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Report of The VI Quinquennial Review Team

(2013 - 18)



ICAR - CENTRAL CITRUS RESEARCH INSTITUTE (INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

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The ICAR- Central Citrus Research Institute (CCRI) (formerly National Research Centre for Citrus) was established at Nagpur in the state of Maharashtra and started functioning from April 1986 onwards. The Quinquennial Review Team (QRT) of the ICAR- Central Citrus Research Institute was constituted by the Hon'ble Director General, ICAR to review progress of the Institute during 01-04-2013 to 31-03-2018 (Letter from Council F. No. I(4)/2018-IA.V dated 29th November, 2018). The composition of the team is : Dr. B.S. Chundawat (Chairman), Dr. A.M. Goswami (Member), Dr. S.R. Bhat (Member), Dr. T.B.S. Rajput (Member), Dr. Y.S. Ahlawat (Member), Dr. P.C. Sharma, (Member) and Dr. A.K. Srivastava, (Member Secretary).

The terms of reference of the QRT were: to critically review the research achievements and their impact and relevance to various issues of Citrus industry of India. The task of QRT also included examining allocation of resources and assessment of physical outputs and outcomes, priorities, programmes, projects in view of perspective and vision documents of the Institute. QRT looked into collaborations, linkages and the need for changes of the programmes, organizational setup/structures and budget allocations.

The Quinquennial Review Team visited ICAR-CCRI Farm, experiments laid-out in fields, laboratories and other infrastructure as well as interacted indepth with scientists and staff. The team also visited farmers' field/citrus growing areas in Maharashtra, Assam and Meghalaya. The QRT also visited the Regional Research Centre for Citrus (RRCC) at Biswanath Chariali, Assam; B.N. College of Agriculture, Assam Agricultural University, Biswanath, Assam and ICAR – Research Complex for NEH Region, Umiam, Meghalaya to take stock of the situation and get first-hand information on the status of the citrus industry. QRT discussed relevant issues with state department officials, citrus growers and Institute Management Committee.

The report of the QRT team is submitted herewith to the Council for kind consideration and further necessary action.

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1. INTRODUCTION

Composition of QRT

In order to undertake research on different applied and basic aspects of citriculture, the ICAR-Central Citrus Research Institute was established at Nagpur in the state of Maharashtra. The work of the ICAR -CCRI was reviewed earlier by five QRTs for the period covering (a) 1986-91, (b) 1991-1997, (c) 1997-2002, (d) 2002-2007 and (e) 2007-13.

The Sixth Quinquennial Review Team (QRT) of the Institute was constituted by the Director General, ICAR to review work done during 1^{st} April, 2013 to 31^{st} March, 2018 vide Office Order F. No. 1 (4)/2018- 1A.V dated 29th November, 2018.

The composition of the team is as follows:

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Terms of Reference of the QRT

The terms of reference of the QRT are : i. critically review the research achievements and their impact, ii. physical outputs and outcomes *vis-a-vis* budget spent, iii. socio-economic impact of research on farmers / beneficiaries, iv. research relevance and budget allocation, v. relationship/ collaboration with SAUs and other stakeholders, vi. linkages with clients /end users, vii. proposed changes in organisation, programmes and budget, viii. constraints hindering the Institute in achieving its objectives and ix. looking forward in respect of programme development, research prioritization and management changes.





Member

Member Secretary

Member





2. THE PROCESS

Meetings, Visits and Interactions

The QRT had a task of taking stock of progress of the ICAR-CCRI for the period of 5 years i.e. 2013 to 2018 and evaluating different research agenda keeping in view the requirements of stakeholders in the citrus industry of the country. The impact had to be analysed along with constraints regarding funds, manpower and infrastructure. Therefore, the QRT had several meetings with all concerned *viz*. scientists and other staff of the Institute, citrus growers, state department officials and also visited the citrus orchards and seen the actual problems faced by the growers in States like Maharashtra, Assam, Meghalaya. The QRT visited the Regional Research Centre for Citrus at Biswanath Chariali, Assam; ICAR – Research Complex for NEH Region, State department farms, University farm, nurseries, etc., in order to have first-hand information about problems *vis-à-vis* agro-climatic conditions.

Date and time	Purpose and place	Observations and Remarks
4th January, 2019 10.00 a.m. – 12.30 p.m.	Meeting at SMD (Hort. Sci.) with Dr. A.K. Singh, DDG (Hort. Sci.), KAB-II, New Delhi and Dr. B. S. Chundawat, Chairman, QRT	Briefing by the DDG (Hort. Sci.) to the QRT about the status of citrus industry in the country, citrus decline problem, issues related to planting material, need for new varieties and other related issues of future citrus industry.
7th February, 2019 10.00a.m. – 12.30 p.m.	ICAR-CCRI, Nagpur, Experimental Farm	Visits to Institute's nursery, plantations of 'Nagpur' mandarin, acid lime, 'Mosambi' orange, field gene banks, national citrus germplasm repository, virus indexing facility, mother blocks of elite plants, rootstock evaluation, water harvesting ponds, vermicompost unit, INM experiment, precision citriculture block and micronutrient experimental block. Nursery management practices under Technology Mission on Citrus, performance of STG derived mother tree.
3.00 p.m. to 6.30 p.m.	PresentationofachievementsbytheDirectorandmeetingwithICAR - CCRI scientists	The QRT discussed flatbed versus raised bed planting system, industrial use of citrus, target intensive research, relevance of research to farmers and

Itinerary of meetings / visits



Date and time	Purpose and place	Observations and Remarks		
		industry, processing technology and commercialization of technologies.		
6.30 - 8.30 p.m.	Visit to ICAR-CCRI Museum, Library, Laboratories	Visits to laboratories, museum and library provided overall idea about on- going research and frontline areas of future research.		
8th February, 2019 9.30 a.m. – 11.30 a.m.	ICAR-CCRI Experimental farm, Presentation	HDP on raised bed, marketing linked production, double line drip irrigation, TOT-based training, role of FPO's on farm demonstration, market intervention.		
12.00 a.m. – 1.30 p.m.	Presentation of achievements by scientists	f Use of changes in soil health related parameters, emphasis on regulation, use of growth regulators.		
3.00 p.m. – 5.00 p.m.	Interaction with IMC of the Institute	Interactive meeting with IMC committee, discussion with the scientist		
5.00 p.m. to 6.00 p.m.	Institute laboratory visit	Use of sensors and sap-flow meters in irrigation monitoring, development of by-products from citrus fruits.		
9th February, 2019, 9.30 a.m 1.30 p.m.	Visits to Citrus orchards at Nimji and Hatla, Nagpur	High density and canopy management, top working, fertigation efficiency, water harvesting		
1.30 p.m. – 6.30 p.m.	Meeting with citrus growers at Warud taluka (Amravati), Orange Growers Association and Commercial packing lines	Nursery act enactment, training on indexing of mother trees, GI marking, waxing materials, global competitiveness of citrus industry, packaging, pack house, subsidy, greening and <i>Waiwar</i> (Oblong fruits)		
24th April, 2019 9.30 a.m 1.30 p.m.	Visit to Experimental Farm of RRCC, Assam	Citrus varieties suited to NEH, performance of mandarin, sweet orange, lemon, pummelo, grapefruit, lime, establishment of model orchards, mother trees of 'Khasi' mandarin and 'Assam' lemon. Citrus germplasm repository, field gene bank, manpower development work.		



Date and time	Purpose and place	Observations and Remarks
3.00 p.m. – 5.30 p.m.	Meeting with staff of B.N. College of Agriculture, AAU, Biswanath	Problems of homestead gardens, citrus as intercrop in tea plantation, citrus area expansion, extension, awareness, improved varieties, transport facility, citrus as a part of agro-forestry, value added product, essential oil, planting material, trunk borer, organic management protocol.
26th April, 2019 9.30 a.m 1.30 p.m.	Visit to 'Khasi' mandarin orchards at Ri-bhoi and Government Nursery at Dwalie, Ri-bhoi, Meghalaya	Orchard establishment at hill slopes, canopy management, Minimum package of practices, planting material, production constraints, use of inputs, elite mother trees, budwood certification.
4.00 p.m. – 5.30 p.m.	Interactive meeting with scientific staff of ICAR Research Complex for NEH Region, Barapani, Officials of State Department of Horticulture, Meghalaya and Coordinator, ATARI, Meghalaya	Soil fertility constraints, small fruit size, die-back, fruit drop, sloppy land management, arecanut as competitive crop to 'Khasi' mandarin, <i>in-situ</i> conservation of rain water, rootstock suitability for 'Khasi' mandarin, demonstration plot for organic 'Khasi' mandarin.
16th July, 2019 10.30 a.m. – 7.00 p.m.	Interaction with the scientists of ICAR-CCRI, Nagpur	Achievements related to different problems and future line of research in each discipline of research.
17th July, 2019 09.30 a.m. – 12.30 p.m.	Interaction meeting with official of State Agri. Deptt. at Amravati	Problems of citrus cultivation, marketing, drip irrigation scheduling, mechanization, long distance transport, subsidy on packaging material and drip irrigation fresh juice parlor, training to farmers, drought.
4.30 p.m. – 5.30 p.m.	Interaction meeting with the farmers of Achalpur and visit to citrus orchards	<i>Waiwar</i> and greening issues water harvesting, fruit cracking, fruit drop, water management, uncertainty of <i>Mrig</i> <i>bahar</i> , visit of citrus growers to ICAR- CCRI, Nagpur and field demonstration.
18th July, 2019 09.30 a.m. – 08.30 p.m.	Finalization and report writing	Discussion among members for finalization of the report.

For detailed proceedings of the meetings and visits of the QRT, please see Annexure - I.



3. GLOBAL AND INDIAN SCENARIO ON CITRUS, ICAR-CCRI HISTORY, ORGANIZATIONAL STRUCTURE AND MANDATE

Introduction

Citrus is one of the most important fruit crops of the world grown in more than 100 countries. More than 70 per cent of the Worlds total citrus production is from northern hemisphere particularly in China, Brazil, India, USA and countries around the Mediterranean. As per the FAO (2017) report global citrus production was 139.80 million metric tonnes and the top citrus producing countries are China (35.47 million tonnes), Brazil (19.07 million tonnes), India (11.14 million tonnes) and USA (8.84 million tonnes). Globally sweet orange accounted for approximately 57 per cent of citrus production, mandarin (25 per cent), Lemon and Limes (10 per cent) and grapefruit, pummelo and others (8 per cent). In India, Citrus (12.4 per cent of total fruit production) is third most important fruit crop after banana (32.6 per cent) and mango (22.1 per cent). It is grown on 1.04 million ha area with 11.14 million tonnes production and 10.30 tonnes/ha productivity (NHB, 2017). Mandarins (Citrus reticulata Blanco) are the largest commercial citrus group in India with 43 per cent share, followed by sweet orange (Citrus sinensis Osbeck) 25 per cent, acid lime (Citrus aurantifolia Swingle), lemons (Citrus limon) 25 per cent share and others sharing 7 per cent. Commercially, 'Kinnow' mandarin is grown in Punjab, Harvana, Himachal Pradesh, western part of Rajasthan and Uttarakhand; 'Khasi' mandarin in North-Eastern Region comprising states like Assam, Meghalaya, Arunachal Pradesh, Sikkim and also Darjeeling area in West Bengal and 'Coorg' mandarin in Kodagu district of Karnataka. Acid lime in Gujarat, Maharashtra, Tamil Nadu, Karnataka, Telangana and Andhra Pradesh. 'Nagpur' mandarin is mainly grown in Vidarbha region of Maharashtra, Jhalawar district of Rajasthan and adjoining Madhya Pradesh. 'Mosambi' is grown in Marathwada region of Maharashtra; 'Sathgudi' in Andhra Pradesh and Telangana; Lemon in NEH region and north western part of the country.

During the last three decades, India has experienced quantum jump of more than 5 fold in production due to increase in area and adoption of new technologies. Adoption of this crop by the farmers indicated good returns and this has been reflected in increased area. However, productivity witnessed little increase. Productivity has increased from 8.5 tonnes/ ha to 11.50 tonnes/ha during last 3 decades (1987-88 to 2017-18). According to latest statistics, maximum productivity (21-22 tonns/ha) has been recorded in Punjab and Karnataka followed by Telangana and Andhra Pradesh (17-18 tonnes/ha).

Scenario of Citrus in India

Citrus research has a long history in India since British era. Rootstock trials were initially started in Lyallpur and Montgomery areas in undivided India. Srirampur (Maharashtra), Chethalli (Karnataka), Katol (Maharashtra) and Abohar (Punjab) have been the old Centres where research on citrus dieback and rootstocks was started long back. India possesses a rich



diversity of wild citrus species which is an important source for direct use as fruit and medicine or as source of genes for improvement of commercial varieties. North-East India along with South-China and North Myanmar is regarded as the centre of origin of Citrus. About 17 species including *C. indica, C. latipes, C. assamensis, C. macroptera, C. rugulosa, C. megaloxycarpa, C. limettioides, C. limmetta* and upto 56 different forms have been reported through different sources.

Between 1961 and 2017-18, area under citrus fruits in India increased from 90,700 ha to 10.77 lakh ha, thus registering 11 folds increase. Production increased from 8,23,000 tonnes to 125.10 lakh tonnes during that period. The average annual growth rate during 1961 to 2017-18 has been 17.40 per cent in terms of area and 25 per cent in terms of production (Table 1).

Year	Area ('000 ha)	Production ('000 tonnes)	Productivity (tonnes/ ha)	Source
1961	90.7	823.70	9.14	Directorate of Economics and Statistics, Ministry of Food and Agriculture, Govt. of India, New Delhi
1968	105.4	1211.90	11.53	India's Export potential for fresh and processed fruits and vegetables ,1968, NHB, New Delhi
1988	279.4	2282.20	8.17	Area and production of fruits and vegetables in India, States profile, NHB, New Delhi
1992	386.9	2820.00	7.30	NHB, New Delhi
1997-98	484.7	4456.10	9.19	Statistical Abstract, Nat. Inst. Agric. Marketing, Jaipur, 2005, NHB, New Delhi
2004	563.0	5680.00	10.09	Statistics of Indian Horticulture, Database, ICAR, New Delhi
2017-18	1077.7	12510.00	11.50	NHB, New Delhi, 2018
58 Years	1100 per cent increase up to 2017-18 since 1961	1500 per cent increase up to 2017-18 since 1961	-	-

Table 1: Growth of citrus industry in India since 1961 to 2017-18



Mandarins, sweet oranges, limes and lemons are major citrus fruits in the country. Grapefruits and pummelos are limited in cultivation. The average yield of citrus fruit as a whole at national level is 11.50 metric tonnes/ha. There is a considerable variation in productivity depending on orchard management. Average productivity of citrus in Andhra Pradesh is 17.0 tonnes/ha, whereas, in some orchards in Vidarbha (Maharashtra) yield of 19-25 tonnes/ha is not uncommon. This indicates the ample scope for increasing average productivity in Maharashtra. Average productivity in Punjab is 21.0 tonnes/ha due to 'Kinnow' mandarin which is prolific bearer. Lower productivity in some states can be attributed to poor management practices and abiotic stresses.

Important Commercial Citrus Fruits of India

Mandarin (Citrus reticulata Blanco)

Mandarins occupy largest area and provide more than 43 per cent production among all citrus fruits grown in India. The commercial cultivars being grown in different regions are 'Nagpur' mandarin (*Santra*) in Maharashtra and Central India; 'Coorg' mandarin in Karnataka and hills of Tamil Nadu and Kerala; 'Khasi' mandarin in north-eastern region; 'Kinnow' mandarin in Punjab, Himachal Pradesh, Haryana, Rajasthan, Western UP, and 'Darjeeling' mandarin in Sikkim and West Bengal.

Among mandarins, cultivation of 'Kinnow' registered a phenomenal growth after introduction in Punjab in 1956. In Punjab, area under 'Kinnow' leaped from 500 ha in 1970 to 50,360 ha in 2015-16. In North-Western parts of the country, 'Local' mandarin and 'Malta' orange have been mostly replaced by 'Kinnow' mainly because of its response to inputs and consequent higher returns. The 'Nagpur' mandarin established itself well in Central India and its producing centres are Vidarbha region of Maharashtra and other states comprising Madhya Pradesh (Agar Malwa, Rajgarh, Shajapur, Chhindwara, Mandsaur) and Rajasthan (Jhalawar and Bhilwara districts).

Sweet orange (Citrus sinensis Osbeck)

The sweet oranges are also referred as tight skin oranges and constitute major share of citrus production in India. The commercial cultivars grown in different regions are 'Mosambi' or 'Musambi' in Maharashtra especially Jalna, Aurangabad, Nanded and Ahmednagar districts; 'Sathgudi' in Andhra Pradesh and Telangana particularly in Nalgonda, Cuddapah, Kurnool and Anantpur districts; 'Hamlin', 'Pineapple', 'Jaffa', 'Valencia Late', 'Blood Red' and 'Malta' in Punjab, Rajasthan and Haryana.

Acid lime (Citrus aurantifolia Swingle) and Lemon (Citrus limon (L.) Burm.f)

These fruits constitute nearly 25 per cent of total citrus production in India from 2,52,000 ha area. Andhra Pradesh alone has about 45,800 ha area under acid lime. Maharashtra, Gujarat, Orissa and Tamil Nadu are other major acid lime producing states. Total production of limes and lemons in the country has been 25,46,000 tonnes during 2017-18. Warm, moderately



moist to dry climate is suitable for limes and high rainfall increases problem of bacterial canker. Hence, the arid irrigated areas suitable for sweet oranges are also promising for acid lime cultivation.

The small round and thin skinned 'Kagzi' is the commercial cultivar of acid lime. During last 2-3 decades, several varieties have been released by many Institutions. Lemons are grown commercially only to limited scale in northern and north-eastern States ('Galgal', 'Baramasi' and 'Assam' lemon). There are several other land races of citrus fruits in NEH region which are grown by locals for domestic consumption and medicinal purposes.

At present, citrus production is 125.10 lakh tonnes in the country, with maximum share of mandarin (52.71 lakh tonnes) followed by Sweet oranges 29.82 lakh tonnes and lime/lemon (25.46 lakh tonnes). The production trend during 2017-18 clearly established increased output of mandarins including 'Kinnow' followed by sweet orange and limes and lemons (Table 2).

Table 2 : Area and Production of various Citrus Crops in India

Area :	000	'ha a	and	Prod	luction	000'	tonnes

Citrus Type	2016-17		2017-18 (Second Estimate)		
childs 19pc	Area	Production	Area	Production	
Lime/Lemon	248	2364	252	2546	
Mandarin	410	4438	428	5271	
Sweet Orange	191	3209	185	2982	
Others	136	1408	145	1712	
Total	985	11419	1009	12510	

Source: Horticultural Statistics, NHB.

Rapid area expansion in sweet orange in last a few years signifies regaining of the confidence of citrus growers. Sweet orange has once been considered as most susceptible to citrus decline. Recently, the area under sweet orange has actually declined in Maharashtra due to water scarcity. In case of acid lime, which was once under threat due to viral (Tristeza) and bacterial (citrus canker) diseases, also recorded a high growth in Gujarat, Maharashtra, Karnataka and Bihar. Thus, inspite of the alarm bells of citrus decline, the country has experienced an expansion in area and production during last one decade, most significant in states like Madhya Pradesh and Rajasthan, which also reflects the contribution of ICAR-CCRI.

Perspective of Citrus Industry in India

The demand of citrus fruits is likely to increase by nearly 1.5 fold with an estimated population of 1450 million by 2030. Moreover, the demand is also increasing for fruits due to improved economy, better health awareness and changing lifestyle among the people. The juice and beverage consumption has increased in the country in recent past.



To achieve these goals of production, as per estimates of ICAR-CCRI, Nagpur, a minimum annual average growth of 5-6 per cent will have to be achieved in next 20 years so as to meet the domestic demand and export commitments. With annual production growth of 8-10 per cent during 1992-93 to 2017-18, it appears that estimated growth rate of 5-6 per cent can be easily achieved to meet the targets set for 2030 (Table 3). The growth in future will have to come from increased productivity rather than area expansion. This demands innovative approaches in technology implementation/transfer coupled with high-tech interventions for increasing productivity. Other citrus fruits like pummelo, grapefruit, citron and land races of lemons (which are useful for pickling) in northern and north-eastern parts need to be promoted for cultivation as community orchards, in backyards and as small scale cultivation.

Citrus type			Projected Production (lakh tonnes)			
••	1992-93	2017-18	2030	2050		
Mandarin	13.40	52.71	35.14	72.00		
Sweet orange	8.93	29.82	54.20	60.00		
Lime and lemon	7.46	25.46	41.57	57.00		
Other citrus fruits	3.90	17.12	15.00	16.90		
Total Production	33.69	125.11	145.91	205.90		
Productivity	7.30	11.50	12.50 tonnes/ha	14.40 tonnes/ha		

Table 3: Projected area and production of major commercial citrus fruits (Mandarin, sweet orange and lime and lemon) up to 2050.

The citrus area during 2017-18 was 10.09 lakh ha and expected to be 12.15 lakh ha by 2030 and 14.30 lakh ha by 2050.

Source : Horticulture Statistics at a Glance 2017; DAC and FW, New Delhi Vision 2030, Published by NRCC, Nagpur in 2010 Vision 2050, Published by ICAR-CCRI, Nagpur in 2015.

The unique geographical location of India makes European, Gulf and South-East Asian markets accessible to Indian citrus fruit. Climatic conditions to grow fruits almost year round offer very good opportunity to tap overseas markets in changing world scenario. The availability of Nagpur mandarin fruits in April-May when most of the mandarin exporters such as Spain and Morocco have almost nil inventories presents export opportunity to European market in summer. Citrus fruits are also a rich source of many health promoting compounds like vitamins, flavanoids, limonoids and pectin. The ever increasing demand for safe and eco-friendly molecules for human health and therapy has led to the identification of citrus bioflavonoids and other nutraceuticals which can generate significant revenue for the nation. With the current 125 crore population, increasing annual per capita citrus fruit availability from 10.00 kg (2017-18) to 10.35 kg and 12.80 kg/year by 2030 and 2050, respectively, and to have surplus for export would require a major jump in productivity



through implementation of new technologies.

Export: India exported 17,231.45; 34,524.55 and 47,539.39 metric tonnes of oranges during 2014-15, 2015-16 and 2016-17, respectively. Export of grapefruit and pummelo was also recorded during these years. There is a scope of exporting lemons and limes also. Total export of 1,92,564.94 metric tonnes of citrus fruits was recorded during last three years (2014-15 to 2016-17). Export of mandarin/tangerine type fruit was 487.05, 2526.98 and 1076.84 metric tonnes during 2014-15, 2015-16 and 2016-17, respectively. Here, it is pertinent to mention that in category of oranges it appears that it was mandarin orange (Santra) because tight jacket oranges ('Mosambi', Satgudi, Malta, Jaffa) are rarely exported from India. Nagpur Santra (mandarin) exported from Vidarbha is also mentioned as oranges in trade. The value of total citrus exports was observed as 109.11, 169.38 and 223.37 crore Indian rupees, during 2014-15, 2015-16 and 2016-17, respectively.

