g), fibre (%), fungi and bacterial growth, functional groups and micronutrients during storage period. The results revealed that fruits packed in Punnet box with antimicrobial film (P6) proved to be the best treatments followed by Punnet box (P5) among all the treatments under room condition which improves the quality and storability of fruits. As the Punnet box with antimicrobial film (P6) shows the considerable slow down in biochemical process like lowest TSS, reducing sugar, total sugar, TSS: Acid ratio and higher amount of titratable acidity, pH, ascorbic acid and phenol content quality compare to other treatments. The least microbial growth was observed in T6. There were not much variation observed in functional groups but micronutrient content varies with storage period.

NITRIC OXIDE TREATMENT FOR POSTHARVEST QUALITY RETENTION OF FRUITS

Kalyan Barman[1], Anil K. Singh[1], Ram Asrey[2] and V.B. Patel[2]
[1]Banaras Hindu University
[2]ICAR- Indian Agricultural Research Institute
E-mail: barman.kalyan@gmail.com

ABSTRACT

Nitric oxide acts as a signaling molecule, implicated in various physiological process and stress responses in plants. Additional evidences indicated that nitric oxide also plays a regulatory role in suppressing respiration and ethylene production rate in different fruits. Postharvest exogenous treatment of mango and guava with sodium nitroprusside, a nitric oxide donor compound showed highly effective in reducing ethylene production thereby delayed the ripening associated changes like loss of texture, colour and changes in soluble solids and acid content. Like climacteric fruits, the response of nitric oxide treatment when investigated in non-climacteric fruits, similar beneficial response was registered. Pericarp browning, the major postharvest problem of litchi that drastically reduces the consumer acceptance of fruit was highly reduced by postharvest nitric oxide treatment. This treatment retained higher anthocyanins and minimized membrane lipid peroxidation in litchi and jamun compared to control. Moisture loss from fruit and incidence of diseases were also suppressed in response to nitric oxide treatment. Nevertheless, the functional fruit quality attributes like ascorbic acid, phenolics, flavonoids, antioxidant capacity and radical scavenging activity were retained higher in all the nitric oxide treated fruits. These studies confirmed that postharvest exogenous application of nitric oxide have great potential for its commercial use to prolong storage life and extend marketability of fruits.

Oral Paper

FUNCTIONAL CHARACTERIZATION OF MODIFIED BANANA STARCH AND PREPARATION OF LOW GLYCAEMIC CONVENIENCE FOODS

Suresh Kumar Paramasivam, S Pushpavalli, Amelia D Keran, T Suprajhaa, KN Shiva, S Uma
ICAR NRC Banana
E-mail: psureshars@gmail.com

ABSTRACT

Banana starch, with magnificent functional properties is found to have numerous applications in food industry. In spite of the potential advantages, when used in native form it poses lacuna in terms of its insolubility in cold water, changes in gelatinization parameters after processing. In this study, native banana starch of var. Kaveri saba is chemically modified by means of Acid thinning, oxidation, cross-linking and hydroxypropylation methods. Native starch reported the highest amylose content (26.03 %) followed by oxidation (25.67 %) and hydroxypropylation with acid thinning modification (15.4 %) reporting the least amylose content. The extent to which modification is incorporated in the starch granules is validated by observing the degree of substitution (0.15 % in STMP, 0.11% in hydroxypropylation), carbonyl (0.04%) and carboxyl content (0.14%) in oxidation methods of modification. Higher swelling power is reported by oxidation (17.9 g/g) and hydroxypropylation methods (29.01 g/g). Owing to the higher values of swelling power, water holding capacity and amylose content, oxidation based modified starch was effectively used for the preparation of pizza base. Substitution of banana composite flour in the blend decreased its spread ratio and specific volume. Sensory evaluation shown that formulation with 10%GBF, 0.4%BMS and 0.6% BP was preferred with acceptable colour, firm crumb texture and taste with low gluten content (up to18-24%). The addition of nutritionally rich unripe banana, its starch and peel flour, possibly will be a choice to develop fibre enriched low gluten pizza base with commercial viability and functional health benefits.

VALUE ADDITION OF KARONDA TO ACHIEVE NUTRITIONAL SECURITY GOALS

Alok Gupta, Karma Beer, Abha Singh, Anil Verma, Ravi SC, Bharti Killadi
ICAR CISH, E-mail: alokguptabhu@gmail.com

ABSTRACT

Karonda (*Carissa carandas* L., family Apocynaceae) is a valuable minor fruit crop that grows wildly in bushes throughout India. This plant has long been used as a source of remedies for treating anaemia, dysentery, diarrhoea and illness prevention. As a result, *Carissa carandas* fruits could be incorporated into the diet as a source of high nutritional quality components with bioactive potential. This fruit has a lot of potential for processing and value addition into products like jam, jelly, toffee, pickle and chutney, fruit drinks (RTS, Squash and Syrup), dried products, and wine, among other things. The ripe fruit is high in iron and has a decent quantity of vitamin C, both of which combines well with sugars and can be used to prepare a variety of jams. The fruits also contain considerable amounts of jelly grade pectin, which can be utilized to make jelly/ jam. The ripe fruit produces an anthocyanin rich red clear juice which can be used as a wonderful refreshing drink in the summer.

The potentiality of processed products from minor fruits in the country is still untapped. However, efforts have been made by various researchers for the development of value-added products from underutilized fruits. It reflects the feasibility for the development of some diversified value-added products from some of the minor fruit crops grown in India in order to minimize the wastage, to promote these products as export items and to uplift the nutritional and socioeconomic status of the vulnerable communities of the country. In the country, the potential for processed products made from minor fruits is still unexplored. Various researchers, however, have undertaken efforts to develop value-added products from underutilised fruits. It represents the possibilities of developing some specialized value-added products from some of the minor fruit crops grown in India in order to reduce waste, promote these products as export items, and improve the nutritional and socioeconomic situation of the country's poorer groups.

Oral Paper

FORMULATION AND NUTRITIONAL EVALUATION OF IMMUNITY BOOSTER-ORGANIC SOUPS

Vinita Singh, Vinita Singh, Priya Vashishtha
C.S.Azad University of Agriculture and Technology, Kanpur
E-mail: svinita2008@gmail.com

ABSTARCT

Soup is very easy to make and use ingredients that are easy to purchase and not costly.Soup also provides a very healthy and nutritious meal.The study was conducted in Food Science and Nutrition Department of C.S.Azad University of Agriculture and Technology,Kanpur,by incorporating equal ratios of muyshroom,tomatoand spinach powder.Mushrooms are a major source of the immune system boosting- includind zinc.People who do not have enoughy zinc in their diet tend to have fewer white blood cells to help fighting disease,which can lead to a reduce immune response.Enriched with the goodness nature,spinach is a rich source of vitamin A,C and K, magnesium.iron and magnese.Including spinach in your daily diet helps in curing several health issues and leads to a stronger immue system.Tomatoes are an excellent source of lycopene,a type of carotene.Lycopene can help immune function and has been shown to prevent some types of cancer.Tomatoes are also rich in vitamin C,one of the top immune boosting nutrients; These vegetables were procured from the organic garden of Kanpur city.Tomato,mushroom and spinach soup powder were prepared by sun drying method .Moreover,powder was analysed for its vaios physiochemical attributes i.e. moisture,ash,and calciumby A.O.A.C method(1970) ,protein by Micro-Kjeldahl method, Fat by SOCS PLUS system.Thus spinach soup powder was high in all nutrients such as fat,calcium and minerals in comparison of tomato and mushroom,but the protien value was high in mushroom.The formulated soup by these powders is a strong immunity booster and excellent source of antioxidants.

NUTRITION EVALUATION OF BISCUIT FORTIFIED THROUGH PLANT RESOURCES

Seema Sonkar, Archana Kumari and Richa Singh
Email: seemanutritionscience@gmail.com

Fortification refers to the addition of micro-nutrients such as trace elements and vitamins into foods in order to improve the nutritional quality of the food. Biscuit is a popular baked product. The major ingredients of biscuits are refined wheat flour, fat and sugar. Biscuits are an energy dense food but lacks in micro nutrients. Moringa is a rich source of proteins, vitamins and minerals. Moringa leaves contain 0.85 mg/100g iron and 440 mg/100g calcium. Beetroot is a rich source of folate, potassium, manganese, iron and vitamin C content. The present study was undertaken on the development of the moringa biscuits incorporating extract of moringa leaves and beetroot. Standardization of all the products was done on the quality parameter. For standardization of products combination of 75g of wheat flour, 25g of bajra (pearl millet) flour, 20 ml of beet root and 10 ml of Moringa leaves were taken. The nutritional characteristics viz. moisture, ash, protein & minerals content of the standardized product were analyzed. Sensory quality of the products was assessed by score card method.

The results reveal that iron fortified biscuit through beetroot and moringa are more nutritious than traditional biscuits.

