Futuristic Technologies in Horticulture

Golden Jubilee Celebration of
Progressive Horticulture Journal
(1969-2019)

Progressive
Horti Culture
Conclave (PHC)-2019

Souvenir

Organized by
Indian Society of Horticultural Research & Development, Uttarakhand
ICAR-Central Institute for Subtropical Horticulture, Lucknow

Co-organizer : Mission Horticulture, Uttarakhand

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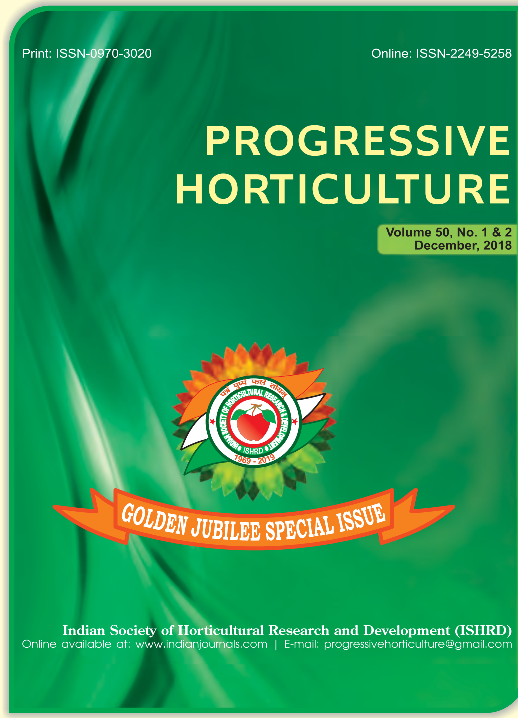
First Issue



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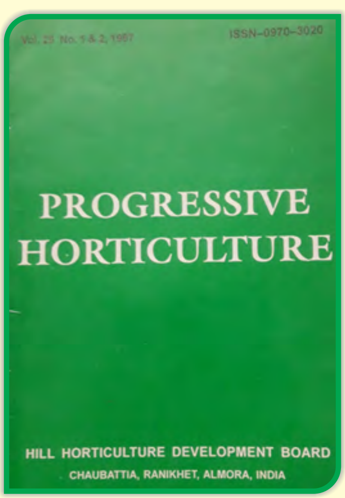

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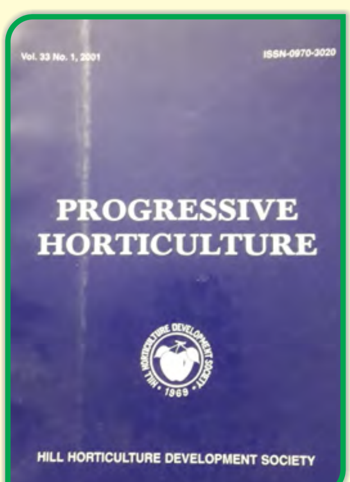

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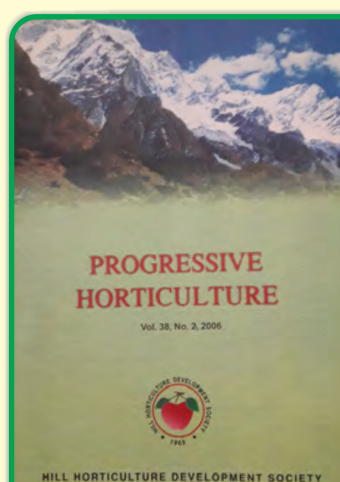

IV Change

Souvenir

Futuristic Technologies in Horticulture

Progressive Horti Culture Conclave (PHC)-2019

Organized by
Indian Society of Horticultural Research & Development, Uttarakhand
ICAR-Central Institute for Subtropical Horticulture, Lucknow

Co-organizer : Mission Horticulture, Uttarakhand

Edited by
A.K. Misra
O.P. Awasthi
S.K. Shukla
Deepa H. Dwivedi
Sandhya Gupta
A.K. Trivedi
Dhiraj Sharma

Organizing Secretary : R A Ram

Co-organizing Secretaries : S.K. Shukla & A.K. Trivedi

Golden Jubilee Celebration of Progressive Horticulture Journal (1969-2019)

Sponsored by

GOLDEN JUBILEE YEAR OF PROGRESSIVE HORTICULTURE JOURNAL

Progressive Horticulture Conclave (PHC-2019) on Futuristic Technologies in Horticulture
December 8-10, 2019

Venue: ICAR-Indian Institute of Sugarcane Research, R.B. Road, Cantt., Lucknow, India

Organized by
Indian Society of Horticultural Research & Development (ISHRD), Uttarakhand
ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP)
Mission Horticulture, Uttarakhand

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Edited by
A.K. Misra
O.P. Awasthi
S.K. Shukla
Deepa H. Dwivedi
Sandhya Gupta
A.K. Trivedi
Dhiraj Sharma

Sponsored by

ISHRD, Uttarakhand
Ministry of Agriculture, Govt. of India
ICAR-CISH, Lucknow
ICAR-IISR, Lucknow
ICAR-NRC Litchi, Muzaffarpur
Govt. of Uttarakhand
Horticulture Mission, Uttarakhand
DRDO, New Delhi
NABARD, Lucknow
UPCAR, Lucknow
UCB, Uttarakhand
UPCST, Lucknow
Dayal Fertilizers, Lucknow
Organic India, Lucknow
IFFCO, Lucknow

Organizing Secretary : R A Ram

Co-organizing Secretaries : S.K. Shukla & A.K. Trivedi

Published by
President, Indian Society of Horticultural Research & Development (ISHRD), Uttarakhand

नरेन्द्र सिंह तोमर

Narendra Singh Tomar

सत्यमेव जयते

कृषि एवं किसान कल्याण,
ग्रामीण विकास तथा पंचायती राज मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली

MINISTER OF AGRICULTURE & FARMERS' WELFARE,
RURAL DEVELOPMENT AND PANCHAYATI RAJ
GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI

Message

It gives me immense pleasure to know that ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) in collaboration with Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand and ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow is organizing Progressive Horticulture Conclave (PHC) - 2019 on "Futuristic Technologies in Horticulture" from 8th -10th December, 2019.

I am also happy to learn that a Souvenir is being brought out on this occasion for the benefit of scientists, academicians, students and farmers. The initiative is timely and assumes significance in view of the various programmes taken up by the Government of India for improving production and productivity of horticultural crops in the country.

India has emerged as a major stakeholder in the global horticulture scenario. This could be made possible due to the concerted efforts of scientists, state departments and progressive farming communities. However, the potential of horticultural crops in the country are yet to be harnessed fully.

I am happy to note that the major issues like future horticultural crops, quality inputs, artificial intelligence, climate change, next generation technological tools, doubling income through innovative technologies of post-harvest, waste & supply chain management, horticultural education, research and development and farmers support system with new policies are proposed to be discussed during the Conclave.

I am sure that the Conclave will come out with valuable recommendations that will be extremely useful in formulating national strategies for enhancing horticultural productivity with quality.

I compliment the organizers for taking the initiative and wish the Progressive Horticulture Conclavc-20 19, a grand success.

14/11/19

(Narendra Singh Tomar)

(Padma Shri) Dr K L Chadha

Ex-Deputy Director General (Horticulture), ICAR and
President, The Horticultural Society of India
F-1, NASC Complex, Todapur, New Delhi-110012

Message

I am pleased to learn that that ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) in collaboration with Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand and ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow is organizing Progressive Horticulture Conclave (PHC) - 2019 during December 8-10, 2019 on the subject **"Futuristic Technologies in Horticulture" to mark the celebration of 50 glorious years of Progressive Horticulture journal**. ICAR-CISH, is well known for the development of several technologies for crop improvement, propagation, production, and protection of various subtropical fruits which have been adopted by the farmers in various parts of the country. I am also happy to learn that a Souvenir is being brought out on the eve of Conclave for the benefit of scientists, academicians, students and farmers. The initiative is timely and assumes significance in view of the various programmes taken up by the Government of India for improving production and productivity of horticultural crops in the country.

I am happy to note that major issues like future horticultural crops, quality inputs, structures/models, artificial intelligence, automation/techniques, climate change, abiotic stresses, next generation technological tools, doubling income through innovative technologies of postharvest, waste & supply chain management, horticultural education, research and development, extension for promoting skill and entrepreneurship, farmer support system with new policies, women empowerment are proposed to be discussed among the scientific community during the Conclave. I am sure that the Conclave will come out with valuable recommendations extremely useful in formulating national strategies for enhancing horticultural productivity and nutritional security.

I extend my warm greetings to the Organizers and wish the Progressive Horticulture Conclave-2019, a grand success.

K.L. Chadha

Date: 11.11.2019

(K. L. Chadha)

डॉ. आनन्द कुमार सिंह
उप महानिदेशक (बागवानी विज्ञान) एवं
कार्यकारी उप महानिदेशक (फसल विज्ञान)

Dr. Anand Kumar Singh
Deputy Director General (Hort. Sci.) &
I/C Deputy Director General (Crop Sci.)

भाकृअनुप
ICAR

भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान भवन–II
पूसा, नई दिल्ली–110012

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
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Message

Diverse agro-climatic and socio-cultural conditions of India significantly support horticulture sector comprising fruits, vegetables, spices, plantation crops, floriculture, medicinal and aromatic plants and mushrooms, etc. This sector has vast potential for further growth and thereby generating employment opportunities for enhanced income of stakeholders. Systematic investments on various aspects of R&D in this sector have been largely rewarding and are aptly reflected in increased production, productivity, availability, export and economics of horticultural produce. Further developments in the sector are possible through intensification of research on various aspects hampering enhanced productivity and production. Indian Council of Agricultural Research in collaboration of vast network of Agricultural Research, Education and Extension system in the country and abroad, is committed to provide desired technological backstopping to achieve further accelerated growth.

The organization of **Progressive Horticulture Conclave (PHC)-2019** in active partnership of researchers, farmers, and development organization is timely initiative to address issues concerning future development in Horticulture Sector. I am happy to note that major issues like future horticultural crops, quality inputs, structures/models, artificial intelligence, climate change and mitigation, biotic/abiotic stresses, next generation technological tools, doubling income through innovative technologies, waste & supply chain management, horticultural education, research and development, extension for promoting skill and entrepreneurship, farmers support system with new policies, women empowerment are proposed to be discussed. I am sure that the Conclave will come out with useful recommendations for all the stakeholders.

It gives me immense pleasure to know that ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) in collaboration with Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand and ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow is organizing Progressive Horticulture Conclave (PHC) - 2019 during December 8-10, 2019 on **Futuristic Technologies in Horticulture**. To commemorate the occasion, a Souvenir is being brought out for the benefit of scientists, academicians, students and farmers.

I congratulate the organizers and wish the participants and meaningful event.

(Anand Kumar Singh)

डॉ. आर. मीनाक्षी सुन्दरम, आई.ए.एस.
सचिव

Dr. R. Meenakshi Sundaram, I.A.S
Secretary

उत्तराखण्ड शासन

विद्यालयी शिक्षा, सहकारिता, मत्स्य, पशुपालन
डेयरी विकास, कृषि, कृषि शिक्षा एवं उद्यान
कार्यालय दूरभाषः 0135–2712012
फैक्स : 0135 – 2655166
4, सुभाष रोड, देहरादून

Message

It gives me immense pleasure to know that Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand in collaboration with ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (U.P) and ICAR – Indian Institute of Sugarcane Research (IISR), Lucknow is organizing Progressive Horticulture Conclave (PHC) – 2019 during December 8-10, 2019 on the subject "Futuristic Technologies in Horticulture". I am also happy to know that a Souvenir is being brought out on the eve of Conclave for the benefit of scientist, academicians, students and farmers. The initiative is timely and assumes significance in view of the various programmes taken up by the Government of Uttarakhand for improving production and productivity of horticultural crops in the State.

I am happy to note that major issues like future horticultural crops, quality inputs, structures/models, artificial intelligence, automation/techniques, climate change, abiotic stress, next generation technological tools, doubling income through innovative technologies of postharvest, waste & supply chain management, horticultural education, research and development, extension for promoting skill and entrepreneurship, farmers support system with new policies, women empowerment are proposed to be discussed among scientific community, development departments, fruit growers, input suppliers, bankers and other agencies during the Conclave. I am sure that the Conclave will come out with valuable recommendations exceedingly beneficial in formulating strategies for enhancing horticultural productivity with quality in the country in general and Uttarakhand/Uttar Pradesh in particular.

I compliment the organizers for taking the initiative and wish the Progressive Horticulture Conclave – 2019, a grand success.

(R. Meenakshi Sundaram)

डा. बिजेन्द्र सिंह
महानिदेशक

Dr. Bijendra Singh
Director General

उत्तर प्रदेश कृषि अनुसंधान परिषद
अष्टम तल, किसान मण्डी भवन, विभूति खण्ड, गोमती नगर
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Uttar Pradesh Council of Agricultural Research
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Phone: 0522-2721626, Fax: 0522-2306802, Mobile: 0800492452
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पत्रांक :
Letter No. : 226/PSDG/2019

दिनांक :
Date : 7/11/2019

Message

I am happy to know that ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) in collaboration with UP Council of Agricultural Research, Lucknow, Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand is organizing Progressive Horticulture Conclave (PHC)-2019 during December 8-10, 2019 on the subject **"Futuristic Technologies in Horticulture".** I am also delighted to note that a Souvenir is being brought out on the eve of Conclave for the benefit of scientists, academicians, students and farmers. The initiative is timely and assumes significance in view of the various programmes taken up by the Government of Uttar Pradesh for improving production and productivity of horticultural crops in the state of Uttar Pradesh.

I am delighted to know that major issue like future horticultural crops, quality inputs, structures/models, artificial intelligence, automation/techniques, climate change, biotic/abiotic stresses, next generation technological tools, doubling income through innovative technologies of postharvest, waste and supply chain management, horticultural education, research and development, extension for promoting skill and entrepreneurship, farmers support system with new policies, women empowerment and proposed to be discussed among scientific community, development departments, fruit growers input suppliers, bankers and other agencies during the Conclave. I am sure that the Conclave will come out with valuable recommendations extremely useful in formulating national strategies for enhancing horticultural productivity with quality.

I wish the Progressive Horticulture Conclave-2019, a grant success.

(Bijendra Singh)

Dr. S.K. Malhotra
Agriculture Commissioner
Phone : + 91-11-23383549, 23381012
E-mail : ag.comm@gmail.com

सत्यमेव जयते

भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि सहकारिता एवं किसान कल्याण विभाग,
कृषि भवन, नई दिल्ली–110001
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture Cooperation
& Farmers Welfare
Krishi Bhawan New Delhl-110001

Dated 08.11.2019

Message

I am delighted to know that Progressive Horticulture Conclave on "Futuristic Technologies in Horticulture" is being organized by Indian Society of Horticulture Research and Development (ISHRD) & ICAR-CISH Lucknow from 8-10 December, 2019.

The national efforts of research and development through ICAR, SAUs and Mission for Integrated Development of Horticulture has paid dividend and India has witnessed remarkable increase in horticulture production to meet the requirement of food and nutrition. Health conscious population is demanding more fruits, vegetables and plantation crops but in the emerging scenario of climate change, the challenges are many to produce more from declining land and water through infusion of innovative technologies.

I am sure that the deliberation in this conclave will lead to a road map for improving productivity and quality of horticulture crops based on futuristic technologies.

I wish the conclave a grand success.

(S.K. Malhotra)

Dr. B.N. Srinivasa Murthy
Horticulture Commissioner

सत्यमेव जयते

Government of India
Ministry of Agriculture and Farmers Welfare
Deptt. of Agriculture, Cooperation and Farmers Welfare,
Krishi Bhawan, New Delhi-110001

Dated: 11 November 2019

Message

It gives me immense pleasure to know that ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) in collaboration with Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand and ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow is organizing Progressive Horticulture Conclave (PHC) - 2019 during December 8-10, 2019 on the subject **"Futuristic Technologies in Horticulture"**. I am also happy to learn that a Souvenir is being brought out on the eve of Conclave for the benefit of scientists, academicians, students and farmers. The initiative is timely and assumes significance in view of the various programmes taken up by the Government of India for improving production and productivity of horticultural crops in the country.

India has emerged as a major stakeholder in the global horticulture scenario. This could be made possible due to the concerted efforts of scientists, state departments and progressive farming community. The efforts made to promote Horticulture through Plan schemes have made visible impact. The recent approach of the government to bring in higher money share to the farmers that the consumer pays for the product he buys and to develop cluster approach in production is essential to success the sector. However, the potential of horticultural crops in the country is yet to be harnessed fully. I am happy to note that major issues like future horticultural crops, quality inputs, artificial intelligence, automation/techniques, climate change, biotic/abiotic stresses, next generation technological tools, doubling income through innovative technologies of postharvest, waste & supply chain management, horticultural education, research and development, extension for promoting skill and entrepreneurship, farmers support system with new policies, women empowerment are proposed to be discussed among scientific community, development departments, fruit growers, input suppliers, bankers and other agencies during the Conclave. I am sure that the Conclave will come out with valuable recommendations that will be extremely useful in formulating national strategies for enhancing horticultural productivity with quality.

I compliment the organizers for taking up the initiative and wish the Progressive Horticulture Conclave-2019, a grand success.

(Dr. B.N.S. Murthy)

भा.कृ.अनु.प.–भारतीय गन्ना अनुसंधान संस्थान
रायबरेली रोड, पोस्ट दिलकुशा, लखनऊ–226 002, भारत
ICAR-Indian Institute of Sugarcane Research
Rai Bareli Road, Dilkusha, Lucknow-226 012

डॉ. अश्विनी दत्त पाठक
निदेशक
Dr Ashwini Dutt Pathak
Director

Message

It gives me immense pleasure to know that ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) in collaboration with our institute, ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow and Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand is organizing Progressive Horticulture Conclave (PHC) - 2019 during December 8-10, 2019 on the subject **"Futuristic Technologies in Horticulture"**. I am also happy to learn that a Souvenir is being brought out on the occasion of Conclave for the benefit of scientists, academicians, students and farmers. The initiative is timely and assumes significance in view of the various programmes taken up by the Government of India for doubling the farmers' income in the country.

Horticulture is the backbone of agricultural growth in the country which accounts for more than 30 per cent of agricultural GDP. India has emerged as a major stakeholder in the global horticulture scenario. This could be made possible due to the concerted efforts of scientists, state departments and progressive farming community. The efforts made to promote Horticulture through Plan schemes have made visible impact. However, the potential of horticultural crops in the country is yet to be harnessed fully. I hope the issues and constraints being faced by farmers will be discussed in the Conclave and suitable strategies be developed.

I compliment the organizers for taking the initiative and wish the Progressive Horticulture Conclave-2019 a grand success.

A D Pathak

(Ashwini Dutt Pathak)

Dr Shailendra Rajan
Director

भा.कृ.अनु.प.–केन्द्रीय उपोष्ण बागवानी संस्थान
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ICAR-Central Institute for Subtropical Horticulture
Rehmankhera, P.O. Kakori, Lucknow - 226 101 (India)

ISO : 9001-2015

Message

I am happy to note that Indian Society of Horticultural Research and Development (ISHRD), Uttarakhand in association with ICAR-Central Institute of Subtropical Horticulture (CISH), Lucknow (UP) is organizing Horticulture Conclave (PHC) - 2019 at ICAR - Indian Institute of Sugarcane Research, Lucknow from December 8-10, 2019 on the subject **“Futuristic Technologies in Horticulture”** which is very relevant in the present context. The event will provide a platform to researchers, academicians/ scholars, entrepreneurs, farmers, development agencies, policy makers and other agencies to discuss, review and formulate the action plan for “Horticultural Revolution” in the country.

I wish the Conclave (PHC) – 2019, a grand success.

Dated : 02.12.2019

(Shailendra Rajan)

Foreword

After achieving self-sufficiency in food production in India, the emphasis has shifted from diversification of Agriculture to Horticulture, Livestock and Fisheries. As a consequence, strengthening of research and development of infrastructure, the horticulture crop production in India outpaced the foodgrain production for the first time during 2013-2014. The trend has been continuing and production for the year 2018-2019 is estimated 312 million tonnes. During the last decade, the area under horticultural crops grew by about 3 per cent per annum with an increase in the annual production by 5.4 per cent and the share of horticulture output in agriculture being more than 33 per cent.

Several innovations and novel initiatives have enabled the Indian horticulture to penetrate in the international markets with significant increase in export of different horticulture commodities. Today, as a result of better synergy between research agencies, institutional collaborations, technological and policy initiatives by different central and state government agencies, proactive participation of private sector, this sector has emerged as a sustainable and viable option for even the small and marginal farmers. Despite the remarkable progress made, keeping in view the burgeoning population, shrinking land resources, depleting biodiversity, threat of climate change, production deficit and gluts and several others, there is a plenty of scope in further consolidating the missing links.

The "Progressive Horticulture Conclave 2019" is being organized to take stock of the present situation in Horticulture and to identify critical gaps in various existing and emerging areas in Horticulture. The conclave on "Futuristic Technologies in Horticulture" which encompasses eleven broad themes including organic farming will enable the researchers, policy makers and various stakeholders to exchange scientific and technical information. The information generated will help in achieving the goal for high quality production, enhance productivity quality and profitability, meet market and consumers market, value addition in a sustainable way. The society had requested resource persons and organizations of repute to contribute in this souvenir and to pen down their experiences to enable formulation of strategies for the future 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 in the Conclave.

On behalf of the Indian Society of Horticulture Research and Development, I take this opportunity to profusely thank the organizers of collaborating institute of this Conclave ICAR-CISH, ICAR-IISR, Lucknow, ICAR-NRC Litchi, Muzaffarpur, members of national advisory committee, local organising committee, office bearers and members of the executive committee of the society, scientists, staff, students, chairmen/coordinators and the dedicated team of different committees who have toiled hard in organizing the "Progressive Horticulture Conclave 2019" entitled "Futuristic Technologies in Horticulture" at Lucknow from 8th to 10th December, 2019 on the eve of Golden Jubilee Celebration of Progressive Horticulture Journal (1969-2019) after the previous symposium organized at Dehradun during the year 2010.

I would also like to place on record our sincere gratitude to all the public and private organizations supporting the Conclave namely, ICAR, NABARD Ministry of Agriculture, Govt. of India, Govt. of Uttarakhand, Govt. of UP, DRDO, New Delhi, UPCAR, Lucknow, UCB, Uttarakhand, UPCST, Lucknow, Dayal Fertilizer, Lucknow, Organic India, Lucknow, IFFCO, Lucknow.

Special appreciation is for the core team of the organizing committee, namely Dr. A. K. Misra, Dr. R. A.Ram, Dr. Sushil K. Shukla, Dr. Ghanshyam Pandey, Dr. Sanjai Diwedi (DRDO), Dr. Shiv Shantanu Singh, GBPUA&T, Pantnagar and several others who have made significant contribution at various stages in organizing the conclave.

I am extremely obliged to all the invited speakers and guest contributors who have responded to our request for participation and presentation. I am sure the Conclave would generate meaningful discussion culminating in more relevant recommendations, which can be projected to different agencies for consideration in framing policies and programmes for future productivity improvement of horticultural farms.

I wish every participant of the Conclave a very happy stay in Lucknow, fruitful discussion and good luck for their future endeavour, particularly students who have to shoulder the future of horticulture in the coming years with many challenges. The Conclave family coveys all the delegates a Very Happy and Prosperous New Year-2020 with dedication to take Indian Horticulture to greater heights.

December 04, 2019

(R. K. Pathak)
President ISHRD

Contents

EVENING LECTURE

Cosmic farming : A ray of hope for sustainable horticulture

R.K. Pathak

Former Director
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Homa Teacher, Five Fold Path Mission
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Background

Energy is needed for every activity. In agriculture, energy from fossil fuel and imported sources are used, which is dwindling and becoming expensive to the government, farmers and to the society. Indiscriminate use of agro chemicals and many other factors have adversely impacted soil biology and environmental ecology. As a result the air which we breathe, water which we drink and food which we consume all are polluted. Combined together these are posing threat to survival of humanity at the planet earth.

On tracing history of ancient agriculture when agrochemicals were not invented, there are number of evidences that country has supremacy in quality production of large number of crops. India was leader in production and export of many spices, silk fabrics, cotton and many others. It is pertinent to mention that people respected the five ultimate source of energy *i.e. Pancha Maha Bhutas* (earth, water, air, sun and ether). In turn, these provided their energy and country was at helm of supremacy in every sphere of life.

It is claimed that all things in the universe including plants and human beings are composed of the five basic elements. It is an established fact that the plants harvest the sun's energy, our main concerns is to understand how to transform sun's energy into edible form? In certain sense, all that is needed for farming with 5 elements: soil, water, light (heat), air and ether. As long as these elements are present, we will be able to practice farming. There is no need or invent new ones. Let us have a closer look at these elements. All natural cosmic food grown with the aid of *Panch Maha Bhutas* without use of chemical fertilizers and pesticides are capable of curing all diseases. *Rishies* called Food Annam Brahma *i.e. Satvik* they are rich in fibre, vitamins, minerals, amino acids and other nutrients. Their keeping quality, taste, flavour are excellent. Cosmic energy or the *Pranic* energy or life of the cosmic foods which are Satvic in nature is more potent in curing diseases and promoting a peaceful and healthy life. Organic foods are easy to digest and assimilate and create fewer wastes within intestine.

Few facts regarding five basic elements

Air-Plants constantly "eat" air. Imagine what we are doing to the air? Many human activities are responsible for change in chemical composition of the air (pollution). In fact we do not have knowledge about how this could influence and affect all forms of life on this planet.

Soil

It can be defined as "Substrate for infinite living organisms". The soil is living organism, born out of a colloidal affair between clay and humus. If there are still any doubt about soil life it would be interesting to know that 1 gram of soil contains between 10 million to 1 billion inhabitants (micro organisms). With time gap, it reaches maturity, it can become sick and it dies. It is very sick and dying today. When it is dead we call it erosion. Then the dead body of the soil is carried away by the winds and waters to the final resting place, the ocean floor. Now more than ever, if our will is to continue to live on this planet, we will have to listen, to understand and respect the soul of the soil. In the soil, air in an ingredient of major importance. It is in pores, the spaces, the small air pockets, that gases and water circulate. Air is important element to plants and human being. It is evident that plant is need of (Carbon 44%, Oxygen 44%, Hydrogen 6% via water, Nitrogen 0.4 to 4% via micro organisms). It is matter of concern that human cannot survive for more than two minutes without oxygen.

Water

Water is next to air and one of the important elements needed by plants and human being. Unfortunately most of our activities are squandering our own resources. In fact India gets enough rain water than many countries. But due to mismanagement almost 50% of rainfalls runs of carrying the life sustaining soil with it. It is true that our rainfall comes pouring down within a few rainy days in the monsoon season. These downpours act as a source of destruction rather than anything else.

Indian traditions have always believed in living in harmony with nature, as evidenced by the daily rituals linked to nature. For instance, it has been proven that *Yajna* creates a pure medicinal atmosphere. It renews the brain cells, revitalizes the skin, purifies blood and prevents growth of pathogenic organisms. Purification of the environment through the constituent electrons of the substances fumigated in the *yajna* is an obvious consequence of this process.

The fire and sun play the most significant role in the purification of the environment. The sages realized that pure water and air are the roots of good health and happiness, hence they considered all these as Gods. The wish to live long and healthy life can be fulfilled only when the environment is unpolluted, clean and peaceful. Unity in diversity is the massage of Vedic physical and metaphysical sciences.

After more than two decades of my involvement for sustainable agriculture and food security, I am of firm view that some innovative technologies from Vedic period can resolve the current crises. Thus, it needs introspection of current system of agriculture and of ancient times. During this period it came to me that cheap and plenty availability of energy sources can pave a way for sustainability in agriculture. Concept of "Cosmic Farming" was conceived by me potential tool for sustainable agriculture.

Points to be considered for plant nutrition

- Plants get their nutrition quantitatively from atmosphere and qualitatively from soil.
- Plants require more than 30 + elements in their production.
- This can be provided through pollution free environment and humus rich soil and variable plants.
- Quality humus is produced by decomposition of organic and animal waste without interference of agro-chemicals.

- Plants have only organic diet *i.e.* in oxidized, chelate and in ionic form which is accomplished by the microbial consortia.
- Fertilizers currently available hardly can provide 5-8 nutrients.
- Almost 78% free N is available in the atmosphere, which can be mediated through legume plants and other soil microbial consortia.
- Plenty of P in non available form in the soil, one has to enhance its solubility.
- Potash is non constituent element, burrowed from soil and returned back through bio mass.
- Humus content in the soil is potent accumulator of solar & cosmic energy has capacity to transmutate any nutrients which are deficient and require by plants.

Cosmic energy is fundamental source of energy. Strange to believe that all around us, great seas of energy of the cosmos in the form sun, planets including earth are freely available. Unlike chemicals sold in the commerce, this energy is free and it isn't toxic; it's highly beneficial. One has to respect these energies and mediate through different means for saving humanity at this crucial juncture. In fact, ancestors respected these sources and utilized their free gesture for welfare of humanity.

Cosmic energy is the source or cause of production

The sun created the earth and source of all energy directly or indirectly available to the earth is also sun. Surprisingly, the power of photosynthesis to convert the solar energy into life force rests only with the green leaves. For growth of any crop, sun light, water, air (oxygen) and soil as supporting medium are essential elements.

Natures' gesture to mediate cosmic energy

It is pertinent to mention that nature has made elaborate arrangement to mediate cosmic energy for welfare of humanity.

- Soil microbial consortia and earthworms have capacity to mediate cosmic energy.
- Millions of lips beneath foliage are busy in inhaling carbon dioxide and exhailing oxygen essential for survival of human being.
- Chlorophyll in foliage mediates solar energy in process of photosynthesis basic step in preparation of food.
- Nodules in leguminous plants have bacteria capable of harnessing free N available in atmosphere.
- Without plants we cannot breathe nor eat.
- Cow with hump which is pyramid shape, belly is mini replica of cosmos and horns have capacity to mediate cosmic energy.

By integration of these, cosmic energy can be mediated by every citizen with little efforts. Farming by synergistic & systematic mediation of energy from different component of cosmos has been dealt as "Cosmic Farming".

Cosmic farming

No chemical fertilizer or organic manure is needed as food for plants. "Cosmic Energy" is the fundamental source of plant growth. The Vedic answer is that cosmic energy is behind all mysteries of nature. It is available through primitive microorganisms in soil as also to the living cells. Therefore, plants have capacity to produce all food elements needed for their growth, without feeding them specific elements. Plant cells can transmutate one element into another as per need of plants through biologically active soil.

Need for "Cosmic Farming" in horticultural crops

There is minimum gap between farms to fork in most of the horticultural crops. Often pesticides are used in evening and crops are harvested in morning. Few are eaten in raw forms, which as potent source of health hazards. Few are dipped in chemicals for giving shining appearance. It is pertinent to mention that trend for consumption of organic produce is expanding rapidly in different countries. Looking strength of country "Cosmic production" in horticultural crops will have many implications in resolving many crises being faced by humanity and enhancing earning of farming communities and other people associated at different stages from production to post harvest handling and marketing.

Points to consider

Great sea of energy from cosmic energy through solar, lunar, planets and earth is available all the time. Interestingly these energies are free, highly beneficial. These energies can be mediated by everyone for well being of humanity. Cosmic energy through stars, planets are available all the time, while solar energy is only available in day hours. Both of these energies are infinite non-polluting renewable source. Some practices, which are helpful in harnessing these energies are:

- Practice of use of BD calender for different farming activities.
- Habitat development through intensive plantation of different kinds of plants including, those belonging to legumunous group.
- Enhancing soil fertility through crop rotation, inclusion of legume as sole crop, cover, inter, green manures, pump crops as per feasibility.
- Practice of mulching whenever, possible as thumb rule.
- Management of few cows with hump and use of her produtcs.
- Enhancing soil humus formation and its maintenance.
- Assertive promotion of homa therapy and use of Agnihotra ash.

Use of BD calendar

Energy from cosmos, sun and other planets reach to earth in a rhythm. Sun light is essential for food formation through the process of photosynthesis, but moon light is equally essential for plant growth. There are certain positive and negative days as per moon's movement in a month. By practice of crop calendar, it results to enhance quality production and ensures minimum incidence of pests. At a minimum they provide a broad frame work/ set of principles to plan and do the farm activities. These introduce a discipline into farming activities and revitalize the soil. Food produced from such living soil has not only more nutrition but increased life forces and vitality.

Habitat development

Plants had been closely associated with humanity since beginning. There is enormous variability in life span, size, and role played by plant to human survival. They are the cheap and effective tool to capture solar energy through the process of photosynthesis, make eco balance in nature, capture N freely available in atmosphere, provide aeration to the soil through deep penetration of roots, thereby capillary movement of rain water, and also help in enhancing activity of earthworm and large number of dwellers working in the soil.

Soil

In fact even today earth is recognized as Annapurna–meaning thereby that all nutrients needed by plants can be obtained from soil. The soil in upper horizon might be deficient in certain elements, but in deeper layer all elements in non available forms are available. Interaction of plants roots duly supplemented with earthworms and many more soil dwellers can play important role in upward movement of nutrients to upper layers, which can be utilized by the plants. Quality humus production takes place through decomposition of organic biomass duly supplemented with animal waste. Few simple practices such as incorporation of biomass, crop rotation, inclusion of legumes in the system, mulching and its drenching with bio enhancers are helpful in enhancement and maintenance of humus in the soil. All efforts need to be concentrated for formation of quality humus and its maintenance which is a prerequisite for soil fertility, crop quality, sound animal and human health.

Earthworms are known pulse of the soil. They play major role in maintenance of soil fertility and quality production. Earthworm is the chief operator of nature's microbe's factory. Local earthworms and uncountable microorganisms in the soil are the chief source of plants nutrition. They eat gravels, limestone organic biomass, move upwards and downwards making capillaries in the soil. This encourages better infiltration of water and helpful in upward movement of nutrients in available forms. Earthworms' excrement contains 5 times more of N, 7 times more of P, 11 times more K and 2 times more Mg and Ca than normal soil. By these activities they are capable of minimizing run off water, better aeration of roots, hence vigorous plants. Earthworms play important role in minimizing root diseases. Soil humus is indicator of soil fertility and quality production.

Mulching

Practice of mulching will keep the soil cool and prevent water loss through evaporation. It provides optimal situations by management of soil temperature, moisture, and dark conditions, friable soil for root development, enhancement of earthworm and termite activities thereby soil fertility. This in turn will enhance other soil life indispensible for plants. The mulch ultimately decomposes and enriches the soil. Once the soil gets better aeration through these processes, giving them better access to subsoil moisture and additionally, capillary action is improved. When plants can develop their full root system, their metabolism is strengthened and they are much better equipped to fight off pests, diseases and water stresses.

Cow

Cow has been regarded as Kamdhenu and most respected family member in ancient culture. In cosmic farming only cow is needed as external input. The hump of indigenous cow is pyramid in shape and belly is replica of mini cosmos full of microbes. Food, which permeates through rumen get enriched with microbial consortia. All products of cow are of immense use in agriculture and human health. Need base bio enhancers can be prepared by the cosmic farmer for enhancing soil fertility, crop productivity and quality.

Bio enhancer

Bio enhancer is almost new concept in Jaivik agriculture. Basically these are prepared by fermenting cow products over specific duration. These are available for all crop activities. Bio enhancers have impact to improve soil fertility, crop productivity & quality, pest and disease management. It is interesting to record that these are potent source of all macro, micro nutrients, PGPR activities, immunity enhancer, drought resistance used in many ways. These can be prepared by every farmer as per need. The main bio enhancers which are commonly used in organic farming are Beejamrita, Jeewammrita, Panchagvaya and many others. There is no compatability with chemicals at any tage of farming but can be integrated with each other for synergistic response.

Homa therapy

One of the major problem humanity currently facing is environmental pollution. Most of current international efforts have not given its dividends. Under these situations, Homa Therapy can provide cheap and effective tool for resolving environmental pollution to survival of human being. Agnihotra is the main pillar of Homa Therapy. It is science of pyramidology, biorhythm of nature, burning of organic substances and sonic power of chanting specific mantras. The resultant ash is full of subtle energies and used for number of farm activities. There is no restriction of caste, creed, education, religion, everyone need to be trained to adopt this technology and can contribute in saving planet earth. Homa therapy can be integrated with any organic farming system to get synergistic response. Integration of Biodynamic and Homa farming can resolve present day crises. Number of success stories on different crops and country are available which can be shared.

Conclusion

To counteract environmental pollution quickly, Agnihotra is a way, if it can be integrated with organic farming systems, it can provide positive impact for survival of humanity at this crucial juncture. Every citizen should strive to play their roles, which are helpful for enhancing availability of breathable air, drinkable water and fertile land for future generations.

Our Moto should be: Plant-Plant-Plant: Agnihotra-Agnihotra-Agnihotra

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Prof R.K. Pathak was born on 3rd August, 1943 at Jaunpur in Uttar Pradesh, India. He did his B.Sc and M.Sc from Govt. Agriculture College, Kanpur of Agra University during 1963 and 1965 respectively and Ph.D. from IARI, New Delhi during 1970; Specialized training on Organic Farming, IOWA, State University, USA.

Service - Horticulturist & Chief Horticulturist, Govt. Hill Fruit Research Station, Chaubatia, Almora; Associate Professor & Professor and Head, Department of Horticulture, N.D. University of Agriculture & Technology; Technical Coordinator, U.P. Diversified Agriculture Project, Uttar Pradesh; Director, Central Institute for Subtropical Horticulture, Lucknow; Chief Consultant and National Horticulture Mission, Govt. of India, Ministry of Agriculture, New Delhi.

Awards - ICAR, Gold Medal, 1970; Dr. Rajendra Prasad Award,1896; Shri Girdhari Lal Chadha Memorial Award, 1997; Vasvik Award, 2002; Rafi Ahmad Kidwai Award, 2002; Dhatri Shree Award, 2003; Hindu Ratna Award, 2015; HIS-Sivashakti, Life Time Achievement, 2017; Life Time Achievement Award, Arid Horticulture Society of India 2018; Life Time Achievement Award of Doctors Krishi Evam Bagwani Vikas Sanstha, 2018 for giving major impetus to eco friendly farming.

Honours - President of Indian Society of Horticultural Research & Development (ISHRD), Uttrakhand; Homa Teacher, Five Fold Path Mission (International Organization); Fellow of National Academy of Agriculture Sciences, Horticultural Society of India, International Society for Noni Science, Aonla Growers Association.

Dedication and interest - Devoted almost two decades to conceive cheap and easy source of energy for sustainable agriculture. During this period, based on field experience coined new term "Cosmic Farming" based on systematic & synergistic mediating energy from everlasting sources in the neighborhood "*Panchamahabhutas*" i.e. earth, water, air, fire and space. Based on this, book entitled "Cosmic Farming in Horticultural Crop" has been conceived. Now trying for assertive promotion of this unique technology in the country through different agencies viz. All India Radio, Seminars, Training and Personal contacts.

THEME 1

FUTURE HORTICULTURAL CROPS AND PRODUCTION TECHNOLOGIES

LEAD LECTURE – 1

Making farmers unperturbed - Horticulture is the way

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The diversification in the agricultural sector mainly of the horticulture sector has become a major source of positive growth for the sector itself and for the nation. This is because, it holds the key to the much-needed diversification in agriculture as horticulture has emerged as a promising source of income acceleration, employment generation, poverty alleviation and export promotion. Further, horticulture is more suited to millions of India's small and marginal farmers as fast-growing crops, such as vegetables, ensure a quicker cash flow to the producer and has tended to expand in the areas which had been slow to adopt green revolution technologies. The contributions of horticultural crops, and their related industries, to society at large are very considerable as wealth generation through the activities of those involved with production, processing, marketing, servicing, and related sectors is significant.

Fruits and vegetables, our source of vitamins and nutrients ; spices, the king ingredient of Indian food which has an eminent position in our culture, extending from north to south; garlands and flowers beautifying every event and festival makes one of most interesting arms of agriculture named as "horticulture". The horticulture sector has been the driving force in stimulating growth of Indian Agriculture. India is currently producing 313.85 million tonnes of horticulture produce from an area of 25.49 million hectares, (3rd Advance Estimates) which has surpassed the estimated food grain production of 284.95 million tonnes (4th Advance Estimate). As a result of changing dietary patterns, the composition of agricultural production has diversified over the years. On the production and productivity fronts, the horticulture sector has outperformed conventional food crops.

Between 2004-05 and 2018-19 (3rd Adv. Est.), horticultural production has achieved an annual growth of 6.29% as compared to around 5.04% growth in food-grains production. This increase in production has come from an increase in acreage as well as productivity. The area under horticulture crops grew by about 2.7% per annum from 18.45 million hectares in 2004-05 to 25.49 million hectares in 2018-19 (3rd Adv. Est.), while the productivity has increased by 0.23% per annum from 9.05 tonnes per hectare in 2004-05 to 12.31 tonnes per hectare in 2018-19 (3rd Adv. Est.). As a result, India has maintained its second rank in the global production of fruits and vegetables, next only to China.The Horticulture is diversified to cover 6 subsectors namely vegetables, fruit crops, spices, ornamentals, plantation crops and mushrooms.

The horticulture section is doing well in India when compared with others food crops, since it fetches good price because of its nature of seasonality. Though sections like movement of the produce and post-harvest practices are few areas where the lion's share of problems persist. The estimation of the potential profits can be drawn by the fact that a farmer producing cereals of 1 kg gets 10 times higher prices for the same produce in horticulture section. And fruits like banana fetches as much as 30 folds more remuneration. Flowers (seasonal) can draw up to 30-35 times of remuneration. Considering this high potential, the concept of doubling farmers income can work magically with horticultural crops. There is a need of shift from traditional crops and cropping pattern.

The international market, undergoes process of sorting, followed by grading and marketing when the produce is brought out of the farm. The international population is more concerned with the quality of the produce and hence A grade produce is supplied to markets and lower grades produce is used by processing industry. However, in India only 2-5% of produce is used for processing. Due to our lower processing potential, India pushes most of its produce to the market where discrete price levels are set depending on the grade of the produce. The Grades A,B,C etc are set depending upon the weight, size of the produce.

For a good produce, We should have a good start. Start in terms of good planting material quality is the most important factor. Percentage of higher grade can be increased by starting off with quality plant material. It generally happens in our Indian set up that quality of grafted material varies due to wrong labelling which sacrifices with the quality matter. Other important factors are timely usage of fertilizers, irrigation, plant protection, intercultural operations etc. are required. Irrigation, which is not available in abundance in the country adds as a huge problem. India has witnessed good monsoon since couple of years. Only few districts are affected by draught conditions. But most of the time, horticulture does not depend on annual rainfall but on assured irrigation. We need back up ground water or harvested water for irrigation throughout the plant life unlike others food crops, like rice, wheat or pulses.

Export in Indian horticulture section has been gaining heights. In the year, 2018-19 the export reached at a worth Rs 20,854.20 cr. Fruits and vegetables alone accounted for Rs. 10237.20 cr export. Flower recorded an export value of Rs. 571.41cr. The cashew processing capacity of Indian peninsular region is huge. But due to non-availability of raw nuts, the processing industries import raw nuts, process them and avail profits. Government is also trying hard to increase the cashew production in the country, being focused on Southern states of Telangana, Karnataka, Tamil Nadu and Gujarat and Chhattisgarh. Cashew is one of the most remunerating crop grown on marginal lands rendering Rs.180-200 for per kg of nuts.

The situation of cold storage in the country is very encouraging. The capacity of cold storage space is not in tune with the requirement and the dearth of power availability makes the cold storages un-functional. The harvest faces 20-30% of post-harvest losses which is attributable to several phases of handling and storage, before the produce reaches the consumer. This loss can be compensated by using cold storages. Every other fruit/vegetable type uses different process/ method for the protection and preservation of produce. We are falling short of various components of cold storage like packed houses, ripening chambers and cold vans etc. Horticultural produce can be stored from 20 days to 6 months using these advancements. The advancements also face gaps when we talk of storage houses for potato, tomato and onion, which are considered to be magic crops. But provisions and efforts are being taken by the government and in another 2-3 years, proper systems are to be developed for the preservation of these magic crops. Farm level small storage structures run by solar energy is the key.

Since the doubling of farmer income is the buzz statement in the country, it needs special mention here. The first and foremost thing for doubling farmer's income is to create market for farmers and provide market access and links for growing their business. We should have a calendar of production for the various crops and analyze their condition likewise. Different states have their different capacities and agro-climatic conditions which favour some specific product. Such states should focus on their speciality and good channels should connect the country for the eminent flow in market. Integrated markets should be developed and shift from traditional to modern practices should be adopted. Alternative sources of income along with horticultural crops should be looked into, like Apiculture, where-in the bees also helps in the pollination and also draws extra income for the farmers. The govt. is also promoting Mission for Integrated Development of Horticulture (MIDH) scheme to support the various components of horticultural crops. Starting with nursery development, covering sustainable irrigation practices, emphasizing on subsidies for storage structures till market linkages, all the prospects are taken care of, under MIDH.

The areas that need to be the focal point in order to gain high productivity at farm level are:

Nursery and planting material

Inadequate availability of certified quality seed/disease-free planting material and slow adoption of improved high yielding cultivars/ hybrids is a major issue. The planting material is the key to quality produce as it forms the base of the orchard, greenhouse or farm produce. Hence the genuine quality in terms of genetic purity, healthy and disease and pest free plant material be it seed or vegetative propagated material needs to be assured.

Recognition of nursery, practice of plant propagation and further hardening at nursery level are important issues. Source of planting material i.e. mother plant, Rooting and growing media and technique followed for the same needs to standardized. Nursery sanitization including tools for tools and equipments also needs to be observed to facilitate proper operations and alleviate the harbouring of pests through weeds. Highest priority should be given towards developments of sound scientific nursery network in the country. Some of the problems in ensuring production of quality planting materials are; (i) absence of genetically uniform rootstocks, (ii) lack of variability for rootstocks, (iii) lack of information on rootstock-scion interactions (iv) year round production through specialized structures, and (v) lack of tissue culture protocols for most crops, and lack of vegetative propagation technique for seed propagated crops. There is a need to start rootstock-breeding selection programme.

Production of healthy and genuine planting material should be intensified in major, commercial crops so that a sound horticulture industry could be established. Further, adoption of recommended nursery standards by the nurseries operating throughout the country should be ensured. Accreditation of nurseries and tissue culture laboratories should be made mandatory for production and sale of quality planting material

Horticulture extension services

The potential in India's horticulture is also stunted by lack of awareness among farmers for best horticulture practices to increase productivity and quality, as well as post-harvest management and primary food processing for value addition, due to poor linkage between R&D sectors, industries and farming communities.

Traceability mechanism

Factors such as the lack of a traceability mechanism from the farm to the consumer, fragmented holdings and restrictions on direct procurement of products from farmers in some States makes it virtually impossible to ensure that products meet export quality standards.

Farm mechanization

Farm mechanization facilitates timely, precise and scientific farm operations, increasing farm input and labour use efficiency. There is need of technology driven development for small and marginal farmers with successful entrepreneurial models. Farm mechanization contributes in increase in crop intensity and yield thus ensuring better returns to the farmer, reduction of weather risk and risk of non-availability of labour thus minimizing post-harvest wastages, improved working conditions and enhanced safety for the farmer, conversion of uncultivable land to agricultural land through advanced tilling technologies as well as increase in rural employment owing to replacement of animal labour and provision of handling of farm machines.

Nutrient management

There is a need of integrated, balanced and effective nutrient management in the growth of horticultural crops. Foliar fertilization, bio-fertilizers, nutrient solubilising microorganisms and fertigation are already established technologies for enhancing NUE in horticulture crops. Fertigation which is the application of water soluble fertilizer along with irrigation water could be a cost-effective method of fertilizer application to achieve better distribution uniformity and fertilizer use efficiency in horticultural crops. Efficient design of fertigation is essential for achieving maximum fertilizer use efficiency.

Good Agricultural Practices (GAP)

In recent years, occurrence of pesticide residues in horticultural produces has posed menace in international trade. The major reason for such food safety related non-compliances occurrence is due to the lack of good agricultural practice (GAP) recommendations, and unregulated applications of pesticides for the management of insect pests and diseases. In most of the importing countries, the maximum residue limit (MRLs) is being set at the default level of 0.01 mg/ kg. In the absence of GAP recommendations, the pre-harvest interval (PHI) or the safe waiting period recommendations have remained unavailable for many of the crop-pesticide combinations. Establishment of effective residue monitoring programmes involving product traceability from farm to consumer level, the implementation of GAP in agrochemical usage, the adherence to the PHI recommendations, label claim and the use of residue-free agro-inputs from reliable sources are among others which can help to minimize residue problems.

Post-harvest handling losses

Heavy post-harvest and handling losses also result in low productivity per unit area and high cost of production. About 30-40 per cent of total horticultural production gets wasted before consumption. The biggest wastage happens during the transportation of horticulture products from the farm gate to mandis and thereafter. Emphasis need to go for rural-based low-cost primary processing and value addition for better storage and good pricing, and also to avoid distress sale. There is lack of structured secondary and tertiary industries related to processing of horticulture products in the vicinity of production areas.

Horticulture marketing

Problem in marketing and distress sale is another area of concern. Under the APMC, States do not allow free sale of produce though it is now being relaxed in some states. Price volatility due to poor market intelligence to small and marginal farmers is a major risk factor in horticulture. There is a dire need for the decentralization and modernization of market yards. Although India is one of the largest and lowest cost producers of high value horticulture commodities and yet has a minuscule share in global trade. The supply constraints, yield gaps and higher logistic costs are the areas where majority of problems persist.

Opportunities in horticulture

India's long growing-seasons, diverse soil and climatic conditions comprising several agro-ecological regions provide ample opportunity to grow a variety of horticulture crops. Thus, efforts are needed in the direction to capitalize on our strengths and remove constraints to meet the goal of moving towards a formidable horticultural growth in India. Horticulture has been identified as a prime mover in increasing farmers' income. The report of committee on Doubling Farmers Income (DFI, 2018), estimates that by the year 2022-23, a production level of 451 million tons has to be achieved, which can be obtained through 2.8 per cent increase in area and 3.1 per cent in productivity. Between 2000 to 2016, horticulture growth rates of 5.8 per cent occurred owing to technological back-up, investment and policy environment. Past trend shows that target of production of 316.41 million tons envisaged for 2020-21 is easily achievable, as production of 313.85 million tons has already been achieved in 2018-19. There is a need to encourage diversification to high value crops (HVC) at the rate of 5 per cent every year. However, production targets translating into increased income for farmers, is an issue, which is yet to be addressed and resolved. This would require promoting innovation in technologies through institutional support as well as sharing of knowledge and technological backing for development through skill enhancement. Following are some of the areas which needs immediate attention.

Protected cultivation

A major opportunity lies in promotion of protected cultivation, as it not only gives better dividends, but also brings pride to the profession and can attract youth including women as well. At present, only ~50,000 ha are under protected cultivation in India, whereas China has 2 million ha. There is need to increase 4 times the area (~2,00,000 ha) under protected cultivation in the next 4-5 years. Production under protected conditions not only provides high water and nutrient use efficiency but it can easily increase the productivity by 3-5 folds over open field cultivation. Use of plastic mulch (25 per cent more yield than no mulched), crop cover or low tunnels (for early crop and protection from low temperature), walk-in-tunnels (for temperate region off-season vegetables), naturally ventilated polyhouses (tomato, cucumber, tomato, flowers), net houses (for large number of vegetables and ornamental plant nurseries), environment controlled greenhouses (healthy nursery and foliage plants, vertical farming of lettuce, strawberry etc., soil-less farming (hydroponics and aeroponics, e.g. lettuce and potato seed production, aquaponics for vegetables), and vegetable grafts, are some important technological interventions that need to be scaled-up and adopted more widely.

Climate smart horticulture

Though the first alarm on climate change in terms on global warming was sounded about four decades before, yet very little progress has been made on the mitigation aspect. The climate change has influenced the Indian agriculture to a great event. As a result of climate change there has been an increase in the ambient temperature, erratic / unseasonal rainfall with special reference to higher intensity due to reduction in number of rainy days and the sea level rise which has been given less attention so far. All the three factors are having negative effect on the land and water resources of the country. Though there is lesser scope for mitigating the climate change in horticulture, efforts are made by different stake holders to address this issue from adaptation angle. The Ministry of Agriculture and Cooperation and Farmers Welfare has given top priority for developing appropriate technologies to combat the climate change by developing adaptive technologies. One of the major reasons for the secret of Israel's success in living with minimum water resources can be ascribed to a great extent on "proper" use of plastics in agriculture. Realizing this, the government of India is operating research and development schemes on Use of Plastics in Agriculture through different agricultural universities and ICAR institutes. A good number of technically feasible and economically viable technologies have been developed by the agricultural scientists. Apart from ministry of Agriculture, the ministry of Textiles is also doing their might in taking the technologies developed to the farmers under "Technical Textiles".

Adoption of lPM technologies on larger scale would facilitate climate smart horticulture. Honeybees as pollinators enhance the crop yield (25-100%) and also provide honey and other products as additional income to the farmers. Therefore, bee keeping can be promoted. This will include bee colony management strategies, and value addition in honey, including quality management.

Modernization of horticultural operations with enhanced investment has the potential to boost the Indian horticulture sector significantly. An integrated holistic approach to increase productivity of horticultural crops by adoption of growth enhancing technologies, pest management systems and precise farming practices would lead to 'Smart Horticulture'. Although many new technologies of seeds and planting material, drip irrigation and fertigation, greenhouse etc. have been adopted, these are sparse and the success stories need to be replicated on larger scale. Examples include banana in Maharashtra and Tamil Nadu, guava and tomato in Chhattisgarh, pomegranate and mango in Gujarat, pineapple in Nagaland, kiwi in Arunachal Pradesh and orchids in Sikkim, off season vegetables in Uttarakhand, etc.

Peri-urban and urban horticulture (PUH)

With rapid expansion of areas under cities and towns, development of sustainable peri-urban and urban horticulture (PUH) is another area of opportunity. It contributes for increasing access to food, advancing livelihoods and improving the environment (waste management, reduce CO2 emissions). Approaching PUH from a value chain perspective would create new opportunities for job and income creation.

Hortipreneurship

Expansion of e-NAMs and promotion of FPOs/VPOs/Cooperative Societies has great potential for promoting hortipreneurs'. The creation of a unified national market, a freer export regime and abolition of the Essential Commodities Act would help in boosting agricultural growth. Recent initiatives of the GoI to open foreign direct investment (FDI) in retail are expected to minimize some of problems related to export of horticulture produce. Provision of dedicated retail chains would improve the situation.

Public private partnership

In order to enhance horticultural production, there is need to promote PPP, in areas like quality planting material and hybrid seed production. Farmers need to be able to access both public-bred and private seed company generated seeds. Increasing financial support to strengthen infrastructure for nucleus and breeder seed production program at ICAR institutes/SAUs would greatly enhance seed production, through agencies like National Seed Corporation (NSC).

Information communication technology (ICT)

A combination of above practices, along with information communication technology (ICT) tools leads to 'Precision Horticulture'. It is a holistic system designed to maximize production and productivity using advanced information technology along with various management practices. Further, surveying and mapping have been essential components for efficient and accurate planning, execution and maintenance of assets, including crop stand and health. Today, drones mean a significant leap for surveying and it is the biggest disruption in the field of mapping. Technological advancement, easy availability and cost reduction in drone technology is a boost to this sectors in recent days with new capabilities. For example, multispectral remote sensing provides radically new perspectives on the health and vigour of crops. It allows growers and scientists to detect areas of stress in a crop and manage these issues immediately. Another benefit of utilization of this technology is Geo-tagging. Geo tagging of tree crops and other crops would help us to assess the number of trees at various vegetative, flowering, yielding stages, so that we can assess / predict the yield, besides the assessment of crop health condition. The limitations of monitoring of performance of crops through collection of data based on ground information like time and space, i.e., large scale application can be easily overcome by application of newer technologies.

Horticulture tourism

India has a major opportunity to explore the potential of horticultural tourism to promote development and increase its participation in the sustainable tourism development. In addition, horticultural tourism creates opportunities for the farmers in the country and provides revenues for horticultural products and environmental preservation. Diversity in cultivation practices are a key prop in the development of horticultural tourism in India. The wide range of agro-climatic conditions and region based horticultural product in relation to its aesthetic and nutritional value offering defines the competitiveness and attractiveness of tourism destinations and the visitors' experience.

LEAD LECTURE - 2

Status, opportunities and challenges of apple cultivation in India

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Apple is an important fruit crop in India and is mainly grown in the mountainous regions of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh and Nagaland. Apple farming is an important horticulture activity and profession of farming communities in these Himalayan states of India. Presently, total area under apple cultivation in India is 3,01,040 ha with 1,58,150 ha in J & K and 1,12,630 ha in Himachal Pradesh, whereas , the total production is 23,26,900 MT with 18,08,330 MT and 4,46,570 MT in in J & K and Himachal Pradesh, respectively. In Himachal Pradesh, apple is the fastest growing economic acidity of the state, accounting for more than 88 per cent of total fruit production and is the mainstay of the economy or over 1.7 lakh families. Over 3,500 crore rupees apple economy in Himachal Pradesh caters to the stakeholders such as transporters, carton manufacturers, controlled atmosphere store/cold chain owners, whole sale fruit dealers and the fruit processing unit owners apart from the growers. Average productivity of apple in India has been estimated at about 7.5 MT/ha which is far below the average world productivity of 30 MT/ha. Among major causes of low productivity in India, unavailability of quality planting material, lack of regular bering varieties and pollinizers, irrigation facilities, modern field tools/machinery and incidence of insect-pests and diseases are foremost. Apart from this, the traditional apple farming is under stress due to changes in the climate. Therefore, it is imperative to understand the variations in he patterns of climate change and identify management practices accordingly. Alternatives like diversification of apple cultivars and pollinizers, scientific nursery production prgramme, development of bud wood bank, high density plantation, integrated water and nutrient management through fertigation, pest and disease management, post harvest management and value addition technologies for improving productivity and quality of apple will ultimately enhance the net income. Furthermore, with the availability of low chill cultivars, we can expand the area under this fruit especially under marginal conditions. Training, skill development and capacity building programmes related to scientific cultivation and management also need to be organized.

LEAD LECTURE - 3

Technological interventions for improved productivity in vegetables

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India is endowed with diverse ecological conditions and vegetable production is distributed across the country. Most of the vegetables are short duration crop easily adjusted in crop diversification, provide higher biomass and return leading to nutritional and economic security to resource-poor farmers. In India, enormous growths in terms of production of vegetables have been achieved from last decades. The production of vegetables has increased from 129.08 million tons in 2008-09 to 187.47 million tons in the year 2018-19. India has made a quantum jump in vegetable production, securing second position in the world after China.

Identifying and selecting the profitable cash vegetable crops to grow is the most crucial factor in a successful commercial farming business. The selection of underutilized vegetables for cultivation especially nearby cities gives good profit. The production of vegetables in India utilizing modern techniques like precision farming, healthy seedling management, mulching and fertigation, bower system, protected cultivation, grafting and use of pollinators needs to be follow to get better returns.

Precision farming techniques

Precision farming is a comprehensive information based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of land resources. It basically means adding the right amount of treatment at the right time and the right location within a field. Precision farming calls for an efficient management of resources through location specific high tech interventions which includes fertigation, protected/greenhouse cultivation, soil and leaf nutrient based fertilizer management, mulching for *in-situ* moisture conservation, micro-propagation, high density planting, drip irrigation, *etc.* Thus, precision agriculture is conceptualized by a system approach to re-organize the total system of agriculture towards a low-input, high-efficiency, and sustainable agriculture.

Healthy seedling management

The supply of nursery on demand to the farmer's door is one of the latest business model adopted by the farmers of the Punjab. This practice may generate the employment and reduce the cost of production by minimizing the seed cost and time. Modern nursery raising under protected conditions gives disease free plants particularly viruses. However, in case of direct sown crops seed of these crops can be grown in plug trays using sterile coco pit growing medium for a short time in poly or net house.

Mulching and drip irrigation

Healthy vegetable crops are grown by using polythene mulch and drip irrigation along with fertigation. Critical stages of moisture stress in vegetables are (a) at transplanting, (b) early flowering and (c) fruit development. Moisture stress at flowering stage results poor fruit set and during fruit development greatly reduced fruit size. Black polythene mulch should be used during winter season (low temperature), whereas reflective mulch is used during summer (high temperature). Reflective mulch also repels aphids and jassids. The use of mulch reduces the weed infestation; increase water and nutrient use efficiency and reduce fruit rotting. About 40-80 per cent higher marketable yield has been reported in mulch and fertigation culture as compared to without much and drip irrigation.

Bower system for growing cucurbits and high density planting

Generally farmers grow vegetable crops on ground in open field or in pot under control conditions. Using of bower facilitates in vegetables for low cost of irrigation, easy pest management, uniform fruit shape, colour, increase harvesting efficiency and high yield. In case of cucurbits it has been observed that if vines are allowed on the ground, nearly 25-30 per cent less yield has been recorded over bower system and 8-10 per cent fruits become unmarketable due to misshaping and discoloration. The planting distance of crops can be reduced and plant population per unit area increased by training of plants on bower system, which increases the fruit yield.

Protected cultivation

Protected cultivation of vegetables is providing opportunities for improving quality, productivity and better market price to the growers by reducing climatic extremes (temperature, rainfall, pest incursion) in hot and cool areas. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off-season. Insectproof net houses can be used to reduce pest and pesticide levels and make virus-free cultivation of tomato, chilli, sweet pepper and other vegetables during the rainy season. Parthenocarpic cucumber production under protected cultivation gives very high yield with quality fruit.

Grafting to boost vegetable production

Grafting is the union of two or more pieces of living plant tissue that grow as a single plant. Grafting vegetable plant onto resistant rootstocks is an effective tool that may enable the susceptible scion to control soil-borne diseases, environmental stresses (resistance against low and high temperatures) and increase yield and quality of vegetables. Besides, it is also used to alter hormonal production which in turn influences sex expression and flowering order of grafted plants. The cultivated area of grafted vegetables, as well as the kinds of vegetables being grafted, has been consistently increased. At present, most of the watermelons, oriental melons, greenhouse cucumbers and several *Solanaceous* crops like tomato, chilli, and brinjal are used for grafting before being transplanted to the field or greenhouse.

Hydroponics : A soilless vegetable production system

Hydroponics refers to the practice of growing plants in nutrient solutions. This can be done either in liquid systems or in aggregate systems in which the plants are planted in a soilless media consisting of substances such as vermiculite, peralite, sand, coconut coir, expanded rock, gravel, rock wool or peat to provide mechanical support. Here roots of the plants are floated in nutrient solution provided with circulating air or bubbling air. This technology is also suited for high value vegetable like tomato, capsicum, cucumber and for leafy vegetables *etc.* Hydroponics systems are used year-round both indoors and outdoors for growing vegetables. The main advantages of hydroponics are soilless cultivation, less use of water, nutrient, safe vegetable and high yield.

Integrated disease and pest management

Vegetables are short duration crops and amenable to attack by various kind of diseases during their production. Occurrence of the disease is based on interaction of crop, environment and pathogen types. A huge crop loss is expected when all the three factors are favourable. In general, 30-80 per cent crop losses have been recorded in different vegetables due to diseases. Among the diseases, wilt and leaf spot are considered to be the major threat to vegetable cultivation. Apart from this, major menace to vegetable production is due to viral diseases especially caused by leaf curl and spotted wilt viruses.

Insect-pests are the major biotic constraints in vegetables production in India. Apart from causing direct damage they also act as vectors for several viral diseases. Average yield loss due to major insect-pests in different parts of the country is reported to vary from 33 to 40 per cent. Among these tomato fruit borer, brinjal shoot and fruit bore, chilli thrips and mite, okra fruit and shoot borer, diamondback moth on cole crops, fruit fly on cucurbits are important ones. In recent context of changing agro-ecosystems and climate, several other insect pests such has serpentine tomato leaf miner, brinjal gall midge, okra stem fly, white fly, fruit fly, giant African snail and bitter gourd leafhopper gradually attaining the major pest status in different regions of the country and adding to heavy loss of crops.

Among farmers, chemical method of control still enjoys first choice because of its easy availability and quick action. Some of the tolerant varieties/lines have been identified against major insect pests and being used as one of the major components of Integrated Pest Management (IPM). Research conducted under All India Coordinated Research Programme (AICRP) on Vegetable Crops at various centres have developed several regional/location specific IPM technologies for many important pests of vegetables.

Use of pollinators

Honeybees, mainly *Apis mellifera*, remain the most economically valuable pollinators for vegetables grown in protected or open field conditions worldwide. In most developing countries, crop production is by small scale farmers, who mainly produce for their own consumption and the extra for market. One of the reasons of not managing pollination is the lack of understanding of its economic value. Generally, 3-4 bee hives are required per acre in vegetable crops for proper pollination with an increased fruit set of 15-20 per cent. For better fruit yield and quality, 81 bee visits per flowers are required. Farmers should use pesticides very judicially and only if necessary, pesticides should be applied in the evening.

Production of organic vegetables

Unlike other food crops, most of the vegetables are succulent and attract several insect pests. Some pesticides used to control them remain chemically active for a long period and produce hazardous effects on the environment. Also, some of them do not degrade and enter the human body along with vegetables consumption. Therefore, a conscious consumer has started demanding organically produced foods. The production of organic vegetables has now become a commercial venture, where organically produced vegetables are available in the market at a premium price. In India it is done only on small scale for domestic and export purposes.

Post-harvest technology and supply chain

Due to 15-20 per cent post harvest losses, an efficient post harvest management has become an absolute necessity. This loss is not only in form of produce in money but also wastage of labour, energy and inputs involved in production of vegetable crops. If farmers can be trained for pre and post-harvest management and value addition, can increased the incremental advantaged over actual income. Harvesting at right maturity is the most important determinant of storage life and finally its quality. Field packing (selection, sorting, trimming, and packaging) of produce at the time of harvest and minimal processing can greatly reduce the number of handling steps in preparation vegetables for marketing. Besides processing of major vegetables, Indian processing industries are also looking for value added products from minor or underutilized crops also.

Future research strategies

Besides developing improved cultivars of major vegetables, following research strategies should be adopted to meet the challenges of vegetable productivity and production.

- Screening of germplasm/landraces for biotic, abiotic stresses and quality traits.
- Development of multiple disease resistant varieties/hybrids with premium attributes.
- Development of male sterile lines, especially in chillies, tomato, eggplant, onion, muskmelon.
- Development of tropical gynoecious lines in cucurbits for economic hybrids seed production.
- Survey, collection and utilization of underutilized crops.
- Development of vegetable-based cropping system.
- Promotion of off-season low cost production technologies of vegetables.
- Training programmes on various aspects of vegetable and its seed production and protection technologies.

Conclusion

It is well established that the vegetable cultivation provides more return and jobs, especially to the small holders and therefore, can contribute to eradicate poverty and hunger. Although commendable progress has been made on the research front and a number of technologies have been developed, poor adoption of such technologies has always been a major handicap in increasing productivity. Therefore, promotion of developed technologies through various mechanisms is key to harness the available technologies, thus ensuring the increased productivity and profitability to the farmers. Likewise, pro-active government policies for development of infrastructure and law enforcement, which support execution of such promotional activities, are equally pertinent to achieve higher productivity.

LEAD LECTURE – 4

Futuristic horticulture technologies an Indian perspective

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At present, futuristic horticulture technologies seems to be very modern and unusual but will become reality and common in future. Application of advance technologies in horticultural production system is increasing at a fast pace and is visible in entire value chain of horticulture crops. Futuristic technologies include various aspects of precision farming; robotics, automation, sensors and mechanization. These are the areas where innovations for improving productivity, reducing input cost and quality improvement are taking place. Not only electronics and machinery, but several advance technologies will appear in future for the development of horticulture sector. This includes application of biotechnological tools, diagnostics and innovative plant nutrition. The areas where lot of research is coming up might be related with development of high yielding varieties, nutraceutical and bioactive compound rich cultivars and many more.

One of the most important applications of newer technologies is through precision horticulture. Geostatistics and Geographic Information Systems (GIS) are the main components of hi-tech horticulture. The specific requirements focus on the site specific aspects of precision farming including variable rate fertilizer, site-specific farming, manage-ment zones, yield mapping, variable rate herbicides application, variable rate irrigation. Remote sensing helps in automatic tractor navigation and robotics, proximal sensing of soils and crops, and profitability and adoption of precision farming.

The drip irrigation system which has become a common component of hi-tech horticulture farm will be managed through Smart Phones and owner of the orchard can check the rate of irrigation, use of fertilizer from anywhere due to automated drip irrigation system. This will enable the reduction in water use for irrigation as well as water use efficiency will also increase. Horticulture farm operation will be managed remotely e way bill from other continent. Mechanization, automation and use of sensors will enable many of the activities through smartphones. One can and monitor the growth of the crop and operations to be undertaken remotely.

Speciallized labour shortage for horticulture production is perpetual. Therefore, robotics can compensate for the availability of a labour and in many operations like vegetable grafting. Use of robotics will increase production and reduce production cost. We do not know in near future many of the operations performed by human labour will be substituted through robots. Intelligent fruit harvesting and many other operations where non-specific mechanization faced performance, robots will help in automation. Wireless internet connectivity will also help in horticultural operations. Monitoring of the growing environment at real time will be possible easily from any heart of the world. Decision taking for important operations of crop remotely controlled. The scouting for the disease, pest and nutrient efficiency in the crops will become easily with the use of censor. 2-D and 3-D cameras can scan the crop and help in decision making in various operations.

Internet dependency will increase as the technologies similar to blockchain become important in international value chain. Participants in a Blockchain network do one-to-one business based on consensus and not through a central intermediary. Database and data mining will help in value chain management. Data may be more safe with the participants as they can retain a copy of the data and are thus not dependent on a central database. Encryption of data will enable no longer be modifications after approval.