Import: India also imported 1137.97, 772.47 and 924.23 metric tonnes of mandarin/tangerine type fruits during 2014-15, 2015-16 and 2016-17, respectively. The oranges imported (mainly tight jacket oranges) were 53,054.23; 46,557.02 and 55,578.62 metric tonnes, during 2014-15, 2015-16 and 2016-17, respectively. These imported fruits find market in super markets/malls of metro cities and other big cities of India. Import of grapefruit, lime and lemons was also recorded during 2014-15, 2015-16 and 2016-17. The value of total imported citrus fruits during 2014-15, 2015-16 and 2016-17 was 190.81, 179.38 and 221.38 crore Indian rupees, respectively.

Import of citrus juices increased during period 2014-15 to 2017-18 from 1416.22 tonnes to 4467.70 tonnes with a corresponding value of 21.78 crore rupees to 41.69 crore rupees. Similarly, juice concentrates and other products like citrus-based jams, jellies and marmalades worth 38.33 crore rupees were imported in 2014-15 which increased to 58.13 crore rupees during 2017-18. Quantity-wise imports of these products were 3059.88 tonnes in 2014-15 that increased to 5277.96 tonnes.

Citrus byproducts such as pectins, essential oils and peels etc. worth Rs 212.08 crore were imported during 2014-15, which increased to Rs 324.80 crore during 2017-18.

Historical Perspective of ICAR - CCRI

Citrus is grown under varied climatic and geographical zones of India. Its cultivation faces a variety of problems leading to 'decline' which is rampant in major citrus growing regions of the country. Reasons are many, and causal factors such as unhealthy planting material, unsuitable soil, improper drainage, malnutrition, water scarcity, artificial water stress, insect-pests and diseases, etc. are known, but the single most common manifestation is drying of twigs. Earlier, ICAR attempted to tackle the problem through a sponsored scheme "Citrus Die-Back" launched in 1949. However, the famous 'Nagpur' mandarin growing tracts in Vidarbha region of Maharashtra and adjoining Madhya Pradesh were left uncovered under this scheme. The need was, therefore, felt at several fora for a Research Station for Citrus to intensify research in this region of the country. In Vidarbha, it is common to observe wide difference in productivity level from one orchard to another, notwithstanding, the similar soil type and climate. Chronologically, the following events took place which paved the way for



the establishment of Research Centre on Citrus:

- The Task Force appointed by the Ministry of Agriculture to investigate the problems of citrus decline in central India, visited the area in April, 1980 and suggested for strengthening the research on citrus in this region.
- Dr. D.J. Hutchison, UNDP Consultant and an Expert on Citrus strongly recommended that a Citrus Research Station should be established at Nagpur, this being the most important area for citrus production in India.
- A request by the Maharashtra Government made to the Director General, ICAR to establish a Citrus Research Station at Nagpur.
- The Quinquennial Review Team (QRT) of IIHR, Bangalore recommended that the work on important problems of citrus may be initiated in the main citrus growing belt of Nagpur area or some other area where suitable facilities can be created. The research work done in this region is likely to be more useful and applicable because the solutions to the problems will be relevant to the main citrus belt.
- The Director General, ICAR agreed for Citrus Research Station at Nagpur in the VI Plan period to tackle problems affecting citrus cultivation.
- The suitable land was selected at Nagpur for establishing a Central Horticultural Experiment Station by a Committee constituted by ICAR and Government of Maharashtra agreed to give 100 hectares of land for its establishment free of cost. In view of the QRT recommendations and broad projections made by the working group, the critical areas were identified with a hope to tackle them in a systematic way at the proposed "Centre for Research on Citrus" established during VII Plan.
- The Central Citrus Research Station under IIHR, Bengaluru at Nagpur was formally inaugurated by Shri P.V. Narasimha Rao, the then Hon'ble Minister for Defence, Govt. of India on 28th July, 1985 and the Centre started functioning from 29th November, 1985 with a skeleton staff.
- In order to undertake research on different applied and fundamental aspects of citriculture, the status of Citrus Research Station was raised to independent National Research Centre for Citrus (NRCC) from April, 1986 in VII Plan.
- The NRC for Citrus was upgraded to the Institute level and renamed as Central Citrus Research Institute (CCRI) in October, 2014 as approved in EFC during the XII Plan.
- The Regional Research Centre for Citrus (RRCC) was established in Assam under ICAR-CCRI, Nagpur in March, 2017 as approved in XII Plan.
- Since then, ICAR-CCRI has been functional working on different problems of citriculture and some useful output has been coming.



Regional Research Centre for Citrus of ICAR-CCRI, Nagpur at Biswanath Chariali, District Biswanath, Assam

With the upgradation of NRC (Citrus) to the Institute level one Regional centre was also approved in Assam. Regional Research Centre for Citrus (RRCC) has been established at Biswanath Chariali, on the campus of Biswanath College of Agriculture, (Assam Agricultural University), Dist. Sonitpur, Assam.

Establishment of First Regional Research Centre for Citrus of ICAR–CCRI, Nagpur at Biswanath Chariali, District Biswanath, Assam: Regional Research Centre for Citrus (RRCC) was sanctioned for North-Eastern region in Assam state under ICAR-CCRI, Nagpur in the EFC of XII Plan. This matter was persuaded since 2014 (approval of XII Plan EFC came in October 2014) to select the site. Out of 5 sites, as suggested by Dr.K.M. Bujarbaruah, Vice-Chancellor of Assam Agricultural University, the survey was conducted and the site at Biswanath College of Agriculture of AAU was selected on the basis of road, rail and air connectivity, suitability of land for cultivation of citrus, climate, availability of sufficient land, availability of water, availability of college rooms to start activities immediately and in consonance of future demand of the citrus Industry. The 42.5 acres land was given by AAU on lease basis for 99 years. Earlier, Biswanath was a Tehsil town in Sonitpur district of Assam. Now, Biswanath has been carved out as a separate district in Assam.

The Memorandum of Understanding (MoU) was signed between Dr. M. S. Ladaniya, Director ICAR-Central Citrus Research Institute, Nagpur and Dr. Tapan Baruah, Associate Dean, Biswanath College of Agriculture (BNCA) in October, 2016. The Lease Deed was also signed between Dr. M. S. Ladaniya, Director, ICAR-Central Citrus Research Institute, Nagpur and Registrar, AAU, Jorhat on 6th March, 2017 in presence of Dr. K. M Bujarbaruah, Vice-Chancellor of Assam Agricultural University at Jorhat, Assam. Assam Agricultural University has given an old Agriculture College building temporarily for setting up of office of Regional Centre. Immediately need based activities have been started at the site and the office has been made operational from March, 2017.

Mandate and Objectives

2.1 Mandate (from beginning to 15th May, 2016)

- To undertake basic and applied research to develop technologies for improvement and increased productivity in citrus
- To act as a repository for genetic resources and scientific information related to citrus
- To undertake research to develop technologies for better shelf life and utilization of citrus fruits considering domestic and export needs
- To act as Centre of training in advanced research methodologies and technology upgradation in citrus
- To collaborate with relevant national and international organizations/Govt. agencies for



citrus research and technology dissemination

• To provide consultancy services and undertake contract research to solve the problems of Citrus Industry

2.2 Revised Mandate (w.e.f. 16th May, 2016)

- Basic, strategic and applied research on crop improvement, sustaining productivity, crop protection and utilization of citrus.
- Repository for genetic resources and scientific information on citrus.
- Nodal centre for training, quarantine, certification and supply of disease-free planting material of citrus.

2.3 Objectives

- Introduction and evaluation of germplasm from indigenous and exotic sources.
- Improvement of rootstocks with special reference to increase production, quality, dwarfing and tolerance/ resistance to drought, *Phytophthora* and nematodes.
- Clonal selection and improvement of 'Nagpur' mandarin, acid lime, sweet orange, grapefruit and pummelo for better production, quality, seedlessness and less limonin content.
- To work out the macro- and micronutrient requirement for commercially grown citrus varieties to establish leaf nutrient standards for sustained productivity.
- To undertake research on water management for conservation, system of irrigation and critical water requirement for induction of flowering and optimum productivity.
- To standardize farming system based on 'Nagpur' mandarin, acid lime and sweet orange.
- To undertake studies on weed control for standardizing most effective weedicide and time of application.
- To standardize technique for regulation of cropping with aid of growth substances.
- To undertake research on the incidence of important insect-pests of 'Nagpur' mandarin and their chemical control measures. Special emphasis will be given to integrate pest management comprising chemical, biological control and other cultural practices for citrus blackfly (*Kolshi*).
- To conduct research on fungal, bacterial and viral diseases of citrus crops with special reference to gummosis (*Phytophthora* spp), twig blight (*Colletotrichum gloeosporioides*), tristeza and greening.
- To multiply and supply virus and nematode free planting material of commercially grown citrus spp.
- Studies on post-harvest technology with special reference to handling, packaging, storage,



post-harvest disease and processing including debittering of citrus juice.

- To work out techniques for waste utilization for extraction of oil, pectin and preparation of animal feed.
- To transfer the technologies evolved/ standardized to the growers.

Organisation and Structure



Administration

During the period under report Dr. M.S. Ladaniya, Director was the administrative head of the Institute. Dr. M.S. Ladaniya took over from 21st September, 2013 and provided good leadership that is evident from establishment of new Research Centre at RRCC, Assam, development of infrastructure *viz*. Farmer's Hostel, Intake well, new pipeline from Ambazari etc., initiation of new externally funded and in-house projects, development of technologies, publications and budget utilization.

Research projects are discussed and finalized by the Institute Research Council (IRC) chaired by the Director. Several other Committees namely (i) ITMU, (ii) ITMC, (iii) Plant Protection Committee, (iv) RTI Committee (v) Purchase Committee, (vi) Price Fixation Committee, (vii) Extension cum Publicity Committee, (viii) Publication Committee (ix) Library Committee, (x) HRD Committee, (xi) Hindi Committee, (xii) Works Committee, (xiii) Farm



Operations cum Job-Contract Committee, (xiv) Welfare cum Recreation Club and Staff Welfare Fund Scheme Committee, (xv) Farm Committee and (xvi) Women's Cell etc. assisted the Director in executing various activities. One Assistant Finance and Accounts Officer (AF and AO) post has been in place during the period under report. Administrative Officer, Assistant Administrative Officer (AAO) and Assistant Finance and Accounts Officer (AF and AO) provided support in administration and financial matters. The details of the important meetings of different Committees held during the period of review are given in **Annexure-II**. ICAR norms have been followed in arranging mandatory meetings of important Committees like the RAC, IMC and IRC etc.

Financial

ICAR-CCRI started in 1985 (from VII Plan) and budget provision (Plan and Non-Plan) from the beginning till XII Plan have been adequate and given in Table 4.

					(Rs.	. In Lakhs)
Sr. No.	Plan Period	Plan	Non-Plan	PHT on Fruits and Veg.	NARP Project on Bio. Tech.	Total
1.	VII Plan (1985-90)	102.25	-	29.54	-	131.79
2.	VIII Plan (1992-97)	440.00	192.27	29.65	61.00	722.92
3.	IX Plan (1997-2002)	724.00	565.00	-	-	1288.00
4.	X Plan (2002-07)	961.67	1087.00	-	-	2048.67
5.	XI Plan (2007-12)	1303.00	1052.00	-	-	2355.00
6.	XII Plan (2012-17)	2800.00	4054.04	-	-	6854.04

Table 4 : Budget provisions from VII Plan onwards

Table 5: Budget Allocation and Expenditure for the period under report

	Р	lan	Non Plan		Grand Total	
Year	Allocation	Expenditure	Allocation	Expenditure	Allocation	Expenditure
2013-14	392.00	372.82	724.36	637.23	1116.36	1010.05
2014-15	272.00	273.96	766.00	751.91	1038.00	1025.87
2015-16	349.50	346.76	965.00	931.87	1314.50	1278.63
2016-17	407.00	402.17	1028.68	958.86	1435.68	1361.03
2017-18	1377.00	1351.31	0.00	0.00	1377.00	1351.31
Total	2797.50	2747.02	3484.04	3279.87	6281.54	6026.89



Infrastructure Development

During the period under review, with the support from ICAR and under NAIP, good number of equipments have been procured and field/infrastructure facilities developed (Annexure -III). However, the pace of technology development globally is very fast and the Institute needs to acquire most modern equipments for its research. The QRT has critically examined the list of equipments in Expenditure Finance Committee Memorandum for XII Plan and is of the opinion that the projections are very modest.

Manpower

Institute has very limited manpower keeping in view its national mandate. Since last four plan period (IX to XII), several posts of technical, administrative and supporting category have been proposed by the Institute, but these posts were not created (Table 6). There are only 19 sanctioned posts of scientists and presently, 16 are in position. Out of total sanctioned posts of 62 staff, only 56 were in position as on 31^{st} March, 2018 (Table 7).

Sr. No.	Plan Period	Scientific	Technical	Administrative	Supporting	Tech. (Workshop)
1.	VII Plan	20	12	8	-	3
2.	VIII Plan	-	11	7	12	1
3.	IX Plan *	-	4	3	27	2
4.	X Plan *	-	4	3	27	2
5.	XI Plan *	-	4	3	27	2
6.	XII Plan *	20	27	18	39	6

Table 6 : Planwise manpower as proposed

(*) As proposed

Recently in revision of scientific manpower (vide Council's letter No. 22(1)/2017-PER-IV Dated 13th November, 2018), 3 posts of scientists {Principal Scientist (1), Sr. Scientist (1) and Scientist (1)} have been sanctioned making it 22. But, these scientists have not yet joined.



Present Staff Position

Staff position as on date (31.03.2018) at ICAR-CCRI, Nagpur is highlighted as below:

Table 7 : Category-wise sanctioned and actual in-position staff

Sr. No.	Category	Sanctioned	In position
1.	Director (RMP)	01	01
2.	Scientific	19	16
3.	Technical	20	20
4.	Administration	11	10
5.	Supporting	11+ (6 as per ADRP)	09
	TOTAL	62+ (6 as per ADRP)	56

Library Facilities Developed (1st April, 2013 to 31st March, 2018)

Good library facilities have been developed to support research, teaching and extension at the Institute. Documentation wing has procures a total of 2033 books and 1270 back volumes of Journals. The Institute has subscribed 31 Indian Journals and 8 Foreign Journals, in addition to database on horticulture in form of CDs. Following facilities have also been created in the library :

- i) Online information search
- ii) Document delivery services
- iii) Reprography services
- iv) Access to online information services (under Cera)
- v) Koha software application
- vi) Horticulture CD database services
- vii) Internet services



Publications (1st April, 2013 to 31st March, 2018)

Research Papers published in peer reviewed journals : 125

Research Papers in International Journals	-	51
Research Papers in National Journals	-	73
Books	-	6
Book chapters	-	37
Technical/Extension bulletins/ Folders	-	31
Technical/Popular articles	-	12
Other publications	-	17

Detailed list of publications is given in Annexure -IV

QRT Comments

The Institute scientists have published a good number of research publications in scientific periodicals of national and international repute. The extension bulletins and other publications have made good impact for the transfer of technology of the ICAR-CCRI. Scientists are encouraged/advised to publish their findings in international journals having high impact factor and bring out extension publications to reach out to clients.



4. PRIORITIES, PROGRAMMES AND PROJECTS

Priorities

- Define soil and climatic requirement of various citrus spp. based on national survey
- Improvement of productivity through elimination/control of causes of decline like resistance breeding, better stock-scion combination, healthy planting material, efficient nutrient and water management, disease and pest prevention, higher planting density and better canopy management.
- Establishment of nursery hubs for the supply of healthy and disease-free planting material.
- Phenotypic and molecular characterization of collected citrus germplasm and cataloguing.
- Seedless or less seeded varieties through ploidy manipulation, mutation breeding, clonal selection, hybridization in 'Nagpur' mandarin, 'Kinnow' and 'Mosambi' orange.
- *Phytophthora* and drought resistant rootstock through marker assisted selection or genome editing.
- Production of elite disease-free planting material in different regions of the country to meet farmers' demand.
- High density cultivation practices protocol using fertigation, pruning, INM, IPM and IDM.
- Development of cultivar and region-specific collaborative projects keeping in view important regional problems.
- Development and description of quality standards for domestic and export trade and processing.
- Development of value-added products from citrus grown in different regions.
- Undertaking multilocation trials and identification and release of new clones/varieties
- Development of eco-friendly production and protection technologies.

Programmes

Focus areas of research

The inter-institutional collaborations and networks for research and development in citriculture will continue and further strengthened. The major focus will be on following aspects:



i) Genetic Resources and Crop Improvement

- Characterization and cataloguing of citrus germplasm using phenotypic anpd molecular markers.
- Marker-aided-selection of citrus germplasm for useful traits e.g. less seeded, suitable for processing, tolerance to biotic and abiotic stresses.
- Clonal selection for better yield and quality and ploidy manipulation for seedlessness.
- Evaluation and barcoding of citrus germplasm.
- Hybridization for scion and rootstock improvement.
- Identification of germplasm tolerant to water stress (drought and flood).
- Evaluation of cultivars for increased CO₂ level and higher temperatures.

ii) Crop and Resource Management and Environment

- Evaluation of new rootstock and scion combination for biotic and abiotic stress management especially tolerance to drought, floods and *Phytophthora* root rot.
- Studies on crop phenology under changed climatic conditions, induction of flowering, crop regulation for assured *Mrig* crop of 'Nagpur' mandarin and fruit quality management.
- Development of agro-techniques for high density planting in major citrus cultivars with emphasis on plant canopy management.
- Development of non-destructive hyper spectral sensor-based technology for nutrient stress sensing as an early nutrient deficiency detection technique.
- Substrate development and nutrient dynamics for rhizospheric changes in nutrient pool and their integration under INM module for nutrient turn over soil carbon accreditation.
- Expansion of DRIS indices and their validation to other commercial citrus cultivars and development of fertility diagnostics as per soil type.
- Development of SSNM into sensor-based DSS (Decision Support System) using variable rate fertilization (VRF) and improved fertilizer use efficiency.
- Development of protocol for organic citrus.
- Plant nutrition with respect to antioxidant system and drought tolerance.
- Irrigation scheduling with Infrared thermometry, pulse irrigation and regulated deficit irrigation and their integration under automated fertigation.
- Evaluation of new drip and micro-jet irrigation systems.
- Development of mitigation / adaptation techniques by addressing the issues of climate change from various biotic and abiotic factors influencing quality production.



iii) Integrated Pest and Disease Management

a) Entomology

- Development of Insecticide Resistance Management (IRM) based IPM for major pests of citrus.
- Refinement of chemical control using new insecticides and methods of application.
- Studies on the frugivorous pests of 'Nagpur' mandarins and its management using push-pull strategy.
- Use of semio-chemicals particularly pheromones for insect pests and kairomones for bio-agents.
- Digital distribution maps of the major pests and bio-agents of citrus in India.
- Conservation of bio-agents in citrus ecosystems and their use in crop protection.
- Refinement of bio-agent multiplication methods.
- Use of botanicals / plant products for the management of citrus insect pests.
- Development of cultivar / region specific IPM modules for major citrus pests.
- Impact of climate change on insect pests dynamics of citrus.
- Development of forecasting system for citrus insect pests.
- Development of expert system for Citrus IPM.
- Field evaluation of bio-control agents for insect and nematode pests.
- Molecular characterization of important pests of citrus.

b) Plant Pathology

- Complete genome sequencing of citrus tristeza virus, citrus mosaic badna virus and *Phytophthora nicotianae* and citrus greening bacterium.
- Development of rapid diagnostic kits for field identification of diseases.
- Developing VIGS and RNA-i mediated disease resistance against citrus viruses like CTV and CMBV.
- Diagnostic method to detect multiple *Phytophthora* spp. in environmental samples and developing farmer-friendly ready-to-use on-site simple diagnostic tools.
- Species / strain specific detection and quantification of *Phytophthora* in host tissue and soil.
- Complete / whole genome sequencing of *Phytophthora nicotianae* for effective management of root rot, foot rot and gummosis in citrus.



- Identification and molecular characterization of *Phytophthora* species and variants / strains pathogenic to citrus.
- Diversity analysis by MLST using ITS, COX-I or II, elongation factor- 1α , β -tubulin and virulence genes in *Phytophthora* isolates.
- Search for efficient biocontrol agent and to frame an integrated management strategy for citrus *Phytophthora* diseases.
- Molecular differentiation and genetic diversity studies of *Xanthomonas citri* pv. *citri* strains and searching for acid lime clone resistant to canker.
- Culturing citrus greening bacterium and development of diagnostic gold standards for citrus greening disease, virus and virus like diseases.
- Diversity analysis, characterization, documentation and conservation of *Phytophthora* spp. infecting citrus.
- Identification of Avr genes from Phytophthora and R-genes from citrus rootstocks.
- Identification of marker linked to *Phytophthora*-root rot resistance and improvement of citrus rootstocks for resistance against *Phytophthora* spp. using marker assisted selection approach.
- Understanding the mechanism of callus formation in gummosis infected citrus trees.
- Understanding the mechanism of *Trichoderma* to control *Phytophthora* in citrus and formulate an integrated management strategy for citrus *Phytophthora* diseases.
- Evaluation of new molecules, bioagents and integrated approach for management of *Phytophthora* diseases.
- Studies on pesticide resistance monitoring in *Phytophthora* diseases.
- Studies on other fungi involved in citrus decline.
- Enhancement of detection sensitivity for low-titer pathogens like viruses (CTV, ICRSV, CMBV, CEVd) and greening bacterium using high through-put rapid diagnostic methods (*viz.* mPCR, qPCR (real time), DNA chips, Microarray).

iv) Post-harvest Technology, Processing and Value Addition

- Development of eco-friendly treatments such as combination of microbial antagonist with GRAS chemicals and physical treatment for better shelf life.
- Nano-composite packaging for fresh fruits and processed products.
- Value addition through aroma and flavour recovery using SFE technique.
- Evaluation of methods of juice concentration, juice powder and juice blending.
- Value addition and waste utilization of commercial citrus fruits.
- Development of value added products using nano-technology.



- High pressure juice processing.
- Development of integrated juice processing technology.

v) Transfer of Technology and Extension

- Working out economics of viable technologies.
- Seeking involvement of public and private organizations during 'Kisan Mela' and other extension activities.
- Undertake trainings for the officials engaged in the citrus growing areas.
- Undertake feasibility study of contract farming in 'Nagpur' mandarin.
- Technology dissemination and adoption through public-private partnership.
- Development of Citrus Information System.
- Transfer of technology through trainings, demonstrations, farmers' fairs, group discussions, meetings etc.

vi) Computer Applications

- Mandarin/ Citrus Information System.
- Citrus Germplasm Resource Information System (CGRIS).
- Citrus data base- Knowledge bank as an Open Access Repository.
- Technology dissemination

RESEARCH PROJECTS

Institute Projects

Genetic Resources and Crop Improvement

- 1. National Citrus repository at CCRI (**ongoing w.e.f. Dec., 1990**)
- 2. Improvement of important commercial citrus scions and rootstocks through *in vitro* techniques (**ongoing w.e.f. July, 2011**)
- 3. Molecular characterization of citrus germplasm (ongoing w.e.f. May, 2016)
- 4. Mutation breeding in citrus (ongoing w.e.f. Sept., 2014)
- 5. Genetic Improvement of Citrus through hybridization (ongoing w.e.f. Sept., 2014)
- 6. Retrofitting of citrus nursery phase for optimizing the production costs of planting stock (**ongoing w.e.f. July 2017**)

Crop and Resource Management



- 7. Evaluation of citrus rootstocks for improving productivity and quality of citrus (ongoing w.e.f. July 2009)
- 8. Development of INM Module for Sustained Productivity of Citrus (ongoing w.e.f. Dec., 2007)
- 9. Response of citrus trees to training, pruning and plant growth retardants with respect to management of canopy architecture, plant density and productivity (ongoing w.e.f. Aug., 2010)
- 10. Micronutrient fertigation in 'Nagpur' mandarin (*Citrus reticulata* Blanco) **Concluded : (July, 2011 to March, 2016**)
- 11. Studies on dynamics of flowering and fruiting in citrus (ongoing w.e.f. July, 2011)
- 12. Nutrient management in citrus nursery plants Concluded : (May, 2014 March 2018)
- 13. Abiotic stress management in citrus (**ongoing w.e.f. May 2014**)
- Feasibility study of contract farming in citrus Concluded : (May, 2014 to March, 2018)
- 15. Evaluation of citrus spp. on raised bed planting system (ongoing w.e.f. April 2015)
- 16. Studies on physiological disorders of citrus fruits (**ongoing w.e.f. Jan., 2015**)
- 17. Constraints of citrus nursery owners in Vidarbha Concluded : (May, 2015 to March, 2017)
- Study of photosynthetic efficiency and phytohormonal levels in different Citrus spp. (Project closed)
- Precision citriculture through enhanced water and nutrient use efficiency in 'Nagpur' mandarin. (Concluded as a flagship project : April, 2015 to March, 2017. Presently ongoing as an Institute project since April, 2017).
- 20. Development of organic production system for 'Nagpur' mandarin (Concluded as a Network project : January, 2015 to March, 2017. Presently ongoing as an Institute project since April, 2017).