POST-HARVEST MELATONIN TREATMENT FOR ENHANCING THE SHELF-LIFE OF GUAVA (*PSIDIUM GUAJAVA* L.) FRUITS DURING STORAGE

Bharati Killadi, Abha Singh, Alok Gupta and D.K.Shukla
Division of Post Harvest Management, ICAR-CISH, Rehmankhera, Lucknow-226101, U.P.
E-mail: bharatipal.pal@gmail.com

Fruit senescence is an irreversible process involving physiological, biochemical and metabolic changes which is accompanied by decline in colour, flavor and nutritionand ultimately shortening shelf-life. Therefore, the study was undertaken to determine the effect of melatonin treatment for enhancing the shelf life of guava (*Psidium guajava* L. cv.Lalit). Freshly harvested physiologically mature guava fruits were dip treated for 5 minutes with melatonin @ 1000 micro molar (T-1), melatonin plus 2% guar gum (T-2), and control (T-3) followed by storage at room temperature. The results indicated that dipping in melatonin plus 2% guar gum, exhibited higher firmness 5.66 Kg/cm^2 and lower physiological weight loss (4.48 per cent) as compared to control fruits dipped in distilled water firmness 3.9 Kg/cm^2 and weight loss (6.16 per cent) on the 8th day of storage. Furthermore, melatonin plus 2% guar gum treatment maintained lower in ascorbic acid content (136.55mg/100g) and TSS (12.56^{0}B) and higher titratable acidity fruit (0.28%) compared to control fruits. These results confirmed the melatonin plus 2% guar gum dipping treatments could be useful for storage of guava fruit to prolong its shelf life for 8 days and maintain its quality.

EFFECT OF PRETREATMENTS ON DEHYDRATION OF OYSTER MUSHROOM

Priya Vashishtha* and Vinita Singh*
Krishi Vigyan Kendra, Hardoi
Directorate of Extension, C.S. Azad University of Agriculture & Tech., Kanpur – 208002 (U.P.)
vashishtha7623@gmail.com

Mushroom is a complete health food which have high medicinal and nutraceutical properties. Nowadays, the demand of mushroom keeps on increasing due to its excellent source of high quality protein, vitamin, mineral and contribute into formulation of balanced diet. Mushroom has been found to inhibit aromatase activity and suppress breast cancer cell proliferation. Mushroom is highly perishable which contain 90 to 95 per cent moisture and starts deteriorating after a few hours depending upon the storage conditions. The shelf life of mushroom varies from 1-2 d at the ambient temperature due to its high moisture content, delicate texture and unique physiology. The undesirable post harvest changes are weight loss, change in colour, liquefaction, loss of moisture and texture reduced the market value and unacceptability of the consumer, the shelf life to oyster mushroom can be extended by drying. Drying is the best and convenient processing technique where the moisture content is greatly lowered which helped to prevent microbial degradation. In order to check discoloration during drying, pretreatment is very important. Pretreatment of mushroom is before drying in one form or other ie. washing in water, KMS, sugar, salt either alone or in combination help in checking enzymatic browning, stabilizing colour, enhancing flavour retension and maintaining textural properties.

The main aim of the present study was to see the effect of pretreatment on dehydration of oyster mushroom in terms of quality and sensorial acceptability. The experiment was conducted with 5 samples and with 5 treatments. Samples of mushroom were sundried by giving various pretreatments i.e., 0.05% Citric acid, 0.05% KMS, 0.05% Citric acid and 0.05% KMS and 0.1%Citric acid and 0.1% KMS. It took 5 d to get the desired final dried product of 6.66 per cent moisture content. From this study, it was found that T5 i.e. pretreatment with 0.1% Citric acid and 0.1% KMS gave the best result in terms of recovery percentage, low moisture content and sensorial score than other treatments. The drying characteristic of the products involving percentage of drying with days of drying were also studied. This technology can be adopted on large scale in order to attract customer to generate income and also for sustaining livelihood of farm women.

NANO STICKER- MULTILAYERED ENCAPSULATION OF 1- MCP AND HEXANAL AS A SMART DELIVERY SYSTEM TO ENHANCE THE SHELF LIFE OF BANANA

Srivignesh Sundaresan[1], Ramesh Kumar A.[1], Manivannan S.[1], Subramanian K.S.[2]
[1]Central University of Tamil Nadu
[2]Tamil Nadu Agricultural University
E-mail: srivignesh.horti@gmail.com

ABSTRACT

In India's bowl of fruits, bananas account for 40% of total fruit yield and 25-30% of post-harvest losses. Post-harvest applications of 1-MCP and Hexanal delay the ripening process temporarily but resumes after a certain time. Despite the fact that these chemicals are well-documented shelf life extenders, but they are highly volatile. Determining the best way to deliver chemicals to fruits in order to extend their shelf life and enhance their availability in the country requires the development of smart delivery systems. A multilayer electrospun nanofiber (ESF) with 1-MCP and Hexanal was created to improve banana shelf life. The SEM and TEM were utilized to characterize the nanofiber, whereas FT-IR was used to confirm functional groups of these chemicals in the inclusion complex. The ESF release kinetics were investigated using GC-MS, and it was discovered that these molecules can be released for 170 days at ambient temperature. The developed ESF (Nano stickers) can easily adhere to the cartoons/ banana bags, where it gradually releases the ripening inhibitor molecules (1-MCP and hexanal) in response to the heat and moisture generated inside the cartoons, delaying the ripening process and ultimately extending the shelf life of banana fruits by 14 days (Grand Naine) in excess compared to control. The qPCR analysis revealed that the shelf life extension is primarily due to downregulation of *MaACO1, MaACO2, MaACS1, MaACS2* and *PLD1*. This enormous shelf life extension results in significant savings for exporters, farmers and dealers by delaying the market clutch of low prices during peak seasons.

X-RAY IMAGING AS A NON-DESTRUCTIVE DETECTION TECHNIQUE FOR JELLY SEED DISORDER IN MANGO (*MANGIFERA INDICA* L.) FRUIT

Rama Krishna Karri[1], Sharma R. R.[2], Srivastav M.[2]
[1]Central University of Tamil Nadu
[2]ICAR-Indian Agricultural Research Institute
E-mail: ramakrishna.karri001@gmail.com

ABSTRACT

Jelly seed is considered a serious internal disorder of mango that appears predominantly in north-Indian mango varieties. It is seen around the stone of the fruit as mesocarp breakdown which in the advanced stage, affects the entire fruit with off-flavour, making the fruit unfit for consumption. The identification of jelly seed disorder becomes difficult as the fruit appears normal and beautiful from the outside, but is only seen when the fruit is cut open. The use of non-destructive techniques like X-ray imaging can be a potential technique for its identification. Two north-Indian commercially grown mango varieties namely 'Langra' and 'Dashehari' which suffers badly from this disorder, were selected for this study. The X-ray imaging of the selected varieties was done and ENVI software method was to evaluate against a manual method for calculating the percentage of affected pulp area. An algorithm was also developed to differentiate between healthy and affected fruit, using image processing (MAT lab) on X-ray images. Our results revealed a high correlation coefficient was obtained between ENVI software method and manual method in 'Langra' (r = 0.931) and 'Dashehari' (r = 0.986) varieties of mango. Based on processed images using ENVI, the 'Dashehari' mango variety (75.16 %) are more severely affected with jelly seed incidence than 'Langra' variety (56.39 %). The image processing algorithm developed was able to significantly differentiate between healthy fruit and jelly seed affected fruit, using percentage edge threshold of 'Langra' (1.17, 3.32) and 'Dashehari' (1.73, 3.17) of X-ray images, respectively. Hence, it can be a reliable non-destructive solution for sensing jelly seed disorder in mango.

ENCAPSULATED NANOFIBERS FOR ETHYLENE SCAVENGING IN SAPOTA FRUITS

Shalini Rudra, Gajanan Gundewadi, Radha Prasanna, Sanjay Singh, Sanjay Dhakate, Anjali An and Tirthanker Banerjee
Indian Agricultural Reaserch Institute
E-mail : gaurshalini@gmail.com

ABSTRACT

Sapota (*Manilkara achras*Mill) is a tropical delicious fruit with very high respiration rate. It has a low shelflife of 4-5 days at rom temperature. With India being the largest producer of sapota, managing its shelf life holds economic importance. To prolong its storability, ethylene scavenger palladium chloride (PdCl2) was incorporated in electrospun PVA nanomats at 1-4% levels. The ethylene scavenging ability of PdCl2 solution was lower than the encapsulated salt. 4% PdCl2 in nanomat had same ethylene scavenging activity as 4% potassium permanganate. The colour of nanomat was bright white (L*> 73) compared toPotassium permanganate mat (L*=68). XRD revealed broad peaks at 2θ ~ 12o and 42.5o indicating presence of palladium in mats. Sapota fruits when packed in corrugated fibre boxes with two nanomats (2*9 cm2) showed higher quality indices (Firmness, TSS, Ascorbic acid, Phenolics) along with lower PLW and respiration rate. While mean PLW of control fruits during8 days storage at 26±2 °C was 8.35%, the PLW of fruits stored with nanomat was 4.47%. Thus use of encapsulated PdCl2 in PVA nanomats can help in retention of fruits quality during storage and transit.