As sensors have played important role in medical and international development, the similar revolution may take place in horticulture particularly in green house management. Their application for the management of pest and disease and particularly integrated pest management will be exploited. The automation mostly will be based on the sensors for energy saving is one of the areas in horticulture production. Greenhouse Technology with several refinements requiring less energy will become important. Especially thermal screens and devices for thermal integration will have impact. Humidity control in relation to energy consumption will also be channelized for increased production, quality and quantity. As a futuristic concept, the electricity and green house production may take place which is at experimental stage presently.

In most of the horticulture advancements ICT will be involved. Horticulture Apps, Smart Phones and specific machinery will be utilizing ICT and software specific to various production systems. Development of specific software will make the technology more robust. ICT will be controlling the supply chain of horticulture commodities. This will be helpful in shortening of the production chain and add value to the products.

Use of sensors for wanting the horticultural product and quality in the cold chain will become an important area for quality assurance. The programme containers with censorship will be more in use with better control on the parameters like temperature related humidity while transportation of fresh produce which includes fruits, vegetables and flowers. Hyper spectral imagine will enable to find out the disease at an early stage in crops which are not visible to human eye. The images captured through these specialized cameras will be utilized for finding out disease and leaf disorder. This will be highly helpful in mitigating the epidemic situation by working in advance.

Commercial indoor farming has become reality and advances made in this direction have shown excellent results by manifold production as compared to open cultivation. Several vegetables are suitable for this type of indoor culture which is mainly based on hydroponics and soilless culture. These form for production capacity per unit area much higher than the normal field condition. The optimization like condition for photosynthesis, use of LEDs and temperature manipulation enables production of multiple crops. Hydropnonic will have its several advance versions. Additionally, acquaponics with rearing of fish along with vegetables will include several sophisticated device. Use of solar energy will become a reality.

Futuristic Technologies for developing countries might be different from developed countries. Under limited resources, farmers hybridize their own innovations with modern technologies as per the existing needs. They evolve technical which has innovative component of rural source environment. These useful and low cost innovations are very well adapted by the farmers of the area. Many of the technologies are learned from resource rich farmers. These are been translated into cost effective ways of improving production and quality. Use of futuristic technologies doesn't mean that the entire system may become dependent on them as these technologies require lot of investments at the initial stage. Horticulture farming systems of many developing countries are not suitable when the farms are very large in size. Under existing land fragmentation scenario of India many technologies of modem agriculture developed as per labour requirement expected for large farms are being substituted through machine utilization. Many a times automation and hi-tech technology application requires initial cost investment that too specific for the very large farm. Farms of medium or small size are not suitable due to initial cost which may not be adopted by other farmer. Many machine based operations can be used through machine sharing models. Under limited land holding conditions these technologies will have better future if contract farming becomes a culture under Indian conditions. Many a times collective farming though conversion of the entire village in production of certain Horticulture commodity can invite these technologies for adoption.

LEAD LECTURE – 5

Transformation from subsistence farming to sustainable horticulture through modern horticultural technologies with special reference to organic production of kiwi and dragon fruit under different agro-climatic conditions of north east states of India

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Among recently introduced fruits Kiwifruit has assumed tremendous popularity in North-Eastern Himalayan states of Sikkim and Arunachal, whereas, Dragon Fruit cultivation has shown significant potential in states of Manipur and Mizoram in *jhumland*. Both fruit find high appeal by consumers and small & marginal farmers due to high benefit-cost ratio through high-tech cultivation techniques.

Kiwifruit initially established in semi-temperate Himachal Pradesh, has wide scope for production in sub-temperate states of North East and is being extensively cultivated in states like Arunachal Pradesh and Sikkim. Whereas, Dragon fruit cultivation is getting popular in sub-tropical north-east.

Despite congenial climate and soil, attaining commercial identity and being prioritized as fruit for area expansion under Horticulture Technology Mission, lack of quality planting material, package of practices, modem technology of precision farming and trained manpower are major productivity constraints. ICAR Roving Team for Temperate Fruits recommended the roadmap for cultivation of temperate fruits in NE Hills in general and Kiwifruit in particular. Extensive survey of Kiwifruit and Dragon fruit growing areas has been undertaken and will be discussed in detail.

The roadmap for quality plant material production with hi-tech horticulture like high density plantations and precision farming needs to be adopted, to harness organic farming potential of vast areas. Also, recent innovations for intensive cultivation of Kiwi and Dragon fruit will substantially increase profits over subsistence farming. This is evidenced in case-studies from Northeast Himalayas. Adopting modern horticultural practices will benefit region's economy comprising mainly marginal farmers whose practices are under threat from changing climate scenario.

LEAD LECTURE – 6

Futuristic technologies in fruit crops

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India is bestowed with varied agro-climatic conditions, which favours the cultivation of wide range fruit crops such as temperate, tropical, subtropical and arid zone fruits. The scenario of horticulture crops in India has become very encouraging. The percentage share of horticulture output in Agriculture has become 30 per cent. Under the purview of Agriculture & allied activities, the share of plan outlay for Horticulture which was 3.9 per cent during 9th Plan, has increased to 4.6 per cent during the Twelfth Plan. Out of 24.90 million hectares, fruit crops occupy an area of 6.53 million ha with the production of 96.75 million tonnes. The production of fruits has increased from 92.91 million tonnes to 96.75 million tonnes over the last 3 years (NHB, 2019 Ist Advance Estimate). The total fruit production was highest in Andhra Pradesh(13%) followed by Maharashtra(11%), Uttar Pradesh (11%), Gujarat (9%), Karnataka (8%), Tamil Nadu (7%), Madhya Pradesh(6%), Bihar (5%), West Bengal (4%), Telungana (4%) and other states (22%).

There is a growing awareness about the climate change and its impact across the globe and at present the cultivation of fruit crops are not easy due to various factors such as shrinking land and water resources, high input and labour cost, uncertainties of market prices and highly perishable nature of fruits. According to global climate change prediction models, the area under grain crops are going to decline, on the other hand there will be increase in area under horticultural crops. Consumption patterns are changing towards high value agricultural commodities and this is driving the process of agricultural diversification in India. High value commodities, particularly horticulture, livestock, and marine products, are highly expenditure elastic compared with grains (Kumar *et al*., 2007). Given rising incomes and higher expenditure elasticity for these commodities, future growth is likely to come from the high value sector (Gulati and Ganguly, 2008).

Diversification into horticultural crops is becoming attractive for many poor farmers around the world. Among horticultural crops, the fruit trees are typically multipurpose in that they provide not only fruits but also has varied uses *viz.*, for medicinal products, livestock fodder, as well as fuel wood and timber at the end of their productive lives. In addition to economic benefits, fruit trees provide greatly to ecosystem services. The Government of India has come out with a slogan "Doubling farmers' income by 2022" by focusing not only on increasing crop yields but also on reducing the cost of cultivation to increase the net income of farmers. The following are some of the varieties and technologies, which can increase the farmers' income many folds. The details of the fruit crop technologies that contribute for doubling the income are discussed in this chapter.

High yielding varieties and hybrids in fruit crops

A total of 210 varieties/hybrids have been released over the last 100 years of fruit breeding of which 89 varieties have been released in last 25 years. Among the released, 70 per cent of the varieties are from clonal selection and 30 per cent are hybrids. The prominent selections are L-49 (Sardar Guava), Coorg Honey Dew Papaya, Nagpur Mandarin, Coorg Mandarin, clones of Anab-e-Shahi (Tas-e-Ganesh, Sonaka & Manak Chaman) & Kishmish Cherni (Sharad Seedless, Saritha Seedless & Krishna Seedless) grapes, jamun (Konkan Bahadoli & Dhupdal) and Jack fruit (PLR-1 & Dubgere), lime (Vikram, Balaji, Primalini, Jai Dev& Saisharbathi) popular in farmer's. Several excellent high yielding hybrids of mango (Amrapali, Mallika, Pusa Surya, Ambika Arka Udaya and Arka Suprabhatah) papaya (CO7, Arka Surya & Arka Prabhat), banana (Udayan, Kaveri Saba & Co1), guava (Arka Kiran, Arka Poorna, Lalit & Swetha), pomegranate (Bhagwa & Ruby), custard apple (Arka Sahan) and passion fruit (Kaveri) have been released for cultivation by the various research institutes and SAUs' to meet the domestic and international need.

Use of rootstocks

In the recent past, there has been a growing awareness about the use rootstocks for tackling the biotic and abiotic stresses in fruit crops. The rootstocks are recommended against a particular situation for successful fruit production. However, the multiplication of those rootstocks in sufficient numbers with assured quality is not available for largescale propagation in those regions affected by abiotic stress *viz.*, as salinity, alkalinity and drought and biotic stresses such as nematodes and pests. While, these rootstocks possess the resistance/tolerance attributes, the quality of the produce by using these root stocks may become another problem in certain situations. This has led to the situation at present wherein the plants produced by private nurserymen are procured by majority of the growers as alternate sources for raising the planting materials. The need in rootstock today is the creation of variability for rootstocks. An example that can be quoted here is the case of 'Dogridge' rootstock which has revolutionized the grape industry in India. Out of 1.2 million ha, about 90 per cent of the grape growing area is under 'Dogridge' rootstock as it possess tolerant drought, salinity and nematodes. Similarly, the polyembryonic mango varieties such as Vellaikolumban, Olur, 13-1 & Kurukan are gaining the popularity in India. In guava, the var.Pusa Srijan and *Psidium molle* are commonly used to induce dwarf and wilt tolerance.

Quality planting materials production

The production and supply of genuine high quality-planting materials either seeds or grafts is of great concern due to the high demand from the farmers. The working group on horticulture under 'Nithi Ayog' has projected 4 fold increase in demand for planting materials of horticultural crops. The plant tissue culture technology has been very successful as an industry and has greatly contributed to the success, as it has advantages such as large-scale multiplication in lesser time, production of virus-free plants and year-round production. The demand for tissue culture banana has increased at a very high rate of 25-30 per cent and there is growing awareness of superiority of tissue-cultured plants. The demand for crops like banana, grapes, papaya, ginger, turmeric, cardamom, vanilla, and potato, Jatropha is increasing. In 2006, Government of India established the "**National Certification System for Tissue Culture Raised Plants (NCS-TCP)**" authorizing the Department of Biotechnology, Ministry of Science & Technology as the certification agency vide the

Gazette nnotification dated 10th March 2006 under the "Seeds Act, 1966" for ensuring production and distribution of quality tissue culture planting materials. The purpose of NCS-TCP is to ensure production and distribution of quality tissue culture planting materials. NCS-TCP is a unique quality management system, first of its kind in the world, which ensures recognition of tissue culture production facility for the production of quality planting material and certification of end products. The technique of micro-grafting is now routinely applied to the recovery of Citrus clones from virus diseases. It consists of *in vitro* grafting of an excised shoot tip apex onto *in vitro* raised and decapitated seedlings as rootstock (Navarro *et al.*, 1981). Applying this technique numerous clones of Clementine, sweet orange, lemon and of other species of Citrus have been recovered from all the virus diseases by various research workers. In India, this technique has been standardized for Nagpur mandarin. Protected cultivation of fruit crops *viz.*, papaya in certain regions of the country help in overcoming the problem of PRSV. This will help in the quality production of fruits. In the recent days, macro propagation of guava through leaf cutting and terminal cuttings are getting popular though the success rate is 60-70 per cent yet the field establishment have been found to be good. Shoot tip grafting of citrus, micro propagation of pomegranate and papaya are being commercially exploited.

High density planting in tropical fruits

Due to urbanization and population explosion there is a continuous decline in the availability of cultivable land. The rising input costs together with the mounting demand for horticultural produce, has led to the adoption of high density planting (HDP) in fruit crops. HDP is one of the important methods to achieve high productivity per unit area both in short duration and perennial horticultural crops. The five important components of HDP are (i) dwarf scion varieties, (ii) dwarf rootstocks and inter-stocks, (iii) training and pruning, (iv) use of chemicals/PGR, and (v) suitable crop management practices being followed in a successful HDP method. Mango plants are generally planted at a distance of 10 to 12 m, which can accommodate about 70 to 100 plants/ha, while Amrapali variety has been recommended by IARI to be grown at 2.5 x 2.5 m (triangular method) and accommodating 1,600 plants/ha yielded up to 22 t/ha. The high-density orchard provides several times (8-9) higher yields than the traditional densities (Gunjate *et al.*, 2009). Dashehari mango at 2.5 m x 3 m (1,333 plants/ha) can also be raised under HDP with pruning and dehorning after the harvesting. HDP has also been achieved with the application of paclobutrazol. Successful HDP (666 plants/ha) plantations of different commercial varieties *viz.*, Kesar, Alphonso, Tommy Atkins, *etc.* has been demonstrated by the Reliance Agro Ltd. at Jamnagar (Gujarat) under arid agro-climate (Bhosale, 2012). In guava, meadow orcharding was found suitable for ultra high-density system of planting at CISH, Lucknow. The meadow orchard system of guava accommodates 5000 plants/ ha, at a spacing of 2.0 x 1.0 m and managed with regular topping and hedging during initial stages, which help in controlling tree size and extending fruit availability (Singh, 2008). Dwarf Cavendish and Robusta are fit to be planted under high density at a distance of 1.2m X 1.2m (6,944 plants/ha) in a rectangular system. Yield realization varies from 86 t/ha in Basarai at 1.5 x 1.5 m to 174 t/ha in Robusta planted at 1.2 m x 1.2 m spacing (Athani *et al.*, 2009; Prabhu, 2012). Dwarf varieties of papaya like Pusa Dwarf, Pusa Nanha and Ranchi make possible to grow papaya under the HDP concept. Normally, papaya varieties are planted at a distance of 2.5 m X 3 m or 2.5 m X 2.5 m, which accommodates 1,333 to 1,600 plants/ha, while Pusa Nanha may be planted at a distance of 1.25 x 1.25 m (6,400 plants/ha). Such orchards may give 3 to 4 times higher yields (60 to 65 tonnes/ha) in comparison to the yield of the traditional orchards (15 to 20 t/ha) with the superb combination of drip irrigation with dwarf varieties. Other varieties like CO-1, CO-2, Pusa Dwarf and Honey Dew-1 are also suitable for high density planting (Bhosale, 2012). In Citrus, high-density orchard is also possible using Troyer Citrange rootstocks at closure planting (1.8 x 1.8 m) accommodates 3086 trees/ha. Kew and Queen cultivars of Pineapple are suitable for HDP using double row method of the planting suckers or slips spaced at 25 to 30 cm in the rows at a distance of 45 to 60 cm with spacing of 90 to 105 cm between the beds (63,000 plants/ha). There is ample scope for expanding area under HDP for the benefit of the fruit growers through higher productivity. The average productivity of pineapple is 15.4 ton/ha but with the adoption of HDP and modification of planting system higher yield can be obtained. The highest fruit yield (61 ton/ha) in Kew cultivars may achieve with a population of 63700 by following 22.5 x 60 x 75 cm (Plant x Row x Trench) spacing.

Fertigation in tropical fruits

Fruit crops because of their deep root systems can harness the nutrients from deeper layers of the soil. Therefore, the general soil-testing programme in which fertility status of 15 cm soil layer is assessed is not useful for fruit crops. Soil sampling from different layers up to 1.5 m will provide a better assessment of soil fertility status for fruit crops. Nutrient status of plant leaf is a better indicator of proper plant nutrition. Fertigation through micro-irrigation system provides a technique of application of water and nutrients to an area of the soil where most of the roots are active for absorption of nutrients requirement by the trees. It has been well demonstrated that the fertigation is expected to increase the nutrient uptake efficiency (30-40%), thereby minimizing leaching losses compared with the application of fertilizer in dry granular form broadcast over a large soil area at less frequent intervals (Narayanamoorthy, 2006). Several studies also proved that fertigation enhances the yield (25-30%) and quality of various fruit crops such as banana (Kavino *et al*., 2002), papaya, mango (Panwar *et al*., 2007), Citrus (Alva *et al*., 2003) and guava (Singh, 2008).

Partial root zone drying (PRD) in fruit crops

In partial root zone drying, half the roots are allowed to dehydrate, which sends signals to the vine (grape) that is experiencing water stress. The irrigated roots on the other side of vine continue to provide sufficient amounts of water so that vital functions like photosynthesis does not cease. By simply switching the wet and dry sectors of the root zone on a regular basis, this transient response was overcome (Dry *et al.,* 1996; Dry and Loveys, 1998). A number of long-term, large-scale field experiments on Shiraz, Cabernet Sauvignon, and Riesling, using a range of irrigation methods, have now been completed (Loveys *et al*., 1997; Dry *et al*., 2000). These included standard drip emitters (2 or 4 litres/h), two per vine in the inter-vine space and placed about 450 mm from the vine trunk and subsurface drip lines, one on each side of the vine row at a depth of 200-250 mm and 350-400 mm from the centre of the row. In all cases, the intention was to create two wetted zones per vine that could be alternately irrigated on a cycle of approximately two weeks, *i.e.*, while one zone was wetted, the other zone would be dried. Soil moisture sensors installed within each wetted zone assessed whether water applied to one side infiltrated to the other, supposedly dry, side. In all cases, there was satisfactory separation of wet and dry zones in a range of soil types under field conditions. Partial root zone drying with furrow/flood irrigation has been successful in experiments with pears and Citrus and in commercial vineyards in the Riverina district of New South Wales, Australia (Clancy, 1999), and with other perennial row-crop fruits.

Pollination in fruit crops

Pollination is one of the most important aspects in fruit production. Pollinators such as bees, birds and bats affect 35 per cent of the world's crop production, increasing outputs of 87 of the leading food crops worldwide. The total economic value of crop pollination worldwide has been estimated at €156 billion annually (Gallai *et al.,* 2009). Studies on crop pollination by insects are becoming increasingly critical because of a perceived global decline in pollinator stocks, with great economical and conservation consequences (Ghazoul, 2005a & 2005b). In the recent years, there has been a concern about declines in both wild and domesticated pollinators, especially honeybees (Reddy *et al.,* 2012a). Verghese and Tandon (1990) studied the pollination behaviour of *Apis florea* on mango and found it to be an important pollinator. Reddy *et al.,* (2012b) recorded four species *viz. Apis florea* (Hymenoptera : Apidae), *Chrysomya megacephala* and *Stomorhina discolor* (Diptera : Calliphoridae), *Eristalinus arvorum* (Dipteral : Syrphidae) as the dominant foragers significantly contributing to mango pollination in Bengaluru, while stingless bee, *Trigona iridipennis* as the most abundant in the *konkan* region in India. Pollinator abundance seems to be influenced by varietal differences. In terms of total pollinator activity, Ratna attracted maximum numbers (3.24/10 panicles), while it was lowest in Sindhu (0.63). Dipterans and bees showed varied preferences to varieties as was evident in case of Alphonso, which recorded the highest number of bees (2.6), while dipteran activity was lowest (0.02). In India, Phartiyal *et al.,* (2012) recorded a total of 12 insect visitors on flowers of sweet orange in *Terai* region. Among the pollinators, the Hymenoptera constituted major group of insects including *A. dorsata*, *A. cerana indica*, *Trigona* spp., *Campsomeriella megachalis* F., and *C. collaris.* Among the Dipterans, syrphid flies were the most frequent visitors including *Syrphus corollae* Fab., *Episyrphus balteatus* De Geer, *Spherophoria* spp. L., and *Melanostoma* spp. L. The per cent fruit setting was higher (8.4 – 12 %) in panicles under open pollination as compared to completely bagged panicles (1.2 - 8.0 %). There are reports that bees play a significant role in the pollination in fruit crops like aonla, avocado, jackfruit, Macadamia, rambutan, strawberry and tamarind. In papaya, besides wind, sphinx moths and honeybees are given credit as pollinators (Stambaugh, 1960). In case of fig, small wasps of the genus *Blastophaga* are the only insects involved in pollination. The wasps develop in special gall flowers wild fig known as Capri. They emerge from these and accumulate pollen as they exit the fruit. They then enter the eye of a Smyrna fig and attempt to oviposit, unsuccessfully, in the long styles of the female blossoms. This activity effects pollination. In commercial plantings the Capri figs containing wasps will be collected and hung on the branches of the Smyrna variety. However, certain new varieties of edible figs are available that do not require this procedure (Free, 1993). Management of native insect pollinators is very important for sustaining agricultural productivity in the long run. Modern beekeeping suffers from attack parasitic mites, honeybee diseases, inability of honeybees to work at low temperature and adverse climatic conditions. These difficulties threaten the honeybees' general utility as a pollinator. Therefore, conservation of biodiversity of honeybees and wild pollinators is important to realize the potential yields of several cross-pollinated crops.

Seed village concept

Seed is the commercial and practical means of multiplication of certain fruit crops *viz.*, papaya, mangosteen & phalsa. At certain times during the cropping period there are many instances when farmers do not get price for their commodities. Seed production, quality assurance and marketing are highly important in the present scenario. To meet the seed demand the seed village concept can be well adopted with this method a particular variety may be multiplied in whole village which can solve the problem of isolation in case of cross pollinated crops and genetic purity. This will also assure availability of seed materials in the local areas as well as other parts of the area. In case of apomictic fruit crops such as mango, citrus, jamun & mangosteen, a large number of uniform and vigorous rootstocks can be raised for commercial multiplication of planting materials. There are many nursery villages in Tamil Nadu (Santhur, Paiyur, Hosur, Erode, Pollachi & Periyakulam), Andhra Pradesh (Kadayam, Vijayavada, Godavari & Eluru), Maharashtra (Pune & Solapur) and Karnataka (Bengaluru, Shivmoga & Sagar) that are multiplying the fruit crops which are commercially viable. Hence, the 'Seed Village' and 'Village Nurseries' can go a long way in increasing the farmer's income.

Resistant breeding a useful tool for increasing profitability

With organically produced products gaining consumer preference the resistance breeding to develop varieties with multiple disease resistance is extremely important. The introgression of genes/ gene pyramiding from wild relatives is one such approach for developing the diseases & pests resistant high yielding varieties which can substantially reduce the production cost. Despite the development of chemical and cultural control measures for the pests and diseases, yet there is significant losses to from production to harvest are still a reality, especially in years where extreme weather is experienced due to climate change. In mango, one of the most significant diseases is anthracnose caused by the fungal pathogen *Colletotrichum gloeosporioides*. The loss due to anthracnose in mango has been studied by various workers and reported to be 25-30 per cent. Bompard (1993) suggested the use of *M. laurina* for incorporating resistance to anthracnose, a fungal disease, and utilizing the genes available in *M. orophila* from Malaysis and *M. dongnaiensis* from Vietnam for developing varieties to make it distant possibility to grow mango in Mediterranean region, since these species grow well in the mountain forests at 1000-1700 metres above mean sea level. *M. altissima* is reported to be free from mango leaf hoppers and tip and seed borers (Angeles, 1991). Besides, there are several *Mangifera* species possess resistant to fruit fly (*M. camptosperma & M. andamanica*) and tolerant salinity which can be used for breeding purposes. The PRSV (Papaya Ring Spot Virus) is a major problem in papaya production, in order to address this issue; the intergeneric hybridisation has been attempted. The intergeneric hybrids of *C. papaya* × *V. quercifolia* validated for hybridity and resistant to 'papaya ringspot virus' (Mendoza-Garces *et al.*, 2010) and similarly the *C. papaya x V. cauliflora* has been validated for hybridity and resistant to PRSV in India (Dinesh *et al.*, 2013). There are several well known interspecific and intergeneraic hybrids in citrus (Tristeza, phytophthora, salinity, alkalinity & drought), grapes (mildew, nematode, salinity & alkanity), banana (viruses & fusarium wilt) and in many temperate fruits. At ICAR-IIHR, attempts are being made to develop rootstocks in grapes, guava and mango to overcome the biotic and abiotic stresses. More emphasis should be given on these aspects in the coming years to breed the scion varieties which are having resistant to major pests and diseases. In the recent past, APEDA is promoting the GAP (Good Agricultural Practices) for exporting the mango, banana & grapes where in the pests and diseases resistant varieties are recommended.

Robotics and sensors in horticulture

The yield prediction and forecasting of horticultural crops is very much important for preventing the market glut especially for fruits and vegetables that are getting low always in order to ensure the good market price for those crops. Several attempts have been made to study the yield of horticultural crops using the ANN, drones, mobile apps, robots and image processing technologies for maturity and yield prediction. Payne *et al.* (2013) attempted to develop an image processing approach for estimation of mango fruit load using a pixel classification-based approach, reporting some success in identification of relatively mature, well coloured mango fruit in images of trees acquired under natural lighting. However, real-world crop load estimation of mango fruit requires counting of fruit at the stone hardening stage, when they are green in colour. Stein *et al.* (2016) used a novel multi-sensor framework to efficiently identify, track, localise and map every piece of fruit in a commercial mango orchard. Similar work has been done in temperate fruits and plantation crops. However, this could be further explored to use them for various intercultural operations and also in pest and disease identification and forewarning.

Nanotechnologies in horticulture

In the present century, the smart agriculture is a way to achieve priority of short and long term development in the countenance of climate change and serves as a link to others (Helar and Chavan, 2015). Nanotechnology is an emerging science that has wide application in horticulture due to very less quantity and precise application *i.e.* nutrient mobilization, bioremediation, growth promoting activity and shelf life extension of fresh and processed products, The recent development of a nanoencapsulated pesticide formulation has slow releasing properties with enhanced solubility, specificity, permeability and stability (Bhattacharyya *et al.*, 2016). These assets are mainly achieved through either protecting the encapsulated active ingredients from premature degradation or increasing their pest control efficacy for a longer period. Formulation of nanoencapsulated pesticides led to reduce the dosage of pesticides and human beings exposure to them which is environmentally friendly for crop protection (Nuruzzaman *et al.*, 2016). In the recent decade nanofertilizers are freely available in the market, but particularly the agricultural fertilizers are still not shaped by the major chemical companies. Nanofertilizers may contain nano zinc, silica, iron and titanium dioxide, ZnCdSe/ZnS core shell QDs, InP/ZnS core shell QDs, Mn/ZnSe QDs, gold nanorods, core shell QDs, *etc.* as well as should endorse control release and improve the its quality. NPs in precise have revealed broad-spectrum antibacterial properties against both Gram-positive and Gram-negative bacteria. ZnO NPs were found to inhibit Staphylococcus aureus (Liu *et al.*, 2009) and AgNPs exhibit concentration-dependent antimicrobial activity against *Escherichia coli*, *Aeromonas hydrophila*, and *Klebsiella pneumoniae* (Aziz *et al.*, 2016). Nanotechnology has been widely applied to the food industry. Green tea with nano-packing, had better maintenance of vitamin C, chlorophyll, polyphenols and amino acids than with normal packing (Hu and Fu, 2003). The antimicrobial mechanism of action of NPs is typically considered as of few prototypes such as oxidative stress and cell damage, metal ion release, or non-oxidative mechanisms (Wang *et al.*, 2017).

Soilless cultivation of fruit crops

Soilless cultivation is becoming popular among the city dwellers and the central and state government has been promoting this activity under the scheme of urban and periurban horticulture. Arka fermented cocopeat, compost, vermicompost, vermiculite and other organic substances are being used to grow papaya, guava and strawberry to certain extent in terraces by using the specialized containers/pots. Hydrophonics is another unexplored area for shallow rooted fruit crops like straw berry and other crops. This technique is very useful for the area where environmental stress (cold, heat, dessert *etc.*) is a major problem (Polycarpou *et al.*, 2005). Treftz and Omaye (2015) reported that, the growing strawberries in hydroponic systems are feasible, at reasonable cost and more sustainable compared to traditionally soil grown systems. Most (87%) of participants could identify differences between hydroponically and soil grown strawberries and 70 per cent preferred the hydroponically grown strawberry ($p = 0.06$). The use of sensory studies in relation to consumer acceptance and nutrient quality will be an important factor to consider for exploring growing methods and techniques in hydroponic technology.

Conclusion

Among the horticultural crops, the fruit crops are climate resilient and more profitable due to growing health awareness. However, the cost of inputs, including seeds, fertilizers, pesticides, fuel to draw out water and machines, is rising; the profit made from sale of crops is declining. On the other hand, present-day wholesale markets have long chain of intermediaries resulting in wide gap between the producer and consumer prices. Direct marketing which prevents the intermediaries and hence gets better price to the farmers which need to be promoted. Many State Governments have started the Cooperative marketing (HOPCOMS & TANHOPS) & processing Ltd. to procure and sale the fruits and vegetables. There is strong network of crop growers associations (Grapes, Mango, Guava, Amla & Banana) which also take care R&D needs of the crop as well as the farmers welfare. Several private companies such as Reliance fresh, Heritage, Spencers, Adani Groups, MORE, Food World and Nilgiris have entered in to the procurement and they provide technical advisories to support the farmers. Similarly, the SAFAL-a unit of Mother Dairy helps the farmers to get the inputs, credits, capacity building and procurements. In Punjab, Council for Citrus and Agro Juicing has been started to help the Kinnow growers. There are few private companies such as Ion Exchange Environ Farms Ltd, Mother Dairy, Rallis India and Sanjeevani Orchards Private Ltd *etc.* have entered with contract farming for fruits and vegetables. Till 2017, as many as 37.2 million farmers were covered under the three schemes namely National Agricultural Insurance Scheme, Modified National Agricultural Insurance Scheme and Weather Based Crop Insurance Scheme which covers only half of them got benefitted from it. *Pradhan Mantri Fasal Bima Yojana* (Prime Minister's Crop Insurance Scheme), the latest government initiative which merges existing insurance schemes, reduces the premium to be paid by farmers and removes the limit on government subsidy to insurance. Hence, the fruit cultivation will be always remunerative to farmers provided if they adopt scientific cultivation and strong marketing network.

References

Angeles, D.E. (1991). *Mangifera altissima*. ***In:*** (eds E.W.M. Verheij and R.E. Coronel.), *Edible Fruits and Nuts,* pp: 206–207. Plant Resources of South East Asia 2. PUDOC. Wegeningen

Anonymous, 2015. Indian Hortculture Database, MOA, GOI, p. 286.

Athani, S.I., Revanappa and Dharmatti,P.R. (2009). Effect of plant density on growth and yield in banana. *Karnataka J. Agric. Sci.,* **22**(1) :143-146.

Aziz, N., Pandey, R., Barman, I., and Prasad, R. (2016). Leveraging the attributes of Mucor hiemalis-derived silver nanoparticles for a synergistic broad-spectrum antimicrobial platform. *Front. Microbiol.* **7**:1984. doi: 10.3389/fmicb.2016.01984.

Bhattacharyya, A., Duraisamy, P., Govindarajan, M., Buhroo, A.A., and Prasad, R. (2016). Nano-biofungicides: emerging trend in insect pest control. ***In:*** Advances and Applications through Fungal Nanobiotechnology, (ed. R. Prasad) Cham: Springer International Publishing, 307–319. doi: 10.1007/978-3-319- 42990-8_15.

Bhosale, J. (2012). High-density cultivation: the new mantra for low cost, better yield. *The Economic Times,* July 12, 2012.

Bompard, J.M., 1993. The genus Mangifera rediscovered: the potential contribution of wild species to mango cultivation. *Acta Horticultuae,* **341**: 69–77.

Chenin Treftz, Fannie Zhang, Stanley T. Omaye. 2015. Comparison between Hydroponic and Soil-Grown Strawberries: Sensory Attributes and Correlations with Nutrient Content. *Food and Nutrition Sciences.* **6:**1371-1380

Clancy, A. 1999. Riverina has the capacity to deliver diverse requirements. *Australian Viticulture* **3**: 38-42.

Dinesh, M.R., G.L. Veena, C. Vasugi, M. Krishna Reddy, K.V. Ravishankar (2013). Intergeneric hybridization in papaya for 'PRSV' tolerance. **161**(24): 357–360.

Dry, P.R. and Loveys, B.R. 1998. Factors influencing grapevine vigour and the potential for control with partial rootzone drying. *Australian Journal of Grape and Wine Research* **4**: 140-148.

Dry, P.R., Loveys, B.R., During, H. and Botting, D.G. (1996). Effects of partial root-zone drying on grapevine vigour, yield composition of fruit and use of water. ***In***: *Proceedings 9th Australian Wine Industry Technical Conference* (eds. C.S. Stockley, A.N. Sas, R.S. Johnstone and T.H. Lee) Adelaide, Australia, Winetitles.

Dry, P.R., Loveys, B.R., Stoll, M., Stewart, D. and McCarthy, M.G. (2000). Partial root zone drying - an update. *Australian Grapegrower and Winemake*r, **438a**: 35-39.

Free, J.B., and I.H. Williams. 1976. Insect pollination of *Anacardiumoccidentale* L., *Mangifera indica* L., Blighiasapida Koening and Perseaamericana Mill. *Trop. Agric.*, **53**: 125-139.

Gallai, N., Salles, J.M., Settele, J. and Vaissi, B.E. (2009). Economic valuation of the vulnerability of world agriculture, *Ecol. Econ.*, **68:** 810-821.

Ghazoul, J. (2005). Pollen and seed dispersal among dispersed plants, *Biol.Rev.*, **80**:41-443.

Gulati, Ashok and Ganguly, Kavery (2008). *Beyond Grain Security: Agriculture Tomorrow*. India 2008. The Business Standard, New Delhi.

Gunjate, R.T., Kumbhar, A.R., Thimaiah, I.M. and Amin, S.M. (2009). Growth and fruiting of some mango cultivars under high density plantation in arid conditions of Gujarat (India), *Acta Hort.*, **820**: 463-468.

Helar, G., and Chavan, A. (2015). Synthesis, characterization and stability of gold nanoparticles using the fungus *Fusarium oxysporum* and its impact on seed. *Int. J. Recent Sci. Res.*, **6:** 3181–3318.

Hu, A. and WandFuZ H. (2003). "Nanotechnology and its Application in Packaging and Packaging Machinery", *Packag. Eng.*, **24:** 22-24.

Jalikop, S.H and Ravindra Kumar (2007). Pseudo-xenic Effect of Allied Annona spp. Pollen in Hand Pollination of cv. 'Arka Sahan' [(A. cherimola ·A. squamosa) · A. squamosa] **42**(7):1534–1538.

Kavino, M., Kumar, N., Soorianathasundaram, K. and Jeyakumar, P. (2002). Effect of source of fertilizers for fertigation on yield and quality of banana cv. Robusta (AAA). *South Indian Horticulture,* **50**: 301-307.

Kumar Praduman, Mruthyunjaya and Pratap S. Birthal (2007). Changing consumption Pattern in South Asia. ***In***: Agricultural Diversification and Smallholders in South Asia. (eds. P.K. Joshi, A. Gulati and Ralph Cummings Jr.), Academic Foundation, New Delhi.

Liu, Y., He, L., Mustapha, A., Li, H., Hu, Z.Q., and Lin, M. (2009). Antibacterial activities of zinc oxide nanoparticles against Escherichia coli O157:H7. *J. Appl. Microbiol.*, **107:** 1193–1201. doi: 10.1111/j.1365-2672.2009.04303.x.

Loveys, B.R., Grant, W.J.R., Dry, P.R. & McCarthy, M.G. 1997. Progress in the development of partial rootzone drying. *The Australian Grapegrower and Winemaker* **403**: 18-20.

Loveys, B.R., Stoll, M., Dry, P.R. & McCarthy, M.G. (1998). Partial rootzone drying stimulates stress responses in grapevine to improve water use efficiency while maintaining crop yield and quality. *The Australian Grapegrower and Winemak*er 414a: 108-113.

Mendoza-Garces, A.C, Magdalita, P.M., Mendioro, M.S., Cruz, F., Dela, S., Villegas, V.N. (2010). Morphological, cytological, biochemical and molecular characterization of *Carica papaya* L., *Vasconcellea quercifolia* (St. Hil.) Hieron and their intergeneric hybrid. *Philippine Journal of Crop Science*, **35** (2) : 1–11.

Narayanamoorthy, A. (2006) Efficiency of Irrigation: A Case of Drip Irrigation. *Occasional Paper No. 45,* National Bank for Agriculture and Rural Development, Mumbai. 38p.

Navarro, L.1992. Citrus shoot tip grafting invitro.In Book. Biotechnology in Agriculture and Forestry, Vol.18, Springer-Verlag Berlin Heiderberg.

Nuruzzaman, M., Rahman, M.M., Liu, Y., and Naidu, R. (2016). Nanoencapsulation, nano-guard for pesticides: a new window for safe application. *J. Agric. Food Chem*. **64:** 1447–1483. doi: 10.1021/acs.jafc.5b05214.

Panwar, R. Singh, S.K, Singhand, C.P., Singh, P.K. (2007). Mango fruit yield and quality improvement through fertigation along with mulch. *Indian J. Agri. Sci*., **77** (10) : 680-684.

Payne, A., Walsh, K., Subedi, P. and Jarvis, D. (2014). Estimating mango crop yield using image analysis using fruit at 'stone hardening' stage and night time imaging. *Computers and Electronics in Agriculture,* **100**:160–167.

Polycarpou, P., Neokleous, D., Chimonidou, D. and Papadopoulos, I. (2005). A closed system for soil less culture adapted to the Cyprus conditions. ***In***: (ed. A. Hamdy, F. El Gamal, A.N. Lamaddalen, C. Bogliotti, and R. Guelloubi), Non-conventional water use. pp. 237241.

Prabhu, M.J. (2012). High- density planting increases banana yield and brings hope. *The Hindu,* August 23, 2012.

Reddy, P.V.R., Varun Rajan, V. and Verghese, A. 2015. A non-meat based artificial diet and protocol for mass rearing of *Chrysomyamegacephala* Fab. (Diptera:Calliphoridae), an important pollinator of mango. *Curr.Sci*.,**108** (1):17-19.

Reddy, P.V.R., Verghese, A., Varun Rajan, V. Rashmi, T. and Kavitha (2012). Diversity and foraging ecology of pollinators in mango (*Mangifera indica*): An Indian perspective. ***In***: Proceedings of International Congress of Entomology, Daegue, South Korea 19-24, August 2012.

Singh, G. (2008). High Density and Meadow Orcharding of Guava, Extn. Bull., 35, (1st Ed). CISH, Luckonw, India.

Singh, G. 1997. Pollination, pollinators and fruit setting in mango. *Acta Hort*., **455**: 116-123.

Stein, M. Suchet Bargoti and James Underwood. (2016). Image Based Mango Fruit Detection, Localisation and Yield Estimation Using Multiple View Geometry. *Sensors*, **16** : 1-25.

Verghese, A. and Tandon, P.L. (1990). Pollination behaviour of *Apis florea* on mango. ***In****: Social Insects. An Indian Perspective*. International Union for Study of Social Insects, Bangalore, India: 60-63.

Wang, L., Hu, C., and Shao, L. (2017). The antimicrobial activity of nanoparticles: present situation and prospects for the future. *Int. J. Nanomed*., **12:**1227–1249. doi: 10.2147/IJN.S121956.

LEAD LECTURE – 7

Current status and future prospects of jackfruit research in India

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Jackfruit (*Artocarpus heterophyllus* Lam.) is a multi-purpose species that provides food, timber, fuel and fodder, in addition to contributing to medicinal and industrial uses. The tree can adapt to a wide range of habitats and is known to mitigate the effects of environmental and climatic changes. India is the second biggest producer of the fruit in the world and is considered the motherland of jackfruit as it is believed to be originated in Western Ghats of Indian sub-continent.

According to the latest National Horticulture Board database, jackfruit is cultivated in approximately 1.85 lakhs hectares of land with annual production of 18.3 lakhs MT. In India, it is grown in large scale particularly in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, Maharashtra, Orissa, West Bengal, Bihar, Assam, North Eastern states, Andaman and Nicobar Islands. Even though it is referred to as a "poor man's food" and has such vast potential, jackfruit remained an underutilized fruit species during the past decade. However, in recent years, it has been one of the future potential crops owing to its vast potential. It is heterozygous, cross-pollinated and mostly seed propagated, resulted in wide range of variation in South and South East Asia, which aids in the selection of superior desirable types. Collection, characterization and evaluation is still the most sought after method for releasing of new jackfruit varieties, owing to this vast amount of variability. The work on collection and conservation of jackfruit started at Indian Institute of Horticultural Research (IIHR), Bengaluru (India) during 2000-01 under Underutilized Tropical Fruits in Asia Network (UTFANET) project funded by International Center for Underutilized Crops (ICUC) for promotion of research on underutilized fruit species. During the same time, Indian Council of Agricultural Research (ICAR) also initiated collection and conservation of jackfruit under the All India Coordinated Research Project (AICRP) as one of the mandate crops besides the efforts of various organisations on this aspect. The research programmes were focused mainly on genetic resources, crop improvement, regular survey and surveillance of pests. Efforts were also directed towards post-harvest processing and value added products by various research and developmental organisations besides individual stake holder efforts.

Owing to its popularity, though many accessions have been characterised for its utilisation, but has led to identification of very few varieties in jackfruit *viz.*, Palur-1Jack, PPI-Jack, PLR(J)-2, Swarna Konkan prolific and Sindoor besides the other selections as , *viz.*, NJT1, NJT2, NJT3 and NJT4 by different State Agricultural Universities with a main focus on table purpose. Also identified the clones *viz.*, Baromahia with 2-3 crops and Rudrakshi and many local types to produce off-season crops between September to December. In recent years, IIHR has also facilitated in identifying another clone having coppery red flakes with small sized fruits as the farmer's variety - Siddu jack. Since, raw jackfruits are also having good demand in India as vegetable for culinary purpose, emphasis is also given on fruit characters like thickness of rind and softness of pulp at premature stage of fruit development. Commonly, jackfruit ripens during March-May in Barak Valley, while in the Assam Valley, fruits ripe during May-July, thus variability in cropping pattern coupled with variation in its maturity has been documented. Accordingly, analysed on the success made in various domains and gaps existed with respect to jackfruit research needs in India.

LEAD LECTURE – 8

Status and potential for humid tropical underutilized fruits in India

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Underutilized fruit crops refer to those fruits which may be high in value but that are not widely grown. The underutilized fruits are found in all climatic regions but a large number of underutilized fruit species are found in tropical region. India have two distinct tropical humid climatic conditions i.e, humid tropical wet climate, which spreads over Malabar Coast, Western Ghats, Southern Assam, Lakshadweep and Andaman and Nicobar Islands and tropical semi hard wet climate, which prevails over most of inland peninsular India except semi arid rain shadow areas. Several underutilized fruits are grown in these humid tropical regions. Jack fruit, karonda, wild jack, kokum, malabar tamarind, yellow mangosteem, *etc.* are important native fruits. Rambutan, avocado, passion fruit, mangosteen, durian, longan, dragon fruit, durian, longan, longsat, breadfruit, macadamia nut, *etc.* are important ones fruits introduced in India during last one century. Some of them, such as rambutan, passion fruit and avocado are commercially cultivated in limited areas. Rambutan was introduced 50-60 years ago from Malaysia and Indonesia. Presently, it is cultivated in Thrissur, Pathanamthitta, Kottayyam and Ernakulum districts of Kerala, Nagerkoil, Courtralam, Nilgiris districts of Tamil Nadu, Dakshina Kannada, Puttur and Kodagu districts of Karnataka. It is estimated that the area under the crop is less than 1000 acres. There is good potential of expansion of this crop in other areas Kerala, Tamil Nadu and Karnataka, Goa, Konkan region and Eastern Coastal regions. Passion Fruit is another important fruits grown mostly in tropical and sub-tropical regions of the world. Passion fruit was introduced in India in early part of twentieth century. It is cultivated in some districts of Karnataka, Kerala and Tamil Nadu. The passion fruit cultivation is rapidly increasing in Mizoram, Nagaland, Manipur and Sikkim. The estimated area and production of passion fruit is 9.11 thousand ha and 45.82 thousand tones, respectively. Avocado was introduced in the early part of the twentieth century. It is grown in Tamil Nadu, Kerala, Karnataka, Sikkim in limited areas. Avocado is grown as mixed crops in coffee in coffe growing areas of Tamilnadu and Karnataka. Dragon fruit, mangosteen, longan, longsat, soursop are other exotic underutilized fruits, which are found successfully growing in some areas. Among the native underutilized fruits, jackfruit and karonda are now cultivated throughout in tropical and subtropical region of in the country. The cultivation of kokum (*Garcinia indica*) is limited to Konkan (Maharashtra), Goa, Western Ghats region of Karnataka and Waynad area of Kerala. Other species of *Garcinia* genus such as malabar tamarind (*Garcinia gummigutta*), yellow mangosteen (*Garcinia xanthochymus*) are still collected from forest. Similarly, wild jack, monkey jack are still collected from forest. The native and exotic underutilized fruits have adapted to the climatic conditions of the humid tropical regions of India. A limited research works have been done on these fruits. Although some promising lines have been identified, but very little work is done on the production technologies of these crops. Considering the importance, there is a need to develop location specific production and post harvest technologies for these crops, so that these may be utilized and diversification strategies are adopted for climate resilient and dietary supplements in future.

LEAD LECTURE – 9

Future Indian super fruits

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Fruits are a rich repository of nutrients, minerals and vitamins and are the protective foods providing immunity from disease. This immunomodulatory function attributed to them is primarily due to the bioactive phytometabolites which are primarily antioxidants and have radical scavenging properties. Flavonoids, anthocyanins, organic acid, carotenoids, polyphenols, and glucosinolates etc. are some of the bioactive principles in fruits. Such fruits which are underutilized and are yet to be commercialized due to lack of standard varieties, cultivation practices etc. have been found to be richer sources of such compounds and thus, have the potential to be exploited as nutraceuticals. It must be appreciated that out of 30,000 edible plant species only 7000 have been cultivated or collected for food and only 30 crops are used for providing 95% of the dietary requirement of the world. Some minor fruits growing in localized areas on marginalized lands are potential crops which could be the source of phytochemical which have pharmaceutical value and consuming such fruits, even in its fresh form, could provide nutritional as well as health benefits. Thus, it would perhaps be appropriate to call such fruits the super fruits of the future. Some important minor fruits which could be exploited for their nutraceutical potential are Barhal (*Artocarpous lakoocha*), Karonda *(Carrisa karandas),* Mahua*(Bassia latifolia)*, Kamrakh *(Averrhoa carambola)*, Khirni *(Manilkara hexandra),* Amra *(Spondias mangifera*), Paniyala *(flokarina indica),* Halphahari *(Phyllanthus acidismus),* Lasodha *(Cordia mixa),* Wood apple *(Feronia limonia),* Cape gooseberry *(Physalis peruviana),* Goolar *(Ficus glomerata),* Kadam *(Anthocephalus kadamba),* Imali *(Tamarindus indica), etc* for the plains; Singhara or waterchestnut (*Trapa natans* var *natans)* and Makhana *(Ferox eurayle)* among the acquatic crops and Kaphal (*Myrica nagi*), Seabuckthorn *(Hippophae* sp.*),* Raspberry *(Rubus* sp.*)*, Chilgoza(*Pinus gerardiana*), Burans *(Rhododendron* sp.*)* etc. among the temperate crops. These are fruits which are rarely included in the fruit bowl as table fruit and are consumed perhaps in the rural areas and that too only in the form of chutneys or pickles. These crops are important on a regional level and have not attained global importance due to the little breeding attention received by them because of which significant yield increases have not been achieved. Growing interest in these crops is due to their high nutritive values (especially Ca, Fe, Vit. C, Vit. A), their use as emergency/alternative food, their capacity to be well adapted to marginal areas, tolerance to stresses, (soil, water, climatic, nutritional), tolerance to pest & disease and their unique nature which adds to crop diversification. Besides this, their role as alternative sources of income, the collapse of commodity prices, greater appreciation of biodiversity's role in enhancing livelihoods, increased participation of communities in setting research agendas, ssearch for cultural identities, demand for traditional food in large multi-ethnic cities and better understanding of the limits of the Green Revolution, have all added to the increasing importance of these fruit crops.

A detailed description of some crops mentioned above is given below:

Monkey jack (*Artocarpus lakoocha* Roxb)

Monkey jack (*Artocarpus lakoocha* Roxb., commonly known as Barhal, belonging to the family Moraceae, is found growing sporadically in the villages and rural areas. It is a tall robust tree and is used for timber and fodder. Its fruits are used for culinary purpose and as fresh fruits in some areas. It is a non-traditional fibre crop and has various ethanobtanic uses *viz.* wood, timber, fodder, pickles, medicines etc. Fruits are a rich source of beta carotene and polyphenols which protect the body from different diseases and helps combat skin cancer since it has anti-inflammatory, antiviral, anticancer and anti-HIV properties. Leaves contain about 16% crude protein and are used as fodder. The bark of the lakoocha tree contains tannins which are useful in treatment of skin problems.

Starfruit (*Averrhoa carambola*)

Starfruit (*Averrhoa carambola*), of the family Oxalidaceae, grows in warmer parts of India, primarily in the southern states especially along the west coast, extending from Kerala up to West Bengal. It is a slow growing tree bearing yellow coloured fruits used as a food appetizer and is used in traditional ayurvedic medication. It has a sour, astringent taste and is a rich source of tannins and polyphenols, sterols, flavonoids, organic acid, lignins, glycosides, etc. besides Vitamin C and organic acids. Ripe carambola is used as a source of food, sliced and served in salads, or used as garnish on seafood. It has many medicinal uses and also contains secondary metabolites which have various biological activities. The high oxalic acid and the caramboxin content in the fruits are at times toxic and make it harmful for people suffering from urinary problems.

Mahua (*Madhuca indica*)

Mahua (*Madhuca latifolia*), native to the Indo-Burma region, is a traditionally important tree for its food, fodder and fuel value distributed ubiquitously over north and central India contributing 30-40% towards the economy of the tribals. It is a hardy, robust, evergreen tree able to survive with very little management even under drought conditions and this imparts the potential for exploitation of the crop in view of the fast depleting ground water, low water, nutrition and managmental requirements of the tree and the diverse avenues for its utilization for timber, fodder, flower, fruit, seed oil etc. It is propagated mainly by seeds which are a rich source of lipids and with potential for use even as a bio-fuel. Mahua flower is commonly used in rural areas for chapattis and has the potential to be used as coolant, expectorant, carminative, aphrodisiac, galactagugue, etc. The major drawback lies in the crop being marginalized with no varietal development, no standard agrotechniques or scientifically developed processed products and even lack of biochemical characterization.

Wood apple (*Limonia acidissima*)

The wood apple,(*Limonia acidissimia* L.) is also known as elephant apple, monkey fruit, kath bel and other dialectal names in India. It can be grown easily in saline- alkaline soils and is resistant to biotic and abiotic stress being hardy in nature. The fruit pulp which is aromatic, sticky and has scattered seeds, makes excellent chutney and it also consumed fresh along with sugar. It is an important fruit used in traditional Auyrveda since it has hypoglycemic, antitumor, larvicidal, antimicrobial, and hepatoprotective activity, and antioxidant potential due to the phytosterols, saponins, polyphenols, flavonoids and ascorbic acid in the pulp. The pulp is a natural detoxifier and helps to improve kidney and stomach functions. It is a natural laxative.

Cape gooseberry (*Physalis peruviana* L.)

The Cape gooseberry (*Physalis peruviana* L.) belongs to family Solanaceae and is an annual or perennial herb bearing globular fruit. It bears small orange fruits which are enclosed in a husk and are eaten fresh or used in making excellent quality of jelly, sauces and particularly jam for which it is called as the "jam fruit of India". Whole berries, seeds, and pulp/peel of Cape gooseberry (*Physalis peruviana*) could well be considered a natural functional food because of the physiological properties associated with its nutritional components. Besides the good nutritional characteristics cape gooseberry fruits are reported to contain biologically active phytochemicals with health benefits comprising phytosterols : mainly campesterol, beta-sitosterol and stigmasterol, PUFA, vitamins A, B, C, E and K alongwith the physalins and withanolides characteristic of the Solanaceae family which impart anti-tumor, anti-oxidant and immunomodulatory properties making them substances of great interest for future research. They also boost the immune system by improving liver function and have a hepatoprotective activity. Some of these compounds have a strong antioxidant property and prevent peroxidative damage to liver microsomes and hepatocytes.

Physalis is reported to be a rich source of withanolides and detailed analysis of the oil samples reveals important nutritional and pharmaceutical potential in the oil from cape gooseberry from India which could be further exploited in future as a source of useful medicinal and nutraceutical compound for the pharma industry.

Gorgon nut (*Ferox* e*uryale* Salisb)

Gorgon nut or Fox nut *(Euryale ferox* Salisb) is an important aquatic crop, belonging to family Nympheaceae and commonly known as Makhana. It is a native of South-East Asia and China, but is distributed in almost every parts of the world. In India, it is distributed in West Bengal, Bihar, Manipur, Tripura, Assam, Jammu and Kashmir, Eastern Odisha, Madhya Pradesh, Rajasthan and Uttar Pradesh. Bihar is a major Makhana producing state in India. The crop is grown in large, shallow, stagnant ponds and has large leaves with thorns. The fruit is enclosed in a hard shell and bears an edible kernel inside.

This kernel is low in saturated fats, sodium and cholesterol and rich in potassium, magnesium and phosphorous. Studies on the phytochemical constituents of the crop are lacking but it is used in traditional Indian medicine for its cardioprotective properties besides being effective in improving fertility. The fruit is reported as a rich source of alkaloids, starch and minerals. The leaves are effective against rheumatism. Makhana is consumed extensively during religious fasts as an ideal staple food.

Water chestnut (*Trapa natans* Var. *bispinosa* Roxb.)

Water chestnut (*Trapa natans* Var. *bispinosa* Roxb) commonly known as 'Singhara' in India. It is an annual, floating leaved aquatic plant found in freshwater wetlands, lakes, ponds, and sluggish reaches of rivers in India where high rainfall is received. The crop is generally grown in low lying fields which become waterlogged in the monsoon. It is grown mainly for human consumption either in the form of fresh fruit, dried to make flour to prepare flattened bread called chapatti or in the shape of sweet dishes of many kinds prepared from the flour of the dried fruit. Kernel is a rich source of carbohydrates, saponins, phytosterols, lipids and fats while the skin contains tannins, flavonoids and glycosides which imparts anti-microbial, analgesic, anti-inflammatory and anti-diabetic properties to the fruit. This aquatic plant is important in water purification as it is successful in bioremediation thereby scavenging heavy metals from polluted water sources.

Kaphal (*Myrica nagi*)

Kaphal (*Myrica nagi*) a wild fruit of sub-temperate evergreen tree found throughout various districts of mid-Himalayan regions mostly the areas situated in Himachal Pradesh. It is a small red or purple large seeded fruit with very little pulp and is commonly known as kaphal or bay-berry or box myrtle. Kaphal contains various active chemical compounds such as myricetin, myricitrin and glycosides. It is important shrub used in traditional medicine to treat various diseases such as diarrhea, typhoid and dysentery, in reducing pain and treating nervine debility. It also shows anti-fungal, anti-bacterial, anti-inflammatory properties. Seeds can be used for extraction of oil useful in rhinitis.

Sea buckthorn (*Hippophae rhamnoides* L.)

Sea buckthorn (*Hippophae rhamnoides* L.) is an ancient plant with modern virtues, due to its nutritional and medicinal value. It is a spiny bush with narrow leaves, and small sized orange-yellow berries. It is cold resistant, and native to Europe and Asia. All parts of Hippophae e.g. berries, leaves, and seed or pulp oils contain many bioactive compounds. They are a rich source of natural antioxidants such as ascorbic acid, tocopherols, carotenoids, flavonoids, while they contain proteins, vitamin C, minerals, lipids (mainly unsaturated fatty acids), sugars, organic acids and phytosterols. Animal and human studies suggest that sea buckthorn may have various beneficial effects: cardioprotective, anti-atherogenic, antioxidant, anti-cancer, immunomodulatory, anti-bacterial, antiviral, and wound healing and anti-inflammatory. It could also be used in human and animal nutrition. Therefore, it would be worthwhile to perform more scientific research on this medicinal plant and to promote its large-scale utilization

India is a country with rich biodiversity and is the home to many such underutilized crops which are a rich and potent source of bioactive metabolites which have health regulatory functions. These are the future super fruits which will leave behind the commercially important fruit crops like mango, banana, litchi etc., owing to the various problems of susceptibility to biotic and abiotic stresses, narrow genetic base, specific nutrition and climatic requirements, etc. We need to identify such crops, characterize their bioactive components, standardize techniques for effective extraction and strive to prepare formulations so that they can be used effectively as functional foods. This would help improve the status of these hitherto underexploited species and additionally give an impetus to the rural socio- economic dynamics.

THEME 2

QUALITY INPUTS AND USE EFFICIENCY

LEAD LECTURE – 10

Impacts of Homa Therapy on mitigating environmental problems including climate disasters

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Pollution of the atmosphere, the soil, and water resources patterns is one of the biggest problems of our time and it affects all areas of life including agriculture and horticulture. In this situation it seems plausible to make use of every method including traditional knowledge which may help to overcome these problems (as it was suggested in the Convention on Biological Diversity (known also as the Rio Convention).

Homa Therapy with Agnihotra as its basic tool comes from ancient vedic knowledge and has wide-reaching beneficial effects on our whole environment, means on our atmosphere, on the soil, and on our water resources. Also biodiversity is increased. But this method of Agnihotra and Homa Therapy has to be understood and evaluated in terms of modern science. This will be done in the presentation - the method will be explained, and its application in solving environmental problems in different areas will be shown.

Following some results we got so far

Atmosphere

In this process of Agnihotra medicinal substances (like cowdung, ghee) are burnt in a copper vessel of precisely prescribed size and shape along with certain mantras (vibrations) at certain times (tuned to the basic biorhythm of sunrise/sunset). Cowdung is known for disinfectant properties. When we burn the cowdung, this disinfectant effect goes to the atmosphere and the atmosphere is disinfected, purified.

- Experiments done with Agnihotra showed that indoor microbial pollution is greatly reduced. Regular practise of Agnihotra controls pathogenic bacteria in an area.
- The concentration of negative ions is an important indicator of atmospheric pollution. The more negative ions in the air, the less pollution.

Normally smoke particles are charged positive. This can be easily tested if we blow cigarette smoke towards an instrument measuring the electric charge of the air. It will show that the concentration of negative ions is getting less. But if you perform Agnihotra and place the same device above the pyramid, the smoke of the Agnihotra fire shows a higher content of negative ions. Agnihotra is thus purifying the air in an area around the pyramid.

Soil

Reports show that

- ❖ Acidic soil was brought back to normal on a Homa Farm in Poland.

  Soil with a pH of 4.4 was brought back to normal by organic farming methods like composting and mulching and Homa Therapy including the use of Agnihotra ash.
- ❖ High salinity in soil could be brought back to normal by Homa atmosphere and by adding some Agnihotra ash. As there are large areas in India of previously fertile land which now are lying barren because of high salinity Homa Therapy could give a solution to a big problem. Water solubility of phosphorus will be increased by adding Agnihotra ash to the soil. This has been shown in institutes both in U.S. as well as recently in Germany. This is due to an increase in phosphorus solubilizing bacteria. Also nitrogen fixing bacteria are increased – and at the same time harmful fungi are controlled by Agnihotra and Agnihotra Ash.
- ❖ Aeration of the soil is increased by Agnihotra.
- ❖ Moisture holding capacity of soil is increased in Homa atmosphere.

Water resources

- ❖ Several reports show that by performing Agnihotra and putting Agnihotra ash in the well, the water quality improves considerably. Non-potable water became good drinking water – in one case the pH came down from 9.5 to 7.2 and the salinity from 1150 ppm to 720 ppm (report from Australia).

  On one farm in Austria officials closed one well as the water was not even good enough for the aninmals to drink. With Homa and putting Agnihotra ash to the well after only two months another inspection was done and they found out now it was good quality drinking water.
- ❖ A simple experiment shows that if you put Agnihotra ash in a container with putrid water within a few days the water becomes clear again.
- ❖ One experiment done in a Polish institute for Environmental Biology showed that by adding Agnihotra ash to water with some decomposing plant matter the beneficial microorganisms grew much better than in control environment.
- ❖ Even without putting Agnihotra ash you can purify water by just keeping it in a closed glass bottle nearby the Agnihotra fire. This experiment has been well documented.

Radioactivity

The ancient vedic knowledge states that radioactivity can be neutralized by Agnihotra and Agnihotra ash.

This statement sounds quite extraordinary or even incredible as there is no technique known to modern science to reduce radioactivity. You cannot change the half life of radioactive elements.

But experience shows that with Homa methods this is possible:

We have the report of one Homa Farm in Austria on which there was no increased radioactivity neither in the milk nor in vegetables after Chernobyl - although on all surrounding farms they had this problem.

Recently an experiment was done at the Academy of Sciences in Kiev where highly radioactive rice was tested. After soaking this rice in Agnihotra ash water, the radioactivity was totally neutralized.

Protection from natural disasters

In December, 2009 there was an unseasonal storm in the Dhule/Jalgaon region of north Maharashtra. 35,000 hectares of farms were damaged, and crores of rupees of crop losses were reported by farmers in the area.

In Parola tehsil 49 villages were affected; in some places 2 feet of ice was reported in the fields from the hail storm. This ice remained in some fields for 3 days after the storm.

There is one Homa Farm in the centre of the affected area called Tapovan. On this Homa Farm there was only minimal damage to the crops which is very unusual as all farms around were heavily affected.

So it seems that Homa Therapy creates some type of beneficial microclimate which acts as a protective shield around these places.

Similar reports of protection from natural disasters we also got from South America:

Stone and mud avalanches stopped right in front of Homa Farms both in Chile and in Venezuela.

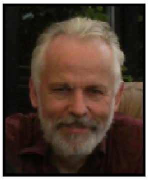
Homa therapy saves life in an industrial catastrophe

During the tragic Union Carbide chemical gas leakage in Bhopal in 1984, when so many tens of thousands of people died, the few residents of the area that were performing regular Agnihotra and who immediately fortified their Agnihotra biosphere with special supplementary healing fires at the time of the leakage, where spared. They did not have gas masks or any other form of protection. They simply stayed in their homes and performed the Homa fires.

This protective shield created by Homa Therapy was powerful enough to save peoples' lives.

The presentation will give an overview on the research done so far on future research suggested about how Agnihotra and Agnihotra Ash help to mitigate problems of the pollution of our atmosphere, the soil, and water resources.

We are creating a healthy microclimate with Homa Therapy methods – and if more and more people are joining these efforts, climate disasters can be avoided.



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❖ Born 1949 in Germany.

❖ Study of Philosophy of Science, Logic and Mathematics in Munich and Erlangen. Master degree 1974 of University Erlangen-Nürnberg (Philosophy of Science, Sociology).

❖ Doctor of Philosophy in 1976, University Erlangen-Nürnberg (Logic, Mathematics, Psychology).

❖ Assistant Professor in Konstanz University, teaching Logic and Methodology of Sciences to students of different faculties.

Business Consultant from 1993.

Since 1980 coordinating research on Homa Therapy, in the beginning mainly in Eastern European countries like Russia, Ukraine, Poland, Yugoslavia, etc., since a couple of years also in India. Here cooperation with different universities like Palampur Agricultural University, Kanpur Agricultural University, Tamil Nadu University, Dharwad University, IIT, Kharagpur, IIT Roorkee, Fergusson College, Pune, Vivekananda University, Bangalore, North Maharashtra University, Pantnagar Agricultural University.

Recent publications:

Bringing Homa Organic Farming into the Mainstream of Indian Agricultural System, Proceedings of the Brainstorming Conference in Cooperation with Planning Commission, Government of India, (Ed. together with Bruce Johnson). Dhule, M.H., 2009.

This book gives an overview on the research on Homa done so far in the field of agriculture and environment.

The Energy Field of Agnihotra. Indian Journal of Traditional Knowledge Vol. 1 (1), January 2015, pp. 63-68 (written together with Dr. Shailendra Sharma)

Impact of Homa Organic Farming in mitigating soil, water and environmental crises, in: Efficiency Centric Management (ECM) in Agriculture, Proceedings of National Symposium (held in October, 2014), G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, INDIA, 2015.

Effects of Agnihotra on Microorganisms. Proceedings of the Annual Convention cum Conference of IAVMI,Patna, Bihar, February 4 – 6, 2019.

Manual: Suggested Experiments with Agnihotra, Mühlingen, Germany, third revised edition 2019.

LEAD LECTURE – 11

Nutrient management through cosmic techniques

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Soil fertility is crucial for survival of humanity at the planet earth. Conventional agriculture is based on fossil fuel and imported sources of energy, which is dwindling and becoming expensive to government, farmers and society. Indiscriminate use of agro chemicals, predomination of monoculture, heavy irrigation and many other factors have adversely impacted soil biology and environmental ecology. As a result the air, which we breathe, water which we drink and food which we consume are all polluted.

Points to be considered for plant nutrition

Plants get their nutrition quantitatively from atmosphere and qualitatively from soil. They require 30 + elements for their quality production, which can be provided through pollution free environment, humus rich soil and variable plants. Plants have only organic diet *i.e.* in oxidized, chelate and in ionic form which is accomplished by the soil microbial consortia. Fertilizers currently available, hardly can provide 5-8 nutrients. Almost 78% free N is available in the atmosphere, which can be mediated through legume plants and other soil microbial consortia. Plenty of P in non soluble form is available is in the soil, one has to enhance its solubility. Potash is non constituent element, burrowed from soil and returned back through biomass. Humus content in the soil is potent accumulator of solar & cosmic energy and even has capacity to transmutate any nutrients which are deficient and require by plants. Hence, maintenance of high humus content is responsible for high quality production.

Natures' gestures to mediate cosmic energy-soil microbial consortia, earthworms and many other soil dwellers have capacity to mediate cosmic energy. Millions of lips beneath foliage are busy in inhaling carbon dioxide and exhaling oxygen. Chlorophyll in foliage mediates solar energy in process of photosynthesis basic step in preparation of food. Nodules in leguminous plants have bacteria capable of harnessing free N available in atmosphere. Without plants, we cannot breathe nor eat. Cow with hump with pyramid shape, belly is mini replica of cosmos and horns have capacity to mediate cosmic energy is needed as external input.

"Cosmic Farming" pertains with use of BD calendar for different farming activities. Habitat development by intensive plantation of different kinds of plants including, leguminous group, enhancing soil fertility through crop rotation, inclusion of legume as sole crop, cover, inter, green manures, pump crops as per feasibility. Practice of mulching whenever possible, management of few cows with hump and use of cow products for different crop activities need to be integrated.

Earthworms are known pulse of the soil. They are nature's microbe's factory. Local earthworms and uncountable microorganisms in the soil are the chief source of plants nutrition. Earthworms' excrement contains 5 times more of N, 7 times more of P, 11 times more K and 2 times more Mg and Ca than normal soil. In appropriate situations earthworms can add more than 100 tons of fertile soils per hectare through their excreta. By these activities they are capable of minimizing runoff water, better soil aeration through their roots, hence vigorous plants. Earthworms play important role in minimizing root diseases by discouraging impact of pathogenic bacteria. By integration of these practices quality production is possible in all crops without use of a gram of chemicals.

Conclusion

Enrich organic input with better nutrients and microbial population to make soil healthy and suitable for higher production. Recycling of crop residue, mulching, frequent use of Jeevamrita during field preparation & irrigation and 6-8 times foliar spray of Panchagavya, without use a gram of agrochemicals, higher production can be obtained. Building up of right microbial culture is much more important than to count N, P and K in the organic menu. Feeding N, P and K through chemical route, will not sustain agriculture for long what is being experienced. Every citizen should strive to play their roles which are helpful for enhancing availability of breathable air, drinkable water, quality production and fertile land for future generations.

Food produced without use of any agrochemicals are "*Satwik*" rich in nutrition with higher therapeutic values, while those produced on killing billions of microbial consortia in soil are "*Tamsik*" responsible of most of human ailments. - R.K. Pathak

Appeal –This concept has been conceived over more than two decades of active involvement in promotion of organic farming. Systematic research and its validation is the need of the hour. If there are any apprehensions or clarification, it will be advisable to contact the author.

LEAD LECTURE – 12

Integrated Nutrient Management in Horticultural Crops

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Exploitive agriculture involving nutrient input far below the quantities removed by the crops coupled with excessive tillage and indiscriminate use of irrigation water led to serious soil health problems over the years. Widespread multinutrient deficiencies and increased soil compaction have emerged as major constraints affecting crop productivity and farm profits. As significant increase in fertiliser consumption seems unlikely in foreseeable future due to economic and ecological reasons, the need for enhancement of nutrient use efficiency through integrated and balanced fertiliser applications is felt more intensely than ever before. It is often said that Indian agriculture is operating at a negative nutrient balance of about 10 million tonnes of NPK. This is to happen when nutrient supplies through external sources are less than nutrient removal by crops from the soil. Negative balances could well indicate that the soils are being mined and that farming systems are unsustainable over the long-term.

The basic concept of INM is the maintenance and improvement of soil fertility through integrating various nutrient resources along with fertilisers for sustaining crop productivity on long-term basis. The concept includes key areas like, maintenance/adjustment of soil fertility, optimum plant nutrient supply, sustaining desired level of productivity, optimization of benefits from all possible sources of nutrients and addressing environmental concerns. This may be achieved through combined use of all possible sources of nutrients and their scientific management for optimum growth, yield and produce quality. Long-term studies undertaken in different soil-crop environments have established the benefits of integrated nutrient management (INM) involving use of organic and biological resources along with fertilisers. Organic manures like urban compost, FYM, crop residues, human excreta, city refuse, rural compost, sewage-sludge, pressmud and other agro-industrial wastes have large nutrient potential. Compost and FYM have traditionally been the important manures for maintaining soil fertility and ensuring yield stability. Other potential organic sources of nutrients such as non-edible oilcakes and wastes from food processing industry are also there. The industrial by-products like spent-wash from distillery, molasses, pressmud etc., from sugar industry and wastes from other food processing industries have good manurial value. Sulphitation pressmud (SPM) has a great potential to supply nutrients in addition to favourable effects on soil properties. These manures apart from supplying major nutrients, are rich source of secondary and micronutrients. They also help improving the physical, chemical and biological properties of the soils. Biofertilisers are the materials containing living or latent cells of agriculturally beneficial microorganisms that play an important role in improving soil fertility and crop productivity due to their capability to fix atmospheric N, solubilize/mobilize P and decompose farm wastes resulting in the release of plant nutrients.