Integrated Pest and Disease Management

- 21. Studies on species composition, bioecology, bioagents and management of citrus mites Concluded : (August, 2011 to March, 2016)
- 22. Studies on multiplication and management of fruit piercing moths *Eudocima* sp (ongoing w.e.f. April, 2015)
- 23. Molecular Detection and Characterization of Phytoplasma infecting Citrus in India. (ongoing w.e.f. June, 2012)



- Endophytic bacteria and fungi as bioagents for management of *Phytophthora* diseases in citrus (Concluded as a Flagship project : April, 2015 to March, 2017.
 Presently ongoing as an Institute project since April, 2017).
- 25. Studies on the prevalence and distribution of plant parasitic nematodes associated with citrus in India (**ongoing w.e.f. May, 2017**)

Post-Harvest Management and Value Addition

- 26. Studies on extending the storage life of citrus fruits (ongoing w.e.f. August, 2008)
- 27. Development of nano packaging materials for extended shelf life of citrus juice and its products **Concluded : (2010 to March, 2018)**
- 28. Development and Preservation of value added products of 'Nagpur' mandarin (*Citrus reticulata* Blanco) fruits Collaboration with CIPHET Ludhiana Concluded : (Oct., 2011 to March, 2014)
- 29. Studies on Development of Value added products from the Citrus fruits (*Citrus spp*). (ongoing w.e.f. 2011)
- 30. Screening of citrus germplasm across India for bio-active compounds at maturity and during storage (**ongoing w.e.f. March 2015**)

Network Projects

- 1. Outreach programme in network mode on management of sucking insect pest on Horticultural crops: citrus - Concluded : (June, 2009 to March, 2017)
- Outreach project on *Phytophthora, Fusarium* and *Ralstonia* Diseases of Horticultural and field crops *Phytophthora* (Citrus).- Concluded : (March, 2009 to March, 2017)
- 3. Network project on Organic Farming in Horticultural Crops Citrus (Concluded as a Network project : January, 2015 to March, 2017. Presently ongoing as an Institute project since April, 2017).
- 4. Micronutrient management in horticultural crops for enhancing yield and quality Citrus Concluded : (January, 2015 to March, 2017)
- Consortium Research Platform on Borers in Network mode : Citrus Concluded : (January, 2015 to March, 2017)
- Consortium Research Platform on Agrobiodiversity Concluded : (October, 2015 to March, 2017)
- 7. Consortium Research Platform on Vaccines and diagnostics (Citrus viruses) (ongoing w.e.f. 2015)



Other Projects

- Seed production in Agricultural crops and fisheries : Citrus Concluded : (January, 2006 to March, 2017)
- 2. Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting sustainable livelihoods, Food Security and Ecosystem services -Concluded : (May, 2009 to December, 2014)
- 3. Finalizing Crop Specific DUS Testing Guidelines for Citrus (*C. reticulata, C. sinensis and C. aurantifolia*) Concluded : (April, 2010 to March, 2014)
- 4. Development of Soil fertility map as a decision support tool for fertilizer recommendation in citrus : IPNI Funded Concluded : (November, 2010 to October, 2014)
- Technology Demonstration of canopy architecture management in citrus through training and pruning for higher density and increased productivity : NHB funded. (Concluded as an Externally funded project : December, 2011 to March, 2018. Presently ongoing as an Institute project since April, 2018).
- 6. Technology Demonstration on Rejuvenation of Declining 'Nagpur' mandarin orchards Concluded : (April, 2012 March, 2014)
- Value chain development in citrus for North East India : DBT funded Concluded : (October, 2012 to April, 2017)
- Novel strategies for molecular diagnosis of plant viruses Concluded : (April, 2013 to March, 2014)
- 9. Crop regulation in 'Nagpur' mandarin in Central India : NHB funded Concluded : (October, 2012 to March, 2016)
- Development and Validation of IPM strategy for mandarin orchards under Semi-Arid (Punjab and Rajasthan) and North Eastern Region of India - In collaboration with NCIPM – Concluded : (April, 2014 to March, 2017)
- Demonstration of mechanical pruning, training, spraying and cultivation technology for increasing the productivity of 'Nagpur' mandarin orchards in Vidarbha region of Maharashtra : NHB funded Concluded : (December, 2014 to December, 2017)
- Horticultural Crop Pest Surveillance, Advisory and Management Project (HORTSAP) – Maharashtra State Government Funded Project (Ongoing w.e.f. October, 2014)
- 13. Structure-function studies on antioxidant defense system of '*Candidatus Liberibacter asiaticus*' towards developing antimicrobials against citrus greening (HLB) [DBT funded] (**ongoing w.e.f. October, 2014**)



- 14. Innovative strategies for climate resilient citriculture-NICRA funded (Ongoing w.e.f. August, 2016)
- Functional Components and antioxidant analysis of Citrus fruits for its potential application in food industry-Funded by FSSAI (Food Safety Standard Authority of India), Ministry of Health and Family Welfare, New Delhi. (ongoing w.e.f. October, 2016).
- 16. "Molecular Diagnostics, Transcriptomics and Cisgenic Approaches to Combat Greening (Huanglongbing) Disease of Citrus". (ongoing w.e.f. January, 2017)

Contract Research projects

- 1. Testing of SURUCHI fruit ripener and sweetener for citrus Concluded : (September, 2009 to March, 2014)
- 2. Evaluation of Cyantraniliprole HGW86 10% OD against insect pests of citrus Concluded : (September, 2015 to September, 2018)

Inter-institutional Project

- 1. Studies on lac based coating formulations for extended shelf life of 'Nagpur' mandarin fruits Concluded : (April, 2011 to March, 2013)
- 2. Studies on insecticide resistance and sex attractants in the management of Citrus leaf miner, *Phyllocnistis citrella* Stainton in collaboration with Indian Institute of Chemical Technology, Hyderabad. Concluded : (March, 2013 to March, 2017)

NICRA Project (Concluded) : (March, 2011 – March, 2015)

- 1. Climate resilience based production management of mandarin : 'Nagpur' mandarin (Co-ordinating Centre ICAR-CCRI, Nagpur)
- 2. Indian Institute of Horticultural Research, Bengaluru, Karnataka (Chethalli) : *Coorg* mandarin
- 3. Dept. of Horticulture, PAU, Ludhiana, Punjab : 'Kinnow' mandarin
- 4. ICAR Research Complex for NEH Region, Barapani, Meghalaya : 'Khasi' mandarin

All India Coordinated Research Project (Ongoing)

1. Management of Genetic Resources and Varietal improvement

- Collection, Characterisation, Conservation, Evaluation and utilization of germplasm
- Evaluation of mandarin cultivar under different agro-climatic conditions
- Evaluation of promising clones of mandarin, Sweet orange, Acid lime and Pummelo



2. Rootstocks

- Evaluation of promising rootstock in citrus
- Studies on exotic rootstocks for optimum growth and productivity of 'Nagpur' mandarin
- Evaluation of hybrid rootstock of 'Nagpur' mandarin and Sweet orange

3. Nutrition

- Study on residual and cumulative effect of nutrients in Citrus.
- 4. Nutrient profiling in citrus orchards of India Concluded : (April, 2011 to March, 2013)
- 5. Citrus Water management
- 6. Climate change in Citrus
- 7. Citrus insect pests
 - Evaluation of various management modules against fruit sucking moth and fruit flies.
- 8. **Citrus diseases greening**
 - Identification and Characterization of CTV isolates of Citrus
- 9. Citrus diseases CTV
 - Studies on greening disease

All research projects are distributed under 5 different themes such as citrus improvement, citrus production, citrus protection, Post-harvest management and Social Sciences and their distribution is given in Table 8.

Projects	Citrus Improvement	Citrus Production	Citrus Protection	Post-Harvest management	Social Science
Institute	6	12	6	6	2
Network	1	2	4	-	-
Other / Externally Funded	3	6	5	2	-
Contract Research	-	1	1	-	-
AICRP	1	5	3	-	-

Table 8 : Themewise matrix of various projects underway at the Institute during 2013-18



CONCLUDED RESEARCH PROJECTS AND ACHIEVEMENTS

Sr. No.	Project	Achievements in brief	
1.	Micronutrient fertigation in 'Nagpur' mandarin (<i>Citrus reticulata</i> Blanco) (In-house project)	Worked out the iron and zinc requirement and the schedule of application in 'Nagpur' mandarin through fertigation.	
2.	Nutrient management in citrus nursery plants (In-house project)	Fertilizer dose along with potting mixture (soil:sand:FYM) (50 per cent) and cocopeat (50 per cent) have been standardized for primary and secondary nursery.	
3.	Feasibility study of contract farming in citrus (In-house project)	The contract duration, price arrangement and payment procedures were important considerations for signing the agreement between growers and private party.	
4.	Constraints of citrus nursery owners in Vidarbha (In-house project)	The norms of issuing license and new licence should be strictly followed to avoid the supply of spurious quality of planting material.	
5.	Study of photosynthetic efficiency and phytohormonal levels in different Citrus spp. (In-house project)	Photosynthetic efficiency of different citrus spp. was identified with their light saturation points (LSP). Acid lime has shown highest photosynthetic efficiency at 1600 PAR, whereas 'NRCC Mandarin Seedless-4', 'NRCC grapefruit' and 'Pummelo-5' shown at 1200 PAR, 'Flame grapefruit' has shown LSP at 1000 PAR, and 'Galgal' has shown LSP at 800 PAR.	
6.	Studies on species composition, bioecology, bioagents and management of citrus mites (In-house project)	Developed a module for the management of rust mites which include foliar application with spiromesifen 240SC @ 0.3ml/l followed by fenazaquin 10EC @ 1 ml/l at 15 days interval at berry stage of 'Nagpur' mandarin fruits in April for <i>Ambia</i> crop and in October for <i>Mrig</i> crop.	
7.	Development of nano packaging materials for extended shelf life of citrus juice and its products	Evaluated 1 per cent ZnO as nono packaging composites for enhancing shelf life of 'Nagpur' mandarin	



Sr. No.	Project	Achievements in brief
8.	Development and Preservation of value added products of 'Nagpur' mandarin (<i>Citrus reticulata</i> Blanco) fruits (In collaboration with CIPHET Ludhiana)	Developed free flowing foam mat drying technique from 'Nagpur' mandarin juice.
9.	Outreach programme in network mode on management of sucking insect pest on Horticultural crops: citrus (ICAR funded under Network project).	Chemical control schedule to protect the spring season flush from citrus psylla and blackfly with foliar application of thiamethoxam @ 0.008 per cent 20 days before flushing, foliar application of abamectin @ 0.0006 per cent and imidacloprid @ 0.009 per cent during flushing at an interval of 20 days) significantly checks the population of psylla below ETL has been worked out.
10.	Outreach project on <i>Phytophthora</i> , <i>Fusarium</i> and <i>Ralstonia</i> Diseases of Horticultural and field crops - <i>Phytophthora</i> (Citrus) (Phytofura project of ICAR).	A total of 260 <i>Phytophthora</i> spp. isolates belonging to 12 different <i>Phytophthora</i> species were obtained from 326 citrus orchards and 68 citrus nurseries situated in 15 states of India. Novel native isolate of biocontrol agent <i>Trichoderma</i> spp. found very effective in controlling root rot disease and subsequently a Talc-based formulation product of <i>Trichoderma harzianum</i> (strain NRCfBA-44) has been developed for field and nursery application.
11.	Micronutrient management in horticultural crops for enhancing yield and quality : Citrus (ICAR funded under Network project).	Delineated the spatial distribution of different nutrient constraints across citrus belts of commercial cultivars and scheduling for foliar application of micronutrients in 'Nagpur' mandarin.
12.	Consortium Research Platform on Borers in Network mode : Citrus (ICAR funded under Consortium project).	Prophylactic method for the management of bark eating caterpillar consisted of spraying the trunk with neem oil 5 per cent or <i>cypermethrin</i> 10EC @ 0.02 per cent before the monsoon and swabbing the trunk upto a height of 1-1.5m with IIHR healer cum sealer along with pruning of affected branches prior to monsoon.


Sr. No.	Project	Achievements in brief
13.	Consortium Research Platform on Agrobiodiversity (Funded by ICAR)	Total 62 accessions of citrus planted in field were characterized based on IPGRI Discriptors for citrus. Simple sequence repeats (SSR) markers were used for the analysis of genetic diversity within 32 accessions. The presence of bioactive compounds in Pummelo and grapefruits could be used as unique chemical markers for the identification of accessions and development of the product having high therapeutic value.
14.	Seed production in Agricultural crops and fisheries : Citrus (Mega Seed project funded by ICAR)	A total of 2,49,242 disease-free plants of citrus were produced ('Nagpur' mandarin, acid lime, Mosambi, and rootstock mother plant) with a total of Rs. 55,92,619/- (Fifty five lakhs ninety two thousand and six hundred nineteen) were income for the Institute. The mother blocks of 'Nagpur' mandarin, 'Mosambi', acid lime and rootstocks (Rangpur lime and rough lemon) were maintained for constant annual supply of seeds throughout the country.
15.	Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity : Promoting sustainable livelihoods, Food Security and Ecosystem services (Funded by Biodiversity)	Identified the usefulness of varieties and species and promote their potential for utilization, custodian farmers, phytochemical evaluation of pummelo fruits, and developed value added products. The training on post- harvest management and marketing. Organised Diversity Fairs for creating awareness among community.
16.	Finalizing Crop Specific DUS Testing Guidelines for Citrus (<i>C. reticulata, C. sinensis and C. aurantifolia</i>) (Funded by PPV and FR)	Finalized crop specific DUS testing guidelines for three Citrus species <i>viz.</i> , mandarin (<i>C. reticulata</i>); sweet orange (<i>C. sinensis</i>) and acid lime (<i>C. aurantifolia</i>). A one day Training - cum Awareness Programme on Protection of Plant Varieties and Farmers Right (PPV and FR) with special reference to Citrus was organized on



Sr. No.	Project	Achievements in brief
		26 th February, 2014 at Mokokchung, Nagaland (NEH Region).
17.	Development of Soil fertility map as a decision support tool for fertilizer recommendation in citrus (Funded by IPNI)	Developed soil test-based ready reckoner for fertilizer recommendation in 'Nagpur' mandarin and 'Khasi' mandarin through a decision support system.
18.	Technology Demonstration on Rejuvenation of Declining 'Nagpur' mandarin orchards (In-house project)	The principal factor for decline in 'Nagpur' mandarin orchard was observed to be ignorance and fatalistic notion collectively leading to neglect of orchard. The social- economic factors equally contribute towards decline. Orchards with absentee landlords experienced more decline with subsidy indirectly contributing towards decline.
19.	Value chain development in citrus for North East India (Funded by DBT)	Developed technology of RTS, Fizzy drinks, peel oil extraction from 'Khasi' mandarin, lime and lemon.
20.	Crop regulation in 'Nagpur' mandarin in Central India (Funded by NHB)	Project did not kick start for want of funds as committed by NHB.
21.	Development and Validation of IPM strategy for mandarin orchards under Semi-Arid (Punjab and Rajasthan) and North Eastern Region of India (In collaboration with NCIPM)	Molecular characterization and bar coding for <i>Trichoderma</i> and <i>Pseudomonas</i> isolates were carried out. 'Kinnow' mandarin samples from farmers field were tested against greening bacterium infection using standardized PCR method.
22.	Demonstration of mechanical pruning, training, spraying and cultivation technology for increasing the productivity of 'Nagpur' mandarin orchards in Vidarbha region of Maharashtra (Funded by NHB)	The mechanical tree pruner and electrostatic orchard sprayer provided by NHB, were used for the demonstration of mechanical tree pruning, training and subsequently spraying of 'Nagpur' mandarin plants at ICAR-CCRI, Nagpur farm blocks as well as the plants of citrus growers orchards in Nagpur and Amravati districts. Mechanical training and pruning of the fully grown up plants of mandarin resulted in uniform fruits besides enhancing the orchard life.



Sr. No.	Project	Achievements in brief
23.	Testing of SURUCHI fruit ripener and sweetener for citrus (Contract Research Project)	Godrej Agrovet product 'Suruchi' can be effectively used for improving the TSS content of the fruits of 'Nagpur' mandarin when sprayed at concentration of 1 to 1.5 ml/l at fortnightly interval starting from about three months before harvest in both <i>Ambia</i> <i>bahar</i> (August-September) and <i>Mrig</i> <i>bahar</i> (January-February). In sweet orange concentrations at 1 to 1.5 ml can be used about three months prior to harvest after withdrawal of monsoon.
24.	Evaluation of Cyantraniliprole HGW86 10percent OD against insect pests of citrus (Contract Research Project)	Cyantraniliprole 10.26 per cent w/w OD @ 60 g a.i./ha against citrus psylla, thrips, leaf miner and @70g a.i/ha against lemon butterfly, with newer mode of action as an alternative to currently recommended insecticides in citrus was observed effective for management of these insect pests below ETL.
25.	Studies on lac based coating formulations for extended shelf life of 'Nagpur' mandarin fruits	Standardised SH 10 formulation as coating of 'Nagpur' mandarin fruits.
26.	Studies on insecticide resistance and sex attractants in the management of Citrus leaf miner, <i>Phyllocnistis</i> <i>citrella</i> Stainton (In collaboration with Indian Institute of Chemical Technology, Hyderabad)	Developed an integrated module consisting of delta traps with graded yellow sticky cards loaded with 15 mg lure in per 30,000 seedlings in nursery and 20 mg lure/0.3 ha for open field + foliar application of thiamethoxam @ 0.008 per cent at 10 days interval followed by acephate @ 0.008 per cent and fenvalerate @ 0.02 per cent at 10 days interval for the management of citrus leaf miner. Lures with yellow sticky cards need to be replaced at 30-45 days interval depending upon pest density.
27.	Climate resilience based production management of mandarin: 'Nagpur' mandarin (ICAR funded under NICRA Project)	Supra-optimal maximum temperatures (> 37^{0} C) in the months of March-April in the years 1994, 1999, 2001, 2004 and 2008 caused heavy drop of fruitlets resulting in yield losses upto 40 per cent. Regression



Sr. No.	Project	Achievements in brief
		analysis of fruit fly and citrus leaf miner trap catch versus weather parameters showed 29 per cent impact on fruit fly trap catch and about 38 per cent impact on trap catch data of citrus leaf miner during 2014.
28.	Nutrient profiling in citrus orchards of India (ICAR funded under AICRP on Fruits)	Developed soil fertility norms for important commercial citrus cultivars like 'Kinnow' mandarin, 'Sathgudi' sweet orange, 'Malta' sweet orange and acid lime to be used for developing Soil Health Card for Citrus.
29.	Functional components and antioxidants analysis of citrus fruit for its potential application in food industry. (Funded by Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, New Delhi)	Commercial citrus species were analysed for functional components namely flavonoids, limonoids, carotenoids, naringin and hesperidin in addition to nutritional components from citrus fruit waste.

Impacting Technologies Developed by the Institute, since its inception

- **Release of varieties and rootstock:** 'NRCC mandarin seedless-4' (seedless with high yield), 'Cutter Valencia' (processing variety), 'Flame Grapefruit' (attractive colour with high yield), 'NRCC Pummelo-5' (yellow coloured fruit with high yield), 'Pummelo US-145' (white fleshed with high yield), 'NRCC Grapefruit-6' (medium sized fruits with very high yield), 'NRCC Acid Lime-7' (high yielding) and 'NRCC Acid Lime-8' (cluster bearing) and 'Alemow' rootstock as an alternative rootstock to rough lemon or Rangpur lime.
- **Production of disease-free planting material:** Protocol for mass production of disease-free planting material of citrus. Shoot-Tip-Grafting for production of disease-free planting material cleaning the scion mother plants and introduced/imported material infected with virus. Micro-budding protocol for producing micro-budded plants within 12 months as against 18 months consumed in conventionally budded plants.
- Fertilizer recommendation: Leaf nutrient standards and soil suitability criteria for soil health card-based balanced fertilizer recommendation in citrus. Different nutrient management strategies *viz.*, INM schedule, site specific nutrient management, foliar fertilization and inorganic fertilizer scheduling for balanced fertilization and inorganic fertilization in citrus orchards.



- Irrigation/Fertigation: Micro-irrigation and fertigation schedules for 'Nagpur' mandarin and acid lime.
- Flowering and crop regulation: Crop regulation and fruit drop management in addition to technique of increasing fruit size.
- Citrus decline: Rejuvenation technology for management of 'Citrus Decline'.
- **Orchard establishment:** Raised-bed planting of citrus for avoiding waterlogging and *Phytophthora* infestation.
- **Insect-pest management:** Management of major insect pests like citrus blackfly, Psylla, leaf miner, mites, etc through timely crop stage-based chemical control schedules and release of bio-control agents in citrus. Monitoring and mass trapping technique for citrus leaf miner using pheromone lures for protected nurseries and pre-bearing citrus orchards.
- **Disease management:** Molecular diagnosis of *Phytophthora nicotianae* and *P.palmivora* causing root rot, foot rot and gummosis disease and their chemical control. Mass multiplication protocol for talcum powder based product of *Tricoderma harzianum* NRCfBA-44 strain useful for management of *Phytophthora* root rot of citrus. Diagnostic tools for greening CTV, ICRVS, CMBV and CEVD. Canker management in acid lime.
- Maturity standards and Post-harvest handling: Maturity standards for major citrus cultivars, post-harvest handling.
- **Degreening:** Technique of colour improvement and degreening using ethylene. Designing of de-greening chamber for 'Nagpur' mandarin and Mosambi cultivars.
- **Packaging:** Packaging containers of corrugated fibre board and packing method for long distance transport.
- **Pre-cooling:** Pre-cooling unit with ½ ton fruit holding capacity and low cost evaporative cool chamber for small scale fruit storage
- **Processing:** Protocol for preparing juice powder from citrus fruits. Technologies for RTS and fizzy drinks using acid lime and mandarin fruits.
- Waste utilization: Animal feed prepared from 'Nagpur' mandarin processing waste.