EVALUATION OF SKELETONIZING AGENTS FOR SEPARATION OF LEAF VEIN SKELETONS OF POLYALTHIA LONGIFOLIA VAR. PENDULA

Moumita Malakar, Sivabalan S
Central University of Tamil Nadu
E-mail: moumitamalakar7@gmail.com

ABSTRACT

Dried or preserved plant materials are indispensable commodities to adorn our surroundings in a cost-effective manner. Skeletonized leaf is a new emerging technology in the field of dry flower arrangement which has good potential to use in the floral cards and other dry floral arrangement as a filler material. They can be a viable alternative of fresh foliages which make them appropriate to use in wide-array of formal and informal flower arrangements too. Recently, this sector exclusively has received huge acceptance from customers end and demands worldwide. Based on this backdrop, an investigation was carried out at Dept. of Horticulture, Central University of Tamil Nadu, Thiruvarur during 2020-2021 to evaluate the skeletonizing agents for preparing leaf vein skeletons of *Polyalthia longifolia* var. *pendula*. The experiment comprised of 10 treatments. The experiment was laid out at Completely Randomized Design with 3 replications. Among various treatments, Sodium hydroxide (NaOH)@15% was found as most effective skeletonizing agent for skeletonization of mature *Polyalthia* leaves with utmost cumulative score of aesthetic and visual qualities. Duration of 75-90 mins was found optimum to get good quality skeletonized leaf. Lower concentration of (10%) NaOH had ranked as second-best agent for skeletonization. The other 2 agents *viz*. Sodium hypochlorite (NaOCl) and Sodium carbonate (Na2CO3) failed to prove their appropriateness to form any skeletons of *Polyalthia* leaf while caused sufficient quality deterioration signs (such as development of dark brown coloration on treated leaves) which had endorsed its inefficacy for making skeletons. To bleach the prepared skeletons different concentrations of normal fabric whitener 'Ala' was utilized but 25% concentration found to be optimum with maximum treatment duration of 2 hrs to obtain complete bleaching of prepared skeletons. Hence, our current findings can definitely cause the value addition for *Polyalthia* sp. on one hand and can add another option as filler elements on another hand.

PHYSICOCHEMICAL AND TOTAL CAROTENOID VARIATIONS OF FRESH KHASI MANDARIN (CITRUS RETICULATA BLANCO.) FRUITS OF TINSUKIA DISTRICT

C. Shahida, G. Soumitra, H. Binita, K. Manisha and B. Aradhana
Assam Agricultural University, Jorhat-13, Assam
E-mail: choudhury.shahida@gmail.com

ABSTRACT

Mandarins (*Citrus reticulata* Blanco.) are much more perishable than any other citrus fruits. A comparative study in *khasi* mandarin orchards was carried out with a view to have information about quality attributes among existing germplasm of *khasi* mandarin orchards in Tinsukia district of Assam state. Five major mandarin growing orchards were selected and mandarin fruits from the orchards were used as experimental material for analysis of fruit samples. The results showed that *khasi* mandarin exhibited plethora of variation location wise in physicochemical attributes. The L*, a*, b* of fruit peel and juice, Juice yield, total carotenoid content, fruit weight, pulp weight, peel weight, pulp peel ratio, seed number, peel thickness and fruit volume were more influenced by locations. However total soluble solids (TSS), titratable acidity (TA), ascorbic acid (AA) and Ph of fruit juice did not vary significantly within the district. The data obtained in this study will facilitate the characteristic evaluation of *khasi* mandarin and provide beneficial guidance for fruit processing.

CHANGES IN QUALITATIVE, NUTRITIONAL AND SENSORY PROFILE OF BANANA BISCUITS PREPARED FROM NATIVE VARIETY OF ANDHRA PRADESH IN STORAGE PERIOD

Kondepalli Venkatasubbaiah[1], Bharathi Devi S.A[1], Rajasekhar M.[2], Venkata Subbaiah, K.[3] and Uma Krishna K.[4]

[1,2,4]College of Horticulture, Venkataramannagudem; [3]KVK, Venkataramannagudem
Dr. Y.S.R. Horticulture
E-mail: venkathort@gmail.com

ABSTRACT

Banana can easily get perished due to presence of high moisture content and also good source of vitamins, minerals and resistant starch. Bananas contribute about 2.7% of the total potassium and fiber consumed by an average adult. So conversion of green mature bananas into banana flour and biscuits promotes more shelf life and also created additional value to farmers during excess production situations. In this regard the research work was conducted to study the changes in qualitative, nutritional and sensory profile of banana biscuits prepared from native variety Karpurachakkerakeli (AAB) of Andhra Pradesh in storage period. The biscuits prepared from banana flour in supplement with wheat flour in various proportions and stored for three months storage period. The prepared biscuits were analyzed for physical (moisture), quality (sugars, starch, crude protein, crude fat, crude fibre, calcium, potassium and non enzymatic browning) and sensory attributes (taste, texture, flavour and crispness) at monthly intervals (0, 30, 60 and 90 days). Biscuits prepared in different proportions with banana and wheat flour, among different proportions, results showed that biscuits storage period significantly affected the physical, quality and sensory attributes of banana biscuits and biscuits prepared from 60% banana flour + 40% wheat flour retained good qualitative and sensory characteristics after 90 days of storage at ambient conditions.

DEVELOPMENT OF LOW-FAT AND ANTHOCYANIN RICH PURPLE SWEET POTATO VACUUM FRIED CHIPS

Chintha Pradeepika, Namrata A. Giri, T. Krishnakumar, M.S. Sajeev, Shanavas Safiya
Central Tuber Crops Research Institute
E-mail: pradeepika.chintha@icar.gov.in

ABSTRACT

Consumer demand for reduced-fat snack products is increasing due to the adverse effects of higher intake of dietary fat causing several non-communicable diseases such as obesity, diabetes, hypertension, heart diseases, and cancer. Hence, food companies are looking for viable and sustainable strategies to develop snack foods containing reduced-fat content to meet the health-conscious consumer demands/trends. In this context, vacuum frying technology is described as sustainable and viable option for the development of healthy snacks containing health-promoting/protecting nutraceuticals coupled with reduced-fat content. The present study was aimed to optimize the vacuum frying using response surface methodology-based Box–Behnken design to produce low-fat and anthocyanin-rich purple sweet potato vacuum fried chips. Results showed the significant impact of frying temperature, vacuum pressure, and frying time on responses. Optimization of selected independent variables was carried out using a numerical optimizer and optimized frying conditions were 105oC of frying temperature, 7min of frying time, and 16.12Kpa of vacuum pressure. Optimized purple sweet potato vacuum fried chips in the present study resulted in 86 % of retention of anthocyanin content and a 35.60 % decline in oil content with lower breaking force (0.69 N) compared to atmospheric deep-fried chips. The results of this study suggested vacuum frying as an efficient technology for the development of healthy snack foods to achieve higher retention of bioactive compounds like anthocyanin content as well as to produce low-fat fried products to meet current demands of health-conscious consumers for the development of reduced-fat snack foods.

RESISTANT STARCH-RICH READY-TO-RECONSTITUTE GRUEL MIX FROM MAKHANA (EURYALE FEROX)

Manashi Das Purkayastha, Justice Deikoomson, Upama Kalita, Ramani K. Thakuria, Samindra Baishya, Ananta Saikia, Soumitra Goswami
Assam Agricultural University
E-mail: manashi.das@aau.ac.in

ABSTRACT

Makhana (*Euryale ferox*), though bestowed with several medicinal properties, is an underutilized crop of the country till date, with negligible commercial product (except makhana pop). The prime objective of this study is to develop a gluten-free nutritious ready-to-reconstitute mix using makhana as the major ingredient (≥60%). The seeds of makhana was processed to increase the resistant starch content and to reduce its foul smell. Processed makhana flour, containing high carbohydrates (68.23%), was then combined with wood apple pulp powder and malted mung bean powder to develop different formulations of ready-to-reconstitute mix (T1-T9). The formulations presented to be a good source of calcium (103-187 mg/g) and iron (16-19 mg/g). Crude protein and carbohydrates content were appreciably high with the maximum content of carbohydrate and protein recorded in T5 (80% makhana, 0% wood apple, 20% malted mung bean) and T4 (60% makhana, 0% wood apple, 40% malted mung bean), respectively. Crude fibre and Radical scavenging activity were high in all the formulations. These formulations were reconstituted in water/milk for assessing sensory properties, water absorption capacity, rehydration ratio and viscosity. Swelling ratio was high in T6 (60% makhana, 20% wood apple pulp, 20% malted mung bean), T8 (60% makhana, 10% wood apple pulp, 30% malted mung bean) and T9 (60% makhana, 30% wood apple pulp, 10% malted mung bean). Rehydration ratio in hot milk was found to be the highest in T8 (60% makhana, 10% wood apple pulp, 30% malted mung bean) followed by T9 (60% makhana, 30% wood apple pulp powder, 10% malted mung bean). T9 (60% makhana, 30% wood apple pulp powder, 10% malted mung bean) suspension also received the highest viscosity. All the formulations received high mean score (≥6.0) for appearance, colour, texture, taste, mouthfeel, flavor, consistency and overall acceptability, which indicates the "likeableness" of the products, without the addition of any extraneous sweetening or flavoring agent(s). T8 (60% makhana, 10% wood apple pulp, 30% malted mung bean) obtained the highest overall acceptability score and was adjudged as the best formulation for ready-to-reconstitute mix. Processed makhana flour can thus be incorporated into different cereals, fruits and pulses in suitable proportions to develop nutritious convenient food products.