Nutrient potential of all biological and industrial wastes has been estimated at 19.113 Mt. The availability of several organic resources will increase with time. For example, additional 1.2-1.5 Mt crop. residues will be generated with every Mt increase in grain production. Additional 0.25 Mt excreta year-1 will be discharged with every million increase in human population. As fertiliser use in most areas is suboptimal, organic resources can supplement available fertiliser supplies. About 25% nutrient needs of Indian agriculture can be met by utilizing various organic sources. According to an estimate, the annual production of dung and urine from bovine population in India is 1228 and 800 Mt, respectively. If the entire wet dung and urine excreted by bovines are conserved for manurial purposes, its potential for supplying major plant nutrients been worked out at 6.96 Mt of N+P2O5+K2O. However, availability is often constrained as most farmers use the dung as fuel and most of the nutrients passed into the urine are lost under the traditional methods of recycling. Estimated current potential of crop residues is 500 Mt, and rice and wheat straws account for 70% of crop residues generated in India. Crop residues can contribute about 8.74 Mt of NPK. Apart from supplying major nutrients, organic resources are rich source of secondary and micronutrients. There is need to evolve appropriate management practices to make use of the stubbles, residues and other on-farm and off-farm biomass. It is amply clear that INM holds great importance in meeting the growing nutrient demands of Indian agriculture. INM helps maintaining production sustainability without any detriment to the environment. Mass awareness should be created among farmers for conservation, recycling and use of organic sources and for preparation of quality compost/ FYM. The Department of Horticulture/Agriculture and fertiliser industry can play a major role. Promotional literatures in local languages be developed and distributed to the farmers and extension personnel. All stakeholders should join hands to promote INM in letter and spirit. Present paper overviews the significance of different ingredients of INM in improving soil physical, chemical and biological properties, nutrient use efficiency, fruit productivity and produce quality.

LEAD LECTURE – 13

4R-Nutrient management guidelines in citrus

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Considering 60 per cent of the world's arable lands having mineral deficiencies or elemental toxicity problems, citrus, by the virtue of its perenniality have emerged as world's leading fruit crop. Nutrient management-based production system of citrus like any other fruit crop is inherently complex to understand due to large variation in nutrient-use-efficiency. Citrus is considered evergreen in nature, blessed with nutrient conservation mechanism, to facilitate an increased carbon return per unit of invested nutrient due to comparatively longer duration of photosynthesis eventually leading to higher nutrient-use-efficiency. Perennial fruit trees play an important role in carbon cycle of terrestrial ecosystems and sequestering atmospheric CO_2 (Carbon sequestration in biomass of citrus trees ranges from 23.9 tons CO_2 ha^{-1} for young trees to 109 tons CO_2 ha^{-1} for mature trees). 4R nutrient management concept, exploiting criteria of right choice of fertilizers at right dose at right stage of right crop Ras been the most pivotal driving force towards improved nutrient-use-efficiency. However, citrus by the virtue of their perennial nature of woody framework (Nutrients locked therein), extended physiological stages of growth, differential root distribution pattern (root volume distribution) and growth stages from the point of view of nutrient requirement and preferential requirement of some nutrients by specific fruit crop, collectively make them nutritionally more efficient than the annual crops.

Our initial efforts were to standardise optimum fertilizer requirement as recommended doses of fertilizers (RDF) through multi-location experiments, scheduling nutrient application across crop phenophases, scheduling fertigation by partitioning both nutrient and water requirement across critical growth stages, backed up by development of cultivar specific nutrient diagnostics, to be in a position to practice advanced methods of nutrient management. Attempts were later made to address these issues with combined use of concepts like Site Specific Nutrient Management (SSNM) and soil fertility spatial variogram-based fertilizer recommendations as decision support tool. The success of SSNM during the last 10 years has been prominently realized on a number of crops *viz.*, cereals, black gram, avocado, citrus *etc.* to cite few success stories. Recent review on the subject introduced a model was introduced to answer three questions pertaining to SSNM in production of perennial crops, namely, which in put factors of crop production are limiting yield; what action should be taken to remove the limiting factors; and what is the potential gain in revenue from taking the action. The suggested model captured the essence of the law of the minimum in yield and revenue increase only if the limiting nutrients are appropriately adjusted. Success of SSNM depends on correctness of measurement and understanding on variability in available supply of nutrients, which can be summarized in three steps *viz.*, i. assessing variation ii. managing variation, and iii. Evaluation. But there is hardly any comprehensive coverage addressing the perennial crops. Spatial maps are fundamental to SSNM addressing variation either soil fertility or leaf nutrient composition because they represent either the spatial state of a growing condition. With new advances in technology, grid sampling for developing precision variogram is increasing. The first step in the process is to divide large fields into small zones using a grid. Next, a representative location within the grid is identified for precision soil sampling. Grid sampling is integrated into global positioning system (GPS) based soil sampling and nutrient-mapping that in turn uses a geographic information systems (GIS) to employ variable rate technology (VRT) for fertilizer applications. Optimum grid size soil mapping using specific nutrient-based spatial variograms as a interpretation tool popularly known as DRIS developed for Khasi mandarin of northeast India and Nagpur mandarin of central India aided in measuring the magnitude of changes in pool of soil available nutrients before and after fertilization.

In another long term experiment, the large fruit yield difference of 30.2 and 48.9 kg/tree initially observed on shallow soil (Typic Ustorthent) and deep soil (Typic Haplustert) in an orchard size of 11 ha, reduced to respective fruit yield of 62.7 and 68.5 kg/tree with corresponding fertilizer does (g/ tree) of 1200 N-600 P-600 K-75 Fe-75 Mn-75 Zn-30 B, and 600 N-400 P-300 K-75 Fe-75 Mn-75 Zn-30 B, suggesting the necessity of fertilizer application on variable rate application for rationality in fertilizer using SSNM as rationale of fertilizer use. The success of VRT depends to a large extent on the quality of fertility management maps. The ratio between nugget semivariance and total semivariance or still was used to define different classes of spatial dependence for leaf nutrient. If ratio was d" 25 per cent, the leaf nutrient was considered to be strongly spatially dependent, or strongly distributed in patches; if ratio was between 26 and 75per cent, the leaf nutrient was considered weakly spatially dependent; if the ratio was 100 per cent, or the slope of the semivariogram was close to zero, the leaf nutrient was considered as not being spatially correlated (pure nugget). Studies on the variations between ground truth yield versus two yield estimation methods (inverse distance weighted (IDW) and density grid method) using Pearson coefficient method further aided in better interpretation. Our studies generating databank on leaf analysis and fruit yield through exploration of 7 states across northeast India were analysed through combined application of diagnosis and recommendation integrated system (DRIS) to determine leaf nutrient optima and geographical information system (GIS), which delineated major production zones facing minimum nutrient constraints through spatial variogram of nutrient constraints.

Any attempt to rationalise the fertilizer use and improve fertilizer efficacy in citrus orchard will surely be associated with consequent enhancement in production provided all other factors are optimum. Limited attempts in the past have been made in perennial crop like citrus, which needs to be managed through precision based technologies. The development of decision support tool based on soil fertility variation is one such viable option to address the nutrient mining and fluctuating yield levels. The utility of precision tool like GIS technology in mapping the fertility status of soil has undoubtedly provided the desired accuracy and effectiveness in fertilizer recommendations. The rhizosphere (0-20 cm) oriented soil samples through four grid sizes (10 x 10 m, 20 x 20 m, 40 x 40 m and 60 x 60 m) were collected using GPS-based tracking system at orchard finally earmarked at Umsaitining Ribhoi district of Meghalaya and Ladgaon (Katol), Nagpur district of Maharashtra. The spatial variograms of these parameters were developed based on data generated through soil tests under different grid sizes were developed using geographical information system (GIS) and interpreted for working out the optimum grid size for soil fertility evaluation in Khasi mandarin. The spatial variogram suggested the optimum grid size for precise soil testing is 40 m x 40 m under hilly terrain of northeast India and Central India of Maharashtra, cultivating Khasi mandarin and Nagpur mandarin, respectively. Based on soil test values for different nutrients, doses of fertilizers and targeted fruit yield, a tripartite prediction models were developed *viz.*, Fertilizer Nitrogen = 13.09 (Targeted Fruit Yield) – 2.37 (Soil test value for Nitrogen); Fertilizer Phosphorous = 4.08 (Targeted Fruit Yield) – 26.83 (Soil test value for Phosphorous); Fertilizer Potassium = 1.69 (Targeted Fruit Yield) – 0.39 (Soil test value for Potassium) for Nagpur mandarin. Similarly, prediction equations for Khasi mandarin were developed as decision support *viz.*, Fertilizer Nitrogen = 13.09 (Targeted Fruit Yield) – 2.37 (Soil test value for Nitrogen); Fertilizer Phosphorous = 4.08 (Targeted Fruit Yield) – 26.83 (Soil test value for Phosphorous); Fertilizer Potassium = 1.69 (Targeted Fruit Yield) – 0.39 (Soil test value for Potassium). These decision supports were duly validated in field and now in process of facilitating advisory service using 4R guidelines in citrus. We are currently working in the process of developing 4R-Nutrient Expert for citrus with the use of above information.

LEAD LECTURE – 14

Advances in horticultural mechanization for enhanced input efficiency

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India has witnessed increase in horticulture production over the last few years. Significant progress has been made in area expansion resulting in higher production. Over the last decade, the area under horticulture grew by 2.6 per cent per annum and annual production increased by 4.8 per cent. During 2017-18, the production of horticulture crops was 311.71 Million Tonnes from an area of 25.43 M.ha. Horticulture sector has become one of the major drivers of growth as it is more remunerative than the agricultural sector (food grains mainly). It has emerged as a promising source of income acceleration, employment generation, poverty alleviation and export promotion. This sector provides employment possibilities across primary, secondary and tertiary sectors. Despite its vital role, the sector suffers from major hindrances and road blocks in production due to labour intensiveness of operations, water scarcity, climate change, disease infestation and post harvest losses. In India, horticulture mechanization is almost at an infant stage and for the growth of this sector; there is immediate need for intervention. Farm Mechanization has immense potential in India. As a general trend, farm operations requiring high power inputs and low control (tillage, transport, water pumping, milling, threshing) are mechanized first and those requiring medium levels of power and control (seeding, spraying, intercultural operations) are mechanized next. The operations requiring high degree of control and low power inputs are mechanized last (transplanting, planting of vegetables, harvesting of fruits and vegetables). This happens so because any work, which is power intensive, can be done faster mechanically and at a lower cost. Whereas, converting human knowledge into machine knowledge is difficult and costly. Growth of the mechanization in India has also followed the same general pattern found worldwide. As a result of this most of the precision requiring operations *i.e.* planting and transplanting of vegetables and harvesting of fruits and vegetables are yet to explore. There is a great scope to reduce the input cost and increase the productivity of farmer through mechanization of vegetable and horticultural crops. The country is now in transition from labor intensive to control intensive agriculture. Precision agriculture and automation is the current trend in agricultural mechanization. There is a great scope to reduce the input cost and increase the productivity of farmer through development of precision based multiple use farm machinery and ensuring availability of high cost machinery on custom hiring basis. With the development of technologies for vegetable mechanization in the form of pneumatic precision planter, onion harvester, carrot harvester, carrot planter many farmers have started growing vegetable crops especially in the nearby of urban areas to fetch higher market value. Urea ammonium nitrate (UAN) application through fertigation for enhancing nitrogen use efficiency and variable rate technology for precise application of granular fertilizer have great potential for input cost saving. The frontier technologies like drone assisted sprayer and robotic precision planter have very good potential. Such technologies are going to improve the efficiency of spraying and planting operation. The battery less solar powered evaporatively cooled storage structures have been developed by the division for extended life of perishable products. All these interventions have a major role to play in reducing input cost and increasing profitability.

LEAD LECTURE – 15

Vegetable seed industry in India: Current status and future challenges

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India produced 184.3 million tons of vegetables including potato from 10.8 million ha area in 2017-18 with a productivity of 17 tons/ha amounting to 10.7 per cent of world production of vegetables. This production figure translates into 284 g per day per individual availability of vegetables in India assuming 1.33 billion population and 25 per cent post-harvest production losses in vegetables. For vegetables, recommended intake is at least 300 g/day/person, which must include 50 g of green leafy vegetables, 200 g other vegetables and 50 g root and tubers. Although gap between current availability of vegetables and requirement is low, it is expected to widen in future as projected demand of vegetables is pegged at 300 million tons by 2050 due to increasing population and most of the projected extra production has to come from productivity increase as scope of area expansion is very limited. Thus, research and development efforts in vegetable sector need to be pursued with more vigour backed up by a strong seed industry. India is fortunate to grow large number of vegetables like potato, okra, tomato, onion, peas and beans, bitter gourd, bottle gourd, eggplant, beetroot, cabbage cauliflower, carrots (red and orange), capsicum (sweet pepper), cucumber, chillies (green and dry) ridge gourd, smooth gourd, ash gourd, pumpkin, radish, broccoli, knol-khol, coriander, spinach, sweet corn and others where potato, onion, hot-pepper (both green and dry), tomato, okra, eggplant, cauliflower, cabbage, peas and beans are major crops covering large areas.

Vegetable seed market value

Globally total seed market stands at USD 60 billion of which India accounts for USD 3.8 billion (INR 27000 CR). Globally vegetable seed market is around USD 9 (15%) of the total seed market of USD 60 billion. Market share of top three countries in Asia in vegetables is China (USD 2500 million = INR 18000 CR), Japan (USD 570 million = INR 4040 CR) and India (USD 560 million = INR 4000 CR). Tomato seed occupies 15 per cent of the total vegetable seed market while cabbage, sweet peppers, hot peppers and gourds have 7 per cent each contributing to global seed industry. Other crops contribute 5-6 per cent. Fresh tomato production at 180 million tons is highest in the world followed by watermelons and onion, each at 100 million tons. Globally Seminis (now acquired by Bayer) is the largest vegetable seed company followed by Limagrain, and Syngenta. Turnover of top ten global seed companies of vegetable seed represents 65 per cent of the total vegetable seed market.

By value, Solanaceaeous crops, namely, tomato, hot-pepper, eggplant, sweet pepper (mostly F1) have largest market share worth 19 per cent. Cucurbits have 17 per cent market share. Malvaceaeous crop represented by only one crop, okra has 16 per cent market share. Root crops (radish, carrot) and bulb crop (onion) have share of 9 per cent. Brassicas have market share of 8 per cent. Large seeded crops like peas and beans (both OPs) and sweet corn (F1 only) have market share of 24 per cent. Leafy vegetables have 2 per cent market share and all other remaining crops have market share of 5 per cent. Further, by value, more than 85 per cent of hybrid and OP seed of vegetables is provided by private seed companies. In general, hybrid seed provided by seed companies are suitable for all geographies and agro-climatic zones. Even in OPs, farmers prefer to buy high quality seed of seed companies rather than using their own saved seed. In major crops like tomato, hot-pepper and okra, seed companies are commercializing hybrids which are highly tolerant to viruses giving farmers high income under disease pressure situations. Early maturing hybrids are available in several vegetable crops giving better commercial price to the farmers.

Vegetable seed volume in India

Area-wise and seed volume-wise, few important vegetables reflect the following scenario. Tomato is planted almost round the year in different parts of India in an area of about 8 lakh ha which is 10 per cent of total vegetable area (excluding potato). Out of total area, 78 per cent is planted with F1 hybrids and the rest 22 per cent is covered by OPs. Most of hybrid seed close to 100 tons is marketed by private seed companies. Leading companies in tomato hybrid seed are Bayer (Seminis), Syngenta, Acsen-Hyveg, and Namdhari Seeds. In India, area under green and dry chillies is close to 10 lakh ha where major 12 types of chillies are grown. These types are based on fruit size, diameter, skin colour, skin texture, skin thickness, upright or pendulum fruiting habit, pungency, red dry colour value, dry fruit storability, *etc.* Hybrid seed of chillies sold in the Indian market is about 100 tons. About 60 per cent of hybrid seed is consumed in Andhra Pradesh and Madhy Pradesh. Leading companies in hot-pepper seed business are Bayer (Seminis), Bejo, Mahyco, VNR, Syngenta, Acsen-Hyveg, and Indo American Hybrid Seed. Sweet pepper (mostly hybrid) is grown under poly-house and under open-field (32000 ha). Eggplant area is on decline and is stagnant at 7 lakh ha. The reason for area decline is primarily due to confusion over Bt. brinjal and requirement for heavy pesticide application. There are more than 10 types of eggplant under commercial cultivation in India and the leading players in eggplant are Mahyco, UPL-Advanta, VNR, Acsen-Hyveg, Ankur, *etc.* Okra is the largest crop in hybrid segment in terms of volume with sale of more than 2000 tons of hybrid seed. Large numbers of old hybrids are going out of commercial seed sale due to impact of yellow vein mosaic virus (YVMV) and lately widespread occurrence of okra enation leaf curl virus (OELCV). Major companies in the okra hybrid seed market are Bayer (Seminis), UPL-Advanta, Acsen-Hyveg, Syngenta, JK, Mahyco, VNR, *etc.* Major vegetable crops under cultivation in India are cabbage, cauliflower, broccoli and knoll-khol spread over an area of 9 lakh ha where cabbage and cauliflower account for 90 per cent of the area. Most of hybrid seeds of Brassicas amounting to 200 tons are imported from Asia and Europe. Breeding efforts on Brassicas are on a limited scale by companies like UPL-Advanta, Syngenta, Seminis (Bayer), Namdhari and Mahyco, *etc.*

Cucurbits including bitter gourd, bottle gourd, ridge gourd, smooth gourd, round gourd, ash gourd, pointed gourd, pumpkin, watermelon, melon and cucumber (both slicing and pickling types) are grown on 13 lakh ha where major area is under bitter gourd, bottle gourd, cucumber and watermelon. Leading companies doing breeding on these crops are East-West, Acsen-Hyveg, Mahyco, Syngenta, Seminis (Bayer), VNR, Namdhari, Chia Tai, UPL-Advanta, Known You and Bejo, *etc.* In India, three types of carrots (Red Imperator, French Nantes, and Japanese Kuroda) of open pollinated types are grown on 4 lakh ha. Hybrid carrots are very limited in quantity in the seed market. Most of red type carrots are sold by local indigenous seed companies. Major companies in the red carrot seed market are Mahyco, Sungro, Acsen-Hyveg, Durga Seed, Pahuja Seed, UPL-Advanta, *etc.* Major players in orange carrot seed market are Clause, Seminis (Bayer), Syngenta, Tokita, Takii, Acsen-HyVeg, Namdhari, Bejo, *etc.*

Onion is major vegetable crop grown on area of 12 lakh ha and this crop is not only consumed on large scale within country but is also the highest foreign exchange earner in horticultural crops. Presently onion seed market which is 90 per cent OP types is dominated by companies like Bejo, Panchganga, Mahyco, Jindal, Malav Seed, East-West, Acsen-HyVeg, Namdhari and many small players. Traded seed is 3000 tons of which 2500 tons is sold by private seed companies and 500 tons by government departments.

Vegetable peas covering an area of about 5 lakh ha include old varieties like Arkel, Bonneville, and Azad Pea 3 being produced largely by public sector organizations. However, there are few new varieties of medium maturity whose seed has been introduced from out-side and these are being marketed by UPL, Pahuja, Acsen-HyVeg and Mahyco, *etc.* Annual seed consumption is about 37000 tons.

Radish mostly OP types are grown both in summer and winter seasons. Tropical radishes, Chetaki and Summer Long types are grown in summer and rainy seasons while temperate types like Hill Queen, Mino Early and Japanese Long are grown in Rabi season. Total area under OPs and hybrids is 3 lakh ha. Few companies like Syngenta, Seminis (Bayer), Acsen-HyVeg, Mahyco, and Advanta are doing research on hybrid breeding in radish.

Beetroot covering an area of 75000 ha includes 33 per cent under hybrids and remaining under OP cultivars like Ruby Queen and DDR. The major companies dealing with hybrid beet root are Sakata, UPL-Advanta and IAHS.

Beans covering an area of 2 lakh ha include primarily French-bean, cowpea and yard long bean and few other types.

Coriander is grown both for fresh leaves and also for seed and covers an area close to 5 lakh ha using primarily imported seed to the tune of 8000 tons. In spinach, still old open-pollinated cultivar, All Green dominates the production spread over 2 lakh ha.

Since 85 per cent of the total vegetable seed requirements is under private seed companies for production/import and sales/marketing, vegetable seed supply is not going to be a limiting factor in present or even in future as there are about 300 private seed companies which are competing in vegetable seed market.

Future challenges

All MNCs and top Indian vegetable seed companies are concentrating on intensive breeding using advance biotechnologies to develop disease resistant and performing hybrids. The merger and acquisition will due to high cost of R & D and issues related to IPRs. The smaller companies which are either producing and selling or outsourcing the seed will be under pressure due to inventories, legal obligations and protection of the varieties. Most of the MNCs and top Indian seed companies will like to produce the seed of key hybrids outside India to avoid pilferage of the parental lines. Professional vegetable growers seem to be less worried about price of vegetable seed or seedlings but are looking for high performance, disease resistance and good quality. In future farmers are likely to accept new seed technologies like priming, pelleting, and multi-coated seeds. High tech vegetable nurseries will be in demand.

Germplasm movement will be on higher scale across the nations. Since many hybrids in vegetables perform across boundaries and major diseases of vegetables are common across the continents, there will be higher import and export of vegetable seeds. Hybridization will value addition will be expanding. Types, taste and shelf-life will have higher ranking than yields. Large numbers of MNCs have already entered Indian seed market and they will invest heavily on R & D on infrastructure and new technologies. GM products development though currently on hold with respect to commercialization, will explore the traits like insect resistance in cabbage, cauliflower, eggplant, okra and virus resistance in potato, tomato and other crops. Farmers saved seed will be on decline. Companies will be held responsible for stated claim related to product performance in a particular environment. Diverse germplasm will be in greater demand to handle complex trait breeding.

Due to climate change and complexity of diseases, durability of the products will be under intense pressure necessitating fast-track breeding and intervention of new technologies. Protected cultivation with specialized products is likely to expand. MNCs will invest more in R & D to take market edge. In next ten years, vegetable seed market is likely to grow by 50 per cent. Doubling the farmers' income by 2022-23 will need annual agriculture growth by more than 14% per year and that will call for a shift from labour intensive to capital and technology intensive agriculture. It is worth mentioning that in vegetables, the seed replacement ratio is second highest at 85 per cent after cotton where it is 100 per cent due to clamour for Bt cotton seed. Seed replacement ratio I vegetables is expected to increase further due to increasing demand of high performing quality seeds with preference to hybrid seeds.

Plant breeding focus shall shift on disease free plants and climate smart cultivars. Cultivation of Bt brinjal in neighboring Bangladesh has helped them growing pest-free brinjal using reduced spray of pesticides and pressure is likely to mount on Indian regulator to give nod for commercialization of Bt brinjal in India which has been kept on hold since 2010. There are reports of farmers growing Bt brinjal in limited pockets in India, though illegally. Once it gets green signal, it will have potential impact worth Rs. 2000 Cr in India. Gene editing, farm mechanization and farmers apps are likely to play bigger role in future.

Innovations will continue to be of critical importance in agriculture including horticulture. Higher level of investment in research will be needed. Use of new technologies will be on increase. There will be demand for facilitating rules, regulations and safeguarding intellectual property environment.

Public sector research establishments are devoid of infrastructure for seed production and their supply chain management and they should shun the notion that they can be a big player in this activity. Instead, they should focus on intensive, high-tech, research and develop parental lines equipped with desirable traits and partner with private seed companies for open-pollinated/hybrid seed production and sales and marketing in PPP mode as is being practiced with open mind by IARI, IIHR, IIVR, etc through simple MoUs/licensing agreements where focus is on ensuring that the seed reaches to the farmers rather than that on resource generation and thereby making the MoU so complicated that it fails to deliver. IARI-wheat and rice model need to be followed in letter and spirit.

References

Kapur, A. (2016). Vegetable seed industry and its future prospects. Invited Review. *Seed Research*, **44** (2): 91-96.

Kapur, A. (2019). Vegetable seed industry creating avenue to enhance seed trade. Paper presented at Seed World-World Seed Trade and Technology Congress, Bangalore, 18-21 Sep. 2019, organized by Indian Council of Food and Agriculture.

Ram, H.H. (2012). Vegetable Breeding-Principles and Practices-Third Revised and Enlarged Edition. Kalyani Publishers, Ludhiana, pp. 791.

Ram, H.H., Upadhya, R., Dubey, R.K., Mandal, B. 2017. Vegetable Seed Production: Principles and Practices. Kalyani Publishers, Ludhiana, India, 713 pp.

Zehr, U.B. (2019). Enhancing seed trade-Future opportunities. Paper presented at Seed World-World Seed Trade and Technology Congress, Bangalore, 18-21 Sep. 2019, organized by Indian Council of Food and Agriculture.

LEAD LECTURE – 16

Optimization of land use with fruit-flower integration for doubling farmers' income

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The demand for horticultural commodity is increasing day by day and to meet the ever increasing targets as per the demand, productivity needs to be raised further. This can be realized in two ways- by increasing area of cultivation and/or through increased efficiency of inputs (both natural and manmade). The scope for the former is very limited worldwide and for the latter, the primary input is the solar energy which is most abundant except in few cases like colder regions. Thus, production per unit area of land, time and inputs can be increased by improving efficiency of the rate and extent to which solar energy is harvested for conversion to economic produce. The strategy for this is to have good canopy cover right from the planting of the crop to harvest. This is possible wherever feasible through optimization of land use especially through annidization of fruit and flower crops. This promotes the possibility of more efficient use of resources like sunlight, nutrient and water, leading to increased biological diversity and higher production stability.

Majority of farmers of our country, are small and marginal farmers. They generally cultivate seasonal crops. Hence, after a certain time interval, they have the scope to earn. While, fruit plants are perennial in nature and commence bearing after long waiting period of 3-5 years .Vagaries of weather many times spoil that scope of earning which aggravates their poverty. In this connection, fruit –flower annidization opens a new door to earn whole round the year as well as there is less risk of complete crop failure. This is a potential technology that can be followed to create framework for perm culture, which is ecologically harmonious, efficient and productive and can be used by farmers anywhere. We can create a fruit – flower guild for the purposes of pest prevention, beneficial attraction, scent masking, soil remediation and general beautification but main goal is the health and fruit production.

To optimize the land use through fruit and flowers following methods can be adopted according to the soil, climate and availability of sunlight.

Intercropping

Inter cropping is the cultivation of two or more crops simultaneously on the same field. Inter cropping has its worth in minimizing production cost per unit area, augmenting additional income and minimizing crop failure. Traditionally orchards are laid out in parallel line to facilitate easy cultural practices and its maintenance. What can be planted under a particular tree should be assessed on a tree-by-basis, because every tree canopy and root system is different. In sustainable agriculture "alley cropping" is a method where rows of fruit or nut trees are planted and the spaces between are used for annual crops. This is done until the trees reach production size and shade out the alley, providing short-term income while, the more valuable trees mature. Partial shade loving crops like gerbera, heliconia and alpinia can be cultivated in fully grown orchards (Fig. 1-6). It is observed that intercropping is a well established practice covering over 12 m ha in South Asia.

Principles of intercropping

- Intercrops should occupy a secondary place in the orchard, primary consideration being given to the perennial fruit trees.
- The crops that may grow tall and have a tendency towards excessive growth should be discouraged.
- At least 120 cm radius must be left from the base of the growing fruit trees for taking intercrops.
- Such intercrops should be selected that do not exhaust the nutrients and moisture from the soil, so essential for the growth of fruit trees.
- Perennial or exhaustive flower crops should be discouraged as an intercrop in the orchard.

Advantages of intercropping

- Intercropping gives additional yield income/unit area than sole cropping.
- Inter-crops maintain the soil fertility as the nutrient uptake is made from both layers of soil.
- Reduction in soil runoff and controls weeds.
- Intercrops provide shade and support to the other crop.
- Inter cropping system utilizes resources efficiently and their productivity is increased.
- Intercropping with cash crops is highly profitable.

Disadvantages of intercropping

- Yield decreases as the crops differ in their competitive abilities.
- Management of intercrop having different cultural practices seems to be difficult task.
- Improved implements cannot be used efficiently.
- Higher amount of fertilizer or irrigation water cannot be utilized properly as the component crops vary in their response of these resources.

Suitable crops for intercropping

Upto 4-5 years

- **Marigold** (*Tagetes erecta* and *Tagetes patula*)**:** It is very good crop for intercropping and also for companion cropping where nematode is serious problem. Flowering starts after 65 days of transplanting and complete within 135 -140 days, therefore crop can be harvested throughout the year by adjusting the planting according to demand**.** French marigold is more effective to control the soil nematode as compare to African marigold.
- **Chrysanthemum (***Chrysanthemum morifolium***):** This is very good short duration intercrop for winter season. Farmers can get extra income by using inter space of fruit crop.
- **Tuberose (***Polianthes tuberosa***):** This is a bulbous fragrant cut flower and also used as loose

Figure 1. Coconut - Marigold intercropping

Figure 2. Coconut - Heliconia intercropping

Figure 3. Grape - Borage - Sweet Allysum intercropping

Figure 4. Areca nut - Gerbera intercropping

Figure 5. Apple - Dandelion intercropping

Figure 6. Grape-Borage intercropping

flowers. As a perennial crop flower can be harvested up to three years. Flowers are also used for extracting the essential oils.

After 5 years

- **Gerbera** (*Gerbera jamesonii*): When fruit plant acquired full growth and creates shade between the rows of plant, then gerbera plant can be planted as inter crop to utilize the shade effect of plants which is beneficial for its growth and flowering. This is also very good crop for multistoried cropping. As a perennial crop flower can be harvested up to three years.
- ***Heliconia* spp.** This is also shade loving plant and used as intercrop. As a perennial crop flower can be harvested up to 7-8 years. Flowers are used as cut flower and present time demand of flower is more due to long shelf life.
- **Foot Ball Lily** (*Haemanthus multiflorus*) : Bulbous cut flowers require shade for its growth and flowering. Flowering takes place in the month of March –April when very few cut flowers are available.
- **Bird of Paradise (***Strelitzia reginae***)** : This is also very costly bulbous cut flower and flourishes very well under the shade of fruit trees. In international market, demand of this flower is very high but due to long gestation period suitable only for large interspaced tree as flowering takes place after 3 years.

Multistoried cropping

The objective of this system of cropping is to utilize the vertical space more effectively. In this system the tallest components have foliage tolerant of strong scorching light and high evaporative demand and the shorter component with foliage requiring shade and or relatively high humidity (Fig. 7-8).

Benefits of multistoried cropping system

- Income per unit area increase substantially with this system and ensures a more evenly distribution of income and employment throughout the year from harvesting different crops in different season.

Figure 7. Coconut-Pepper- Alpinia Cropping

Figure 8. Moringa-Grape- Sweet Allysum Cropping

- Minimize risks of crop yield loss. This system enables a steady supply of farm products the whole round the year.
- Generates jobs & provides better labour use pattern.
- Helps to maximize land use. All growing space is used as crop fit together vertically (tall, medium & short), horizontally (all planting spots occupied) and underground (deep-rooted and shallow-rooted plants).
- Reduces the impacts of hazards like high intensity rainfall, soil erosion and landslides.
- Efficiently utilizes the soil moisture at different depths of soil and catch solar energy at different heights.
- Natural resources are utilized properly. Efficiency in water use. Enrich in fertility status of soils.
- Improve the soil characteristics and adds organic matter to soil
- Effective utilization of leaching materials.
- It helps in effective weed control.
- It provides partial guaranty against market glut of single commodity.
- Efficient cultivation of a range of products is possible.
- Crops can be grown according to market preference.
- Higher production as the cultivation process is accelerated.
- Better and more consistent crop quality.
- Maintain an ecological balance.
- A mix of tree and plant species that could grow well in the multi-storied system.
- There are several secondary outputs from the system.
- Increase biodiversity which reduces pest and disease pressure.
- Provide micro-climate conditions that benefit crops underneath. e.g. gerbera

Companion cropping

Companion cropping is growing of different crops together or near each other that benefit each other. Planting companion plants for fruit trees is a great way to help them thrive. The idea behind this age-old gardening practice is that certain plants are beneficial to other plants when placed in close proximity. It is the practice of planting a diversity of beneficial herbs, flowers and cover crops (also called living mulches) in an intimate grouping. In companion planting, these plants are called "family friends" and planting them together around a main crop such as a fruit tree forms a "plant neighborhood". Plants that have friends and live in a plant neighborhood grow better and produce more. Some plants attract beneficial insects, some repel predators and some are even said to affect the flavor of edible fruits. In addition to these benefits, companion planting also adds visual interest to orchard with flower plants colorfully mingled together. Finally, planting companion flowers and herbs with fruit trees in orchard creates biodiversity. And so it mimics a natural system, sharing in its resilience and high sustainable yield. Some great companion plants which help fruit trees growing and producing are as follows (Fig. 9).

Figure 9. Examples of companion cropping

Marigold (*Tagetes erecta* and *Tagetes patula)*: A great pest deterrent and slug trap. Keep the soil free from nematodes.

Pansy (*Viola tricolor*): Annual, full sun to part shade. Repels Japanese beetles.

Sweet Alyssum (*Alyssum maritimum*): Drought tolerant annual and will re-seed readily. Will spread to form a ground cover. Tiny flowers are perfect for attracting delicate beneficial like chalcid wasps and hover flies, whose larvae devour aphids. The sweet smelling blossoms also attracts bees.

Lavender (*Lavendula officinalis*): A flowering plant in the mint family, many cultivars of which are extensively cultivated in temperate climates. The plant is technically a perennial, though it is a short-lived one often losing vigor as time passes by. Lavender is extremely useful around fruit trees due to its repellant qualities, many insects and animals find it repulsive and will therefore avoid it all costs. Besides benefiting the fruit tree, lavender will benefit many other types of plants and should therefore be incorporated into any garden plan.

Tansy (*Tanacetum vulgare***)** : Is a herbaceous perennial flowering plant of the Aster family. Tansy is commonly cultivated and used for its insect repellent properties. It is used as a biological pest control in organic gardens and sustainable agriculture. In England, Tansy is placed on window sills to repel flies, sprigs are placed in bed linens to drive away pests, and it has been used as an ant repellent.

Southernwood (*Artmesia abrotanum*): A flowering plant native to Europe. The growing plant tends to repel fruit tree moths when grown in an orchard; the fresh plant can also be rubbed on the skin to deter other insects. This plant is commonly dries and used in the house to repel ants and other indoor pests.

Nasturtium (*Tropaeolum majus*): Commonly known as Nasturtium literally means "nose twister" or "nose-tweaker", a reference to the peppery scent and taste of the flowers. Nasturtium is used in herbal medicine for their antiseptic and expectorant qualities. When planted under apple trees it is a powerful deterrent of the notorious codling moth. Pungent aroma and peppery taste of plant repels bugs, deters aphids, whiteflies, squash bug and cucumber beetles. One of the best plants at attracting predatory insects.

Hyssop (*Hyssopus officinalis*): A herbaceous plant as an antiseptic, cough reliever, and expectorant, it is commonly used as an aromatic herb. Drought tolerance makes this an ideal plant for underneath the canopy of a fruit tree, flowers make it a beneficial insect attractor. Hyssop shares many of the same benefits as mint since they are from the same family, though it is not as invasive so it is typically more suited to inter planting than mint.

Wormwood (*Artemesia absinthium*): It is a herbaceous, perennial plant with a fibrous root system. A powerful animal repellant suitable for plantings at the edge of properties. Wormwood is also a powerful insect repellant; it can be made into a tea or applied as sporadic mulch throughout the garden. Wormwood produces a powerful poison and therefore should never be used directly on food crops, applications should be indirect.

Dandelion (*Taraxcum officinales*): Tap-rooted biennial or perennial herbaceous plants, native to temperate areas of the world. Dandelions are thought to have evolved about thirty million years ago in Eurasia, they have been used by humans as food and herb for much of recorded history. Dandelions are one of the first plants to bloom in the spring and therefore are a very important source of nectar and pollen early in the season. Its tap-root will bring up nutrients for shallower-rooting plants, and add minerals and nitrogen to the soil. Dandelions are even said to emit ethylene gas which helps fruit ripen

Borage (*Borago officnalis*): One of the best bee-attracting plants. Its periwinkle blue blossoms are edible, and it self-seeds readily, but is not aggressive. A borage ad traces minerals to the soil and is a good addition to the compost pile and fruit tree mulch. It is said to benefit any plant it is growing next to by increasing resistance to pests and plant disease.

Chamomile: (*Matricaria recutita*): Host to hoverflies and wasps. A low-growing annual that accumulates calcium, potassium and sulfur, later returning these nutrients to the soil at the end of its cycle. Will re-seed and can tolerate many soil conditions. Growing chamomile of any type is considered to be a tonic for anything you grow in the garden.

Chives (*Allium schoenoprasum*): Great companion to fruit trees. Planted among apple trees, it helps prevent scab, but it takes about three years for the chives to prevent the disease.

Comfrey (*Symphytum officinale*): Large leaves die back each year, making it good mulch. 'Mines' nutrients by sending down a long tap root that can go as deep as ten feet. Its taproot enables it to accumulate minerals and vitamins in its leaves, including calcium, phosphorous, potassium, magnesium, iron, and vitamins A, C and B-12. When the leaves are composted, these minerals and vitamins are returned to improve the soil and made available to plants.

References

Kumar, N. (1997). Introduction to Horticulture, *Rajlakshmi Publication*, Nagercoil, pp: 15.47. 15.50

Singh, J., Arya, C.K., Bhatnagar, P., Jain, S.K. and Pandey, S.B.S. (2012). Intercropping in orchards is better option. *Indian Horticulture.* **1**: 5-7.

LEAD LECTURE - 17

Horticulture based agroforestry in arid region of Rajasthan

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Arid regions of the world are diverse in terms of climate, soils, vegetation, animals and life style and activities of people. The binding feature of all arid regions in the world is aridity. Of the total area of arid zones of the world, Africa, accounts for 46.1 per cent followed by Asia (35.5 %). Majority of rest 19.4 per cent of arid zones are spread over in Australia, North America (Mexico and Southern part of USA), and South America. The Indian arid zone covers around 12 per cent of country's geographical area occupying 31.8 million ha of land. The hot Indian arid zone is spread in 31.8-million-hectare area of which major part is in northwestern India (28.57 m ha) and some in southern India (3.13 mha). It covers parts of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab and Rajasthan states of India (Table 1 and Fig. 1). The arid regions of Rajasthan, Gujarat, Punjab, and Haryana together constitute Great Indian Desert, better known as Thar. As arid western Rajasthan accounts for 61 per cent of hot arid region of country, therefore it is considered principle hot arid region. Major part of it occurs between Aravalli ranges on the east and southeast and Thal desert of Pakistan (Thal desert is simply the western extension of Thar, only name has been changed) which is spread up to Suleman Kithara ranges in extreme west.

The region is characterized by frequent drought and extremes of aridity due to low to erratic rainfall (100-420 mm/year), extremes of temperature (-5 to 50°C), long sun shine duration (6.6-10 hours), low relative humidity (30-80%), high wind velocity (9-13 kmph) and high evapo-transpiration (1500-2000mm). Nearly 70 per cent of the region is occupied by light textured sandy to sandy loam soils. Poor fertility, low water holding capacity, high erosion and undulating topography pose problem to soil management in this region. On irrigated lands the ground water availability is meager and problematic particularly due to deep water table, high salinity and negligible recharge. Sand dunes are a dominant land formation of the region. More than 58 per cent of the area is sandy and intensities of dunes vary place to place. In general, soils contain 1.8-4.5 per cent clay, 0.4-1.3 per cent silt, 63.7 – 87.3 per cent fine sand and 11.3 – 30.3 per cent coarse sand. Vegetation constitutes primary source of life support where animal husbandry being major vocation of people that depends entirely on natural vegetation, besides being of direct economic relevance, provides stability to wind prone sandy friable surface covering nearly two-third of the region. Further, inhospitable climate, too deep or too shallow soils with low moisture and poor fertility, deep underground water, which is often brackish or saline, coupled with intense biotic pressure permits specialized plants, which are well adapted to these climatic, edaphic and biotic adversities and fluctuations. With the increasing biotic pressure, most of the arid and semi-arid regions are confronted with the challenges of producing more per unit land with uncertain and dwindling supplies of water.

The production and life support system in this part of hot Indian arid zone are constrained by climatic limitations. The human population density of this part of the country is quite high (127 person/km2) as compared to global average of 6–8 persons per km^2 for arid zones. Large tracts of

Table 1. Distribution of arid regions in different states of India

State	Area (million hectares)	Total percentage
Rajasthan	19.61	61.00
Gujarat	06.22	19.60
Punjab and Haryana	02.73	09.00
Andhra Pradesh	02.15	07.00
Karnataka	00.86	03.00
Maharashtra	00.13	00.4
Total	31.70	-

Bhandari *et al.*, 2014

lands in Thar desert region of Rajasthan having widely scattered trees/shrubs of various species in association with crops of food grain and fodder as the best example of traditional agroforestry. To overcome this adverse effect, Agroforestry is way of life in arid western Rajasthan and this approach has been widely advocated as a means to harmonize use of scarce inputs so as to make production system sustainable and climate smart. There are many pathways through which agroforestry qualify as an adaptation to climate change, especially in arid regions of the country. In fragile ecosystems of hot arid regions of India, agriculture alone cannot be a dependable enterprise, hence the desert dwellers with their traditional wisdom are integrating forestry into farming since ages in order to confer stability and generate assured income (Narain and Tewari, 2001).

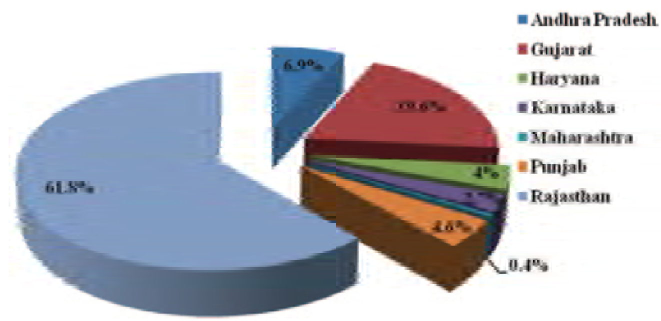

Fig. 1. Distribution of hot arid region in different states of India
Bhandari *et al.*, 2014

Fruit based diversified cropping system for arid region

In the hot arid region of Rajasthan, agricultural development is a challenging task. Crop yield under arid conditions is low and uncertain. The climate is hostile, soils are infertile and unproductive, and biotic pressure is intense. Agriculture is subject to uncertainty due to erratic and low rainfall. About 95 per cent area of the arid western Rajasthan depends upon monsoon rains for crop production. Raising trees and shrubs in the arid zone ensures against drought due to production of wood, leaves, pods or fruits even under such difficult conditions. In such circumstances, growing fruit trees with crops can meet the need of desert dwellers in terms of balanced diet, fuel-wood, fodder and other useful products. Fruit based cropping system is now considered to be the most ideal strategy to provide food, nutrition and income security to the people (Awasthi and Pareek, 2008). Integration of annual crops with fruit trees yields multiple outputs that ensure production and income generation (Randhawa, 1990 and Osman, 2003) in a sustainable manner. Natural resources (land, solar radiation, water, soil) as well as socio-economic inputs (labour, credit, power, market infrastructure) are efficiently utilized. Crop productivity under tree canopy is enhanced due to improved soil fertility and ameliorative influence of shade by reducing understorey temperature and evapotranspiration (Bunderson *et al*., 1990). Incorporation of fruit trees into the cropping system is more remunerative. It increases the resilience of the system over time. It enables to

- Maximize system productivity on annual basis
- Utilize resources with high efficiency through due consideration of various interactions and direct, residual and cumulative effects occurring in soil-plant-atmosphere continuum
- Intensify input use *vis-à-vis* quality of environment
- Impart sustainability of farm resources and environment in long term perspective
- Some of the horticultural crops which are suitable in arid region of Rajasthan are given below.

Indian Jujube (*Ziziphus mauritiana* Lamk.)

The Indian jujube (Ber) of family Rhamnaceae is one of the most ancient cultivated fruit trees in north Indian plains. It grows even on marginal lands or inferior soils where most other fruit trees either fail to grow or give very poor performance. It is regarded as the king of arid zone fruits and also as poor man's apple. There are three main species found in the country. The *Z. mauritiana* is the main species of commercial importance with its several varieties. *Z. nummularia* is prized for leaves (rich in protein) which provide fodder (Pala) for livestock. The third one, *Z. rotundifolia* also bears edible fruits but of smaller size. It is used as rootstock for commercial Indian jujube. The seeds contain saponins, jujubogenin and obelin lactone. Jujube fruits contain fairly high amount of vitamin C, besides vitamin A, B, protein, calcium and phosphorus (Jawanda and Bal, 1978).

It is a perennial hardy fruit tree which gives income from multiple products such as fruits, fodder and fuel wood even in severe drought conditions to the resource deficient farmers. It is the only fruit crop which can give good returns even under rainfed conditions and can be grown in a variety of soils and climatic conditions ranging from sub-tropical to tropical.

Indian Mesquite (*Prosopis cineraria* (L.) Druce)

Indian mesquite (khejri) of family Fabaceae is an important component of farming system and plays significant role in the economy of Indian desert. It is found growing in the arid and semi-arid parts of Rajasthan, Gujarat, Haryana, Punjab, Delhi and some parts of southern India. This tree grows well in all sorts of climatic constraints which is evidenced by the fact that new foliar growth, flowering and fruiting occur during extreme dry months (March–June) when most other trees of the desert remain leafless or dormant. Because of its multiple economic value and suitability in agro forestry systems, it is conserved in arable land where its population is regulated by the farmer. All arid land forms except hills and saline depression receiving an average rainfall of 150–500 mm are having good density of the tree. The immature pods are rich in crude protein, carbohydrates and minerals. Duhan *et al.* (1992) recorded 18 per cent crude protein, 56 per cent carbohydrates, 0.4 per cent each of phosphorus and calcium and 0.02 per cent iron in immature pods, which are used as vegetable both fresh as well as after dehydration, while ripe dried pods having 9–14 per cent crude protein and 6–16 per cent sugar (Arya *et al.* 1991) can be powdered and used in the preparation of bakery items such as biscuits and cookies. The variability in pod quality traits is most important from the horticultural quality point of view. Diversity was observed in pod characteristic such as taste, tenderness, fiber content, color, length, thickness, seed number, seed size, protein content and mineral constituents (Pareek, 2002).

Indian Gooseberry (*Emblica officinalis* Gaertn.)

The Indian gooseberry (Aonla) of family Euphorbiaceae is being cultivated in India since Vedic Era. As a result of intensive research and development, it has attained commercial status and also proved to be potential fruit crop for arid ecosystem. It is hardy, prolific bearer and highly remunerative even without much care and can be grown in variable agro-climatic and soil conditions. The fruits are recognized for their nutritive, medicinal and therapeutical values and are rich source of vitamin C (4–9 mg/g^{-1}), pectin, iron, calcium and phosphorus. The fruit is the main ingredient in Chayvanprash and triphala used in Ayurvedic medicine.

Indian Cherry (*Cordia myxa* L.)

Indian cherry of family Boraginaceae, locally known as lasoda is another important fruit plant suitable for arid and semi-arid regions of India. Its fruits and other parts have multiple uses in human health, nutrition and other uses. Green unripe fruits are important as fresh vegetable and pickles during April–May when availability of conventional vegetables is scarce. The species is also important ecologically in providing vegetative cover as tree component of arid farming system, preventing soil erosion and promoting biodiversity. The advantage with this species for agro forestry system is that it offers least competition with rainy season crops since its fruiting season is during summer season when main crops are already harvested. This plant also offers scope in using harvested rain water for fruit production since it requires irrigation only for 2–3 months period during summer season (April–June).

Pomegranate (*Punica granatum* L.)

Pomegranate (Anar) of family Lythraceae is an economically important commercial fruit crop of arid and semi-arid regions. Commercial plantations of pomegranate exist in Maharashtra, Gujarat, Rajasthan, Andhra Pradesh and Karnataka owing to its preference for arid climate. Its xerophytic characteristics and hardy nature makes it suitable crop for dry, rainfed, pasture and undulating land, where other fruit crops cannot grow successfully. Besides, being a favorite table fruit it is also used for preparation of juice and squash. Dried seeds give an important condiment coined as anardana. It also has medicinal value and rind is being used for dyeing cloths.

Kair (*Capparis decidua* (Forsk.) Edgew)

Kair is a multipurpose, perennial, woody shrub or small tree of family Capparaceae which grows widely without much care in the Thar Desert of western Rajasthan. It is much branched, leafless bushy and thrives well in the most adverse climatic conditions and in the soils of poor fertility. It is highly suitable for stabilizing sand dunes and controlling soil erosion by wind and water. Due to its xerophytic adaptive nature, the plant grows successfully under harsh climatic conditions. Its berry shaped unripe fruits are rich in carbohydrates, proteins and minerals used as fresh vegetables and in the preparation of pickles. Dehydrated fruits are used in the off season as vegetable either alone or in combination with other dried vegetables. In general, it is highly valued by inhabitants of hot arid areas (Meghwal and Vashishtha, 1998).

Karonda (*Carissa carandas* L.)

Karonda is an evergreen spiny shrub or a small tree up to 3 m height and suitable for arid tropics and sub-tropics. It grows successfully on marginal and wastelands. The plant is also useful for making attractive thorny dense hedge around any fruit orchard. It yields a heavy crop of attractive berry like fruits which are edible and rich in vitamin C and minerals especially iron, calcium, magnesium and phosphorus. Mature fruit contains high amount of pectin and, therefore, besides being suitable for making pickle, it can be exploited for making jelly, jam, squash, syrup and chutney, which are of great demand in the international market. Its main flowering season is March–April with fruits maturing during August–September which enables the plants to make best use of monsoon rain. However, some varieties/plant types also flower during October–November.

Bengal Quince (*Aegle marmelos* (Linn.) Correa)

Bengal quince (Bael) of family Rutaceae is an indigenous hardy fruit crop and can be grown successfully in dry areas. It is well known for its nutritional and therapeutic properties. The ripe fruits are laxative and unripe ones are prescribed for diarrhea and dysentery and are in great demand for native system of medicine such as Ayurvedic. Various chemical constituents, *viz.* alkaloids, coumarins and steroids have been isolated and identified from different parts of bael tree such as leaves, wood, root and bark by various workers. The marmelosin content of fruit is known as the panacea of the stomach ailments.

Kinnow (*Citrus reticulata* Blanco)

Kinnow mandarin is a hybrid cultivar of citrus developed by crossing King (*Citrus nobilis*) with Willow leaf (*Citrus deliciosa*) and is extensively grown in Punjab and Rajasthan states of India. This easy peel citrus developed has assumed special economic importance and export demand due to its high juice content, special flavor, and as a rich source of vitamin C. Its beautiful golden orange color, abundant juice, excellent aroma and taste have contributed greatly to the success of this fruit.

Kachri (*Cucumus callosus* (Rottl.) Cogn)

Kachri, a drought hardy cucurbit grows naturally and is also cultivated with rainfed crops. It is a short duration crop. Flowering starts just after 30–35 days of sowing and produces 2–8 kg per vine small sized edible fruits of high nutritive value with little care. The fruits are rich in minerals specially calcium and used fresh in garnishing of vegetables. Most desert inhabitants store fruits round the year as dried slices, whole dried or in powder form for use. This is generally grown in all farming systems in combination with other rainy season crops without any competition for available soil moisture.

Major horti based agroforestry systems in Rajasthan

Based on the diversity of fruit, vegetable and other crops grown in arid region, the major cropping systems that emerge at the macro level are (Singh and Verma, 2010):

1. Horti-Agri system
2. Horti-Pastoral system
3. Horti-Agri-Pastoral system

Horti-Agri system

Growing of vegetable crops, pearl millet, moth bean, cluster bean, and gram between khejri, ber, lasoda, pilu and kair is a prevalent traditional Horti-Agri system in the arid region. Growing of fruit trees as an overstorey component and ground storey crops in association enforce the dual purpose of moisture and nutrient extraction in subsurface as well as above the soil surface (Table 2). Singh (1980) reported that in arid condition of western Rajasthan about 25-40 per cent water penetrates into murram sub-stratum during the rainfall or irrigation which is of no use for moderately rooted crops/grasses but inclusion of fruit trees under different alternate land use system due to their deep rooting characteristics, the water can be efficiently utilized by the fruit trees.

Table 2. Recommended agri-horti crops component for Indian arid regions

Growing conditions	Horticultural component			Crop component
	High storey	Medium storey	Ground storey	
Rainfed (150–300 mm)	Bordi and Indian mesquite	Jhar ber	Cucurbits and guar	Guar, moth bean, pearl millet and sesame
Rainfed (300–500 mm)	Indian cherry, Indian jujube and Indian mesquite	Jhar ber	Cowpea, cucurbits, guar and Indian bean	Cowpea, guar, green gram, moth bean, pearl millet and sesame
Irrigated	Bengal quince, Indian gooseberry Indian jujube and Indian mesquite	Guava, kinnow, karonda, lime, pomegranate and sweet orange	Brinjal, chilli, cole crops, cucurbits, garlic, okra, onion, peas, root/leafy vegetables and tomato	Chickpea, green gram, groundnut mustard and seed spices

Bhandari *et al.,* 2014

Ber based system

Growing of vegetable crops, pearl millet, moth bean, cluster bean, and gram between the trees of *Ziziphus nummularia* (Jharber), *Ziziphus rotundifolia* (Bordi) and *Z. mauritiana* is a prevalent traditional practice in the arid region. Crops like pearl millet, cluster bean and moth bean grow in association with jharber even on soil sediments in rocky plateaus near Jaisalmer and Jodhpur. Cluster bean has been found to be a good intercrop at all the locations. In agrihorticulture study involving ber plants and mung bean during subnormal years when rainfall was 51.3 per cent less than the long term average of 360 mm at Jodhpur, the yield of mung bean grown with ber was reduced by 44.2 per cent whereas under sole crop mung bean yield was reduced by 51 per cent. (Faroda, 1998). Gupta *et al.*, 2000 reported that three-year-old plantation of ber (*Z. mauritiana*) at a density of 400 plants/ha in association with green gram performed very well with a seasonal rainfall of 210mm. Intercropped green gram yielded only 160 kg ha-1 as against 620 kg ha-1 from pure crop. The fruit yield from the intercropped system increased the net profit to 2, 886. This system is however generally recommended for areas with rainfall more than 250-300mm.

Leguminous crop sown under ber (*Ziziphus mauritiana* cv. Seb) plantation produced 0.2 t/ha of grain and 0.8t/ha quality ber fruits from same land unit even when seasonal rainfall is 200mm, thus rendering a drought proofing mechanism to the system. The density of ber plants were kept 400 individuals/ha (Gupta *et al.*, 1997). The economics of this improved system indicated that in case of sole leguminous crop (mung bean) farming, the net profit per hectare was Rs. 4800/-, however, in case of ber intercropping, the profit was Rs. 8000/- per ha (Table 3). (Roy *et al.*, 2011)

Table 3. Improved agroforestry practices in horti-agriculture system (Ber+Mung bean)

Treatment	Annual Rainfall (mm)	Fruit Yield (Kg/ha)	Grain yield (Kg/ha)	Net profit (Rs. /ha)
Sole crop	200	-	520	4800
Intercropped with Ber	200	800	200	8000

Roy *et al.,* 2011

Aonla-based system

Aonla is one of the important fruit crops of arid region. However, despite its adaptability in arid climate, productivity and economic return of the crop are affected by low temperature (-2°C) and frost (CIAH, 2006) which cause economic loss to the growers. In order to mitigate the risk of total crop failure, suitable multistory crop combinations were evaluated at Central Institute for Arid Horticulture during 2004-2008 in the interspace of aonla orchard which could generate extra income, improve productivity, ameliorate and improve ecological situations (Awasthi *et al.*, 2009). Moth bean grown during kharif season was a common ground storey crop grown in rotation with *rabi* crops *i.e.*, fenugreek, chick pea, mustard and cumin. Growth parameters in terms of plant height, stem girth, canopy spread and canopy volume of aonla was recorded to be significantly more with intercrops compared with its sole plantation. Higher grain and straw yield were recorded in moth bean-chickpea (497, 1250 kg/ha) and moth bean-fenugreek (465, 1161 kg/ha) crop sequence. Amongst the *rabi* crops, grain yield of fenugreek, chickpea, mustard and cumin were higher by 28.05, 38.11, 19.96 and 36.05 per cent, respectively, when grown in association with aonla compared to its sole crops. The highest net profit (28260/ha) was obtained from moth bean-cumin cropping system, followed by moth bean-chickpea (25024/ha) cropping system. Moth bean-chickpea intercropping with aonla supplemented 22.01, 5.00 and 27.90 kg/ha nitrogen, phosphorus and potassium through crop residues, followed by moth bean, fenugreek crop sequence. In a similar study, Arya *et al.*, 2010 recorded significant differences in yield levels of perennial as well as ground storey components in multi species cropping models as compared to sole cropping. The growth and yield in perennial components were more under the multispecies cropping system, *i.e.* aonla-ber-karonda-clusterbean-brinjal and aonla-ber-karonda clusterbean- fallow. Minimum yield was recorded in sole perennial crops. Plant height, number of branches/plant, pods/silique/fruits/plants and yield was found to be superior in multispecies cropping systems of aonla-ber-karonda-clusterbean-brinjal and aonla-ber-karonda-mothbean Indian mustard as compared to sole cropping except mustard where a reverse trend was observed.

Khejri based system

Prosopis cineraria, commonly known as khejri is considered as a "Kalpvriksha" of the Indian desert. It is one the chief indigenous tree of the Indian north-western plains and gently undulating ravine lands. The trees have monolayer canopy and deep root system and provide nutritious edible pods and fuel wood to the human beings, nutritious forage to the animals and fertility to the poor soils. Farmers usually grow jowar, pearl millet, moth bean and cluster bean between the scattered khejri trees in the arid region. Puri et al. (1992, 1994) observed the yield of chickpea also improved and resulted in higher soil fertility and moisture conservation. Maximum net return (15,197/ha) and benefit-cost ratio (3.73) were obtained when pearl millet in kharif was followed by toria in *rabi* between the khejri trees (Kaushik and Kumar, 2003). Yield of fodder crops during both kharif and *rabi* seasons was higher in association with khejri trees as compared to sole cropping (Table 4).

Table 4. *Prosopis cineraria* based cropping system

Location	Average rainfall (mm)	Crops
Bikaner	240	
Jodhpur	290	Jowar, Pearl millet, Moth bean, Cluster bean and Sesame
Barmer	350	
Nagaur	362	
Pali	490	

Awasthi *et al.*, 2007

Cordia based system

Lasora (*Cordia myxa*.) also known as cherry of the desert, owing to its higher productivity, suitability to adverse soil and climatic conditions and high processing value is now becoming popular as monoculture and horti-agri system. Cordia myxa has been observed to be a suitable tree in association with which several crops can be grown (Table 5).

Table 5. Cordia based agroforestry system in arid zone

Location	Av. rainfall (mm)	Crops	
		Rainfed	Irrigated
Jodhpur (Pipad)	290	Pearl millet, Cluster bean	Rapeseed, mustard, Wheat, Green gram
Pali and adjoining areas	490	Vegetables, Pearl millet, cluster bean, taramira	Raya, Wheat, Green gram
Jalore, Sirohi	434-544	Vegetables, cluster bean, Pearl millet	Rapeseed, Mustard
Bikaner, Barmer	243-350	Pearl millet	Rapeseed, Mustard

Awasthi *et al.*, 2007

Horti-pastoral system

A combination of fruit trees and pasture species, commonly known as "Horti-pastoral system" is one of the several ways to satisfy human needs and alleviate cattle hunger. The system involves growing of fruit trees and grasses in combination during the initial and later years of trees growth as per the suitability of the species. Fruit trees usually form the first tier whereas grasses are grown as ground storey crop. Such system sustains the requirement of rural masses for fodder through leaves, grasses and fruits, which is a much-needed component in human diet. In such system it is however, important to ensure that forage crops do not effect the growth and development of the main crop. Trees such as Jharber or bordi are commonly grown in the rural areas and is an important top feed species. Even in drought years when crop fail, the top feed of this species comes to the rescue of the farmers. The trees are heavily lopped during winter for its leaf fodder known as "pala". One-hectare area of jharber may yield about 125 kg of pala. The perennial grasses such as sewan, anjan and dhaman besides karad (*D. annulatum*), *P. antidotale* and *Schima nervosum* are found in natural pasturelands, gochar, oran and range lands and give high forage yield under rainfed conditions.

Suitable ber based pastoral combinations for arid regions are ber-anjan; jharber-anjan; jharber-sewan and boradi-anjan. Results of growing different grass species between productive and unproductive ber trees with varying degree of reports have been reported. Ber based-pastoral studies on sandy rangelands of Rajasthan revealed that *Cenchrus ciliaris- Ziziphus mauritiana* system produced 1.2 t/ha forage and did not affect the fruit yield (Sharma and Diwakar, 1989). Ber trees were planted at spacement of 6 X 6 m and grass *Cenchrus ciliaris* was introduced between tree rows after third year. On average, the dry grass production was 1.55 t/ha/year (Tewari *et al*., 1999). The fruit, leaf fodder and fuel wood production from ber was 2.77, 1.87, 2.64 t/ha/year, respectively (Table 6).

Table 6. Horti-pastoral system in farmers field

Year	Dry grass (t/ha)	Tree product		
		Fuelwood (t/ha)	Leaf fodder (t/ha)	Fruit yield (t/ha)
1	1.50	3.10	2.13	3.10
2	1.67	2.74	1.80	2.74
3	1.42	2.46	1.71	2.49
4	1.66	2.49	1.63	2.85
5	1.48	2.43	2.01	2.80
6	1.57	2.63	1.94	2.67
Average	1.55	2.64	1.87	2.77

Tewari *et al.,* 1999

Horti-agri-pastoral system

Horti-Agri-Pastoral system refers to the combinations of fruit crops along with other agricultural or fodder crops in a manner that farmers gets some return throughout the year. This is however, variable and depends on the demand of a farmer and agro-climatic situations. For instance, if a farmers approach is livestock oriented, he can diversify his crops such as Ber-Kair- Grass or Ber-Pilu-Lana (*H. salichornicum*) or Ber-Drumstick-Grass, Through these systems the farmers can obtain fodder through ber, pilu, lana (a preferred feed for camels) and moringa leaves as top feed whereas fodder through grasses. Lana (*Haloxylon salichornicum*) is very common and preferred feed by the camels. It is naturally found in saline patches of arid region. The crop models have to be critically adjusted seeing into the rooting behaviour, fruiting period and food cum fodder demand particularly during the lean period. The crop-pasture components selected in the models can be made to interact synergistically to increase the productivity and generate higher net returns. While growing agricultural and fodder crops in association with fruit trees due consideration should be given on tree morphology and other characteristic so that there is a symbiotic association between over storey and ground storey components.

Role of horti based agroforestry in arid region of Rajasthan

Production and livelihood improvement

Agroforestry systems are helpful in maintaining soil productivity at optimum levels over a long period of time, when compared to agricultural crops alone, because the leguminous trees used in agroforestry systems fix nitrogen. Leaf litter also generally aids micro-nutrients in the soil. Combining agricultural crops with trees helps in increasing the productivity of the land. Studies were initiated at Arid Forest Research Institute, Jodhpur (AFRI) in 1991 on several agroforestry models with varying tree densities and crop combinations. Intercropping and a low tree density at 400 trees ha-1 were beneficial for *P. cineraria* (khejri) compared to an uncropped and high tree density of 1600 trees ha-1. In another experiment, it was observed that forage yield decreased with increasing density of P. cineraria trees (Ahuja, 1980).

In view of the increasing fodder and fruit requirement by rural people for themselves and their livestock, studies with fodder and fruit yielding tree species in agroforestry system were started at AFRI in July 1994. Three tree species, *viz. Emblica officinalis*, *Colophospermum mopane* and *Hardwickia binata*, were planted. The crop was harvested and the yield of mung bean was recorded. The highest yield was found under *Emblica officinalis* (330 kg ha^{-1}) followed by *C. mopane* (313 kg ha^{-1}) and *H. binata* (303 kg ha^{-1}), respectively (ICFRE, 1995). The characteristics of undergrown crops also determine the impact of canopy cover. Agroforestry gives more income to the farmer per unit area of land than pure agriculture or forestry. Agroforestry contributes to livelihood improvement in arid regions of India, where people have a long history of accumulated local knowledge. Arid regions are particularly notable for ethano-forestry practices and indigenous knowledge system on growing trees on farm lands. The economics of previously discussed traditional agroforestry systems of arid western Rajasthan indicated that net B:C ratio of such systems is generally on positive sides (Table 7).

Table 7. Economics of traditional agroforestry systems of arid western Rajasthan

Agroforestry system	Expenditure (Rs./ha)	Returns (Rs./ha)			Gross returns (Rs./ha)	Net returns (Rs./ha)	Net B:C ratio
		Crops	Fuel wood	Leaf fodder			
P. cineraria-A. nilotica based	1850	4103	1230	870	6203	4353	2.3
P. cineraria based	1550	3670	600	420	4690	3140	2.0
Z. *spp. - P. cineraria* based	1550	1506	620	600	2726	1176	0.7
Z. spp. - *P. cineraria - Salvadora* spp. based	1500	1400	500	500	2400	900	0.6

Nutrient content of important fruit trees from arid zone of Rajasthan

Forests have provided food and shelter to man since ages. About 20 per cent of the plants occurring in the forests are reported to have direct utility to mankind. Around 600 plant species in Indian forests are enumerated to have food value. Arid zone vegetation comprises a wide range of edible fruit bearing and food producing species *viz*., *Capparis decidua* (Kair), *Cordia dichotoma* (lasora), *Ziziphus mauritiana* (ber), *Ziziphus nummularia* (Bordi), *Salvadora oleoides* (Jal), *Balanites aegyptiaca* (Hingota), *Prosopis cineraria* (Khejri) *etc*., which play an important role in the nutrition of children in rural and urban areas alike and are relished by them. Most of these fruits are rich sources of protein and energy. Kair is a rich source of fibre, vitamin A and vitamin C. Ber is richer than apple in protein, phosphorous, calcium, carotene and vitamin C. However, they are often undervalued and underutilized as more exotic fruits become accessible. Also most of these are not cultivated and there is only scant and dispersed knowledge about them. Their production and consumption provides a dietary supplement as well as commercial opportunity. Potential fruit species from arid region are reviewed in context with their nutrient contents (Rathore, 2009).

Soil and environmental improvement

Agroforestry practices play an important role in improving the fertility of the soils. Increases in amount of nitrogen and phosphorus and other macro- and micronutrients are reported under the growth of 14-yr-old plantation of *P. cineraria,* as compared to a bare site and *Prosopis juliflora* of the same age (Shankarnarayan, 1984). It is reported that the forage species produce higher biomass under *P. cineraria* tree canopy due to a high fertility status (Aggarwal *et al.,* 1976 and Singh and Lal, 1969). Soil profile characteristics have been studied in *P. cineraria* and *A. nilotica* plantations (Singh and Lal, 1969). The silt + clay increased up to a depth of 120 cm, and at subsequent depths the reverse trends were observed. However, in open field devoid of trees, the increase in silt + clay was found only up to a depth of 90 cm (Singh and Lal, 1969). Such improvements in soil physical conditions resulted in the maintenance of higher soil moisture beneath these trees (Gupta and Saxena, 1978).

Windbreaks and shelterbelts are known to have beneficial effects on agricultural production throughout the world (Frank *et al*., 1976). Experimental shelterbelts of *A. nilotica* and *Dalbergia sissoo* were established over 102 km in square blocks at the Central Mechanized Farm of Central Arid Zone Research Institute (CAZRI), Jodhpur at Suratgarh in Bikaner District, Rajasthan. Reduction in wind speed was greater in the monsoon period (July-September) than the summer period before the monsoon (April-June). There was a 5-14 per cent reduction in evapotranspiration from April to July. In general, the use of shelterbelts brought about a 50 per cent reduction in the magnitude of wind erosion. In the *Cassia siamea* shelterbelt, the soil loss was 184.3 kg ha^{-1}, while in bare soil (*i.e.* without any shelterbelt) it was 346.8 kg ha^{-1} (Roy *et al.,* 2014).

Agroforestry systems play a critical role in controlling soil erosion

There are several ways by which climate change manifests soil degradation. Higher temperatures and drier conditions lead to lower organic matter accumulation in the soil resulting in poor soil structure, reduction in infiltration of rain water and increase in runoff and erosion (Rao *et al*., 1998) while the expected increase in the occurrence of extreme rainfall events will adversely impact on the severity, frequency, and extent of erosion (WMO, 2005). The woody component in agroforestry systems helps in reducing soil erosion which is the most harmful abiotic stress in arid region (Table 8). It was observed if rows of trees are planted right angle to wind direction a tremendous amount of soil drop can be checked from agricultural fields. The shelterbelts on agricultural fields form a type of agroforestry practice (Gupta *et al*., 1984).