5. ACHIVEMENTS

Research Highlights (2013-2018)

1. Germplasm

• Citrus germplasm maintained at ICAR-CCRI headquarter are as follows :

There are total 614 citrus accessions maintained in National Citrus Repository and Field Gene Bank over the period of time since inception of the Institute.

Total number of citrus accessions collected and maintained are as follows :

- Exotic = 62 Rootstock = 23, Scion = 39 (Mandarin, Sweet orange, Pummelo and Grapefruit) collected mostly from USA, Japan, Australia and Niger.
- Indigenous collection = 552
- Superior clone selected : 'Nagpur' mandarin = 79, Acid lime = 12, 'Mosambi' = 15, 'Pummelo' = 9, Citron = 2

Source	Spp. and varieties	
Brazil	Sweet orange: 'Hamlin', 'Pera', 'Natal', 'Valencia' and 'Westin'.	
USA	Sweet orange: 'Diller', 'Delta' 'Valencia', 'Salustiana', 'Trovita', 'Marrs Early' and 'Cara-Cara'	
	Grapefruit: 'Rio Red' and 'Red Ruby'	
Punjab	Sweet orange: 'Blood Red', 'Pineapple' and 'Jaffa'	
	Grapefruit: 'Marsh Seedless', 'Red Blush' and 'Star Ruby'	
	Lemon: 'Pant lemon-1', 'Kagzi Kalan', 'Baramasi Lemon' and 'Assam Lemon'.	
Dr. PDKV, Akola; MPKV, Rahuri; AICRP, Tirupati and Periyakulam;	Acid lime: 'PDKV Bahar', 'Chakradhar', 'Phule Sharbati', 'Sai Sharbati', 'Balaji', 'NRCC-7', 'NRCC - 8', 'Parmalini', 'Vikram', 'Jai Devi'.	
Haryana	Sweet orange: 'New Hall', 'Lanelate', 'Valencia Olinda' and 'Washington Navel'	
	Mandarin: 'W. Murcot', 'Clementine', 'Michal', 'Daisy', 'Pearly Tangelo'.	

• During the period under report, following new germplasm was introduced and evaluation has been initiated in field/laboratory.



II Citrus Improvement

Following new varieties and technologies have been developed :

- 'NRCC Mandarin Seedless-4' has been released as commercially seedless cultivar since it produced fruit with less seed (2.62 seed per fruit) compared with control plants (12.50 seeds per fruit). Average fruit weight is 145.9 g and fruit quality is at par with 'Nagpur' mandarin (TSS 10.2 per cent and 0. 72 per cent acidity).
- 'NRCC Acid Lime-7' has been released as high yielding variety (yield potential 54.0 tonnes/ha) with high juice content (50.50 per cent) and very attractive yellow fruit peel colour.
- 'NRCC Acid Lime-8' has been released as a cluster bearing variety and very high yielding (59.0 tonnes/ha). Fruits are bigger (45.10 × 45.33 mm). Average fruit weight is 50g and juice content is 51.53 per cent.
- 'NRCC Pummelo-5' has been released as one of the very promising pummelo variety good for table purpose. Yellow colour fruit with tasty red colour segments good for table purpose, has very good blend of high TSS and acidity. Recently, it is proposed to be released at States' level also.
- 'NRCC Grapefruit-6' has been released having medium sized fruits (375 g fruit weight) with high juice content (46.40 per cent) and very soft tender segments good for table purpose as well as juice purpose, very high yielding 42.09 tonnes/ha at 6×6m spacing.
- 'Cutter Valencia' has been released as late sweet orange with excellent taste, matures in early December and can be held on tree upto February. Bigger sized fruits (208 g) with high juice content (47.18 per cent) and very soft yellow colour segments good for table as well as juice purpose. This is promising sweet orange variety for juice processing.
- 'Flame Grapefruit' has been released having very attractive colour with pink blush on fruit surface, tender segments with high juice content and commercially seedless and red flesh colour. Recently it is proposed to be released at State level.
- 'US Pummelo-145' has been released having medium sized fruits with high juice content (31.56 per cent) and very soft tender segments good for table purpose as well as juice purpose.
- 'Alemow (*Citrus macrophylla*)' has been identified as a *Phytophthora* root rot tolerant rootstock. Medium size canopy imparts prolific bearing to the scion 'Nagpur' mandarin and acid lime.
- Performance of STG-derived plants, micro-budded plants and conventionally produced disease-free planting material has been evaluated in field by the Institute.



- Complete plantlet regeneration obtained from hybrid endosperm rescue via somatic embryogenesis in 'Nagpur' mandarin and sweet orange. Triploid status has been confirmed by Flow Cytometry from M/s Ankur Seeds Pvt. Ltd. and also by conventional cytology.
- Devised and improved a novel methodology of producing tetraploids based on *in vivo* colchicine treatment of microbudded plants of two commercial scions *viz.*, 'Nagpur' mandarin and Sweet orange. Ten surviving 'Nagpur' mandarin and Sweet orange microbudded plants after ploidy analysis by Flow Cytometry were confirmed as tetraploids and mixoploids.
- A method to induce tetraploidy in commercial citrus rootstocks by treating the germinating seeds (2-week-old) with colchicine was developed for Rough lemon and Rangpur lime. Stable tetraploids were successfully produced in the commercial rootstocks and confirmed both by Flow Cytometry and chromosome count.
- Obtained complete plantlet regeneration through direct organogenesis from mature nodal explants of important citrus rootstocks *viz.*, Alemow (*C. macrophylla* L.), Rangpur Lime Brazilian (*C. limonia* Osb.), Rough lemon (*C. Jambheri lush*) and commercially important citrus scions *C. aurantifolia* cultivars 'NRCC-7', 'NRCC-8', 'Chakradhar' and 'Sai Sharbati', *C. lemon* cultivars 'Baramasi' lemon, 'Pant' lemon, 'Assam' lemon, 'Kagzi Kalan', *C.reticulata* cultivars, 'NRCC Mandarin Seedless-4' and *C. paradisi* Macf. cultivar 'Flame' grapefruit. As many as 371 regenerated plants were taken to field for onward evaluation.
- Obtained complete plantlet regeneration protocol via nucellar embryogenesis in commercial citrus rootstocks *viz.*, Rough lemon, Rangpur lime, Alemow and also in citrus scions *viz.*, sweet orange and acid lime through ovular explants from controlled pollination.
- Shoot tip grafting technique standardized for exotic citrus cultivars *viz.*, 'Flame' grapefruit, 'Frost Owari', 'Star Ruby', 'Ruby Blood orange', 'Corsica', 'Cutter Valencia', 'Pummelo US-145', 'Pera' and 'Natal' and indigenous citrus cultivars *viz.*, 'NRCC Mandarin Seedless-4' and 'Assam' lemon.
- The complete technical knowhow has been licenced for commercial production of disease-free planting stock of promising indigenous and exotic citrus cultivars involving shoot tip grafting and other innovative propagation techniques.
- Microbudding technique standardized in all commercial citrus cultivars *viz.*, sweet orange, acid lime, 'Kinnow', 'Calamondin' and promising CCRI 4 exotic cultivars ('Cutter Valencia', 'Flame' grapefruit, 'Pummelo US-145' and 'Frost owari' mandarin) and indigenous promising cultivars (NRCC grapefruit 6, NRCC pummelo-5 and 'NRCC Mandarin Seedless-4') for multiplication and early market release of quality budgrafts. Through microbudding technique these varieties were propagated and around 10,000 elite citrus planting stock has been sold.
- Retrofitting of Citrus nursery phase for lowering the production time and cost of



planting stock. In containerized nursery the rootstocks seedlings are raised in primary and secondary nurseries prior to budding. To reduce the nursery phase to 12-13 months in place of conventional propagation time of 20-22 months, the seeds are directly sown in the polybags, bypassing the 6-8 months period primary nursery stage.

- A total of 135 markers (90 SSR and 45 InDel) were screened in the citrus germplasm and identified 74 (46 SSR and 28 indel) polymorphic markers. These 74 polymorphic markers were further utilised in sweet orange and lemon varieties to assess their genetic diversity.
- After screening 135 markers (90 SSR and 45 InDel) in eleven major rootstocks we have identified combination of 5 markers (3 InDels and 2 SSR) able to distinguish all the eleven major citrus rootstocks.
- Simple Sequence Repeats (SSR) markers were identified to differentiate the nucellar and zygotic seedlings of different crosses made in the citrus species.
- In acid lime group, crossing was made on acid lime background for canker resistance using citron, 'Assam' lemon and 'Adajamir' as recurrent parents and 75 progeny seedlings are field transferred. In sweet orange group crossing was attempted on 'Mosambi' background using exotic sweet orange cultivars *viz.*, 'Pera', 'Ruby Blood Red', 'Cutter Valencia', 'Hamlin', 'Natal' etc. However, out of 37 crossing combinations, success was achieved in only 9 combinations and 52 seedlings of progeny were raised for field transfer. In rootstock improvement programme for development of biotic stress, trifoliate orange and its hybrids (citranges) are being used as donor parents on Rough lemon and Rangpur lime. Distant hybridization was attempted to develop segregating population using sweet orange, pummelo and grapefruit cultivars. As many as 124 crosses were made and 108 progenies are being further studied after transplantation.

III Quality Planting Materials

- *In-vitro* Shoot Tip Grafting (STG) technique standardized and disease-free mothertree blocks were established for bud wood. Introduced/imported material was also cleaned with STG as important tool in quarantine.
- About 14.00 lakh disease-free planting material of 'Nagpur' mandarin, 'Mosambi' sweet orange and acid lime distributed to farmers, KVKs, SAUs. Revenue of Rs. 4.51 crores generated in last 5 years.
- Approximately 4,975 ha brought under disease-free plantation of citrus in Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Karnataka, Odisha, Tamil Nadu, Punjab, and North-East region.
- Citrus nursery at ICAR-CCRI, Nagpur has been rated as '5 STAR' (*****) nursery in the country with indexing facility for six important citrus pathogens namely *Tristeza*, Citrus Mosaic, Ringspot, Exocortis, citrus greening and *Phytoplasma*.





IV Citrus Production

- On raised-bed system of planting combined with fertigation, evaluation of sweet oranges *viz*. 'Blood Red', 'Jaffa' and 'Pineapple' and grapefruits *viz*. 'Star Ruby', 'Marsh Seedless' and 'Red Blush' on rough lemon rootstock are producing encouraging results with respect to fruit quality and yield under Nagpur conditions. As a mid-season to late maturing varieties, these fruits will provide wider availability window in the market and better returns to growers.
- Cultivar specific nutrient diagnostics using leaf and soil analysis was developed for commercial citrus cultivars like 'Nagpur' mandarin, 'Kinnow' mandarin, 'Malta' sweet orange, Acid lime and 'Sathgudi' sweet orange for the first time in the country. This is one basic effort towards laying a sound basis for SOIL HEALTH CARDS for citrus growers.
- The application of vermicompost loaded with microbial consortium (100 per cent N-equivalent basis) + IPM₂ (foliar application of Horticultural Minieral oil (2 per cent) followed by *Beauveria bassiana* @ 5g/1 and *Azadirachtin* (1 per cent) @ 4 ml/1) + IDM₁ Bordeaux paste (CuSO₄ : Lime: Water = 1:1:10) as pre monsoon /post monsoon trunk application along with *Trichoderma harzianum* native antagonistic strain, NRCfBA29 (100g/plant) with carrier material of FYM (1kg) as soil application at root zone recorded maximum soil and plant nutrients, plant height, canopy volume, fruit yield, number of fruits, fruit weight and lower incidence of insect pests and diseases.



- A microbial consortium comprising five microbes *viz.*, *Micrococcus yunnanesis*, *Bacillus Pseudomycoides*, *Paenibacillus alvei*, *Acinetobactor radioresistens and Aspergillus flavus* have been developed, evaluated under pre-evaluation and integrated soil fertility management mode under field condition which showed a sharp cut of CO₂ release from soil, besides increasing fruit yield over conventional soil fertility management using inorganic fertilizers. The developed microbial consortium will be commercialized very soon.
- Decision support based on variation in magnitude of fertilizers response to variable rate of fertilizer application (Combination of GPS, GIS, and DRIS) was developed using the fertilizer doses prediction model at a given soil-test values for a range of targeted fruit yield.
- Out of 5 exotic varieties from Brazil *viz.* 'Pera', 'Natal', 'Westin', 'Valencia' and 'Hamlin' on rootstocks such as *Volkameriana* and *limocravo*, the 'Natal', 'Valencia' and 'Hamlin' have produced encouraging results with respect to Juice content, palatability and market availability. 'Hamlin' is early while 'Natal' and 'Valencia' are late season. These varieties may prove promising for processing purpose.
- Lemon varieties 'Pant' lemon, 'Assam' lemon, 'Kagzi Kalan' and 'Baramasi' lemon have been evaluated as budded plants on rough lemon rootstock on raised-bed system. Pant lemon and Baramasi lemon have produced yield of 9.26 and 14.21 tonnes per ha, respectively in second year.
- Fe + Mn + Zn + B + Mo + 2,4 –D (10 ppm) + urea (1 per cent) (Foliar spray of 0.50 per cent FeSO₄ + 0.50 per cent MnSO₄ + 0.50 per cent Zn SO₄ + 0.25 per cent borax + 0.25 per cent ammonium molybdate + 10 ppm 2,4 -D + 1 per cent urea at anthesis, pea size, marble size and initiation of fruit enlargement size) was observed to increase fruit yield and fruit quality, in addition to nutrient density of fruits.
- The critical stages of water for 'Nagpur' mandarin have been identified. These are in the order of stage III (May-June), II (March-April) and I (January-February) in Central India.
- The critical water need of the 'Nagpur' mandarin is worked out at irrigation schedule with 80:80:80:80:80 per cent evaporation replenishment (ER) under Central Indian conditions. Irrigation with 80 per cent ER in all the stages I-V (flowering and fruit set-I, marble stage II, fruit growth stage III, fruit maturity stage-IV and colour break stage V) is optimum water requirement.
- The irrigation schedule with 80 per cent ER along with 80 per cent RDF fertigation in all stages I-V (flowering and fruit set-I, marble stage II, fruit growth stage III, fruit maturity stage-IV and colour break stage V) of growth of 'Nagpur' mandarin is recommended for transfer under Central Indian Nagpur conditions.
- The dose of zinc sulphate and iron sulphate micronutrients with fertigation was developed on bearing 'Nagpur' mandarin. The growth of the plants was higher in fertigation than soil application. The highest fruit yield per tree was in the fertigation



of ZnSO₄ @ 300 g/plant and fertigation of FeSO₄ @ 200 g/plant.

- Based on the phenological observations with respect to phenomena of flowering stimulus and expression of actual flowering in 'Nagpur' mandarin during two major flushes *viz.*, Monsoon flowering locally called as *Mrig bahar* (June-July flowering) and spring flowering locally called as *Ambia bahar* (January-February flowering), the ideal weather parameters were standardized.
- The experimental results with the use of GA_3 15 ppm+ boric acid 0.5 per cent + calcium chloride 1 per cent yielded good effect in correcting stylar end breakdown in 'Nagpur' mandarin
- Application of paclobutrazol 6g as soil application or chlormequat chloride at 2000 ppm after intermittent irrigation during stress period restores physiological water deficit stress in 'Nagpur' mandarin.
- Based on the climatic parameters, optimum conditions for flowering and fruiting of 'Nagpur' mandarin in Central India were determined. The citrus growers are given the integrated advisory to avoid the disorder and minimise the losses.
- Fruit oblongation is a physiological disorder and not having direct association with citrus greening. Abscisic acid concentration increased fruit oblongness in 'Nagpur' mandarin under excess moisture and moisture stress conditions. Physiological disorder of fruit oblongness is more prominent in rootstock of Galgal (~35 per cent) followed by Rangpur lime (~15 per cent) and Shekwasa x Rough Lemon (~7 per cent).
- High density planting experiments in acid lime has produced very promising results. Acid lime 'Pramalini' (Seedling plants) produced 35.40 tonne/ha at 2.5×2.5 m as compared to 10.46 tonnes/ha at 5×5 m Acid lime, 'Kagzi' on Rangpur lime rootstock at very high density 3×1 m and 4×1 m yielded 44 to 45 tonnes/ha, respectively.
- Photosynthetic efficiency of different citrus spp. was identified with their light saturation points (LSP). Acid lime has shown highest photosynthetic efficiency at 1600 PAR, whereas 'NRCC Mandarin Seedless-4', 'NRCC grapefruit' and 'Pummelo-5' shown at 1200 PAR, 'Flame grapefruit' has shown LSP at 1000 PAR, and 'Galgal' has shown LSP at 800 PAR.
- 'Nagpur' mandarin on 'Rangpur Lime' rootstock at 3×1 m spacing and 3×2 m spacing yielded 33.99 and 18.38 tonnes/ha while at 6×3 m and 6×6 m spacing yield was 8.78 and 5.00 tonnes/ha, respectively, based three years average. At 2×2 m (2500 plant/ha) and 4×2m (1250 plants/ha) three years average, yields were 45.19 and 32.67 tonnes/ha, respectively.
- In case of acid lime and 'Rangpur' lime primary nursery, it is recommended to use 20 g N + 10 g P + 10 g K + *Trichoderma* strain 44 per tray along with normal potting mixture (soil : sand : FYM in ratio of 1:1:1) to get healthy, vigorous acid lime seedlings. After emergence, fertilizer may be applied at the rate of 1-2 g/tray after dissolving in sufficient quantity of water. At one month interval it is again given by



increasing dose by 1-2 gram. For Rough lemon, it is recommended to use 40 g N + 25 g P + 25 g K + *Trichoderma* strain 44 per tray. This dose needs to be split.

- In secondary nursery for 'Rough' lemon and 'Rangpur' lime, it is recommended to use 6 g N + 3 g P + 3 g K + *Trichoderma* strain 44 on per plant is utilized. This dose to be split during six month period. For acid lime secondary nursery, use 2 g N + 1 g P + 1 g K + *Trichoderma* strain 44 per plant. This dose to be split_during six month period.
- A promising rootstock *Alemow* was found to be very productive for 'Nagpur' mandarin and acid lime. The rootstock has been evaluated in the farmers orchard and is very much useful for increasing the fruit yield. It is adaptable in Central India.
- The improved raised bed system is being evaluated for all the citrus spp. and very encouraging results with respect to growth and production for mandarin, sweet orange, exotic sweet orange, grapefruit, pummelo and lemon varieties have been obtained. The experiment is in progress. Raised bed system resulted in reduced *Phytophthora* disease and better drainage. This system is easy to maintain with fertigation and mulching. Intercrops such as Brinjal, Tomato, Okra and cucurbitaceous crops could be successfully grown.

V. Citrus Protection

- An integrated module consisting of delta traps with graded yellow sticky cards loaded with 15 mg lure per 30, 000 seedlings in nursery and 20 mg lure per 0.30 ha for open field + foliar application of thiamethoxam @ 0.008 per cent at 10 days interval followed by acephate @ 0.008 per cent and fenvalerate @ 0.02 per cent at 10 days interval is helpful to reduce the infestation levels up to 68 per cent apart from reducing the spray frequency. Lures may be replaced at 30-45 days interval and yellow sticky cards depending upon pest density.
- Foliar application with spiromesifen 240SC @ 0.30 ml/l followed by fenazaquin 10EC @ 1 ml/l at 15 days interval at berry stage of 'Nagpur' mandarin fruits in April for *Ambia* crop and in October for *Mrig* crop effectively checks the mite (*Phyllocoptruta oleivora* and *Brevipalpus rugulosus*) infestation (<10 per cent) under Nagpur conditions.
- Cyantraniliprole 10.26 per cent w/w OD @ 60 g a.i./ha against citrus psylla, thrips, leaf miner and @70g a.i/ha against lemon butterfly can be recommended for the effective management of these insect pests of citrus below ETL.
- Evaluation of different repellents against fruit sucking moth (FSM) by hanging polypropylene sachets with phorate or acephate 10g @ 2 per tree coinciding with colour breaking stage of 'Nagpur' mandarin fruits of *Ambia* significantly reduced the fruits drop (< 7 per cent) due to FSM.
- A talc based formulation of a native strain (NRCfBA-44, isolated from Vidarbha



region of Maharashtra soil) of bio-control fungus *Trichoderma harzianum*, useful for the management of *Phytophthora* root rot disease of citrus. It also promotes growth of citrus plants. It is an eco-friendly component of management.

- A rapid and sensitive diagnostic assay based on the polymerase chain reaction (PCR) has been developed for detecting greening bacterium in plant as well as insect vector (psyllids) very quickly and reliably. The entire procedure can be completed within 6 hours time : 2 hours for DNA extraction, 3 hours for PCR and 1 hour for analysis of PCR products by agarose gel electrophoresis.
- Developed PCR-based diagnostic techniques for Citrus greening, CTV, CMBV, ICRSV and citrus Phytoplasma in infected plants using different pathogen specific primers.
- Developed LAMP based diagnostic kits for citrus greening disease and citrus tristeza virus. These developed kits are now ready for commercialization.
- Standardization of duplex PCR technique for simultaneous detection of CTV and citrus greening; CMBV and citrus greening.
- Developed RPA-LFA based diagnostics for citrus greening disease.
- Developed Real Time PCR Technique for detection of citrus greening disease and CTV.
- Identified 2S Albumin protein (isolated from pumpkin seeds) as an effective inhibitory molecule for control of citrus greening disease under screen house condition.

VI. Post-harvest Management

- The quantification of hesperidin and other bioactive compounds in citrus was done in high performance liquid chromatography (HPLC).
- The technology of carbonated beverage from 'Nagpur' mandarin and acid lime was given to M/s. Paliwal Udyog Ltd. Carbonated drinks were prepared from firm and mature 'Nagpur' mandarin and acid lime with fruit juice (15 per cent). Dosing method was used for the preparation of carbonated (fizzy) drinks. Fizzy drinks were filled and sealed in PET bottles for marketing.
- The technology of RTS from acid lime was given to M/s. Paliwal Udyog Ltd and licensing agreement was signed. Potassium meta-bisulphite (KMS) was used as a class II preservative and was added as per FSSAI standards. The prepared RTS drinks are filled and sealed in PET bottles for marketing.
- Pummelo candy was prepared from peel of firm and mature fruits as per FSSAI regulations. The candy was vacuum packed in aluminium foil packets and stored in ambient condition for marketing purpose.

VII. Agriculture Extension Management



- Type of occupation and annual income of the citrus grower showed significant relationship with the perceived acceptability of contract farming. Inadequate water for irrigation followed by price uncertainty were observed to be main risk factors in acid lime farming as perceived by the growers. The guaranteed and fixed pricing structures were believed to be the main advantage of contract farming. Pricing arrangement and payment procedures received maximum preference for signing an agreement.
- Studies on constraints of citrus nursery owners of Vidarbha showed a significant negative relation of type of occupation and significant positive relation of communication behaviour with the acceptability towards containerized nursery system. The guaranteed and fixed price structure, minimum support price and need for providing appropriate technology, necessity of issuing permits for nursery growers, availability of guanine rootstocks are the issues/action to be taken by Government agencies for sustenance of citrus nursery business.

VIII. Regional Research Centre for Citrus

Plantation and citrus germplasm bank : Varietal evaluation studies have been initiated during 2017 on raised-bed and flat bed (Plain field) planting system. So far 29 citrus varieties of sweet orange, mandarin, limes, lemon, grapefruit and pummelo have been planted. In field gene bank of citrus, a total of 51 accessions have been planted and some of them have started flowering and fruiting.