INFLUENCE OF PRE-HARVEST FOLIAR APPLICATION OF IRON ON POST-HARVEST LIFE OF GLADIOLUS CV. MALAVIYA KIRAN

Anjana Sisodia, Aasha Lamsal and Sibasankar Giri
Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, Uttar Pradesh
E-mail: anjana.floriculture@gmail.com

ABSTRACT

Gladiolus has a high economic value as a cut flower and is referred as the "Queen of bulbous flower". An investigation was carried out at Horticulture farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India during the year 2020-2021 to study the effect of pre-harvest application of iron on post-harvest life in gladiolus cv. Malaviya Kiran. Randomized Block Design (RBD) was used to conduct the experiment with 11 treatments and 4 replications. The treatments used were Control (distilled water), FeSO4 0.1%, FeSO4 0.2%, FeSO4 0.3%, FeSO4 0.4%, FeSO4 0.5%, FeSO4 0.6%, FeSO4 0.7%, FeSO4 0.8%, FeSO4 0.9% and FeSO4 1.0%. Treatments FeSO4 0.3% and FeSO4 0.5% showed the best results compared to other treatments. Flowering duration of 3rd floret was found to be maximum with FeSO4 0.3%, FeSO4 0.4% and FeSO4 0.2% (4.67 days) each. While, the treatment of FeSO4 0.3% and FeSO4 0.8% (4.67 days) each showed the maximum flowering duration of last floret. Similarly, maximum diameter (6.47 cm) and length (7.97 cm) of 5th floret, maximum number of opened florets at a time (5.33), maximum vase life (9.67 days) was noted with FeSO4 0.3%. Whereas, FeSO4 0.5% recorded maximum length (7.95 cm) and diameter (6.72 cm) of 3rd floret. Similarly, maximum weight of spike at 1st day (39.28 g) and 3rd day (39.39 g), maximum water uptake by spike at 6th day (39.00 ml) and 9th day (44.33 ml) was found with FeSO4 0.5%, treatment.

STUDIES ON PRESERVATION OF NAGPUR MANDARIN SEGMENTS IN SUGAR SYRUP

Surendra Patil, Anjali Khade, Arvind Sonkamble, Abhay Gedam, Rutuja Deshmukh
Department Of Horticulture
E-mail: surendrapatil@pdkv.ac.in

ABSTRACT

An experiment entitled "Studies on preservation of Nagpur mandarin segments in sugar syrup" was carried out during the year 2017-18 at Post Harvest Technology Laboratory, Department of Horticulture, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with the objectives to assess the effect of sugar concentrations on preservation of Nagpur mandarin segments and to study the physico-chemical changes in Nagpur mandarin segments during the storage. The experiment was conducted in RBD design consisting of eight treatments and three replications with using seedless Nagpur mandarin segments. Observations of Nagpur mandarin segments viz., physical, chemical and sensory evaluation were recorded periodically at 15 days of interval. From the findings it was observed that, there was gradual increase in length, breadth and weight of Nagpur mandarin segments in sugar syrup concentrations during storage period of 120 days. In chemical analysis there was a gradual increase in TSS (%), reducing sugar (%), total sugar (%), non-reducing sugar (%) and there was no microbial infestation found up to four month of storage period. Further, the experimental data recorded on sensory qualities of Nagpur mandarin segments in sugar syrup at an interval of 15 days. The overall scores of Taste, colour, flavour, texture found decrease in trend with the advancement of storage period.

ENHANCING GROWERS INCOME THROUGH ADOPTION OF DOV FOR RAISIN MAKING IN NASIK

Ajay Sharma, Ramhari Somkuwar, Ajay Upadhyay
ICAR-National Research Centre for Grapes
E-mail: ajaysharma.icar@gmail.com

ABSTRACT

In India, Maharashtra is well known for table grape production and contributes about 85% of total grape production. Approx. 40% of the country's production is in the Nashik region, essentially for table grape purpose. The grapes are well appreciated in overseas market and contribute substantially to export earnings. The lockdown during #Covid19 pandemic in March, 2020 affected harvest and sale of grapes adversely. About 9 lakhs tonnes of grapes were in vineyards of Maharashtra state, with about 4.0 to 4.5 lakhs tonnes in Nashik alone. Labours were not available for harvest. Even the harvested produce could fetch only Rs 7-15/kg, which could not meet even the production cost. Grape drying was only option to save the grapes in Nasik, but no basic infrastructure was available for drying.The growers were advised to dry grapes by adopting Drying on Vine (DOV) or dry the grapes between rows of grape vines. The message was very pertinent to save the grapes and spread very fast among grape growers. Stakeholders understood the ground situation and started grape drying by suggested measures. In Nashik district alone, a total of 3 lakhs tons grapes were utilized for raisin making. Out of that 25-30 thousand tons of grapes were converted into raisins by adopting DOV method. Stakeholders prepared the raisins and able to supply in market. By this intervention, valuable crop was saved and stakeholders could get Rs 60 to 80 per kg of raisin in the market.

PROCESS TIME REDUCTION FOR DEVELOPMENT OF CANDIED MOUSAMBI PEEL

Alka Joshi, Shruti Sethi, OP Awasthi
ICAR-IARI
E-mail: alka.foodtech@gmail.com

ABSTRACT

India is the leading producer of citrus fruits after Mexico. *Mousambi* (*Citrus limetta*), also known as sweet lime, is a citrus fruit variety, popular because of its high juice recovery percentage and sweet taste. Citrus peels are one of the merely processed products of citrus industry that can cater to waste management to deliver the bio-functionality of peel in the form of shelf stable candied ready-to-eat product. Candied citrus peels were developed using *mousambi* peel, for which, high sugar (65o Brix) and prolonged process time are the two major hurdles for commercialization. Therefore, sugar and process time reduction was the main target to plan this study. Blanching time, sugar concentration, pectin content and infusion time were the four influencing process variables for standardization of the product. Boiling of pierced citrus peels followed by dipping in 1 percent pectin solution significantly helped in reduction of the astringency as well as texturization of citrus peels with low sugar content (51o Brix). Three interventions, namely partial removal of albedo layer, layering while infusion with sugars followed by 'U loop' drying cycle significantly reduced the process time from 48 h (for control) to 24 h for candied citrus peel development. Accelerated osmo-drying study at 70oC showed that solid gain mechanism predominated over the water loss phenomena from candied peel resulting in Intermediate Moisture Food (IMF). The developed candied *mousambi* peel was olive green in colour with RGB value of 97, 93, 61. The developed product was found to be rich in flavonoids (1476.23 mg QE/100 g on dry weight basis) and possessed high antioxidant potential (367.41 µmol Trolox/g) with sufficient shelf stability (3 months under ambient conditions in transparent PET jars).

Oral Paper

ALTERING THE TECHNO-FUNCTIONAL PROPERTIES OF POTATO POWDER FOR SUITABLE FOOD APPLICATIONS

Shruti Sethi, Ahmad Farid Azizi, Alka Joshi, Pinky Raigond
Indian Agricultural research Institute, New Delhi
E-mail: docsethi@gmail.com

ABSTRACT

Potato flour can be incorporated into food formulations for various functional benefits. The study was conducted to investigate the influence of boiling on the techno-functional quality of potato flour obtained from four cultivars, *viz*., Kufri Chipsona, Kufri Frysona, Kufri Jyoti and Kufri Bahar. Findings revealed that functionality of potato powder was significantly influenced by variety and boiling treatment. Boiling expanded the end use profile of potato flour due to its more acceptable colour, flavor expression and resistant starch content. Rapid Visco Analyzer studies revealed that processing varieties showed higher peak viscosities than the table purpose varieties. Boiled flour showed a sharp decline in the pasting temperature, peak viscosity, breakdown value, set back and final viscosity. Detailed characterization revealed that raw powder of Kufri Chipsona 1 and Kufri Bahar are suitable to act as thickening agents owing to their high water absorption and peak viscosity. Low pasting temperature such as observed for boiled Kufri Chipsona 1 powder is good for use in baked products. Low breakdown value as observed for boiled powder of Kufri Chipsona 1 is desirable for development of weaning foods. Of the four varieties studied, both the table varieties (Kufri Jyoti and Kufri Bahar) exhibited higher resistant starch upon boiling that is in tune with the prevailing dietary preferences. Hence, the study revealed that a traditional processing method ‘boiling’ can significantly modify the techno-functional characteristics of the potato powder.