Table 8. Effect of different type of shelterbelts on soil erosion

Type of shelterbelt	Total amount of soil loss (kg/ha)		
	Year I	Year II	Mean
Prosopis juliflora	93.2	609.3	351.2
Cassia siamea	91.5	277.1	184.2
Acacia tortilis	106.0	494.1	300.0
Agricultural field without trees	262.7	831.0	546.8

Roy *et al.,* 2014

Carbon sequestration through horti based agroforestry systems

Carbon sequestration in different agroforestry systems occurs both belowground, in the form of enhancement of soil carbon plus root biomass and aboveground as carbon stored in standing biomass (Fig. 2). Average sequestration potential in agroforestry has been estimated to be 25 t C ha^{-1} over 96 million ha of land in India and 6-15 tC ha^{-1} over 75.9 Mha in China (Ravindranath *et al*., 2008). Watson *et al*., (2000) estimated carbon gain of 0.72 Mg C ha-1 yr^{-1} on 4000 million ha land under agroforestry, with potential for sequestering 26 Tg C yr-1 by 2010 and 45 Tg C yr^{-1} by 2040. Proper design and management of agroforestry practices can make them effective carbon sink. As in other land-use systems, the extent of C sequestered will depend on the amount of C in standing biomass, recalcitrant C remaining in the soil and C sequestered in wood products. Average carbon storage by agroforestry practices has been estimated as 9, 21, 50 and 63 Mg C ha^{-1} in semiarid, sub-humid, humid and temperate regions (Montagnini and Nair, 2004).

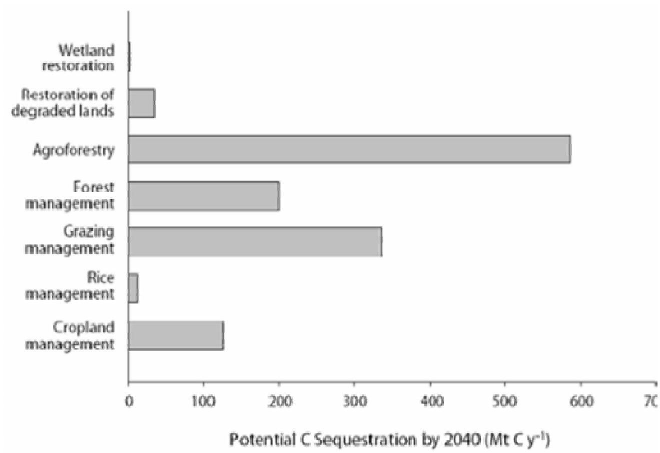

Fig. 2. Carbon sequestration of different land management options
(Adopted from IPCC 2000)

References

Aggarwal, R.K., Gupta, J.P., Saxena, S.K. and Muthana, K.D. (1976). Studies on soil physicochemical and ecological changes under twelve-year-old five desert tree species of Western Rajasthan. *Indian Forester*, **1**(2): 863-872.

Ahuja, L.D. 1980. Grass production under khejri. Central Arid Zone Research Institute (CAZRI), Monograph No. 11, CAZRI, Jodhpur (Raj.), India, pp. 28-30.

Annonimous (1995). Annual Report of Indian Council of Forestry Research & Education, Dehradun, India.

Annonimous (2000). Special Report on Land use, Land use change and forestry. Summary for Policy makers. Geneva, Switzerland. 20 p.

Annonymous (2005). Climate and Land degradation. WMO – No. 989, 2005, World Meteorological Organization.

Annonymous (2006). Annual Report (2005-2006). Research Achievements. Plant genetic resource management in aonla. CIAH. pp 7-8.

Arya, R., Awasthi, O.P., Singh, J. and Arya, C.K. (2010). Comparison of fruit based multi-species cropping system under arid region of Rajasthan. *Indian Journal of Agricultural Sciences*, **80** (5): 423-426.

Awasthi, O. P. and Pareek, O. P. (2008). Horticulture-based cropping system for arid regions-a review. *Range Management and Agroforestry*, **29** (2): 67-74.

Awasthi, O.P, Saroj, P.L., Singh, I.S. and More, T.A. (2007). Fruit based diversified cropping system for arid regions. Technical bulletin: 25. Published by T.A. More, Director, CIAH, Beechwal, Bikaner, Rajasthan.

Awasthi, O.P., Singh, I.S. and More, T.A. (2009). Performance of intercrops during establishment phase of aonla (*Emblica officinalis*) orchard. *Indian Journal of Agricultural Sciences*, **79** (8): 587-91.

Bhandari, P.R., Meghwal and Lodha, S. (2014). Horticulture Based Production Systems in Indian Arid Regions. ***In***: Sustainable Horticultural Systems, Sustainable Development and Biodiversity (ed. D. Nandwani), Springer International Publishing Switzerland 2, DOI 10.1007/978-3-319-06904-3-2.

Bunderson, W.T., Wakeel, A.E., Saad, Z. and Hashim, I. (1990). Agroforestry practices in Western Sudan. ***In***: Planning for Agroforestry (eds. W. Budd *et al*). New York, Elsevier Science Publisher.

Duhan, A., Chauhan, B.M. and Punia, D. (1992). Nutritional value of some nonconventional plant foods of India. *Plant Foods Hum. Nutr.*, **42**: 193-200.

Faroda, A.S. 1998. Arid zone research: an overview. ***In***: Fifty Years of arid Zone research in India (ed. A.S. Faroda and Manjeet Singh). CAZRI, Jodhpur. pp: 1-16.

Frank, A.B., Harris, D.G. and Wills, W.O. (1976). Influence of windbreaks on crop performance and snow management in North Dakota. ***In***: (ed. R.W. Tinus). Shelterbelts on the Great Plains, Proceedings of Symposium, GPAC Publication No. 78, Denver Co, USA, pp. 41-48.

Gupta J.P. and Saxena, S.K. (1978). Studies on monitoring of dynamics of moisture in the soil and the performance of ground flora under desertic communities of trees. *Indian Journal of Ecology*, **5**:30-36.

Gupta, J.P., Rao, G.G.S.N., Ramakrishna, Y.S. and Ramana, R. (1984). Role of Shelterbelts in Arid zone. *Indian Farming*, **34** (7): 29-30.

Jawanda, J.S. and Bal, J.S. (1978). The ber, highly paying and rich in food value. *Indian Horticulture*, **3**(3): 19-21.

Kaushik, N., Kumar Virendra (2003). Khejri (*Prosopis cineraria*) based agroforestry system for arid Haryana, India. *Journal of Arid Environment*, **55**: 433-450.

Montagnini, F. and Nair, P.K.R. (2004). Carbon sequestration: An underexploited environmental benefits of agroforestry systems. Agroforestry systems, **61**: 281-295.

Narrain, P and Tewari, J.C. (2005). Trees on Agricultural fields: a unique basis of life supports in Thar Desert. ***In***: Multipurpose Trees in the Tropics: Management and Improvement Strategies (eds. V.P. Tewari and Srivastava). Arid Forest Research Institute, Jodhpur, pp.516-523.

Osman, M. 2003. Alternate landuse systems for sustainable production in rainfed areas. ***In***: Agroforestry-potential and opportunities (eds. P.S. Pathak and Ram Newaj): pp. 177-181.

Puri, S, Kumar, Anil and Kumar, A. (1992). Management and establishment of *Prosopis cineraria* in hot deserts of India. ***In***: Integrated land use management for tropical agriculture: Proceedings Second International Symposium Queensland, 15 September to 25 September 1992. Module 2, 46: 1-46.

Puri, S., Kumar, A. and Singh, S. (1994). Productivity of *Cicer arietinum* (chickpea) under a *Prosopis cineraria* agroforestry system in the arid regions of India. In: Special issue: Acacia and Prosopis. *Journal-of-Arid-Environments*, **27**(1): 85-98.

Randhawa, K. S. (1990). Pulse based cropping system in juvenile orchards. International Symposium on Natural Resource management for sustainable agriculture.

Rathore, M. (2009). Nutrient content of important fruit trees from arid zone of Rajasthan. *Journal of Horticulture and Forestry*, **1**(7): 103-108.

Ravindranath, N.H., Chaturvedi, R.K. and Murthy, I.K. (2008). Forest Conservation, afforestation and reforestation in India: Implications for Forest Carbon Stocks. *Current Science*, **95**(2): 216-222.

Roy, M.M., Tewari, J.C. and Moola ram (2011). Agroforestry for climate change adaptations and livelihood improvement in Indian hot arid regions. *International Journal of Agriculture and Crop sciences*, **3**(2): 43-54.

Shankarnarayan, K.A. (1984). Influence of *Prosopis cineraria* and *Acacia nilotica* on soil fertility and crop yield. ***In***: Agroforestry in Arid and Semi-Arid Zones (ed. K.A. Shankarnarayan)., Central Arid Zone Research Institute (CAZRI) Publication No. 24, Jodhpur (Raj.), India, pp. 59-66.

Sharma, S.K. and Diwakar, G.D. (1989). Economic evaluation of hortipastrol system on arid region of western Rajasthan. *Indian Journal of Range Management,* **10** (2): 119-122.

Singh, K.S. and Lal, P. (1969). Effect of khejri *(Prosopis spicigera* linn.) and Babool *(Acacia arabica)* trees on soil fertility and profile characteristics. *Annals of Arid Zone*, **8**: 33-36.

Tewari, J.C., Bohra, M.D. and Harsh, L.N. (1999). Structure and production function of traditional extensive agroforestry system and scope of intensive agroforestry in Thar desert. *Indian Journal of Agroforestry*, **1**(1): 81-94.

Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N.H., Vetardo, D.J. and Dokken, D.J. (Eds.). (2000). Land use, Land use change, and Forestry. A special report of the Intergovernmental Panel on climate change. Cambridge University Press, NY.

LEAD LECTURE – 18

Utilising non-conventional niches and horticultural plantations for fodder security in India

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Livestock sector has a share of about 27 per cent to total GDP contributed by Indian agriculture. Productivity of Indian livestock is much lower compared to developed countries. The main causes behind lower output are under-nourishment of livestock and lack of availability of good quality of green & dry fodder and concentrates. At present there is deficit of 18 per cent in dry fodder, 35 per cent in green fodder and 28 per cent in feed concentrate and with the current level of growth in forage resources, there will be 18.4 per cent deficit in green fodder and 13.2 per cent deficit in dry fodder in the year 2050. The availability of green fodder will be more difficult under changing climatic conditions prevailing in the country in terms of floods, intermittent dry spells, drought; cyclones etc will lead to livestock rearing will further become costlier. In recent years change in climatic situations has greater impact on sustainability of fodder and food crops in the system. To mitigate the effect of climate change, climate resilient forage production systems need to be evaluated with efficient utilization of available natural resources and to improve the production and productivity of forage crops under different farming situations and land use management. The area under fodder crop is continuously declining due to ever increasing pressure on arable lands for food and cash crops. There is very little chance to increase area under arable land. However, there are potential niches for utilisation and integration of forages particularly perennial grasses, shrubs & spineless cactus in farm/field boundaries, road side, river basins and considerable areas under orchards/ grooves. Therefore, ample scope is there for maximizing forage production in space and time, through integration of forage crops in established or grown up plantations of MPTS/fruit orchard or establishing plantations in degraded lands. Fruit and multipurpose tree species (MPTS) based farming system (Horti-silvi-pastoral, silvi- pastoral and horti-pastoral system), along with livestock helps in improving livelihood and economic sustenance of framers in arid and semi-arid as well as in coastal areas. The holistic approach of utilisation of unutilised lands through integration in wide spacing of orchards or growing fodder as sole stand in boundaries has tremendous potential towards fodder security in India.

LEAD LECTURE – 19

Poly4 – A novel natural mineral fertilizer to offer balance nutrition of horticultural crops and sustaining soil fertility with minimal carbon footprint

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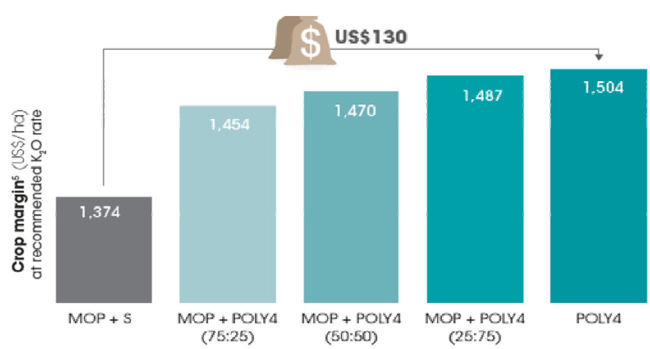
Indian Agriculture is changing pace in terms of socio-economic transformations developing towards economic enterprise from subsistence agricultural livelihood. Accelerated economic growth and urbanizations led by market and business focused growth coupled with Industrialization and IT in last three decades brought a paradigm shift of agrarian socio-economy which was earlier considered as subsistence.

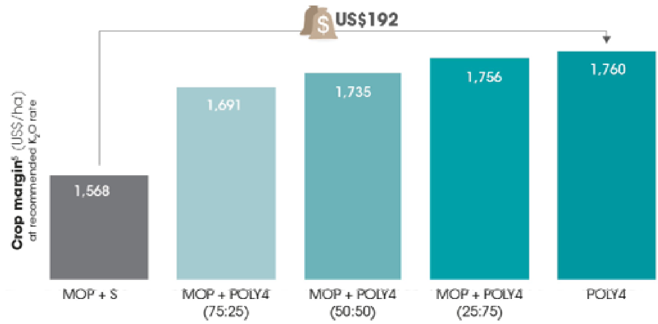
The demographic changes and improvement in middle class horizon preference of food habits are changing dramatically and hence, consumption of fruits and vegetables recorded fast growth and due to absence of quality farm produce import of produce are reported to have reached over 2687.5 crore rupee in horticulture segment and 17.4 million tons of edible oil import is estimated in year 2018-19, which was 16.3 MMT in 2017-18 (USDA Gain Report, 2018) and the oil import bill was accounted 14710 crore in year 2016-17.

Indian agriculture land holdings are dominated by small and middle size land holders therefore application of modern agro-technologies has limiting impact on yield and quality improvement due to poor farm credit availability and lack of market access. POLY4 (Polyhalite) -a multi-nutrient mineral fertiliser is a ray of hope for Indian farmers offering improvement of yield and quality thereby raising farm income but also sustaining soil health. Poly4 is an evaporite mineral, a hydrated sulphate of potassium, calcium and magnesium with formula: $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$. Polyhalite crystallizes in the triclinic system, although crystals are very rare. The normal habit is massive to fibrous. It is typically colourless, white to grey, Poly4 consist of 14 per cent K2O, 19 per cent Sulphate Sulphur, 6 per cent MgO and 17 per cent CaO naturally along with traces of micro-nutrients, POLY4 is also has organic certifications. Reduced carbon emission is another benefit of using POLY4, since, its manufacture from a natural mineral does not require chemical beneficiation. MOP and SOP products, on the other hand, produce 3-4 times the amount of CO_2 emissions as POLY4on a unit K basis.



Source: Final report of 'Assessment of POLY-4 (Polyhalite) for productivity, quality of potato and K, S use efficiency in soils of western plain zone of Uttar Pradesh' Benefit cost analysis of CRC SVBUA&T Meerut

Global average of 15 technical trials of Poly4 on potato bridge14 per cent yield gap to MOP as K source, In Potato trials with SVBPU&T Meerut POLY4 yielded substantial economic returns over 9000-13000 rupees per hectare to Potato growers as compare to traditional fertiliser applications. The trial conducted in CRC of SVBPUA&T Meerut results and ARS Buland Shahar:



Source: Final report of 'Assessment of POLY-4 (Polyhalite) for productivity, quality of potato and K, S use efficiency in soils of western plain zone of Uttar Pradesh' Benefit cost analysis of ARS, Buland Shahar of SVBUA&T Meerut

The POLY4 trial on Potato conducted in 2017-18 at Agriculture Research Station Bulandshahar delivered better marketable yield with higher economic returns to potato growers. Along with these economic benefits post-harvest soil nutrient status was also improved in respects of primary and secondary elements.

Sacks *et al.* 2017 concluded that in tomato grown under green house cultivation, the opportunity of replacing large amounts of costly liquidfertilizer with a basal application of Polyhalite is very promising. It enables the application of Ca and Mg at the pre-planting stage, with no need for additional application during the growing season. This is especially important where the irrigation water lacks these essential nutrients. Polyhalite can provide 33 per cent of the K dose, aswell as N-free Mg, thus reducing K-Mg competition and avoidingsurplus N nutrition

Assessment of above experimental findings should attract the attentions of Agronomists towards supplementing multi-nutrient requirements of food and cash crops as one of the principal tools of sustaining soil fertility with improvement in yield, quality and farmers income.

The new and multi-nutrient mineral POLY4, is showing potential for improving farmer's income in Indian context. POLY4 supports mandate of the Union Indian Government on doubling the farm income through various agro-technological means.

Further, in line with global concern of agricultural environmental impact, POLY4 fertiliser solutions have a low carbon footprint.

References

Anonymous (2018). Commodity Profile of Edible Oil for April – 2018, Ministry of Agriculture & Farmers Welfare, Government of India.

Furia Lino, Hallett Paul, Raffan Annette, Wang Huoyan, Lewis Timothy David (2018). Exploring the impact of Polyhalite (POLY4) application on soil sodium.

http://agriexchange.apeda.gov.in/importtoindia/exportstatement.aspx

https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Oilseeds%20and%20Products%20Annual_New%20Delhi_India_4-13-2018.pdf

https://www.researchgate.net/publication/310774237

https://www.researchgate.net/publication/327061174.

Robert Meakin, Paul Hallett, Timothy D. Lewis, James Woodhall, John Elphinstone, Annette Raffman (2016). The Influence of Polyhalite Calcium on Club Root and Aspects of Soil Structure.

Sacks, M, Gantz, S., Mezuman, U., Peled, L. and Imas, P. (2017). Polyhalite -a multi-nutrient fertiliser preventing Ca & Mg deficiencies in greenhouse tomatoes under desalinise irrigation water.*e-ifc*No. 51, December 2017

Shahi, U.P., Dhyani, B.P. & Rawal, Sanjay (2017-18). Assessment of POLY-4 (Polyhalite) for productivity, quality of potato and K, S use efficiency in soils of western plain zone of Uttar Pradesh. Annual Report

Timothy D. Lewis, Kiran Pavuluri, Robert Meakin (2016). Demonstrating the importance of sulphur in fertilizer plans for corn and barley using Polyhalite. 25th International Symposium of the International Scientific Centre for Fertilizers (CIEC). 1-26.

THEME 3

STRUCTURES/MODELS, ARTIFICIAL INTELLIGENCE, AUTOMATION/TECHNIQUES FOR FUTURE NEEDS

LEAD LECTURE – 20

Gene exploitation for polyhouse vegetable crop improvement in India

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India is the second largest producer of vegetables in the world, however, as per the medical council of India, the production is much less than the requirement, if balanced diet is to be provided to every individual. The blooming targeted production can be achieved by different ways, *e.g.*, bringing additional area under vegetable crops, using hybrid seeds/good planting materials and use of improved agro-techniques. Another potential approach is perfection and promotion of protected cultivation technology. However, the protected cultivation technologies are still in its preliminary stage in India and concentrated efforts are required from all concerned agencies to bring it at par with the global standards. In view of the fragmented land holdings of the farmers need to be encouraged so that modern technologies of cultivation can be adopted for increasing productivity and profitability with quality produce. With adoption of polyhouse and micro irrigation along with water source augmentation structures, socio-economic status of small and marginal farmers can be enhanced with generation of gainful employment. Area under protected cultivation and especially low cost greenhouses can be increased manifold in peri-urban areas. Production of high value vegetables during off-season via-a-vis production of high value vegetable in protected structures would benefit growers due to high price of the produce in metropolitan market.

Vegetable crop breeding and varieties for greenhouse

The introduction of greenhouse/polyhouse cultivation in India has a time lag in relation to many countries. China started protected cultivation technology almost at the same time when India made its beginning. But now China, Japan and USA are the leading countries having large area under greenhouse for horticultural crops in the world and have also developed a number of tomato, cucumber and capsicum varieties through greenhouse breeding. But on the other hand India is lagging behind because of less awareness among the farmers, lack of suitable varieties and other limiting aspects like cost, structures, *etc.*

In India the area under greenhouse cultivation of vegetable crop is 3000 hectares, which is mainly in Maharashtra, Himachal Pradesh, Uttarakhand, Karnataka and Jammu & Kashmir. The total area under greenhouse in Uttarakhand is 250 hectares (Directorate of Horticulture, Govt. of Uttarakhand 2016). Hence, there appears ample scope for increasing area under low cost polyhouse in many folds in peri-urban areas of Uttarakhand for production of high value vegetables during off season for taking advantage of high price of the available market in nearby cities. The vegetables are considered as protective food and have high potential for protected cultivation. Breeding of crops like parthenocarpic cucumber, tomato, capsicum *etc.* have added advantages in the polyhouse.

Breeding of parthenocarpic cucumber at Pantnagar

Parthenocarpy is the ability to develop fruits without pollination. The inheritance of parthenocarpy in cucumber is conditioned by an incomplete dominant gene Pc. In the homozygous condition PP produces parthenocarpic fruit early, with the first developing generally by 5th node. Heterozygous Pp plant produces parthenocarpic fruit later than homozygous plant and fewer in number. The homozygous recessive pp produces no parthenocarpic fruits. Trapping of pistillate flowers was effective in identifying homozygous pp plant but failed to identify heterozygous plants. This character is controlled by an incompletely dominant gene *Pc.* It is being explained that the inheritance of parthenocarpy is by three independent, isomeric major genes with additive action, together with a non-allelic interaction of the homozygote-heterozygote type. Indications have been found for linkages between genes that govern parthenocarpy femaleness and the spined/hairy fruit character.

Varieties

Some of the popular parthenocarpic varieties from multinational seed companies are Kalunga, Bellissma, Millagon, Discover, Marianna, Fitness, Aramon, Fidelio. 90-0048. E 1828, B 1157, Sweet success (AAs), Country Fair, Bush Crop, Space Master, Patio Pick, Bush Whopper, Bush Champion, Bush Pickler, Euro-American, Adrian, AI Rashid F1, Mustang, Bronco, Sandra, Boneva, Daleva, Padex, Fertila, Factum, Fanspot, Femfrance, Toska 70, Farbio, Corona, Sweet Slice, Radja, Bella, La Reine.

Knowing the fact that there is no such variety which is exactly suitable for polyhouse cultivation in Indian conditions. Hence, research work at G.B Pant University of Agriculture & Technology was initiated in 2002 to develop parthenocarpic cucumber varieties. After continuous efforts two varieties of cucumber were developed for the first time for commercial cultivation by public sector institute Pantnagar for commercial greenhouse cultivation.

The details of the varieties are as below:

Pant parthenocarpic cucumber - 2

1. First harvesting starts after 30 days of sowing
2. Plant bears only female flowers (gynoecious) *i.e.* 551 in number per plant
3. Average fruit weight is 400-450 g
4. The average yield is 1755 q/ha
5. Plant produces seedless fruits (Parthenocarpic in nature)

Pant parthenocarpic cucumber - 3

1. First harvesting starts after 32 days of sowing
2. Plant bears only female flowers (gynoecious) *i.e.* 465 in number per plant
3. The single fruit weighs about is 350-400 g
4. The average yield is 1605 q/ha
5. Plant produces seedless fruits (Parthenocarpic in nature)

Breeding of green house tomato at Pantnagar

Tomato is a very good source of income to small and marginal farmers and contributes to the nutrition of the consumers. It is a rich source of vitamins and organic acids. It is a warm season crop and thrives well in temperatures between 16-30^{0}C and is neither tolerant to frost, nor to waterlogged conditions. It is well fitted in different cropping systems which include cereals, grains, pulses and oilseeds.

The tomato flowers are normally perfect. There are four to eight flowers in each compound inflorescence. Light protective anther cone surrounding the stigma leads to self pollination. Emasculation is usually done one day prior to anthesis. At this stage the sepal's starts getting separated and the anthers and corral begins to change from light to dark yellow colour. The stigma is fully receptive at this stage allowing for pollination even immediately after emasculation.

Tomato is high value vegetable crop for off season and main season production under polyhouse/greenhouses. The differences are observed in production and productivity in polyhouse bred tomato (350-450 tones/ha) and field bred tomato (150-200 tones) under polyhouse condition. The average productivity of open field bred variety comes around 250 q/ha, whereas under polyhouse structures, it is about 800q/ha (AICVIP Annual Report 2002-2004). The seed cost of such tomato varieties is very high, *i.e.* between (1.50 and 2.00 lakh/kg) and the grower also faces the problem of importing the seed every time. These two factors ultimately affect the cost: benefit ratio and the interest of polyhouse tomato growers.

Many traditional varieties such as Pusa Ruby, Pusa Early Dwarf, Hisar Lalima, Punjab Chuhara, Hisar Arun, Arka Ashish, Arka Gaurav, Pant Bahar, Pant Tomato-3 etc till date are available in the market in plenty but none of them are best suited for polyhouse cultivation.

Considering the importance and high seed cost of Israeli polyhouse bred tomato varieties, breeding for polyhouse tomato was initiated for the first time at G.B.Pant University of Agriculture & Technology, Pantnagar. The important genes favoring polyhouse cultivation were also exploited. Gene 'sp' responsible for indeterminate character was utilized for the development of these varieties. By adopting appropriate selection methods and hybrid breeding procedures two varieties namely, Pant Polyhouse Bred Tomato-2 and Pant Polyhouse Bred Tomato Hybrid-1 were developed and released. The features of varieties are as under:

Pant polyhouse bred tomato - 2

1. The variety bears 5-6 fruits per cluster
2. The Single fruit weighs around 100-105 g
3. The average fruit yield is 1291 q/ha
4. The fruits have better storage quality because of its thick pericarp (0.9-1.0 cm)

Pant polyhouse bred hybrid tomato-1

1. The variety is having 7-8 fruits per cluster
2. The single fruit weighs around 130-140 g
3. Its average yield is 1616 q/ha
4. Because of its thick pericarp (1.0-1.25 cm), the fruits have better storage quality

Besides these some varieties indigenous and multi-national seed companies are also available in the market. These are Rakshita, Naveen-2000, Avinash-2, Snehlata, Heem Sohna, GS-600 and V.L Tomato 4, Tropic, Dombello, Tuckcross-520

LEAD LECTURE – 21

Vertical farming : A future technology for urban and peri- urban horticulture

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High population pressure, rising food prices, socio-economic and environmental stresses, food, nutrition, health and environmental security a serious challenge. The urban and peri-urban horticulture is aimed to meet part of food demand by efficient utilization of land. Small land holdings and uncertain climatic conditions restricts regular and higher production. Vertical vegetable farming is the practice of growing crops in vertically stacked layers for short stature crops whereas for fruits, adapting the ideal training systems. The practice can use soil, hydroponic or areoponic as growing methods.

Vertical cultivation attempts to produce food in challenging situations, like where arable land is rare or unavailable. The method helps towns, deserts and cities for grow different types of fruits and vegetables by using skyscraper-like designs and precision agriculture methods. The vertical farming has efficiency to increase the many fold production by using the vertical space with multiple cropping under adverse climate with minimum external inputs and energy. This technology is highly protective, amenable to automation, conserve water and land which are essential in present day context of acute water scarcity, degraded soils, and severe market competition.

Vertical farming is a method of cultivation where commercially viable crops cultivated using limited land and utilizing vertical space for the development of plants. One of the seven wonders of world, the hanging garden of Babylon, is example of vertical farming, where plants were grown in steady stream of water. The higher yield makes it economically viable and commercially feasible in high density and expensive peri-urban land areas. The production and daily delivery to market of perishable horticultural crops from small holding farmers close to large urban centres (peri-urban horticulture; market gardening) have been important for millennia (Looney, 2014). Globally, peri-urban agriculture is gaining attention from governments, and many international organisations like the United Nations Conference on Environment and Development (UNCED), United Nations Centre for Human Settlements (UNCHS), the Food and Agriculture Organization and the Consultative Group on International Agricultural Research (CGIAR). FAO Committee on Agriculture had mandated to consider peri-urban as an integral part of agricultural system and had recognized its important role in feeding and greening the cities with due attention to health and safety regulations (Veenhuizen and Danso, 2007; FAO, 2009).

In fruits, especially temperate fruits, vertical training of trees is age old practice followed by the commercial and backyard farmers as well. Training grape vines vertically in the background of wall has been documented in ancient literature as well as century old documentary evidences of various vertical training systems are available. In deciduous crops like apples and peers the several training systems had been evolved and modified versions have been adapted by integrating the application of vertical farming principles in fruit crops. In recent year, this technology is being evaluated in subtropical fruits like guava and encouraging results have shown that the vertical farming cannot be only hobby but it can be a technique for boosting up commercial production of this crop.

Advantage of vertical farming

1. Efficient utilization of vertical space, more crop produced in limited area or without land also
2. Higher yield per unit area as vertical space is used
3. Vertical farming can be efficient in *controlled environment to produce round the year crop of certain species*
4. It saves water, soil and labour
5. Fewer pests and diseases
6. Environment friendly and reduces pollution

Limitations of vertical farming

1. Only few specific crops can be grown
2. Initial investment may higher
3. Needs specialized know how
4. Some systems may face the light scarcity due to plant arrangement

Crops suitable for vertical farming

Crops for vertical farming are of high value nature and require some specific characters. The spur bearing fruit crops like apple and grapes can be grown under vertical farming as their size can be controlled by pruning and training. In vegetables, indeterminate type of tomato, capsicum and cucumber can be grown using the single stem or double stem training system. Short stature single harvest high value vegetables like lettuce, broccoli, red cabbage, swish chard etc. placed on vertical structures and grown according to need of the house hold or market demand.

Technique of vertical farming of fruit crops

Shrinking land and faster growing population has increase pressure for farming having vertical growth in production. Land fragmentation and passion for roof top gardening lead the vertical farming techniques. Apart from temperate fruits like apple, peach, cherry, vertical farming techniques have been successfully demonstrated in guava, strawberry, grape, kiwifruits, custard apple, apple - ber *etc.* Vertical farming techniques involve cultivating fruit crops suitable for vertical canopy rather horizontal spread.

Vertical axis architecture (single axis)

It is vertical space harvesting tree architecture, in this training system, trees are planted at 0.75 x 1.5 m spacing (P x P – R x R), the single axis (main leaders) are trained up to 2.5-3.0 meter height with short primary scaffold radiating at 15-20 cm interval throughout the length of main trunk. This system accommodates nearly 9000 plants/hectare on M-9 root stocks. Since the trees are raised on M-9 root stock, the poor anchorage can be supported by two wires at 4 and 8 feet height erecting on iron angle of 15 feet height. The foremost advantage of this training system is that it requires very less amount of spray input and time. The fruit harvesting, pruning and intercultural operations are very easy to carry. The colour development was also found best due to maximum sunlight illuminance.

Spindle bush architecture

Spindle bush training system is a modification of central leader training system evolved for the dwarfing type of root stock. The plant architecture is suitable for the high density planting of apple. In this training system, no mechanical support is required to hold the plants in position. The trees are allowed to grow to the height of 2.5-3.0 meter with 15-20 lateral branches radiating around the main trunk at 15-20 cm interval. The scion varieties are budded on dwarfing or semis dwarfing type root stocks and well feathered plants are planted at 2-3 m distance. After planting, the plants were headed back at 45-60 cm height to encourage the lateral branches. The laterals were encouraged at 15-20 cm interval, the main leader was allowed to grow to the height of 2.5-3 m. The final tree gives the look of bush type tree. The trees are small in size and bearing surface are close to the main trunk hence it is very productive and the quality was also excellent.

Head and spread plant architecture

This training system is also known as two tier training system and has proven to be very productive in India. It has been found suitable for the cultivars raised on dwarf, semi-dwarf and vigorous root stocks. In this training system, after planting the well feathered saplings were planted at 2 x 3 m spacing. The main scaffold was removed at 45-60 cm height to encourage the lateral scaffolds. In this system, first 4-5 group of the branches were encouraged after 45 cm of height after that up to 60 cm no laterals were allowed to develop. The 2nd groups of scaffold (5-6 laterals) were allowed to develop primary branches on which fruiting spurs were allowed. In this system, the fruiting also occurs in the inner periphery due to good exposure to the sunlight. Further, the fruits develop excellent colour in comparison to the spindle bush, modified leader training system. 80-90 per cent fruits were of 'A' grade. The plant architectural engineering offers good scope for high quality apple production with high productivity per unit area through intensive orcharding and use of modern scientific concept of plant architectural engineering. The modern plant architectural technique is helpful in efficient utilization of natural resources under changing climatic scenario. The temperate fruit especially apple can be increased.

Tree architecture for tropical and subtropical fruits

Guava, mango, custard apple, ber and aonla under HDP systems, though it gives high yield during initial stage but as the tree advances in age light interception and aeration decreases inside the canopy due to shading and overcrowding, resulting low yields and poor quality. In order to develop efficient canopy architecture for HDP, the ICAR-CISH has initiated experiment on tree architecture especially in guava and mango with objective to have sustained high yield and quality.

Guava

It is one of the most important candid for growing vertically hits canopy can be easily maintained through is failure approve training system. At ICAR-CISH, vertically grown guava of CISH-Lalit cultivar has given very encouraging results. The yield and fruit quality are excellent. Varieties responding to pruning can be easily converted into espalier tree shape.

The iron angles post having 9 feet length were fixed with the help of cement and concrete at 6-7 meters intervals on which 5-6 wires (tiers) were erected. First wire erected at 45 cm from ground level and remaining wires at 45-50 cm intervals. After erecting the structure well feathered grafted saplings were planted at 1.5 x 3.0 m (R-R x P-P) distance during July- August. In this system 2,222 trees per hectare are accommodated as compared to traditional system (204 plants/ha). First scaffold branches were trained at 45 cm from ground level and rest scaffolds at 45-50 cm interval. Thus 8-10 main branches allowed on 4-5 tiers, on which fruiting shoots to be promoted. In order to promote side branch notching and girdling were done as required. In this training system top most scaffolds are at 260-270 cm or 8-9 feet height. The main trunk was terminated leaving 10-15 cm from last scaffolds, thus final tree height was 8-9 feet. Total spread of tree canopy was 1.5-2 feet in both the sides (between rows).

Since, the branch bending were performed on the wire erected at 90^0 angle, hence, it alter the apical dominance, which resulted in better fruit bud formation at the basal portion of scaffolds the tree. The trees trained on espalier architecture are compact and its periphery is close to the main trunk, hence, effective cropping area is more, leading to a larger production. Since, most of the leaves are exposed to sunlight, hence, maximum light interception took place. High dry matter production led to more photosynthates 250- 480 g/fruit) and attractive in appearance with red blushed fruit surface. Guava in this architecture bears 35 to 40 fruits (7-8 kg/tree) and projected yield (14.89 t/ha) from one year old tree.

Advantage of espalier architecture system

1. Ease in training, pruning, fruit picking and inter-culture operations
2. Ease in spray of growth regulators, insecticide and fungicide
3. Minimum wastage of spray materials and more trees can be sprayed in a shorter period of time
4. Branch, shoot as well as leaf positioning are possible in this architecture
5. Since the scaffolds are managed in tier system hence, good air drainage helps to minimise microbial population
6. Cost effective and easy to develop this structure

Fewer incidences of disease and insect due to maximum exposure of the scaffolds branches were observed. The fruits are attractive in appearance, larger in size and most of the fruits are 'A' grade size. Popularization of such architecture system will help to the farmers in production of export quality fruits and doubling the farmer's income.

Pear

Columnar trees can be trained up to 3 m with a base of 60 cm. These upright trees bear full-size apples. Clonal dwarfing rootstocks can play important role. Pear fruit has been trained on espalier and vertical axis training system. These techniques are suitable training tree in vertical space for higher yield and quality fruits.

Custard apple

It is another important fruit crops suitable for raising under espalier architecture. Custard apple respond well to pruning, so most of the orchard on commercial scale are being raised on espalier architecture.

Apple-ber

This fruits are coming up largely due to precocious bearing habit and pruning response helps to train this fruit on pergola architecture. It can also trained on espalier architecture.

Grape

Grape is one of the most suitable fruit crops which can be trained to several structures utilizing vertical space. It is one of the ancient crops which received lot of attention for developing vying structures. Vertically Vines can be very well trained in a background of wall. Kniffin is also architecture for raising grape vertically.

Kiwi fruit

It is most important vine crops which fitted well in vertical tree architecture. Espalier (kniffin) and pergola are most important architecture suitable for this fruits under HDP. On vertical training structure tree bears more than 70-80 kg fruit/tree. The vertical training practiced along with leaves and shoot positioning on the trellis. Harvesting of fruits, spraying and nutrition application are easy in this tree architecture.

Peach and Nectarine

Peach and nectarine can be easily grown up to the height of 1.5 meters. These crops can be trained into pillar or columnar shape and well shaped canopy can be maintained using appropriate pruning.

Pomegranate

Similar to guava, pomegranate also responses to the pruning and can be easily grown vertically along with the walls or in big pots. Seasonal pruning is useful in maintaining the shape of the canopy as well as fruiting pattern during different seasons. It can also trained on espalier architecture or on kniffin.

1. Vertical axis system in flowring 2. Vertical axis system in fruiting 3. Dragon fruit in espalier 4. Guava in espalier system

Techniques vertical farming in vegetable crops

Vegetable are most suitable for vertical farming and commercially becoming popular under Indian conditions**.** It can be divided in two parts according to crop growing nature i.e.

1. Vertical farming system for indeterminate type of vegetable crops
2. Vertical farming system for short stature high value vegetable crops

Vertical farming system for indeterminate type of vegetable crops is most popular in India under greenhouse vegetable production for efficient vertical space utilization. Only those crops could get place in green houses that utilizes the vertical space like indeterminate tomato, cucumber and capsicum or gives multiple harvest like geranium and rose. Inseminate crops grown under following vertical system.

Single stem system

Single stem system plants are trained to one stem that is physically supported by twine hanging from an overhead wire or support of bamboo stick. The wires are located above the rows and run the length of the row. After clipping the plants to the twine is to lean the plants in the direction that they will eventually be trained along the row. Clipping the plants to the twine is to lean the plants in the direction that they will eventually be trained along the row. Under this system of farming plant spacing is kept closer to get the higher yield.

Double stem system

Double stem system plants are trained to two stem that is physically supported by twine hanging from an overhead wire or support of bamboo stick. The wires are located above the rows and run the length of the row. After clipping the plants to the twine is to lean the plants in the direction that they will eventually be trained along the row. Clipping the plants to the twine is to lean the plants in the direction that they will eventually be trained along the row. Under this system plants are kept at wider spacing to avoid the overcrowding.

Vertical farming system for short stature vegetables

Vertical post system

In this system, plats are arranged on vertical post. According to situation many types of containers are used like plastic pots and plastic pipes or bags. It is also known as verti-grow system. Liquid fertilizer is applied through drip system. 20-30 plant can be accommodated on one post. It is suitable for leafy vegetables like lettuce Chinese, cabbage, celery, spinach, Swiss chard *etc.*

Horizontal post system

Horizontal arrangement pipe is made on posts at definite interval according crops. The hole is filled with media and crop is planted in holes. There may be four to five tier up to the height of 6 to 7 feet as convenience. Nutrient and water is supplied through drip.

Rack system

Racks are used to grow the plants vertically. Rack may be five to six terraces according to convenience of handling. Pots, grow bags, trays or channels can be utilized for growing of plant. Water or nutrients can be applied through drip or manually.

1. Single stem system 2. Dubble stem system 3. Vertical post system 4. Horizental rack system

Horizontal tray or pot system

The structure is made as multi layered bench either of iron, concrete or wooden in 4 to 5 layers at 45 cm interval. Trays, pots or plastic channels are placed according to crops. CISH has developed low cost the vertical farming techniques using the bamboo for short duration single harvest crops. Four type container *i.e.* black polythene bags, white polythene bags, plastics pots and earthen pots were used for evaluating 10 lettuce varieties under vertical structure in five layers. There was no difference in container during winter but summer earthen pots were better in yield than other types. The variety Grisma was high yielder among the varieties. Though yield/ plant was higher under field growing conditions but yield per m^2 area in vertical farming was higher 2.5 times than field growing conditions.

Future strategy

1. Varieties suitable for vertical gardening of vegetables should be developed or identified
2. Package of practices for fruit crop vertical gardening can be developed using varieties responsive to pruning
3. Vertical farming technique may be popularized among urban and peri-urban garden lovers through awareness and training
4. Low cost structure using local material may be designed for successful growing of determinate vegetable types
5. For vertical training of fruit crops, low cost structures should be designed

Conclusion

Vertical gardening of fruits has been tradition, the well-accepted concept is being in practice for many centuries particularly in grapes, apples, and peers. The principal is the very adapted in deciduous crops and presently demonstrated in subtropical fruits like guava. With increasing availability of the structures and containers the system is being adopted for growing vegetables in urban areas. Under limited land availability conditions, vertical farming can be suitable option for the production of fruits and vegetables in urban and peri urban areas, but there is a need to identify varieties, standardize structures and package of practices for making it more popular.

References

Annonymous (2009). Food agriculture and cities: Challenges of food and nutritional security, agriculture ecosystem management in an urbanising world. FAO food for cities multidisciplinary initiative position paper. FAO Rome, pp-45

Veenhuizem, V.R. and Danso, G. (2007). Profitability and suitability of urban and peri-urban agriculture. FAO agriculture management, marketing and finance. Occasional paper no-19 Rome FAO.

Deva Kumar, C. and Chhonker, P.K. (2013). Urban and peri-urban agriculture- Policy paper no.67. National academy of Agricultural Sciences, New Delhi, 12P.

Loony, N.E. (2014).The place of urban and peri- urban horticulture in nurturing and nourishing the urban poor: Researchable issue for horticultural Science. Acta Horticulturae 10: 1021-1.

LEAD LECTURE – 22

Automation in vegetable nursery raising: Needs for future

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Traditional method of vegetable nursery raising suffers from a number of climatic factors and stresses. The shortage of agricultural laborers nears the city and out of the city areas, technical knowhow etc. ultimately increases the production cost and deteriorate the quality of seedlings. The automation in vegetable nursery produces sufficient quantities of high quality seedlings to satisfy the needs of users in very short span of time at cheaper rate. Healthy vegetable seedlings up to a large extent determine the productivity and profitability from vegetable cultivation. The automated seedlings raising technology enhanced cropping intensity, change in cropping pattern and quantitative and qualitative improvement in the marketable yields. Now-a-day's vegetable seedlings are being raised in plug treys by automation under controlled conditions round the year. The plug tray raised transplants are uniform, bold and establish better in the field because of less root damage.

A lot of advancement in the field of vegetable nursery has been made either in terms of automation or in terms of growing medium. A number machine has been developed in India and in abroad to make the nursery raising easy and convenient by which the raising of seedlings under controlled environment become easier and labour intensive. The growth chambers are usually an insulated room where temperature and relative humidity can be maintained which ease to germinate the seedlings very less time compared to open field conditions. Air circulation is important to ensure uniform temperature and humidity throughout the chamber. Cell trays are used by commercial growers to produce seedlings for planting out. The seedlings are easily removed from the tray for transplanting and the growth check to transplants from cell trays is minimal when planted in the field compared to the use of other types of transplants. Seedlings from cell trays may be used in manual or automatic transplanters. Soil-less mixes are usually used for commercial seedling production. Commercial sterilised soil-less mixtures are available with added fertiliser and this simplifies the production process. Different plant species require differing amounts of space, nutrients and water. Accordingly larger (12) to smaller (300) cell sizes containers/ treys are used for raising the nursery for bolder to smaller vegetable seeds. They may have cell sizes as small as 0.8 inch square or as large as 6 inches square. Therefore, transplants growing in larger cells require less frequent watering and fertilizing. Plastic and polystyrene containers most often come in straight row arrangements. Polystyrene containers normally have inverted pyramid-shaped cells that taper toward the bottom. The number of cells in a container depends on the cell size. So, there are a series of advancement made in span of time in the field of nursery raising where one can raise healthy seedlings in any part of the year successfully with automation. This may be helpful to the entrepreneurs to establish a vegetable nursery for self-employment and future prospects.

THEME 4

CHALLENGES AND MITIGATION ON CLIMATE CHANGE, BIOTIC AND ABIOTIC STRESSES IN HORTICULTURE

LEAD LECTURE – 23

Good agricultural practices for safe and sustainable production

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Agriculture is the mainstay of Indian economy. It feeds the nation and provides raw material for food industry. It is now at the threshold of taking initiative towards commercialization agriculture. To make this effort effective modern techniques and technologies are inducted in Indian agriculture. It is now ushering in a new era for agriculture to compete with global players. But the big challenge today is balancing economic growth and negative impact on environment. This leads to the emphasis on sustainable agriculture.

With the advent of World Trade Organization (WTO) in 1995 a global trade regime has been established for free flow of agriculture produce. This got further momentum by Agreement on Agriculture (AoA) under WTO exerting pressure for opening up of Indian agriculture to global completion. Though it imposes challenges but also offers tremendous opportunities for Indian agriculture to play an important role in the international markets. The challenge of global markets is no where greater than in the primary food sector.

Although the green revolution greatly benefited, the country had to pay a heavy price for uncontrolled used of chemical fertilizers, irrigation water and pest control products leading to adverse environment impact, degradation and increased salinity in soil, deforestation and depletion of water resources. There is therefore a need to develop a well thought-out strategy to modify the current agricultural practices to attain a more sustainable agriculture. This is being shaped up through implementation of Good Agricultural Practices (GAP), which provides a structured methodology to harness the new technology without its adverse impact on environment and health and safety of people.

Good Agricultural Practices are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability. They are applied through sustainable agricultural methods, such as integrated pest management, integrated fertilizer management and conservation agriculture. They rely on four principles:

- Economically and efficiently produce sufficient), safe and nutritious food leading to food security, food quality and food safety,

- Sustain and enhance natural resources,
- Maintain viable farming enterprises and contribute to sustainable livelihoods, and
- Meet cultural and social demands of society.

The concept of GAPs has changed in recent years because of a rapidly changing agriculture, globalization of world trade, emerging food borne illness, pollution of water, appearance of pesticide resistance pest and diseases, erosion. This provides the opportunity to assess and decide on which farming practices to follow at each step in the production process. For each agricultural production system, it aims at allowing a comprehensive management strategy, providing for the capability for tactical adjustments in response to changes. The implementation of such a management strategy requires knowing, understanding, planning, measuring, monitoring, and record-keeping at each step of the production process.

Application of GAP also ensures regulatory compliance and food safety to the consumer. This helps in conservation of resources, judicious utilization of resources and maximization of yield, thus making agriculture produce more competitive by exploiting vast fertile land with diverge agro-climatic conditions and low cost of labour to boost export.

What is needed is introduce modern management and control methods by introducing standardization, quality control and certification systems to reap the benefit of Good Agricultural Practices. A World Bank Report states "Stricter standards can provide :

- Stimulus for investments in supply-chain modernization,
- Provide increased incentives for adoption of better safety and quality control practices in agriculture and food manufacturing,
- Help clarify the appropriate and necessary roles of government in food safety and agricultural health management.
- Compliance process can result in new forms of competitive advantage and contribute to more sustainable and profitable trade over the long term. "

GAP is thus an integrated system to provide base for organized development of food industry ensuring hazard free inputs which come from hazards associated with the elements of land, input, processes and output of agricultural production to achieve productivity, sustainability, quality and safe produce

Important concepts and definitions

a) **Accreditation :** Procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks

b) **Certification :** Procedure by which an independent and competent third party certifies that a product, process, material or service conforms to specified requirements

c) **Environment :** Water, air, land, wild species of fauna & flora and any inter relationship between them, as well as relationship with living organisms.

d) **Food safety :** Assurance that food will not cause harm to the consumer for whom it is prepared and/or eaten according to its intended use

e) **Good Agriculture Practices :** Practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products

f) **Hazard :** A biological, chemical, physical agent in, or condition of, food with the potential to cause an adverse health effect.

g) **Integrated Pest Management :** IPM is a sustainable approach to managing pests by combining biological, cultural, mechanical and chemical tools in a way that minimizes economic, health and environmental risks.

h) **Inspection :** An examination of all agricultural practices in order to verify compliance to requirements specified in this standard.

i) **Quality :** Degree to which a set of inherent characteristics fulfils requirements

j) **Quality management :** coordinated activities to direct and control an organization with regard to quality

k) **Quality Management System :** Management system to direct and control an organization with regard to quality

l) **Pollution :** Contamination of natural environment by the addition to air or water of substances potentially toxic or otherwise harmful to man and animals for example, SO_2, CO_2, radio-active fall out insecticides *etc.*

m) **Sustainable agriculture :** All agricultural production systems and practices which are economically viable, environmentally sound, and socially acceptable ...” “. . . and which contribute to a better quality of life for agricultural producers and their families and the general public.”

n) **Standardization :** An activity giving solution to repetitive applications to problems in the sphere of science, technology, economics etc aimed at the achievement of the optimum degree of order in a given context

o) **Standard :** A technical specification/ other document available to general public, drawn up with cooperation and consensus or general approval of all interests affected by it.It is based on consolidated result of science, technology and experience and is aimed at promotion of optimum community benefits.

Potential benefits and challenges of good agricultural practices

Potential benefits

- ❖ Appropriate adoption and monitoring of GAP helps improve the safety and quality of food and other agricultural products.
- ❖ Implementation of GAP increases agricultural productivity, lowers production costs and reduces losses
- ❖ It ensures optimization of use of natural resources- land, water, human capital, and enhances information sharing and consensus on “good farming practices”
- ❖ It increases food safety and quality of produce by reducing undesirable practices thus leading to continuous improvement

- It supports long term thinking and assists evolving strategies on agricultural practices to be in tune the developments
- It helps identifying constraints faced, institutional support needed and government interventions to promote GAPs
- It reduces the risk of food safety lapses in agricultural field practices, harvest and post harvest handling and storage produce
- Verify best practices with some reference points so that it is done systematically and consistently throughout the world
- It may help reduce the risk of non-compliance with national and international regulations, standards and guidelines regarding permitted pesticides, maximum levels of contaminants in food and non-food agricultural products
- It helps promote sustainable agriculture and contribute to meeting national and international environment and social development objectives.

Challenges

- GAP implementation and especially record keeping and certification will increase production costs at the initial stages,
- Lack of harmonization between existing GAP-related schemes and availability of affordable certification systems often leads to increased confusion and certification costs for farmers and exporters.
- Lack of availability of technical manpower to assist in development and evaluation of the system to ensure conformity to the GAP requirements to enable certification.
- The standards on GAP can be used to serve competing interests of specific stakeholders in agri-food supply chains by modifying supplier-buyer relations.
- There is a high risk that small scale farmers will not be able to seize export market opportunities unless they are adequately informed, technically prepared and organized to meet this new challenge with governments and public agencies playing a facilitating role.
- Compliance with GAP standards does not always foster all the environmental and social benefits which are claimed.
- Awareness raising is needed of 'win-win' practices which lead to improvements in terms of yield and production efficiencies as well as environment and health and safety of workers. One such approach is Integrated Production and Pest Management (IPPM).
- Lack of motivation/incentive, even though the produces from GAP certified farms have better quality and better opportunity for selling but the price is almost the same in the market.

Basic elements of good agricultural practices

Farm selection and farm management

The basic approach to farming is to select the suitable location, examine soil condition, study topography and meteorological information. In all these the most important consideration is soil which is the basis of all agricultural production, and the conservation and improvement of this valuable resource. Good soil husbandry ensures long-term fertility of soil, aids yield and profitability

Soil type mapping is necessary and should be done for all identified farm, based on a soil profile or soil analysis or local /regional cartographic soil-type map. Once located, farms are plotted into manageable units.

Legal entity of the farm is established and then registration of farms, proper plotting and identification to enable the farms help to redress complaints and taking corrective actions and maintaining traceability of its produce

Rational use and application of pesticides

Excessive and indiscriminate use of pesticides leaves high levels of pesticide residues in the produce, which increases hazard for the health of consumers. This may in the short-term increase productivity, but in the long-term this practice not only leave high levels of pesticide residues in the produce affecting health and safety of consumers but also leave negative impact of environment. There is an international cry to reduce pesticide residues in raw materials and food products. Food safety has become paramount concern in the international trade of food.

Control of pesticide residues is an important element of GAP by judicious utilization of pesticides and implementing Integrated Pest management Practices. But there is no effective mechanism at present for monitoring pesticide application at the farm level due to inadequate infrastructure particularly testing facilities of pesticide residues as per international standards. It is therefore necessary to develop a national monitoring mechanism for pesticide residues to control them in the farm produce.

GAP requires a system whereby each pesticide application is recorded with their doses and timings and names of pesticides applied. It also recommends that growers maintain an approved pesticides list with both the product name and active ingredient and use only those approved pesticides

Judicious use of fertilizers

A scientific agriculture demands a decision making process based on specific crop requirements, available nutrients in the soil and available nutrients from farm manure and crop residues. Required doses and correct application not only optimize use fertilizers but also avoid degradation of soils and the environment by excessive.

GAP requires application of fertilizers in optimum doses and timed to maximize the efficacy and uptake by target crops. It recommends application of fertilizers (organic or inorganic) given by competent authority. All applications of soil and foliar fertilizers, both organic and inorganic, are recorded. Besides Gap helps in harnessing environment nitrogen by proper crop rotation alternating leguminous and non leguminous crops and nitrogen fixing azotobacter.

It requires maintenance of inventory of inorganic fertilizer and record of use. Similarly it provides for storage of inorganic fertilizers in an appropriate manner, which reduces the risk of contamination of watercourses. It bans the use of human sewage on the farm as source of nutrients.

Survey on implementation of GAP standards has revealed 30-40 percent savings in the inputs-pesticides, fertilizers and water.

Soil conservation and soil management

Soil is the basis of all agricultural production, and the conservation and improvement of this valuable resource is essential. Good soil husbandry ensures long-term fertility of soil, aids yield and profitability. It must be maintained by:

- Reducing erosion by wind and water through hedging and ditching
- Maintaining or restoring soil organic content, by manure application, crop rotation
- Reduce soil compaction issues (by avoiding using heavy mechanical devices)
- Maintain soil structure, by limiting heavy tillage practices
- *In situ* green manuring by growing pulse crops like cowpea, horse gram, sunhemp *etc.*

GAP advocates good agronomic practices and application of field cultivation techniques used to reduce the possibility of soil degradation soil erosion such as mulching and/or cross line techniques on slopes and/or drains and/or sowing grass or green fertilizers, trees and bushes on borders of sites, *etc.* Cultivation techniques such as proper crop rotation and mix cropping used that improve or maintain soil structure, and to avoid soil compaction and reduce the possibility of soil erosion.

Irrigation and water conservation

Water is a scarce natural resource and irrigation should be triggered by appropriate forecasting of the need for specific crops and by use of technology and equipment allowing for efficient use of irrigation water such as drip irrigation, sprinkler irrigation(See fig02) *etc.*

GAP requires calculated use of water based on scientific methods of prediction of the water requirement of the crop and use the method of irrigation in light of water conservation. There should be a water management plan to optimise water usage and reduce waste and record maintained for irrigation/fertigation water usage.

The use of untreated sewage water for irrigation been banned under GAP. To protect the environment, water should be extracted from a sustainable source where extraction id guided by law approval should be sought from water authorities.

Good Water Conservation Practices

- Practice schedule irrigation, with monitoring of plant needs, and soil water reserve status to avoid water loss by drainage
- Prevent soil salinization by limiting water input to needs, and recycling water whenever possible
- Avoid crops with high water requirements in a low availability region
- Avoid drainage and fertilizer run-off
- Maintain permanent soil covering, in particular in winter to avoid nitrogen run-off
- Manage carefully water table, by limiting heavy output of water
- Restore or maintain wetlands (see marshlands)
- Provide good water points for livestock
- Insitu water harvesting by digging catch pits, crescent bunds across slope

Integrated pest management

IPM is strategy which combines all practical methods of managing pests including biological, cultural, physical and chemical methods in a manner that attains the producer's production goals while minimizing economic, health and environmental risks. It is a sustainable approach to managing pests by combining biological, cultural, mechanical and chemical tools in a way that minimizes economic, health and environmental risks.

Integrated Pest Management (IPM) involves a careful consideration of all available pest control techniques, pest population and the subsequent integration of appropriate measures that discourage the development of pest populations, and keeps plant protection products and other interventions to the levels that are economically justified and reduce residues in crops to minimize risks to human health and the environment.

Gap builds IPM systems on sound scientific basis requiring evidence from producers of implementation of activities in the following manner:

a) Prevention- how pests are prevented from entering the farm,

b) Observation and Monitoring- what are observation and monitoring techniques used at the farm and

c) Intervention- how intervention activities performed without having impact of safety and environment. Where plant protection products have been used objective must be achieved with the appropriate minimum input.

IPM is a sustainable approach to managing pests by combining biological, cultural, mechanical and chemical tools in a way that minimizes economic, health and environmental risks.

Produce storage and handling

Where pest attack adversely affect the economic value of a crop, it may be necessary to intervene with specific pest control methods, including plant protection products. In such cases correct use, handling and storage of plant protection products becomes essential.

Producers should only use plant protection products that are registered and approved for the target crop. All the plant protection product applications are recorded including the crop name and/or variety with justification

The Plant Protection Product should be stored and handled in such a way that it does not lead to contamination of soil, water sources and environment obsolete plant protection products are securely maintained and identified and disposed of by authorized or approved channels.

Empty Plant Protection Product Containers should be disposed off in a manner that avoids exposure to humans, contamination of the environment. When empty containers rinsed either via the use of an integrated pressure-rinsing device on the application equipment, or at least three times with water, the rinsate from empty containers returned to the application equipment tank and empty containers kept secure until disposal.

Pre-harvest application of pesticides

There is wide spread practice of using pesticide before harvest without the consideration of its effect on consumers. This is also borne of the fact the growers do not know the implication of interval of pesticide use. There is a scientific basis for keeping certain interval between use of pesticides and harvest.

GAP requires the producer to demonstrate that all pre-harvest intervals have been observed for plant protection products applied to the crops, through the use of clear documented procedures such as plant protection product application records and crop harvest dates from treated locations. Specifically in continuous harvesting situations, there are systems in place in the field e.g. warning signs, time of application *etc.* to ensure compliance to registered pre-harvest intervals

Harvesting practices

Harvest management of crops is important for better recovery of yield and avoidance of waste. It is an important stage where proper norms need to be applied for judging maturity of crops and for risk free handling such as proper hygienic practices as most of the produce either goes for direct consumption or for processing by the food industry.

GAP requires that hygiene instructions and procedures for handling produce to avoid contamination of the product are followed. This includes personal hygiene, tools and container hygiene (See Fig 03), cleanliness transport vehicles and toilet facilities. It also requires documented inspection process in place to ensure compliance with defined quality and food safety criteria and provide protection from contamination.

Post-harvest treatments

Post harvest treatment of produce with chemicals and pesticides is an important area of produce protection and food safety. There are admissible practices such as use of post-harvest biocides, waxes and plant protection products and there are undesirable practices such as direct application of pesticide in stored grains. It is not uncommon in rural India to treat produce with pesticides meant for sale and not to treat produce meant for household consumption. This reveals the fact that he knows the implications of use pesticides for stored grains

GAP requires that all the biocides, waxes and plant protection products used for post harvest protection of the harvested crop should officially be registered or permitted by the appropriate governmental agency in the country. The documented post harvest biocide, wax and crop protection product application records need to be maintained including the technically responsible person for the harvested crop handling process to demonstrate competence and knowledge with regard to the application of biocides, waxes and plant protection products preferably supported by nationally recognized certificates or formal training.

Records to be maintained on the following:

- The lot or batch of harvested crop treated,
- Geographical area, the name or reference of the farm or harvested crop handling site,
- Exact dates (day/month/year) of the applications,
- Type of treatment used for product application (spraying, drenching, gassing *etc.*),
- Trade name of the products applied,

- Amount of product in weight or volume per litre of water used,
- Name of the operator who has applied,
- Common name of the pest, disease to be treated.

There are chemicals used for ripening produce such as mango and bananas. These are often non permitted chemicals and are harmful to health. Similarly there are chemicals used for enhancing the surface appeal appearance of the produce.

Workers health, safety and welfare

People are key to the safe and efficient operation of any farm. Farm staff and contractors as well as producers themselves stand for the quality of the produce and for environmental protection. Education and training will help progress towards sustainability and build on social capital.

GAP ensures safe practice in the work place and that all workers understand, and are competent to perform their duties; are provided with proper equipment to allow them to work safely; and that, in the event of accidents, proper and timely assistance can be obtained

GAP also requires that the farms:

- Conduct risk assessment for safe and healthy working conditions and t to identify areas of risk to worker,
- Develop health, safety and hygiene policy,
- Provide training on health, safety and hygiene,
- Prepare emergency preparedness plan including first aid kits and identify hazardous substances,
- Provide protective clothing and equipment
- Identify a person from the management for workers health safety and welfare.

The facilities should deal with accidental operator contamination. All plant protection product/ chemical storage facilities and all filling/mixing areas present on the farm have eye wash capability and a source of clean water, a complete first aid kit and a clear accident procedure with emergency contact telephone numbers or basic steps of primary accident care, all permanently and clearly signed.

Traceability

Traceability is now a very important aspect of international trade of agricultural ptoduce. In defining traceability, it is important to distinguish between the terms "tracking" and "tracing" Tracking is the capability to follow a path of a specified unit and/or batch of product through the supply chain as it moves between organizations towards the final point-of-process, point-of-sale or point-of-service.

Tracing is the capability to identify the origin, movements and relevant associated information of a particular unit and/or batch of product located within the supply chain by reference to records held upstream (Fig 05)

In the event of any thing going wrong or product is implicated on food safety reasons, producer should be able to find out where things have gone wrong and if necessary recall the product.

Protection of environment

Farming and environment are inseparably linked. Managing wildlife and landscape is of great importance; enhancement of species as well as structural diversity of land and landscape features will benefit the abundance and diversity of flora and fauna.

GAP requires a written action plan which aims to enhance habitats and increase biodiversity on the farm. This includes knowledge of IPM practices, of nutrient use of crops, conservation sites. It emphasizes the growth of healthy crops with the least possible disruption of agro-ecosystems and encourages natural pest control mechanisms.

Standardization of good agricultural practices

A multiplicity of Good Agricultural Practices (GAP) codes, standards and regulations have been developed in recent years by the food industry and producers organizations but also governments and NGOs, aiming to codify agricultural practices at farm level for a range of commodities. Their purpose varies from fulfillment of trade and government regulatory requirements, particularly with regard to food safety and quality, to more specific requirements of specialty or niche markets.

The challenge of globalizing markets is nowhere greater than in the primary food sector. The world trade Organization's (WTO) agreement on Technical barriers to trade (TBT) recognized standards as facilitator of global trade. Good Agricultural Practices are practices address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products. The GAP standards in these areas must address these concepts and may serve as a reference tool for deciding, at each step in the production process, on practices and/or outcomes that are environmentally sustainable and socially acceptable. The implementation of GAP should therefore contribute to Sustainable Agriculture.

The objective of these GAP codes, standards and regulations include, to a varying degree:

- ensuring safety and quality of produce in the food chain
- capturing new market advantages by modifying supply chain governance
- improving natural resources use, workers health and working conditions, and/or
- creating new market opportunities for farmers and exporters in developing countries.

These four 'pillars' of GAP (economic viability, environmental sustainability, social acceptability and food safety and quality) are included in most private and public sector standards, but the scope which they actually cover varies widely.

Just like in other technology areas standards from International Organization for Standardization (ISO) becomes the bench mark, GolobalGAP standards brought out by Food Plus, Germany, a private venture standard has become bench for Good Agricultural Practices. GolobalGAP standard has established itself as a key reference for Good Agricultural Practices in the global market-place, by translating consumer requirements into agricultural production in a rapidly growing list of countries-currently more than 80 on every continent. It is a private sector body that sets voluntary standards for the certification of agricultural products around the globe. The aim is to establish ONE standard for

Good Agricultural Practice (GAP) with different product applications capable of fitting to the whole of global agriculture.

As many other on-farm assurance systems have been in place for some time prior to the existence of GLOBALGAP, a way had to be found to encourage the development of regionally adjusted management systems and so to prevent farmers from having to undergo multiple audits. Existing national or regional farm assurance schemes that have successfully completed their benchmarking process are recognized as an equivalent to GLOBALGAP.

GlobalGAP is a global reference scheme for good agricultural practice, managed by the GLOBALGAP Secretariat. It focuses on:

- Good Agricultural practices- best agricultural practices available
- Food Safety - derived from the generic application of HACCP principles;
- Environment Protection - based on good agricultural practices designed to minimize negative environment effects
- Occupational Health, Safety and Welfare -establishes a global level of farm occupational health and safety& awareness & responsibility regarding social issues
- Animal Welfare - establishes a global level of animal welfare criteria on farms

Since agricultural practices vary considerably from country to country from and region to regions due to agro climatic variations, Cultural practices, regulatory frame work.

On similar Good Agricultural Practices Standards may be drafted in India as per our local conditions, practices, requirements *etc.*

References

Food and Agriculture Organisation www.fao.org

Global G.A.P website www.globalgap.org

Indian Council of Research www.icar.org.in

Quality Council of India website www.qcin.org

World Bank website www.worldbank.org

LEAD LECTURE – 24

Challenges and strategies of insect pest management in fruit crops

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Despite numerous constrictions and impediments, fruit crop industry is burgeoning and its production is approaching new heights in India. Fruit industry has been a focus area of research and development and a quantum jump in area and production has been recorded after NHM implementation in this sector. Ecological, varietal and management variability affect the fruit crops productivity across the country. Various kinds of fruit crop husbandry like traditional to ultramodern and precision to protected are prevalent depending upon commercial potential of the crop, farmers' capacity and regional suitability. Among various factors that contribute to income from fruit crops, cost of cultivation and losses are the two key factors that determine the profit margin to a great extent. Out of various types of losses, biotic losses are critical because these can be minimized with certain interventions. However, the cost of minimizing the biotic loss depends upon knowledge and skill of cultivators. Owing to evergreen vegetation and tender plant parts, a number of insect pests attack fruit crops that not only reduce the yield quantitatively but also qualitatively.

Several insect pests are reported to cause substantive loss to fruit crops. Chemical control options are also available but not for all the pests and situations. There has been emphasis on implementation of IPM as well; however, an extremely gradual adoption of alternative pest management options as compared to pesticides has been a trend in Indian Agriculture. The challenges that contribute to low adoption of such alternative options have been discussed here.

Implementation of IPM programs and adoption of IPM practices in a given ecological region have consistently been remained a challenge. Demonstrating the superiority of IPM practices over conventional control tools especially pesticides and convincing the farmers have been the most unnerving challenge. Further, the government policy, social acceptance of technologies, effectiveness of available IPM extension methods, level of training / knowledge imparted and availability of IPM materials are the key challenges. Adoption of IPM in any crop system invariably endures a challenge especially when policy is to produce more without quality concerns. Government policy and regulations when give emphasis on increasing production through extensive use of chemicals, it slows down the process for adoption of safe food production. The implementation of IPM, therefore, requires identification and elimination of policy constraints that are likely to reduce the chance of its adoption. Cuba, Indonesia and Philippines are examples of countries where IPM has thrived well after government declared to support IPM as the national pest management strategy. Though governments in India have considered frequent investment on IPM, no incentive has been accorded in the market where IPM led fruit produce can receive preference. In India two extremes of food segments are seen; either certified organic or non- certified. There is no space and incentive for GAP or IPM based produce.

Maintenance of soil quality, nutrient recycling and its balance, pollination and pest management are the key considerations in sustainable fruit production system. Diversity in the Agroecosystem ensures the availability of required inputs to the plant and soil over the space and time. Diversified farming system supports substantially greater biodiversity, soil quality, carbon sequestration, water-holding capacity, energy-use efficiency and resistance. Relative to conventional monocultures, diversified farming systems enhances the control of weeds, diseases and arthropod pests with increased pollination services. Depleting ecosystem services present a challenge to get benefit of natural pest management. India ranks 2nd in food production (in monetary terms) but 11th in pesticide use. It indicates the level of ecosystem services that Indian farmers receive from existing biodiversity as against USA, China, Argentina and Brazil who use 80 per cent of world pesticides. Nevertheless, the agro-biodiversity in Indian context is decreasing across the ecosystem and mono cropping is increasing. Collective farm size under monocrop has increased and non-crop areas in and around the orchards and farms have reduced. This collective simplification of agro-ecosystem has led to loss of biodiversity and thereby reduced supply of ecosystem services to and from cultivated areas. In absence of ecosystem services, purchase and use of off farm inputs (fertilizer, pesticides, *etc.*) has gone up. Exploitive fruit under simplified ecosystem is eco-system service reductive system and therefore, various negative impacts on flora, fauna, society and economics are encountered. For instance, there are more than 100 natural enemies in mango ecosystem which play vital role in pest population regulation whereas applied bio-control relies on a few laboratories reared natural enemies. In order to appreciate the benefit of these indigenous natural enemies, it is necessary to give more emphasis on their conservation and enhancement. Insecticides are proven effective and the problems associated with them are insufficient to change farmers' attitudes; the impacts of alternative control have inadequately been documented; farmers are unprepared to encourage weeds and diversity on their land; the idea of "biodiversity" is considered too complex to be useful in practice. Further, lack of efficient diversified model of pest management in fruit crops is equally lacking. However, gradually diversity is being considered substantial in pest management programmes with a realization that diversity and pest outbreaks are not causally related. It is a challenge to maintain the biodiversity and despite all kinds of perceived benefits; diversity based pest management is not well unappreciated by farmers as against insecticide.

Farmer weaknesses in terms of decision, knowledge and financial capacity come in the way of adoption of fruit pest management. IPM practices may offer many advantages like ecological sustainability, environmental conservation and better health for the society but they must undergo social acceptance by farmers. Farmers judge the relative advantage, compatibility and complexity of alternative tools as against of prevailing practice. New technologies usually present a situation of risk and uncertainty and therefore farmers rarely consider alternatives to pesticides when dealing with imminent pest problems in the fruit ecosystem. They have limited resources and depend on small farms for income generation; therefore, unless effectiveness of new practices is clear, adoption is unlikely to occur. They focus on short-term goals and therefore, need to be convinced with the effectiveness of alternative practices in their farm to switch over from chemicals based farming.