Farm infrastructure : Drip system has been installed having provision of fertigation. Tube well facility has been created. The RRCC has started functioning with basic infrastructure after renovation of old college building temporarily given by BNCA, in this, RRCC which has one room for administration, one Director's room one training hall, four laboratory rooms and one store room.

Impact of Technologies developed/Achievements

- 1. Approximately an area of 4975 ha has been brought under disease free planting material supplied by the ICAR-CCRI in Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Karnataka, Odisha, Tamil Nadu, Punjab and NEH region.
- 2. With microbudding technology, the cost of production of nursery plants has been brought down by 30 per cent and nursery time by 25 per cent.
- 3. The *Trichoderma herzianum*, talcum powder based product of the institute has brought down *Phytophthora* root rot incidence by 60 per cent in farmers fields.
- 4. With the distribution of disease free planting material the life span of 'Nagpur' mandarin has increased by 10 to 12 years and its production has increased by 2.5 to 3 times.
- 5. The technologies of RTS and carbonated beverage have been commercialized and



approximately 50,000 bottles of RTS and carbonated beverages of acid lime and 'Nagpur' mandarin have been marketed by the entrepreneurs M/s. Paliwal Udyog Ltd. making business of Rs. 6 lakh during last 2 years.

- 6. The ICAR-CCRI technologies are in demand and nurseries are being developed by
 - Mr. H.U. Gugle Agro biotech, Ahmednagar, M.S.
 - Karunamaya Agro tech. Nagpur
 - Seven star fruits Pvt. Ltd. Mumbai
 - M/s KJB, Agro, Tamil Nadu
 - M/s Shivam Nursery, Nagpur
- 7. The production and productivity of a large number of citrus orchards increased due to trainings and demonstrations received by the citrus growers from ICAR-CCRI, Nagpur.
- 8. The institute's website has been visited by 35,000 growers which in turn helped to disseminate ICAR-CCRI technologies.

Extension and Transfer of Technology

Technology transfer programmes like trainings of citrus growers and officers, *Kisan Melas*, demonstrations in growers' fields, meetings with growers and visits to orchards were carried out extensively by the Institute during 2013-18. Emphasis was also given on training and transfer of technology in NEH region where 'Khasi' mandarin is the major commercial citrus crop. ICAR-CCRI is affiliated to Agricultural Skill Council of India (ASCI). Qualification pack on "citrus fruit grower" which includes all the nursery management practices has been approved w.e.f. 24th January, 2017. Skill development programme of 200 hrs (one month) are being conducted. The number of programmes and beneficiaries are given in Table 9.

Kisan Mela

The Institute organized two '*Rashtriya Kisan melas*' which attracted more than 2000 farmers from all citrus growing states of the country during 2014 and 2018 (Annexure- V).

Consultancy Services

The Institute provided consultancy services to eight private companies/entrepreneurs - The areas of consultancy were i) RTS and Carbonated Drinks, ii) Shoot Tip Grafting in production of disease free planting material of citrus, iii) Storage of acid lime, iv) Analysis of Hesperidin and other compounds, v) Establishment of mechanized packing line and cold store, vi) Hi-tech nursery management and vii) Microbudding propagation technique. Revenue was generated through transfer of technology from these consultancies (Annexure - V)

Table 9 : Training programmes organized by ICAR-CCRI, Nagpur for growers and officers



Type of Training	Duration of training	Total trainings organized	Participants benefitted		
Training programmes for citrus g	Training programmes for citrus growers from other parts of the country				
	1 dav	4	81		
	3 days	5	57		
On-Campus	7 days	4	99		
	15 days	1	11		
	30 days	6	85		
	1 day	10	1254		
Off-campus	3 days	1	69		
*	7 days	1	5		
Training programmes for citrus g	rowers of NEH r	egion			
On-Campus	1 day	1	19		
	3 days	5	85		
Off-campus (in NEH states)	1 day	1	59		
	3 days	10	893		
Training programmes under TSP					
On-Campus	1 day	1	10		
Off-campus	1 day	8	661		
	3 days	2	120		
Total		60	3495		
Summer/ Winter School					
 'Advances in Citriculture', 7-27th May, 2013 	21 days	1	16		
 Precision Citriculture for Sustainable Production and Post- harvest Management during 15th October – 4th November, 2015. 	21 days	1	26		
International trainings					
 Training on Citrus virology for one scientist of Oman was conducted during 18-24th November, 2013 under Indo- Oman bilateral cooperation programme in Agriculture 	7 days	1	1		
• Nursery management, Shoot-tip- grafting, fruit fly management, citrus greening and <i>Phytophthora</i> root rot management and virus and virus like diseases sponsored by Government of Nepal during 6-8 th June, 2017.	3 days	1	12		
Total =		4	55		
Grand total		64	3550		

The details of trainings are given in Annexure - V

Services offered



Following technical services have been provided to the end users as and when required.

- Scientists' field visits for diagnosis and remediation of pests and diseases
- Disease and insect pest identification
- Leaf and soil analysis
- Soil and water management advisory services
- Automatic mechanical pruning and spraying
- Insect-pest disease management advisory services.
- Citrus cultivation practices and management through Mobile app "CCRI-Citrus".

Visits of Growers, Students and Officers

During 2013-18, 5477 farmers, 708 officers and 2283 students from different parts of the country visited the Institute and they were shown the technologies developed.

Exhibitions

Institute displayed its technologies through its stalls in 47 exhibitions organized by SAUs and ICAR Institutes/ State Governments, private organizations and colleges during 2013-18 in different parts of the country. Scientists participated in these events and demonstrated technologies and publications were sold. Thousands of farmers visited ICAR-CCRI stall during these exhibitions (Annexure -V)

Accreditation of ICAR-CCRI Nursery

- The National Horticultural Board had recommended the NRCC nursery with 5 star (*****) rating for a period of 2 years and later a surveillance team under the leadership of Dr. B. K. Karkara, Consultant NHB Sr. B.R. Deoghare, Dy. Director, NHB visited NRCC nursery on 3rd October, 2013.
- National Horticulture Board constituted a committee and an expert team under the Chairmanship of Dr Y.R.Channana visited National Research Centre for Citrus, Nursery for Accreditation on 11th September, 2014 for renewal of 5 star (*****) rating and appreciated the NRCC nursery and other infrastructure facilities.
- National Horticulture Board, Gurgaon assessed citrus nurseries of the Institute for accreditation and rating the nursery on 3rd June, 2017. The assessment team has rated ICAR-CCRI and TMC nursery as 3 Star (***) for 'Nagpur' mandarin, Sweet orange and Acid lime in the scale of one to three star rating systems for period of 2 years w.e.f 5th July, 2017

ISO 9001:2008 Certification

ICAR – Central Citrus Research Institute, Nagpur, the premier institute on citrus research in the country has been awarded the ISO 9001 : 2008 from Swiss Cert Pvt. Ltd. for quality services in research, extension and other relevant services on citrus. It is a matter of pride that within a year of upgradation to institute level and on eve of 30^{th} Anniversary Institute got



this prestigious recognition. It reaffirms claim that the Institute follows all the Standard Operating Procedures (SOPs) followed at the international level.

Swachh Bharat Abhiyan

With the launch of '*Swachh Bharat Abhiyan*' in 2014 on the day of birth anniversary of Mahatma Gandhi, on 2nd October the ICAR-CCRI, Nagpur initiated cleanliness campaign at its premises right from the main gate of the campus, office premises, parking areas, residential colony, areas around the net houses, screen houses and farm house. During 2014, 2015, 2016, 2017 and 2018, this programme has been implemented. Director of the Institute administered the pledge 'Swachhta Shapath' to all the staff members. Institute also observed "Swachhta Pakhwada" in which various activities were undertaken.

Mera Gaon Mera Gaurav (My Village My Pride)

ICAR-CCRI, Nagpur adopted two villages *viz.*, Panchgaon and Hetikundi of Maharashtra under "*Mera Gaon Mera Gaurav*". Technical information is being provided to farmers on technical and other related aspects in time frame through personal visits. Demonstration on "Organic production of 'Nagpur' mandarin" has been taken up at these two villages.

Technology Mission on Citrus (TMC)

Technology Mission on Citrus (TMC) has started functioning at ICAR-CCRI for Vidarbha region from January 2007. The programme was extended to Marathwada region in Maharashtra (in collaboration with MAU, Parbhani) during 2009 and to Chhindwara region in Madhya Pradesh (in collaboration with JNKVV, Jabalpur) during 2011. Its objectives are 1) production of disease-free planting material, 2) skill development/capacity building/training of citrus growers and State Department/KVK/ZP officers and 3) demonstration of rejuvenation and improved technologies in citrus orchards. The other objectives being participation in Agri-exhibitions, organizing *Kisan Melas*, farmers meetings, distribution of citrus related literature in local language etc.

These programmes covered 8 districts of Vidarbha, 6 districts of Marathwada and 1 district of Chhindwara. So far 47,484 citrus growers were trained during one-day (8 hrs.) training programme and 2857 officers were trained during four-day long (32 hrs.) trainings apart from 388 nurserymen. In all, 18.73 lakh plants of various citrus varieties and rootstocks were sold thus covering 6732 hectare land under disease-free plants. During this period, 70 demonstrations were completed in citrus growers' fields in which consecutively for 3 years citrus rejuvenation/improved technologies were shown convincingly. Presently, 42 such demonstrations are underway in 13 districts. TMC also took part in 60 agri-exhibitions across India and jointly organized seminar/symposia with CCRI/SAU and 13 *Kisan Melas* with CCRI/SAUs. In all 28 publications including citrus *Samachar Patrika*, technology manual (*Hastapustika*)/charts in local language were published and distributed free of cost to farmers.

Human Resource Development



- i. During the period under report, three training programmes/workshops organised on 'Technology Transfer and Commercialization: IPR issues' to sensitise the scientists and technical staff of the Institute about the importance of transfer of technology and its commercialization
- ii. As a part of capacity building of its staff, the Institute has done commendable job of training its scientists at reputed International and national organization. Scientists are regularly receiving the honors from various countries for presentation as keynote speakers. During the period under report the scientists have participated in 1 International and 28 National training programmes. Technical staff was trained in 19 trainings, while administrative and supporting was trained in 11 and 2 trainings, respectively in National training programmes (Annexure VI).

Symposia / Workshops / Seminars Organized by CCRI

- i. "National Citrus Meet" was organised in collaboration with Protection of Plant Varieties and Farmers Rights Authority (PPV and FRA), Govt. of India at ICAR-CCRI, Nagpur from 12-13th August, 2013. About 12 Directors of different ICAR Institutes and more than 120 scientists across India participated. On this occasion 16 farmers from different citrus growing areas of the country were felicitated.
- "Interactive meeting with Citrus growers" was held on 22nd August, 2014. Hon'ble Shri Nitin Gadkari, Union Minister of Road Transport, Highways and Shipping, GoI presided over the meeting.
- Stakeholders Meet on Good practices was organised at Jarud (Amravati) on 20th June, 2014.
- iv. Brain storming dialogue on Viral and Greening Diseases of Citrus : Challenges and way forward was organised on 28th July, 2015 to discuss strategies to tackle emerging threats of greening and viral diseases of citrus and work-out the future roadmap.
- National Symposium on Sustainable Citrus Production Way Forward was organised to commemorate 30 years of completion of Institutes service during 27-29th November, 2015.
- vi. "Intellectual Convention on Doubling of Farmers' Income through Citrus Cultivation" was organised on 23rd November, 2017.
- vii. The 'World Orange Festival 2017' was organised at Nagpur from 16-18th December, 2017 wherein the Institute was the knowledge partner.

Meetings Organized

i. Organised MDST meeting on 18th December, 2013, at Jarud (Amravati Site office). Total 21 members including scientist from the Institute and members from other organisations like KVK, MOGA, Samarth Mahila Sanstha, DHAN foundation, Ag. Dept. of Maharashtra, Nursery growers and farmers attended the meeting.



- ii. The 'Ninth National Project Steering Committee (NPSC) Meeting' of the project on Conservation and sustainable use of cultivated and Wild Tropical Fruit Diversity: Promising Sustainable Livelihoods, Food Security and Ecosystem Services (UNEP/GEF) was held from 13-15th February, 2014 at the Institute under the Chairmanship of Dr. N. K. Krishna Kumar, DDG, (Hort.) and NPSC Chair, ICAR, Ministry of Agriculture, New Delhi. Dr. Bhuwon Sthapit, Regional Project Coordinator, Dr. V. A. Parthasarathy, National Project Co-ordinator, Dr. V. Ramanatha Rao, Technical Consultant, Bioversity International.
- iii. The Third Task Force Meeting of DUS project on Citrus was organized on 10th March, 2014, under the Chairmanship of Dr. V. A. Parthasarathy, Former Director and Emeritus Scientist, IISR, Calicut for finalization of DUS guidelines, Dr. R. R. Hanchinal, Chairperson, PPV and FR Authority New Delhi, Dr. R. C. Agrawal, Registrar General, PPV and FR Authority, New Delhi, Dr. S. N. Pandey, Ex-ADG (Hort.) ICAR, Dr. Umesh Srivastava, Ex- ADG (Hort.) ICAR, Dr. H. Ravishankar, Director CISH, Dr. Manoj Srivastava, Registrar, PPV and FR Authority, New Delhi.
- iv. Group meeting of All India Coordinated Project on Citrus for researchers working under All India Coordinated Project (Citrus) was during 2nd -3rd September, 2014 at NRCC, Nagpur. Total 42 researchers from various centres and 5 experts deliberated on various issues concerning citrus cultivation in different parts of the country.
- v. Meeting of farmers and all other stakeholders on 20th June, 2014 at H.M. Umekar D.Ed. College, Jarud (Amravati) under UNEP/GEF project "Conservation and sustainable use of cultivated and wild tropical fruit species for livelihood generation, food security and environmental service" in which more than 250 farmers participated.
- vi. A meeting was organized by the State Agriculture Deptt., Nagpur to discuss the future policies on Climate Change, disease-free planting material etc. on 24th June, 2015 which was Chaired by Shri Atul Patne, IAS, Director (Hort.), GOI and Dr. M.S. Ladaniya, Director, ICAR-CCRI, Nagpur.
- vii. A meeting for Innovative and Applied Bioprocessing (CIAB), Mohali, Punjab under the Chairmanship of Dr. M. S. Ladaniya, Director to discuss "Zero waste processing of citrus fruits and their shelf life extension" on 2nd April, 2016 at ICAR-CCRI, Nagpur which was attended by Dr. Rajendra Singh Sangwan, CEO, CIAB, Mohali and Dr. Dinesh Kumar, Pr. Scientist (Hort.) CCRI, Nagpur.
- viii. Pepsico India Holdings Pvt. Ltd., Gurgaon, Haryana convened a Meeting on Citrus Road Map to support Citrus farming community of Maharashtra on 6th April 2017 at ICAR-CCRI Nagpur. Dr. M.S. Ladaniya, Director, Mr. Jaideep Bhatia, Agro Director, Pepsico alongwith Sh. Vijay Kumar Ghawate, Joint Director, Agriculture, Nagpur Division participated to discuss the road map for capability development of citrus farmers.
- ix. Bankers and entrepreneurs meet: Twenty five bankers representing various banks visited the institute to understand the latest developments in the field of citrus



cultivation and scope for bank finance therein on 21st September, 2017 as per programme organized by (CAB) RBI, Pune State focused Programme on Financing Agriculture in Nagpur (September 20 to 22, 2017). The entrepreneurs Mr. Paliwal and Mr. Chaurasia also participated.

x. The QRT (AICRP) meeting: ICAR-CCRI organized a review of the coordinated programmes on citrus under AICRP on fruits by Quinquennial Review Team on 22nd -23rd March, 2018 under the Chairmanship of Dr. K.L. Chadha, former DDG (Hort.) ICAR.

Revenue Generated

ICAR-CCRI has generated considerable revenue through farm products, commercialization of technologies, contract research projects, consultancy and other services (Table 10).

The Institute has provided consultancy, and also licensing agreements were signed with private agencies regarding nursery establishment, technologies on "Shoot Tip grafting", microbudding techniques for plant multiplication of citrus, post-harvest management of citrus fruits, RTS drinks from acid lime and carbonated drinks from acid lime and 'Nagpur' mandarin fruits.

Veen	Tongot	Revenue Generated	
rear	Target	Actual as per Target	Overall Receipt
2013-14	29.40	16.55	55.11
2014-15	36.40	33.73	42.11
2015-16	74.96	31.23	72.84
2016-17	89.95	26.08	82.38
2017-18	41.37	41.37	89.31
Total	272.08	148.96	341.75

Table 10 : Revenue Generation by ICAR- CCRI, Nagpur (2013-14 to 2017-18)

Awards / Recognitions

ICAR-CCRI, Nagpur received a variety of awards and recognitions through its meritorious research work of staff. Some of the prominent awards during the period are: *Maharashtra Bhusan Award*-2013, IPNI International Award-2014, *Karyalaya Deep Puraskar*-2015, *Nagar Rajbhasha Karyanvi Samiti* (NARAKAS) as 2nd Best Award, Vasantrao Naik Krishi Award-2016, B.H. Jain Award, World Aqua Foundation Award and Shri. Girdhari Lal Chadha Memorial Gold medal in fruit Science. The scientists of the Institute received as many as 3 fellowships of different academic societies and 17 best poster awards (Table 11) in different seminars/symposia/conferences, the hallmark of excellence in scientific outcome.



These are all in addition to recognition as Chairman/Co-chairman of Technical sessions in different scientific of academic events held Nationally or Internationally.

Fable 11 : Awards a	d Recognitions	s received by ICAR	R-CCRI, Nagpur	(2013-18)
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Award and Recognitions	Number
Individual awards	18
Fellowship of Professional Societies received by Scientists	3
Best poster awards in Seminar/Symposium/Conference/Workshop	17
Appointment on University Academic Council/Senate/Management Council/ Board	5
Election on Executive Council/Management Council of Professional Societies	8
Hindi Rajya Bhasha Sansthan Award/Nagar Rajbhasha Karyanvi Samiti for Hindi publication	2



6. LINKAGES

The Institute has strengthened collaborations with Government and private organizations for research and transfer of technology during 2013-18.

International and National Institutions

International

Linkage	Project	Status
Bio-diversity International	Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting sustainable livelihoods, Food Security and Ecosystem services.	Started in May, 2009 and concluded in December, 2014
International Plant Nutrition Institute (IPNI)	Development of Soil fertility map as a decision support tool for fertilizer recommendation in citrus - IPNI Funded.	Started in November 2010 and concluded in October, 2014

National Institutes

Linkage	Project Title	Status
Indian Institute of Horticultural Research, Bengaluru	Outreach programme in network mode on management of sucking insect pest on Horticultural crops - citrus.	Started in June, 2009 and concluded in March, 2017
	Micronutrient management in horticultural crops for enhancing yield and quality - Citrus	Started in January, 2015 and concluded in March, 2017
	Consortium Research Platform on Borers in Network mode - Citrus	Started in January, 2015 and concluded in March, 2017
	Consortium Research Platform (CRP) on Agro Biodiversity	Started in October, 2015 and concluded in March, 2017
	Consortium Research Platform (CRP) on Vaccines and diagnostics	On-going since October, 2015
Indian Institute of Spices Research (IISR), Calicut	Outreach project on <i>Phytophthora</i> , <i>Fusarium</i> and <i>Ralstonia</i> Diseases of Horticultural and field crops- <i>Phytophthora</i> (Citrus).	Started in March, 2009 and concluded in March, 2017



Linkage Project Title		Status
	Network project on Organic Farming in Horticultural Crops - Citrus	Started in January, 2015 and concluded in March, 2017
Directorate of Seed Research, MAU, Uttar Pradesh	Seed production in Agricultural crops and fisheries-Citrus.	Started in January, 2006 and concluded in March, 2017
Ministry of Agriculture and Farmers Welfare, Govt. of India, New Delhi.	Crop Specific DUS Testing Guidelines for Citrus (C. reticulauta, C. sinensis and C. aurantifolia).	Started in April, 2010 and concluded in March, 2014
Indian Institute of Natural Resin and Gum, Ranchi.	Studies on lac based coating formulations for extended shelf life of 'Nagpur' mandarin fruits.	Started in April, 2011 and concluded in March,2013
National Horticulture Board, Gurugram	Demonstration of canopy architecture management in citrus through training and pruning for higher density and increased productivity.	Started in December, 2011 and concluded in March, 2018
	TechnologyDemonstrationonRejuvenationofDeclining'Nagpur'mandarin orchards	Started in April, 2012 and concluded in March, 2014
	Crop regulation in 'Nagpur' mandarin in Central India	Started in October, 2012 and concluded in March, 2016
	Demonstration of mechanical pruning, training, spraying and cultivation technology for increasing the productivity of 'Nagpur' mandarin orchards in Vidarbha region of Maharashtra	Started in December, 2014 and concluded in December, 2017
Department of Biotechnology, New Delhi	Value Chain development in citrus for North East India	Started in October, 2012 and concluded in April, 2017
	Structure and function studies on antioxidant defense system of <i>Candidatus</i> <i>liberibacter asiaticus</i> towards developing antimicrobials against citrus greening (HLB)	On-going since October, 2014



Linkage	Project Title	Status
	Molecular diagnostics, transcriptomics and cisgenic approaches to combat citrus greening (Huanglongbing) disease of citrus	On-going since January, 2017
Indian Institute of Chemical Technology, Hyderabad	Studies on insecticide resistance and sex attractants in the management of citrus leaf miner, <i>Phyllocnistis citrella</i> Stainton	Started in March, 2013 and concluded in March, 2017
National Centre for Integrated Pest Management (NCPIM), New Delhi	Development and Validation of IPM strategies for mandarin orchards under Semi-Arid (Punjab and Rajasthan) and North Eastern Regions of India - In collaboration with NCIPM	Started in April, 2014 and concluded in March, 2017
Govt. of Maharashtra	Horticultural Crop Pest Surveillance, Advisory and Management Project (HORTSAP)	On-going since October, 2014
Central Potato Research Institute, Shimla	 CRP on Nano-technology Studies on Nano-composite packaging for extended shelf life and quality of 'Nagpur' mandarin fruit, segments and juice products. Developing diagnostics against CTV and CMBV two major viruses infecting citrus in India. 	On-going since January, 2015
PlantHormoneAnalysisLaboratory,DivisionofPlantPhysiologyBiochemistry,IIHR,Bengaluru	Studies on Dynamics of flowering and fruiting in citrus	On-going since July, 2011
Dupont, Mumbai	Evaluation of Cyantraniliprole HGW86 10% OD against insect pests of citrus	StartedinSeptember,2015andconcludedSeptember,2018
FSSAI, Ministry of Health and Family welfare, New Delhi,	Functional components and antioxidants analysis of citrus fruits for its potential application in food industry	Ongoing since October, 2016
Vidarbha Development Board, Nagpur, Govt. of Maharashtra	Study / Consultancy report on "Road map of citrus industry for the development of Vidarbha"	Started in April, 2017 and concluded in June, 2018



Collaboration with Academic Institutions /SAU's during 2013-18

- Linkages were developed with Sam Higginbottom Institute of Agriculture and Technology, Allahabad; Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur; Sant Gadge Baba Amravati University; Banda University of Agriculture and Technology (BUAT), Banda, Uttar Pradesh; Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh and Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu and Dr. Ambedkar College, under Rashtrasant Tukadoji Maharaj (RTM), Nagpur University by signing memorandum of understanding as Research Guide / Co-Guide for M.Sc / Ph.D research of students. Many students of these Institutes/Universities completed their M.Sc. ad Ph.D. thesis research work at ICAR-CCRI for their degree programme.
- Institute has developed collaboration with Indian Institute of Technology (IIT), Roorkee; Visvesvaraya National Institute of Technology (VNIT), Nagpur and Department of Biotechnology (DBT), New Delhi by taking up collaborative research programmes.