PEA POD POWDER AS FUNCTIONAL INGREDIENT IN MAYONNAISE: EFFECT ON RHEOLOGY AND STABILITY

V R Sagar[1], Shalini Rudra[1], Entesar Hanan[2], Vasudha Sharma[2], Santanu Basu[3]
[1]Indian Agricultural Research Institute
[2]Jamia Hamdard
[3]Swedish University of Agricultural Sciences
E-mail: gaurshalini@gmail.com

ABSTRACT

Pea pods, accounting for 30-40% of fresh peas and a major by-product from pea industry were blanched and dehydrated. Upon analysis, a nutritious, sweet, fibrous material with potential as ingredient for functionalizing popular foods was revealed. The pea pod powder (PPP) was incorporated in eggless, low fat mayonnaise for enriching it with dietary fibre and micronutrients. Inclusion of PPP in mayonnaise led to better sensory attributes which corroborated with rheological and textural parameters. Droplet distribution and higher hysteresis area, consistency coefficient and apparent viscosity results indicated beneficial effect of PPP on emulsion stability. The tribological investigation clearly revealed distinct sensory profile compared to the rheological behaviour. Higher activation energy and heat stability index demonstrated the stability of emulsions.

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Kailash Bhawan, Chandra Shekhar Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Session XI

NEW INITIATIVES IN PRODUCE MANAGEMENT

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Brief Bio-data

Shri Ram Narayan Ghatak

Dr. Ram Narayan Ghatak is a development sector professional with over two and a half decades of experience in agribusiness, agri and food supply chain management, producer collectives, rural livelihoods, agri-banking, and financial inclusion.

Dr. Ghatak started his career working with the dairy cooperatives while being part of the National Cooperative Dairy Federation of India Limited (NCDFI), Anand, Gujarat. Currently he is the Chief Executive Officer (CEO) at Indigram Labs Foundation, the Technology Business Incubation arm of the Indian Society of Agribusiness Professionals (ISAP) group. Before joining ISAP, Dr. Ghatak worked with ACCESS Development Services as Sr. Vice President cum Head of Operations, New Delhi and Head of Business Strategy, Rural and Inclusive Banking Group at ICICI Bank, Mumbai.

Dr. Ghatak is a Post Graduate Diploma in Rural Management from the Institute of Rural Management, Anand, Gujarat (IRMA). Before joining IRMA, he did his MSc and PhD in Agricultural Economics and he is a graduate in Agriculture

EXPERIENCE OF FPOS IN PRODUCE MANAGEMENT OF HORTICULTURE CROPS

Shri Ram Narayan Ghatak
CEO, INDIGRAM LAB'S Foundation, Mohan Cooperative Industrial Estate, New Delhi 110044
Email: ceo@indigramlabs.org

Collectivization of the small and marginal farmers, into Farmer Producer Organisations (FPOs, farmers' organisation of average size of 500 to 600 smallholder farmers) and their constituent Producer Groups (PGs, a collective of average 15 to 20 farmers growing similar crops from the same or adjacent villages) has been found to be an effective strategy to address the vulnerability of the smallholder farmers. Therefore, over the years, the government has made significant investment in promoting FPOs and PGs across states to help the smallholder farmers connect better with the market to access investment, technology, and innovation. The FPOs and PGs were promoted under a variety of programmes spearheaded by the Small Farmers Agri-business Consortium (SFAC), a Society incorporated by the Government of India to promote the interests of the smallholder farmers. The national efforts were reinforced by the governments in the states and were also joined by the Rural Livelihoods Missions (SRLMs) and the National Bank for Agriculture and Rural Development (NABARD). Policy and funding support from the central and state governments and their various agencies and other philanthropic foundations has led to a manifold increase in the number of FPOs. What started as a trickle has reached a significant scale. By the end of 2019, the country had around 8000 FPOs spread over the states. The Union Budget 2019 provided a further thrust to the FPC movement with plans to set up and promote 10,000 FPCs over the next five years with critical responsibility on SFAC, NABARD, and National Cooperative Development Corporation (NCDC) to lead the program.

As a Resource Institution, ISAP has promoted more than 250 FPOs over the last decade, many of them are in fruits and vegetables, and it will be happy to share its experiences in promoting such grass root level farmers' organisations that go through the hard way of discovering their adaptability to navigate through the competitive business eco-system to gradually establish themselves.

Brief Bio-data

Dr R.N. Padaria

Dr. Rabindra Nath Padaria is working as Professor & Head (acting) in the Division of Agricultural Extension at ICAR-Indian Agricultural Research Institute (IARI), New Delhi. He has more than 27years of experience in research, teaching and extension. Extension systems, Climate change adaptation, Farmer participatory research, Indigenous knowledge system, Socio-economic and environmental implication based research (Big dams and transgenic agriculture), and gender empowerment have been his major areas of research. Having teaching experience of more than 15 years, he has made significant contributions in postgraduate teaching at IARI, New Delhi. As course leader he is actively involved in teaching courses like Methods of Social research; Advances in Agricultural Extension; Techniques of Measurement in Behavioural Science; Monitoring, Evaluation and Impact Assessment Techniques; Agricultural Research, Research Ethics and Rural Development Programmes.

He has been bestowed with the Best Teacher Award of IARI for his outstanding contributions in extension education. For outstanding research on socio-economic assessment of Narmada Sagar project, he was awarded Jawaharlal Nehru Award by ICAR in Ph.D. and received ICAR's Bharat Ratna Dr C. Subramaniam Award for Outstanding Teachers as well as Swami Sahjanand Sarawati Award of ICAR for outstanding work extension work in mango. He has been recipient of other several professional awards.

Development of Frameworks for effectiveness of extension models, Socio-economic assessment of Bt. Cotton in India, Farmer Participatory Assessment and Refinement of technology, Farmer participatory ITK validation of ITK; devising of extension models like Livelihood extension, community based extension, Integrated Farming System, and Pusa mKRISHI for climate change adaptation; gender empowerment; development of training and practical manuals; development of psychological instruments and indices; development of educational videos; development of Technology Information Centre, Village Resource Centres and Custom Hire Centre for promotion of technologies among end users; have been the major significant achievements.

He has more than 100 national and international publications.

NEW INITIATIVES IN ESTABLISHING FARMERS PRODUCER ORGANIZATIONS FOR QUALITY PRODUCTION AND EXPORT

R.N. Padaria
Division of Agricultural Extension; ICAR-Indian Agricultural Research Institute, New Delhi-110012
Email: rabi64@gmail.com

ABSTRACT

There is a growing emphasis upon group-based approaches in initiatives to improve farmers' economic and social being. One of the most important examples of group action for farming is Farmer Producer Organizations. FPO is a kind of producer organization (a legal body created by primary producers such as farmers, weavers and fishermen) whose members are farmers. FPOs can be registered in India under the Cooperative Society Act, the Indian Companies Act, or the Indian Trust Act. Collective action through farmer groups could help the members to strengthen their access to information; access to technology, credit and inputs; acquisition of skills; quality production and post-harvest management; attaining economy of scale; vertical integration; initiation of processing and value addition and other agri-based enterprises; lowering of production and transaction costs; remaining competitive in rapidly changing markets; enhancing bargaining power; and linkages with markets and other service agencies. Analysis of the elements that enable the sustainability of farmers' groups is necessary to give momentum to the empowerment process. Using factor analysis, a research study with the members of farmers' organization identified robust financial management, member incentives, trust, democratic leadership style, fairness in transactions, and the organization's identity or brand as the factors perceived for organization's long-term viability. Though the attempts have been undertaken to promote FPOs, more attention should be paid on hand-holding, technological backstopping, financial and infrastructural support arrangements for quality production, value addition and horti-business initiatives.

Brief Bio-data

Dr Ranjit Kumar

Dr Ranjit Kumar is presently the Principal Scientist & Head, Agribusiness Management Division, ICAR-NAARM, Hyderabad. He has done his PhD in Agricultural Economics from IARI, New Delhi and MSc in Dairy Economics from NDRI, Karnal. He has more than 21 years of experience in teaching, research and capacity building in the area of agricultural marketing, value-chain analysis, technology adoption, FPO & entrepreneurship development and policy analysis. He is the founder member of Technology Business Incubator centre (a-IDEA) of ICAR-NAARM, helping agri-startups in ideation, business development and acceleration. He has also worked extensively in promotion and developing capacity of FPOs. Dr. Kumar has handled several multi-disciplinary research projects, sponsored by national and foreign agencies. He has worked at different ICAR and CGIAR institutes (ICRISAT & IFPRI). He is invited reviewer of several international (Elsevier and Springer) and national journals. He has played leading role in building and promoting the Agribusiness Management education (PGDM-ABM) programme of ICAR-NAARM. He has guided post-graduate students in Agricultural Economics and Agribusiness Management.