Delivery system for IPM practice, tools and inputs for many crops in general and fruit crops, in particular, is additionally a challenge. Research scientists develop innovative techniques which are then transferred to farmers. The conventional model of technology transfer, however, is considered as inappropriate in implementing IPM practices as it is not a fixed prescription but depends on the farmer's ability to experiment and make decisions. A face to face relationship between IPM worker and farmers is needed as opposed to top-down extension approaches. Here in this case, the role of the farmer as a researcher in testing and refining of sustainable technologies is more important. Sufficient training and technical support to farmers is lacking in many fruit crops. They are even not efficient to identify the pests, parasites, tools to be used, and majority of them depend on pesticide sellers. Nowadays many WhatsApp groups are providing this service being administered by scientists and department people. Many times, their recommendations are also not up to the mark.

There is an educational challenge for farmers, research and extension personnel in fruit crop to enjoy access to information on alternative pest control practices. Farmers lack biological and ecological information desired for pest management; even extension agents and subject matter specialists lack sufficient training and experience in system-based technologies which are key to IPM practices. Perhaps the most formidable challenge is to upgrade the knowledge of farmers at least to identify the pest and its damage symptoms.

The availability of timely and quality pest management inputs is a challenge. The alternative management tools are available to farmers mostly in government funded projects but it becomes unavailable once project is withdrawn. Meticulous attention is required to cull out the entry of spurious plant protection chemicals in market channel. Quality of market products (bio agents and bio-pesticides) remains a challenge and there is not a sufficient mechanism to handle this situation. Pesticide industry interference especially in promotion of chemical farming has also been reported. It is said that chemical farming is a subsidized farming where a farmer manages all kinds of subsidy by default but it does not happen with IPM based farming.

Fruit farmers possess diverse kinds of production systems with varying degree of resources and crops. It is a challenge to unite fruit farmers for collective action for particular crop cultivation. Pest management is effective when it is implemented at ecosystem scale. As process of fruit IPM learning requires an environment where all the participants are involved in a continuous process of sharing and learning so that they act as "unifying force" in a given area which can be nurtured by interdisciplinary problem solving experts to create an IPM oriented farmer groups. IPM implementation can benefit from a certain number of individuals, groups and organizations driven by a common goal of safe production of fruit commodities which is not seen in this sector.

Pesticide application technology under unavoidable situations holds the key to make pest control effective. Looking to the pest location and canopy height in perennial fruit like mango, it remains a challenge for farmers to monitor, make decision and target the pest. For example, thrips remains on ventral surface and most of the customized spray agencies throw the spray solution on dorsal surface of the canopy that trickle down without stroking the thrips. Perhaps farmers are restoring 7-8 sprays for thrips control. In the same way, borer management in high canopy trees is again an onerous task. Borers lay eggs sequentially and any spray remains effective for 7-10 days; time and again spraying is not possible that's why pest like tent caterpillar causing severe damage in mango.

Research weaknesses leading to development of weak IPM technologies is itself a challenge. Pest spectrum in fruit is changing fast and old problems remain unresolved. Increasing sucking pest menace in vegetables, high prevalence of vectors and viral diseases in the light of climate change, difficult pests under protected fruit, BSFB in brinjal, bacterial blight in the pomegranate, malformation in mango, fusarium wilt in the guava, recent race of banana wilt and mite in coconut are some of the examples wherein, a lot of investment has been made but successful IPM tool is yet to be worked out.

Mango borer was reported in India in 1955 which was not a major pest till 1993. Thereafter, the pest became a major in Andhra Pradesh, Orissa, West Bengal and Bihar. Similarly, a mango bunch borer is being recorded in Malihabad and Sharanpur area. Likewise, thrips have become the severe problem in certain areas and shoot gall psylla and inflorescence midge infestation is recorded in nontraditional areas. Researchers need to be adequately prepared and acquainted with such pest shift and resurgence and practices associated with this. Special research programme is needed for some of the newly emerged and expanded pests like inflorescence midge (Dipteran-has no specific recommendation), shoot gall psylla (very old recommendation by Dr Gajendra Singh is still in use), thrips (no mango based recommendation.), mango bunch borer (no specific recommendation) mango red banded caterpillar (Chlorpyriphos based recommendation from AP) to tackle them amicably. Impact and methods of off season pest management practices through alternative methods on pest incidence (borers, thrips, hoppers in mango) in cropping season needs to be worked out. Use of damaged materials and pruned materials in mass emergence device for natural enemies and conservation of indigenous natural enemies with off season shelter and food for their sustenance needs to be worked out.

Real-time data on area under different fruit crops, maturity/harvesting period, pest attack, forecasting and advisory remain a challenge for improving pest management actions in fruit. E pest surveillance, development of mobile based app and application of remote sensing are still in infant stage in fruit sector.

There were days when pesticide screening was a common practice among the plant protection workers. Currently infrequently this is performed especially in perennial fruit. Label claim has added another hurdle in choosing and recommending the pesticide in fruit. There is a need to pursue the authority and companies to increase the basket of label claim pesticides in fruit, at the same time, the pest monitoring and pesticide application technology needs to be improved. Residue monitoring especially in fruit commodities being eaten raw still remains a far cry.

Pace of evaluation of bio-pesticide and bio-agents for the fruit pest needs to be improved, at the same time; the production of these agents at domestic level may be standardized. Field rearing cages and devices for self-perpetuation and field inoculative release may be designed. Fogging with diesel and malathian was reported once upon a time to be remarkably effective for the most noxious pest like hopper in mango. After wards, no work has been carried out on this; it reduces the pesticide load many fold. Fogging, if effective may be useful not only hoppers but also for thrips, however suitable fogging machine needs to be devised. Drone based monitoring and pesticide application may be tested at pilot scale. Fruit industry mechanization from plant protection view is also a need of hour.

Targeting the pest for spray at height and location is a challenge in perennial fruit. Ideal canopy impact needs to be demonstrated for its superiority as for pest management is concerned. Making ideal tree architecture and framing the newly planted trees from beginning, skirting, opening up of central canopy and hygiene pruning to remove the pest inoculums are the key operations. Reduction in the tree height by rejuvenation or sequential reduction through girdling across the traditional mango belt will certainly improve the sunlight harnessing, reduced pest incidence, quality production, better pest monitoring, targeted spray and thereby reduced pesticide consumption and health hazards. Banana, pine apple, mango, guava, apple and for that matter many crops are now cultivated under HDP mode. Likewise many ornamental and vegetable are cultivated under protected condition of net house and poly house. The micro climate and pest dynamics is changed under modified growing environment, hence package of practice and pest management strategies need to be devised accordingly.

Shortage of well-qualified IPM experts and extensionists for better IPM is encountered. Technology centre and quality input supply centre near production areas, field technology assessment centre in production areas, ensuring the availability of tested technology and timely advisement remain murky areas which require attention. Pest management extension system, the most required assistance in fruit crops may work effectively if village level technology source and problem solving diagnostic centres are made functional and public sector agencies, agri-clinics, FPOs, cooperatives, PRI, NGOs and para- workers join this task under KVK acting as nodal agency with the help of modern ICT. However, the vast network of KVKs, still remain isolated when it comes to pest management with specific reference to perennial fruits.

Pest management capacity and ability to take risk among fruit farmers comes from the level of income accrued from it. This can be witnessed in the form of knowledge, input use, risk bearing capacity and income of peri-urban and market linked farmers as against distantly located farmers. Farmers producer group based marketing, use of government mediated e-market channel, harnessing the potential of off season produce, cost and risk of long distance produce transportation, brand development, ripening and cold storage facilities, produce sale app for direct home delivery, demand and prevailing rates etc need to be supported for better income and thereby pest management adoption.

Working on above aspects in unifying manner right from government level to field level to address the challenges would represent the appropriate strategy to make IPM a simplified method of pest management in fruit crops.

LEAD LECTURE – 25

Advances in rootstock research and its role in mitigating abiotic stress in fruit crops

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It is well understood that rootstock is inextricably linked with the success or failure of orcharding enterprise because plant's first line of defense against abiotic stress is in its roots. More than twenty horticultural characteristics are reported to be influenced by the rootstock. Certain species of rootstock and ecotypes seem to have a combination of key genes, quantitative trait loci and molecular networks that mediate plant responses to drought, salinity, heat, freeze tolerance and other abiotic stresses. Therefore, use of suitable rootstock that would induce tolerance to abiotic stresses or enable exclusion of uptake of toxic chemicals by the roots would be useful to prevent or reduce economic losses. Purposefully selected rootstocks enables the scion variety to express its genetic potential in terms of tolerance to various abiotic stress, fruit quality and achieving real yield, modify architecture of plants. Climate change on the other hand is projected to have significant impacts on conditions affecting fruit industry which is substantiated by the facts like declining apple productivity, erratic flowering in mango, damage due to frost and chilling injury in aonla and ber. Salinization is one of the most serious problems confronting citriculture industry in India. World's best Kinnow producing areas of Rajasthan *viz.*, Sri Ganganagar and Abohar are facing the desire consequences of increased salinization which have resulted due to indiscriminate use of irrigation water, similarly increased salinization have resulted in significant decrease in guava productivity due to wilt as a result of secondary infection due to phytophthora. All these situations are compelling the orchardist towards a gradual shift to other crops. Such uncalled situations are not only a threat to nutritional security but also a hindrance for healthy economic growth of the country. To circumvent such crisis, and to enhance fruit productivity, development of newer and responsive rootstock (s), use of wild relatives to various abiotic stresses combined with the advances in rootstock technologies to achieve the targeted production for the future is the need of the hour. This paper is an attempt to provide a brief review of the rootstock resources, technologies developed and future line of root stock research in some of the major tropical, subtropical, temperate and arid fruits of the hot and cold region.

Mango

Mango (*Mangifera indica* L.) the national fruit of India and King of fruits is known as for its delicious taste, vitamins and minerals. It has a paramount place in Indian fruit industry accounting for 34.9 per cent of area and 20.7 per cent of total fruit production in the country and is also the largest producer of mango in the world which share 45.1per cent in the world mango production. However, mango production is severally impacted by several abiotic stresses. To mitigate the challenges, the focus in mango rootstock research led to the development of rootstocks for varied situations that could confer resistance to adverse soil conditions and affect vigour of the scion. In this backdrop, aspects of polyembryony for uniformity; dwarfing characters for establishing HDP systems; tolerance to calcareous soils and physiological compatibility to scion assume specificity, for example salt tolerant rootstocks *viz*. Bappakai, Olour, Kurakkan from India, 13/1 (Israel), Gomera 1 (Canary island), Sukary (Egypt) and GPL-1 and ML-2 tolerant to sodicity (Andaman islands) has been identified (Gazit and Kadman, 1980., Duran Zuazo *et al*., 2003., Hafez *et al*., 2011). With the identification of these rootstocks, it is now possible to grow mango commercially in salt affected soils. Plant growth, extent of bearing and fruit quality of Amrapali grafted on Kurukkan has been found to be at par to that of grafted on seedling rootstocks. Some tolerant rootstock such as Pullima for drought from Sri Lanka, flood tolerant rootstock, *Mangifera gedbe, Mangifera decandra,* Cultivar, Than ca (Vietnam), Turpentine and Number 11 for high soil pH (Florida) and rootstock tolerance to adverse drainage condition, Hilacha from Colombia have been identified, thus offering scope for mango cultivation in these abiotic stressed areas (Jauhari *et al*. 1972., Van Hau *et al*. 2001., Mossler and Crane, 2013). Wild relative *Mangifera orophilla* for cold tolerance.

Citrus

Citrus (*Citrus* spp.) is the third most important fruit crop of India after banana and mango. Its cultivation globally however, has been bogged down by common problems associated with abiotic stresses such as drought, extreme temperature, salinity and others which severely influence the growth and development of both rootstocks and/or scions, thus reducing both fruit production and fruit quality. Great stresses associated with root system, rootstocks that are seedy, highly nucellar, graft compatible with commercial cultivars, high degree of horticultural performance along with ensuring parity of fruit quality parameters with those of seedling origin are some of the great challenges to the citrus industry. Citriculturist all over the world however, have researched in depth and developed an array of rootstocks tolerant to various abiotic stresses. Citrus rootstock, Rangpur lime can adapt to alkalinity, salinity and calcareous soils and can impart resistance to cold and can provide high-quality fruits. Similarly Cleoptera mandarin has the ability to tolerate salinity and cold (Santana-Vieira *et al*., 2016). F&A5 and F&A13 developed from Spain are tolerant to salinity (Forner *et al*., 2003). Karna Khatta (India) has been reported to be a drought tolerant rootstock for Kinnow mandarin (Kumar *et al*., 2018). Similarly Sunki Maravilha mandarin (Brazil) can sustain drought. Sour orange the world most popular rootstock although has certain inherent problems is a cold tolerant rootstock and suitable for growing different citrus species in the colder regions.

Grape

Commercial viticulture in the country has undergone sea change in the country impacted by rootstock. Apart from biotic stresses grape production and productivity is threatened by abiotic stresses also, such as low water availability (drought), excess water (flooding/water logging), extremes of temperatures (cold, chilling, frost, and heat), salinity, mineral deficiency and toxicity.

In India problems associated with grape production are salinity build up in soils and water, chlorides in irrigation water and excess levels of sodium and drought in and around grape cultivated area. The use of rootstocks in grape cultivation due to twin problems of drought and soil salinity has gained popularity, and almost all newer vineyards are being planted on stress tolerant rootstocks only. The popular rootstocks of grape 'Dogridge B' and '110 R' are presently being employed mainly to overcome the adverse effects of abiotic stresses like drought and soil salinity . *V. rupestris, V.*

berlandieri and V. champinii wild types and its related genotypes are more tolerant to drought than *V. riparia* types due to shallow root system. These species are important because having some peculiarities like *Vitis rupestris* based rootstocks [St. George, 1103P, AXR#1 (3309C)] are having broadly distributed roots, relatively drought tolerant, moderate to high vigor and mid season maturity. Similarly *V. berlandieri* based rootstocks (110R, 140Ru, 420A, 5BB) are characterized by deeper roots, drought tolerant, higher vigor and delayed maturity. While, *V. champinii* related rootstocks are having (Dogridge, Ramsey (Salt Creek), Freedom, Harmony, GRNs) deeper roots, drought tolerant, salt tolerance but variable in hybrids. Pavlousek (2012) reported that rootstock hybrids that contain *Vitis berlandieri*, *Vitis riparia* and *V. cinerea* in their pedigree show better drought resistance as compared to hybrids with *Vitis rupestris* and *Vitis amurensis* which show a medium tolerance to these conditions. Jogaiah *et al*. (2014) reported that rootstocks belonging to *Vitis berlandieri* × *Vitis rupestris* (110R, 1103P, 99R, and B2/56) showed better osmotic adjustment and increased water use efficiency followed by the rootstocks belonging to *Vitis champinii* species (Dogridge and Salt Creek).

Guava

Guava (*Psidium guajava* L.) is an important fruit crop of India. It is a hardy fruit crop and is cultivated successfully even in neglected soils. It has gained considerable prominence on account of its high nutritive value, availability at moderate prices, a pleasant aroma and good flavour. The rootstock studies related to abiotic stress in guava are very meager. Sa *et al*. (2016) reported that *in vitro* screening of Brazilian guava rootstock 'Crioula' can tolerate salt concentration up to 1.8 dS m^{-1}. Other potential species as rootstocks include *P. cujavillis, P. molle, P. cattleianum* and *P. guineense.* Somatic cell genetic technologies for developing rootstocks tolerant to abiotic stress hold promise.

Ber

Among arid fruits ber (*Ziziphus mauritiana* Lam) is an important fruit crop. Maheshwari and Singh (1965) recogonised six economically important species in India. These are *Z. mauritiana* (ber), *Z. nummularia* (*jharber*), *Z. oenoplia* (*makoh*), *Z. rugosa* (*suran ber*), *Z. sativa* Gaertn (*Z. vulgaris* Lam. *Kandiari*) and Z. *xylopyrus* Hochst. Ex A. Rich. Tent. (*kat ber*). Awasthi *et al*. (1995) reported that wild jujube *Z. rotundifolia* can be grown upto 60.5% ESP and 20.25 dsm^{-1} salinity which suggest the scope for future breeding work on this line. From the diverse germplasm mainained on *Ziziphus rotundifolia* at ICAR-CIAH, Bikaner, cultivars Tikadi, Dandan and Mahravali were identified for their tolerance to frost and low temperature (-3^{0}C). The role of rootstock for low temperature tolerance in the scion cultivars and vice-versa needs to be investigated for their use in the breeding programme. Dasuanzao and Cuisuanzao from China have some characteristic abilities of drought resistance, leanness tolerance and adaptability and should be exploited in the arid and semi-arid regions of the Indian subcontinent.

Annonas

In annonas various species can be used as rootstocks to which desirable species can be grafted. Seedling rootstocks of annonas are generally derived from heterogeneous open-pollinated plants. *A. reticulata* can withstand diverse ecological conditions and survive long dry periods. It is very useful as a vigorous rootstock. It is well adapted to unfavourable soil conditions and can grow in soils having pH 5.0 to 8.0. Because of its high tolerance to variable soil types, it is considered to be a good rootstock for cherimoya and sour sop. *A. diversifolia* also has similar ecological amplitude, but has been less widely used.

Future outlook

Requirements for an ideal rootstock are many and no single rootstock possess all of the desired attributes, a number of superior stocks are sought each suited to a particular set of conditions. The future requirements of rootstocks should focus on:

- Survey, selection and evaluation of a large number of indigenous species in different fruit crops so as to explore their possibility to use as rootstocks under different agro climatic conditions.
- Understand the gene pool to identify taxa and a series of specific genotypes which can be of value as rootstocks.
- To develop rootstocks which can control the overall tree morphology and its vigour and to maximise its adaptation to different edaphic conditions.
- To standardize rootstocks in relation to productivity objectives, for use in orchard versus agro forestry systems and for use in adaptation to stress conditions.
- For basic research on rootstock genotypes for stress tolerance and in relation to the value of useful soil microflora such as mycorrhizae.
- Development, introduction and testing of new clonal rootstocks for fruits where such rootstocks are not presently available.
- Development of complex hybrids through inter and intra-specific hybridization to develop more versatile rootstocks to increase their usefulness and adaptation with respect to compatibility, size control, precocity, productivity and resistance to biotic and biotic factors.
- Development of virus free material for all commercial rootstocks to reduce virus related incompatibility problems and to maintain sustainability in productivity and fruit quality. There is a need to refine the procedures for virus testing so that in future all the commercial rootstocks are available as virus free.
- Development and use of self-rooted scions which will eliminate compatibility problems on one hand and will also reduce the high cost of intensive orchard establishment on the other.

References

Awasthi, O.P., Pathak, R.K. and Pandey, S.D. (1995). Effect of sodicity and salinity on four scion cultivars budded on Indian jujube (*Ziziphus mauritiana*). *Indian Journal of Agricultural sciences*, **65**(5): 363-67.

Duran, V.H., Raya, A.M. and Aguilar, J. (2003). Salt tolerance of mango rootstocks (*Magnifera indica* L. cv. Osteen). *Spanish Journal of Agricultural Research*, **1**(1): 68-78.

Forner, J.B., Forner-Giner, M.A., and Alcaide, A. (2003). Forner-Alcaide 5 and Forner-Alcaide 13: two new citrus rootstocks released in Spain. *Hort Science*, **38**(4) : 629-630.

Gazit, S. and Kadman, A. (1980). 13-1 Mango rootstock selection. *Hort Science,* 57:81-87.

Hafez, O.M., Saleh, M.A., Ellil, A. and Kassab, O.M. (2011). Impact of ascorbic acid in salt tolerant of some mango rootstock seedlings. *Journal of Applied Sciences Research*, **7**(11): 1492-1500.

Jauhari, O.S., Teaotia, S.S. ad Upadhyay, S.K. (1972). Rootstocks studies in *Mangifera indica* L. *Acta Horticulturae*, **24:** 107-109.

Jogaiah, S., Ramteke, S. D., Sharma, J. and Upadhyay, A. K. (2014). Moisture and salinity stress induced changes in biochemical constituents and water relations of different grape rootstock cultivars. *International journal of Agronomy*

Kumar, S., Awasthi, O.P., Dubey, A.K., Pandey, R., Sharma, V.K., Mishra, A.K. and Sharma, R.M. (2018). Root morphology and the effect of rootstocks on leaf nutrient acquisition of Kinnow mandarin (*Citrus nobilis* Loureiro× *Citrus reticulata* Blanco). *The Journal of Horticultural Science and Biotechnology*, **93**(1): 100-106.

Maheshwari, P. and Singh, U. (1965). Dictionary of economic Plants in India. ICAR, New Delhi.

Mossler, M.A. and Crane, J. (2013). Florida/Crop Pest Mangement Program. Profile: Mango. University of Florida. IFAS Extension. Publication #CIR 140. https://edis.ifas.ufl.edu/pi052.

LEAD LECTURE – 26

Suppression of diseases of horticultural crops through plant and soil health management

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India is second largest producer of fruits and vegetables in the world, accounting roughly 10 per cent and 15 per cent respectively, of total global production. Over the last decade, the area under horticulture grew by 2.6 per cent per annum and annual production increased by 4.8 per cent. During 2017-18, the production of horticulture crops was 311.71 Million tonnes from an area of 25.43 million hectares (Horticultural Statistics at a Glance, 2018). Among vegetables, India ranks second in the production of potato, onion, cauliflower, brinjal and cabbage. In fruits, it is the largest producer of banana, mango, guava, lemon and papaya. But, the total production is quite below the requirements at the recommended dietary allowances of 90 g of fruits per capita per day as laid by Indian Council of Medical Research. Plant diseases are the major constraints in increasing the productivity of fruits and vegetables crops. Huge pre– and post– harvest losses are caused by various plant pathogens and unfavorable environments leading to the total failure of the crops. Intensive agriculture provides greatest opportunities for the buildup of many new diseases and insect–pests. Plant protection mainly aims to attain maximum yield by keeping the crops healthy and preventing the losses occurring from diseases. A principle of plant disease management broadly includes preventive measures and curative measures that cure the plants suffering from diseases. But none of the control methods when applied individually provide satisfactory and effective disease control. Hence, suppression of diseases of fruits and vegetables crops through improving plant and soil health could be the complete solution of all the disease problems.

Currently, fungal diseases (root rot, wilt, leaf spots, blight/ anthracnose) and root-knot nematodes are common and important diseases during horticultural crop cultivation. Synthetic chemicals have been extensively used by farmers for protecting horticultural plants. Consequently, toxic residue of pesticides in raw material posed serious concerns of risk to human health. Thus, plant diseases create challenging problems in commercial agriculture and pose real economic threats. Therefore, the health of horticultural plants are of major concern, even there should be a common practice for no or minimal use of synthetic pesticides. In this context, following strategies could be used for the sustainable diseases management of horticultural crops.

Biological control of plant pathogens

We must have noticed that certain organism restricting the growth of the other in their natural habitat; either they are competing for food or for space. Nevertheless one is going to affected in different terms, such organisms are known as antagonists. These antagonists or the natural enemies when used intentionally in larger prospect are known as biocontrol agents, and the other is referred as pathogen or pest. In other words, the method uses nature's own in-built mechanisms to ensure equilibrium. Biocontrol is being practiced in agriculture prior the term itself came into use, which was discovered as a result of trial and error (Baker and Cook, 1974).

Talking about plant pathogens, they can be bacteria, fungi, nematode or virus. Fungi are the major pathogens means to be deal with, as they are sporogenous that can survive in the soil even if a susceptible host is not present. Referring to the disease triangle, biotic stress occurs when a pathogen interacts with a susceptible host plant in a favorable environment. However, environmental factors may support or depress the susceptibility of the host and the pathogenicity of the pathogen. Here, the fourth fundamental element along with a susceptible host, a pathogen and a favorable environment is adequate time to pose a disease, referred as "disease quadrangle", now days.

Types of symptoms expected from a phytopathogen

Fungi : Spores are typically spread by wind, rain or may sustain in soil, mechanical means and infected plant material, they exhibit yellowing of leaves, spots, lesions, blights, wilts, cankers, rots, mildews, leaf spots, root rots, fruiting bodies and blotches.

Bacteria: These are typically spread by rain, mechanical means, planting material and vectors (like insects). Symptoms of bacterial infection can be seen as yellowing, spots, wilts, rots, blights, water-soaking, cankers, exudates, galls, and watery blotches.

Viruses: These a cellular organisms cause mottling, leaf and stem distortions, mosaic patterns, rings and stunned growth of plants. Viruses cause interesting symptoms, some are beautiful. They spread through vectors, mechanical means and infected plant material.

Strategies of microbial based biocontrol

The escalating human population and increasing demand for a healthy and steady food supply has been the primary concern in the 21st century with emphasis on controlling plant disease that reduces crop yield. Current approaches employed for disease control are mainly based on genetically resistant host plant, application of synthetic pesticides/fungicides and management of the planting environment which ultimately develops resistance in pathogenic microorganisms chemical fungicides. (Strange, 1993; Thomas and Fisher, 1999).

In contrast to synthetic chemicals, biocontrol of phytopathogens using microorganisms put forward a powerful alternative, with markedly endless resource. Plant rhizospheric inhabitants are being exploited for the purpose with the idea that abundance of a particular beneficial strain in the vicinity of a plant should suppress soil borne diseases without producing long term effects on the other microbes dwelling there (NRC Report, 1996; Howarth, 1991; Gilbert *et al.*, 1993; Osburn *et al.*, 1995).

Biological control of phytopathogens includes complex interactions between organism-plant cell-soil and several mechanisms of disease suppression by a single or mixture of microorganism. Since, these microbes used as biocontrol agents are specific for a particular plant rhizosphere, thus they adapt the environment easily. (Gómez *et al.*, 2017; Cook, 1993; Benbrook *et al.*, 1996).

Biocontrol through microbial agents is generally, the purposeful utilization of resident living organisms or introduced microbial formulations. Several strains of bacteria and fungal genera including *Pseudomonas*, *Bacillus*, *Streptomyces*, *Agrobacterium*, *Serratia*, *Trichoderma*, *Aspergillus*, *Metarrhizium*, *Beauvaria* and non-pathogenic *Fusarium* respectively have proven their potential as biocontrol agents. Maintaining healthy soils must be a primary objective to achieve as it acts as the first line of defense and for an effective biocontrol activity *i.e.* suppressive soils. "Soil in which disease development is suppressed even though the pathogen is introduced in the presence of a susceptible host". Two major approaches that are being employed for crop and soil health management, The "Black box" approach and the Silver box approach.

Black box approach

Technique or combination of techniques that are employed for conservation and enhancement of naturally resident microbial community that acts against the phytopathogens this includes various practices traditional agriculture. High content of organic matter in soils are shown to elevate soil biodiversity and also helps creating ambient environment abundance for beneficial soil microorganisms. As beneficial microbes increase in number in the soil and plant vicinity the soil suppressiveness increases. The phenomenon of such suppressive soil is believed to be biological in nature since fumigation or heat-sterilization of the soil abolishes such effect in the soil, and if the pathogen is re-introduced severity of disease gets worse. Following are some traditional and new farming practices that are employed for a healthy soil and plant health:

- Crop rotation: at least 3 yrs interval between crops in the same family
- Cover crops
- Exclusion of disease free seeds, plant stock, water source
- Control insects that can carry disease
- Soil solarization
- Reduced- or no- tillage practices
- Precision farming
- Intercropping and use of green manure
- Raised bed plantation
- Good sanitation from the prior season
- Resistant varieties or genetically modified cultivars
- Use of compost materials
- Adaptation and promotion of organic and biodynamic farming systems
- Avoidance of overhead irrigation
- Provide unfavorable condition for pathogen (mulches, maximizing air circulation, increased soil drainage)

Silver bullet approach

Amending soils with application of specific strains of microorganisms as biocontrol agents is termed as 'Silver bullet' approach. Several strains of bacteria and fungal genera including *Pseudomonas, Bacillus, Streptomyces, Agrobacterium, Serratia, Trichoderma, Aspergillus, Metarrhizium, Beauvaria* and non-pathogenic *Fusarium* have proven their potential as biocontrol agents. As prior *i.e.*

black box approach can be achieved through good agricultural practice; this is an augmentative regimen using single or multiple organisms. A single inoculant comprises of only one specific bacterial/fungal species however the formulations may contain more than one type/genera and species. Frequency of soil application may depend on the type of soil, pathogen and amount of the pathogen. Strategies of silver bullet include periodic or inundative release of the biocontrol agent (Chandrashekara *et al.,* 2012; Vinale *et al.,* 2009; Pal and Gardener, 2006; Rosskopf *et al.,* 1999).

Advantages of biocontrol strategies

- ❖ Low cost and cheaper than any other methods with no toxicity to the plant, environment or humans
- ❖ High efficacy against specific plant pathogen and protect the crop throughout the crop period
- ❖ Biocontrol agents multiply easily in the soil leavening no residues behind
- ❖ Biocontrol agents can eliminate pathogens from the site of infection
- ❖ Enhances plant growth itself or by encouraging the beneficial soil microflora resulting increased crop yield
- ❖ Helps in the volatilization and sequestration of certain inorganic nutrients
- ❖ With ease in handling and application to the target site these can be combined with biofertilizers
- ❖ Biocontrol agents are easy to manufacture as it only requires simple training.

Disadvantages

Advantages come with certain disadvantages as well:

- ❖ Pathogen and disease specific in nature, in contrast fungicides are broad spectrum in nature
- ❖ Biocontrol agents establish themselves in the given environment actively but not instantaneously providing slow effect in controlling the diseases
- ❖ Few biocontrol agents are being marketed presently and low in quantities; (however the no. is increasing now a days)
- ❖ Biocontrol strategy is only a preventive measure rather than curative measure
- ❖ Contamination with unwanted organism is a common problem with short shelf life of biocontrol agent *eg*. Fungal formulations have viability for ~4month similarly bacterial formulations have ~3month of shelf life.
- ❖ Environmental conditions play a vital role in efficacy of biocontrol agent with a certain amount of population
- ❖ A biocontrol agent under certain circumstances can transform to a potential pathogen.

Conclusion

Biocontrol agents are considered as the probiotics for the soil health which ultimately gives a healthy plant and good yield. Recent studies showed that, fungus and bacterial plant probiotics are able to establish a relationship with fruit and horticultural crops and as a result of this interaction some plant compounds, which are beneficial to human health with increased production. On one hand, as outlined above, the market for bacterial fertilizers is growing, but the effects of these commercialized bacteria on food quality parameters are not detailed. Application of plant probiotic bacteria improves the quality of fruit and vegetables by increasing vitamins, flavonoids and antioxidants content, among other benefits. However, there are other functional food compounds that can also be potentially improved by fungal and bacterial inoculants. In the future, new research approaches such as metabolomic studies, comparing fruits and vegetables grown with and without the application of fungus and plant probiotic bacteria, may reveal additional beneficial effects on the quality of food crops from the applications of these types of bioagents.

References

Baker, K.F., and Cook, R.J. (1974). Biological Control of Plant Pathogens, W. H. Freeman and Co, San Francisco, California (Book, reprinted in 1982, *American Phytopathology Society*, St. Paul, Minnesota). 433 pp.

Benbrook, C.M., Groth, E., Halloran, J.M., Hansen, M.K. and Marquardt, S. (1996). Pest Management at the Crossroads, Consumers Union, Yonkers. 272 pp.

Chandrashekara K.N., Manivannan, S. and Chandrashekara, C. and Chakravarthi M. (2012). Biological Control of Plant Diseases. Ecofriendly Innovative Approaches in Plant Disease Management Chapter 10. pp. 147-66.

Cook, R.J. (1993). Making greater use of introduced microorganisms for biocontrol control of plant pathogens. *Annu. Rev. Phytopathol*, **31**: 53-80.

Gilbert, G.S., Parke, J.L., Clayton, M.K. and Handelsman, J. (1993). Effects of an introduced bacterium on bacterial communities on roots. *Ecology*, **74**: 840-854.

Gómez A. J., Lera, L.C., Bayón, M.F., Rivas, R. (2017). Plant probiotic bacteria enhance the quality of fruit and horticultural crops. *AIMS Microbiology*, **3**(3): 483-501.

Howarth, F.G. (1991) Environmental impacts of classical biological control. *Annu. Rev. Entomol.* **36**: 485-509.

Horticultural Statistics at a Glance (2018). Ministry of Agriculture & Farmers Welfare, ICAR, New Delhi.

NRC Report (1996). Ecologically Based Pest Management: New Solutions for a New Century, Natl. Acad. Sci. Press, 144 pp.

Osburn, R.M., Milner, J.L., Oplinger, E.S., Smith, R.S. and Handelsman, J. (1995) Effect of *Bacillus cereus* UW85 on the yield of soybean at two ¢eld sites in Wisconsin. *Plant Disease*, **79**: 551-556.

Pal K.K. and McSpadden G.B. (2006). Biological Control of Plant Pathogens. The Plant Health Instructor. DOI: 10.1094/PHI-A-*2006*-1117-02

Rosskopf, E.N., Charudattan, R., & Kadir, J.B. (1999). Use of Plant Pathogens in Weed Control. Handbook of Biological Control, 891–918.

Strange, R.N. (1993) Plant Disease Control: Towards Environmentally Acceptable Methods, Chapman and Hall, New York. 354 pp.

Thomas, S. Bellows and Fisher, T.W. (1999). Handbook of Biological Control Principles and Applications of Biological Control. 1046 pp.

Vinale F., Ghisalberti E.L., Sivasithamparam K., Marra, R. and Ritieni, A. (2009). Factors affecting the production of *Trichoderma harzianum* secondary metabolites during the interaction with different plant pathogens. *Lett. Appl. Microbiol*, **48**: 705-711.

LEAD LECTURE – 27

Improvement of cucurbit crops: Emerging challenges and strategies under climate change

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In addition to natural climate variability observed over comparable time periods a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere is called "Climate change" (UNFCC, 1992). Vulnerability of any system to climate change is the degree to which these systems are susceptible and unable to survive with the adverse impacts of climate change (Schneider et al. 2007). According to Fahad *et al*., 2007, due to climate change, drought, and heat stress have become the most important limiting factors to crop productivity and ultimately the food security. Increasing temperatures, declining and more unpredictable rainfall, more frequent extreme weather, droughts, increased level of CO_2 and higher severity of pest and disease incidence are the changes that took place in the climate gradually over decades (Parry *et al*., 2007, Kotschi, 2007, Morton, 2007, Brown and Funk, 2008, Lobell *et al*., 2008, Cotter and Tirado, 2008). Average global combined temperature of land and ocean surface has increased by 0.85^0C between 1880 and 2012 (IPCC, 2014).

The major challenges are to increase the productivity on sustainable basis to manage the food and nutritional security. Among the vegetable crops, cucurbits are mostly adopted to stress condition. Due to climate change, many new diseases and pests are emerging and becoming the threat for the farmers. The cucurbitaceous family consists about 118 genera and 825 species, which include cucumbers, melons, watermelons, pumpkins, squash, and many others indigenous crops grown in different part of country. Many of the cucurbits like, bottle gourd, bitter gourd, pumpkin, ash gourd, cucumber and pointed gourd are considered medicinally important and health improving vegetables. Cucurbits share ~ 5 per cent of the total vegetable production in India and according to FAO estimates, it is cultivated on about 0.64 million ha with the productivity of 10.61 t/ha. According to an estimate, India will need to produce 300 million tonnes of vegetables by 2050 to meet the requirement of increasing population.

The genetic potential of cucurbits and production are constantly threatened by environmental stresses, including biotic and abiotic factors that reduce crop yield and quality. During the growing season, cucurbits plants face many unacceptable environmental conditions, like drought, heat, salinity, flooding, heavy metals, and change in soil pH. These stresses have negative impact on plants survival, biomass production and estimated up to 82% loss of final yield. In recent years, with changes in the cropping systems and climate, and introduction of highly input intensive high yielding varieties/hybrids, a shift in pest status has been observed. Apart from the regular insect pests *viz*., cucurbit fruit fly (*Bactrocera cucurbitae* Coq.), red pumpkin beetle (*Raphidopalpa foveicollis* Lucas, 1849), whitefly (*Bemisia tabaci* (Genn.)), serpentine leaf miner (*Liriomyza trifolii* (Burgess)) there is a paradigm of shift of insect pests in cucurbits crops in recent years. Emergence/re-emergence of insect pests has occurred in this popular summer vegetables. Occurrence of melon weevil, (*Acythopeus curvirostris citrulli*) as a serious pest was recorded from sponge and ridge gourds. About 70-80 per cent fruits and 30 per cent shoots of sponge gourd were severely damaged by this weevil (Halder *et al*., 2016). The white plume moth (*Sphenarches caffer* (Zeller)) was observed as an emerging and serious threat in bottle gourd. Larvae of plume moth, *S. caffer* damaged the leaves and buds of bottle gourd by scraping the chlorophyll portion and damage was more severe when they fed on the emerging buds resulting in restricted growth of the plants. Recently serious incidence of a mirid bug, (*Nesidiocoris cruentatus* (Ballard)) was observed on tender leaves and young fruits of bottle gourd. Brown puncture spots with on the rind with sap oozing out from the tender fruits was the characteristic symptoms of this sucking pests. The affected fruits often failed to fetch a good market price (Halder *et al*., 2017). Cucumber moth or pumpkin caterpillar [*Diaphania indica* (Saunders)] has become an emerging pest of cucurbitaceous crops especially bitter gourd, cucumber, pointed gourd and gherkin. Light green larvae feed chlorophyll portion of the leaves by webbing them together. They also feed the reproductive parts of the plants *viz*., flowers and young fruits causing serious damage (Rai *et al*., 2014). As most of the cucurbits are grown during summer season, the severity of red spider mite is also increasing day by day. The ability of a crop to withstand a particular stress is directly related to its survival and productivity.

In recent years, blossom blight- *Choanephora infundibulifera* (30%), bacterial wilt and angular leaf spot - *Erwinia* spp. (10%), Cucurbit *aphid borne yellows virus* (46%), downey mildew- *Pseudopernospora cubensis* (32%), gummy stem blight- *Didymella bryoniae* (50%), leaf spot (*Cercospoara* and *Colletotrichum*), 18- 23 per cent, powdery mildew- *Erysiphe cichoracearum* (28%), root knot nematode- *Meloidogyne* spp. (5%), Tomato leaf curl New Delhi virus (22-47%), wilt (*Fusarium* spp.), Zucchini yellow mosaic virus (10%), became major emerging problem for the cultivation of almost all the cucurbits in India under abrupt weather condition/changing climatic scenario. These diseases are more severe on cucurbits under protected cultivation when the temperature rises above 30 °C and humidity 80%. In general temperature and moisture play important role for fungal and bacterial pathogen biology such as survival, germination, infection and disease development. High moisture favours incidence of soil borne pathogens such as Phytophthora, *Pythium, R. solani, Macrophomina* and *Sclerotium rolfsii*.

Due to fluctuation in temperature and high vector population the dynamics of virus infestation are changing very fast. In a survey of curbitaceous crops in Uttar Pradesh; poty virus, tospo viruses, begomo viruses, tobamo virus, polerovirus and cucumovirus were detected in the samples. The maximum percent of incidence was recorded for begmovirus (93.33%) followed by poty virus (39.44) and tobamovirus (38.33%). The extent of damage was found maximum in cucumber, snake gourd, watermelon and ridge gourd. These types of viruses adapt rapidly to changing conditions.

Screening of germplasms for various abiotic and biotic stress and using those identified resistance lines in a breeding programme is one of the way to combat climate change. Advanced biotechnological technologies will also be helpful in development of durable tolerant cucurbits varieties/hybrids which will be suitable for fluctuating climatic condition. There is tremendous genetic diversity within the family, and the range of adaptation for cucurbit species includes tropical and subtropical regions, arid deserts, and temperate regions. Screening and evaluation of diverse collection of cucurbits accessions may provide an opportunity to broaden the genetic base and a boost to current breeding program. Resistance sources are generally present in landraces and wild

Table 1. Major biotic stresses and their sources of resistance

Crop/ biotic stress	Resistance sources
Muskmelon	
Powdery mildew	PMR-45, PMR-450, PMR-5, PMR-6, PI-124111 Edisto, PMR-45 and PMR-450; Georgia-47 and C-68; Campo and PMR-6; Arka Rajhans, RM-43 and Pusa Sharbati Campo, Jacumba, Levlita, PM-5 and PMR-6, PI 164323, and PI 180283
Downey mildew	MR-1, PI 414723, DMDR-1, DMDR-2
CGMMV	DVRM-1, 2, *Cucumis africanus, Cucumis ficifolium, Cucumis anguria*
Fruit fly	*Cucumis callosus*
Nematode	*Cucumis metuliferus*
White fly	*Cucumisasper, Cucumis denteri, cucumis dipsaceus, Cucumis sagittatus*
Fusarium wilt	Delicious-51 and C. melo var. reticulatus, indorus, chito, and flexuosus
Gummy stem blight	Line PI 140471
CMV	Freeman
WMV	PI 414723, B 66–5 and *C. metuliferus*
Zucchini yellow mosaic virus	PI 161375
Watermelon	
Fusarium wilt	Summitte, Conqueror, Charlistm gray, Dixilee, Crimson sweet
Anthracnose	Fair, Charleston gray, congo, PI 189225, Black Stone and Cargo
Powdery mildew, downy mildew, and anthracnose	Arka Manik
Bottle gourd	
CMV, SMV, WMV	PI 271353
Fusarium wilt	Taiwan variety Renshi, Delicious-51 and *C. melo* var. *reticulatus*, *indorus*, *chito*, and *flexuosus*
Cucumber	
Anthracnose	PI 175111, PI 175120, PI 179676, PI 182445, wise 2757 (USA) and PI 197087
Downey mildew	B-184, B159, wise 2757 (USA), Chinese Long and Poinsette
Powdery mildew	PI 200815, PI 200818, *Cucumis hardwikkii,* wise 2757 (USA), PI 197087, Poinestee, Yomaki, Sparton Salad, PI 197088, *Cucumis ficifolia, C. anguria, C. dinteri and C. sagittatus*, *C. ficifolia* accessions IVf 1801 and PI 280231, *C. anguria* PI 147065, *C. anguria* var. *anguria*, *C. dinteri* PI 374209, and *C. sagittatus* PI 282441
CMV	Wisc SMR-12, SMR-15, SMR-18, wise 2757 (USA), TMG-1, Tokyo Long Green, Chinese Long, Wisconsin and Table Green
CGMMV	Cucumis anguria
WMV	Table Green and Sarinam
Pumpkin	
PM and Viruses	*Cucurbita lundelliana, Cucrbita martenezii*
ZYMV, WMV	*C. ecuadorensis, C. faetidistima, Cucrbita martenezii*

DM - downy mildew; MM - muskmelon mosaic virus; CGMMV - cucurbits green motel mosaic virus; SMV-squash mosaic virus relatives (Table 1). Most of the resistant varieties in cucurbits have been developed by simple selection (Table 2). For developing multiple biotic stress resistant lines, validity of already available molecular markers with established linkage may be tested in order to examine their feasible use in breeding programme for development of parental lines.

Table 2. Resistance varieties developed in cucurbits

Cucurbits	Varieties developed	Resistant to
Muskmelon	Arka Rajhans	Powdery mildew
	Punjab Rasila	Downy mildew
	DVRM-1, DVRM-2	Cucumber Green Mottle Mosaic Virus
	DMDR-1, DMDR-2	Downy mildew (resistance source only
Watermelon	Arka Manik	Anthracnose, powdery mildew, downy mildew (multiple resistance)

Screening and evaluation of diverse collection of cucurbits accessions may provide an opportunity to broaden the genetic base and a boost to current breeding program. A long term approach is needed to redress the adversities and imbalances that exist today to bring about comprehensive change in cultivation graph of cucurbits crop. Drought stress is the major constrains to crop productivity. The screening of the *Cucumis* crops not only entitles the physiological screening of the plant itself but also the physical plant growth performance as the yield are taken into account for the calculation of adaptability. Our group establish a drought stress screening methodology to identify the drought tolerant melons genotype based on some selected parameters which includes yield, physiological parameters like relative water content, electrolyte leakage and photosynthetic efficiency, additionally biochemical parameters which includes various photosynthesis pigments and visual symptoms on 5 points scale (1-5), namely, highly drought tolerant (1), drought tolerant (2), average drought tolerant (3), drought susceptible (4) and highly drought susceptible (5), based on the observations, 5 genotypes, which include 2 lines Cucumis callosus (SKY/DR/RS-101 and AHK-200), 1 line each of Cucumis melo (SC-15), Cucumis melo var. momordica (VRSM-58) and *Cucumis melo* var. chate (arya), were identified as drought tolerant genotypes (Pandey *et al*. 2016; Pandey et al. 2013). To validate the SC-15 muskmelon genotype drought tolerance further study was carried under pot condition at 0, 7, 14, and 21 days of progressive water stress. Although water deficit caused a significant decline in relative water content, the magnitude of reduction was lower in SC-15. Electrolyte leakage, hydrogen peroxide, and malonydialdehyde generation were higher in susceptible genotype EC-564755, whereas accumulation of proline was higher in SC-15. Higher activities of antioxidant enzymes, such as catalase, superoxide dismutase, ascorbate peroxidase, guaiacol peroxidase, and glutathione reductase, and higher expression of the respective genes were recorded in drought tolerant genotype SC-15 (Ansari *et al*., 2017).

A separate study to validate the field identified drought tolerant and susceptible muskmelon genotype under pot condition was reported, in which morpho-physiological and biochemical analyses were carried out in eight diverse indigenous muskmelon genotypes exposed to different degrees of water deficit. The ability of genotypes BS-25, and especially MJ-7, to counteract better the negative effect of water-deficit was associated with maintaining higher relative water content, photosynthetic rate, efficiency of PSII, and photosynthetic pigments compare to other genotypes. Furthermore, MJ-7 showed a better ability to maintain cellular homeostasis than the others. It was indicated by a stimulated antioxidative defense system, *i.e.*, higher activities of antioxidant enzymes, accumulation of nonenzymatic antioxidants together with lower concentration of reactive oxygen species and malondialdehyde (Ansari *et al*., 2018).

Further establish and expand the knowledge about molecular mechanism involved in drought tolerance muskmelon genotype SC-15, which exhibits high drought resistance as reported in earlier, was exposed to deficient water condition and studied for alteration in molecular and proteomic profile changes in the leaves. Peptide mass fingerprinting (PMF) showed that drought increased the relative abundance of 38 spots while decreases10 spots of protein. The identified proteins belong to protein synthesis, photosynthesis, nucleotide biosynthesis, stress response, transcription regulation, metabolism, energy and DNA binding. A drought-induced MADSbox transcription factor was identified. The present findings indicate that under drought muskmelon elevates the abundance of defense proteins and suppresses catabolic proteins, which exhibits possible mechanisms adopted by SC-15 to counter the impacts of drought induced stress (Ansari *et al*., 2019).

Conventional breeding as well as molecular approaches are used for development of new varieties/lines. CRISPR-Cas9 and gene editing new technology are being used fir development of new lines with targeted gene. The development of hybrid/varieties with better adaptability under off-season should be undertaken. For developing multiple biotic stress resistant lines, validity of already available molecular markers with established linkage may be tested in order to examine their feasible use in breeding programme for development of parental lines.

References

Abewoy, D. (2018). Review on Impacts of Climate Change on Vegetable Production and its Management Practices. *Advances in Crop Science and Technology*. DOI: 10.4172/2329-8863.1000330.

Ansari, W.A., Atri, N., Ahmad, J., Qureshi, M.I., Singh, B., Kumar, R., Singh, B., Pandey, S. (2019). Drought mediated physiological and molecular changes in muskmelon (*Cucumis melo* L.). PLoS ONE 14(9): e0222647. https://doi.org/10.1371/journal. pone.0222647.

Ansari, W.A., Atri, N., Singh, B., Kumar, P., Pandey, S. (2018). Morpho-physiological and biochemical responses of muskmelon genotypes to different degree of water deficit. *Photosynthetica,* **56**(4) : 1019-1030.

Ansari, W.A., Atri, N., Singh, B., Pandey, S. (2017). Physiological adaptation, antioxidant changes and gene expression analysis of two muskmelon accessions under water deficit condition. *Biologia Platarum,* **61**(2): 333-341.

Halder, J., Kushwaha, D., Deb, D. and Rai, A.B. (2017). Effect of meteorological parameters on abundance of mirid bug, *Nesidiocoris cruentatus* (Ballard) (Hemiptera: Miridae): An emerging insect pest of bottle gourd. *Journal of Agrometeorology*, **19**(2):180-182.

Halder, J., Kushwaha, D., Ra, A.B., Dey, D., Chaubey, T. and Singh, B. (2016). First record of *Acythopeus curvirostris citrulli* (Marshall) (Coleoptera: Curculionidae) on sponge gourd, *Luffa cylindrica* (Linn.), its bionomics, diurnal activity and ecofriendly management. *Vegetable Science*, **43**(2): 190-197.

Pandey, S., Ansari, W.A., Atri, N., Singh, B., Gupta, S., Bhat, K.V. (2016). Standardization of screening technique and evaluation of muskmelon genotypes for drought tolerance. PGR characterization and utilization **16**(1): 1-8.

Pandey, S., Ansari, W.A., Pandey, M., Singh, B. (2017). Genetic diversity of cucumber (*Cucumis sativus*) estimated by EST-SSR markers and morpho-physiological traits. *Physiology and molecular biology of plants,* **24**(1): 135-146, 2018.

Pandey, S., Ansari, W.A., Jha, A., Bhatt, K.V., Singh, B. 2013. Evaluation of melons and indigenous Cucumis spp. genotypes for drought tolerance. *Acta Horticulture*, **979**: 335-339.

Rai, A.B., Loganathan, M., Halder, J., Venkataravanappa, V., Naik, P.S. (2014). Eco-friendly approaches for sustainable management of vegetable pests. Technical Bulletin, ICAR-IIVR, Varanasi - 221305, Uttar Pradesh, 104pp.

LEAD LECTURE – 28

Strategies to meet newer challenges of mango diseases

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Recent past has witnessed a lot of deviation in dynamics of diseases of mango and a few diseases have emerged as new challenge. It is not at all easy to pinpoint the reasons behind shifts but changing climate and ecological factors look prominent. The deviations in pathogen behaviour and host responses have also been noticed. The incidence of diseases occurring on leaves and panicles have been fluctuating and been managed with economical inputs but fruit diseases have been the matter of concern. The root and stem infections have posed great threat in recent past. Diseases like wilt, branch drying, twig drying, dieback and shoulder browning are the present issues to be taken care of by growers to minimize the losses.

Wilt

Occurrence and losses

Wilt disease caused by *Ceratocystis fimbriata* has been severely affecting a diversity of plant hosts worldwide. It is causing severe losses to perennial trees including mango. Many pathogenic fungi were isolated from mango trees suffering from decline and wilt in Brazil, Oman, Pakistan and India, and *Ceratocystis fimbriata*, *C. omanensis* and *Lasiodiplodia theobromae* were proved to be the main causal organisms. In India, mango wilt was first reported during 2006 and detailed studies were carried out recently. Survey studies confirmed incidence of mango wilt in 14 major mango growing states in India.

Symptoms

Full grown mango trees may wilt within a few days and dry leaves hang on trees for longer period of time or shedding of green leaves may occur and tree dies over a period of 2-6 months. Leaves of wilting trees have necrotic symptoms along with midrib followed by whole leaf necrosis, drying of twigs resulting in wilting of whole tree. *C. fimbriata* infection in stem causes dark reddish-brown to purple to deep-brown or black staining in the xylem.

Factors affecting disease development

Establishment of pathogens in new areas, their proliferation and disease development are highly dependent on existing microclimate *i.e.* temperature, moisture, humidity and their seasonal variations, host availability and inoculum spread. *Ceratocystis* spp. reproduces better between 25-30 °C and activity is reduced with reduction in temperature. Soil pH around 7.5 has been reported to be optimum and it is suppressed above 9.0 and below 5.0. Complete darkness with 100 per cent relative humidity favours its growth. Boron deficiency may enhance its infection in roots. Since, the fungus mostly gets entry into host through wounds; root damage during intercultural operations enhances the wilt incidence. Inocula spread is facilitated by flood irrigation. Infestation of bark beetle may also promote the inoculums spread with them or through frass created by them.

Management

Sanitation is an effective for disease control. Fungicides injected into the stems may provide instant protection. Because most forms of the species are easily transmitted in cuttings, unrestricted movement of cuttings or other propagation material is potentially dangerous. Recently, we have developed integrated management package of practices against mango wilt. It includes:

1. To avoid damage to roots, minimum tillage should be adopted and deep ploughing should completely be avoided in mango orchards. Intercrops should always be grown beyond canopy area, if grown in young orchards.
2. Wilt affected and nearby trees should be treated with thiophanate methyl 70WP @ 50, 100 or 150 g per tree for trees of 2-15, 16-35 and above 35 years age respectively as soil drench.
3. Infected or wilted branches should be pruned and cut ends should be pasted with copper sulphate or copper oxychloride (5.0 % solution).
4. Aerial portion of trees should be sprayed with carbendazim 50 WP or propiconazole 25EC @ 0.1% on appearance of first symptom.
5. If infestation of Scolytid beetle is observed in orchard, it should be managed by spray of chlorpyriphos 20EC @ 0.2 to 0.3 per cent at 15 days interval.
6. Irrigation must be done using drip system or channels to avoid disease dispersal through water from infected tree to healthy trees. 7. Recommended doses of manure and fertilizers should be applied in orchards and proper soil moisture should also be maintained regularly.

Branch drying, twig drying and dieback

Occurrence and losses

During 1975-1985, the disease was severe in western U.P. and assumed alarming proportions in few locations. In Moradabad, 30-40 per cent roadside and other plantations were affected. However, incidence of dieback has been reduced in recent past but it has taken the form of branch blight or twig drying. The cause of the disease is *Botryodiplodia theobromae* and its closely related species of fungi.

Symptoms

The disease is characterized by dying back of twigs from top downwards, followed by complete defoliation. Discolouration and darkening of bark at a certain distance from the tip is the external evidence of disease. The upper leaves lose their healthy green colour and gradually turn brown accompanied by upward rolling of leaf margin. Cracks appear on branches, which exude gum before they die. It has been found that infection occurs at node at variable distance below the growing point and part of the twig above and below this point dies. In recent past, incidence of twig drying or blight has been recorded high as compared to dieback. The major portion of mango canopy becomes blighted during rainy season and orchards are severely affected.

Factors affecting disease development

High summer temperatures predispose the mango plants to the attack of the disease through reducing the vitality of the plant. Relative humidity of about 80 per cent, maximum and minimum temperature of 31.5ÚC and 25.9ÚC, respectively, and rains favoured disease development. The organism is a wound parasite and is capable of causing great damage when mango grafts are kept in a humid propagation shed.

Management

Preventive measures, such as selection of scion from healthy trees, sterilization of the budding knife, keeping the grafted tree in a relatively dry environment and gradual exposure to full sunlight are effective. Pruning of the diseased twigs 7-8 cm below the infection site followed by spray of copper oxychloride (0.3%) has been effective in managing the disease. However, extra care of trees for water and nutrition is necessary for better recovery.

Shoulder browning

Occurrence and losses

Severe incidence of shoulder browning disease has been observed in Uttar Pradesh and Uttarakhand during rainy season. The disease is a widespread problem in Uttar Pradesh and almost everywhere in India wherever fruits remain on trees after onset of monsoon. The disease is caused by a complex of *Colletotrichum gloeosporioides*, *Capnodium mangiferae* and *Alternaria alternata*.

Symptoms

The symptoms of the disease mostly appear in the form of browning of epicarp of the fruits on shoulder region accompanied with tear staining pattern. The symptoms are caused by staining of epicarp with dripping or draining of rain water containing canopy wash, and with the infestation of fungi.

Factors affecting disease development:

Weather plays a key role in disease incidence and development of this disease. Incidence and severity of the disease had significant negative correlation with maximum temperature. Correlation of disease with relative humidity was observed positive and significant. Correlation between disease and weather parameters depicted that number of rainy days and amount of rainfall are the main factors directly influencing the disease development. Temperature and relative humidity fluctuate according to the distribution and frequency of rains and thus, disease development was accordingly affected.

Management

Management of this disease is of great significance for export as well as for reducing post harvest rotting of fruits. Bagging of fruits and tree oil spray has been used successfully. Difenoconazole @ 0.05 per cent has been found the most effective fungicide to manage shoulder browning in mango. Residues of difenoconazole persisted up to 21 days in mango fruits. Other treatments like, Metalaxyl + mancozeb (0.2%) and myclobutanil (0.1%) were also found effective.

LEAD LECTURE – 29

Usefullness of microbes for enhancing plant secondary metabolites and nematode disease management in maps

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The economic growth of any nation relies on optimisation of agricultural crop production, an enhancement in the export and subsequently reduction on avoidable imports. Further the availability of nutritious and healthy food, disease protective food supplements and therapeutics are among the several factors that decide quality of life worldwide. Such scenario can arise by large scale cultivation and production of medicinal and aromatic plants. In this lecture major focus will be made on diseases caused by phytonematodes threatening the yield, biomass and bioactive potential of medicinal and aromatic plants (MAPs). Among the different phytopathogens plant parasitic nematodes are a major group of pathogen causing serious threat to the future prospects of MAPs worldwide. It constitutes one of the most important groups of pathogenic organisms prevalent in and around the root system thus, playing a significant role in the plant growth and yield reductions. Undoubtedly, these nematodes are associated with most of the MAPs and cause significant damage, but the magnitude of crop damage has been established in only few plants. The damage caused by these nematode pests to particular MAPs depends on crop and cultivars, nematode species, level of inoculums in soil and the environment. The most severe damage generally occurs in the field when high level of nematode inoculums is planted with susceptible host plants. The major crops which suffer from root-knot nematode infestation are: Menthol mint (*Mentha arvensis*), Henbanes (*Hyoscyamus* spp.), Basil (*Ocimum* spp.), Opium poppy (*Papaver somniferum*), Ashwagandha (*Withania somnifera*.), Serpagandha (*Rauvolfia serpentina*) Coleus (*Coleus forskohlii*), Qinghao (*Artemisia annua*), Brahmi (*Bacopa monnieri*) and Safed musli (*Chlorophytum borivillianum*). The assault on the environment through the use of chemical nematicides as well as unreliable results from cultural methods of nematode management has necessitated the search for sustainable, effective and environmentally acceptable nematode management options. Useful microbes like plant growth promoting bacteria, mutualistic fungi, and other nematode antagonists disfavor the multiplication and development of phytonematode population in soil, thereby enhancing the growth/yield of the crop. As my group has developed a better understanding of the complex ecologies of soils and agricultural ecosystems, more strategies for exploitation of microbes for the enhancement of plant secondary metabolites in MAPs is the need of the hour. The present lecture has thus been designed keeping in mind the different approaches adopted for not only managing nematodes but also the ways by which the plant secondary metabolites can be enhanced.

LEAD LECTURE – 30

ITK in insect pest management

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Insect pests are one of the major threats for crop loss. The chemical control of insect pests is predominant, but traditional pest control practices are still continued especially remote areas because it is cheap, easy to adopt and locally available resources. ITK is the localized community based knowledge gained by their experience on trial and error experiments to solve the particular problems and transmitted from generation to generations. It is therefore rightly said that when a knowledgeable old person dies, a whole library disappears. Its offer us prophylactic and curative measures, those could be arranged from locally available material, for managing the crop pests. But ITK is constantly under threat because it is orally transferred from one generation to another. If precious traditional knowledge generated over the ages is lost then it would be a huge loss for mankind. There is a strong urgency to document and validate ITK before it gets lost with time.

The ITKs are eco- friendly and compatible to insect pest management practices. It is not a sole method of pest control. Adoption of ITK based crop protection measures as an alternative to pesticides might help in restoring the biodiversity of natural enemies. Blending of indigenous knowledge with IPM method of insect pest management is the need of the day to support sustainable development of agriculture.

The innovative ideas of farmers in solving technical problems by local resource managements are therefore, gaining importance in recent years. Innovations based on traditional knowledge have also been emphasized by the National Innovation Foundation (NIF) and Department of Science & Technology, Govt. of India. The World Summit on Sustainable Development (WSSD) held at Johannesburg in South Africa during 2002 has strongly advocated the use of local technical knowledge in crop husbandry package.

Indigenous plant protection knowledge

The most widely used pesticidal plants in ITK with their mechanism of action against the insect pests are presented below.

ITKs for fruit crops pests management

Some of the common traditional practices followed by local farmers generation to generation in different fruit crops are listed below,

Mango

- Dried leaves and twigs are burnt and fumigated under the tree during early morning before sunrise or late evening after sun set drive away the hoppers.

Table 1. List of plants with mechanism of action against insect pests

Common name	Scientific name	Pests managed	Plant part used	Mechanism of action
Neem	*Azadirachta indica*	Sucking pest, defoliators	Leaf, twig, bark, seed, kernel	Contact, stomach poison, oviposition deterrent, repellent, metabolic distruptor and toxicant
Tobacco	*Nicotiana tobacum*	Defoliators	Leaf and stem	Stomach poison and repellent
Pungam	*Pongamia pinnata*	Sucking pest and defoliators	Leaf and seeds	Antifeedant and repellent
Calotropis	*Calotropis gigantea*	defoliators	Leaf and twig	Stomach poison and growth inhibitor
Custard apple	*Annona squamosa*	Defoliators	Leaf, twig, seeds	Antifeedant and anti repellent
Indian privet	*Vitex negundo*	Defoliators	Leaf, twig, seeds	Contact poison and growth inhibitor
Adathoda	*Justica adhatoda*	Leaf scrappers	Leaf	Antifeedant
Garlic	*Allium sativum*	Defoliators and sucking pests	Pods	Repellent, antifeedant and toxicant
Nerium	*Nerium olearander*	Defoliators	Leaf and stem	Repellent, antifeedant and toxicant
Wild marygold	*Tagetes minuta*	Defoliators	Flower	Repellent and toxicant
Black pepper	*Piper nigrum*	Defoliators	Leaf	Toxicant, oviposition deterrent
Babool	*Acacia nilotica*	Stemborer and leaf feeders	Crushed powder from leaves seed and bark	Antifeedant

- One kg of leaf extract of kasaraka mixed with 10 lit of water and boiled then, kept it overnight. The diluted in 1:1 ratio and sprayed during flowering from leafhopper infestation. (Kamatekar, S.2014)
- Amruta balli 1D 2 kg + parangi patta 1D 2 kg + Jaddi balli one kg, mixed in 10 lit of water, then kept for decomposition for one week, filter the solution and diluted in 1:1 ratio and sprayed during nursery stage for the management all insect pest of mango. (Kamatekar, S.2014)
- Tare leaves 2 kg, Anale leaves 2 kg, Tarmaric rhizomes 1kg, Emblica leaves 2 kg, Esmungare leaves 2 kg, Kasaraka leaves 2 kg, Adasoge roots 1 kg, papaya stems 2 kg and vayu vilanga leaves 2 kg boiled for 7-8 hr in 50 lit of water and cool 2-3 hours then, filtered solution is mixed in 1:1 ratio and sprayed for the management all the insect pests of mango. (Kamatekar, S.2014)
- For prevention of infestation of shoot borer in mango tree, common salt is mixed with soil near the collar region of tree.
- Neem oil is sprayed to control the hoppers.

- Pepper plant residues after the harvest can be burnt in mango orchard to control nut weevil menace.
- Basin (*Ocimum sanctum*) in mango orchard acts as a trap crop for fruit flies.
- Planting of coriander, mint, ginger and turmeric in mango orchards deter mango pests.
- 20 g of *Ocimum sanctum* (holy basil) leaves are crushed and the extract along with the crushed leaves are placed inside a coconut shell, which is then filled with 100 ml water. To increase the keeping quality of the extract, 0.5 g citric acid is added and the extract is then poisoned by mixing 0.5 g carbofuran 3G. The traps are suspended from mango tree branches at a rate of 4 traps per tree. The fruit flies feed on the ocimum extract and are killed.
- Make a trap using a 2-liter disposable water bottle: Two holes at a height of 5cm from the bottom of bottle are made and for hanging the trap, use a string which is pushed through a hole drilled in the centre of the cap from inside. The attractant mixture for fruit flies is then prepared by mixing 1 cup of vinegar, 2 cups of water and 1 tablespoon of honey and shakes this well before use. Fill the trap with this mixture up to the level of holes and hang the container about 5 feet high. Flies will enter the container and fall into the attractant.

Guava

- Pounding 2kg.of foliage of *Calotropis sp.* with 3 kg of neem cake, soaking them in 20 lit. of water for four days and dissolving the extract in 200 lit.of water and spraying for one acre to control all the pests.
- Neem seed kernel extract or neem cake solution is sprayed to control leaf miner.
- Four kg of neem seeds are powdered and dissolved in 100 litres of water and filtered. Add 10 lit. of cow urine and mix it with 50 g of detergent powder. Spraying this extract will control leaf miner.

Citrus/Mandarin orange

- One kg Leaves of Agave is boiled in 10 lit. of water for 6-7 min. Filtered solution is diluted in 1:1 ratio for spraying, during seedling stage to avoid citrus leaf miner. (Kamatekar, S.2014)
- One kg Mukkadaka leaf mixed in10 lit cow urine. 100 ml honey and 10 gm asoefitida is added, Filtered solution is diluted in ratio 1:1 for spray during the larva stage of citrus butterfly. (Kamatekar, S.2014)
- Kasaraka leaves one kg + seta pala leave 1kg, mixed in 10 lit water and kept for decomposition for one week. Filtered the solution and diluted in 1:1 ratio for spraying against mealybug infestation. (Kamatekar, S.2014)
- Collected orange seeds are mixed with ash to avoid ants' attack.
- Orange trees attacked by stem borer are given lime wash, holes are cleaned and plugged with lime soaked cotton or wrapped with lemon grass.
- Trapping of nocturnal fruit- piercing moths by putting a box with pieces of pineapple or banana, drenched in an insecticide in the orchard.
- Application fish cleaned water/kerosene oil at the base of plant to avoid citrus trunk borer.
- Bamboo poles connecting citrus tree to control citrus defoliators.

- Placing red ant nests on the citrus plant against citrus defoliators.
- Citrus trunk borer (*Anoplophora versteegi*) is mechanically controlled by inserting sharp bamboo sticks in the affected Citrus trunk.
- 4 kg tobacco leaves and twigs are boiled in 40 liters of water for 40 min. After cooling, 1kg soap powder is mixed and solution is diluted 7-8 times and sprayed to control aphids and whiteflies in citrus plants.
- Smoking below the citrus plant at the time of flowering control citrus insect pests

Litchi

- Spraying biodynamic liquid pesticides or neem oil (3%) for control leaf roller, fruit borer, shoot borer, fruit sucking moth and bark eating caterpillar etc.
- Spray of biodynamic liquid pesticides at new leaf emergence time against litchi mite.
- Applying the mixture of 'marotti' (jungli badam / *Hydnocarpus pentandra*) oil cake and sand in the leaf axils of coconut palm prevents infestation of rhinoceros beetle.
- Application of sand and salt in equal proportion in the leaf axils of coconut during Aug-Sep prevents attack of rhinoceros beetle.
- Keep flowers of 'chempakam' (*Michelia champaca*) in the bored holes of weevil on the coconut palm to repel their adults.
- Planting 'panikoorkka' (*Pelctranthus amboinicus*) as intercrop in coconut garden will repel rhinoceros beetle and red palm weevil.
- Close all the boreholes of red palm weevil, make a new hole above these holes, insert cotton soaked in eucalyptus oil in the new hole and close it with cement. The young ones of the weevil inside the trunk will be destroyed.
- Smoke the palms by firing dry leaves, coconut leaves and organic wastes at the base of the palm to control mites.
- Apply garlic solution (Grind 20- 30 g of garlic and take the extract in one litre of water) at the bottom of the crown to prevent mites.
- Application of leaves of 'karingotta' (*Quassia indica*) and 'kanjiram' (*Strychnos nuxvomica*) in coconut basins will reduce the attack of termites.
- Mix powder of fused electric bulb with coconut flakes and used in coconut gardens to manage rodents. This practice is followed in Thanjavur district of Tamil Nadu.
- Pieces of cotton or thermocole, dipped in jaggery solution, made into small packets and spread in orchard. Rats which consume these will suffer from gastric bloating disorders due to the swelling of cotton or therocole in stomach.
- Wild arrowroot is planted in coconut garden for preventing /controlling termites.
- Spray lime solution on the seedlings so as to prevent termites.
- Lime solution is painted on the tree trunk to about 1m from the base to reduce the attack of white ants on the trunk.
- Coil the trunk of coconut palm with coconut leaves and bamboo thorn to control problems created by rats and thieves.

- At the time of planting coconut seedlings, plant 1-2 tubers of arrowroot in the pit. This will keep away the root grubs and termites.
- Planting turmeric along with coconut seedlings will prevent the attack of root grubs and termites.

ITK in termite management

- The dye prepared from noni (*Morinda citrifolia*) is mixed with garlic extract which completely checked the termite revages in trees.
- Paint prepared from 1 part of gum of *Gardenia gummifera*, 2 parts of *Asafoetida*, 2 parts of Aloe and 2 parts of castor oil cake control termite menace in trees.
- Application of sheared human hair obtained from barber's shop, applied on live mounds and along the infested pathways has good control on termites.
- Plantation of 5-6 rhizomes of *Curcuma aromatic* in coconut basin offers prevention of termite measure in fruit plants.
- Usage of washing powder by the farmers is useful and economic anti termite measure in fruit plants.
- In Goa, plastering trees, especially mango, cashew and coconut with black mud from salt pans, locally called "*agaracho chikhol*" and sprinkling of jiggery around the tree by farmers in order to attract large black ants, the natural enemy of termite, reduce termite attack.
- Sheep hair, wood ash of kiln is used to the tree base by farmers to reduce termite attack.
- Common salt tied in the cloth bag kept in irrigation channel shows termite preventive measure.
- A common practice of termite control is smoking termitaria to suffocate and kill the colony.
- In coconut field, the tree trunk is painted with waste engine oil upto 40 cm height from the bottom in order to keep termite away in field.
- Cashew stem borer and termite attack on cashew trunk were managed by application of coal tar and kerosene (2:1 ratio).