Linkage with Private Sector

Strong linkages have been established with the private sector particularly pesticide, fertilizers and agro-chemical manufacturing companies. Contract research projects have been signed with these companies for testing their new molecules/products as paid up trials. Linkages have also been established with private sector for commercialization of technology developed by the Institute.

- A contract research project 'Testing of SURUCHI fruit ripener and sweetener for citrus'with Godrej Agrovet Ltd, Mumbai
- A contract research project 'Evaluation of Cyantraniliprole HGW86 10% OD against insect pests of citrus' with Dupont, Mumbai.
- Technology of RTS and Carbonated Drinks given to M/s. Paliwal Udyog Ltd., Kalmeshwar through licensing.
- Technology of 'Shoot-Tip-Grafting for production of disease free planting material of citrus' given to M/s. H. U. Gugle, Agrobiotech Company, Ahmednagar through licensing.
- Consultancy on Storage of lemon given to Mr. Suresh N. Mungalpara, Gujarat.
- Consultancy for analysis of Hesperidin and other compounds was given to Mr. Sanjiv Keshava, Orem Enterprises, Gurgaon, Haryana.
- Consultancy for establishment of mechanised packing line and cold store was given to ECS, Nagaland
- Technology of Hi-tech nursery management for production of disease-free planting



material in citrus was given to Karunamaya Agrotech, Nagpur through licensing agreement.

- Technology of Shoot-tip-grafting and establishment of Citrus nursery for production of disease-free planting material was given to M/s. Seven Star Fruits Pvt. Ltd., Mumbai through licensing agreement.
- Technology of Microbudding propagation technique to shorten the Citrus nursery phase was given to M/s. KJB Agro, Ootacamund, Tamil Nadu through licensing agreement.
- A Power Purchase Agreement (PPA) signed between Clean Max Enviro Energy Solutions Pvt. Ltd, Mumbai and ICAR-CCRI, Nagpur for the implementation of the Rooftop Solar PV system.

Linkage with AICRP (Fruits)

• Governing Body approved that Director, NRCC (now ICAR-CCRI) will look after the responsibilities of Co-ordinating the AICRP on Citrus from Nagpur and accordingly the technical programme of all the Centre's of AICRP on citrus is being monitored. A group meeting of researcher's of citrus crops under All India Coordinated Project on (Fruits) was organised during 2nd -3rd September, 2014 at ICAR-CCRI, Nagpur. The research work of citrus under AICRP (fruits) at all the Centres *viz.*, Ludhiana, Sri Ganganagar, Akola, Rahuri, Tirupati, Perriyakulam, Chettali, Tinsukhia, Pasighat, Delhi and Darjeeling is being monitored by Director, CCRI as Citrus crop co-ordinator.

Linkage with NHB

- National Horticulture Board has funded three research projects during the period under review and sponsored Rs. 2.00 lakhs for the *Rashtriya Kisan Mela* held during 30th-31st October, 2014.
- The mechanical citrus tree pruner (BMV FL600, Italy), electrostatic sprayer (Orange) and air blast sprayer (Caffini) funded by NHB were imported during April-June 2015. These machines were demonstrated at ICAR CCRI experimental farm blocks and at farmers' orchards of Mr. Bandu Dalal at Bhadangi village of Kalmeshwar tahasil Dist. Nagpur and two orchards of Mr. Nitin Phalke and Mr. Punjabrao Phalke at Telkamathe village of Kalmeshwar tahasil (Dist. Nagpur). Pruning was also demonstrated at Bhendala (Patansawangi) nursery farm of State Agric. Deptt and Private orchard of Mr. Eknath Choudhari at Warud on 5th January 2018. In collaboration with State Agriculture department, pruning services with the help of automatic pruning machine are being provided.
- The Scientist of the Institute collaborates with NHB staff at Nagpur for finalising proposals of fruit plantations under NHB schemes in periodical LoI meetings and nursery accreditations committee meetings.



Linkage with State Agriculture or Horticulture Deptt./State or Central Govt. Agencies/Exporters

- A team of staff headed by Sh. Prashant Waghmare, AGM, APEDA, Mumbai and Sh. D. M. Sable, MSAMB, Pune alongwith fruit exporters had a meeting with Dr. M. S. Ladaniya, Director on 23rd February, 2018 to discuss on the interventions required for strengthening the supply chain of export of 'Nagpur' mandarin and also visited orchard of progressive grower Mr. Dhiraj Junghare. This meeting resulted in export of *Mrig* crop 'Nagpur' mandarin fruit by air cargo (3 tonnes) to UAE during February and March, 2018. APEDA provided subsidy/funding and MSAMB logistic help to exporters.
- Vidarbha Development Board (VDB), a Statutory Body of Government of Maharashtra provided funds to ICAR-CCRI, Nagpur for the study on "Citrus industry in Vidarbha". The funds of Rs.9.60 lakh was approved by the VDB, Nagpur and the detailed report entitled "Roadmap of citrus industry for the development of Vidarbha" was submitted by ICAR - CCRI to Vidarbha Development Board in May, 2018.



7. HUMAN, PHYSICAL AND FINANCIAL RESOURCES

Human Resources

ICAR-Central Citrus Research Institute has the current scientific staff strength of 19, which is very limited in terms of catering the national mandate of the Institute. In addition, scientists of the institute do not have sufficient technical and supporting staff to assist research. At newly established Regional Research Centre for Citrus at Biswanath (Assam) there is absolutely no sanctioned post, (scientific, technical, administrative or supporting). Under these circumstances, Institute has to divert lot of sanctioned budget towards hiring contractual staff of technical expertise to ensure the smooth functioning. This incurs an unwarranted constraint on allocated budget of the institute. The QRT strongly recommends the earliest recruitment of scientific, technical, administrative and supporting staff as provided in this document.

ICAR-CCRI is now having a Regional Research Centre for Citrus (RRCC) operational at Biswanath Chariali (Assam). Lot many useful activities have already been initiated on research front. Development of farmhouse and administrative building is proposed to be undertaken soon. There is an immediate need to consider sanctioning of atleast 5 scientists (each in the discipline of Horticulture, Soil science, Entomology, Pathology and Agric. Extension), so that RRCC stands on its sound scientific and infrastructural footing. ICAR-CCRI as an Institute, despite gaining its higher status during last 5 years, continues to work with meagre strength of scientific staff, with just one scientist in many of the disciplines like Biotechnology, Plant pathology, Virology, Water management, Soil Science, Post-harvest Technology and Agri. Extension. Such meagre staff strength makes it quite difficult to operate the Institute through divisions. Likewise, there is no scientist in the disciplines of Physiology, Biochemistry, Computer Application, Agricultural Statistics and Economics. Such staff situation is a big handicap in delivering the expected outcome through basic/strategic/applied research on a national scale. To handle such situation, atleast 15 scientists, 32 technical, 9 administrative and 18 supporting staff are required at the institute (including RRCC) as highlighted in detailed consolidated recommendations.

Physical Resources

ICAR-CCRI has created good infrastructure during 2013-18 with respect to both advanced scientific equipments as well as various civil works. Institute has already initiated exercise for the development of master plan. This Institute is in dire need of infrastructure for video-conferencing and technology transfer services through mass communication, geo-spatial laboratory for downloading of the IRS data and connecting with Geographical Information System (GIS), sensor-based fertigation system at the experimental farm and un-interrupted irrigation water supply through additional storage tanks and an efficient distribution and delivery of irrigation water using a totally transformed / improved irrigation system design, considering the increasing age of the citrus plantation. Therefore, a greater emphasis on micro-irrigation / fertigation redesigning is strongly advocated.



Financial Resources

ICAR-CCRI received plan budget allocation of Rs. 2800.00 lakhs and non-plan budget of Rs.3784 lakhs (Rs 6584.04 lakhs as total budget) during XII plan of 2012-17. Out of this totalbudget, Rs. 6026.89 lakhs was spent. Institute also received a budget of Rs 30.43 lakhs and Rs.47.80 lakhs for NEH and TSP activities respectively during 2013-2018. Considering the elevated mandate of the Institute on national perspective with one Regional Centre, this fund allocation is not sufficient to meet out the staggering expenditures involved. The QRT also recommends that financial and administrative control of citrus centres of AICRP (fruits) should also be placed at the control of ICAR-CCRI, as has been recommended by previous QRT also, since it is a premier institute working exclusively on citrus at national level and such an arrangement will be helpful in strengthening the work on regional requirement of citrus industry.



8. PLANNING FOR THE FUTURE

Research of ICAR - CCRI needs to be planned keeping in view following points:

- i. Targeted collection based on desired traits for utilization of the existing citrus biodiversity. A latest appraisal on citrus diversity of Citrus Biosphere Reserve at Tura, Meghalaya should be undertaken by the Institute to ascertain the existing richness of citrus diversity compared to previous assessment by the Institute.
- ii. Conservation of important duplicates of genetic resources of citrus at RRCC Biswanath Chariali, Assam for future use in citrus improvement programs
- iii. Large scale commercialization of microbudding propagation technique for diseases-free planting materials of citrus
- iv. Development of STG-based protocol for citrus sanitation and quarantine of introduced varieties
- v. Development of mutant population (using physical and chemical mutagens) and segregating population (using hybridization) in rootstock genotypes and scion varieties.
- vi. Scion breeding and transgenic citrus rootstocks using biotechnological tools (cisgenics, QTL mapping, CRISPR technologies and RNAi)
- vii. In-vitro pollen conservation of citrus germplasm
- viii. Development of expert system for data management of citrus genetic resources including the tools for avoiding duplicate collection.
- ix. Long term evaluation of citrus performance under flat bed versus raised bed planting system
- x. Input-use-efficiency through drip (Sub-surface drip irrigation) and fertigation / biofertigation for sustainable citrus production
- xi. High density planting and land-utilisation-efficiency vis-a-vis production sustainability
- xii. Crop regulation for staggered and extended fruit availability
- xiii. Development of advanced citrus production system for ensured exportable fruit quality
- xiv. Revisit on the life cycle of major insect pests and diseases in the context of climate change.
- xv. Concerted studies on insect-vector relationship vis-a-vis HLB, CTV etc.
- xvi. Field application kit for on-field diagnosis of HLB (*vis-à-vis* Waybar) and viable management strategy.
- xvii. Marker assisted selection of resistance to *Phytophthora*-induced root rot and exploitation of endophytes and improvement of existing bioagents for enhanced antagonism.



- xviii. Distribution and diversity analysis of plant parasitic nematodes in citrus belts of India to identify hot spots of citrus nematodes and development of integrated management strategies
- xix. Development of non-hazardous (safe) technologies for fresh fruit handling for an extended shelf life of fruits
- xx. Evaluation / development of new processing varieties for development of processed and value added products
- xxi. Development of smart packaging protocols
- xxii. Gap analysis in TOT with regard to citrus technologies and their redressal

Anticipatory Research

- i. Insect-pests and disease dynamics *vis-a-vis* climate change and development of forecasting models, decision support for their outbreaks
- ii. Package of practices for high density orchards on raised-bed system with fertigation
- iii. HLB management in advanced production system
- iv. Package of practices for HDP and HLB-plus vis-a-vis HLB-minus orchards
- v. Establishment of model 'Khasi' mandarin orchard using organic management practices and canopy management practices

Infrastructure Development

With the development of master plan of the Institute, an additional space is being created for taking up a variety of infrastructural developments in terms of extension of different laboratories for multiplication/large scale production of different products and services, which have been developed over the years by the Institute. The details of different farm developments and equipments purchased during 2013-18 are further annexed through Annexure-III.

Expectations of Stakeholders

The major stakeholders of the technologies developed by the Institute are citrus growers by and large and the private companies who are licensed to adopt the technologies of this Institute. However, several issues such as drip irrigation technology and subsidy, soil and water conservation, supply of disease-free planting material, applications of remote sensing and imaging techniques in ground water survey, orchard health and disease mapping, precision farming and geopositioning system, are some glaring concerns to citrus growers, across the country.

The most unfortunate aspect of citrus cultivation, not only in Central India, but the country as a whole, is the absence of production oriented incentives to the grass root level growers. There is hardly any stability in pricing, thereby, marketing woes of the citrus growers continue, especially



when major part of the production routed as fresh fruits only. To increase awareness towards nutritional security through citrus fruits is an open challenge to different stakeholders of citrus industry. The print and electronic media could be well mobilised to fulfil the objective of health benefits of citrus fruits amongst masses.

Expectations of ICAR-CCRI

ICAR-CCRI by now has come out with a variety of user friendly technologies and products that could find large scale field application. The biggest expectation is the establishment of Referral Laboratory where citrus growers could be advised through Soil Health Card (soil and leaf analysis services), insect pests and disease diagnosis, indexing of pathogens in nursery, fruit quality appraisal, analysis of different products, technical advisory service to be accomplished within a shortest possible time by attending even an individual citrus grower. Similar kind of facilities are also required for value addition and processing, at incubation centre at the Institute so that entrepreneurs get hands on real-time business training for manufacture of products. There is no fool proof system to compute citrus area and production on a countrywide basis. Application of remote sensing technologies would be handy not only in addressing this issue, but the citrus decline menace could be efficiently monitored and kept in check. Establishment of geo-spatial technology laboratory would pave the way for such application. ICAR-CCRI also needs recruitment of new staff in Scientific, Technical, Administrative and supporting categories at the earliest to fulfil its mandate.

Bottlenecks

New scientists have, though, started joining this Institute but the number is far below expected requirement, with the result, many of the areas of citrus research continue to be neglected. The present strength of scientific, administrative, technical and supporting staff is not sufficient to address the variety of issues, which this Institute has been facing in the past from different commercial citrus belts of the country.

Unfortunately, like other crops, there continues to be a glaring gap in citrus productivity obtained at experimental field versus average citrus growers' field (There are however, some private citrus orchards, where the productivity is even on par with internationally obtained productivity level). In such a scenario role of an effective TOT-based programs assumes a paramount importance. Therefore, the extension wing of the Institute needs to be strengthened to realise the goal of increasing production and productivity.



9. OVERALL ASSESSMENT

India with 12.51 million tonnes of citrus production from 1.07 million ha area is currently at number 3 after China and Brazil. The world citrus is dominated by sweet orange with a 57 per cent contribution followed by mandarins (25 per cent), limes and lemons (10 per cent) and rest contributed by grapefruit and other citrus fruits (8 per cent). Indian citrus industry is dominated by mandarins ('Nagpur', 'Kinnow', 'Coorg' and 'Khasi' mandarin) followed by sweet oranges and limes in that order. The demand of citrus fruits is likely to increase by nearly 1.5 fold with an estimated population of 1450 million by 2030.

Demand is also increasing for fruits due to improving economy, better health awareness and changing lifestyles of people. The juice and beverage consumption has increased in the country in recent past. Therefore, a minimum 5.7 per cent annual average growth of the past two decades will have to be maintained during the next 20 years so as to meet the domestic demand and fulfil global trade commitments.

Major problem of decline in citrus plantations of the country is due to a complex or a syndrome of pathogens, water scarcity, nutritional deficiency, general neglect of recommended cultivation practices, and use of spurious uncertified planting material in establishing new orchards. Consequently, the expected full potential of citrus is never realized. *Phytophthora* was recorded in young and old trees although well-managed 20-25 years old healthy orchards has not been uncommon.

The status of Central Citrus Research Station was upgraded on 1st April 1986 to National Research Centre for Citrus (NRCC) and since then, the Centre has completed its fruitful 32 years. NRCC was further upgraded as Central Citrus Research Institute on October 29, 2014. The Institute has the mandate to undertake basic and applied research for developing technologies in crop improvement, production, protection and post-harvest management and increased productivity in citrus apart from training of stakeholders, transfer of technologies and developing linkages and collaborations with common interest. During the 5 years (2013-18) under review, ICAR-CCRI has done very good work in terms of developing a large number of technologies and disseminated them to farming community and industry, with the result, Institute has a strong impact on citrus industry of India.

The Institute had a budget of Rs.2797.50 lakhs (plan) and Rs.3484.04 lakhs (non-plan) lakhs during 2013-18 and almost entire allocation has been utilized. Institute has sanctioned posts of 19 scientists but only 16 are in position. Similarly, 20 technical posts are sanctioned while 20 are in position. With 11 administrative and equal number of supporting staff, the Institute has a total of 62 sanctioned posts but 56 are in position presently. Although, the Institute has a good infrastructure, yet it needs further strengthening for meeting expectations of the growers and to address the problems of citrus industry in national perspective.



Institute's publications record is praiseworthy. Extension bulletins and other publications need to be translated into regional languages. The Institute published as many as 180 research papers, of which 164 are cited with total number of citations at 2681 and 15 citations per publication on an average during 2013-18. Nearly 10 per cent publications were made in NAAS rating of 8-10 and other 40 per cent in NAAS rating of 6-8 at national level.

This Institute with its present manpower and infrastructure, has developed several useful technologies in the areas of plant improvement, production, protection and post-harvest management. Institute has released 9 different varieties including one rootstock Alemow (*Citrus macrophylla*) has been identified as promising rootstock for higher yield and moderate tolerance to *Phytophthora*. Institute developed some very useful products *viz. Trichoderma* based formulation, microbial consortium, RTS, Fizzy drinks as value added products, which would go a long way in giving the Institute the desired recognition. The sale of about 14.00 lakh planting material has generated revenue of Rs.451.65 lakhs during 2013-18 under review. It is noteworthy to mention that against an overall target of Rs.272.08 lakhs, the Institute generated a revenue of Rs.341.75 lakhs through sale of planting material, produce (fruits from Institute's plantation), publications, contractual projects and consultancies.

During the period under review, the Institute has trained 3550 citrus growers and officers from different parts of the country. In human resource development, Institute has trained its scientists at national and international institutes of repute besides training its technical, administrative and supporting staff. Institute also organized 7 national symposia/ seminars, a brain storming session and several important meetings during 2013-18. During this period, 5477 farmers, 708 officers and 2283 students from different parts of the country visited the Institute. Institute also displayed its technologies in 47 exhibitions organized by SAUs and ICAR Institutes / State Governments, private organizations and colleges. The Institute has organized two *Rashtriya Kisan Melas* during the period under report.

The Institute has received ISO 9001:2008 Certification and scientists bagged many national awards and recognitions/accolades, besides fellow of academic societies.

ICAR-CCRI has done impressive work of licensing of technologies and providing consultancy services to private companies and entrepreneurs. The Institute has effective linkages with private industry through Contract Research Projects. It also has collaborations through network and joint (collaborative) projects with various institutes. However, the QRT suggest collaboration with International Institutes conducting research on citrus under the ICAR policy. This should be prioritized for building excellence in research.

The Institute needs research thrust for developing technologies to mitigate effects of changing climate. The citrus plantations should be able to adapt to changes of Global warming through climate resilient citriculture. Keeping in view shortage of water and *Phytophthora* root rot and HLB problems, research needs to be strengthened in developing rootstocks for drought,


Phytophthora and HLB tolerance. Good work has been carried out by the Institute in the area of fresh fruit handling, packing and transport. The technologies/processes products developed should be up-scaled and commercialized to reach out to maximum citrus growers.

It is a high time to shift AICRP from IIHR, Bangalore and place it under the control of Director, ICAR-CCRI, Nagpur. Stakeholders from all citrus growing areas of the country have many expectations and in order to meet their demand, the Institute needs overhauling in its organizational structure. The staff is limited and the Institute cannot fulfill its obligations and regional demands. Therefore, it should be strengthened suitably with scientific, technical, administrative and supporting staff, infrastructure and laboratory facilities as given in section on Consolidated Recommendations.

Major recommendations of the last Quinquennial Review Team (QRT) period (01. 4. 2007 to 31.3.2013) and Action taken report was reviewed by the present the QRT. The present QRT also endorses and recommends major suggestions of the last QRT

Sr. No.	QRT Recommendations	Council's Comments	Action Report / Comments	Observations of the QRT (2013- 18)
1.	Water requirement of the Centre has increased tremendously with initiation of large scale disease-free planting material production programme. Intake well in Ambazari lake and separate higher capacity water carrying pipe line up to the Centre is must without which it may become difficult to sustain farm and research activities.	Agreed. This has been proposed in XII Plan. Time Frame : 2014-2016	The intake well and pipeline has already been installed and right now, it is in operation.	No comment, since this recommendation has already been addressed. But, irrigation design needs to be reoriented in the light of increasing age of the experimental trees. Entire Experimental farm should be brought under fertigation.
2.	With changing times Good Agricultural Practices (GAP) and food safety are the watch words for all the stakeholders in citrus industry. There is a pressing need to establish a Referral Laboratory at NRCC,	A proposal has been forwarded to National Horticulture Board (NHB) for Referral Lab. NHB is ready to provide funds for building and equipments. The	The proposal forwarded to NHB for Referral Lab is under consideration. Efforts are also being made to get some funding from Maharashtra State. The necessary	This is an important issue in the context of this Institute's outcome. Referral Laboratory is a must have requirement. Therefore, every effort should be



Sr. No.	QRT Recommendations	Council's Comments	Action Report / Comments	Observations of the QRT (2013- 18)
	Nagpur keeping in view expertise developed by scientists of the Centre and demand from the stakeholders for the services like - DNA fingerprinting of rootstocks/ planting material, high-tech indexing/diagnostic facility, Soil and leaf analysis, Insect-pest identification and management and fruit and product quality analysis pesticide residues.	proposal for highly skilled manpower is included in XII Plan. Time Frame : 2014-2016	meetings have to be fixed in this matter.	made by the institute to establish Referral Laboratory, since it will add a different dynamics to products and services offered by the Institute.
3.	In order to fulfil national mandate and meet regional needs, NRCC should be upgraded to the National Institute or Project Directorate on Citrus to give citrus the right status as No. 1 Fruit to meet out nutritional security of the country.	Not Agreed. NRC for Citrus shall function in the same mode. But the Director NRCC shall supervise the AICRP research on citrus. Time Frame : Not Applicable.	NRCC has already been upgraded to Central Citrus Research Institute with one Regional Research Centre at Biswanath Chariali, Assam in operation to cater the needs of Northeast citrus industry.	Well taken. The Regional Research Centre for Citrus at Biswanath is supposed to cater the technological needs of citrus of northeast India, where providing scientific footing to the citrus industry is more required than citrus industry of any other region. Nevertheless, it needs to be supported with additional scientific, administrative, technical and supporting staff to address the prevailing and anticipated issues.
4.	Research on citrus in	Agreed. The	Director, CCRI,	Full control of



Sr.	ORT	Council's	Action Report /	Observations of
No.	Recommendations	Comments	Comments	the ORT (2013-
				18)
	AICRP on Tropical Fruits which is presently located at IIHR, Bangalore should be shifted to new Directorate at Nagpur. At present there is no citrus research worth mentioning being carried out at IIHR, Bangalore. Research being carried out at Chethalli is very little as compared to work at NRCC, Nagpur. Director NRCC should look after the responsibilities of Co-ordinating the AICRP on Citrus from Nagpur.	Director NRCC, will look after the responsibilities of Co-ordinating the AICRP on Citrus from Nagpur.	Nagpur has been nominated as citrus crop co- ordinator for present system of AICRP (fruits) operating from IIHR, Bengaluru. ICAR - CCRI is providing only technical/Scientific support on citrus in AICRP. Financial and Administrative powers are with PC, AICRP (fruits) only.	citrus research from AICRP on fruits should lie with ICAR-CCRI to deliver better results and also to reach out to the requirements of regional level citrus industry. Financial, administrative and technical responsibility of AICRP (Citrus) should be with ICAR-CCRI Nagpur. Efforts should be made to operationalise the entire citrus research of AICRP on Fruits from ICAR-CCRI, Nagpur.
5.	NRCC has a large gene bank. Characterization of the entire germplasm should be carried out using phenotypic and molecular descriptors. Promising germplasm should be used in crop improvement programme.	Agreed. New initiatives would be taken through proposing projects in this line with availability of more manpower. Time Frame : 2014-2017	Characterization of the collected germplasm is underway using phenotypic and molecular descriptors. Work with respect to location of duplicates and redundancies, IP protection as well as use in breeding programmes have already been initiated with the joining of Scientist (Biotechnology) and Senior Scientist (Horticulture).	The QRT is also of the opinion that this work should be completed as early as possible to shortlist the duplicates and define the core collection of the citrus diversity. How to check out the movements of duplicates is another issue to look at. Molecular characterization using GBS technology should be employed to assess the diversity among citrus



Sr. No.	QRT Recommendations	Council's Comments	Action Report / Comments	Observations of the QRT (2013- 18)
			including the rootstock breeding and scion improvement.	collections. Molecular and morphological data should be used to group and identify core accessions
6.	There is a need to develop seedless varieties in 'Nagpur' mandarin and 'Mosambi' sweet orange. Seedlessness through ploidy manipulation and artificial mutation in 'Nagpur' and 'Kinnow' mandarin and 'Mosambi' sweet orange should be attempted.	Agreed. Research on these lines has been initiated and it would be further strengthened. Time Frame : 2014-2017	A seedless mandarin named as 'NRCC Mandarin Seedless-4' developed by clonal selection has been released at Institute level. Ploidy manipulation and mutation for seedlessness is underway.	Research on these important issues should be continued with an eye on earliness or later maturity traits in 'Nagpur' mandarin, 'Kinnow' mandarin and 'Mosambi'.
7.	<i>Phytophthora</i> induced root rot and collar rot are the major diseases of citrus at national level. Therefore, development of resistant rootstock to Phytophthora through marker assisted selection (MAS) is a priority.	Research work to evaluate <i>Phytophthora</i> tolerant rootstock hybrids is already underway. New rootstocks are also being evaluated for their tolerance to <i>Phytophthora</i> in field. This programme to develop resistant rootstock to <i>Phytophthora</i> through MAS would be strengthened. Time Frame : 2014-2017	A pair of SCAR marker (SC1/SC2) are already developed that can be used for marker assisted selection (MAS) in citrus rootstock breeding programme aiming at the development of cultivars resistant/tolerant to <i>Phytophthora</i> root rot.	Good success has already been achieved from various approaches. Such concerted efforts should be continued.