Dr Kumar has received LBS Young Scientist Award (Biennium) in Social Sciences by ICAR, New Delhi; Best Faculty Award 2020 and Best Trainer Award 2021 by ICAR-NAARM; Best Paper Award by Agricultural Economics Research Association (India), New Delhi. Dr. Kumar participated in conferences and scientific meetings and visited about 10 foreign countries. He has published more than 75 research articles in peer reviewed national and international journals.

BRINGING SYNERGY BETWEEN FPOS AND AGRI-STARTUPS FOR VALUE CREATION FOR HORTICULTURE FARMERS IN INDIA

Ranjit Kumar
Agri-Business Management Division, ICAR-National Academy of Agricultural Research Management, Hyderabad-500 030, Telangana
E-mail: ranjitkumar@naarm.org.in

ABSTRACT

In agriculture, the demand for innovations are rising rapidly to reduce the frictions in last mile delivery to the farmers. The marriage between new agricultural technologies like seeds, soil health based nutrients application, precision farming, irrigation technologies, etc. with modern technologies like application of artificial intelligence (AI), internet of things (IoT), machine learning (ML), data science, *etc.* demand paradigm shift in agriculture sector. Horticulture sector with high value commodities are also grappled with the highest post-harvest losses. It insists organizing farmers into producer groups, linking farmers to markets, bringing value addition infrastructure and services at the doorstep of the farmers so as to allow farmers capture the maximum value from the value chain. Food and Agri-startups, on the other side are innovations-based enterprises which help in making available the right products and services at right time at least possible costs. India is home of primarily smallholder farmers, where more than 86 per cent farmers are small and marginal. It becomes quite challenging for the agri-startups to connect and deal with individual farmers. The policy changes brought in the year 2002 to promote farmers producers organizations (FPOs) can be a boon for entire sector by bringing both the initiatives together. For the farmer to produce a high-quality produce, there is a need for right inputs, information, infrastructure and market linkages. These farmers through aggregation/ collectivization can reduce the transaction costs significantly, access the inputs at much cheaper rate, get quality advisory services and with professional management under FPO, can navigate the markets well. Bringing collaboration between Farmer Producer Organizations (FPOs) and Agri-startups together will fill the gap in the horticulture supply chain. Concurrently, food processing industry as well as consumers can have better assurance about the production practices, in other words traceability through technologies provided by the agri-startups. Thus, by way of FPOs and agri-startups, even smallholder farmers can have access to high-quality inputs or information and trade directly with large processors or retailers or even participate in export market and realize the maximum price for their produce. With the development of technology, accessibility of networks in remote rural regions, spiking of smartphones or tablets, remote sensing, cloud-based internet services, Agri-tech startups are giving suitable and innovative answers to a numerous challenges faced all over the agricultural value chain. A new age of business and evolving startups in the country are guiding the way in disrupting the age-old agriculture system with innovative ideas and inexpensive solutions. These startups have become the bridging link between the farmers, retailers, wholesalers, input dealers and consumers joining each of them and giving strong marketing linkages and quality produce on time. Therefore, to harness full potential of horticultural sector in the country, in terms of ensuring better farm income as well as better nutrition to the consumers, synergy between FPOs and Agri-startups is imperative. All efforts need to be made to enable the ecosystem to support both the initiatives to make *Atmanirbhar Bharat* a reality.

Dr Bhanu Pratap Singh

Bhanu Pratap Singh is alumni of Indian Institute of Foreign Trade & IIM Kozhikode LIVE. He carries 18+ years experience in Livelihoods, Agriculture Extension, Skill Development, Exports Promotion & GI registration facilitation. He has been facilitator for 16 crops of North East GI Registration.

He had earlier served National Skills Foundation of India as Head of North East Region, worked as Officer on Special Duty for MBDA, Government of Meghalaya for Skills/market, also served USIndia SME Council headquartered at washingotn as Director-North East Region.

Currently he is founder CEO, North East Foundation & also founder ED of a start up, North East Farm Sales Promotion, which promote NE GI & unique products across globe & has been incubated at Manage, IIMCIP & IIM Kozhikode

He had actual experience of arrangign export tie ups for Meghalaya to Bangaldesh via land border.

He was awarded International award on spreading Mahatama Gandhi ji thoguhts through movie media in 2009 & has also trained & paced more than 10000 BPL youth in past & also facilitated setting up 10 Free food for destitutes centers in Delhi in consultation with CM office Delhi in 2008

IMPACT OF GEOGRAPHICAL INDICATIONS OF HORTICULTURAL CROPS ON TRADE AND LIVELIHOODS-

Bhanu Pratap Singh
Founder Executive Director, North East Farm Sales Promotion
ednortheastsales@gmail.com

- Importance of GI
- Current awareness about GI to masses/missing areas
- Future Potential of GI with regards to income enhancement of farmers, trade, Exports
- Role of GIs in promoting country as Economic Super Power
- Recent/current initiatives of Government of India towards promotion of GI as sector
- Actions needed at producers level to maximise benefit out of GI
- Actions needed at other stakeholders levels, Universities/Research Institutes/ Extension Institutions
- Vision setting to use GI as tool towards making India a economic super power

Dr Ram Singh

Dr. Ram Singh is Professor at Indian Institute of Foreign Trade, New Delhi with over 20 years of teaching experience. His academic qualification is B. Com; MBA, Ph. D, UGC- NET Qualified; PGDIBO; Certificate in Managing Global Governance from German Development Institute, Bonn, Germany. He also holds Master Certificate in SCM & Logistics from Michigan State University, USA. He specializes; both in training & research; in areas such as Export Import Procedure; Trade Policy & Trade Logistics. He has authored two text books, first on “International Trade Operations” with Excel Publications, another on “International Trade Logistics” with Oxford University Press. His third text book entitled “Export Management” with Oxford University Press is soon to hit the market. He has also co-authored a book on “Exim Finance” with Vikas Publications. He has authored 38 research publications and has done 9 Structured Contents Module for trade courses for universities like Jamia Milia Islamia; New Delhi / Sikkim Manipal University; Bangalore / Pondicherry University Pondicherry / MD Rohtak University / Indira Gandhi National Open University New Delhi. Dr. Singh has done program for firms like ITC; ONGC; IOC; HPCL; Hindalco; Oliveitup (Italy; EU commission) STC; MMTC; Brenttag India; SRF Chemical; HSBC: Yes Bank; Royal Bank of Scotland, ECGC; Almost all Export Promotion Councils/Commodity Boards/Export Development Authorities (on need basis) CSIR; Bank Staff College of Public Sector Banks etc. Dr. Ram Singh is directly involved in training of Indian Trade Services (ITS) probationers, Ministry of Commerce; GOI. He is visiting faculty NACEN (Faridabad & Bombay) for Training Indian Revenue Services (IRS) Officials. He is also visiting faculty to IFM Darussalam (Tanzania). As mandate for capacity building of African Diplomats from Government of India, he has been directly involved in Diplomat Training Program of 7 African countries namely; Angola; South Africa; Uganda; Rwanda; Tanzania; Namibia and Niger.

STRATEGIES FOR BALANCING RISING FRUITS AND VEGETABLES IMPORTS

Ram Singh
International Trade Operations & Logistics, Indian Institute of Foreign Trade, New Delhi
E-mail: ramsingh@iift.edu

ABSTRACT

India's total import of vegetable is US$ 1.64 billion for the calendar year 2020. India's total exports of vegetable is US$ 1.22 billion in 2020. Only leguminous vegetables constitute a major chunk of India's vegetable import, valuing around US$ 1.56 billion. India has negative balance of trade for vegetables, courtesy pulses imports. There is negative balance of trade of US$ 428 million. The negative balance for pulses trade constitutes around 1.30 billion, factoring India export some quantity of pulses in value added form. India's export of fruits is mere US$ 1.31 billion in 2020. India's imports of fruits constitute US$ 3.19 billion in 2020. There exists a negative trade balance of US$ 1.88 billion in 2020. India is net importer of fruits primarily of dry fruits (almonds, pista etc), coconut, kinds of cashew nut, dates, figs, avocado and apples, pear, quinces. Trade instruments have limited role to balance India's import of horticulture. We may continue to import certain products that cannot be produced and keep on enhancing exports of what we can product efficiently. Out whole focus should be on brining equilibrium in trade so that net outflow of foreign exchange can be avoided. Trade benefits all, ensure welfare of both producers and consumer but we must keep the national welfare in mind.