ITK in rodent control

- Putting of cycle tyre tube in the mouth of the rodent borrow menace rodents because the black cycle tube act as a rat scarer due to its snake like appearance
- Pouring of vermilion water in the trapped rodent and releasing in the field the other rodent of the field runs away due to the red colour appearance of the released rodent.
- The fruit skins of kaunj are kept in the rate holes. This causes severe itching rats when they come in contact with these fruits.

Importance of ITK

- ITK is easy skill and experience dependence so the people of a community can solve their problems easily.
- Many ITK have scientific value and may use for scientific research.
- It is subjective and linked with farming and involves low cost input use.
- ITK is eco--friendly for agricultural system.

Table 2. Common traditional pests management practices of north east India

Mechanisms	Insects	Reference
Placing of red tree ant (*Oecophylla smaragdina*) nest on the citrus plant	Citrus Defoliators	Deka et al., 2006
Application of fish cleaned water at the base of plant	Citrus trunk borer	Barooah and Pathak, 2009, Deka et al., 2006
Application of kerosene oil to the fruit tree trunks	Citrus trunk borer	Barooah and Pathak, 2009
Common salt is applied to the base of plants	Banana Snails and slugs	Barooah and Pathak, 2009
Smoke is generated at the base of fruit trees	Fruit moth Jack fruit, mango	Barooah and Pathak, 2009
Placing of long hair of women in the crown portion of coconut tree	Rhinoceros beetle Coconut	Deka et al., 2006
Placing of a dead frog at the base of the coconut plant @ 1 trap/m^2.	Rhinoceros beetle Coconut	Deka et al., 2006
The fragmented human hair and dry fish mixture are kept in the crown	Squirrel Coconut	Deka et al., 2006
Killing the larva by inserting wire hook in the bored hole and also form soil below the tree	Red palm weevil Arecanut	Umdor, 2004
Catapults and drum beating birds and monkeys	Fruit orchard	Barooah and Pathak, 2009
Use of ' Changsim' (*Sapium baccatum*) or 'Tuthekme' (*Dendropthoe falcate*) or 'Rakseng' (*Morus macroura*) or 'Khasi-bol(*Bridelia retusa*) fruits to attract insect predators (Birds)	Fruit trees Lepidopteran pests	Sinha et al., 2004

- ❖ The knowledge are localized and situation specific. So ITK help the farmer to take decision in their own way.

Limitations

- ❖ ITK have been passed from generation to generation orally. Errors are bound to creep in ITK in the absence of proper documentation.
- ❖ Many of the ITK passed on to the community members in the form of proverbs, folkores and folk song. So many time members cannot remember them easily.
- ❖ The scientific community does not accept them because many of them have not scientific interpretation.
- ❖ ITK fail to hand up to the scientific rationality and hence modern technology lost of many ITK.
- ❖ Travelling to remote places, staying there, documenting the details and publication require funds.

- While non-availability of material input is a major problem in the adoption of indigenous farm practices by a majority of small and medium farmers but non-availability of labour is a major problem to big farmers.
- Time consuming and labour intensive
- No rewards for indigenous farming practices by government officials
- Absence of financial support from Govemment/other agencies
- Lack of proper and institutional information sources on IK in agriculture
- Negative attitude of elite and educated people.

Conclusion

The documented ITKs serve as a ready reference that provides valuable inputs for the agricultural scientists for further study to determine their scientific rationality and effectiveness. Since ITKs are mostly organic, eco-friendly, sustainable, viable and cost effective, there is a need to explore, verify, modify and scientifically validate these practices for their wider use and its execution in the various IPM modules. As the world is moving towards "Go green" slogan, extension agencies should intensify their efforts to organize extension educational programs like trainings, demonstrations, field days, etc., to motivate the farmers to accept and adopt the traditional indigenous plant protection practices, which are safer to the environment. The body of knowledge, science and techniques used by rural people for pest management if well documented can make an important contribution to the agricultural society. If an effort is made towards production of Indigenous Technical Knowledge (ITK) based products on cottage scale, it can be an economically viable option for sustainable development of eco-friendly pesticides/insecticides for their wider use and application.

References

Altieri, M. (2003). The socio-cultural and food security impacts of genetic pollution via transgenic crops of traditional varieties in Latin American Centre of peasant agriculture. *Bulletin of Science Technology Society*, pp: 350-359.

Barooah, M. amd Pathak, A. (2009). Indigenous knowledge and practices of *Thengal Kachari* women in sustainable management of *bari* system of farming. *Indigenous Journal of Technical Knowledge*, **8**(1): 25-40.

Deka, M.K., Bhuyan, M. and Hazarika, L.K. (2006). Traditional pest management practices of Assam. *Indian J. Traditional Knowledge*, **5** (1): 75-78.

Devanand, I. and Kamala, M. (2017). Indigenous traditional knowledge on crop protection practices. *Int. J. of Agri. Sc and Res.* **7**: 345-352.

Husain A.S. and M. Sundaramari, M. (2011). Scientific rationality and evaluative perception on indigenous plant protection practices on coconut (*Cocos nucifera* L). *Research Article Journal of Plantation Crops*, **39** (2): 290-298.

Husain, A.S and Sundaramari, M. (2018). Scientific Rationality of Indigenous Plant Protection Practices on Banana (*Musa* spp.) Cultivation. *Indian Journal of Extension Education*. **54**(1): 59-64.

Kamatekar, S. (2014). Documentation and characterization of tropical fruit tree genetic resources and associated indigenous traditional knowledge in coastal and up-ghat regions of Uttarakannada, Central Western Ghats. Department of forest biology and tree improvement College of forestry, Sirsi, Uiversity of Agricultural Sciences, Dharwad, pp.68-69.

Sharma and Gogoi (1999). Agricultural traditional wisdom of Assam. *Assam Agri-History*, **3**(3): 199-206.

Sinha B, Choudhury, D. and Roy, S. (2004). Traditional practices in pest management: some examples from North-East India, In: *Regional seminar on the Role of biodiversity and environmental strategies in North East India*, 1-9, online available at, http://ssrn.com/abstract=1303383.

Umdor, M. (2004). Indigenepus practice on protection of Areca catechu Linn. seedlings: A case study in Meghalaya. *Indian Journal of Traditional Knowledge*. 3(3):253- 255.

Venkata Ramaiah, P. and Rama Raju, K.V. (2004). Blending of Indigenous Technologies with judicious use of external inputs for sustainable agriculture paper Peoples Wisdom. Gosh, S.N (ed.). National Council of Development Communication, Sundarpur, Varanasi, pp. 249-253.

THEME 5

BURSTING THE BARRIERS IN HORTICULTURE AND USING NEXT GENERATION TECHNOLOGICAL TOOLS

LEAD LECTURE – 31

Strategy for improvement in grape (*Vitis* spp.) in India

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Germplasm management and improvement in grape started since 1956 at the ICAR-Indian Agricultural Research Institute, New Delhi. The total collection of germplasm of grape during 1956-2001, as shown in the register maintained at the Division of Fruits and Horticultural Technology of the Institute, was 552 (115 indigenous, 437 exotic). The ICAR-IARI, New Delhi continued to supply the grape germplasm on demand to other research institutions including IIHR, Bengaluru, State Agricultural Universities (SAUs), AICRP Centres, *etc.* With the passage of time, the number of geremplasm, however, depleted at some places including IARI, New Delhi due to some unfavorable conditions. The present status of germplasm collection reported from AICRP Centres is 60 at ICAR-IARI, New Delhi, 18 at PAU, Ludhiana, 51 at Rajmata Vijayaraje Sciendia Krishi Vishwa Vidyalay, KNK College of Horticulture, Mandasaur (M.P), 55 at ICAR-IIHR, Bengaluru, 426 at ICAR-NRC for Grapes, Pune and 62 cultivars and 29 wild species at Agarkar Research Institute (ARI), Pune. At ICAR-IIHR, the grape germplasm is being multiplied and maintained at its Central Horticultural Experiment Station, Hirehalli (Karnataka). Molecular markers ISSR, AFLP, RAPD and microsatellites have been developed for the analysis of germplasm genotypes. This will help in identifying confusing variety names and progenitors of unknown genotypes.

Many accessions of grape rootstock are available at NRC for Grapes, Pune and IIHR (CHES, Hirehalli). Rootstocks 1613C, Dogridge, SXR, 99 Rcl.13ES, *Vitis parviflora, Vitis longii*, So-4cl.762, Ramsey, Degrasset and 110R (*Vitis berlandieri* x *V. rupestris*) had vigorous growth at CHES, Hirehalli. Rootstock 1613C exhibited longest shoot growth eight months after planting and Degrasset had deeper root system and vigorous growth at ARI, Pune.

Promising introductions identified earlier at IARI, New Delhi for table use include Cardinal, Gold, Muscat Oliver, New Perlette and Sultanine-II. These varieties should also be evaluated along with Red Globe under AICRP (Fruits) for their suitability in different agro-climatic conditions. Agro-technique should be worked out for these varieties.

Grape breeding work was initiated at the ICAR-IARI, New Delhi in 1962. Emasculation in grape is a tedious task. IARI selected reflex stamen type (functionally female) variety as female parent to get rid of the process of emasculation and doing direct pollination with male parent. Selection of suitable parent varieties in hybridization changed as per the shift of strategies of grape breeding work at different places as well as at different times in the same organization. The strategies of the previous work have been mentioned in the text of the manuscript. Future strategy of grape improvement work has been discussed aspect-wise for taking up the programme in a systematic manner.

In the beginning, Pusa Seedless grape variety with more elongated berry was selected as a clone of Thompson Seedless. Early ripening black seedless variety Beauty Seedless, an introduction from California (USA) and mid-season cv. Pusa Seedless were released by IARI for commercial cultivation. Perlette, another early and seedless variety is introduction from California, which was recommended by the IARI New Delhi and PAU, Ludhiana for growing it in North India. Inter-varietal hybridization resulted in many promising hybrids and varieties Pusa Urvashi (table), Pusa Navrang (juice) and Pusa Trishar (table and raisin) released by IARI, New Delhi, 11 varieties for table use and juice and wine making by ICAR-IIHR, Bengaluru and Manjri Medika released by ICAR-NRC for Grapes, Pune for Commercial cultivation. Clonal selections Tas-a-Ganesh, Manik Chaman and Sonaka from Thompson Seedless and Khushdil from Anab-e-Shahi are under commercial cultivation. Manjri Naveen, a clonal selection from Centennial Seedless, has been released as table and raisin variety by NRC for Grapes, Pune for commercial cultivation.

The information on inheritance of vegetative, plant sex and fruit characters is contained in the manuscript which will enable breeder to formulate the meaningful breeding programme in grape. Embryo rescue culture technique will help in interspecific hybridization and also when seedless variety is used as seed parent.

LEAD LECTURE – 32

Breeding of citrus for nutritional quality and environmental stress tolerance: Challenges and opportunities

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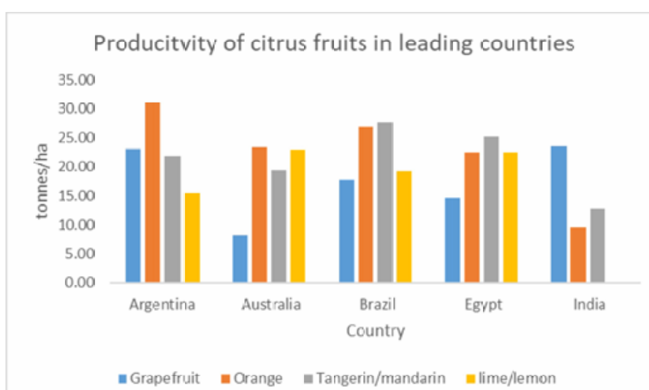
The prevalence of citrus rootstocks namely, rough lemon, *Karna khatta*, sour orange, Rangpur lime, Cleopatra mandarin *etc.* in the India is presently threatened by the spread of phytophthora rot, Citrus Tristeza Virus (CTV) combined with abiotic constraints such as drought, salinity and alkalinity. Besides, huanglongbing disease is also serious threat for commercially grown mandarin and sweet orange scion varieties. Hence, for sustainable growth of citrus industry, attention is required to develop highly prized scion varieties having tolerance to huanglongbing as well as multi stresses tolerant rootstock hybrids. Matching progenitors can be found in citrus germplasm to combine the desired traits, particularly between *Poncirus, Eremocitrus, Microcitrus* and *Citrus* genera. However, varietal improvement through sexual hybridization faces some constrains and nucellar embryony has been a major obstacle in the systematic production of F1 hybrids in citrus. Furthermore, identification of sexual hybrid embryos usually requires additional analyses such as molecular analysis (Tusa *et al*., 2002). The situation could be even more complex in interploid crosses owing to post-zygotic incompatibilities that induce endosperm failure and subsequent embryo abortion. Within the perspective of high polyembryony, immature embryo culture (Hu and Ferrira, 1998) along with application molecular markers which can expedite the recovery and recognition of hybrid seedlings (Bastianel *et al*., 1998; Ruiz *et al*., 2000) are needed in citrus improvement. China, India, Nigeria, Brazil, Mexico, the USA, Spain, Egypt, Italy and Argentina are the top ten citrus producing countries of the world (Zhang *et al*., 2018). The productivity of leading citrus growing countries is given in Fig. 1.

For sustainable growth of citrus industry, attention is required to develop highly prized scion varieties as well as multi stresses tolerant rootstock hybrids. Various environmental stresses such as soil or water salinity, drought and the major biotic constrains include diseases such as CVC, citrus canker, leprosis, tristeza, black spot, sudden death, and more recently, huanglongbing, in addition to many pests that challenge the citriculture growth of citrus industry in many commercially citrus growing areas. These environmental factors deserve attention, which are associated to



Source FAO, 2016-17

Fig. 1. Productivity of different citrus fruits in leading citrus growing countries

characteristics of individual citrus groups, expressing the necessity of better understanding to support future work on plant breeding, for instance, fruit quality (juice colour, seeedlessness, nutritional composition). In this crop, rootstocks play a preeminent role in improving yield, quality and protection against environmental stresses. Moreover, most of the environmental factors that limits the growth of citriculture may be combat through use of suitable resistant rootstocks.

Opportunities

Though apomixis has been observed in more than 400 plant species (Ozias-Akins 2006) but except for apple and citrus, apomixis is rarely found in agricultural crop plants. The apomictic progeny inherits the mother's genotype. Thus, apomixis can fix desirable genotypes for research and breeding (Spillane *et al*., 2001). The offspring derived from nucellar embryony in *Citrus* possess the same genetic constitution as the female parent, can be multiplied through seeds and exploited as rootstocks. Another significant trait in citrus breeding is self-incompatibility (SI). SI is associated with parthenocarpy, which yields seedless citrus fruit (Gambettaii *et al*., 2013; Kakade *et al*., 2017). Many commercial cultivars of citrus are self-compatible and seedy. However, seedlessness is an important commercial feature in many fruits. Furthermore, source for abiotic and biotic tolerance/ resistance are available in different species/cultivars. Likewise, higher ascorbic acid, narigine lamonine and mineral nutrients are available in different commercial and wild relatives. Hence, rootstock and scion variety(ies) can be developed with better agronomic performance using available source within citrus. Genotypes /species having traits important for citrus scion and rootstock breeding are given in table 1. Besides, more than a half million citrus ESTs (Expressed Sequence Tags) have been obtained and deposited to public databases in recent years (Delseny *et al*., 2010). These sequences were obtained from various tissues of over 15 citrus accessions, related genera and hybrids.

Challenges in citrus breeding

Besides, long juvenile phase and heterozygous nature, existence of polyembryonyic behaviour is the main cause of concern in citrus improvement through inter specific or inter generic hybridization. This special phenomenon of nucellar embryony in citrus, is a kind of sporophytic apomixis. Many nucellar embryos can develop alongside the zygotic embryo in an individual seed in certain *Citrus* species that are classified as polyembryonic. Nucellar seedlings are a nuisance in Citrus breeding programs because of difficult in the identification of zygotic seedlings (Frost and Soost, 1968). Developing new hybrids via sexual hybridization in such genotypes through conventional breeding programme is most difficult due to polyembryonic behaviour of both parents. When crosses are made out between polyembryonic citrus genotypes, the zygotic embryos may compete for nutrients and space with vigorous nucellar embryos (Soost and Roose, 1996), subsequently no recovery of hybrid seedlings. The majority of seedlings arising from polyembryonic seeds match to the maternal genotype, and are called nucellar seedlings. Furthermore, identification of sexual hybrid embryos usually requires additional analyses such as cytology, flow cytometry, isoenzyme, or molecular analysis (Tusa *et al*., 2002). The situation could be even more complex in interploid crosses owing to post-zygotic incompatibilities that induce endosperm failure and subsequent embryo abortion; in consequence, the number of viable hybrid progeny is dramatically reduced. Further, characters such as fruit quality and fruit yield are quantitatively inherited, and the development of the QTL marker is urgently needed.

Table 1. Some important citrus genotypes for breeding pragramme

Genotypes	Positive traits	Negative traits
Scion improvement		
Pummelo	Deep red colour, highly nutritive with naringene and limonine, hardy plant	Thick peel, highly seedy with less juice content
Grapefruit	Seedlessness, deep red colour, nutritive with, naringene, limonine	Bitter juice, susceptible to sun scalding and canker
Lemon	Thornless, resistant to canker, summer month fruiting under subtropical region	Susceptible to measophyll collapse physiological disorder, less acidic and prone to fruit cracking
Lime	High citric acid, juicy, excellent fruit quality, tolerant to fruit cracking, highly polyembryonic	Highly susceptible to canker
Tangerine	Easy peeling, heavy yielding, bearer harvesting	Highly susceptible to granulation
Rootstock improvement		
Attani	Na and Cl excluder, dwarf	Highly susceptible to phytophthora
Rangpur lime	Cl excluder	Susceptible to Citrus Blight and citrus Sudden Death
Cleopatra mandarin	Cl excluder, good cold tolerance, unaffected by CTV and CVd, deep root system, is quite well adapted to dry conditions and drought tolerant	susceptible to citrus nematode and blight
Rough lemon	Vigorous, tolerant to CTV and CVd	Susceptible to citrus nematodes and Phytophthora root rot
Webster trifoliate	Na excluder, resistance to the citrus nematode, some species of Phytophthora, and to CTV, dwarf	susceptible to Cl and CVd, deciduous in nature
Rubidaux	Na excluder, *Phytophthora* and CTV resistant, dwarf	susceptible to Cl, deciduous in nature
Pomeroy	Na excluder, P*hytophthora* and CTV resistant, dwarf	susceptible to Cl, deciduous in nature
Troyer citrange	Na excluder, *Phytophthora* tolerant	Susceptible to Cl and Troyer and Carrizo inherited their susceptibility to CVd
Sour orange	Cl excluder, *Phytophthora* tolerant	Highly susceptible to CTV

Procedures to be adopted for varietal development in citrus

- Generation of more of hybrids through embryo rescue
- Hybridity confirmation by molecular markers (SSR)
- Selection based on stakeholder's needs and first evaluation of promising ones at experimental site.
- Second evaluation of selected promising hybrids in different citrus growing areas.

- Optimization of managemental practices and estimation of commercial value¸
- Production of saplings and commercial plantings

Approached to enhanced hybrid seedling recovery

Within the perspective of high polyembryony, immature embryo culture is important (Hu and Ferrira, 1998) but selecting suitable embryo age, media and adequate *in vitro* procedures (Jaskani *et al*., 2005) along with molecular markers which would expedite the recovery and recognition of hybrid seedlings (Bastianel *et al*., 1998; Ruiz *et al*., 2000) are needed for better recovery of hybrid seedlings.

Application of molecular approaches for hybridity confirmation

The use of molecular technologies will help to overcome the obstacles of juvenility and polyembryony in citrus breeding. DNA markers are genomic based, and considered to be the best of the biochemical markers. They have been widely used in citrus hybrid identification, such as SSR (Tan *et al*., 2007), RFLP (Carimi *et al*., 1998), and RAPD (Andrade-Rodrígue *et al*., 2004). Further single nucleotide polymorphism markers have been emerged as the best markers for that they are the most abundant in the genome and the easiest to analyze. The citrus genomic sequence information (Xu *et al*., 2013) and the increasingly accumulated citrus EST data are the very useful resources for the development of SNP markers. Zhu *et al*. (2013) found single nucleotide polymorphism-based allele specific PCR (AS-PCR) was successfully employed as a handy tool to confirm and identify zygotic seedlings of Shantou-Suanju x trifoliate oranges crosses. Recently, Soni *et al*., (2019) established that the use of three SSR markers (TAA45, CAC15 and CAC39) were enough to efficiently identify hybrids developed from sour orange × Sacaton citrumelo crosses.

Conclusion

Citrus is one of the most significant and extensively grown fruit crops. It possesses several special reproductive characteristics, such as nucellar embryony and self-incompatibility. During the past decade, the emergence of novel technologies and the construction of multiple citrus reference genomes have facilitated rapid advances to our understanding of nucellar embryony. To accelerate the breeding efficiency for cultivating more citrus varieties with golden qualities and stable characters, it is essential to develop technologies for better exploitation of nucellar embryony and apomixes for development of desired trait specific scion and rootstock variety(ies).

References

Batygina, T.B., Vinogradova, G.Y. (2007). Phenomenon of polyembryony. Genetic heterogenity of seeds. *Russian Journal of Developmental, Biology*, **38**: 126–151.

Cameron, J.W, Soost, R.K. (1979). Sexual and nucellar embryony in F1 hybrids and advanced crosses of Citrus with Poncirus. *J Am Soc Hortic Sci*., **104** : 408–410.

Carimi, F., De Pasquale, F., Crescimanno, F.G. (1999). Somatic embryogenesis and plant regeneration from pistil thin cell layers of *Citrus. Plant Cell Report*., 18935940.

Chagas, E.A., Pasqual, M., Ramos, J.D., Pio, L.A.S., Dutra, L.F. and Cazetta, J.O. (2005). Activated charcoal and gibberellic acid concentrations on immature embryos culture. *Ciencia e Agrotecnologia,* **29** (6):1125-1131.

Driver, J.A. & Kuniyuki, A.H. (1984). *In vitro* propagation of paradox walnut rootstock. *Hort Science*, **19**: 507–509.

Gambetta, G., Gravin, A., Fasiolo, C., Fornero, C., Galiger, S., Inzaurralde, C., Rey, F. (2013). Self-incompatibility, parthenocarpy andreduction of seed presence in 'Afourer' mandarin. *Sci Hortic*, **164** : 183–188.

Gamborg, O.L., Miller, R.A. and Ojima, K. (1968). Nutrient requirements of suspension culture of soybean root cells. *Experimental Cell Research,* **50**: 156-158.

Jaskani, M.J., Khan, I.A. and Khan, M.M. (2005). Fruit set, seed development and embryo germination in interploid crosses of citrus. *Scientia Horticulturae*, **107** : 51–57.

Kakade, V., Dubey, A.K., Sharma, R.M. and Malik, S.K. (2017). Gametophytic self-incompatibility causes seedlessness in 'Kagzi Kalan' lemon (*Citrus limon*). *The J. Hortic Sci. Biotechnol*, http://dx.doi.org/10.1080/14620316.2016.1276415.

Kurt, S. and Ulger, S. (2014). Production of common sour orange × *Carrizo citrange* hybrids using embryo rescue. *International Journal of Fruit Science*, **14**: 42–48.

Murashige, T. and Tucker, P.H. (1969). Growth factor requirements of citrus tissue culture. 1st *International Citrus Symposium*, **3**: 1155–1161.

Ozias-Akins, P. (2006). Apomixis: developmental characteristics and genetics. *Crit Rev Plant Sci.* **25**: 199–214.

Soni, A., Dubey, A.K., Gupta, A., Sharma, R.M., Awasthi, O.P., Bharadwaj, C. and Sharma, N. (2019). Optimizing embryo age and media for enhancing hybrid seedling recovery in sour orange (*Citrus aurantium*) × Sacaton citrumelo (*C. paradisi* × *Poncirus trifoliata*) crosses through embryo rescue, Plant Breeding, 1–9. DOI: 10.1111/pbr.12690.

Spillane, C., Steimer, A., Grossniklaus, U (2001). Apomixis in agriculture: the quest for clonal seeds. *Sex Plant Reprod*, **14**:179–187.

Tan, M., Song, J. and Deng, X. (2007). Production of two mandarin x trifoliate orange hybrid populations *via* embryo rescue with veriûcation by SSR analysis. *Euphytica*, **157** :155–160.

Turgutoglu, E., Kurt, S. and Demir, G. (2015). Effect of GA_3 concentrations in basal medium on embryos germination of Cleopatra mandarin x Carrizo citrange and Cleopatra mandarin x Flying Dragon. *Ekin Journal of Crop Breeding and Genetics*, **1**: 17-19.

Viloria, Z., Grosser, J.W. and Bracho, B. (2005). Immature embryo rescue, culture and seedling development of acid citrus fruit derived from interploid hybridization. *Plant Cell Tissue and Organ Culture*, **82**:159–167.

Wang, J.F., Chen, Z.G. and Lin, T.X. (1999). Observation on the embryonic development in citrus after cross pollination. *Biology of Reproduction,* **8** (2): 57–63.

White, P.R. (1943). A Handbook of Plant Tissue Culture. The Jacques Catlell Press, Lancaster, Pa.

LEAD LECTURE – 33

Biotechnology as tool for horticultural crop improvement : Current and future perspective

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The main aims of agricultural and horticultural biotechnologies are sustainability, food security and the production of novel biomaterials. While practicing agriculture taking care of our environment and keeping a proper ecological balance is required. Food security is met by satisfying caloric needs, proteins, lipids, vitamins, minerals and all other nutritional factors quantitatively and qualitatively. The examples of plant-based biomaterials are pharmaceuticals, bioplastics and biofuels. The first agricultural revolution was followed by gradual, long-term changes in crop qualitative and quantitative traits via natural and human-directed breeding and selection. The crop varieties which are available nowadays are the result of traditional plant breeding. However, the traditional breeding methods are no longer sufficiently powerful to fulfil current and future needs. The knowledge of genomics paradigms has advanced considerably in the past decade resulting into deeper understanding of genetic and epigenetic processes related to plant growth and development and response to the environment.

This era of omics, including genomics, transcriptomics, epigenomics, proteomics and metabolomics can facilitate biotechnological improvement of horticultural crops, particularly for physiological phenotypes that are regulated by complex genetic and epigenetic mechanisms. As epigenetics regulates various developmental and environmental responses, it is predicted that reprogramming of the epigenome will be an important factor in crop breeding and cultivar development. Additionally, the advances in horticulture biotechnology depend on the application of cell biology, biochemistry, metabolism, the various omics, systems and synthetic biology approaches as the components. Furthermore major achievements in plant biology are the new methods of plant genome engineering like bacterial RNA-directed CRISPR–Cas9 endonuclease, a versatile tool for site-specific genome modification in eukaryotes. The rapidly expanding genome engineering arsenal provide extraordinary control over the genetic information of plant genomes and is important for revealing plant metabolic, physiological and morphological traits and therefore for better controlling and modifying biological structure and function. However, the outcome of laboratory studies cannot be translated and applied to agricultural practices without rigorous testing and screening. Various studiesare already carried out in the direction for understanding crosstalk between biology and agriculture/horticulture, providing direction to more effective and productive development of new cultivars.

Bridging the genotype–phenotype gap (Fig. 1) is one of the major agro-technology visions used for saving time and money. Gene discovery integrates molecular biology and omics techniques, which are followed by the gene transformation stages and various tissue culture operations. Early development of transformed plant candidates occurs following *in vitro* plant regeneration, yielding plant candidates for various traits. The resulting plant candidates undergo several additional evaluation and assessment steps throughout the screening and development phases, selecting the plant lines that present good stress tolerance, while, maintaining other desirable traits such as yield, growth, and development. The major procedure which is followed is the selection of few plants from thousands using conventional, field-based selection processes that require whole seasons and repeated large-scale field trials. This long process may last several years and requires considerable resources, limiting the number of promising candidates that can be screened simultaneously. However the high-resolution, high-throughput diagnostic screening platform can be applied for the study of whole-plant physiological performance that serves as phenotypic screening – 'physiolomics' – thereby bridging the existing genotype–phenotype gap. Hundreds of plants subjected to multiple combinations of stressful conditions may be screened simultaneously at particular stages of their life cycles. The phenotyping screening system can dramatically accelerate the development process and allow continuous measurement of crop behaviour under controlled standard and stress conditions, to eliminate at an early stage in the greenhouse those candidates that are unlikely to perform well in field trials. The costs of the phenotyping process are an important issue, however, the technology is rapidly developing and as yet it is difficult to estimate the costs. Plants passing this phase will go directly to the obligatory trait-integration field trials that will always be required before market launch. This final verification stage should integrate expected environmental conditions with the desired traits, leading to the selection of a few superior plants that exhibit good stress tolerance as well as other desirable traits.

Once, the screening parameters have been satisfied, the products can be released into the field and the market. The product yield and quality (nutritional value, taste, colour, aroma, shelf life) and botanical traits of importance to plant development (e.g., shoot and root architecture, growth and

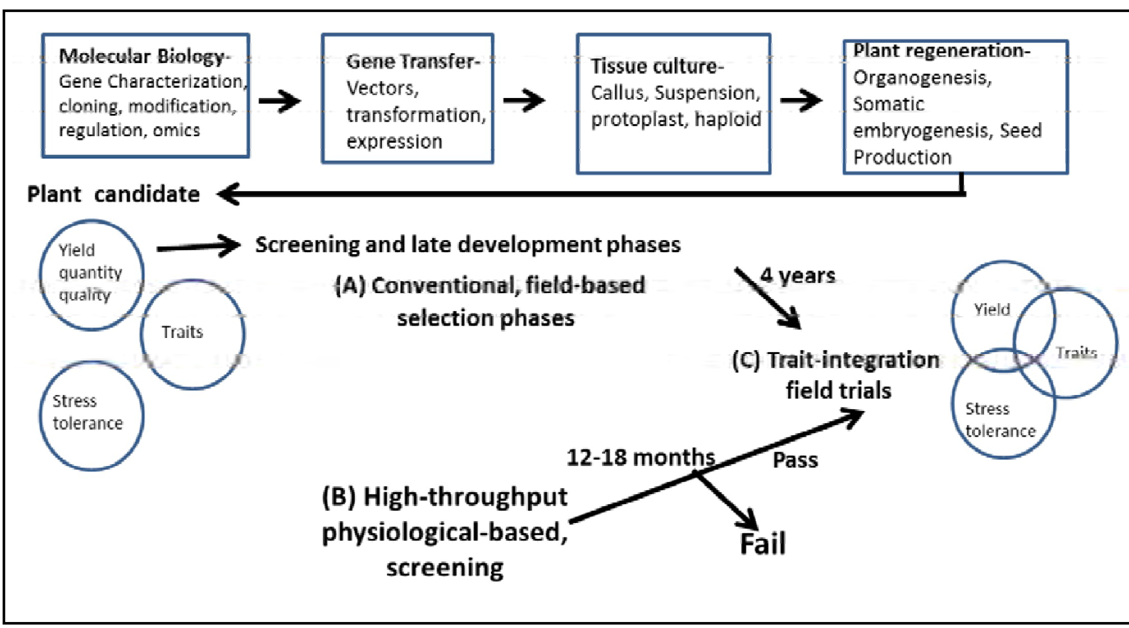

Fig. 1. Bridging the genotype–phenotype gap

elongation, genetic control of flowering) must be considered. Moreover, in view of the detrimental changes in climatic conditions tolerance and adaptation to abiotic and biotic stresses should be considered. Enormous efforts into developing crops with higher tolerance to drought, heat, cold temperatures and salinity have been performed. Various studies have identified a large number of genetic and molecular networks underlying plant adaptation to adverse environmental growth conditions. However, all biotechnological applications should be thoroughly examined regarding global food security, economic, sociological, ethical and public acceptance.

LEAD LECTURE – 34

Current status and recent advancements in mango genomics

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In the centre of origin and diversity in Southeast Asia, India is leading mango (*Mangifera indica* L.) producer in the world. It is one of the most important fruit crops in the developing world and an important source of income for millions of poor in the humid tropics and subtropics. Over the last decades, research in fruit genomics has lagged behind that of model and agricultural systems, however the advent of next-generation sequencing technologies has galvanised fruit genomics research. The enormous genetic diversity and need to mitigate the effects of climate change have catapulted genomics approaches, as newer tools and technologies are now available to decipher genic and intergenic regions, to gain insights into plant molecular responses. Dwarfing architecture, early and regular flowering, resistance to abiotic (salinity, water logging, drought) and biotic (insect-pests, diseases) stresses, longer shelf-life, higher yield, flavor and nutritional quality of fruit are some of the highly desirable breeding traits in mango. ICAR-Consortia partners, published draft genome in 2016 with a genome size of 446 Mb, using newer chemistries and softwares for assembly, polishing and genome mapping. Availability of mango genomic information, has immense potential to assist in precision breeding and marker development. RAD-based marker discovery using a panel of 84 mango varieties, on Illumina HiSeq 2000 platform yielded a total of 1.25 million SNPs. Phylogenetic tree using 749 common SNPs across these varieties revealed three major lineages which was compared with geographical locations. Mango fruit ontogeny studies revealed cuticle biosynthesis pathway genes responsible for cuticle accumulation, wax biosynthesis and wax transport. An improved understanding of the molecular processes involved in cuticle formation and modification has considerable potential value in designing strategies to improve fruit quality, peel colour, glossiness, texture, and uniformity, and it also plays an important role in shelf life. Ethylene biosynthesis and signaling pathway genes along with flavor and aroma pathway gene products have been implicated in plant hormone signal transduction, starch and sucrose metabolism, galactose metabolism and terpenoid backbone biosynthesis. Structural genes in anthocyanins and carotenoid biosynthesis pathways were utilised for mining genes for attractive fruit peel defined by red blush and pulp having high carotenoid biosynthesis during fruit ripening. Such genes can now be used for molecular breeding. Molecular mechanism undermining salinity stress responses and flowering traits include genes involved in sugar metabolism, membrane transporters, signal transduction, hormone transporters, ROS scavenging system and osmo-regulation processes. These efforts summarise progress in development of genomic resources in mango for enhancing breeding efforts.

THEME 6

INNOVATIVE TECHNOLOGIES OF POST HARVEST, VALUE ADDITION, WASTE AND SUPPLY MANAGEMENT

LEAD LECTURE – 35

Reducing pre and postharvest losses in litchi through advanced tools and techniques

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Litchi is today grown in about 100000 ha throughout the country with production above 700000 MT. Litchi is beset with production issues mainly fruit cracking, sunburn, and infestation with fruit borer among many. A study at our centre has revealed that upto 30 per cent of harvested litchi is sorted out as unmarketable produce due to poor quality of fruit at harvest. Also, upto 43 per cent losses can take place in the complicated journey of litchi from farm to retailer. There is, therefore, a deeply felt need to address production-related practices that result in poor fruit quality at harvest. No postharvest intervention can improve the quality of fruit after harvest; only the quality can be maintained. At ICAR-NRCL, refinement in litchi production practices including canopy management, sunlight modulation, water and nutrient management, fruit bunch bagging and IPM tools for insect pests and diseases are some approaches that have proved immense potential in production of the highest quality fruit in litchi. These approaches not only result in more production (quantity) but also increase production of Class-I fruits (quality). Litchi is a delicate fruit crop and highly perishable. Following proper harvest practices and postharvest treatments can reduce postharvest losses and wastage in the supply chain.

Litchi grows into huge trees if left unchecked. Large-statured trees are not only difficult to manage in terms of orchard and cultural practices like insect pest management, harvesting, pruning etc, but also only few plants are accommodated per unit area. Canopy modulation in litchi has been given wide synthesis at ICAR-NRCL where efforts have gone into accommodating more number of plants in any unit area along with tree architecture for allocating optimum space for ideal plant growth and production. Plant spacing at 8 m x 4 m and 6 m x 4 m, single canopy with multiple root system, have given promising results. Light interception under centre-opening canopy architecture has been found to improve the percentage of Class-I fruits in litchi in addition to increase in productivity.

Some important factors that limit higher productivity and quality in litchi are sunburn, fruit cracking, fruit drop, and insect pests and diseases, especially fruit and shoot borer. Fruit bagging through use of non-woven polypropylene (PP) bags have been tested and proved successful. As per studies conducted at the centre, bagging done 30-40 days before anticipated harvest gives the best result with minimal infestation of fruit borer, reduced sunburn and cracking, thereby significantly increasing the percentage of class-I fruits. The centre has also developed an integrated approach to reduce the menace of fruit borer and litchi mite.

Litchi farmers usually practise early harvesting to exploit the profit that early marketing brings. A common practise is to harvest the crop once the colour break occurs and fruits show pinkish colouration. Fruits at this stage are less in weight, with low TSS and high acidity, traits that are undesirable from quality and consumer point of view. Our studies have established that litchi should ideally be harvested at the correct fruit maturity to harness optimum yield and quality. TSS : acid ratio of more than 40 is one of the most important reliable indicators of correct harvest maturity. Also, fruit growth during last stage of fruit maturity (after colour break) is characterised by growth of the edible portion, the aril. Therefore, harvesting of litchi at the correct stage of maturity results in the increase yield up to 40-50 per cent.

Litchi is highly perishable after harvest and fruits turn brown within 24 hours if proper postharvest practices are not followed. Browning irreversibly impacts the marketability of litchi as the red colour of litchi pericarp is the most important factor that consumers consider in their decision to purchase. Wherever litchi is grown, harvesting period lies during the hottest time of the year. High field heat during harvest time is the norm and adds to the perishability of litchi by increasing the metabolic rate of tissues. At ICAR-NRCL, hydro-cooling studies have shown to reduce the rate of respiration and metabolism and the rate of desiccation, thereby reducing the rate of pericarp browning. Other postharvest treatments have also been standardized that increases the shelf life and marketability of litchi.

One of the most important ways to improve productivity and generate income from litchi production system is the component of processing and value addition. Litchi is a highly flavourful fruit and finds high acceptance among consumers especially in the form of refreshing beverages. The centre has developed process and protocols for preparation of different value-added products of litchi such as litchi pulp, litchi squash and RTS, litchi wine, litchi nut, dehydrated litchi pulp *etc.* These products are not only popular among consumers but also find increasing interest among entrepreneurs for development of enterprises and business models.

This paper delves into these factors and practices in production and postharvest chain that leads to generation of loss or waste in litchi, and suggests refined tools and practices to minimize them. Produce saved from loss or waste, throughout the litchi production system, can be beneficially utilized for achieving food and nutritional security to our masses.

LEAD LECTURE – 36

Postharvest management in horticultural produce for livelihood and rural development

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India occupies second position in production of fruit and vegetable crops in the world with a production of 306 million tonnes. This monumental achievement is becoming self defeating, due to colossal postharvest losses, which remains a matter of concern both for the planners and the farmers.

It is reported that one third of the food produced is lost after production, which is about 1.3 billion tonnes per year. In low-income countries, the food is wasted or lost at early and middle stages of the supply chain than at the consumer or household level, while in high income countries it is more at consumer level or retailer level, as the processed food becomes unfit for consumption. In under-developed or developing countries the loss is mainly due to un-scientific handling, packaging, storage and processing of horticultural commodities at production centres as a result of poor infrastructure. This situation makes the Indian growers vulnerable to market risks, as he/she is forced to sell the harvested produce without expecting a decent return on the investment or often making a loss.

As per the 2011 census, 68.70 per cent of total population in India resides in rural areas, where agriculture/horticulture is the primary source of livelihood. While the share of farmer in the consumers' rupee is dwindling, high returns on investment in horticulture is attracting corporate to farming. There are technological and infrastructural gap from farm to market and then to plate, which needs to be addressed with active participation of all the stakeholders. A systematic and sustainable model of integrated pre and postharvest management not only would plug the leakage and increase the availability of fruits and vegetables, but also improves accessibility and affordability through economic empowerment achievable by employment generation and livelihood options.

Several pre-harvest factors like genetic/varietal differences, physiological stress, mechanical injury, abiotic stress like temperature, humidity, water and nutrition; biotic stress like invasion by pathogens and insects are also responsible for postharvest losses. The postharvest causes for losses include improper harvesting, unscientific handling and transportation, lack of cold storage/cold chain facilities, spoilages and lack of processing facilities. As fruits and vegetables deteriorate rapidly after harvest due to enhanced respiratory activity, temperature management plays an important role in its control and hence establishment of refrigerated distribution system is an essential part of the improved postharvest management strategy in perishables. The concept of use of cold stores for short & long term storage of fruits and vegetables and to link it with supply chain or distribution network is lacking both at farmers and traders level.

Establishment of pack houses, processing and value addition centres in and around production catchment areas can stop the transportation of total crop (including the residues) to the urban markets that create pollution there. As the availability of fresh produce decreases, the demand for processed products increases creating more demand for the same. This would make the markets more structured and stabilize the prices of perishable commodities. Development of rural areas into semi-urban clusters through small scale rural industrialization provides urban facilities in rural areas (PURA dream of Dr.A.P.J. Abdul Kalam), as the supporting environment like road, housing, banks, schools, *etc.*, would spring up on its own in the surroundings. With rural industrialization there would be need for skill development centres to service to the rural industries. This would enhance the employment opportunities to rural youth and will prevent migration from rural areas to urban and would help in retaining rural youth in horticulture and allied activities. This multiplier effect would bring overall development in the rural areas, which would ensure food, nutritional and livelihood security and overall rural development.

LEAD LECTURE – 37

Secondary agriculture for value added products from fruit and vegetable waste

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India is undergoing transition from an agriculture-based economy to a products-and-services-based economy leading to economic and social transformation. Though, the country has achieved self sufficiency in primary agriculture, yet attention is needed on secondary agriculture and value added agro-commodities for better returns, employment generation and growth of rural economy.

Post harvest losses due to fruit and vegetable waste are to the extent of 18 per cent and their management becomes the major concern of stake holders and environmentalists. Heaps of the waste increase the air pollution and health problems in the area, landfill, dumping, composting or using as feed in digester of biogas plant are some commonly used methods to manage this waste. But, these practices are less profitable and environment friendly. Since, these waste have rich nutritional value, some time more than the utilized part, nowadays lot of emphasis is being laid on using it as raw material for certain value added products.

Following factors favour this approach to enhance farmers' income through additional engagement in produce processing and value addition in production catchments.

- There exist need to utilize the whole biomass generated from agricultural production for processing and value addition with twin objectives of maximizing the income generation and minimizing wastage for achieving better quality of life and cleaner environment.
- The fruit industry waste includes peel, pomace, seeds, trimmings. These are excellent source of natural products for various food and non-food industries, such as nutraceuticals, phytochemicals, pharmaceuticals, cosmetics, bio-fuels, *etc.* These environment - friendly natural derivatives permit substitution of synthetic products with greater consumer acceptability, while creating new income generation avenues.

Examples of secondary agriculture include vitamins from grains, oil from rice bran, starched sugar from corn, milk and protein from soybean, industrial chemicals and biofuel from sugarcane and ligno-cellulosic biomass, fiber boards from rice straw, high-value animal byproducts, in addition to the well-known medicinal plants and herbal products not yet fully capitalized in India. Several fruits and vegetable waste are being used as raw material for production of organic acids, essential oils, biofertuilizer, biopesticide, enzymes, fermented and non fermented beverages, bio fuel and protein enriched feed, *etc.* Hence, the future of secondary agriculture is very promising in country like India.

LEAD LECTURE – 38

Post-harvest management of fruits and vegetables

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Fruits and vegetables play a unique role in country's economy, nutritional security, **poverty** alleviation and employment generation. These crops are highly perishable commodities and spoiled in considerable quantity at various steps of handling which need to be minimized. Further these commodities are seasonal in nature and prices go down considerably during the glut period and production becomes uneconomical due to distress sale. Thus, an increase in production of fruits and vegetables will have little value if the produce is not properly handled or utilized. The cost involved in preventing the losses is always cheaper than the cost of production hence, post-harvest management is very vital to reduce the gap between production and net availability.

India has wide diversity in climate and soil provide great scope for growing a wide variety of fruits and vegetables compared with any other country across the globe. India is the second largest producer of fruits and vegetables in the world after china. Presently fruit crops cover 6.53 million hectares of area and contribute 96.75 million tonnes of production, whereas vegetable crops cover 10.44 million hectares of area and produce 187.47 million tonnes of production.

Although the area and production of fruits and vegetables has increased manifold, there is considerable gap between their gross production and net availability to the consumer. Quality of a sizable produce deteriorates by the time it reaches the market consumers, which adversely affects the competitiveness in the market and the profits earned by farmers. Losses of horticultural produce occur after harvest owing to their inefficient handling and transportation. India witnesses nearly 4.6-15.9 per cent wastage in fruits and vegetables annually, as a result of lack of recent harvesting practices and inadequate cold chain infrastructure. The major contributory factors for such huge losses in addition to the seasonability and perishability of fruits and vegetables are-

- Lack of keeping quality
- Market glut
- Improper harvesting practices
- Improper handling practices
- Inappropriate transport
- Inappropriate grading and packaging
- Inadequacy of infrastructure
- Meager quantity processed

Efficient management of the produce during harvest, grading, packaging, transport, storage and marketing can prevent these losses. There are also constraints of poor infrastructure and involvement of too many middlemen in the market. At present, post-harvest management of horticultural produce in the country is far from satisfactory. Strategies aimed at reducing post-harvest losses right from farmers' field until the produce reaches the end users have to be worked out and put in place to achieve our national goal of food and nutritional security. Several post-harvest management technologies that have been developed by different lCAR, CSIR institutes and State Agricultural Universities can be effectively utilized in addressing post-harvest problems.

Post-harvest management strategies

Maturity standards

Horticultural crops should be harvested at their appropriate stage of maturity, failing which the produce is likely to have poor colour, flavour, poor quality and low keeping quality or storage life. Harvesting at the right stage leads to enhanced shelf life, ensures sensory quality, regulates harvesting and packaging operations, minimizes losses and maximizes profits.

Harvesting

Fruit harvesting at proper stage of maturity has direct effect on quality and market value of the produce. Stage of harvesting influences the post-harvest enzymatic activities of horticultural produce, which determine the levels of different pigments, sugars, acids, flavours and vitamins. Different crops require different methods of harvesting and proper handling.

Harvesting should be done at proper stage of maturity with suitable method during the coolest part of the day; early morning or late afternoon. Damage or bruising during collection and dumping due to improper care, delay in precooling (mango, grapes, litchi, leafy vegetables *etc.*) and curing (potato, sweet potato, yam, onion, garlic, dates *etc.*) cause considerable losses in fruit and vegetables. Harvested fruits and vegetables should be precooled within 4-6 hours.

Use of pre-harvest chemicals

Auxins, gibberellins, cytokinins, ethylene, growth retardants and inhibitors, abscisic acid are commonly used for regulation of various physiological processes so as to increase production and enhance post-harvest life of horticultural produce.

Moreover pre-harvest application of GA_3 at maturity stage delays ripening and improves storage life in mango and guava and also improves colour in citrus. Technologies available for artificially ripening fruits like mango, banana and papaya need to be promoted to avoid use of harmful and carcinogenic chemicals like $CaCl_2$. Banana ripening chambers and ethylene generation systems should be established at various sites of production and marketing for artificial ripening of such fruits.

Several commercial waxes available in the market can be gainfully promoted for improving storage life in fruits like kinnow, guava and vegetables like brinjal, tomato, capsicum. Use of CIPC in potato, degreening, waxing, VHT reduce losses during storage. Vapour Heat Treatment (VHT) which is an effective means of controlling infestation of fruit flies should be promoted in case of fruits like mango and guava intended for newly established retail chains as also for export.

Handling and transport

Handling and transport are important components which come right after harvesting. Multi-hand handling of fresh produce is the main cause of qualitative and quantitative deterioration. Mostly the handling and transportation is done by tractor trollies/trucks which make produce vulnerable to speedy loss either by physical, biological or pathological means. Strategies to minimize the losses due to inappropriate transport are -

- Discourage open truck, cart load and tempo for long distance transport
- Provision of padded and refrigerated trucks for long distance transport
- Selection of cost effective route for shipment
- Use pallet for loading and unloading

There is lack of technical knowhow at farmers' level regarding handling and transportation techniques. This component requires adequate attention in order to strengthen post-harvest value-chain right from field itself. Some of the basic tips which can be practised by the growers are -

- Adoption of plastic crates/bins in entire handling chain, by farmers, wholesalers, and retailers at field and market levels
- Use of vegetable washing machines at farmers' level and promotion of mechanized sorting, grading and washing at production catchment area and marketing site
- Use of appropriate packaging material, *viz.* punnets for strawberry and mushrooms; individual skin wrapping in citrus, tray-packaging for okra, tomato, mushroom, cut vegetables and fruits
- CFB boxes for guava, kinnow, pomegranate and mango
- Use of refrigerated vans containers for long-distance transportation of fruits, vegetables and flowers

Grading and packing

Although sorting and grading are very important unit operations for appropriate post-harvest management of horticultural produce, yet it is seldom being used in commercial operation in India barring a few recently established supply chains. Through Government and Cooperative's initiative, some organized grading facilities could be set up where farmers can get their produce graded on custom hire basis. Mechanical grading of citrus in Punjab and Haryana, and mango in Uttar Pradesh are being undertaken at packaging centers installed with mechanical graders.

Packaging fresh fruits and vegetables is one of the important steps in the long and complicated journey from grower to consumer. Proper packaging of a product can reduce not only bruising due to impact/compression, but can also facilitate marketing, reduce moisture loss, prevent microbial contamination, reduce pilferage and maintain suitable environment during marketing. Packaging containers with rough surface and weak strength, packing without post-harvest treatment, improper packing (very loose and deep), imbalance of CO_2 and O_2 in CA storage (particularly for mango, papaya, banana and pomegranate) causes considerably losses in various fruits and vegetables. The strategies to minimize the losses due to inappropriate packaging are -

- Fabricating the cost effective, strong, smooth surface, wax coated and ventilated boxes

- Use of plastic crate, corrugated fiber board boxes, plastic corrugated box and sacks for bulk packaging
- Post-harvest treatments to minimize the decay during transport and storage - Use of ethylene absorbents– $KMNO_4$, sulphur dioxide releasing pads in grapes, fungicide treatment and skin coating to reduce decay
- Cost effective waxing, shrink wrapping and modified atmospheric packaging should be standardized

Storage

High field temperatures at harvest are detrimental to the keeping quality of horticultural produce, thus reducing physiological and biochemical changes. Fruits like mango, grape, and vegetables like pea and okra which deteriorate fast need precooling treatment. There are several methods of cooling, namely, forced air cooling, vacuum cooling, hydro cooling, package icing and top icing. There is need to establish pre-cooling units and a cold chain for storage and transportation of fruits and vegetables.

Cold storage in India has been largely adopted for long-term storage of potatoes, onions and high value crops like apple, grape and flowers. There is an urgent need to develop multipurpose cold storage facilities focusing on all fruits and vegetables. Besides cold storages some low cost storages like evaporative cool storage, zero energy cool chamber, onion stores, *etc.* are also used in our country. Moreover, controlled atmosphere (CA) storage technique is the most important innovation in fruit storage which can be exploited.

Processing

A considerable amount of fruits and vegetables produced are lost due to improper post-harvest management and lack of appropriate processing technologies. Approximately 2 per cent of fruits and vegetables produced are processed in India as against 65 per cent in the US, 70 per cent in Brazil, 78 per cent in the Philippines, 80 per cent in South Africa and 83 per cent in Malaysia. Some of the popular processed or value added products in the country are frozen peas, dried onions and garlic powder, ginger and garlic paste, jams of mixed fruits, juice/pulp and concentrates of orange and litchi, squashes of orange, mango, litchi, canned beans, frozen beans, cauliflower and okra; pickles of mango, lime, chillies and mixed fruits and vegetables; tomato ketchup and puree; mango fruit drink and nectar, chilli sauce, mango chutney *etc.* Lack of adequate internal demand for processed products, lack of suitable varieties for quality products and high cost of processed products which are not within the reach of common man are the factors for meager processing of fruits and vegetables. Strategies suggested to promote the processing that helps to reduce the losses are –

- Identify suitable varieties for processing into various products.
- Develop value added products from the varieties available in large quantities.
- Capacity building for cost and quality competitiveness of processed fruits and vegetables in the international trade.
- Minimize the overhead costs and cost of processed products by the selection of containers, their size and labeling.

- Ensure the supply of fruits to a processing factory round the year by staggering planting, pruning and bahar treatment.
- Establishing the processing units in the vicinity of production sites.
- Utilization of waste generated from the fruit and vegetable processing.

The horticulture industry has major contribution for improving food security, enhancing rural employment, alleviating poverty and export-promotion. Increased urbanization, improved standards of living, and the convenience needs of dual income families poised to major market potentialities in the food processing and marketing sectors. The main issues to be addressed are through public private partnership. Our ultimate aim should be convergence of technologies minimizing of post-harvest handling losses, value addition, by-product utilization and promotion of export and emergence of products or processes, by interfacing and networking of various stakeholders.

LEAD LECTURE – 39

Development and commercialization of fruit and vegetable based snack foods as an alternative to HFSS - A success story

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There is a growing awareness that the daily diet is an important determinant for a healthy life and consumers are looking for the products with an ability to improve their health and well being besides providing basic nutrients. Fruits and vegetables are rich sources of many vitamins, minerals, fiber and phytochemicals and their consumption directly contributes to various health benefits. However, most fresh fruits and vegetables have a short harvest season and are sensitive to deterioration and even when stored under refrigerated conditions. Therefore, changing its state from fresh to fruit bar or fruit leather as well as dehydrated slices is an effective way for their preservation. Technologies for making dehydrated fruits and vegetables slices through employing various techniques such as osmotic dehydration, vacuum impregnation, fortification as well as combined processing in mango, papaya, guava, banana, pineapple, jackfruit, sapota, aonla, carrot, pumpkin, beetroot and muskmelon, as well as fruit bars from mango, papaya, guava have been successfully developed at ICAR-IIHR and commercialized to several entrepreneurs. Dehydrated slices are highly concentrated products while, fruit bars basically made from fruit pulp retains most of the nutrients, minerals and flavour constituents, thus forming a good nutritional supplement. Further, these nutritious snack foods will be a healthier alternative to foods which are high in salt, sugar and fat (HFSS). This will also meets the increasingly health-conscious consumers requirements of a convenient form of nutritional snack food having disease prevention and health-promoting compounds.

LEAD LECTURE – 40

Fruit and vegetable processing technologies for boosting the income of farmers/entrepreneurs in present scenario

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In our country more than a quarter population is living below poverty line. Out of total population living in the rural parts of India, 25.7 per cent is living below the poverty line whereas, in the urban areas, the situation is a better with 13.7 per cent of the population living below poverty line. Fruit and vegetable processing as self employment may be one of the important sector for reduction of poverty, boost the income and also provide the employment youth and women of rural as well as urban area. Only 2.2 per cent of produced fruits and vegetables is processed in our country, while level of processing is 65 per cent in USA, 70 per cent in France and Brazil and 83 per cent in Malaysia, it reflects that much more possibilities to increase the value addition through processed fruits and vegetables. India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. Therefore, Indian government anticipates the growth in this sector by 25 per cent of the total produce till 2025. There is a surge in demand for fruits & vegetables as a result of a shift in consumption. Accordingly, Indian farmers are also shifting production towards horticulture crops to cash in on the growing demand. India ranks second in fruits and vegetables production in the world, as per National Horticulture Database (NHB, 2016-2017) India produced 92 million metric tons of fruits and 175 million metric tons of vegetables. The area under cultivation of fruits stood at 6.48 million hectares while vegetables were cultivated at 10.29 million hectares. Post harvest losses in horticultural produce are varied from 5 to 40 per cent which amounts to more than rupees 8000 crore per annum. If we subject our produce to value addition the losses can be minimized. Therefore, fruits and vegetables are right material for value addition because they are more profitable, has high degree of processability and richness in health promoting compounds and higher potential for export.

In the present scenario when the globe has become a single market it has to be competitive, the diversification, quality enhancement and value addition have become key words of success in trade at national and international level. Value addition helps in avoidance of post harvest losses, industrialization, doubling income employment generation, export, extended availability of produce, foreign exchange earnings product and diversification, easy marketing *etc.* We need to focus on those processing sectors which are cost effective, simple, medium to small scale industry based set up and needs involvement of more numbers of youths and women in production and marketing. Taking into consideration of financial, social and educational background of farmers of our country following processing products are required to be promoted.

Drying and dehydrated products

Dehydration preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dehydrated fruits and vegetables varies from 5 to 25 percent depending on the food. During this process, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. Dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow. In this process, a single layer of fruits or vegetables are spread on trays which are placed inside the dehydrator. On account of the concentrated form, low cost, convenience and easy transportability dehydrated fruit and vegetable products become highly popular among the armed forces. Dehydration techniques have been greatly improved to get over defects like undesirable changes in colour, taste and flavour during storage and distribution. Example of dehydrated processed products are powder of raw mango, garlic, onion, tomato, potato, spinach, ginger, aonla, turmeric and bael.

Osmo dehydrated products

Osmotic dehydration has received greater attention in recent years as an effective method for preservation of fruits and vegetables. It is less energy intensive than air or vacuum drying process because it can be conducted at low or ambient temperature. It has potential advantages for the processing industry to maintain the food quality and to preserve the wholesomeness of the food. It involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable. Osmotic concentration is the process of water removal from fruits and vegetables, because the cell membranes are semi-permeable and allow water to pass through them more rapidly than sugar. During osmosis small quantity of fruit acid is removed along with water. It is a dynamic process, in which water and acid are removed at first and then move slowly, while sugar penetration is very slight at first but increases with the time. Therefore, the characteristics of the product can be varied by controlling temperature, sugar syrup concentration, concentration of osmosis solution, time of osmosis *etc.* to make osmotic concentration process faster. The osmotic dehydration process is influenced by various variables such as pretreatment, temperature of sugar solution and additives on the mass transfer. The osmotic air-dried products were high in superior quality and reported that the osmosis process removed water from fruits and vegetables slices to the extent of 40-50 per cent of the weight, but not enough for storage. Therefore, to remove water up to safe levels further drying is needed. Moreover, variables like maturity, variety, pretreatments, temperature, nature and concentration of osmotic agent, agitation, geometry of the material, fruit pieces to osmotic solution ratio, physico-chemical properties, additives, structure and pressure affecting the osmotic dehydration process greatly influences this process. Aonla, bael, mango, pine apple, guava, ber, muskmelon, papaya, are important fruits which can be used for candy preparation. The preservation of fruits and vegetables by osmotic dehydration process add value to the finished product, which is wholesome, nutritious and available round the year.

Minimally processed product

The demand of foods which retain their natural flavour, colour, texture and contain fewer additives leads to the development of minimal processing technologies. New techniques for maintaining quality and inhibiting undesired microbial growth are demanded in all the steps of the production and distribution chain. There is a general trend to increase fresh fruit and vegetable consumption. Basically fruits and vegetables are basic ingredients of the human diet, associated with a beneficial and healthy function against numerous diseases. This beneficial effect has been attributed to non-essential food constituents, phytonutrients, that posse a relevant bioactivity when consumed as a part of regular diet. Fresh-cut fruits and vegetables emerged to fulfill consumer’s demands of healthy, palatable and easy to prepare plant foods. 'Minimal processing' describes non thermal technologies to process food in a manner to guarantee the food safety and preservation as well as to maintain as much as possible the fresh-like characteristics of fruits and vegetables. Although between processing and consumption a span of several days occurs, consumers still desire to have fresh fruits and vegetables. However, it is well-known that processing promotes a faster physiological deterioration, biochemical changes and microbial degradation of the product resulting in degradation of the colour, texture and flavor. Storage temperature is the single most important factor affecting spoilage of minimally processed fruit and vegetables. However, there are many other preservation techniques that are currently being used by the minimally process industry such as antioxidants, chlorines and modified atmosphere packaging (MAP). Moreover, new techniques for maintaining quality and inhibiting undesired microbial growth are demanded in all the steps of the production and distribution which may lead in improvement of the quality and shelf-life of these products. The ready to cook vegetables and ready to eat fruits like pine apple, mango, papaya, jackfruit and muskmelon may create important domain in the market as minimal processed products.

Frozen product

Freezing requires the least amount of food preparation before storage and under optimum conditions it has the best nutrient, flavour and texture retention. Since food remains micro biologically safe during freezing, its shelf life is determined by chemical and physical changes that occur during storage. With the development of mechanical refrigeration and quick freezing techniques, the frozen food industry has expanded rapidly. The lower the storage temperature, the slower will be the rate of a chemical or enzymatic reaction, but most of them still continue at any temperature. Therefore, it is

Different processed products developed in the Department of Post Harvest Technology NDUAT, Kumarganj, Faizabad.

a common practice to inactivate enzymes in vegetables by scalding or blanching the latter before freezing when practicable. The rate of freezing of food depends upon a number of factors such as the method employed, the temperature, circulation of air or refrigerant, size and shape of package, kind of food *etc.* When compared to most other food preservation methods, freezing requires the least amount of food preparation before storage and under optimum conditions it has the best nutrient, flavour and texture retention. Since, food remains microbiologically safe during freezing, its shelf life is determined by chemical and physical changes that occur during storage.

Freezing is cheaper than canning, frozen products are of better quality than canned products, but for storage of frozen products uninterrupted supply of electricity is essential. Freezing methods includes quickly frozen by direct immersion, direct contact with refrigerant and air blast freezing, dehydro- freezing, freeze drying, cryogenic freezing and accelerated freeze drying. Apart from pea, vegetables like carrot, cauliflower, broccoli and french bean can be processed as frozen product.

The implementation of a set of above mentioned postharvest technologies are need based, cost effective and suitable for reducing losses and keeping perishable fruits and vegetables fresh longer. It will also transform them into long-lasting products to obtain better return. Finally, this will promote the well- being of the rural as well as urban population as a whole and help to improve economy. Thus, by adopting above discussed simple technologies for value addition and the optimum utilization of horticultural produce has potential to improve better financial return, food nutrient and value of humanity. Thus fruit processing may helpful for decreasing poverty percentage in rural as well as urban area of our country.

THEME 7

INDIGENOUS TECHNOLOGIES AND HORTICULTURE FOR HEALTH, HEALING, HAPPINESS AND ENVIRONMENT

LEAD LECTURE – 41

Biodynamics and homa farming-technologies for sustainable horticulture and climate change adaptation

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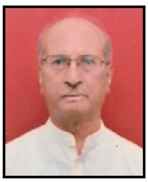
Biodynamics or Biodynamic Farming originated from eight lectures that Rudolf Steiner gave to a large gathering of farmers, doctors and followers of Anthroposophy in June 1924. Since then, the Biodynamics developed its scientific techniques and progressed by leaps and bounds with contributions from many scientists and followers of the system like E. Pfeiffer, Maria Thun, Eugene and Lilli Kolisko, T. Gallen Hieronymus, Peter Proctor, Hugh Loveletc, *etc.* Maria Thun developed barrel composting method and also perfected the Biodynamic farming and gardening calendar, which is being followed throughout the world today. Koliskos, developed the "Homeopathic Potentising Techniques" and T. Gallen Hieronymus developed "Cosmiculture" or "Cosmic Pipe Technology". Hugh Lovel has further improved and developed the Cosmic Pipe Technology into "Quantum Field Broadcaster" and "Quantum Agriculture". Peter Proctor has been instrumental in development of "Biodynamic Farming" in India.

Although "Homa Therapy Farming" surfaced after the Chernobyl nuclear disaster in 1986 and publication of the book, "Secretes of the Soil" by Peter Tompkins and Christopher Bird and another book written by Shri. Vasant Paranjpe, "Homa Therapy our Last Chance" in 1989. Its origin dates back to Vedic period and Vedantic period and literature." Kashyapiya Krishi Sukti" a treatise whch may date back over 1200 years before, recommends in unequivocal terms that Dev Yajnya and Bhut Yajnya should be performed for Agriculture and Environment.

"Homa Organic Farming" or "Vedic Krishi Paddhati" or "Chaitanya Krishi" as it may be called in brief, is based onapplication of Agnihotra/ Homa/ Yajnya at the farm to create an agriculturally productive system with eco-balance in the surrounding environment in which the farm exists and forms part of the eco-system. Its basic objective is not only to improve yield and quality of farm produce but also to purify the atmosphere and establish equilibrium in the environment and the seasons. Homa Farming distinguishes itself from other organic farming methods by providing tools/techniques for reduction in atmospheric pollution and purification of elements like Air, Water and Earth (soil) through performance of Agnihotras/Homas/Yajnyas. The Life Bio-Energy forces are enhanced due to purification of atmosphere for healthy growth of plants. The Resonance Point at the farm acts as a Cosmic Energy Centre connecting the farm with environment, elements and the cosmos. Agnihotra/Homas/Yajnyas are tuned to the bio-rhythms of sun and moon cycles and the positions of constellations in the Zodiac. These performances heal the atmosphere and the healed atmosphere heals the plant life, animal life and human life. According to Vedic Sciences performances of certain Yajnyas have built-in techniques for establishing Atmospheric Order, Ecological balance and Rain induction.

On the basis of Author's understanding and experience of both the systems at his own farm, he considers that both these systems have lot of similarities and are well-equipped to deal with present day problems and provide solutions for Sustainable Agriculture. There are many areas in which fusion of both the methodologies/technologies, after due research and development, can work wonders. *e.g.* Biogas slurry enrichment and its soil application.



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Born on 15th December, 1945, he has done panoramic studies and reference work in Organic Farming, Biodynamic Farming, Homa Farming, Permaculture and Ancient Indian Agriculture

Attended vocational training programme in, Agri-Eco Trourism organized by MITCON in November, 2010

Attended " International Homa Teachers Course organized by Five Fold Path Mission at Tapovan, Dhulia District

Has about 40 years vast experience in the corporate sector.

Retired as Executive Director and Company Secretary of Phil Corporation Ltd. in 2009.

Deeply interested in Organic Farming and development of Agri-EcoProduction Systems of Sustainable Agriculture. Developed from barren land, fully Integrated Organic Farm certified under NPOP/NOP Standards.

Practicing Organic Farming since 1998 and Homa Organic Farming since July 2010.

Recognition and Awards in Organic Agriculture Field:

- August-2014: - **Prestigious Award,** "Krishi Bhushan Sendriya Sheti (Organic Farming) 2013" **from Department of Agriculture and Cooperation, Maharashtra State Government.**
- January-2018: - **National Level** "Jaivik India Award-Best Organic Farmer-Central and West Zone (II Prize)" **at the"International Trade Fair and Conference on Millets and Organics-2018" organised at Bengaluru jointly by International Competence Centre for Organic Agriculture (ICCOA) and Agriculture Department of Karnataka State Government.**
- August- 2019: - "OFIC-2019 - Organic Farmer of the Year" **at the Organic Food India Conclave (OFIC)- 2019 jointly organised by TEFLA and ICCOA.**
- **Septembe -2019**: - **"Sipani Anusandhan Farm Award 2018" from Asian Agri-History Foundation, for the Best Paper, 'A Report on 'Chaitanya Krishi' Homa Organic Farming for Sustainability and Climate Change Adaptation"**published in the International Quarterly Journal" Asian Agri-History 2018 Vol 22(1)"

LEAD LECTURE – 42

Concept of bio-enhancer and its role in horticultural crops

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Bio enhancers are organic preparations, obtained by active fermentation of animal & plant residues over specific duration. These are rich source of microbial consortia, macro, micronutrients and plant growth promoting substances including immunity enhancers. In general these are utilized to treat seeds/seedlings, enhance decomposition of organic materials thereby enrich soil and induce better plant vigour.

In general bio-enhancers are of two types

Plant based

These are prepared from whole tender plants and leaves *viz*; sun hemp, dhaincha (*Sesbania*), *Erythrina* and other legumes as potent source of nitrogen, leaves of neem, *pongamia*, Subabul (*Leucaena leucocephala*), glyricidia, *lantana, Calotropis* and other local plants having pesticidal properties, weeds viz; P*arthenium*, stinging nettle, *Cassia tora, etc.*

Animal based

These are prepared with cattle dung, sheep and goat droppings, fish manures. Combinations of plant and animal byproducts have better impacts on crop production. Liquid manures/pesticides are prepared by fermentation of animal and plant residues over specific duration.

Bio-enhancers can be grouped as simple and special preparations. Brief account of these has been dealt below:

Special bio-enhancers

Numbers of cow based bio-enhancers alone or in combination of few other products have been developed in different organic farming systems and their impact has been recorded. Salient features of few of the selected bio-enhancers and their impact has been discussed as under:

Biodynamic preparations

Biodynamic preparations *i.e.* BD-500-507, CPP and biodynamic liquid pesticide are used in biodynamic agriculture. 45 bacterial isolates had been isolated from different biodynamic preparations and studied for their multifarious plant growth promoting activity in laboratory through (i) production of indole-3-acetic acid (IAA) (ii) The ability of isolates to use ACC (1-aminocyclopropane-1-carobylic acid) as a sole nitrogen source in minimal salts medium/ Ammonia production, production of siderophore and hydrocyanic acid (HCN).

Isolated microbes *viz.*; CISH-PGPR-BD -500 -2, CISH-PGPR-BD -500 -4 and CISH-PGPR-BD -500 –C recorded all four PGPR activities. Isolates no CISH-PGPR-BD-500 -1, CISH-PGPR-BD -500 -3, CISH-PGPR-BD -501 C III and CISH-PGPR-BD -502 I recorded only three PGPR activities.

Microbial analysis of biodynamic preparations showed that BD- 505 contained total bacteria ($110.3 \times 10^8 cfug^{-1}$) and BD-506 contained maximum fungi population ($35.07 \times 10^5 cfug^{-1}$). BD-507 contained maximum Actinomycetes ($792.0 \times 10^6 cfug^{-1}$). Cow pat pit contained gram positive and negative bacteria ($184.1 \times 10^5 cfug^{-1}$), ($225.1 \times 10^5 cfug^{-1}$). BD-504 contained *Pseudomonas* ($21.73 \times 10^6 cfug^{-1}$) and p-solubilizing microbes ($39.63 \times 10^5 cfug^{-1}$). Maximum population of *Azotobacter* ($201.4 \times 10^5 cfug^{-1}$) and *Azospirillum* ($830.3 \times 10^5 cfug^{-1}$) were isolated from BD-507. Cow pat pit contained maximum *Rhizobium* ($310.8 \times 10^7 cfug^{-1}$).