Sr.	QRT	Council's	Action Report /	Observations of
No.	Recommendations	Comments	Comments	the QRT (2013- 18)
8.	Citrus canker resistant variety of acid lime need to be developed to reduce the cost of cultivation in terms of pesticide sprays.	Efforts are on to identify canker tolerant clone of acid lime. Time Frame : 2014-2017	Canker resistant lines in acid lime have been identified through <i>in-vivo</i> field studies for onward use in breeding programme to develop canker resistant acid lime.	The gene responsible for susceptibility to canker has been identified. So, efforts to engineer resistance through genome editing may be pursued
9.	Cultivar–specific and region-based technologies for Sathgudi and 'Mosambi' orange, 'Coorg' mandarin, 'Khasi' mandarin, 'Kinnow' mandarin and 'Nagpur' mandarin needs to be developed and transferred considering important regional problems	Agreed. Efforts would be made to further strengthen linkages with regional ICAR institutes and SAUs for frontline demonstrations of technologies and tackle regional problems. Time Frame : 2014-2017	Collaboration with regional ICAR institutes and SAUs for training and demonstrations have been undertaken through a number of TOT-based programmes in NEH region. Several collaborative research programmes are in progress with SAUs and ICAR Institutes.	This is an important area of technology realisation in field. ICAR-CCRI with establishment of Regional Research Centre should identify priority areas of immediate concern in 'Assam' lemon and 'Khasi' mandarin and work upon them in collaboration with ICAR, RC for NEH Region, Barapani, Meghalaya and CAU, Imphal front-line demonstration of ICAR-CCRI technologies can be started in collaboration with these Institute. However, in case of other cultivars, Brainstorming meeting involving SAUs, KVKs and concerned State departments to pinpoint the available



Sr.	QRT	Council's	Action Report /	Observations of
INO.	Recommendations	Comments	Comments	18)
				technology /technical know- how before attempting research on same issues again to avoid any duplication in efforts
10.	Processes should be developed for value added products like juices, powders, beverages, essential oils pectin etc. from citrus fruits available in various regions with the help of CFTRI, Mysore.	Agreed. Efforts will be made to collaborate with CFTRI Mysore for developing value added products from citrus available in different regions of the country. Time Frame : 2014-2017	Institute has developed RTS, juice powders, carbonated beverages and other nutraceuticals from different citrus species, which are in the process of further refinement. Many of them have been commercialized <i>viz.</i> RTS (ready to serve) from Acid lime fruits, carbonated drinks of acid lime fruits , carbonated drinks of 'Nagpur' mandarin, Storage of Lemons, analysis of flavonoids by HPLC and mechanized packing line and cold storage	ICAR-CCRI should make some serious efforts in undertaking some collaborative research with CIPHET, CFTRI like institutions to upscale the success obtained by this Institute on these issues.



Action Taken Report on the recommendations of the QRT (01.04.2006 to 31.03.2011) for AICRP on Tropical and Sub-Tropical Fruits (now AICRP on Fruits)

Sl. No	QRT recommendations	Councils comments	Action taken	Observations of QRT (2013-18)
1.	In addition to the above centres, the committee has also gone into the programme of co- ordination being conducted at IIHR, Bengaluru, NRC Banana, Trichy and NRC Citrus, Nagpur. The committee suggested that the technical guidance to all the co- ordinating centres must emerge from the NRCs for respective crops. Similarly, IIHR, Bengaluru should extend the desired support to the co- ordinating centres for all other mandated crops in the programme.	Noted for compliance	ICAR-CCRI, Nagpur has been entrusted to look after the responsibilities of coordinating the citrus research under AICRP, organized a first Group Meeting of citrus researchers working under AICRP (Citrus) during 2 nd -3 rd September, 2014 to review the progress of all the AICRP Citrus centres and accordingly the technical programme is being monitored. ICAR- CCRI, Nagpur shall have decisive role in technical matters while its role is advisory in case of administrative and financial matters. • Dr. M.S. Ladaniya, Director, ICAR- CCRI, Nagpur visited Abohar, Tinsukia, Rahuri and Akola Centres and reviewed the research work under AICRP.	ICAR-CCRI should be given full charge of citrus research operational through AICRP on fruits, instead of technical inputs alone. This will enable to set region-wise agenda on citrus research and realise impact of citrus research nationally.
2.	It is observed that there is no close linkage between the project co- ordinating unit with the Universities or the Centres in respect of the technologies being generated by each from the point of	Noted for compliance. Accordingly, the matter will be communicated to different university authorities and a linkage will be established for cross learning.	Mandarin clones (N ₄ , N ₂₈ , N ₃₄ , N ₃₈ , N ₄₃ and N ₅₁), Acid lime clones (NRCC Niboo-2, NRCC Niboo-3, NRCC Niboo-4 and KL-12), Pummelo clones (PTF- 1, PTF-2, PTF-3, NRCC Pummelo- 1, NRCC Pummelo- 2, NRCC Pummelo- 3	Council should take this issue with concerned university to make AICRP programmes more effective and output oriented. This will lessen the dependence
	their performance.		NRCC Pummelo- 4 and	different ICAR-



SI. No	QRT recommendations	Councils comments	Action taken	Observations of QRT (2013-18)
	The technology developed at the different research organisations has to be included in the co-ordinating programmes.		NRCC Pummelo- 5), Grapefruit clones (Flame Grapefruit and NRCC Grapefruit- 6) and Rootstocks like NRCC rootstock- 2, NRCC rootstock- 4, NRCC rootstock- 4, NRCC rootstock- 6 and Alemow (C. macrophylla) from ICAR-CCRI, Nagpur are included in the experiments for their evaluation at different AICRP Citrus centres.	Institutes / Centres as well. Universities should be more pro-active to get benefit of AICRP technologies and collaborate with ICAR Institutes (Commodity based Institutes)
3.	There is a need to strengthen the programmes on rootstocks breeding with the aim; (i) To induce resistance in Rangpur lime (Nagpur and Bangalore), (ii) To incorporate the genes of <i>Trichoderma</i> and <i>Pseudomonas</i> , (iii) Use of rootstock being developed at NRCC for future breeding.	Experiments on the evaluation of newly identified rootstocks at NRC on Citrus is in progress at different centres. However, the aspect related to inducing resistance in Rangpur lime and for the aspects relating to incorporation of genes <i>Trichoderma</i> and <i>Pseudomonas</i> , NRC on Citrus will be requested to implement.	The requisite infrastructure and manpower (Plant Breeder) for development of transgenics for desired characters in citrus are not available with the institute. For advanced biotechnological work more staff in biotechnology section is required. At present only one biotechnologist is available who recently joined in February, 2016.	Systematic breeding programmes for rootstock and scion should be initiated involving scientists at the AICRP centres. Genetics of important traits should be worked out and linked with molecular markers. Therefore, additional monetary resources and manpower should be infused in breeding and biotechnology
4.	The committee observed very poor research on microbiological aspects due to the fact that there are less generation of technologies in this	Noted for compliance.	The requisite manpower (Micro- biologist) for microbial aspects is not available with ICAR-CCRI, Nagpur.	ICAR-CCRI has done good research on development of microbial consortium and evaluated through nursery response



Sl. No	QRT recommendations	Councils comments	Action taken	Observations of QRT (2013-18)
	field. It is suggested that strong microbiological research should be done at ICAR centres of the programme.			and long term field studies for fertilizer and improvement of soil health. A microbial antagonist <i>Trichoderma</i> <i>harzianum</i> has been identified and commercial formulation has been developed against <i>Phytophthora.</i> Efforts on endophytes research from disease and nutrient management point of view are also in progress at the Institute.
5.	It is suggested that model fruit parks to demonstrate the precision horticultural technologies for banana, sapota, papaya, mandarin orange, sweet orange and acid lime should be established at few important centres such as Periyakulam, Rahuri, Coimbatore, Bangalore, Nagpur, Arabhavi, Trichy, Ranchi, Gandevi and Mohanpur.	Under the component of demonstration of improved technology, model fruit parks will be established at the identified centres based on the funding support under the subhead FLD during 12 th plan.	For model citrus fruit parks to demonstrate the AICRP Citrus technologies, three blocks (one each for Acid lime, Sweet orange and 'Nagpur' mandarin) have been identified at ICAR- CCRI farm.	The efforts should be continued to ensure that such concepts provide best of education to citrus growers / officials visiting the Institute.



10. CONSOLIDATED RECOMMENDATIONS

During the period of establishment of this institute during 1980s citrus was the second most important commercial fruit of India after mango. Citrus crops suffered from low productivity and the problem was assigned to citrus decline syndrome, a multi-factor problem ascribed to choice of species, soil, climate, salinity, waterlogging, poor management (nutrients and water), rootstock, diseases (virus, bacteria fungi, nematode), insect pests, etc. Therefore, to revive the industry and for making it economically viable, institute was established. Accordingly, vision, mandate, and objectives were set and programmes developed. So far, many new technologies have been developed and transferred to users. The ICAR-CCRI has been serving the citrus industry of the country for last 34 years now and it has many achievements to its credit. In order to strengthen the programme further, the QRT makes following recommendations:

Research

Citrus Germplasm Resources, Improvement and Biotechnology

- i. Germplasm of citrus should be characterized using molecular approaches (genotyping-by-sequencing) to get a comprehensive idea of genetic diversity, clonal identity, duplication or mislabeling of the collections. These data should be used to conduct Genome-Wide Association Study (GWAS) analysis.
- ii. As most of the citrus species produce polyembryonic seeds, germplasm of such accessions should be cryopreserved for long term conservation. Therefore, facilities for cryopreservation should be developed at ICAR-CCRI, Nagpur.
- iii. Citrus improvement should move from clonal selection of natural variants to active breeding. Therefore, breeding of root stocks and scions of different types of citrus such as lemon, lime, mandarin and sweet orange should be initiated for selected traits where confirmed donors for each trait have been already identified.
- iv. Work on gene/genome editing should be initiated for engineering traits such as canker resistance (lime), seedlessness (in all types of citrus) where genes governing the traits are well characterized.

Citrus Production

- i. Planting density should be standardized for High Density Planting. The key aspects such as canopy management, use of dwarfing rootstock, crop regulation, fertigation requirement, insect-pest and disease management should be standardized.
- ii. Citrus-based farming system should be standardized.
- iii. Physiological basis of flowering and crop regulation should be ascertained.



- iv. Technology for organic production of 'Khasi' mandarin should be developed in collaboration with concerned local agencies. Similarly, organic production protocol should be standardized for 'Mosambi' orange and acid lime.
- v. Comparative evaluation of INM, fertigation/biofertigation and chemical fertilization should be undertaken for quality citrus production and changes in soil health-related parameters.
- vi. Develop sensor based surface and sub-surface irrigation and fertigation schedules (nutrient constraint) based on plant phenological stages for production of high/export quality fruits.
- vii. The major citrus production centres, supply centres and export routes should be mapped on a countrywide scale to have a trade map of citrus.
- viii.Modern irrigation techniques including partial root drying, deficit irrigation, sensorbased automated irrigation should be taken up in citrus in view of the climate change scenario.

Citrus Protection

- i. The leads obtained in the management of fruit fly and fruit sucking moths should be continued with the emphasis on use of baits/ pheromones and other eco-friendly control measures.
- ii. Work on development of leaf miner lures should be further strengthened.
- iii. Efforts on mass multiplication strategies of insect-pest parasites and predators should be used to manage these pests.
- iv. Basic work on diversity, feeding mechanisms and development of pheromones as a control measure of trunk borer in 'Khasi' mandarin should be undertaken.
- v. Protocol for field diagnosis of HLB should be standardized. The viral diseases like tristeza, citrus ringspot and others need to be molecularly characterized and their diagnostics should be developed.
- vi. An in-depth study should be undertaken to assess the diversity of citrus nematodes, their ecological niches and association with *Phytophthora*.

Post-harvest Management

- i. Botanicals and microbial antagonists should be tried and standardized as treatment for management of post-harvest diseases for extension of shelf life.
- ii. Efforts should be made to develop non-hazardous fruit coatings for extending shelf life and improving appearance of fruits.
- iii. Nutritional and nutraceutical value of all cultivated, wild and semi-wild relatives of



citrus should be ascertained for development of nutraceutical-rich health products.

- iv. New varieties released by ICAR-CCRI should be evaluated for shelf life storage ability, processing and value addition.
- v. Technology for producing spray dried powder from 'Nagpur' mandarin, 'Kinnow' mandarin and some promising sweet orange varieties should be standardized to make RTS or instant, reconstituted juice.
- vi. Efforts should be made for development of high value products like pectin, flavonoids, oil, antioxidants, etc. from the citrus peel and pomace to utilize processing industry waste and value addition.

Products and Services

- i. The bioformulation of *Trichoderma* should be commercialized on large scale after completing the toxicological studies. (The monetary demands for conducting toxicological studies should be met from the Institute fund).
- ii. Production of disease-free planting material for farmers and nurserymen, production of microbial products as a small scale livelihood venture, development of value added products, sale of rootstock seeds etc. should be the focus areas of earning additional revenues.

Research Programme at RRCC, Biswanath Chariali, Assam

- i. Establishment of citrus Germplasm bank as a safety duplicate at RRCC Biswanath Chariali, Assam.
- ii. Collection of superior clones of 'Khasi' mandarin and 'Assam' lemon.
- iii. Production of disease-free planting material of budded plants of 'Khasi' mandarin.
- iv. Evaluation of citrus cultivars of various commercial species for recommendation in NEH region.
- v. Survey, collection and evaluation of citrus variability for different traits in NEH region.
- vi. Establishment of demonstration blocks of technologies developed by ICAR-CCRI, Nagpur.
- vii. Development of package of practices for organic 'Khasi' mandarin production.

General Recommendations

i. Mechanization of citriculture should be pursued. In particular, artificial intelligence and robotics should be exploited for pruning, spraying and harvesting.



Infrastructure

- i. Institute should establish Referral Laboratory on its premises based on analytical methods / procedure standardized by the Institute. Required funds should be provided for contractual manpower to be hired to run this Referral Lab and to procure equipments.
- ii. For future, the QRT recommends that in-view of institutes unique character, it should receive better support for research on breeding (crop improvement), bio-technology, physiology, nutrient and water management, plant protection, processing and value addition. For these research areas, the QRT recommends provision of advanced equipments.
- iii. Modern equipments such as transmission electron microscope, compound microscope, flow cytometer, microchip electrophoresis, ground penetrating root radar, GCEAD, DNA bio-analyzer with dedicated camera, micro-array machine, multimode micro-plate reader, ICP analyser are suggested to be procured.
- iv. New infrastructure like screen houses; renovation of farmhouse and main building, staff quarters, farm roads; fertigation system for entire plantation, electrification etc. are urgently required to modernize the infrastructure of the Institute. At RRCC Biswanath Chariali infrastructure like road, fertigation system, farm house building and main laboratory cum administrative building, compound wall and fencing need to be created on urgent basis.

Financial and Human Resources

- An additional staff of 10 Scientists (Horticulture-2, Genetics and Plant Breeding-1, Soil Science-1, Soil and Water Conservation Engg. 1, Plant Physiology-1, Plant Biochemistry-1, Plant Virology 1, Food Science and Technology-1 and Extension Education -1) along with 23 technical officers; 4 administrative staff (Sr. Admn. Officer, Asst. Admin. Officer, Finance and Accounts Officer and Assistant) and 12 supporting staff is recommended at the headquarters. As many 5 scientists (Horticulture-1, Soil Science-1, Entomology 1, Plant Virology 1 and Extension Education 1); 9 technical staff, 5 administrative staff and 6 supporting staff is recommended at the Regional Centre, (RRCC Biswanath Chariali), Assam.
- ii. The entire citrus research of the country should be located at one place and ICAR -Central Citrus Research Institute, Nagpur is the right place, where from entire citrus research should be regulated. The citrus research work done under AICRP (Fruits) is not accessible to the QRT of the Institute for review. Hence, the citrus research undertaken at ICAR-CCRI, Nagpur and under AICRP should be brought under one umbrella as has been recommended by the previous QRT by giving full administrative and financial control of citrus research undertaken through AICRP.



Linkages

- i. Effective research collaboration should be made with other government and private organizations in order to make linkages with different centres of excellence on citrus research at both national and international level including countries, such as USA, Brazil, Spain, South Africa, Australia etc.
- ii. With the kind of technologies the ICAR- CCRI has developed over the years, the Institute should establish its leadership in SAARC Countries. At the same time, initiatives should be taken up to have collaborations with Institutions like EMBRAPA, Brazil and Chinese Academy of Agri. Sciences, China. Efforts should be made to develop trade map with Nepal, Bhutan, Bangladesh.
- iii. Collaboration should be established with different Institutes within India for work in frontier areas. For example, DNA based characterization of germplasm may be undertaken with NBPGR. Similarly, collaboration with National Institute of Agricultural Biotechnology, Chandigarh may be explored for genome editing of citrus.

11. ANNEXURES



Annexure - I

The proceedings of the Meetings/ visits of the QRT to different places.

First Meeting (Interaction with Hon'ble DDG, Hort. Sci), ICAR, New Delhi

A meeting for briefing of the QRT by the Hon'ble DDG (Hort. Sci.) was held on 4th January, 2019 in the Hort. Sci. Div. of ICAR. The following were present in the meeting:

- 1. Dr. A. K. Singh, DDG (Hort. Sci.), Div. Hort. Sci., KAB II, ICAR, New Delhi.
- 2. Prof. B. S. Chundawat, Ex. Vice-Chancellor, GAU, Navsari, Gujarat and Chairman QRT of ICAR- CCRI, Nagpur.
- 3. Dr. M. S. Ladaniya, Director, ICAR- CCRI, Nagpur.
- 4. Dr. A. K. Srivastava, Principal Scientist (Soil Science), ICAR-CCRI, Nagpur and Member Secretary, QRT.

The meeting started with the introduction of background information of QRT briefed by Member Secretary QRT. Thereafter, the discussion on expectations of QRT was elaborated by Hon'ble DDG (Hort. Sci.), Dr. A. K. Singh. The salient points of these deliberations are as follows:

- While deliberating on the functions of the current QRT, the new recommendations must ensure that whether or not, the recommendations of the last QRT have been implemented by the ICAR-CCRI, Nagpur.
- Whether resources available with the Institute are fully utilised including the human resource.
- Success stories in the past five years could be highlighted with emphasis on environmental sustainability, even the achievement of individual scientist can be assessed including the quality of publication brought out by them.
- Those research programmes continuing over a long period of time may be recommended to be discontinued, if such programmes fail to deliver expected results within a given time frame.
- While highlighting the undoubted success of disease free planting materials of citrus, the other sides of such programme should also be looked into:
- Performance of disease-free planting material planted in new field and how long they remain disease-free in main field.
- Two conventionally used rootstocks *viz.*, Rough lemon and Rangpur lime are in use over a long period of time, it remains to be re-established whether these two rootstocks are still effective in light of emerging soil borne pathogens, pests and



climate change related more pressing issues.

- A protocol emphasizing identification of nucellar seedlings must be developed to shorten the time taken to develop the ready to use planting material. Nucellar seedlings can be identified with 100 per cent surety when developed from nucellar tissues in test tube or on growing medium. Rootstock produced through this method and through traditional method shall be compared in field study after budding with scion.
- While assessing the annual requirement of disease free planting material on a countrywide basis, replacement rate should be kept in mind.
- A great amount of soil as growing medium is needed especially considering such a huge number of nursery plants annually, a time will come, where availability of good soil would be in limited supply, why not to develop some substrate using different types of agricultural wastes, so that dependence on fertile soil is minimised.
- A procedure should be devised to find out the flow of disease free planting material to locate which are the major new plantation areas.
- There are some promising areas of Rajasthan in north India and Arunachal Pradesh in northeast India, we need to ensure the supply of healthy disease-free planting material to establish the future citrus industry in India.
- We need to develop a comprehensive crop planning for suitability of different citrus cultivars in non-conventional area of citrus. For example, suitability of tangerines, pomelos, grapefruits etc, we need to develop commercial belts of these cultivars. But water availability, site evaluation, market availability, buying capacity, consumers preference etc must be ascertained. Let us develop a districtwise crop map on a countrywide scale to have a blueprint of major citrus supply centres. We also need to develop a trade map to pinpoint the areas where excess production is to be sold out.
- Time has come to revisit the concept of increased production, which should be replaced with quality production. At the same time, there is a strong necessity to develop value chain management with a concept "Farm-to-Plate".
- Options available need to be explored to double the farmers income, while doing so, the recommendations of subsequent RACs should also be considered.
- Many of the insecticides/ pesticides / fungicides/ growth hormones / herbicides/ even micronutrients are recommended in different doses, but farmers / practitioners have no access to such precise measurements at farm level. Can't we develop some pouch packaging or some kind of smart packaging, just use once and throw, so that the recommendations at farm level are implemented with precision with minimum possibility of technology failure.
- There is absolutely no doubt that high density planting has aided tremendously in boosting the factor productivity but at the same time, transformed these plants quite vulnerable to incidence of pests and diseases due to frequent pruning. We need to re-



strategise these issues to sustain the success of such programmes.