Dr R.K. Kakani

Dr Rajesh K Kakani, outstanding Plant Breeder by profession carries 25 years of research experience in developing high yielding varieties of horticulture and field crops. Presently, he is Principal Scientist, at ICAR-CAZRI, Jodhpur, Rajasthan. Born on July 5, 1967 at Ajmer, Rajasthan. He graduated from Rajasthan University, Jaipur and later obtained his post-graduation and doctoral degrees from Rajasthan Agricultural University, Bikaner, where he started his professional career as Assistant Professor in 1996. He developed 16 varieties which were notified by GOI including 5 high yielding varieties of moth bean for the hot arid. Later he joined the Agricultural Research Services of ICAR research in 2007 as Senior Scientist & Seed Spice Breeder at National Research Centre on Seed Spices, Ajmer. He developed 10 high yielding varieties of seed spice crops namely fenugreek (4), coriander (2), fennel (1), nigella (1), *ajwain* (1), and dill (1). He acted a team member in various scientific groups working on development of production & protection technologies, crop physiology, quality assessment & enhancement in seed spices. His initiatives strengthened farmer's participatory seed production programme. He collected genetic wealth in different seed spices from isolated & remote location of India.

He has authored more than 100 publications that include more than 59 research papers in national and international journals, book chapters, popular articles and technical bulletins. His ability as a teacher also got flourished by guiding 13 scholars for their post-graduation degrees. He is Fellow of Indian Society of Arid Legumes, Jodhpur and Indian Society of Seed Spices, Ajmer.

SEED SPICES EXPORTS-CONSTRAINTS AND OPPORTUNITIES

R.K. Kakani[1], R. K. Solanki[1] and Balraj Singh[2]
[1]ICAR-Central Arid Zone Research Institute, Jodhpur-342006, Rajasthan
[2] Project Coordinator AICRP-HB&P, New Delhi-110012
E-mail: rkkakani.nrcss@rediffmail.com

ABSTRACT

In India, Rajasthan and Gujarat have maximum area under cultivation and are major producer of seed spices. Thus both the states are known as "Seed Spice Bowl". Rajasthan ranks first in coriander, fenugreek and ajwain production and second in cumin, fennel, and dill seed. Gujarat stands first in cumin, dill and fennel production and second in fenugreek and ajwain.

Various seed spices products like oils, oleoresins, essential oils, organic products, curry powders/mixtures and spices mixes are enlarging the seed spices export basket. There is a boom in the export of spice (including seed spices) oils and oleoresins. The global demand of seed spices is more than five lakh tonnes and India fulfills the need by about 70%.

The seed spices export as whole has been increased from 1,88,530 tonnes with a value of Rs. 1,70,593 lakhs during 2011-12 to 3,49,695 tonnes with a value of Rs. 4,33,568 lakhs. This increase is 85.48 per cent in terms of quantity and 154.15 per cent in terms of value is massive. The abrupt rise in seed spices export is indicative of the quality India is producing and competing well with other nations to meet the export standards of developed countries by following improved agricultural practices, role of government bodies, research institutions, exporting agencies, and spice board is also significant.

Still the scope to enhance export is immense; there are few constraints which are limiting the seed spices exports which needs to be addressed are lack of proper tracking of production area, lower productivity or inconsistency in production, poor quality of produce both in extrinsic e.g. physical purity and cleanliness and intrinsic quality e.g. essential oils content, residual toxicity, microbial load, etc., low exploration of value addition potential, lack of quality management in crop production, lack of proper training to the spice grower, traders, processors and exporters, lack of market intelligence, lack of organic seed spices production, competitive prices from other sources.

Few strategies have been suggested to increase production and export are production of seed spices with good agricultural practices (GAP) for exportable quality production; meeting regular and assured supply of seed spices.

Dr Rajeev Ranjan

Rajeev Ranjan is a native of the Jharkhand. He is an agriculture graduate from Assam Agriculture University, Jorhat, and a Master's in Business Administration with a specialization in HRM.

With a motivation to "apply ones knowledge for the benefit of people living at the margins", Rajeev joined PRADAN way back in 2003. PRADAN (Professional Assistance of Development Action, New Delhi) is a national-level non-profit organization whose mission is to enable most marginalized people especially rural women, to earn a decent living and take charge of their own lives.

Rajeev started his with works on agriculture promotion with tribal communities of Jharkhand through prototyping livelihood models which later was scaled up through national flagship programs like SGSY, IAP, MGNREGA and NRLM. He pioneered the Mango based horticulture model, Irrigated Agriculture (IA) and Agriculture Production Cluster (APC) model in Jharkhand. Rajeev has directly implemented nearly 200 acres of Mango plantations under the Tribal welfare prototype scheme and the Special SGSY program in tribal-dominated Gumla and Lohardaga district of Jharkhand through his hand and now supporting more than 18,000 HH in mango based intercropping system. He is currently leading the Mango-based Intercropping theme of PRADAN. His support is sought by other Organizations, other PRADAN states, and the Jharkhand MGNREGS Horticulture program as a resource person. He is a member of the Technical Advisory Committee of MGNREGS Cell, Govt of Jharkhand for the state program on Horticulture called Birsa Munda Harit Gram Yojna.

Working with small & marginal women farmers of remote tribal areas, he realized that these farmers individually will not be able to negotiate with bigger market forces and influence them in their favor. So it is important to collectivize these women farmers into an economic collective, synchronize their planning & production, and get them to link with the market. So currently he is supporting teams in promoting and nurturing FPOs to bring the market closer at their doorsteps.

He is currently working as Integrator, PRADAN (Farm-based Livelihood vertical), and based at Ranchi, Jharkhand.

EMPOWERING TRIBALS IN JHARKHAND THROUGH HORTICULTURAL ENTERPRISES

Rajeev Ranjan
Integrator, Professional Assistance for Development Action (PRADAN), Ranchi
E-mail: rajeevranjan@pradan.net

ABSTRACT

The state of Jharkhand is home to nearly a tenth of the country's Scheduled Tribes, who constitute 27% of Jharkhand's population. The predominant livelihood of the tribal farming community is rain-fed agriculture-based-and the prevalence of subsistence economy renders the farmers with a meager amount of market surplus. Mono-cropping is prevalent across regions, leading to increased food insecurity. In this state, the tribal communities, although resource-rich, are economically poor. Migration is a rampant phenomenon. So the major question for different stakeholders from the Developmental sector was, "is there a way whereby the resources can be utilized in a way to improve the livelihood condition of these tribal families to lead a dignified life ?" Professional Assistance for Development Action (PRADAN) was founded in 1983 by young professionals inspired by the belief that well-educated people, with empathy towards the poor, must work directly with them at the grassroots to alleviate mass poverty in rural India. PRADAN seeks to realize its vision of creating a just and equitable society where everyone lives and works with dignity by building robust collectives of women that will strive for large-scale change in the human condition. At present, PRADAN works in the 7 poorest states of India with nearly 8.9 lakh smallholder women farmer's families to improve their livelihood.

To address the livelihood issues of the tribal communities of Jharkhand, PRADAN has been popularizing mango-based intercropping model. This livelihood prototype has emerged after our long work with these communities and the technical support of ICAR RCER Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi. The main strategies adopted by PRADAN for promoting the mango-based intercropping model are Cluster Approach; Building community interest and understanding, ensuring selection of suitable farmers/ areas/Cultivars, ensuring monthly POPs, developing locally tailored prototypes (including intercrop), Quality inputs & Fencing, building community-level capabilities and resource persons, completing detailed planning, and ensuring family level ownership through weekly review meetings, Linkages with markets, government institution & policy advocacy. The 1 acre model of mango based Intercropping model has shown its potential to pull out families from the economic poverty cycle and make the family a Lakhpati family merely from 1 acre of land. Based on the data of the last 10 years, yield levels ranging between 30 q/acre to 35 q/acre have been obtained by farmers from mango orchards. Apart from the income from mango, farmers have earned nearly 25,000-45,000 rupees per acre per annum by intercropping vegetables.

Dr R.A. Kaushik

Born on September 17, 1965 at Kaila (Bhiwani) in Haryana. Prof. Ram Avtar Kaushik did his B.Sc. (Hons) Agri., M.Sc. and Ph.D. Horticulture from CCS, Haryana Agricultural University, Hisar. He did his Post Doctorate from Ben Gurion University, Israel as a VATT Fellow. Dr Kaushik started his career as Scientist (Horticulture) at HAU Regional Research Station, Bawal in 1993 became Associate Professor in 2002 and at MPUAT, Udaipur selected as Prof. of Horticulture in 2007. Served as Prof. & Head from 2007 to 2015, then Director Resident Instructions and presently he is Director Extension Education at MPUAT, Udaipur.

He has guided 23 Ph.D. and 20 M.Sc. students and handled several research projects funded by NATP, DBT, NAIP, ICAR, RKVY as PI. He has developed several technologies for cultivation and processing of arid fruits, which are widely being adopted by the farmers 20 recommendations. He has published 130 research papers in national and international journals, 70 popular articles, 4 books, 3 bulletins, 15 book chapters and several training manuals.