Panchagavya

It is a special bio-enhancer prepared from five products obtained from cow, *i.e.* dung, urine, milk, curd and ghee. The effective micro organisms in *Panchagavya* were the mixed culture of naturally occurring, beneficial microbes, mostly lactic acid bacteria (*Lactobacillus*), yeast (*Saccharomyces*), actinomycetes (*Streptomyces*), photosynthetic bacteria (*Rhodopsuedomonas*) and certain fungi (*Aspergillus*). *Panchagavya* use after 18th days been found more effective than other days Nutritional analysis of *Panchagavya* revealed that it possesses almost all macro, micronutrients and growth promoting hormones (IAA, GA) required for plant growth.

Dasgavaya

As name indicates, *Dasgavya* is a mixture of ten products, consisting of *Panchagavya* and certain plant extracts. The leaf extracts of five commonly available weed plants, *viz.*, *Artemisia nilagirica, Leucas aspera, Lantana camera, Datura metal* and *Phytolacca dulcamera* are obtained by soaking the plant materials separately in cow urine for ten days. The extract is collected, mixed well with *Panchagavya* and left for 25 days. *Dasagavya* has potential to promote growth and boost immunity in the plant system against pests and diseases. Its' regular use at a concentration of 3 per cent solution has been found very effective in large number of crops pests and diseases such as leaf spot, blight, mildew, and rust of vegetables.

Jeevamrita

It is prepared with cow dung, urine, jaggery, pulse flour and virgin soil by simple facilities created in the village with minimum expenditure. Jeevamrita is a rich bio-formulation contains consortia of beneficial microbes. Systematic microbial analysis of Jeevamrita from the 0 day to 20th days of preparation suggests that formulation should be used within 6-9 days for maximum benefits. Systematic microbial analysis of jeevamrita showed that it contains *Azotobacter* (1.12×10^5), *Azospirillum* (0.6×10^5), *Rhizobium* (12.41×10^6) and Phosphate solubilizing microbes (3.94×10^6). Besides above, it also contains pseudomonas (2.89×10^7) and actinomycetes (3.1×10^6).

Beejamrita

Beejamrita prepared with locally available materials for seed and seedlings treatment. As preparation is very cheap and cost effective, can easily be prepared and used by small and marginal farmers. Every time fresh *Beejamrita* is prepared and used for treatment of seeds/ seedlings and other plant parts before sowing/planting/transplanting. Microbial analysis of Beejamrita suggests that it should be used on 7th days of preparation.

Amritpani

Systematic microbial analysis of Amritpani from 0-20 days suggests that Amritpani should be utilized from 6-9th days of preparation for maximum effectiveness. It contains beneficial microbes *viz*.; nitrogen fixing, phosphorus solubilizing and bio agents. After application in soil it improves humus content, earthworm activity and thus soil fertility and crop productivity.

Use of *Amritpani* along with 250 g rhizospheric soil of *Ficus benghalensis* tree and organic mulching in organic production of guava has given maximum return (INR 1,27,746 /ha) with benefit cost ratio (4.4) compared to INR 1,20,820 and 3.7 with application of 350 g N, 150 g P_2O_5 and 350 g K_2O/ tree.

Vermi wash

Vermi wash is a liquid leach ate obtained by excess water to saturate the vermi compost bed substrate. In fact vermi wash is an enriched bio-enhancer prepared from the heavy population of earthworms reared in earthen pots/plastic or cement container. Microbiological study of vermi wash revealed that it contains nitrogen-fixing bacteria like *Azotobactre*r sp., *Agrobacterium* sp. and *Rhizobium* sp. and some phosphate solubilizing bacteria. Microbial analysis of vermi wash showed that it contains *Azotobacter*, *Agrobacterium* and *Rhizobium* and Phosphate solubilizing microbes. Besides above, it also contains total heterotrophs *i.e.*; *Pseudomonas* 0.01 x 10^7, Phosphate solubilizing microbes 0.06 x 10^6, *Rhizobium* 0.07x 10^5, *Azotobacter* 0.14 x 10^6 and *Azospirillum* 0.007 x 10^6.

Strategies for promotion

- Bio-enhancers have immense potential to improve soil fertility, crop productivity and pest management.
- Most of information on these preparations has been experienced by Indian farmers since ancient time but number of apprehensions is persisting for use of bio- enhancers which requires initiation of systematic research for further explanations.
- Comparative evaluation of bio-enhancers prepared through ingredients from same breed, same feed under similar conditions need to be elucidated.
- There is need for delineation of nutrient status (macro and micro nutrients), plant growth promoting factors, immunity enhancer ability *etc.* for their quick acceptance by the scientific and farming community.
- Comparative evaluation of aforesaid bio-enhancers for their nutritive value and impact on different crop activities will resolve many issues being faced by the farmers.

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Born on 3rd July 1960 in village of Kauria Bazaar of Azamgarh district, Uttar Pradesh.

- Graduation and post graduation in agriculture and horticulture from Narendra Dev University of Agriculture and Technology, Faizabad, U.P. Ph D from Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani, W.B. ·
- Since, 2000, dedicatedly worked on organic farming in horticultural crops. Extensively worked on organic management of horticultural crops and concentrated on on farm production of quality organic inputs using locally available materials and developed a model for production of quality composts, bio-enhancers and bio-pesticides. Appointed as consultant of organic farming to Uttrakhand government from 2004-2007, as resource person to IFAD for Organic Agriculture for Poverty Reduction in Asia during 2005. I have promoted organic farming practices in NEH regions of India through trainings and demonstrations for more than decade and contributed to Sikkim has been declared as first organic state of India in 2014. I have been awarded for outstanding contribution in improving Livelihood Security through Livestock based Farming System in Barabanki and Raebareli districts of U.P" of thousand farmers by DG, ICAR and Secretary DARE in 2011.
- Also extensively worked on nutrient management in mango and guava and developed technologies for nutrients source, method and time of application for sustainable production.
- Also worked on nursery management and developed new method of grafting technique in aonla and bael, which has become common method of propagation in northern India.
- Published 3 books, 29 book chapters, 35 popular articles, 31 research articles in national and international journals, 16 extension bulletins, 9 extension folders and practical manual on organic production.

LEAD LECTURE – 43

Biodynamic agriculture : A boon for small farmers of India

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Agriculture in India is moving towards a threshold of dynamic changes. Nearly 3000 farmers are opting out of agriculture every day, leading to an all-time low of people engaged in this very traditional occupation. Farmers have also been driven to suicides (15,000 farmers are dead in the last ten years) in different states leading to a gamut of review programs and schemes. Such a situation is a result of complex short sighted polices, badly managed programs and lack of holistic approach towards agriculture development. There is an urgent need for a holistic and inclusive plan of action, which secures the food for the teaming 1.2 billion people with the social and economic justice for the people engaged in agriculture. A regenerative system is the need of the hour, which supports the natural environment to withstand the climate change and other vagaries in the agriculture.

Soil is the base of all agriculture processes and presently the soil in the entire country is over mined and exploited and as a result it is sick. The soil ecosystem does not have the capacity, even to withstand a single season of climate change or imbalanced nutrient supply. Modern agriculture technology is largely externalized and input based. The present practices do not address the soil health and on the contrary increase biotic pressure on the agro –ecosystem thereby marginalizing risk taking capacity by the farmer leading him to either opt out of the occupation or give up his life. The extension and technology transfer interventions most crucial for the farmer are carried out largely by commercial companies and are sales oriented.

Organic agriculture is knowledge based approach and needs the investment of time and energy in the field. The concept of organic agriculture in the world over the time emerged out of questions and experiences of sensitive, practicing farmers, thinkers and practitioners like Rudolf Steiner, Albert Howard, Eva Balfour, Masanobu Fukuoka *etc.* during the mid twentieth century (1924-1960). In India the pulse of Organic agriculture is traced down to small initiatives by farmers and expanded to various landscapes and rather quickly turned into policies in a number of states.

Dr Rudolf Steiner (founder Anthroposophy and Biodynamic Agriculture) is the world's first critique (1924) of modern agriculture. Dr Rudolf Steiner's lectures on biodynamic agriculture gave a new perspective of food production in context with the cosmic world. This perspective was firmly embedded within the social and agrarian fabric of the pastorals and farmers in the entire world but was practiced in traditional understanding of nature. The metamorphosis of the seasons, signs from the heavenly bodies, animal behaviour, characterization and quality of the abundant flora *etc.* have been the essential ingredients of disciplines used by the agrarian society. Biodynamic agriculture contributes to these very strong and successful traditions and accentuates on the science behind them with a new synthesis and understanding.

Biodynamic agriculture principals are based on aligning with the cosmic energy preponderant in the universe which is responsible for the creation and preservation of all life. While practicing biodynamic agriculture the more physical evidences of impact are observed in the drastic improvement of soil structure, increased carbon content, balanced pH , availability of trace elements, increased production cycle of the crops, suppressed disease and pest incidence, high nutrition content in the food products through the methodology of chromatography *etc.*

Prominent International Research studies have shown that biodynamic agriculture practices have an edge over other technologies and sequester more carbon depicting better mitigation capability than other practices. Biodynamic agriculture systems are cost beneficial as most of the practices are knowledge based.

Biodynamic practices for small and marginal farmers : Adoption and technology transfer

Traditional Indian agriculture complete with mixed crops, integrated farming systems, *etc.* provides enough resources for the farmers to generate inputs for the farm. Biodynamic systems enhance the traditional systems with the use of the preparations and the planting calendar. SUPA Biotech is a small initiative to introduce the biodynamic farming systems to the small farmers preferably having their own animal husbandry. Contrary to the models of biodynamic agriculture where centrally managed associations manage the farmers who are extremely large, in India the model was based on extension and demonstration.

Small and marginal farmers along with their family members can prepare all the basic inputs like Biodynamic Compost, Cow Pat Pit and Biodynamic Liquid manure cum pesticide by utilising farm waste, animal dung and cow urine, available in abundance in the farm itself. SUPA started out in the extension and promotion activities in the year 1998 in a modest way with a handful of village Master Trainers armed with small slide projectors in the mountains of Uttarakhand state. The organization has progressed over the years with evolved methods and tools of extension and adoption of Biodynamic agriculture. Farmer Field Schools (FFS) especially for biodynamic farming have been developed. In the last thirteen years, more than 50,000 farmers have been trained and similar numbers have adopted the technology and systems in crops ranging from cotton, pulses, bananas, pomegranate, cereals, basmati, vegetables *etc.* The FFS model which includes 'training of trainers' before the beginning of the program has been extremely successful as a tool for technology transfer of biodynamic agriculture. The organization carried out the training and promotion of biodynamic technology among the debt ridden as well as suicide prone villages under the externally aided project CAIM project in Vidharbha, Maharshtra. Even though the organization objective was not directed towards the mitigation of social distress, while filing the end of project report it has been found that in the entire project period (6 yrs) there has not been a single case of farmer suicide.

SUPA through its innovative methods has promoted and demonstrated the large scale agriculture biomass recycling method. The locally available farm waste known by a number of vernacular names like 'parsa', 'ukirda', 'ghura', *etc.* have been very popular and now accepted by the farmers. The compost as the first small step towards regenerative or organic agriculture was one of the first entry point programs undertaken by SUPA.

Indigenous traditional knowledge & use of the planting calendar

India is home to numerous botanicals and home remedies for different plants and diseases in agriculture too. SUPA has been constantly doing action research and advocating the use of different locally available botanicals to be used for plant protection. Among the use of vegetable extracts, practices using bells for virus attacks in papaya *etc.*, butter milk for fungus *etc.* are the other practices being used where SUPA is constantly documenting and researching.

SUPA has worked extensively and intensively with the farmers in different parts of the country and parts of Nepal, Africa *etc.* SUPA has also evolved its tutorials and extension materials as per the needs of the farmers.

India is home to regional agriculture practices where the farmers use traditional almanacs for farming operations. These almanacs are guides for using different dates for different operations, some dates (tithi) denote climatic changes and calamities. Over the years these practices have been lost and the farmers refuse to believe in these systems anymore. SUPA has made user friendly planting calendars in the local languages. These calendars are discussed among the farmers and are encouraged to be used by the farmers. Each year SUPA documents the results of the use of the calendar and promotes this cost free technique to as many farmers as possible.

Synergy with research organizations

SUPA has constantly engaged with research organizations. SUPA has worked together with a number of technical universities as well as research institutions for action research, field trials and demonstrations for Biodynamic agriculture. The results support the various state governments as well as other stake holders to promote Biodynamic systems into main stream agriculture for small farmers. Some of the trials are as under:

1. Mahatma Phule Agriculture University, Rahuri (M.S.) studied comparative impact of Biodynamic system compare to other organic practices on wheat and red gram. The results were significant in relation to yield, cost of production, increasing organic 'C' and soil pH.
2. Vasant Dada Sugar Institute, Pune (M.S.) studied Biodynamic impact on sugarcane for 5 years and found increasing organic 'C' level, higher Brix level and sustainable yield over chemical field.
3. Dr. Punjabrao Deshmukh Agriculture University, Akola (M.S.) has taken research on Biodynamic farming practices for soybean, red gram, wheat and onion, since last 3 years. Results are significant as compare to other organic practices and chemical farming practices. The university scientists also conducted farmer's response cum impact on soil health with 101 farmers from six distressed districts of Vidarbha under CAIM project in the year 2015-16. The study reviles that the Biodynamic system is simple and suitable for small and marginal farmers as it is cost effective, improves soil health and reduces dependency on market. This university allotted an on farm field study at village Talegaon, district Akola (M.S.) to a M.Sc. student on soybean crop through various organic practices including Biodynamic.
4. Central Institute of Subtropical Horticulture (CISH under ICAR), Lucknow, (U.P.) has researched on mango, guava and a number of vegetable cultivation through Biodynamic system. Biodynamic system was found sustainable for mango production especially for disease control. This institute has also analysed the critical Biodynamic inputs at their lab. The result shows that there is healthy consortium of beneficial microbes for soil health and plant growth.
5. Study on same line was conducted at ICRISAT, Hyderabad (A.P.).

6. SUPA has also commissioned private research institutions for the Biodynamic preparations contents, active ingredients and their genemapping.

Biodynamics and soil health

Presently the condition of agriculture soils in India needs more attention and nutrition. Even though there are numerous programs being implemented in the country on soil health, the farmers are not aware of the status of their soils and subsequent treatment for them. Depleted soils need more than balanced nutrition through chemicals. SUPA has been training and teaching farmers for more than 15 years the reconstruction of soil with the help of biodynamic agriculture and other cropping techniques. It has been found out that Biodynamic agriculture is a faster way of soil rejuvenation and balance which has been tested empirically and practically with the technical partnership of State Agriculture University. International finding anyway support that biodynamic agriculture sequesters more carbon as compared to other systems. Hundreds of farmers practicing biodynamic agriculture experience that the field scenario related to soil retention, weeds as well as biodiversity in the fields have improved drastically. This has been much documented in the foot hills of Satpuda mountain ranges in Akola District (M.S.) as well as in the potato farmers in the Himalayan mountain regions.

Conclusion

Having worked for 20 years in the mainstreaming of biodynamic agriculture systems and having a farmers adoption numbers of 50,000 plus in different parts of the country, we can conclude that Biodynamic systems is a healthy mix of knowledge transfer as well technology. It is one of the most cost beneficial systems for farmers and builds farmers capacity to farm better. The farm organism and farm ecosystems rejuvenate better than any other system. Lastly the consumers receive food which is dynamic and charged with life energies.

Ms Binita Shah

Dehradun, Nainital,
Uttarakhand

Ms Binita is an Organic/Biodynamic Farmer, Social –Entrepreneur & Agriculture Development Professional. Early in life Ms Binita realized the significance of natural environment and made Biodynamic Agriculture (specialized kind of Organic Agriculture), a life mission. She came to live in remote ancestral Orchard in village Supi, Nainital in her late twenties to and set up an organization dedicated for the promotion of organic agriculture. Was the Prime Mover for the Organic Agriculture Policy for Government of Uttarakhand in 2002and headed the Organic commodity Board (2003-2015). Today SARG Vikas Samiti is a national player in Organic Agriculture Development and has the credit of making 1 million composts among farmers of four states. Is Board member in PDKV Jaivik Kheti Mission, State Govt. of Maharashtra.

LEAD LECTURE – 44

Kunapajal its impact in select horticultural crops

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Vedic literatures (*Vrikshayurveda*) have clearly outlined and systematized agricultural practices that insisted on the use of *kunapajala* (decomposed product of fish or animals in liquid form) to enhance the biological efficiency of crop plants and the production of fruits and vegetables. In India, organic farming was a well developed and systematized agriculture practice during the past and this "ancient wisdom" obtained through Vedas. *Kunapajala* was used in agriculture for improving soil and plants health and protective measures against pests and diseases. In preparation of *Kunapajala* was based on use of animal wastes fermentation underground to contain foul odor, and also to protect the materials from omnivorous scavengers. It was prepared from virtually any animal waste and therefore, gave flexibility to farmers in sourcing their materials. Application of *Kunapajala* was being liquid can quickly reach the rhizosphere when applied. Since, ingredients are fermented these would become available to plant faster than in the case of traditionally applied organic matter. Species of *Azotobacter, Azospirillium, Pseudomonas, Rhizobium* and phosphate solublizing bacteria (PSB) have been detected in Kunapajala. In addition, substantial amounts of total organic carbon, gibberellic acid and indole acetic acid (IAA) have been observed (Nene, 2018).

On this background for more than decades, we had been attempting to see implication of Kunapajala in two selected horticultural crops *i.e.* Tea and aonla growing in two different climatic situations. In use of animal flesh there was number of apprehensions.

Kunupjal

As most of us know the earth is made of "5 *tatwas*" sky, air, fire, water, land. They form the life in material form. Various combinations give different things, example plants, animals, humans, birds *etc.* All are made of the 5 elements. They grow by taking energy from these basic elements and when die, all go back to the earth. This cycle continue over centuries.

In preparation of *Kunapajal* we use local plants and products from local. These are chopped into small pieces along with animal wastes were boiled for 3 hours in copper utensil. Juices obtained were used as enriched manure and for foliar spray.

I take pleasure of presenting my experiences over decades. In use of animal wastes, there were many apprehensions and therefore we have been able to select few shrubs and trees commonly found in these two regions.

It is easy to prepare specific preparations after fermenting over specific duration and it has shown promising response in tea plantation. Our main objectives were to conceive simple practices which can be adopted by commonly adopted by "Tea Plantations" as effective tool. Ingredients used in preparation of *Kunapajala* in Assam were those available from the surrounding area and can be grown within a year. In Assam common ingredients found effective by us are *Karange* (*Pongamia pinnata), Makiati (Falminas trocifolia), Digalati (Litsea salisfolia), Belongini i.e.* wild ferns *(Diplazium esculentum)*, Sagargoti *(Caesalpinia bonduc) and Amia Haldi i.e.* Turmeric. In addition cow dung, cow urine, animal waste along with copper wire boiled for three hours to get the extract.

Precaution

Spray and ground application should be done at sunrise or sunset only. This is the time when the stomata is open the maximum and also minimum evaporation takes place. Beside application of extract, regularly smoking (dhooona) in early morning at sunrise and late evening the air in the atmosphere is heavy.

Dhoona and foliar spray

The stomata of the plants open maximum at sunset and sunrise. Dhoona along with foliar spray helps the plants take in nutritious.

Surprisingly it is similar to the principle of Agnihotra *i.e.* smoke done at this time spreads well all over field, thus, keep pests under control.

As per quality it is no doubt much better than conventional produce. It tastes better because it has natural manure. Also quantity wise our production has not gone down. Let's take example of a man eating only organic food – his output will remain the same as a man with conventional food.

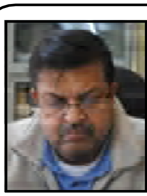
We have been getting 10000 kgs of tea leaves per hectare which is just around the normal average.

Tea plantations which are regularly using chemicals are seeing a drop in their crop. When they have applied our methods their crops have doubled. TATA tea estate Hatikuli increased their crop by 1 Lac kgs tea made after applying our solutions in a year.

Result - We get higher crop yield, sustainable production, and healthy human and animal life, generation of local employment, longer life expectancy and harmony in society.

Remarks - In Asssam there are 2 plants *Makiati* and *Digalati*, linked to *Goru Bihu* in April which are used to wash cows. This is a centuries old tradition. I picked this up from there and applied it and it is doing well. We don't use neem in Assam as it not local to that area. Instead we use *Karange.*

I have 10 acres of aonla plantation near Jaipur in Rajasthan for number of years kunapajal is prepared from locally available herbs along with cow products. We practice mulching with locally available biomass. Besides quality production ours is the only farm in which there are minimum incidence of low temperature during winter and high temperature and moisture deficiency in summer months.



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Born in a business family in 1957 in Dibrugarh, Assam and studied in Dibrugarh, Indore, Jaipur and Kolkata.
Doing organic and realized that the biggest challenge is to make compost at the earliest. On the basis of Vedic literatures (*Vrikshayurveda*) using of *kunapajala* (decomposed product of fish or animals in liquid form) to enhance the biological efficiency of crop plants and the production of fruits and vegetables. Species of *Azotobacter, Azospirillium, Pseudomonas, Rhizobium* and phosphate solublizing bacteria (PSB) have been detected in Kunapajala. In addition, substantial amounts of total organic carbon, gibberellic acid and indole acetic acid (IAA) have been observed.

THEME 8, 9, 10, 11

SUCCESS STORIES IN HORTICULTURE AND ORGANIC PRODUCTION, EXTENSION, HORTI-BUSINESS AND ENTREPRENEURSHIP, FUTURE STRATEGIES, GOVT. SUPPORT AND POLICIES AND WOMEN ENPOWERMENT

LEAD LECTURE – 45

Farmer-friendly technologies for enhancing income and nutritional security in arid region

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A vast land resource is characterized as arid region (Table 1). The arid region has a lot of potential with the diverse climatic conditions suitable for various agriculture, horticulture and animal husbandry based activities. Horticulture crops play an important role in the diversification of agriculture and improvement of economic condition of farmers in arid region. At present India is

Table 1. Extent of arid region in India

Regions	Area (m ha)	% of total arid region in India	% of geographical area of India	Districts
A Hort. arid region	**31.71**	**80.20**	**9.64**	
a. North-west India	28.56	72.26	8.68	
Western Rajasthan	19.61 (196150)	49.61	5.96	Bikaner, Barmer, Jaisalmer, Sri Ganganagar, Churu, Pali, Jalore, Nagaur, Ajmer, Sikar, Jhunjhunu
North-western Gujarat	6.22 (62180)	15.73	1.89	Kuchchh, Amreli, Surendranagar, Junagarh, Banaskantha, Mehsana, Jamnagar
South-western Punjab	1.45 (14510)	3.67	0.44	Ferozpur, Bhatinda
South-western Haryana	1.28 (12840)	3.25	0.39	Hisar, Rohtak
b. Southern India	3.15	7.94	0.96	
Andhra Pradesh	2.16 (21550)	5.45	0.66	Anantpur, Cuddapah, Kurnool
Karnataka	0.86 (8570)	2.17	0.26	Dharwar, Chitradurg, Bellary, Raichur
Maharashtra	0.13 (1290)	0.32	0.04	Dhulia, Nasik, Sholapur, Satara
B. Cold Arid Region	**7.83**	**19.80**	**2.38**	
Jammu & Kashmir	7.00	17.70	2.13	Leh, Kargil
Himachal Pradesh	0.83	2.10	0.25	Lahual Spiti, Chamba, Kinnaur
Total (A+B)	**39.54**	**100.00**	**12.02**	

Values in parentheses are area in km^2; Dhandar and Saroj (2004) the second largest producer of horticulture produce. India has marched ahead from food sufficiency to nutritional security, which is visible with rise in the production, productivity and availability of an array of horticulture products round the year.

This is a good sign to address the burning issues like malnutrition, greening of marginal and arid regions, dwindling rural employment, empowering women, availability of safe foods, post harvest management and value addition, enhancing export opportunities, *etc.* Despite the impressive achievements in horticulture sector, still low productivity is a challenge and matter of concerned particularly in arid region. The harsh climatic in arid region are the major issues to be tackled with new farmers-friendly technologies in crop improvement and production system.

Arid and semi-arid fruit crops such as ber (*Ziziphus mauritiana*), aonla (*Emblica officinalis*), bael (*Aegle marmelos*), pomegranate (*Punica granatum*), date palm (*Phoenix dactylifera*), mango (*mangifera indica*), phalsa (*Grewia subinaequalis*), wood apple (*Feronia limonia*), custard apple (*Annona squamosa*), fig (*Ficus carica*), guava (*Psidium guajava*), citrus sp., tamarind (*Tamarindus indica*), mulberry (*Morus* sp.) and lasoda (*Cordia myxa*) *etc.*, and in arid and semi-arid vegetables such as watermelon (*C. lanatus*), musk melon (*C. melo*), ridge gourd (*Lufa acutangula*), bottle gourd (*Lagenaria siceraria*), bitter gourd (*Memordica charantia*), khejri (*Prosopis cineraria*), cluster bean (*Cyamopsis tetragonoloba*), cow pea (*Vigna unguiculata*), brinjal (*Solanum melongena*), chilli (*Capsicum annuum*), tomato (*Solanum lycopersicon*), drumstick (*Moringa oleifera*) and 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 (anthocyanin, carotenoids, phenols and flavonoids) and dietary fibers. Some horticultural crops such as water melon and cucumber provide

Table 2. Varieties of arid and semi arid horticultural developed by ICAR-CIAH, Bikaner

Fruits/perennials	Variety released	Vegetables	Variety released
Ber	Thar Sevika, Thar Bhubhraj and Thar Malti	Mateera	AHW-19, AHW-65, Thar Manak
Aonla	Goma Aishwarya	Bottle gourd	Thar Samridhi
Bael	Goma Yashi, Thar Divya, Thar Neelkanth	Kachri	AHK-119, AHK-200
Jamun	Goma Priyanka, Thar Kranti	Snap melon	AHS-10, AHS-82
Pomegranate	Goma Khatta	Kakri	AHC- 2, AHC- 13
Tamarind	Goma Prateek	Cluster bean	Thar Bhadavi
Mulberry	Thar Lohit and Thar Harit	Sword bean	Thar Mahi
Phalsa	Thar Pragati	Indian bean	Thar Kartiki, Thar Maghi
Khirni	Thar Rituraj	Pumpkin	Thar Kavi
Karonda	Thar Kamal	Ridge gourd	Thar Karni
Chironji	Thar Priya	Ivy gourd	Thar Sundari
Mahua	Thar Madhu	Palak	Thar Hariparna
Lasoda	Thar Bold	Sponge gourd	Thar Tapish
Wood apple	Thar Gaurav	Brinjal	Thar Rachit
Khejri	Thar Shobha	Longmelon	Thar Sheetal
Moringa	Thar Harsh		

(Source: Saroj *et al.* 2018)

very low calories, whereas some others such as date palm are rich in starch which provides energy in good amount. Therefore, farmer-friendly horticultural technologies play important role for enhancing income and providing nutritional security in the arid region. Some of farmers-friendly technologies to overcome the barriers in production system for enhancing farmer's income through horticulture are presented below.

Improved varieties

The climatic conditions of arid region are very harsh and selection of a variety and crop for this region is highly important for economic production. The selected crop and variety should complete their vegetative and reproductive phase during maximum moisture availability period. The arid fruits like ber, pomegranate, custard apple, aonla and sour lime and vegetables such as water melon, kachri, khejri, cluster bean, *etc.* meet this requirement. The ICAR- Central Institute for Arid Horticulture, Bikaner has released numbers of varieties of arid fruits and vegetable crops (Table 2) for enhancing income and nutritional security in arid region.

After evaluation of germplasm by AICRPs, ICAR institutes and SAUs, a number of varieties of arid fruit and vegetable crops have been developed/recommended for cultivation in arid and semi regions for income and nutritional security. In ber, Gola, Seb and Mundia varieties for extremely dry regions, Banarasi Kadaka, Kaithli, and Umran for dry regions and Sanaur-2 and Mehrun for comparatively humid areas have been suggested for cultivation. The major emphasis was given to develop high-yielding, open-pollinated varieties and hybrids that are resistant/tolerant to major biotic and abiotic stress factors, efficient in input use, and adapted to different agro-climates, suited for irrigated and rainfed areas. Varieties and hybrids have also been tailored with ideal maturity and plant architecture for intensification and diversification of cropping systems.

Fruit based cropping systems

Fruit based cropping system is comprised of a combination of perennial and annual plant species as different components in the same piece of land arranged in a geometry that facilitates maximum utilization of vertical and horizontal space for economic production. Storing carbon in plants and soils is one of the approaches for mitigating high atmospheric concentrations of carbon dioxide which results in global warming. These fruit crops are considered to have high carbon sequestration potential, particularly in accumulating carbon in the soil through litter fall, and decomposition of plant residues**.** Awasthi and Singh (2011) suggested that under arid climatic conditions, drought hardy fruit crops such as jharberi (*Z. numularia*), bordi (*Z. rotundifolia*), ber (*Z. mauritiana*), aonla (*E. officinalis*), bael (*Aegle marmelos*), lasoda (*Cordia myxa*), ker (*Capparis decidua*), pilu (*Salvadora oleoides*) can survive well and provide income to the farmers even under severe drought conditions. For sustainable production, nutritional security, economize productivity and ecological restoration, suitable fruit based cropping system integrating perennial fruit trees, annual crops (vegetables, grains, legumes and medicinal plants), grasses (annuals and perennials) such as aonla-ber-brinjal-moth bean-fenugreek, ber-cluster bean-mustard, ber-Indian aloe have been developed for arid region. In hot arid region various type of fruit based cropping systems are being followed depending upon agro climatic condition, crop grown and resources availability. Some popularly adopted systems are described below.

Ber based cropping system

Ber is one of the important cultivated fruit trees of north India and known as the king of arid zone fruits. It grows even on sandy soils where most other fruit trees give poor performance. Awasthi and Singh, (2011) observed that under hot arid condition ber cultivar Gola as over storey component and cluster bean, mustard and Indian aloe can be integrated into the system as compatible ground storey component as compared to groundnut, wheat which is dominated rotation under irrigated hot arid condition.

Aonla based system

Aonla has attained commercial status and also proved to be potential fruit crop for arid ecosystem. It is hardy, prolific bearer and highly remunerative and can be grown in marginal and sandy soils. In arid climate highest net profit was obtained in aonla based cropping system intercropped with mothbean- cumin system flowed by mothbean-chickpea cropping system as reported by Awasthi *et al.,* (2009).The tree canopy of aonla allows filtered light and permit intercropping even after it has made full growth.

Khejri based system

Khejri is an important component of farming system in hot arid region. This tree grows well in all sorts of climatic constraints, which is evidenced by the fact that new foliar growth, flowering and fruiting occur during severe dry months (March–June) when most other trees of the desert remain leafless or dormant. In khejri based cropping system ber, lasora, pilu and ker can be grown as filler crops while pearl millet, mothbean, clusterbean and sesame can be grown as intercrops. In hot arid region of Rajasthan farmers grow pearl millet, mothbean, cluster bean, and chickpea as intercrop in between lines of khejri.

Nursery management

The availability of quality planting material is major constraint in arid horticulture. Therefore, propagation techniques of different fruit crop have been standardized. In ber, budding in polytube-raised rootstocks has been standardized by Pareek (1978). Saroj *et al.* (2000) standardised aonla propagation by growing rootstocks in poly bags and subsequent patch budding during July on 5-6 month old rootstocks. The vegetative propagation of ber was standardized for arid environment and it was observed that application of 7500 ppm IBA along with 1000 ppm thiourea can give good rooting in semi hardwood cutting (Bhargava *et al.*, 2006). Singh & Singh (2006) propagated jamun through patch budding during March and softwood grafting during August. In pomegranate application IBA 2500 ppm to semi hardwood cutting during July- September gave good results for rooting (Saroj *et al.,* 2008). In tamarind, patch budding during August and softwood grafting during May gives good success (Singh and Singh, 2007). Vegetative propagation technique of some of the important arid and semi arid fruit crops is presented in Table 3. Date palm is propagated by division of sucker. A date palm plant produces only 20-25 suckers in whole life. Hence, attempts have been made to propagate this species by tissue culture and some success has been achieved. Besides standardization of techniques of multiplication; provision of growing structures, rooting substrate, foliar feeding, use of portrays, root trainers, techniques of hardening along with efficient transportation are also important factors in nursery management (Saroj, 2002).

Table 3. Propagation techniques of arid fruit crops

Crop	Propagated methods	Time
Aonla	Patch budding	July-August
Bael	Soft wood grafting and patch budding	June-July
Ber	T-Budding	June-July
Chironji	Soft wood grafting	July-August
Jamun	Soft wood grafting and patch budding	March, July-August
Ker	Cutting and micro-propagation	August -Sept.
Khejri	Patch budding	June-Sept.
Lasora	Patch budding and micro-propagation	June-July
Pomegranate	Semi hard wood cutting	Feb.-March, July-Sept.
Tamarind	Soft wood grafting and patch budding	July-Sept.
Date palm	Suckers	July-August
Karonda	Seeds	July-August
Phalsa	Seeds	July-August
Mahua	Soft wood grafting	March-April

Canopy management

Canopy management is one of the predominant technologies by which huge and unmanageable trees are properly managed to make them more productive. Canopy management is based on the choice of tree size, number of tree per hectare and pruning technique, so as to optimize the production of assimilation and its conversion into economic yield. This is only possible with the management of canopy to intercept maximum light in the innermost parts of trees. The canopy management has direct correlation with dry matter production, flower bud initiation and fruit quality. The major principal followed in designing canopy are distribution of branches of arms and branches, fruiting areas, space for aeration and light penetration.

In pomegranate, training operation starts after 6-8 months to develop structural framework and last up to 2-3 years after planting. The lowest branch should be allowed to develop at 30-40 cm above the ground with single stem training or multi stem training. In arid region, multiple stem training (3-5 stems) system is preferred in pomegranate to avoid losses of stems/plants by termite attack which is severe problem in hot arid region in initial stage of orchard development. Pruning is done twice a year to remove dried twigs, branches and maintain balance between vegetative and reproductive growth. Major pruning is practiced just after harvest in winter and light pruning is done at flower regulation during May-June. In severe bacterial blight infected orchards, heavy pruning is done after harvest and remove as far as possible diseased portion. Apply 10 per cent bordeaux paste on the cut end of plant after training and pruning.

In ber, pruning is performed during end of May in North India, January in Tamil Nadu and April end in Maharashtra. The main shoots of the previous season are cut back by retaining 15-25 nodes, depending upon location, cultivar, plant age and vigour. All the secondary shoots are completely removed. As a result of light pruning for several years, long non-flowering shoots develop. To eliminate this, half the number of shoots on the tree should be pruned keeping normal length and remaining half should be pruned keeping one to two nodes to induce new growth for fruiting in the following year. In phalsa, the time of pruning should be regulated according to the flowering period and should result in maximum number of new shoots on which bearing takes place. Established phalsa bushes should be pruned at 150 cm height once a year during January in north India and twice a year (December and June) in south India. Pruning from ground level is done either to rejuvenate old bushes or to train young plants into bush form. Canopy management in custard apple with cultivar Balanagar recorded that pruning at 75 days after last harvesting with 25% intensity gave good yields.

Irrigation and nutrient management

Water is one of the crucial inputs in agricultural production accounting for about 80 per cent of the water withdrawals in India. Alarming rates of ground water depletion and serious environmental and social problems of some of the major irrigation projects on one hand, and the multiple benefits of irrigation water in enhancing production and productivity, food security and poverty alleviation highlights the importance of proper irrigation system for agriculture sector. Drip irrigation has great potential due to high water use efficiency and increased yield. Besides water saving (60%), yield can be increased up to 30-35 per cent by drip irrigation. In fruit crops, drip irrigation system with 2-4 adjustable drippers per plant should be installed depending upon age of the tree. For one to three year old plants, 2 drippers/plant may be enough to provide required irrigation to the plant, whereas from fourth year onwards 4 drippers/plant found better. Even fertilizers and chemicals can be applied through drip irrigation. In pomegranate, for nonbearing trees, about 5-25 litres/plant/day and 20-65 litres/plant/day for bearing trees are needed (Chandra *et al*., 2011). Excess irrigation should be avoided which may increase wilt and nematode problems in the orchards. Therefore, judicious irrigation should be provided to the plants. Covering the soil with inorganic or organic mulches during dry months after the rainy season conserves soil moisture and saves irrigation water, creates favorable conditions for plant growth and development.

The ICAR and SAUs has generated site-specific nutrient management packages for different horticultural crops to enhance farmers' income. Studies have been conducted at different AICRP centers for water and nutrient management in arid fruit crops. In this context, Aruppukotai centre worked on *in-situ* moisture conservation in aonla and observed that *in-situ* planting of aonla in sunken basin with 5 per cent slope plus with black polythene mulch (600 gauges) registered the highest soil moisture, morphological characters, fruit yield, chlorophyll stability index (CSI) and relative water content (RWC) at Aruppukottai. Fifty per cent recommended dose of N at fortnightly intervals through drip irrigation in pomegranate is giving promising results at Anantapur centre. In pomegranate, maximum marketable fruit yield was recorded with 20 per cent wetting zone and 750 : 250 : 250 g NPK/tree in drip fertigation.

At Anantapur, plants irrigated with drip and mulch with irrigation schedule at IW/CPE ratio of 0.8 in pomegranate fruit crop are giving maximum fruit yield. In fig, 40 per cent wetting zone with 900 : 250 : 275 g NPK/tree applied through drip irrigation gave significantly higher fruit yield at Rahuri. At Rahuri centre, maximum marketable fruit yield of pomegranate was recorded with 20 per cent wetting zone and 625 : 250 : 250 g NPK/tree in drip fertigation. In integrated nutrient management trial, 50 per cent inorganic & rest 50 per cent through FYM & biofertilizers proved apposite sources of nutrients in different arid fruit crops at Bikaner (date palm), Aruppukottai, Rahuri, Faizabad (ber and phalsa), Bengaluru (annona) and Jobner (aonla), Rahuri (fig cv. Poona Fig) centres. Combined foliar application of iron, zinc and boron gave the highest fruit yield in pomegranate cv. Bhagwa at Rahuri centre. At Bikaner centre foliar Application of iron and thiourea at *doka* stage in date palm gave highest fruit yield. At Faizabad centre in bael cv. NB-17 growth does not affect up to 20 ESP and beyond that survival and growth diminishes significantly. Salt tolerance studies in ber revealed that *Ziziphus rotundifolia* performed better than *Z. nummularia* particularly after $10dSm^{-1}$ salinity. Under Bengaluru conditions, a fertilizer dose of 500 g N, 250 g P_2O_5 and 250 g K_2O per plant per year in two splits during May and another post monsoon along with 30-40 kg of FYM and 1 kg neem cake for each plant of pomegranate is recommended. In aonla fertilizer dose with combination of 100 g N, 50 g P_2O_5, 50g K_2O per plant per year (1000 g N, 500 g P_2O_5 and 500 g K_2O of 10 year old plant) is recommended for commercial cultivation in UP. In fertilizer dose with combination of 100 g N, 50 g P_2O_5, 50 g K_2O per plant per year (800 g N, 400 g P_2O_5 and 400 g K_2O of 8 year old plant) is recommended for commercial cultivation of bael in UP.

Fertigation techniques have been standardized in pomegranate, aonla, fig and ber, where it has been demonstrated that saving of nearly 45 per cent of irrigation water and 38 per cent of fertilizer could be achieved. INM studies revealed that application of nutrients through 50 per cent from inorganic, 25 per cent organic and 25 per cent biofertilizer was apposite combination for aonla and bael at Faizabad, pomegranate at Rahuri and Anantapur, fig at Rahuri and Jadhavwadi centres.

Integrated pest and disease management

Detailed studies on pest and disease management have been carried out in arid horticultural crops. At Mundra centre pheromones have been standardized for management of red palm weevil in date palm. *Verticillium lecanii* @ 6g/l was found effective for the management of mealy bug on pomegranate. Spray monocrotophos (0.03%) & carbaryl (0.1%) is suggested for management of fruit fly in ber. Spray of botanical pesticides have also found effective to manage the different pests. Bio-agents *viz*. *Pseudomonas fluorescence* and *Trichoderma* spp. in combination with karathane effectively managed the powdery mildew in ber. Spray of wettable sulphur for management of powdery mildew in ber is recommended. Management measures for leaf & fruit spot with ziram (0.25%) have been standardized. Fig rust can be managed by 3-4 sprays of 0.2 per cent chlorothalonil or copper oxychloride (0.40%) during the crop susceptibility period. For the management of ber fruit fly carbaryl 50 WP 0.1 per cent has been found superior. Three to four sprays at 0.01 per cent starting from peanut stage till maturity can check the fruit fly incidence effectively. Fenthion 100 EC 0.05% at an interval of 15 days checked the spread of disease. For ber powdery mildew, 2-4 sprays of dinocap or carbendazim or triedomorph or thiophenate methyl (0.1%) or wettable sulfur (0.2%) at 15-20 days interval were found effective during the most vulnerable period starting with the onset of the disease. Pomegranate bark eating caterpillar can be effectively checked by spraying the infested bark with any of the pesticides like monocrotophos 36 WSC (0.08%), fenvalerate 20 EC (0.04%), quinalphos 25 EC (0.08%). Rotational use of deltamelthrin 28 EC at 0.002% and carbaryl 50 WP at 21 days interval starting from fruit set has been found most effective for management of pomegranate fruit borer.

In ber, one prophylactic spray at flowering with 7 subsequent sprays at 10 days interval with 0.2 per cent wettable sulphur were effective for management of powdery mildew. For the management of powdery mildew in ber, 2-4 sprays of 0.2 per cent sulfex or 0.1 per cent karathane or 0.2 per cent bavistin should be done at 20 days interval. For ber leaf spot, mancozeb (0.3%) found to be best fungicide followed by captafol (0.3%) and topsin-M (0.1%). Black leaf spot of ber can be controlled with carbendazim (0.2%) spray. Management of sariopsis leaf spot of ber can be done by 0.2 per cent dithane Z-78 or Blitox-50 when sprayed 2-3 times at 15 days interval. Two sprays with monocrotophos 0.03 per cent and third spray with 0.1 per cent carbaryl at 15 days interval starting from pea size fruits managed ber fruit fly effectively. For the control of ber fruit fly, 2 sprays of 0.03 per cent phosphomidon or dimethoate or monocrotophos should be done at monthly interval. For the control of ber fruit fly, prophylactic sprays of 0.03 per cent oxydemeton or dimethoate starting from the stage when 70-80 per cent fruits have attained pea size may be done. The spray should be repeated at one-month interval. To check the incidence of fruit fly at maturity or ripening stage, ber trees should be sprayed with 0.05 per cent malathion + 0.5 per cent gur or sugar solution; repeat the spray at weekly interval, if necessary. Three sprays of deltamethrin 0.002 per cent or 0.05 per cent dichlorvos starting from pea size fruits controlled fruit borers. Spray of 0.1 per cent carbaryl 50 WDP or monocrotophos 0.05 per cent proved effective for chafer beetles.

Post harvest management and value addition

Value addition in horticulture is an integral part in increasing farmer's income by reducing post harvest losses and transforming horticultural produce to nutritionally rich value added quality product. Low cost drying technology of vegetables offers a highly effective and practical means of preserving vegetables in large quantity with extended shelf life of 6-8 months at ambient storage condition. Storage temperature is most important factor for maintaining quality of horticultural produce after harvest. Storage in refrigerated vehicles and cool chain facility retards the aging due to ripening, softening and colour change.

To enhance the shelf life of arid fruits, post harvest studies have been carried out. In pomegranate, pouch packed juice and stored at cool conditions showed slower degradation in anthocyanin and ascorbic acid content. The shelf life was found maximum (90 days) when it was kept under cool storage conditions of pomegranate. In date palm, boiling of doka stage berries for 20 minutes followed by dehydration at 50^0C for 70 hours is recommended for preparation of good quality dry dates (chhuhara). Half dang stage berries can be processed to prepare soft dates (pind khajoor) by dehydrating at 50^0C for 70 hours. Khalal stage of cv. Halawy has been found appropriate for making best quality dry dates in Kuchchh region of India. It is recommended that, the fruits of Barhee variety should be dipped in boiling water for 60 seconds and then dried in air circulating tray at 45°C for 60-65 hours to produce pind khajoor. Low to medium quality of date varieties are useful for preparing good quality date chutney. Ingredients of chutney should be 1 kg date pulp + 600 g sugar + 50 g tamarind pulp + 20 lime juice. In fig, fruits blanched with sulfination before drying had a beneficial effect in maintaining colour, flavour and texture of the product in cv. Deanna. Fig jam can be stored up to 45 days without any deteriorating the quality. The post harvest losses in horticultural produce are very high (25-30 %) owing to perishable nature. Accordingly, attempts have been made to process the fruits and vegetables into value added products so that the glut and post harvest losses can be reduced. A large number of value added products have been prepared using arid and semi- arid horticultural crops. Some of the products are presented in table 4.

Organic horticulture

Organic horticulture has great potential to provide benefits in terms of environmental protection,

Table 4. Value added products developed from arid horticultural crops

Bael powder	It is prepared from the pulp of ripe bael. It has high medicinal and nutritional value. The powder was screened and packed in polythene sachets which can be reconstituted just before serving with chilled water.
Kinnow RTS	The kinnow juice blended with carrot juice and mint were found to be highly acceptable over those blended with ginger extract.
Aonla shreds	Aonla shreds treated with 2 per cent salt which helped in higher retention of ascorbic acid and acidity.
Aonla based mouth freshener	Aonla base material is mixed with beet root extract as a natural colouring source. It has very good consumer acceptability and shelf-life of 12 months.
Aonla Murabba (Preserve)	It is prepared by pricking the aonla fruits and dip in 2 per cent common salt for 24 hrs. It is then boiled and dipped in sugar solution.
Aonla Pickle	One kg of aonla segments after blanching mixed with salt (150 g), red chilli powder (50 g), turmeric powder (100 g) and nigella seeds (100 g). The whole content was immersed in about 300 ml oil and stored.
Lalima	It is a natural colorant cum nutraceutical supplement "Lalima" from karonda fruit cv. CIAH Sel.-1. One ml of the derived formulation is sufficient to give pleasing colour to 100 ml of any color less fruit beverage with anthocyanin, and phenols.
Kachri based curry powder	Kachri based ready-to-use curry powder was prepared by mixing kachri powder with other ingredients, which has high culinary value
Date palm Biscuit	Date palm biscuit were prepared from doka or Khalal stage fruits, which has high nutritional value.
Watermelon candy	Candy from the processing waste of watermelon, *i.e.,* rind which constitutes about 35- 38 per cent of the total fruit weight.

conservation of nonrenewable resources and improved food quality. According to the FiBL –IFOAM, 37 million hectare area is under organic agriculture worldwide and India having 0.8 million hectare under organic agriculture. In arid region, some of the fruits and vegetable like cucurbitaceous vegetables, sangri, kair, karonda and cluster bean are produced organically due traditional farming system and non-availability of chemical inputs in remote areas or economical availability of organic input. Food produced through conventional horticultural practices by using of agrochemicals is unsafe or harmful human health and also toxic to environment. Organic food production in horticultural crop is highly remunerative than the conventional production system. Further safety of horticulture produce can be ensured using new generation organic inputs like organic fertilizers and pesticides and bio-agents.

Mechanization in horticulture

The major field operations for horticultural crops includes nursery preparation, planting, intercultural operation, irrigation, plant protection, harvesting, grading, packaging and transport. All these operations are predominantly depends on human labour owing to shortage of appropriate economical machinery and lack of commercial cultivation. Horticultural crops are highly suitable to mechanization from nursery to post harvest handling. Now days various tools and machinery are available for nursery seedling production, transplanting, spraying of chemicals *etc.* Mechanized tractor driven sprayer not only save time but also helps in efficient utilization of chemicals. Varieties suitable for mechanical harvesting and mechanical harvesters are developed for various horticultural crops which ensure timely harvest with minimum crop losses.

Tunnel technology for vegetable cultivation

The low cost protected structures particularly low tunnels with some modification are become a viable option for successful cultivation of cucurbits in arid regions. With the use of protective structures such as row covers or low tunnels vegetable crops like muskmelon, watermelon, longmelon, roundmelon, bitter gourd, bottle gourd, summer squash, *etc.* can be grown very early in the spring or summer season so that the produce to the market can be sent early in the season. It also extends the growing season for selected vegetable crops when large quantities of the crop produce are not available results in higher prices from their off-season produce. For example, crops like longmelon, roundmelon, bottle gourd, bitter gourd, muskmelon, summer squash, *etc.* if grown early in spring or early summer often command a greater price on the market to the growers. Low tunnels are flexible transparent covering that are installed over the rows or individual beds to enhance plant growth by warming the air around the plants using heat from the sun especially during winter season. Plastic tunnels are transparent which provides required sunshine to the plants, and the plastic also plays a barrier against the cool air in winter. Different cucurbits transplanted from first week of December to first week of February advanced the crop by 30-60 days over their normal season of cultivation. For example, if the muskmelon crop transplanted in first week of February, can be harvested in third week of April and mid January transplanted crop can be harvested in first week of April. Similarly, other cucurbitaceous crops such as bottle gourd, round melon, summer squash and bitter gourd can be advanced 40-60 days early than the normal season under low tunnels and on an average the cost benefit ratio of 2.0-3.5 can be obtained.

Conclusion

Arid fruit crops 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, which play important role in malnutrition alleviation and obesity management in arid and semi arid regions of India. With the adoption of farmer-friendly technologies, a substantial area is cultivated under horticultural crops. A large number of varieties/cultivars have been developed from different organizations which are playing significant role in sustainable production for nutritional security in arid and semi-arid regions of India. However, there is a need to address various issues for further refinement of technology as per site specific need. The major issues are utilization of plant genetic resources and its conservation and improvement, exploitation of biotechnology in arid horticultural crops, protected cultivation for quality yield and off season production, mechanization, efficient utilization of water resources, solar and wind energy, adoption of fruit based cropping systems, organic farming, and post harvest management with proper grading, packaging and marketing.

References

Awasthi, O.P. and Singh, A.K. (2011). Fruit based diversified cropping system for arid region. Procedings of ISMF&MP, Kalyani, W.B., pp.157-162.

Awasthi, O.P., Singh, I.S., and More, T.A. (2009). Performance of intercrops during establishment phase of aonla (*Emblica officinalis*) orchard. *Indian J. of Agril. Sci.*, **79**(8): 587-591.

Bhargava, R. Verma, P. Saroj, P.L. and Chauhan, N. (2006). Propagation of *Capparis decidua* through cuttings. *Indian Forester*, **132**(6): 737-745.

Chanadra, R., Suroshe, S., Sharma, J., Marathe, R.A. and Meshram, D.T. (2011). Pomegranate growing manual. *National Research Centre on Pomegranate*, Solapur (MS), India, pp.29.

Dhandar, D.G., Saroj, P.L. (2004). Changing scenario in Arid Horticulture, ***In***: Advances in Arid Horticulture, Vol. I (Eds. Saroj, P.L. *et al.*), Pub. International Book Distributing Co., Lucknow, pp. 1-27.

Pareek, O.P. (1978). Quicker way for raising ber orchard. *Indian Hort.*, **23**:5-6.

Saroj, P.L. Bhargava, R. Singh, R.S. and Krishna, H. (2018). *ICAR- CIAH An overview*. CIAH/Tech/ Pub. No. 60. pp.1-15.

Saroj, P.L. (2002). Techniques of nursery management in arid conditions. ***In***: Proceeding of 'National Training on Management of Arid Horticulture' at RAU, Bikaner, pp. 77-82.

Saroj, P.L. Awasthi, O.P. Bhargava, R. and Singh, U.V. 2008. Standardization of pomegranate propagation by cutting under mist system in hot arid region. *Indian J. Hort.*, **65** (1): 25-30.

Saroj, P.L. Nath, Vishal and Vashishtha, B.B. (2000). Effect of polycontainers on germination, seedling vigour, root characters and budding success in aonla. *Indian J. Hort.*, **57**(4): 300-304.

Singh, S. and Singh, A.K. (2006). Standardization of method and time of propagation in jamun (*Syzygium cuminii*) under semi arid environment of western India. *Indian J. Ag. Sci.*, **76**:142-45.

Singh, S. and Singh, A.K. (2007). Standardization of method and time of vegetative propagation in tamarind under semi arid environment of western India. *Indian J. Hort.*, **64**(1): 45-49.

LEAD LECTURE – 46

Impact assessment of diversified horticulture modules in augmenting income of mango farmers

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Mango production remains a major livelihood option in Malihabad belt of Lucknow, Uttar Pradesh. Efforts made under Farmer FIRST project in diversifying mango orcharding through integration of poultry, accommodating intercrop in mango orchards, on farm value addition of raw mango, demonstration of GAP in mango and providing marketing links to mango growers during 2017-2019 yielded very interesting results in terms of income augmentation. The data subjected to Difference in Difference revealed the impact of interventions. Hundred Dashehari mango orchards from three villages of Malihabad block were integrated with rural poultry. Impact assessment of two years revealed that farmers realized a net income of Rs.168497 per acre by integrating rural poultry compared to non integrated orchards (Rs. 55311/acre). The BC ratio of mango orchard-based poultry farming was significantly higher (3.29) as compared to mono crop of mango production which registered low benefit cost ratio (2.88). Significant reduction in leaf webber incidence in mango orchards integrated with poultry was demonstrated. Those farmers who adopted this technology sprayed pesticides 3 times during the year and spent only Rs.7910/ acre as compared to those not adopted the technology and spent around Rs. 14080/acre on 6-7 pesticide sprays. A total reduction in input cost of 43.8 per cent was observed in mango orchards where poultry was integrated. A total of 30 farmers adopted CISH Mango-Good Agricultural Practice (CISH Mango-GAP), exploited Geographical Indication (GI) of Malihabadi Dashehari and linked to local and distant marketing channels through Mandi Parishad of Uttar Pradesh. The highest net price per kg mango (Rs. 58.4) was obtained in distant marketing followed by direct marketing to local consumer (Rs. 32.43) in urban area whereas, lowest net price per kg mango (Rs. 20) was obtained in traditional marketing. GAP adoption and market linkages led to 93.08 per cent enhancement in farmer's income compared to traditional production, harvesting, post harvest practices and marketing. Fruit quality and consumer appeal for fruits were enhanced by good harvesting and post harvest handling practices, packaging, branding and market linkages which helped in getting lucrative prices of mango fruits. A total of 30 farmers were demonstrated intercropping of turmeric variety ND-2 with higher curcumin content in mango orchards. Turmeric was planted in 10 per cent of total mango orchard area, which lies unutilized between rows of mango trees. A new method of turmeric processing was also demonstrated where turmeric powder can be prepared at farmer's field without boiling of rhizomes. Profit earned from sole mango crop was compared with income received from turmeric intercropped orchards. Net profit of sole mango crop was Rs. 53325/acre, whereas in mango + turmeric system Rs. 58020 net profit received. Benefit cost ratio was also observed higher in case of mango + turmeric system. Percent increase in income through adoption of turmeric as intercrop over sole mango crop was estimated 8.81 per cent. Farmer FIRST introduced and demonstrated an innovative method of raw mango powder production to farm women (30 numbers) in Mohammad Nagar

Talukedari village for production of hygienic and good quality dried slices from dropped and cracked raw fruits and then grinding them in a pulverizer to produce good quality Amchur. A lowcost solardrier have been developed and distributed in village for fast drying of slices. This intervention help in hygienically and quick drying of mango slices which enhance productivity and income of the farmer 60-80 per cent by selling mango powder.

LEAD LECTURE – 47

Integrated farming system: A viable approach for increasing farm income and nutritional security of smallholder farmers in eastern region

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The eastern region comprising of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha and West Bengal, occupy about 21.85 per cent geographical area and supports 34 per cent human and 31 per cent livestock population of India. The population density (616 nos./km^2) is 1.61-fold higher in the region compared to the national average (382 nos./km^2). Since, the number of operational holdings increased from 37.89 million nos. in 2000-01 to 47.19 million nos. in 2010-11, the average size of holding was reduced from 0.84 ha to 0.72 ha during 2010-11 as compared to 1.18 ha at the national level. Within the region, the fragmentation increased significantly in Bihar where the average size of holding has come down from 0.58 to 0.39 ha. Agriculture is the mainstay of economy in the region, where 84 per cent population is rural. The share of smallholder farmers (marginal and small farmers) accounted for around 86 per cent of operational holdings in the region. The per capita income (Rs. 62,631) of the region is however; much lower than the national average (Rs. 94,130). Bihar has the lowest per capita income (Rs. 34,168) in the country. Though the eastern region is rich in natural resources, social capital and traditional knowledge, its potential could not be harnessed in terms of improving agricultural productivity, poverty alleviation and livelihood improvement. Eastern states are likely to be the worst hit by climate change. Floods and drought/drought like situations have become a regular phenomenon in the region jeopardizing food and nutritional security and farm income of the smallholder farmers. The smallholder agriculture is expected to continue in the foreseeable future with rise in population pressure on the land, and demand for land for competing alternative uses.

Eastern states have ample scope for increasing productivity in system mode, wherein the synergy of field crop-horticulture-livestock-fish-agroforestry could be harnessed. Productivity of the system, however, will depend on recycling of renewable farm resources, which call for integrating livestock, fish, poultry and duckery so as to develop sustainable production systems. Hence, research strategies should aim at productivity enhancement, diversification, minimization of production losses through risk management, processing and value addition and commercialization based on market intelligence.

Integrated Farming System (IFS) is generally considered relevant to the rural poor. The emphasis in such system is on optimizing resource utilization rather than maximizing the productivity of a certain component in the system. The concept of IFS has come into picture in order to achieve food and nutrition security at household and even at individual level besides generating employment opportunities, increasing cropping intensity and net income of the farming family and conservation of natural resources. Integrated farming system, also involves agricultural intensifications, diversification and value addition. It helps improve physical and economic access to food, thereby sustaining food security. IFS is generally considered relevant to the rural poor. The emphasis in such system is on optimizing resource utilization rather than maximizing the productivity of a certain component in the system. The concept of IFS has come into picture in order to achieve food and nutrition security at household and even at individual level besides generating employment opportunities, increasing cropping intensity and net income of the farming family, and conservation of natural resources. Integrated farming system, also involves agricultural intensifications, diversification and value addition. It helps improve physical and economic access to food, thereby sustaining food security.

The ICAR Research Complex for Eastern Region, Patna has developed different location specific IFS models for small and marginal farmers according to land and resource availability for improving livelihood security and income of small and marginal farmers of the region.

- The 1 acre IFS model comprises of integration of crops including fruits and vegetables (3500 m^2) + goat (20 + 1 nos.) + poultry (200 birds/cycle of 35-40 days) + mushroom and vermicomposting for irrigated midland situation. With an initial investment cost of Rs.1,02,220/-, this model fetches a net annual returns of Rs. 89,413 with B : C ratio of 1.7 and income sustainability index of 77.2.
- The 2 acre IFS model integrates crops including fruits and vegetables (6500 m^2) + livestock (2 cows + 2 calves) + fish/duck (1000 m^2) for low land situation. With an initial investment of Rs.2,05,500/-, this model fetches a net annual returns of Rs. 1,42,244 with B : C ratio of 1.8 and income sustainability index of 79.8.
- Recycling of various farm wastes within the system added 56.5 kg N, 39.6 kg P and 42.7 kg K to the soil valued Rs. 4,826/year in the 2 acre IFS model, and 44.0 kg N, 29.5 kg P and 31.2 kg K valued Rs. 3,175/year in one acre model.
- Total carbon sequestration (2011-17) under crop + goat + poultry and crop + livestock + dairy IFS model were 1.04 Mg C/1 acre and 5.6 Mg C/2 acre, respectively. The energy output : input ratio varied from 2.54 in 2 acre to 3.18 in 1 acre model.
- Makhana is an aquatic crop largely grown in ponds of north Bihar as mono crop with low productivity and profits. In order to improve its productivity and income from the same water body, the crop was integrated with fish and water chestnut in the ponds. This integration has resulted in net returns of Rs. 88,910/ha as against Rs. 48,960/ha in traditional method of Makhana alone.

Fig. 1. Integrated farming system

These IFS models were validated in different farmers' fields of Nalanda, Vaishali, Darbhanga, Buxar, Gaya, Betiah, Patna, Bhagalpur *etc.* districts and were found promising. The technology was pushed over to State

Agriculture Department for its dissemination on large scale. Department of Agriculture, Government of Bihar has selected a total no. of 1068 farmer (two farmers from each block) from 534 blocks for its adoption and also provided a subsidy of Rs. 10,000/farmer to integrate any of enterprise with their crop.

It may be concluded that empowering farmers to improve their incomes is complex, as farming families rarely earn money from a single source. Hence, promotion of 'Integrated farming system' approach (Fig. 1) involving synergic blending of crops, horticulture, dairy, fisheries, poultry, *etc.* seems viable option to provide regular income and at site employment to small land holders, decreasing cultivation cost through multiple use of resources and providing much needed resilience for predicted climate change scenario.

LEAD LECTURE – 48

Horticulture issues and challenges in north eastern India

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The north eastern region of India comprises of eight states *viz.*, Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Mizoram, Nagaland and Sikkim. The total area of North East occupies 7.7 per cent of India's total geographic area supporting 50 per cent of the biodiversity in the country. The region has been blessed by nature with one of the richest flora and fauna on the earth and regarded as one of the 'Biodiversity Hot Spot' areas in the world. 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 horticultural crops 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 genotypes of cucurbits, solanaceous vegetables, ginger, turmeric, bamboo, leafy vegetables *etc.* are having unique quality because of their locational advantage.

Though, agriculture is the major source of livelihood for the major section of people of the region, still it has been remaining complex, diverse and risk-prone and resulting into the low level of productivity and low income since decades. Under this situation, probably horticulture sector has desirable attributes to accelerate the agricultural growth process in the region. Horticultural sector plays very important role towards sustainable rural livelihoods in all farming system in general and in rainfed and hilly farming system in particular like the north east region. Horticulture can give a means of diversification and give food and nutritional security. Further most of these crops are rich in vitamins, minerals and such other bioactive molecules. These crops have the potentiality to alleviate the poverty, food and can give nutritional security and also play a major role in meeting the need of nutritional and ethno medicinal uses of the rural tribal people of region since time immemorial. Nutrition security implies physical, economic and social access to balanced diet for every citizen. Malnutrition has a complex aetiology and its prevention requires awareness and access at affordable price to all the above-unreached and undernourished. In this direction horticulture can play crucial role in the region. However, there exist a couple of issues, like low productivity, low technological adoption or non-adoption of scientific cultivation practices, poor investment capacity, small and fragmented land holding, subsistence farming, *etc.* Lack of quality planting materials, lack of modernization and mechanization, land tenure and ownership system of the region, inadequate agro-inputs, lack of irrigation facilities are some of the major issues lies with the region. High postharvest losses, poor marketing and post-harvest infrastructure also remain constraint in the region. However, these challenges can be addressed with more R&D specific to NE India, better extension programmes, quality planting materials, development of related infrastructures, financial and export oriented support, organic farming, commercial farming with industrial linkages, *etc.* The details of issues and challenges in theregion will be discussed in this paper.

LEAD LECTURE – 49

Entrepreneurial opportunities in horticulture

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Economic development of any nation depends primarily on the important role played by entrepreneurs, which is of vital importance in developing country like India, where there are ample opportunities for using innovations to exploit the available resources. Rural development is presently linked to entrepreneurship and government institutions and agencies promoting rural development now consider entrepreneurship as a strategic development intervention that could accelerate the rural development process. Farmers are now taking it as an instrument for improving farm earnings and women see it as an employment possibility near their homes which provide autonomy, independence and reduced need for social support.

Our country is traditionally rich in horticultural production due to its diverse and unique agro-climatic conditions which is conducive for growing wide range of horticultural crops like fruits, vegetables, flowers, spices, nuts, tuber crops, mushrooms, medicinal and aromatic plants. There exists innumerable business opportunities in the horticulture sector of India. Investors and entrepreneurs, from all over the world, are making greater investments into the sector and are actively involved in trading of India's horticulture crops. The importance of horticultural sector in Indian economy can be visualized from the fact that it accounts for about one third of India's agricultural GDP from approx. 10 per cent of the cropped area.

Among the high value crops in India, horticultural crops command high value not only in terms of their potential in generating income and employment, but also on the basis of export-earning opportunities. With the changing consumption pattern towards horticultural crops and rising per capita income, there is an increase in internal demand as well as export opportunities for horticultural crops. The new generation of educated farmers and unemployed rural youth has an opportunity to become entrepreneur and adopt horticulture as a business enterprise. A farmer does not become an entrepreneur only by adopting new agricultural technology but he becomes an entrepreneur only when he comes to be an operator of farm business.

The first steps involve choosing the right idea or business and then conducting sufficient research to ensure that idea is feasible. A successful horticulturist will know and understand the primary reasons for establishing their enterprise and will have chosen a crop and business structure that fits with their lifestyle and personal objectives. Horticultural crops usually require intensive management and it will be important to know the agro-technology involving irrigation and nutrition requirements, rotation requirements, potential weeds, pests and diseases, right varietal selection and post-harvest handling with requirements for and costs of machinery, equipment and buildings; safety requirements, marketing skills including exports. An entrepreneur is required to have a long term vision and established network. He should know the market, product/service and selling strategy with legal requirements and regulations. He should know the land capability and logistical requirements and have adequate financing and time with right business structure. Good record keeping and feedback/review with strive for continuous improvement to market the product will help manage the risks.

LEAD LECTURE – 50

Top ten challenges before future horticulture

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Horticulture (fruits including nuts; vegetables including potato, tuber crops, mushroom; ornamental plants including cut flowers; spices; plantation crops and medicinal & aromatic plants) play important role in Indian agriculture. It has become a key driver for economic development in many of the states in the country. Presently, horticulture alone contributes about 30.4 per cent to GDP of agriculture. India has emerged as the second largest producer of fruits and vegetables in the world and largest producer of crops like mango, banana, coconut, cashew, papaya, and pomegranate. Many states in India like Maharashtra, Andhra Pradesh, Himachal Pradesh, Jammu Kashmir, Uttrakhand, *etc.* are focusing on horticulture to improve the productivity and farm income. India is the largest producer and exporter of spices at global level and also has recorded highest productivity in the world in many crops like grape, banana, cassava, peas and pomegranate. Keeping the future challenging issues in mind, such as fast increasing global population, food & nutritional security, reducing land & water resources, ill effects of climate change & pollution, unemployment *etc.*, horticulture has enormous potential toaddress such challenging issues. However, there will be urgent need to focus onkey factors, in order to succeed in future. Top ten issues, as felt by the author, are listed below with brief description.

Quality planting material

Seeds and planting material play an important role in horticultural produce and profitability of farmers. Non-availability of quality seeds and planting material has been a perpetual issue for the growers. It has been observed that number of research findings and papers are available in open domain to address almost every issue that exist on the topic today. However, timely availability of desired seeds and planting material for commercial horticulture is like waging war. A large number of imports are being made in India, especially of vegetables and flowers seeds. Our public funded institutions like universities, research institutions and state machineries *etc.* can not address the challenge. There is readily available market which can be tapped for business development in support with start-ups and private entrepreneurs.

Alternate production technologies

Fast raising population, reducing per capita availability of cultivable land & water resources, degradation of land and ill effects of climate change, *etc.* are mega challenges before us. Such issues are going to affect expansion of horticulture in days to come. A number of publications have been made to find alternate strategies to these issues. Protected cultivation, soilless cultivation, vertical farming, indoor horticulture, *etc.* are some classical examples which need to be studied, customised and developed as per the need of the time and location. Till now only limited and scattered information are available. To make break through, there is need to develop complete package & practises and proper support system in order topopularise these technologies. Secondly, such technologies need not be considered as alternative to open field and orchard cultivation, but to be used as supplementary technologies for specific crops and different environments, also under extreme conditions.

Efficient input management

Timely availability and efficient use of resources is one of the most important limiting factor in horticultural production. It not only affects yield, quality and profitability of the farmers but also play important role in pollution control and, environmental & product safety. Major resources like water, fertilizers/ago-chemicals, seeds/planting material, manpower, *etc.* need to be used in judicious manner, at right time and at right dose. Caution may be prepared and highlighted on the issues. This will improve farm efficiency and quality of produce, thereby increasing profitability of the farmers.

Toxin free & quality of produce

Safety of the horticultural produce is going to be a major market issue, since consumers are becoming aware about the ill effects of toxicity. Heavy metal contaminations and pathogenic contamination are two major concerns on the subject. Various SOPs, testing kits/facilities and certification, *etc.* are blooming to address the issue. The importing countries are framing stringent rules and strong monitoring mechanism. Ignoring/relaxing any such issue will drastically damage the horticulture industry, as it is directly affecting the global and domestic market and related to health of the people.

Effective post harvest management

Post harvest losses in horticultural crops are very high and share major component in farmers' income/profit. At every step from harvest till it reaches consumer's table, there are substantial loss at several points. Though many technologies are available to handle the issue, but still it will remain as one of the most important challenge in future also. Effective mechanisation, storage, transport and value addition with proper supply chain management techniques only will minimise the losses and improve the profit of the famers, with least input. This also has potential to improve our export to the other countries.

Mechanisation, tools/equipment and artificial intelligence

Till now horticultural engineering support has been very weak and poor. The tools and equipments used at various stages of production, harvesting, post-harvest/processing are very primitive and not users' friendly. It is predicted that most of orchard and post-harvest operations will now be mechanised and supported with Artificial intelligence, related data and past experience. This will not only conserve time and resources, but also reduce losses and damages, which will enable to make right decisions at faster pace.

Successful models and stories

In diverse country like India, transferring technology to the farmers' field is really challenging.

Indian farmers are very apprehensive about the change to new technologies/practices, because of small land holding, poor resources and lack of strong support system, which challenge their livelihood in case of failure. The most effective and successful means of technology transfer is our country has been through models and success stories. There is need to develop more and more models and success stories in various zones on different technologies which can easily be replicated by others. This will make our technology programme faster andeffective.

Farmers' friendly market link

Marketing of horticultural produce is the most important but weak link affecting farmers' profitability. Horticultural produce being highly soft and perishable, poses special challenges in marketing. Poor marketing infrastructures, link between producers and consumer and too many but inefficient middle agents are some key factors which need to be improved. With revolution of information technologies, marketing can be developed directly between producer and consumer and hurdles need to be removed to make effective transfer of produce farm to plate. This only has the potential to double famers' profit.

Knowledge management with focused R&D and education

Knowledge is ultimate power and key to success in any business. Lot of knowledge has been created by researchers, farmers, industry, scholars, entrepreneurs, *etc.* which lies *in silo* and in different forms. It is not only difficult to retrieve them but also to understand and further translate into reality. With the use of modern tools, such experience/ knowledge need to be made available in easy to understand and usable by the framers, keeping their requirement in mind. Many such initiatives have been made in the form of mobile App and farmers advisory services, *etc.* which caters the need of the farmers, based on crop, soil region, climate, forecasting and market information services, *etc.* On the other hand, our academic and R&D institutions need to be more focused on real ground problems faced by the growers and take up as research issues. Quality of our education also needs to be improved with more focus on skill development, rather on the current process of knowledge based education/ testing.

Innovations in horticulture

There are number of agencies, universities and institutions *etc.* which are excellent seat of knowledge for horticultural science. Number of new concepts are developed, proven with data & experimentation. However, when it comes to address the challenges, or solve any problem on ground, most of our findings prove to be either a failure or not sustainable. This happens because our approach to tackle the problem is only in bits and pieces. There is strong need to switch over to technology development, from science development approach. This will give complete solution package to the challenges, and also help to boost innovation in horticulture.

LEAD LECTURE – 51

Status of horticulture in Rajasthan

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Rajasthan is the largest state of India, constituting 10.4 per cent of total geographical area and 5.5 per cent of total population of the country. Its, two-third population depends on agriculture and allied activities for their livelihood. The state has 10 agro-climatic zones and gifted with varied soil and climatic conditions comprising warm humid in South-Eastern part to cool dry western part of the state. In Rajasthan in which about 61 per cent of its total area spread over 12 districts falls under the arid zone (Fig.1.). In the state semi-arid area covers about 16 per cent while humid regions and sub-humid regions account about 15 per cent and 8 per cent of its total landmass respectively (Swai *et al.* 2011). Agriculture especially cultivation of seasonal crops becomes many times fragile and frequency of crop failure make it prohibitive to continue on with farming. Horticulture provides continuum in production management scenario.

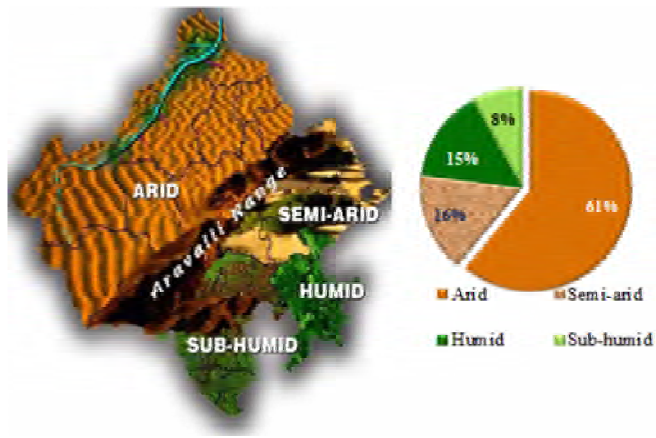

Fig. 1. Agro-climatic regions of Rajasthan

Land use pattern

A major part of the state is dominated by parched and dry land which includes extensive geography of rocky terrain, wetlands, rolling sand dunes and barren tracts (Fig. 2). The total area of the state is 342.79 lac hectare. The total land area of the state is divided into cultivable and non- cultivable land. Of this, 53 per cent area is under net area sown (181.69 lakh hectare), 11.18 per cent under cultivable waste land (38.31 lakh hectare), 8.03 per cent is under forests (27.53 lakh hectare), 6.98 per cent under barren and uncultivable land (23.91 lakh

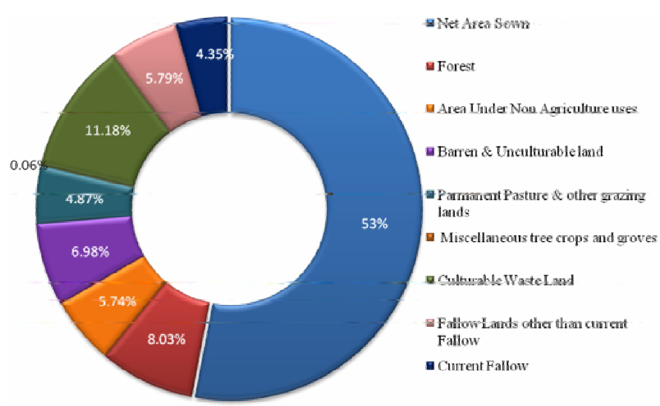

Fig. 2. Land use Statistics of the state

hectare), 5.79 per cent under fallow land other than current fallow (19.83 lakh hectare), 5.74 per cent area is under non–agriculture use (19.69 lakh hectare), 4.87 per cent under permanent pastures (16.70 lakh hectare), 4.35 per cent under current fallow (14.91 lakh hectare) and 0.06 per cent land under miscellaneous tree crops and groves (0.22 lakh hectare) (Anon., 2019b).

If seen in totality very less portion of cultivable land has been put forth under horticultural production. This gap may be lowered down by bringing a part of cultivable land, cultivable waste land and other culturable waste land under production of fruit crops.

Agro-climatic conditions

In Rajasthan, agriculture is primarily rainfed. The average annual rainfall is 575 mm which is variable both in time (3 out of 5 years are drought year) and quantum (23.55 cm to 99.9 cm). The average annual rainfall varies region to region (Table 1.).

Table 1. Climatic conditions of the state according to different regions

Regions	Average rainfall (mm)	Temperature (°C)	
		Min.	Max.
Arid	33.2	5.3	45.0
Semi-arid	53.7	8.3	42.0
Sub-humid	72.2	7.8	40.5
Humid	82.7	10.6	41.0

Source: Anon., 2016

The average climatic conditions of the state remain harsh for major duration of the year. The crop growing days are very less, which make profitable cultivation of field crops many times very difficult. The growing period prevails in the rang of 60 days in arid region, 60-90 days in semi-arid region and more than 210 days in tropical humid areas (Singh, 2016).

Suitable horticultural crops

The climatic sphere in the state favours cultivation of a range of horticultural crops varying from annuals to perennial. Many horticultural crops are produced of unparallel standard which are not produced anywhere else in other part of the country. Bright sunny days, high solar radiation, atmospheric dryness, light soil etc. offers amenability in production of crop with unique sweetness, taste and flavour. Some horticultural crops bound especially to the state are as under:

The aridity and consequently the salinity of the soil restrain production of horticultural crops in the state. Even then, some tolerant crops make it amenable to grow in different type of saline situations. The tolerant level of different fruits against salinity is as under:

Status of horticulture

The diverse agro-ecological conditions dominating in the state is amenable for growing horticultural crops. Out of the net cultivated area (181.6 lac hectares) of the state, horticultural crops are grown in an area of about 10 lac hectares with an annual production of about 14 lac tonnes. As

Suitable horticultural crops	Dominant region
Vegetables	
Chilli	Mathania (Jodhpur)
Pea	Choumu (Jaipur)
Onion	Alawar, Bassi (Jaipur)
Tomato	Bassi (Jaipur)
Muskmelon	Tonk
Watermelon	Bikaner
Roundmelon	Shahpura (Jaipur)
Fruits	
Date palm	Bikaner, Jaisalmer, Barmer
Guava	Sawaimadhopur
Jamun	Ajmer
Ber	Choumu
Aonla	Choumu
Kinnow	Sriganganagar
Mandarin	Jhalawar
Pomegranate	Jalore, Jodhpur
Khejari	Bikaner
Kair	Bikaner, Jaipur
Spices	
Cumin	Jalore, Barmer, Pali, Jodhpur, Nagaur,
Coriandar	Jhalawar
Fennel	Sirohi, Tonk
Fenugreek	Nagaur
Garlic	Kota, Jhalawar, Chittorgarh, Baran

per 1st advance estimate 2018-19 by National Horticulture Board (NHB), Gurgaon, Haryana, the area of fruit crops is about 0.60 lac hectare, and the production is 8.95 lac tonnes in the state. Area and production vegetable crops in the state are 1.68 lac ha. and 17.67 lac tonnes respectively. Likewise,

Salt tolerance of different fruit crops

High tolerance (ESP 40-50, EC 9-12 dsm^{-1})	:	Date palm, ber, woodapple
Medium tolerance (ESP 30-40, EC 9-12 dsm^{-1})	:	Aonla, tamarind, jamun, mahua, lasoda, karonda, phalsa, khirni, custard apple
Weak tolerance (ESP 20-30, EC 6-9 dsm^{-1})	:	Guava, citrus, mango, bael
Susceptible tolerance (ESP <20, EC <6 dsm^{-1})	:	Banana, papaya, pineapple

(Singh *et al.* 2005).

the area and production of flowers are 4 thousand ha. and 7.5 thousand tonnes, whereas the state produces 14.59 lac tonnes of spices from 11.22 lac ha. area (Table: 2.). In flower crops rose is only commercially cultivated flower crop in the state. Marigold and chrysanthemum are also cultivated at small scale.

Table 2. Area, production and productivity of fruits, vegetable and spices

Year	Fruit			Vegetable			Spices		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
2002-03 to 2006-07	24503	297563	12144	115388	606632	5257	453719	416021	917
2007-08 to 2011-12	31936	473238	14818	145183	890147	6131	668692	653742	978
2012-13 to 2016-17	41726	712658	16987	160320	1450711	8870	891384	916568	1006
2017-18	54207	736350	13584	166234	1699584	10224	902650	1392301	1542
2018-19	59780	895000	-	16855	176753	-	112214	145914	-

Note: Area in hectare, Production in tonnes, Productivity in kg per hectare.
Source: Anon. 2019a and Anon., 2019b.

Rajasthan is having prominent position in production of seed spices in the country. The state contributes about of 82 per cent of fenugreek and 56 per cent of total coriander produced in India. Almost all of isabgol husk (isabgol), mehandi (henna) and ajowain are produced in the state (Table: 3.).

Table 3. Per cent sharing of seed spices in national production

Crop	Per cent sharing	Crop	Per cent sharing
Fenugreek	82	Isabgol	About 100 per cent
Coriander	56	Mehandi	About 100 per cent
Cumin	26	Ajowain	About 100 per cent
Garlic	14		
Fennel	6		

The productivity of the land is poor in the state by and large especially in western Rajasthan which experiences the curse of aridity. The biological efficiency of the land can be enhanced following inter-horticultural crops. Option of inter horticulture as inter-crop/cover crop/green manure crop by selecting amenable crops are helpful in establishing orchard in arid areas. Inter horticulture is essential for quick rehabilitation of waste land, soil conservation, moisture conservation. Assured income and in popularizing commercial horticulture.

Some suitable inter-horticultural crops are as undetr:

- Pulses : Urd, moong, soyabean, groundnut, lentil, gram
- Oilseeds: Taramira, rapeseed, till, linseed
- Cereals: wheat, barley, oat, jowar, bajra
- Medicinal plants: Senna, ashwagandha, stevia, asparahus, aloe, giloe
- Seed spices and aromatic crops: Cumin, coriander, fenugreek, fennel, dill
- Vegetables: Brinjal, chilli, tomato, onion, okra.

Processing

The processing of horticultural crops is the important aspect for food and nutritional security. It not only increases the income and employment of the farmers, but also reduces the postharvest losses and provide the product in off season. Rajasthan holds opportunities to produces many fruits, vegetables, spices, medicinal and aromatic crops. A sizeable quantum of production goes waste annually. The extent of wastes in horticultural crops due to inadequate postharvest handling is 20-30 per cent lost annually (Singh, 2014). This kind of losses can be prevented by diverting the fresh produce towards value addition.

There is immense potentiality of tapping value addition potential by diversifying product range. A range of produce can be developed out of fruit. Some common processed products based on fruits grown in the state are as under:

Fruit Crops	Value added products
Datepalm	Chhuhara, Soft Dates, Shreds, Toffee, Mouth Freshener, Pickle, Toddy, Nira
Aonla	Chyavanprash, Trifala, Preserve, Candy, Squash, Aonla Shreds
Bael	Nectar, Squash, RTS, Toffee, Dried Bael, Syrup, Juice, Blended Juice
Karonda	Candy, Jam, Jelly, Preserve, Pickle
Pomegranate	Jam, Anardana, RTS, Squash, Juice, Anar-Rab, Wine, Mouth Freshener, Rind Powder
Phalsa	Juice, Squash, RTS, Dehydrated Products
Ber	Chhuhara, Squash, Dried Ber, RTS, Candy
Khejri	Biscuits, Dried Pod (Sangri), Laddoo
Jamun	Squash, Syrup, Powder
Lasoda	Pickle, Panchkuta, Dehydrated Products
Tamarind	Chutney, Jam, Pulp, Candy
Kair	Pickle, Mouth Freshener, Dehydrated Products

Marketing facilities

Horticultural marketing is continued to be plagued by many market imperfections, such as, inadequate infrastructure, lack of scientific grading system, lack of digitalization *etc.* Present marketing system is characterized with long, fragmented supply chain, high wastage, low share of producers in price spread, which is unable to meet the demand of quality produce to the consumers. Proper marketing facilities does not provide only good amount of cash income to the farmers but also encourage further development in both production and processing. In horticultural farming, if farmers increase production, they need more attention to be paid on the fact that their produce must be marketed at a rewarding price. In this sector, where prices are rarely regulated, economic viability depends as much upon marketing skills as on the technical expertise of the farmer. The government of Rajasthan tends to regulate the marketing of horticultural product so as to make farmer better able to fetch lucrative price of their produce. In the regard several mandi at different places have been operationalized (Table 4).

Table 4. Marketing facilities for different horticultural produce in the state

Place	Horticultural produce
Medanta city, Nagaur	Cumin
Alawar	Onion
Ramganj mandi	Coriandar
Choumu	Aonla
Bhawani mandi	Mandarin
Sawaimadhopur	Guava
Chhipabadod	Garlic
Tonk	Chilli
Bassi	Onion
Pushkar	Rose
Sojat	Mehandi
Bhinmal	Isabgol

Education, research and extension

The Rajasthan is divided administratively in 33 districts. A variety of climatic conditions prevails in the state ranging from extreme arid to sub-humid regions. In national climatological mapping, the state falls under zone 14th (Western dry zone). To cope up with the requirement of farming community there are 5 agricultural universities in the state. At present there are 49 colleges of agriculture (govt. 19, private 30) (Table: 5). Across agricultural universities in the state, the total intake capacity at UG level is 3724, PG level 251 (normal 226, payment 25) and Ph.D. level is 100 (normal 79, payment 21). Including various segments of education, in all, there are 79 universities and 2957 college in the state. The average admission in the state decreased from 725 in 2010-11 to 526 in 2017-18 (Rajasthan Patrika, 22 August, 2019). It calls for the attention on the mode of imparting quality education.

In order to make the agricultural sustainable and a profitable activity, there are networks of research station distributed across entire climatic zones of the state. As on today there are 18 research stations in the state.

The outcome of the research coming out from the agricultural institutions is made available to the farmers through the directorate of extension, working with each agricultural university. Besides, agricultural universities, there are a separate setup of government of Rajasthan, to facilitate the dissemination of farm science technology to the door level of the farmers through its extension wing in administrative setup. The directorate has aim to satiate the gap between the between the available technology and its availability at farmers door step.

Future thrust

- ❖ Ensuring availability of quality planting material
- ❖ Water conservation
- ❖ Diversification of agriculture with horticulture in agro-forestry module

Table 5. Agriculture colleges in Rajasthan

University	College Name	Type	Seats
AU, Jodhpur	COA, Jodhpur	Constitutes	44
	COA, Sumerpur, Pali	Constitutes	44
	COA, Nagaur	Constitutes	50
SKNAU, Jobner	SKN, COA, Jobner	Constitutes	108
	COA, Lalsot, Dausa	Constitutes	54
	COA, Kumher, Bharatpur	Constitutes	60
	COA, Fatehpur-Shekhawati (Sikar)	Constitutes	60
	COA, Navgaon, Alwar	Constitutes	60
	SKN College of Agri-Bussiness, Jobner, Jaipur	Constitutes	60
	BBD Govt. College, Chimanpura, Sahpura	Affiliated	60
	Govt. College Uniara, Tonk	Affiliated	60
	Late Moolchand Meena Ag. College, Lalsot Dausa	Affiliated	60
	Dayanand College, Ajmer	Affiliated	60
	M.B. College, Purani Tonk, Tonk	Affiliated	60
	Maharaja Surajmal Ag. College, Rahimpur, Bharatpur	Affiliated	60
	Pandit Deen Dayal Upadhyay Ag. College, Deoli, Tonk	Affiliated	120
	O.P. Agriculture College, Budhwal, Behor, Alwar	Affiliated	60
	Ganeshi Lal Ag. College, Kishangarh Bas, Alwar	Affiliated	60
	Rukmani Devi Memorial Ag. College, Mandwar, Sarawali (Dausa)	Affiliated	60
	Shekhawati Institute, Jaipur Road, Sikar	Affiliated	120
	Apex Agriculture College, Rawatsar, Hanumangarh	Affiliated	60
	COA, Kotputali , Jaipur	Constitutes	60
	COA, Basedi , Dhaulpur	Constitutes	60
MPUAT, Udaipur	Rajasthan College of Agriculture, Udaipur	Constitutes	88
	College of Agriculture, Bhilwara	Constitutes	60
	College of Fisheries, Udaipur	Constitutes	30
	CDFST (B. Tech (Dairy Technology), Udaipur	Constitutes	30
	CDFST (B. Tech (Dairy Technology), Udaipur	Constitutes	25
	Govind Guru PG College, Banswara	Affiliated	60
	RNT COA, Kapasan	Affiliated	120
SKRAU, Bikaner	College of Agriculture, Bikaner	Constitutes	88
	Ch. Paramaram Godara, Ag. College, Bhadra, Hanumangarh	Affiliated	120
	S. K. Mahavidhiyalaya, G.V. Sangaria, Hanumangarh	Affiliated	120
	Parmanand Degree College, Gajsinghpur	Affiliated	120
	Sardar Bhagat Singh Shikshan Sansthan, Goluwala, Hanumangarh	Affiliated	120
	Sarawati Shikshan Sadan, Agri. College, Shriganganagar	Affiliated	120
	Mahaveer International College, Gharsana, Sriganganagar	Affiliated	120
	Surendra Kaur Memorial Ag. College, Padampura Sriganganagar	Affiliated	120
	Swami Sri Prannath Parnami Ag. College, Padampur, Shri Ganganagar	Affiliated	120
	GSGD Girls Ag. College 25 BB Padampur, Sriganganagar	Affiliated	60
	Maharaja Agarsen Ag. College Suratgarh	Affiliated	120
	Chaudhary Nand Ram Memorial Krishi Mahavidhyalaya Gogamedi, Hanumangarh	Affiliated	60
	B. R. College of Ag. Sahawa Churu	Affiliated	120
	S.P.N. Ag. College, Goluwala, Hanumangarh	Affiliated	60
	CH. Girdhari Ram Dhaka Agriculture College ,Kohala, Hanumangarh	Affiliated	60
AU, Kota	College of Agriculture, Ummedganj-Kota	Constitutes	60
	College of Horticulture and Forestry, Jhalawar	Constitutes	103
	Sahid Captain Ripudaman Government College, Sawai Madhopur	Affiliated	60
	MBDDS Mahila Krishi Mahavidhyalay, Siswali, Baran	Affiliated	60
Total			3724

Research stations
Agriculture Research Station, Bichhwal, Bikaner
Agriculture Research Station, Sri Karni Marg, Sriganganagar
Agriculture Research Station, Durgapura Jaipur
Agriculture Research Station, Fatehpur, Sikar
Agriculture Research Station Navgaon, Alwar
Agriculture Research Station, Keshwana, Jalore
Agriculture Research Station, Mandor, Jodhpur
Agriculture Research Station, Hanumangurh
Agriculture Research Station, Tabiji, Ajmer
Agriculture Research Station, Kotputali, Jaipur
Regional Agriculture Research Station, Diggi, Tonk
Agriculture Research Station, Udaipur
Agriculture Research Station, Ummedganj, Kota
Horticulture And Forestry Agriculture Research Sub-station, Khanpur, Jhalawar
Agriculture Research Station, Bokhat Farm, Banswara
Agriculture Research Sub-station, Pratapgurh
Agriculture Research Sub-station, Aklera, Jhalawar

- Integrated nutrient management
- Organic farming
- Genetic manipulation of adopted spices for quality upgradation
- Marketing management
- Generation of skilled man power

References

Anonymous (2011), Report of Joint Inspection Team in its Visit to Rajasthan during 05-09 January, 2011, National Horticulture Mission, Ministry of Agriculture Department of Agriculture & Cooperation, Krishi Bhavan, New Delhi.

Anonymous (2016). Report of the Expert Committee on Rajasthan Agriculture. *Government of India*.

Anonymous (2019a). *Indian Horticulture Database*, 2019. Published from National Horticulture Board, Gurgaon, 1.

Anonymous (2019b). Economic Reviews 2018-19, Directorate of Economics and Statistics, Rajasthan, Jaipur.

Singh, J., (2014). ***In***: *Basic Horticulture*, Kalyani publishers, Ludhiana,337.

Singh, J., Yadav, P.K., Verma, I.M. and Sudarsan, Y. (2005). ***In***: *Stratagies for sustainable fruit production in fragile agro-ecosystem of arid region*. Winter School Compendium, 60.

Singh, R.P., 2016. In: *Sustainable development of dryland agriculture in India*. Scientific Publishers (India), 61.

Swain, M., Patel, R. H. and Ojha, M. (2011). *Impacts of National Horticulture Mission Scheme in Rajasthan* (No. 142). *Research Report*, 5.

LEAD LECTURE – 52

Present scenario, challenges, opportunities and prospects for horticulture development in Uttarakhand

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Uttarakhand is primarily hilly State with only about 10 per cent of its total geographical area in the plain areas (Haridwar, Udham Singh Nagar and some parts of Dehradun and Nainital districts), while the remaining areas of the State are hilly. Further, more than three fourth (78%) of its total population depends on agriculture and horticulture for livelihood. Horticulture which includes fruits, vegetables, spices, tubers, ornamental plants, medicinal & aromatic plants, mushroom and plantation crops has emerged as vital for the socio-economic development of the State, and across the globe to ensure the nutritional security, environmental services, employment generation, health care and above all effective and productive land use.

Horticulture scenario in uttarakhand

Horticulture plays a vital role in the economic development of the State. The creditability of horticultural sector including fruits, vegetables, floriculture, spices, tea and medicinal & aromatic plants; mushroom, bee-keeping has been well established in improving productivity of land, generating employment, improving socio-economic conditions of the farmers and entrepreneurs, enhancing exports and above all providing nutritional security to the people. The major horticultural crops are apple, pear, peach, plum, apricot, mango, litchi, citrus fruits, aonla & guava and off-season vegetables such as tomato, pea, cauliflower, cabbage and capsicum. Spices including ginger, turmeric, garlic and chili are also grown at large.

The climatic conditions of the hills are most suitable for the growth and development of not only the various types of quality apples but also a variety of other fruits including pear, peach, plum, apricot, cherry, kiwi, strawberry and various varieties of wild herbs. The weather conditions are conducive for production of off-season vegetables and potato making it possible for them to be sold at very competitive prices.

Out of the total geographical area of 53.48 lakh hectares of the State, about 7.01 lakh hectares of land is under agricultural crops and about 2.93 lakh hectares area is covered under the horticulture crops. Annual turnover of Horticulture crops in the State is approximately Rs. 3200 crores and Horticulture sector has more than 30 per cent contribution in the State's agriculture sector's Gross Domestic Product.

Classification of state according to various agro-climatic conditions

The climate of the State varies according to the elevation. It can be divided into four agro-climatic sub-regions as indicated in Table 1.

Table 1. Classification of state according to various agro-climatic conditions

Zone	Farming situation	Soil	Rainfall (mm/year)	Districts	Crops
Zone A up to 1000 m	Tarai irrigated	Alluvial	1400	U.S. Nagar and Haridwar	All seasonal vegetables, spices, mango, guava, aonla, litchi, pomegranate and lime
	Bhabar irrigated	Alluvial mixed with boulders and shingles	1400	Nainital, Dehradun and Pauri	All seasonal vegetables, potato, spices, mango, guava, aonla, litchi, pomegranate & citrus.
	Irrigated lower hills (600-1000 m)	Alluvial sandy soil	2000-2400	Champawat, Pauri Dehradun, Nainital, Tehri	All seasonal vegetables, potato, spices, mango, guava, aonla, litchi, pomegranate, citrus, plums & peaches.
	Rain-fed lower hills (600-1000 m)	Residual sandy loam	2000-2400	Champawat, Pauri, Dehradun, Bageshwar, Nainital, Chamoli, Rudraprayag, Tehri	Potato, tomato, other seasonal vegetables, spices, mango, aonla, guava, pomegranate & citrus.
Zone B 1000-1500m	Mid hills south aspect (1000-1500 m)	Sandy loam	1200- 1300	Champawat, Nainital, Almora, Bageshwar, Dehradun, Tehri, Chamoli, Rudraprayag, Uttarkashi	Off-season vegetables, citrus, stone fruits, peach, plums, walnut and other nut fruits.
	Mid hills (North-East) (1000-1500 m)	Sandy loam	1200- 1300	Champawat, Nainital, Almora, Dehradun, Tehri, Bageshwar, Chamoli, Rudraprayag, Uttarkashi	Off-season vegetables, potato, pear, stone fruits, pomegranate, apple and peach.
Zone C 1500-2400m	High hills (1500-2400 m)	Red to dark	1200- 2500	Pithoragarh, Nainital, Almora,, Bageshwar, Champawat, Pauri, Chamoli, Tehri, Rudraprayag, Uttarkashi	Off-season vegetables, potato, peaches, plums, pomegranate, apple and peach.
Zone D >2400 m	Very high hills (2500–3500 m))	Red to dark Black clay	1300	Pithoragarh, Chamoli, Uttarkashi	Off-season and European vegetables, potato, apple & cherry.

Horticulture production statistics

Fruits, vegetable, spices and flowers

The area under horticultural crops has increased from 1.17 lakh ha in 2002-03 to 2.93 lakh ha in 2017-18 and production increased from 8.90 lakh MT (2002-03) to 17.55 lakh MT during 2018-19. Among this, fruit production is 6.64 lakh MT within an area of 1.80 lakh hectare, vegetable production is 6.30 lakh MT within an area of 0.71 lakh hectare, potato production is 3.64 lakh MT within an area of 0.26 lakh hectare, spices production is 0.94 lakh MT within area of 0.14 lakh hectare while flowers are cultivated in 1562 hectare area with production of 3017 MT loose flowers and 18.63 crore spikes of cut flowers. However, demand for fruits, vegetables, flowers and spices are increasing much faster than growth in production. Moreover, matching investment in infrastructure for value addition particularly cold chain and processing has not been resulting in avoidable wastages/value loss up to 30 per cent of the production volumes.

Bee keeping

Facing the majestic snow-covered peaks of Mt. Chaukhamba in Garhwal Himalayas of Uttarakhand is situated a fairly large town known as Guptakashi (Rudraprayag) which has emerged a major hub for beekeeping business in the State. The region, blessed with densely populated flora and fauna, attracts *Apis cerana indica*, commonly known as Indian honey bee. These indigenous species of honey bees are considered as relatively non- aggressive and rarely exhibit swarming behavior, which makes them ideal for bee keeping. During 2018-19, about 6,162 bee-keepers produced 2,116 MT of honey through 71, 808 bee-colonies, which include both *Apis cerana indica* and *Apis mellifera.*

Mushroom

The State due to its geographical location and climatic conditions makes it highly suitable for mushroom cultivation. Currently the State is producing three commercial varieties of mushroom – Button, Oyster, and Milky. All of these can be produced round the year in succession. In the year 2018-19, the total mushroom production of the State was 13,375 tonnes. The cultivation of Button Mushroom under controlled condition is being done by the farmer successfully with a range of 100 kg per day to 6000 kg per day. Since mushroom cultivation is an indoor activity, it doesn't suffer from the negative impacts of intense climatic conditions and wild animal attacks. Besides, this activity can become a good source of livelihood for women, who can carry it out within the house premises and contribute significantly to the State's vision of Doubling of farmers' income by year 2022.

Opportunities and challenges for horticulture development in Uttarakhand

Horticulture has proved boom for the hill states of the country where it holds much more potential than traditional field crops. Crops suitable for temperate and sub-temperate climate have far more demand than production due to availability of limited land with specific conditions. On the other hand, demand for such fruits and vegetables are increasing very fast due to changing profile and preferences of consumers of the urban areas. Since, State of Uttarakhand situated in the North - Western Himalayan region consisting of mountainous tracks with elevation ranging from 350–7816 m above mean sea level has suitable agro climatic conditions for growing sub-tropical and temperate crops and is well placed to take advantage of demand side opportunities. Horticulture is the major activity covering sizeable arable area of the State. Pome fruits (apple and pear) are the major fruit crops grown in the State followed by walnut, stone fruits *etc.* The State ranks at number one in production of pear, peach, plum and apricot, second in walnut and third in production of apple in the country. The State has taken lead in grading and packing of apple. Marketable surplus fruit is sold in corrugated cartons in well-defined grades. However, there is ample scope for setting up of industrial units for primary/minimal processing, juice concentrate, jams, jellies and marmalades. It is pertinent to note that State horticulturists have preferred to remain the suppliers of primary products rather than diversify into value-added finished products.

It is realized that with the existing kind of marketing infrastructure and other facilities, it is difficult for the stakeholders to harness opportunities at competitive prices while maintaining the quality throughout the supply chain during lean period. Hence, a need was felt for strong backward and forward integration for product availability, developing procedures and systems in both infrastructure and manpower to meet the world standards. While studying the supply chain of important fruits and vegetables in Uttarakhand, the biggest hurdle noted was to procure the commodities at the right price and quality. Many constraints have been identified and to strengthen its position, aimed at following:

- Development of innovative technology including cool chain, handling, transportation, storage *etc.* to increase availability by minimizing post-harvest losses.
- Formulation of conditions for development of markets and marketing infrastructure including e-marketing and assessment of trading performance.
- Application of International codes and standards (CODEX, HACCP and E/U standards) for food safety and quality assurance.

Issues of concern for supply chain development

- Good agricultural practices for production of high quality raw material
- Safe, damage free harvest, transport and handling practices devices
- Maintenance of high quality during storage
- Cost effective utilization of processing waste & by-products
- Packaging having international safety
- Private investment in processing, market infrastructure, market developments and contract farming
- Policy and regulatory framework for processing, safety, quality, traceability, public-private-partnership
- Linking of horticulture markets for transparent market information
- Minimize risk of the farmers

Another National issue in the supply chain is the inadequate post-harvest infrastructure, lack of knowledge & skill which causes about 20-30 per cent loss in horticulture produce. Post-harvest management does not only mean reducing waste but also maintaining the standard and prolonged availability of quality produce. The extent of losses of fruits and vegetables varies from highly perishable to perishable fruits and vegetables. The major causes of loss are improper handling, poor packing, improper storage, uncontrolled temperature, road block due to heavy rain *etc.*

In Uttarakhand, the producers' share in consumer price is very less in case of perishable produce and the major share goes in the hands of market intermediaries due to inefficient supply chains. Therefore, supply chain management may be a powerful tool in linking farmers directly to the markets to achieve better returns. Supply chain development not only benefits the private sector but also creates spin-offs that stimulate social, economic and environmental sustainable development in the region (employment generation, value addition and decreasing the loss percentage). Public support (*e.g.* development of the institutional infrastructure) plays an important role to create an enabling environment for supply chain development. Such support might take the form of a public-private partnership in a supply chain to share experiences, risks and bottlenecks.

Opportunities

Robust domestic demand currently being met through imports

The demand for fruits and vegetables are increasing very fast due to changing profile and preferences of consumers of the urban areas. Due to limited cultivable land and other factors, it is not possible in present situation to meet the consumer demand. As a result India is importing different fruits which include apple, nuts and stone fruits. Import of apple alone has touched about 1 million MT (approx. 40% of India's production) and is growing at an annual rate of 15 per cent. Similarly, demand for nuts is also increasing very fast and India is importing more than 150 thousand MT of nuts.

Suitable agro-climatic conditions for growing horticulture crops

Horticulture crops suitable for temperate and sub-temperate climate have far more demand than production due to scarcity of limited land mass having such favorable climatic conditions. The State has the right type of agro-climatic conditions for growing sub-tropical and temperate crops. Therefore, it is well placed to take advantage of demand side opportunities.

Increased income and creation of employment opportunities

Horticulture can address many important issues faced by the State. It can increase farmers' incomes and generate ample employment opportunities.

Challenges

The State faces a number of sectoral, institutional and policy challenges which need to be addressed more systematically if the full potential is to be realized and translated into sustainable development impacts. These include:

Climate change impact

According to the Inter-governmental Panel on Climate Change (IPCC) global average temperature may increase between about 0.15 and 0.3^{0}C per decade from 1990 to 2005 and continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system. The effects of climate change on crop and food production are already evident in several regions of the world. Uttarakhand is most vulnerable to climate-mediated risks and has shown 'above average warming' in the 20th century. In Uttarakhand, available evidence of vulnerability and risk assessment of the agri and horticulture sector suggests – (i) More than half of the agriculture land in the hill districts of the State are prone to drought, (ii) Increases in the frequency of droughts and cloud blast are likely to affect production negatively, especially in subsistence sectors, (iii) higher night temperatures may increase the dark respiration of plants, diminishing net biomass production, (iv) the productivity of most crops will decrease due to increase in temperature and decreased water availability, (v) spatial changes in the diversity of tropical/sub-tropical crops (maize, rice, *etc.*) and spatial changes in the diversity of temperate crops (apple, cabbage, cauliflower, carrot, potato), (vi) present (agro) ecological zones could shift in some cases over hundreds of kilometres.

Lack of infrastructure

Poor road connectivity in the hilly areas and insufficient warehouses/cool storage units results in up to 30 per cent loss of production volumes. Modern infrastructure for post-harvest management is lacking. Most of the processing plants are located in the foothills of State due to lack of modern infrastructure and unskilled labour. In hills, without adequate irrigation infrastructure, the agriculture is heavily dependent on inconsistent rainfalls which results in low productivity.

Limited access to appropriate production technologies

Limited access to appropriate production technology including elite planting material, leads to low productivity. There is lack of awareness about modern farm machinery.

Insufficiently developed water management systems

The State's horticulture is almost entirely dependent on rainfall despite available water resources, challenging research system and extension services leading to inappropriate horticulture practices.

Lack of market facility

Small farmers in a market-oriented agribusiness get further marginalised mainly due to the dominance of mandis, a chain of well-organised intermediaries who control the entire process, trading & facilitate the farmers by credit supply for farm inputs, transportation , marketing of produce as well as urgent family needs of farmers.

Addressing these constraints to horticulture development will require a predictable and supportive policy environment for private sector development, better access to product and input markets, and improved farmer's access to horticultural extension services and financial services. Horticulture can address many issues being faced by the State. It can increase farmers' incomes, generate employment and add value to increase overall share in the GDP and ultimately minimize the migration from the hills.

Government schemes for horticulture development

Table-2 indicates the list of on-going schemes and programs in horticulture and agriculture sector from Central and State support.

Technological interventions for development of horticulture

The farmers of Uttarakhand were encouraged to shift from cultivation of cereals to the cultivation of horticulture crops as this sector has vast potential. The development of horticulture also depends on the presence of various kinds of infrastructure, value added activities, collection and transport of the produce to the market. Horticulture produce are of perishable nature which leads to the necessity of a network of warehouses and cold storages.

The incentives that State gave to the small farmers to shift towards horticulture production resulted in the development of this sector. The State provided the farmers subsidy for setting up of nurseries, distribution of planting material, vegetable seed production, area expansion, rejuvenation

Table 2. Government schemes for horticulture development

Scheme Name	Assistance pattern/Subsidy
Mission for Integrated Development of Horticulture (MIDH)	❖ Production of Planting material ❖ Hi-tech nursery (4 ha) of Rs. 25.00 lakh/ha (50% subsidy) ❖ Small Nursery (1 ha) of Rs. 15.00 lakh/ha (50% subsidy) ❖ Upgrading nursery infrastructure (Up to Rs. 10.00 lakh/ nursery of 4 ha) (40% subsidy) ❖ Strengthening of existing Tissue Culture (TC) units of Rs. 20.00 lakh /unit (50% subsidy) ❖ Setting up of new TC Units of Rs. 250.00 lakh/unit (40% subsidy) ❖ Seed production for vegetables and spices ❖ Open pollinated crops of Rs. 35,000/ha (50% subsidy) ❖ Import of planting material of Rs. 100.00 lakh (100% subsidy for public sector) ❖ Seed infrastructure of Rs. 200 lakh (50% subsidy) ❖ Establishment of new gardens (Area expansion upto 4 ha per beneficiary) ❖ Cost intensive crops a. Fruit crops like Grape, Kiwi, Passion fruit *etc.* (50% subsidy) b. High density planting (mango, guava, litchi, pomegranate, apple, citrus etc- (50% subsidy) ❖ Fruit crops other than cost intensive (50% subsidy) ❖ Vegetable (For maximum area of 2 ha per beneficiary) (50% subsidy) ❖ Mushrooms (Production unit of 20 lakh /unit, Spawn unit of Rs. 15 lakh/unit (40% subsidy) ❖ Flowers (For a maximum of 2 ha per beneficiary) (50% subsidy) ❖ Spices (For a maximum area of 4 ha per beneficiary) (50% subsidy) ❖ Aromatic Plants (For a maximum area of 4 ha per beneficiary) (50% subsidy) ❖ Creation of Water resources (50% subsidy) ❖ Poly house (Fan Pad and Naturally Ventilated) (50% subsidy) ❖ Shade Net House (Tubular structure of Rs. 710/Sqm and Rs. 816/Sqm for hilly areas ❖ Anti Hail Net of Rs. 35/Sqm.- 50% of cost limited 5000 sq.m. per beneficiary. ❖ Plastic Tunnel of Rs. 60/Sqm and Rs.75/Sqm for hilly areas.- 50% of cost limited 1000 sq.m. per beneficiary. ❖ Horticulture Mechanization (35 to 50% subsidy) ❖ Bee Keeping (40% subsidy) ❖ Promotion of Integrated Nutrient Management (INM) Integrated Pest Management (IPM) (50% subsidy) ❖ Integrated Post Harvest Management and Marketing (35% to 55% subsidy) ❖ Establishment of Food Processing Unit (50% subsidy). ❖ Human Resource Development (100% subsidy).
Pradhan Mantri Krishi Sichai Yojna (PMKSY)- Per Drop More Crop	❖ Assistance for installation of micro irrigation system (45% subsidy for large farmers and 55% for small, marginal and women farmers).
Paramparagat Krishi Vikas Yojna (PKVY)	❖ Adoption of Participatory Guarantee System (PGS) certification through cluster approach ❖ PGS Certification and Quality control ❖ Adoption of organic village for manure management and biological nitrogen harvesting through cluster approach ❖ Integrated Manure Management
Revised Weather Based Crop Insurance (WBCIS)	❖ 13 horticulture crops covered *viz.* Apple, Mango, Malta, Orange, Mausami, Litchi, Tomato, Ginger, Potato, French bean, Pea & Chilli. ❖ Hail storm covered in apple. ❖ 5% farmers share as a premium.

of old and senile orchards, creation of community and individual water sources, protected cultivation (especially anti hail net to protect fruit damage), INM/IPM, organic farming, pollination support through bee keeping, promotion of mushroom cultivation, mechanization, training of farmers and officials, awareness campaign, post harvest management and marketing are taken up. PHM components include on farm handling units, cold storages, CA storages, pre-cooling units, ripening chambers, primary processing / value addition units, refrigerated vans, rural markets, whole sale & terminal markets, functional infrastructure for collection, sorting, grading packing, establishment of horticulture produce based new processing units, modernization and up-gradation of existing units are taken up.

Pre-harvest interventions

Adoption of best practices.-Innovative Hi-Tech horticultural practices under **HMNEH** scheme:

- To ensure the quality planting material established 123 nurseries in public sector (52) and private sector (71).
- For Establishment of new orchards under cost intensive, high density and normal plantation of fruits an area of 38558 ha has been covered.
- Area expansion under vegetable of 23325 ha, spices of 9507 ha and flower of 2694 ha have been covered.
- Rejuvenation of old and senile orchards for enhancing production. Under this 14952 ha orchards of different crop were rejuvenated.
- Total 3876 tube wells / ponds have been established to ensure water availability.
- An area of 14400 ha has been covered under micro irrigation (drip/sprinkler) for judicious use of available water.
- An area of about 12.00 lakh sqm under Poly house, 80,000 sqm under Shade net house, 30.00 lakh sqm under Anti hail net and 4031 ha under plastic mulching have been covered under protected cultivation.
- Total 4068 vermi compost unit and 1245 HDPE vermibed have been established on farmer field for promotion of organic farming.
- Under mechanization component, 5614 tools/machine have been distributed to farmers.

Cluster approach

At present there are 1050 clusters in the 13 districts of the State including clusters of fruits, vegetables, spices and flowers, which cover 6563 villages and around 27564 ha. area.

Post-harvest interventions

- There must be equilibrium between pre & post harvest activities; otherwise desired return of the farmer produce cannot be realized. Keeping in view the importance of post harvest activities, 302 pack houses, 18 cold storages, 04 CA Storages, 22 Cold Chains, 04 refrigerated transport vehicles, 03 ripening chambers have been established.
- To ensure the quality produce to consumer at reasonable price 05 collection, sorting/grading, packing units have been established.

- Very limited processing facility was available at the time of creation of State in the year 2000 consuming only 1per cent of horticultural produce in processing at that time. As the production increased, number of processing unit also increased and reached up to 402 units till 2019. Now these units are consuming more than 10% of Horticultural production.

Recent initiatives

1. **Attracting investment opportunities in horticulture and allied sector:** Uttarakhand Investment Summit – 2018 was organized in the State during 7-8th Oct, 2018 to attract the investment in horticulture sector (establishment of hi-tech nursery, mushroom, bee keeping and horticulture based food processing *etc.*) worth Rs. 2299 crore, which would cater the growth of horticulture sector in the State
2. **Horti-tourism:-**The State of Uttarakhand is blessed with pleasant climate, natural beauty, major snow peaks of Himalaya, with rich fauna & flora along with well developed orchards of apple and other temperate fruits, which attract the people to visit as they really want to enjoy such beautiful and peaceful places. Hence Horti-tourism is another important component to generate additional income by doing horticulture. To promote the Horti-tourism operations for the purpose of visit of tourists, working horticultural farms/ villages (fruit orchards or vegetable gardens or ornamental gardens) with hospitality will be developed in the State.
3. **Promoting organic horticulture:** Government has declared 10 blocks of different districts of the State for the promotion of organic farming. Under Paramparagat Krishi Vikas Yojna (PKVY), 1206 new clusters of vegetables, spices, flowers and fruits have been identified, which cover 24120 ha area of the State. This will enhance the area under organic horticulture in the State promoting health and environment friendly production of horticultural crops.
4. **Infrastructure support from NABARD:** Recently NABARD has sanctioned 03 Integrated Pack House in Chamoli, Dehradun and Nainital districts with modern facilities of collection, sorting, grading and packing for horticulture produce under Warehousing Infrastructure Fund (WIF) scheme. Another project for the establishment of Controlled Atmosphere (CA) Storage for Apple is being proposed in Aarakot, Uttarkashi district. Besides, 13 projects for strengthening of irrigation facilities in the Government Gardens has also been sanctioned by NABARD under Rural Infrastructure Development Fund (RIDF) scheme. This will result in socio-economic upliftment of farmers in rural hilly areas of the State.
5. **Marketing of horticultural produce:** For the promotion of marketing of horticultural produce including floriculture, mushroom and bee keeping, Uttarakhand Horticulture Marketing Board has been setup by the State Government. The Board is involved in the declaration of Minimum Support Price (MSP) of Apple, Pear and Citrus *etc.* Besides, for promotion and branding of horticulture produce various festivals / exhibitions and buyer-seller meet are also being organized.
6. **Uttarakhand integrated horticulture development project (UKIHDP):** Uttarakhand Integrated Horticulture Development Project (UKIHDP) has recently being prepared by the Department of Horticulture and Food Processing following intensive consultations with all stakeholders, and its interventions are geared towards attracting private investors and promoting professional producer organizations. The project is under process for sanction from suitable external agency. The total financial outlay of the proposed project is Rs. 700.00 crore. The proposed project

would harness the potential of the state by production enhancement of high value crops, establishing market linkages and value addition through efficient post- harvest management and processing. The overall goal of the project is to holistically enhance production, productivity, processing and market access of selected horticulture commodities on small and marginal landholdings and support agro-entrepreneurs in Uttarakhand thereby improving the socio-economic and environmental benefits for the State.

Conclusion

The land available in the State cannot be increased but due to intervention of innovative technology, production and productivity can be increased to a greater extent. Furthermore, the diligence of post harvest management and processing will increase availability of horticulture produce, even during lean period. Horti-tourism may provide an income stream to overcome the family property and opportunities for succeeding generations. Further we can say horti- tourism, value added approach before harvest may strengthen farmers economically. Besides, Pre and Post harvest management activities is being executed with convergence of State sector and Central sector schemes *i.e.* HMNEH, PMKSY (PDMC), RKVY, PKVY, MNREGA, Pradhan Mantri Kisan Sampada Yojana and other related EAP (Externally Aided Projects) schemes like Ajivika. Some other initiatives are also taken in this sector to enhance the production, productivity, post harvest management and marketing. Some recent initiatives like Uttarakhand Integrated Horticulture Development Project and invitation of investment in Horticulture through Uttarakhand Investment Summit organized in 2018 in the State are also undertaken. Recently the Government has passed Uttarakhand Fruit Nursery (Regulation) Bill 2019 for regulating the production of quality planting material of fruit crops in the State, which will soon become an act and result in availability of good quality planting material for the orchardists of the State. These approaches may play a vital role in enhancement of production, productivity, reduction of post harvest losses, generation of employment and revenue which would be helpful in reducing the rate of migration of unemployed youth from the hilly areas of the State.

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Technological interventions for sustaining hill horticulture under changing climate

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Since ancient agriculture is one of important sector for livelihood security of the human being all over the world. The major source of economy and sector of sustainability of the country like India is agriculture. About 60 per cent Indian population still depends on agriculture for their livelihood security. The people involved in agriculture felt in security due to changed climatic condition, fluctuation in prices, unavailability of proper and quality inputs in time, biotic and abiotic stresses, unorganized marketing, high inputs cost and low price of the produce, no certain and continuous income, *etc.*

Now a days many other sectors like electronics, automobiles, machinery, medical, tourism, housing, constructions, designing and mining, *etc.* are coming up very fast, which are not only glamorous and fascinate, attracting all the people especially youth. The people are relying on these sectors because of certainty in income and future security.

India has been bestowed with diverse climate flora and fauna and physio-geographical conditions and as such is most suitable for growing various kinds of agricultural and horticultural crops. Horticulture sector provides employment opportunities across primary, secondary and tertiary sectors as well as livelihood security. This sector also enables the population at large to enjoy with variety of fruit, vegetables, spices, flowers, medicinal and aromatic plants and balanced diet for healthy living. The sector has gained prominence over the last few years in terms of economy and production. The horticultural production has placed India among the foremost countries, next to China. India is largest producer, consumer and exporter of spices and also the largest producer of mango, banana, papaya, coconut, arecanut and cashew nut in the world. Significant progress in area and production has been made in horticulture resulting in higher production. Over the last decade, the area under horticulture grew by 2.6 per cent per annum and annual production increased by 4.8 per cent. During the year 2017-18, the production of horticultural crops was 311.71 m.t. from an area of 25.43 m.ha. The horticulture sector in India is characterized by small and segregated farms with low yield per unit area and huge post-harvest loses, owing to outdated package of practices and poor adoption of climate resilient technologies.

The world economy has adversely been influenced by extreme weather conditions *viz.*, hot and cold waves, droughts, floods, hailstorm, avalanche, thunder clouds, landslides associated with lightning and rise of sea level as well as natural calamities, such as earthquake, tsunami and volcanic eruption may responsible for the change of chemical composition of atmosphere (IPCC, 2013).

Horticultural crops particularly fruit and vegetable crops are relatively resilient to the climate change. Vegetables are mostly grown by small and marginal farmers and augment the income of the farmers. The technological change has been major driving force for increasing horticultural and agricultural productivity and promoting development of these sectors.

The knowledge about the impact and consequences of climate change on horticultural crop is limited. The issues of climate change and solution thereof requires thorough analysis, advance planning, technological interventions and improved management.

Implication of climate change in horticulture

Two major parameters of climate change that has far reaching implications on agriculture in general and horticulture in particular are more erratic rainfall patterns and unpredictable hightemperature spells will consequently reduce the crop productivity. Latitudinal and altitudinal shifts in ecological and agro-economic zones, land degradation, extreme geographical events, reduced water availability, rise in sea level and salinization are postulated (FAO, 2004).

According to Datta (2013), the climate will have many impacts on horticultural crop production, productivity, quality and development, few are mentioned below:

- There would be some/new areas which are presently unsuitable for some/certain horticultural crop may become suitable for certain horticultural crops like spices, vegetables, *etc.*
- Rise in temperature may not show much variation in photoperiod, hence production timing may change which results faster maturity of photosensitive crops.
- The reduction in winter regime and chilling hours in temperate regions affect the temperate crops; as a result the temperate horticultural crops like apple will shift to the higher altitude as rise in 1^{0}C temperature the apple crops shifted to 100 m above.
- The requirement and frequency of irrigation will increase.
- The heat unit requirement will achieve in much lesser duration.
- Floral abortions, flower and fruit drop will be more and occurred frequently.
- Higher temperature and high humidity invites many/new strains of pests and pathogens.
- Higher temperature affect the tuberization in potato, fruit setting and fruit quality in tomato, capsicum, *etc.*, bolting in crucifers and onion, anthocyanin production in apple and capsicum.
- Coastal region can expect much faster percolation of sea water in inland water tables causing more salinity.

Technological interventions to be adopted to sustain the hill horticulture

Numbers of useful cost effective technologies are available to sustain the hill horticulture. Some of the technologies developed by ICAR-Central Institute of Temperate Horticulture are listed below.

Technologies

- High and medium density orcharding with suitable varieties in apple (Modified Centre Leader, Espalier System, Vertical axis system); almond, apricot and pech (Y-Trellis in peach).
- Drip irrigation, fertigation, rainwater harvesting and moisture conservation in apple and almond.
- Rejuvenation of old apple and almond orchards through pruning, nutrient and pest management.

- Production of quality corms of saffron and gladiolus and plug plant production in Fuchsia.
- Suitable intercrops, pollinizers and pollinators for higher fruit set and yield and early farm income in almond and apple.
- Floral biology, pollination and pollinizer requirement in walnut.
- Low cost efficient vegetative propagation techniques in walnut through wedge grafting and chip budding under low cost polyhouses and cuttings in apple and pomegranate using PGR.
- Varieties/hybrids and production technologies for protected cultivation of tomato, cucumber, capsicum, broccoli, chinese cabbage, lettuce, parthenocarpic cucumber, cherry tomato, strawberry, gladiolus, gerbera, carnation and alstroemaria.
- Technologies for organic baby corn production using vermicompost + biospirillum + biophos + biopotash.
- High Density Planting System in Apple, peach, plum.
- Training, pruning system in tomato, capsicum, cucumber under polyhouse.
- Intercropping of pea & cauliflower under apple orchards.
- 'Integrated Nutrient Management' in High Density Planting apple plantation under different mulching
- Organic agro techniques for peach under HDPS (VC + mycorrhiza ; Nadep + mycorrhiza; FYM + mycorrhiza)
- Cost effective production technology (Low cost polyhouse) for cut flower production in carnation (cv. Niva, Master, Crimson Tempo; NPK-15 : 10 : 10 + 600 gm VC & 20 x 30 cm spacing)
- Budding/grafting time in walnut under polyhouse (Feb-March:- Chip budding - 80.8 per cent; Tongue grafting- 70.5 per cent; Wedge grafting – 76.5 per cent.
- Cost effective organic growing media such as soil, FYM, vermicompost, forest litter along and their combinationsfor raising veg. seedlings of tomato, capsicum, cucumber, broccoli, Chinese cabbage and lettuce.
- Developed crop diversification technology for round the year vegetable production under protected condition in mid& high Hills of UK. In High hills, capsicum provided profit of Rs. 31735.00 (BCR - 9.20) / 200 sq.mt.andLettuce gave worth ofRs. 10905.00 (BCR-3.70) / 200 sq.mt.Likewise, in mid hills the capsicum crop gave a profit of Rs. 12105.50 with B:C ratio of 3.51 was on the top / 200 sq.mt. and lettuce returned an amount of Rs. 9231.00 (BCR-3.13)/ 200 sq.mt.
- The technologies for enriched and dispersible vermiballs and vermibars.

Varieties identified/standardized/developed

Besides above technologies, some crop and varieties have also been developed/ standardized for sustaining the hill horticultural crop production. In tomato (VL-4, CITH-M-T-5, Badshah), Cherry tomato (Pusa Cherry-1, CITH-M-CT-2,4,6), French bean (CITH-M-FB-1, VL-Bean-2), Garden Pea (VL-7, 10, 11, 13),, Capsicum (Hybrids Bharat, Orebelle, Bombay, KT-1, CITH-M-SP-4, VLSM-3),Parthenocarpic cucumber (PC-1, 3), Cucumber (Japanese Long Green, Pusa Sanyog), Garlic (CITH-M-G-1), Broccoli (KTS-1), Chinese Cabbage (Solan Band Sarson),Lettuce (Ice Berg, Lolla Rosa), Apple (CITH LodhApple-1, Starkrimson, Crimson Gold, Chaubatia Anupam, Red Spur, Skyline Supreme, Oregon spur, Red Chief, Red Gold, Vance Delicious, Silver Spur, Mollish Delicious, Bhura Delicious, Tydman's Early Worester, *etc.*),Peach (Red June, Red Nectrine, Florda King, Paradelux, Sharbati),Plum (Santa Rosa, Satsuma, Kajegi,); Apricot (CITH-A-1, 2, 3; Hercot, Afgani, K.S.-1, A.S.-1, A.S.-2,Kiwi fruit (Allison, Haward, Abbott, Tomari), walnut (CITH-W 1 to 10,Opexcultury, Suleiman), cherry (CITH-C-1 & 2).

Besides also standardized exotic vegetables under Kumaon hill conditions (Broccoli cvs. KTS-1, Palam Harita; Parsley cv. Moss Curled; Knolkhol cv. Winner; Snow pea cv. MithiPhali.

Post-harvest management practices and value added products

To overcome the problem of post-harvest losses, following technologies were developed and standardized.

- Maturity indices for important apple varieties.
- A low cost technology for making osmo - dehydrated products of apricot, cherry, rose hip and cape gooseberry including packaging (apricot, cape gooseberry and plum fruit bar; cape gooseberry fruit jam).
- Technology for improving shelf life and retention of quality of peach, apple and cherry using semi-permeable film, Aloevara gel coating and by use of different chemical treatment.
- Technology for minimal processing and value addition of exotic vegetables for storage and quality maintenance.
- In apricot and plum, a quality fruit bar was prepared having excellent texture, color, aroma, taste, chewing quality, non-sticky attributes with least browning and spoilage which can be stored up to nine months without loss in quality, nutrition and appeal
- Technology for preparation of squash by blending in different ratios of underutilized fruits like Rhododendron + Galgal + Ginger.
- In gerbera, cultivars Dune, Winter Queen, Dana Ellen, Carambola and Kayak were identified for commercial cut flower production on the basis of improved floral attributes, vase life and minimal stem bending incidence.
- In minor fruits, processing technology for making novel value added products of cape gooseberry (jam, jelly, sauces and dehydrated products) and mulberry (jam and jelly)

Pests and pathogen management

The technologies for pest and pathogen management have also been developed/standardize to reduce crop pest load to sustain the hill horticulture as listed below:

- Integrated management module for control of Fusarium wilt in chilli, Phytophtora fruit rot of tomato, corm rot of saffron and IDPM module for protected cultivation of tomato, cucumber and capsicum.
- In apple management of red mites through miticides, scab by fungicide kresoxim methyl and canker by AM fungi (*Glomus* sp.).
- Spray schedule against major canker and foliar diseases of apple in Uttarakhand.
- Management package for major soil borne diseases of apple in Uttarakhand.

- Studied efficacy of *Arbuscular mycorrhiza* in controlling the brown stem canker & survivability of MM106 root stock of apple.

Quality planting material production

To expand the area under improved crop/varieties, the production and multiplication of quality seed and planting material is also under taken and in this regard.

- Established root stock and bud wood banks of elite commercial varieties of apple, almond and walnut with virus indexing facility.
- Established bud wood bank and mother block of apple, peach, plum, kiwifruit, almond, walnut, apricot, pear, strawberry, besides, grape, olive, pomegranate, *etc.*
- Besides also maintained and multiplied important clonal rootstocks of apple (MM.106, MM.111, M.9, EMLA-106, M-26, M-27, ANLARP, B-9, *M. baccata, M. sargentii, M. sikkimensis, M. floribunda, M. microcarpa, M. simcoe, M. purpuria, M. mandscurica, M. eseltine, M. prunifolia, M. robusta, M. orientale, M. crimson brilliant, M. sieboldii)* and cherry (Mazzard, Mahaleb, Colt). Apart from it the truthful level seeds of vegetable crops are also produced to supply to the farmers/indenting agencies.

Technological interventions strategies

There is need of technological intervention for sustaining the horticultural crop production in general and temperate horticultural crops production in particular under changing climate. Some of the strategies are to be adapted as listed below:

- Water harvesting including rain water harvesting, conservation, recycling and efficient utilization to be taken priority.
- Soil health management through organic and bio inoculant/farming and efficient nutrient management are the need of the era.
- Conservation and integrated farming system approach including integrated nutrient, pests and pathogen, weed management practices are important approaches for sustainability.
- Crop rotation, intercropping, multiple cropping, mixed cropping and relay cropping system are still sustainable cropping systems.
- Integration of ITKs with scientific and recent/advance production and post-harvest management technologies can prove sustainable approach under changing climate.
- Efficient use of natural resources in scientific manner.
- Adoption of climate resilient crops, varieties, hybrids, diversification, technologies.
- Use of early maturing, low chill requirement crops and varieties as well as adoption of protected cultivation.
- Adoption of high density planting system and proper canopy management approaches with dwarfing root stock plants in fruit crops particularly in temperate fruit crops.
- Cultivation of low volume high value crops.
- Use of quality seeds and planting materials.
- Expansion of locally adopted/traditional crops/landraces and technologies.

- Zonalization of crops/varieties and area as well as exploration and exploitation of new and potential area.

Strategies for sustaining hill horticulture:

The emphasis should be given on followings to sustain the hill horticulture:

- Introduction and adoption of economically viable crops & technologies.
- Use of quality seeds and planting materials of High Yielding Varieties & Hybrids.
- Zonalization of crop and exploration and exploitation of new/rich areas.
- Crop & Technology diversification.
- Promotion of high value and underutilized/minor/traditional crops/land races.
- Promotion of protected cultivation & precision farming.
- Integration of advanced technologies with Indigenous Technical Knowledge.
- Water harvesting, conservation, and recycling through micro irrigation and in-situ soil moisture conservation.
- Efficient use and recycling of natural & farm resources.
- Reduction in input cost & input production at site.
- Integrated Farming System, Home Stead Faming System, High Density Planting System, Organic farming, Inter space utilization.
- Efficient management of plant nutrients, weeds, insect, pests and diseases.
- Post-harvest Technology& Value addition and organized marketing.

Conclusion

The ecosystems which are most vulnerable to the specter of climate change are high altitudinal mountains such as Himalayas. The Himalayas ranges are youngest and loftiest among the mountain system of the world as stated by Khoshoo (1992). The world highest mountain chain represent a highly complex and diversified system both in terms of biological and physical attributes and is one of the among 34 global biodiversity hotspots. The hill populaces are majorly depending upon biodiversity for their livelihood. But the changing climate destabilizing the system of cozy living of the hill states. The factors like industrial emission, automobile emission, use of fuel wood, house hold emission, burning of crop residues, hydropower, constructions, deforestations *etc.* are most responsible for climate change. The coping range of each horticultural crop is determined by the climate in which it has developed. Hence, there is need to thoroughly understand the potential climate change impact on plant productivity, in order to identify appropriate crop/variety and their management strategies. Horticulture based farming systems have high potential for sequestering carbon for mitigation of climate change. The perennial trees act as carbon sinks by sequestering the atmospheric carbon. There is also need to develop good simulation models for horticultural fruit and vegetable crops. The emphasis should be given on development of production system for improved soil and water efficiency to adapt the hot and dry conditions. Similarly, strategies like changing sowing or planting time, modifying manure and fertilizer application, providing irrigation during critical stages of crop growth and conservation of soil moisture reserves by mulching with crop residues and biodegradable materials and other mulching materials are the most important interventions besides protected cultivation, high density and intercropping system, integrated farming systems with integrated nutrient, weeds, pests and pathogen management as well as crop variety and technology diversification.

To meet the challenges of such changing climatic conditions, many technologies and strategies were developed by researchers, which are also adopted by the farmers and horticulturist. One of the important ways to enhance or improve the genetic tolerance to such stresses by developing tolerant varieties. However, due to insufficient genetic variability in relation to genetic tolerance the breeding for climatic stress tolerance in horticultural crop has remained a slow process. Further, changing the root system through grafting over selected vigorous root stocks is also a significant method of adapting plants to counteract environmental stress and improving tolerance. In nut shell, it could be inferred that development of climate resilient horticultural crops and varieties which are tolerant to extreme weather conditions and stresses appeared due to extreme high and low temperatures, drought and floods, salinity, alkalinity and acidicity, frost and hails, *etc.* and climate proofing through genomics and biotechnology would essentially require, besides production, protection, management practices suited to the crop under changing climate.

References

Anonymous (2004). Impact of climate change on agriculture in Asia and the Pacific. Twenty-seventh FAO. Regional Conferences for Asia and the Pacific. Beijing, China, 17-21. May.

Anonymous (2010-11 to 2018-19). Annual Reports (2010-11 to 2018-19). ICAR-Central Institute of Temperate Horticulture, Srinagar (J&K).

Dutta, S. (2013). Impact of climate change in Indian Horticulture- A Review. *International Journal of Science, Environment*. **2** (4): 661-671.

Irena, R. and Aloni, B. (1994). Flowering, fruit set, fruit development and fruit quality under different environmental conditions in Tomato and Pepper crops. *Acta Horticulturae.* pp. 45-55.

Kanaujia, S.P., Maiti, C.S. (2017). Text Book of Vegetable Production. Today and Tomorrow's Printers and Publishers. pp. 1-345.

Khoshoo T.N. (1992). Plant Diversity in Himalayas: Conservation and Utilization. G.B. Pant Memorial Lecture II, G.B. Pant institute of Himalayan Environment and development. Almora. 1-129.

Kishor, A., Narayan, R., Brijwal, M., Attri, B.L., Kumar, A. and Debnath, S. (2018). Performance of some new apple cultivars for yield and physico-chemical characters under mid-hill conditions of Uttarakhand. *Indian Journal Horticulture,* **75**(1): 8-14.

Kishor, A., Narayan, R., Brijwal, M., Attri, B.L., Kumar, A. and Debnath, S. (2018). Storage behaviour of apple cultivars under ambient conditions. *Indian Journal Horticulture,* **75**(2): 319-325.

Malhotra, S.K. (2016). Horticultural crops and climate change - A review. Ministry of Agriculture and Farmers Welfare, government of India, New Delhi. pp. 12-21.

Maninder, J.K. and Singh, L. (2015). Technological interventions for Livelihood Development and climate change mitigation in Indian North-Western Himalayas. *Global NEST Journal,* **17** (1): 50-60.

Narayan, R. (2018). Sabji Utpadan Takniki. Today and Tomorrow's Printers and Publishers. pp. 1-272.

Narayan, R., Kishor, A., Tiwari, V.K., Singh, R.K. and Mer, M.S. (2019). Beej Rahit Kheere Ki Kheti Hai Labhkari. *Phal Phool*, 13-16.

Narayan, R., Mer, M.S. and Singh, R.K. 2019. Barani Sabji Utpadan Takaniki. Kisan Bharati, **50** (6): 29-35.

Narayan, R., Singh, D. B., Narayan, S. and Mer, M. S. (2018). Parvatiya Chetron mein lahsun ki lambi prakashawadhi wali prajatiyon ki vaigyanik kheti. *Kisan Bharati*, **49** (11): 28-33.

Narayan, R., Singh, D.B. and Kishor, A. (2018). Smarika: "Badlati Jalvayu Mein Uccha Takniki Parvatiya Bagwani Ke Ubharate Rujhan" par Sangosthi. ICAR-CITH, RS, Mukteshwar. pp. 1-163.

Pena, R.D.L. and Hughes, J. (2007). Improving Vegetable Productivity in a variable and Changing Climate. *An open Access Journal published by ICRISAT*. pp. 1-22.

Shaban, D. and Hussein, A. (2012). Climate change and its impact on the productivity and quality of vegetable crops. *Journal of Applied Sciences Research,* **8** (8):4359-4383.

Singh, N.S., Sharma, D.P. and Chand, H. (2016). Impact of climate change on apple production in India: A Review. *Current World Environment*, **11** (1): 1-9.

Singh, V.P., Singh, P.K., Bhatt, L., Maurya, S.K. and Jeena, A.S. (2013). Low cost protected structures for enhancing productivity and Livelihood security of Farming community of Uttarakhand Hills-An Overview. *Progressive Research,* **8** (2): 155-159.

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4.	Dr O. P. Awasthi, Pr. Scientist	ICAR-IARI, New Delhi
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2.	Dr Ajay Sharma, Pr. Scientist	ICAR-NRC Grapes, Pune
3.	Dr Rattan Kumar, JD (Hort.)	Deptt. of Hort and Fruit Processing, Govt. of Uttarakhand
4.	Dr S. L. Chawla, Assoc. Prof.	ASPEE, COHF, NAU, Navsari, Gujarat
2016		
1.	Dr B. N. Hazarika, Dean	COH&F, CAU, Passighat, Arunanchal Pradesh
2.	Dr S. K. Verma, Pr. Scientist	ICAR-IIVR, Varanasi (U.P.)
3.	Dr R. M. Sharma, Pr. Scientist	Division of F&HT, ICAR-IARI, New Delhi
4.	Dr R. G. Somkuwar, Pr. Scientist	ICAR-NRC Grapes
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3.	Dr Tribhuvan Chaubey, Pr. Scientist	ICAR-IIVR, Varanasi (U.P.)
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3.	Dr T. Stobdan, Scientist E	DIAHR, DRDO, Leh
4.	Dr K. K. Singh, Dean	College of Hort., Dr RPCAU, Samastipur, Bihar

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2015

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2016

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2017

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2018

1.	Dr V. K. Tripathi, I/C Head	Department of Horticulture, CSAUA&T, Kanpur
2.	Dr Ashok Kumar Pandey	Head, Department of Horticulture, Janta College, Bakewar, Etawah 2016124 (U.P.)

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2014

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2.	Dr Jaydeep Halder, Scientist	ICAR-IIVR, Varanasi (U.P.)

2015

1.	Dr T. K. Koley, Scientist	ICAR Complex for Eastern Region, Patna
2.	Mr. Muneeb Ahmed, Asstt. Prof.	SKUAST, Srinagar, Kashmir

2016

1.	Dr Ajitabh Bora, Scientist	DRL, DRDO, Tejpur, Assam

2017

1.	Dr Tejpal Singh, SMS	VCSG, Uttarakhand University of Agriculture, Bharsar, Uttarakhand
2.	NFS	

2018

1.	Dr Sudip Kumar Dutta, Scientist NFS	ICAR-RC-NEHR-Sikkim

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**The above shortlisted candidates should make their presentation for 10 minutes before the committee during the PHC-2019 for final selection.*

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About the Society

Indian Society of Horticultural Research and Development (ISHRD)

Registered under the Societies Registration Act XXI, 1860, ISHRD was established in March, 1969, with a view to promote interdisciplinary research in the field of horticulture and to provide a forum for expressing views on policies and programmes relating to horticultural research and development. The society provides a platform for communicating research data, creative ideas and policies among the interested researchers involved in activities related to fruit crops, vegetables, flowers, ornamental crops, medicinal and aromatic plants, plantation crops, spices and condiments and other crops considered under the wide area of horticulture.

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Progressive Horticulture, an official scientific publication of ISHRD, is a peer reviewed journal being published since 1969. The society published the first issue of Progressive Horticulture Journal as a quarterly : April- June 1969, with an annual subscription of Rs 15/- under the leadership of Dr SS Teaotia, Dr SK Bose, Sh BN Agnihotri and Dr RP Srivastava as its founder editorial board. During the journey of progress Dr JN Seth, Dr SD Lal Mishra, Dr PL Gautam, Dr HP Singh and Dr RK Pathak contributed towards enrichment of society and the journal in different capacities as President, Editor, etc.

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