Dr Kaushik is recipient of several awards such as Outstanding Service Award by MPUAT, Udaipur, SARC Scientist of the year 2011, H.S. Mehta Young Scientist award (2011), six best paper presentation awards and one best research paper published in Indian Journal of Arid Horticulture, Mahindra Samrdhi Award, Best Teacher Award by Times of India and member BSMA (Horticulture). He has visited Israel, USA and Netherlands for presenting his research paper for advanced training and executive member Indian Society of Arid Horticulture.

TRANSFORMING LIVELIHOOD OF TRIBALS THROUGH DEVELOPING VALUE CHAIN IN UNDERUTILIZED FRUITS

R. A. Kaushik
Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap Univ. of Agriculture & Technology, C-10, Durga Nursery Road, Udaipur 313001 Rajasthan
E-mail: rajeevranjan@pradan.net

ABSTRACT

There are several minor fruits like custard apple, aonla, ber, mahua, jamun, drumstick, *etc.*, which grow naturally in forest area which is a habitat for tribal's. Processing and value addition in these minor fruits would provide employment, nutritional and economical security and these activities can easily be undertaken by tribal farmers particularly the women. Several government agencies and NGOs have chosen these fruits and their processing and value addition as an intervention for empowerment of tribal women and there are several success stories, which need to be replicated in similar situations/ locations. We at MPUAT Udaipur, Rajasthan along with an NGO and private partners have demonstrated that how processing and value addition in underutilized fruits transformed the life of tribals and provided lots of entrepreneurship opportunities. A pilot study, comprising of 500 tribal farmers from 30 villages of Udaipur, Sirohi and Pali districts of Rajasthan was conducted with to highlight and understand the importance of setting up a value chain for these farmers. In order to ensure that the farmers receive better price for their product, the intervention involved adding value to the fruit before selling it in the market. Experts from the Maharana Pratap University of Agriculture and Technology, Udaipur, provided technical support for this intervention. Browning free technology was adopted for the processing of the custard apple, which helped in increasing the shelf life of the finished product from a few days to more than a year. The intervention involved the establishment of fruit collection centres at the village level, a processing unit, a storage unit and a marketing network to promote the sale of the produce. Tribals were provided training on the process of grading, sorting, weighing and documentation. It was the first time in the area that the tribal women got the opportunity to get involved in such activities and earn a living for them and their family.

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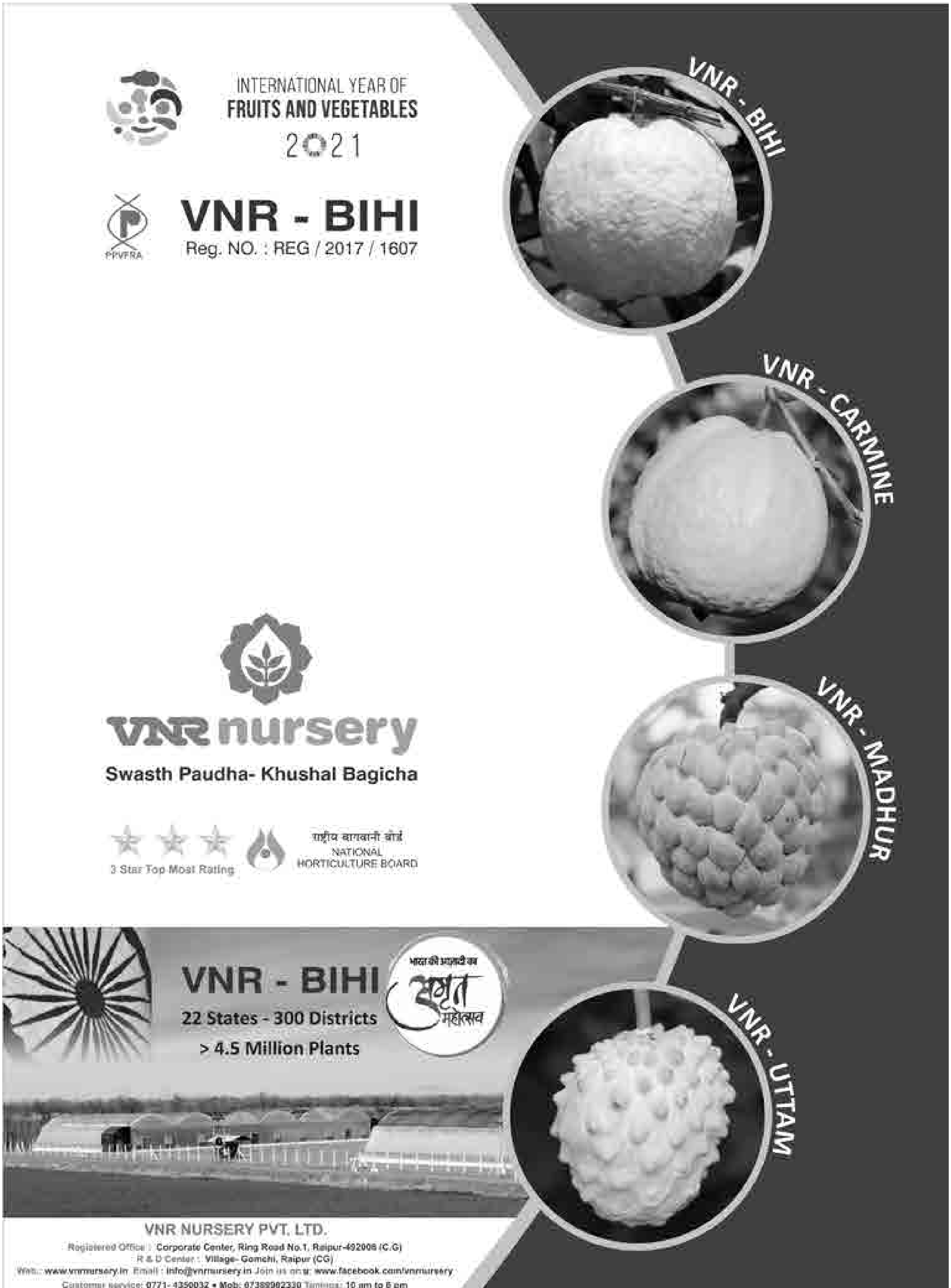

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Mahyco Grow and Seven Star Fruits Pvt Ltd

Founded in 1964 by Dr. B. R. Barwale, Maharashtra Hybrid Seeds Company Limited, popularly called as Mahyco is the flagship company of the **Mahyco Grow**, Mahyco was founded with a vision to bring science based solution to address farming challenges, through Seeds. Today, **Mahyco Grow** has three business verticals – Hybrid seeds, Engineering, and Fresh produce. Dr. Barwale is widely regarded as the father of the Indian seed Industry and his contribution was acknowledged through several awards including the 12th World Food Prize by the World Food Prize Foundation in 1998 and the Padma Bhushan award in March 2001 from Govt of India in recognition of his immense contribution to IndianAgriculture.

Seven Star Fruits Pvt Ltd(SSFPL), a part of **MahycoGrow**, which is accredited by many International organizations for its best quality produce, is one of the leading exporters of fresh fruits and vegetables from India. The company also has a fast growing domestic fruits and vegetables business and is one of the leading suppliers to majororganised retail outlets in the country. Seven Star Fruits also has a fast growing Direct to Home delivery business of Fruits and Vegetables which are farm sourced, hygienically packed and delivered directly to customers' doorsteps.Seven Star Fruits Pvt Ltd has recently expanded into nursery and planting material business, given that there is a need gap for quality genetics in Indian horticulture.

Improving Apple Productivity in India

The adoption of high-density apple orchards on dwarfing rootstocks has allowed apple farmers mainly in the developed countries to achieve higher yield and better fruit quality. The Apple productivity in India currently is far lower than the global average productivity.But the Apple productivity in India has been affected mainly due to unavailability of dwarfing rootstocks suitableforhighdensityplantation. SSFPL is working actively on collaborating with global partners to bring in better rootstocks & germ plasm to improve the productivity and quality of apple production in India.

The joint Cornell University and United States Department of Agriculture-AgriculturalResearch Service (USDAARS) Apple Rootstock Breeding and Evaluation Program developed GENEVA® series of apple rootstocks with an emphasis on productivity, yield efficiency, ease of nursery propagation, wooly aphid, replanting disease and fire blight resistance etc. SSFPL has exclusive license for multiplication and propagation of GENEVA® rootstocks in India.

The Club varieties of Apple that we would bring in will help in meeting the expectations of premium segments of customers with better colour, improved shelf life, higher packouts, and meeting the taste requirements of sophisticated consumers, thereby lending themselves for differentiation. Overall better and consistent quality of these varieties will help in branding, thereby ensuring more consistent prices for the farmers produce.SSFPL would develop a modern and efficient supply chain for Apple in the interest of helping both the producers and consumers.