- We need to develop a greater diversity in both rootstock as well as scion. Many of the imported germplasm materials are yet beyond the reach of ICAR-CCRI, they should be procured by the Institute without delay, but with proper backup of indexing. At the same time, newer varieties should also be evaluated with a cluster of farmers.
- Why the productivity of citrus in India remains more or less stable, despite muiltifold increase in area and production the defining reasons for such discrepancy should be explored.
- The success story of ICAR- CCRI on Citrus Rejuvenation Technology needs to be replicated at other citrus commercial belts of the country.
- It is to be studied whether a farmer household can have sufficient livelihood on citrus crop only. Whether 2 or 3 different citrus crops like acid lime, 'Mosambi', mandarin can be suggested for sufficient income generation. Even if this is not sufficient to provide required income to the family, what kind of integrated farming system shall be suggested.
- With the kind of technologies, the ICAR- CCRI has developed over the years, let us try to establish our leadership in SAARC Countries. At the same time, initiatives should be taken up to have collaborations with Institutions like EMPRAPA, Brazil and Chinese Academy of Agri. Sciences, China. Efforts should be made to develop trade map with Nepal, Bhutan, Bangladesh.
- A report on the Brazilian citrus varieties being grown at ICAR-CCRI Nagpur should be sent to DDG (Hort. Sci.).
- Information on import of Juice, frozen concentrate and other citrus products and by products should be collected.

Chairman QRT, Prof. B. S. Chundawat put forth some issues into the discussion, which are as follows:

- * How can we improve the proportion of exportable quality of citrus fruits or more uniform fruit size.
- * Many of the clones of mandarins, sweet orange, pummelo, grapefruit, acid lime have been identified by the ICAR-CCRI, these materials need to be multiplied on a large scale to realise their impact in growers field, instead of multiplying our conventional scion variety.
- * We need to look into the comparative study of frontline citrus growing countries *visa-vis* Indian citrus industry to have first hand information on "Dos and Donts" with respect to citrus industry of India.
- * Technology package needs a better orientation for small citrus farmers.
- * The status of Citrus industry of India should be prepared and supplied to the QRT



during the next formal meeting of the QRT.

- * Whether livelihood to a farm family can be secured through citrus farming alone? If so, how much area of citrus farm can sustain farm family of a given size.
- * An investigative study should be carried out by putting all the developed ICAR-CCRI technologies into some identified citrus orchards to have their impact evaluated in field.

The meeting ended with vote of thanks to Hon'ble DDG (Hort. Sci.), Dr A. K. Singh and Prof. B. S. Chundawat, Chairman QRT.

Second Meeting (7-9th February, 2019)

The second meeting of the QRT was convened during 7-9th February, 2019 at ICAR-CCRI, Nagpur. The following members attended the meeting :

- i. Dr. B.S.Chundawat (Chairman)
- ii. Dr. A.M.Goswami (Member)
- iii. Dr. S.R. Bhat (Member)
- iv. Dr. T.B.S. Rajput (Member)
- v. Dr. Y.S. Ahlawat (Member)
- vi. Dr. P.C. Sharma (Member)
- vii. Dr. M. S. Ladaniya, Director, ICAR-CCRI, Nagpur
- viii. Dr. A. K. Srivastava, Principal Scientist (Member Secretary)

February 7, 2019

The meeting of QRT started with floral welcome of all the QRT members by Dr. M. S. Ladaniya, Director, ICAR-CCRI, Nagpur and introduced the QRT with scientific staff of the ICAR-CCRI, Nagpur

The team went around the Experimental Farm, visited experiments in field and the nursery block where disease-free planting material is being produced including the Technology Mission on Citrus. The QRT also visited the laboratories and nurseries, where STG and microbudding techniques are being followed. The QRT suggested to use the most efficient method of propagation, which consumes less time and use the most efficient rootstock put forth by the Institute. After a long term studies, the Alemow rootstock has been identified and popularized by the Institute. QRT suggested that seeds and seedlings of this rootstock should be given to nurserymen and farmers for its extensive use.

The QRT visited different experiments *viz.*, i. Evaluation of micronutrient mixtures for growth and productivity of 'Nagpur' mandarin and ii. Evaluation of exotic sweet orange and grapefruit varieties on raised bed. The QRT suggested that performance of flatbed versus



raised bed should be evaluated through long term evaluation. Later, the QRT visited experimental block of exotic sweet orange on raised bed using Brazilian sweet orange and rootstock combinations and experiments entitled "Effect of training, pruning and growth retardants on canopy management and productivity of acid lime under different spacings" and "Evaluation of exotic varieties such as 'Flame grapefruit', 'Cutter Valencia', 'US-145', 'Ruby', etc. The QRT visited the experimental block where hybrid progeny (developed through hybridization) has been planted. The QRT suggested for ideotyping of parents to move ahead for crossing. The QRT also suggested to workout the industrial use of lemons processing and value addition while visiting the experiment on "Evaluation of lemon varieties". The QRT appreciated the work on precision citriculture.

In afternoon, Dr. M.S. Ladaniya, Director presented "Achievements of ICAR-CCRI, Nagpur" where he highlighted the technologies developed by the Institute during 2013-18 in addition to citrus research carried out under AICRP Fruits. Thereafter, presentations were made by Dr.N. Vijayakumari, Pr. Scientist (Hort.); Dr. I. P. Singh, Pr. Scientist (Hort.); Dr. A.A. Murkute, Pr. Scientist (Hort.); Dr. Prasanth Tej Kumar J., Scientist (Biotech.) on the achievements of research projects handled by them. Two issues emerged from these presentations, they were: use of markers to distinguish rough lemon from 'Galgal' and natural variability in crosses made.

8th February, 2019

Second day of the QRT meeting started with field visit to different experimental blocks. In the beginning, the experimental block of Dr. A.A. Murkute, Pr. Scientist (Hort.), evaluation of acid lime varieties on raised bed by Dr. R.K. Sonkar, Pr. Scientist (Hort.) and germplasm repository under screen house by Dr. I.P. Singh, Pr. Scientist (Hort.) were visited by the QRT.

In the afternoon, Dr. R.K. Sonkar, Pr. Scientist (Horticulture) presented his work on "Evaluation of sweet orange on raised bed" which was followed by presentation by Dr. A.K. Srivastava, Pr. Scientist (Soil Science) on citrus nutrition; Dr. P.S. Shirgure, Pr. Scientist (SWCE) on water management; Dr. Dinesh Kumar, Pr. Scientist (Horti.) on PHT; Dr. A.D. Huchche, Pr. Scientist (Hort.) on flowering and crop regulation; Dr. A.K.Das, Pr. Scientist (Pl. Patho.) on fungal and bacterial diseases, and Dr. Anjitha George, Scientist (Ento.) on insect pests management. During these presentations, various suggestions were given, which comprised of: changes in physico-chemical properties in response to INM treatments, amount of fertigation applied in high density planting, emphasis on electronic radar for non-destructive estimation of fruit maturity, ideal growing conditions for flowering and crop regulation.

The QRT later interacted with IMC members of the Institute. The following IMC members were present:

- Dr. P.S. Tiwari, CIAE, Bhopal (Member)
- Dr. Pradnya Golghate, Govt. of Maharashtra (Member-representative)



• Dr. Archana Kadu, Principal, Regional Training Agril. Institute, Nagpur (Member-representative)

The issues like HDP on raised bed, reasons of low citrus productivity, double line method of drip irrigation, processing units, TOT-based training, on-farm training, adoption of village, role of FPOs, small size grader, market interventions, uniform recommendation considering the variety of recommendations emerging from different sources, pruners to be developed in collaboration with CIAE, Bhopal and role of drones etc. were discussed.

Visit of QRT to different laboratories of the institute was also conducted in the evening.

9th February, 2019

This day was in fact devoted to field visit of the QRT. The field visit started with demonstration on high density planting of acid lime and 'Nagpur' mandarin at Nimji, Kalmeshwar. Thereafter, the QRT was taken to visit the 'Nagpur' mandarin orchard of Mr. Dhiraj Junghare at, Hatla, Katol Dist. Nagpur. This orchard has been maintained through fertigation and other high precision-based gadgets at 6×3 m spacing.

A meeting with the farmers and President of Orange Growers Association of India was also organised at Warud, Amravati district. In this meeting a number of issues were raised. These were : enactment of nursery act, indexing of mother trees of private nurseries, GI marketing of 'Nagpur' mandarin, waxing materials, global competitiveness of Indian citrus industry, packaging having more strength. Later, the QRT visited packing line owned by Shri. Taj Khan at Warud, where the 'Nagpur' mandarin fruits are packaged in three grades after post-harvest treatments. Such Post- harvest handling practices are gradually picking up in this region.

During the three day meeting of the QRT, following suggestions / recommendations have emerged :

- Only the most efficient method of propagation should be used, which consumes much less time.
- Comparison of flatbed versus raised bed for crop performance should be undertaken.
- Ideotyping of parents for crossing should be done.
- Recommendations of the institute should relate to mandate.
- Scientists should visit the major citrus growing areas of the country to know the exact problems of citrus industry.
- Institute should look at the utilization of juice concentrates coming from other countries.
- Pooled data analysis should be made mandatory.
- Once identified as a best rootstock, it should be used for all commercial multiplication purposes.
- Citrus syndrome of decline should be addressed with regard to causal factors and their



management. Any technological gap, in addressing either diagnosis or management of citrus decline, if any, should be addressed.

- Specific traits of each species should be identified and used in molecular characterization as utilizable traits.
- Comparative study on performance of STG derived plants, microbuds and conventionally produced planting materials, should be undertaken.
- The best rootstock for microbudding should be worked out.
- Fidelity of mother trees under screenhouse should always be maintained. The periodicity of indexing of mother trees should be worked out.
- Emphasis on studies regarding non-destructive estimation of fruit maturity should be given.
- Ideal conditions of flowering and crop regulation should be worked out.
- Use of sensors in regulating irrigation should be initiated.
- Institute should provide an additional perspective to solve different problems faced by the citrus industry.
- Different products and by-products developed by the Institute should be commercialized especially for production through small scale units.
- Matters such as enforcement of nursery act for indexing of mother trees of nurserymen, GI marketing, waxing material, packing materials etc, should be taken up with concerned agencies/users for their benefit.

Third Meeting (24-26th April, 2019)

The QRT visit to Regional Research Centre for Citrus, (RRCC), Biswanath Chariali, Assam and ICAR-RC for NEH Region, Umiam, Meghalaya (24-26th April, 2019)

Visit to RRCC

This Regional Centre was approved under ICAR-CCRI, Nagpur by ICAR in EFC meeting XII Plan (2012-2017) to be established in Assam. The Centre was established to create a base in NEH (a home / origin of citrus) and to improve access to regional citrus industry. The objective of RRCC is also to develop region-specific technologies and disseminate them to address issues of regional citrus industry. Nevertheless, the site is not a representative of situation where citrus is cultivated, but can be useful, if it is extended to valleys and plain lands in competition with other crops.

The following are the mandates of RRCC :

- 1) Set-up repository of citrus genetic resources and characterization thereof.
- 2) Production of disease-free and true-to-type budded plants of 'Khasi' mandarin and other citrus cultivars.
- 3) Develop suitable technologies for citrus production and post-harvest management



keeping in view regional needs of entire NEH region,

- 4) Disseminate technologies through skill development, trainings, frontline demonstrations,
- 5) Collaborate with regional SAUs, ICAR Institutes and State Agric./ Hort. departments and other suitable Govt. and NGO agencies,
- 6) Promote citrus cultivation and citrus industry in NEH region through all possible support and programmes.
- 7) Replication of technologies generated at main Institute for dissemination and demonstration.

During 2012-17, no separate funds were allocated for the Regional Centre. But, during plan period of 2017- 2020, funds were allocated for farm building, tractor and implement shed and for various equipments under Grant-in Capital. The operational expenditure is being met through funds of the Institute. The QRT visited RRCC on 24th April, 2019 and reviewed the experiments in the field. The QRT visited following experiments at the station :

- Evaluation of Citrus spp. on raised-bed and flat-bed (plain) planting system : In this experiment as many 31 citrus varieties/cultivars of Citrus (mandarin, sweet orange, pummelo, grapefruit, acid lime and lemon) have been planted. The objective is to evaluate the performance of commercial and promising citrus varieties under agroclimatic conditions of NE.
- 2) Evaluation of Citrus germplasm : The objective was to have Field Gene Bank under agro-climatic conditions of NE region. Citrus is originated in NEH region and several spp. are reported from Assam also like *Citrus assamensis*. Therefore, whatever germplasm is available at ICAR-CCRI, Nagpur have been planted at RRCC to have safety duplicate. At present, 51 accessions of citrus have been planted.
- 3) Farm facilities : The facilities like tube well, drip irrigation system and electricity supply for tube well pump have been created.
- 4) Entire field where farm building and tractor/implement shed are to be constructed, has been taken in possession from BNCA. It is being demarcated and cleaned to prepare for construction and plantation. So far, out of total 42.5 acres of land under RRCC, almost 22 acres have been cleaned and made suitable for plantation. The remaining 22.5 acres is yet to be cleaned. Plantation as mentioned above has been done on around 6 acres of land.

Thereafter, the QRT visited RRCC office established in old college building which has been handed by BNCA for temporary establishment of this Centre. Facilities created were: i. Director's room, ii. Administration room, iii. Training hall (chairs and other facility to be created; lap top and projector already procured), iv. Laboratories, v. store room, vi. two sitting rooms for scientists and toilets. Under equipments, microscope (1) and oven (1) have been purchased for nematological studies at RRCC. Office furniture and facilities like Fax



and scanning machine, Desktop computer, inverter batteries for electricity supply have been procured. Telephone and internet have also been made available. Electrification, lighting and water supply have been accomplished.

Interactive meeting with stakeholders at BNCA

The stakeholders such as BNCA staff, Programme Co-ordinators of KVKs (Lakhimpur, Sonitpur, Biswanath Chariali and Dhemaji districts), State Agric. Deptt. Staff, Head of Deptt. of various faculties such as Plant Breeding and Genetics, Plant Pathology, Plant Physiology, Soil Science, Horticulture etc. were present.

Associate Dean of BNCA, Dr. R.N. Burman gave brief overview of citrus cultivation in the districts on north bank of Brahmaputra (*viz.*, Tezpur, Sonitpur, Biswanath, North Lakhimpur, Dhemaji). He stated that there is a good scope to increase citrus in this area, since several traditional crops are not profitable. Gunjan Gogoi, Programme Co-ordinator from Dhemaji district Assam informed that 470 ha is under 'Assam' lemon in that district alone. 'Khasi' mandarin is grown under "Bari" system near house (Homestead garden), where 5-10 trees are grown by households. The commercial mono crop plantations of 'Khasi' mandarin are not available in above mentioned districts, but there is a potential to grow the 'Khasi' mandarin keeping in view the suitability of agro-climatic conditions. This entire region has sub-tropical climate and citrus performs very good under this type of climate.

Those present in the meeting were: Dr. B.S. Chundawat, Dr. A.M. Goswami, Dr. T.B.S. Rajput, Dr. Y.S. Ahlawat, Dr. S.R. Bhatt, Dr.P.M. Sharma, Dr. M.S. Ladaniya, Dr. A.K. Srivastava. From Assam- Dr. R.N. Burman, Associate Dean of BNCA; Dr. P.K. Sharma, Chief Scientist, ICAR-AICRP Dryland Agric. Project at Biswanath; Shri. P.C. Deka, PC KVK, Sonitpur; Dr. B.C. Deka, PC, KVK, Lakhimpur, Sri. Gunjan Gogoi, P.C. KVK, Dhemaji; Dr. J.P. Dutta, Principal Sci, RARS (AAU), Lakhimpur; Dr. Gautam, Head, Hort. Deptt; Dr. R.K. Goswami, Head Deptt of Pl. Physiology; Dr. K.K. Das, Head Pl. Pathology Deptt; Dr. M.D. Sharma, Head, Deptt of Breeding and Genetics; District Horticulture Officers from Biswanath and Sonitpur; Several other faculty members of BNCA; Dr. Kiran Kumar Kommu, Scientist CCRI, Nagpur, Sr. Technical Officers of CCRI, Shri. Bhaladhare and Shri.Gadge.

The following researchable issues emerged through this meeting:

- 1) Extensive survey for variability and uses of different Citrus spp. and varieties.
- 2) Collection of citrus germplasm of Assam and other NEH states and their documentation and characterization.
- 3) Fruit cracking in 'Assam' lemon, premature fruit drop and deficiency of micro- and macronutrients.
- 4) Crop regulation in 'Assam' lemon to get crop during March-June when prices are high.



- 5) Establishing repository of traditional and exotic citrus varieties and cultivars.
- 6) Analysis of essential oils from traditional citrus germplasm of NEH.
- 7) Package of practices for organic cultivation of 'Khasi' mandarin and 'Assam' lemon.

The participants also expressed their views, which could be summarized as:

- 1) There is a great scope to explore possibility of establishing 'Khasi' mandarin orchards in the north bank area of Brahmaputra river (Tezpur, Sonitpur, Biswanath Chariali, Lakhimpur and Dhemaji districts).
- 2) Demonstrations should be started at farmers field to show-case advanced technologies for production of good quality fruit of 'Khasi' mandarin with the collaboration of State Agric. Deptt.
- 3) Market link should be established, so as to ensure remunerative prices to growers as the production starts.
- 4) Demonstrations should be started for rejuvenation of existing 'Khasi' mandarin plantations.
- 5) Disease-free planting material should be provided to growers.
- 6) New varieties of mandarin should be given to farmers.
- 7) Awareness to be created about management of trunk-borer, bark eating caterpillar and sooty mould.

Visit to ICAR RC for NEH Region, Umiam, Meghalaya, 26th April, 2019

The QRT visited 'Khasi' mandarin grower's orchard (Owner Shri. Rowin Syngkli at Nongkhrah) in Nongpoh area of Ri-Bhoi district of Meghalaya on 26th April, 2019. Also visited Citrus nursery at Dewlieh farm of State Agriculture Department at Nongpoh. The nursery had 432 mother trees of 'Khasi' mandarin and distributeed 15000 budded plants of 'Khasi' mandarin to growers. This nursery was given 2 star rating in 2016. Under Indo-Israel Project, the Department of Agriculture, Directorate of Horticulture has established this nursery. The nursery does not have rootstock block of its own.

The officers of state Agriculture Department and ICAR RC for NEH region present during the visit were :

- 1) Dr. K. B. Lakiang, Asstt. Director Horticulture, Nongpoh.
- 2) Shri. B. Keri, ADO, I/C. Dewlieh Farm.
- 3) Dr. H. Rymbai, Scientist (Hort), ICAR RC for NEH region.
- 4) Dr. Nishant Deshmukh, Sr. Scientist, ICAR RC for NEH region.



The following issues emerged during visit:

- 1) Plants were largely seedlings.
- 2) Plantation of 'Khasi' mandarin was on steep slopes (50-70 per cent) without proper terracing is expected to under perform.
- 3) Planting layout was not prepared and proper distance between the plants was not maintained but it appeared to be 5x5 m.
- 4) There was no proper nutrient and water management as per recommendation.
- 5) Plants were having infection of lichens.
- 6) The plant growth was lanky due to competition for sunlight.
- 7) Plant canopy is very small and plants were of seedling origin.

The recommended rootstocks for the region are *Citrus volkameriana*, and rough lemon.

In the afternoon, the interactive meeting of the QRT with all the stakeholders was arranged.

The stakeholders such as State Department officials (Dist. Hort officials of West Khasi Hills, East Khasi district, East Garo Hills, Ri bhoi), ICAR-ATARI (Agriculture Technology Application Research Institute), Programme Co-ordinator, Krishi Vigyan Kendra (KVK attached to ICAR RC for NEH region), Head of Departments of Soil Science, Horticulture and scientists of ICAR RC for NEH region were present. The following officials were present during the meeting:

Dr. B.S. Chundawat, Dr. A.M. Goswami, Dr. TBS Rajput, Dr. YS Ahlawat, Dr. SR Bhatt, Dr.P.M. Sharma, Dr. M.S. Ladaniya, Dr. AK Srivastava. From Meghalaya; Dr. S.K. Das (Director In-charge, ICAR RC for NEH region), Dr. S.A. Hazarika, Head , Soil Sci Div.; Dr. A.K. Singha, ATARI In-charge, Umiam; Dr. Nurul Islam, PC, KVK, Umiam, Dr.U. Baruah, SMS, Hort (KVK); Shri. B. Keri, ADO, In-charge, Dewlieh Farm,Nongpoh; Mrs. V.Renthlei, Dist Hort. Officer, East Garo hills;Dr. H. Rymbai, Scientist (Hort), ICAR RC for NEH region; many other officials of Mghalaya state Hort. Deptt; Dr. Nishant Deshmukh, Sr. Scientist, ICAR RC for NEH region.

The issues emerged were :

- 1) Plantation on steep slope.
- 2) Non-availability of healthy planting material.
- 3) Canopy management for ease of management and harvesting crop.
- 4) Package of organic production.
- 5) In-composition of homesteads share of citrus in the region in terms of species and varieties.
- 6) Dissemination of knowledge and technologies.
- 7) Training of stakeholders with common interest.
- 8) Role of drip irrigation.



9) Micronutrient deficiency.

Fourth Meeting (16-18th July, 2019)

The fourth meeting of the QRT was undertaken during 16-18th July, 2019 for discussion of final report writing. During the three days of meeting, following members were present.

- Dr. B.S.Chundawat (Chairman)
- Dr. A.M.Goswami (Member)
- Dr. S.R. Bhat (Member)-Joined on 17th July, 2019
- Dr. T.B.S. Rajput (Member)
- Dr. Y.S. Alhawat (Member)
- Dr. P.C. Sharma (Member)-Joined on 17th July, 2019
- Dr. M.S. Ladaniya, Director, ICAR-CCRI, Nagpur
- Dr. A.K. Srivastava, Principal Scientist (Member Secretary)

16th July, 2019

On the first day, the QRT interacted with individual scientist about their research achievement, future line of research and infrastructural facilities needed. The scientist with whom the QRT interacted were: Dr. I.P.Singh, Pr.Scientist (Hort.); Dr. Murkute, Pr. Scientist (Hort.); Dr. Tej Kumar, Scientist (Biotechnology); Dr. A.K.Srivastava, Pr.Scientist (Soil Science); Dr.A.D. Huchche, Pr.Scientist (Hort.); Dr. P.S Shirgure, Pr.Scientist (Soil and Water Consevation Engg.); Dr.D.K Ghosh, Pr.Scientist (Pl.Pathology); Dr. A.K Das, Pr.Scientist (Pl.Pathology); Dr.Anjitha George, Scientist (Entomology); Dr. Dinesh Kumar, Pr.Scientist (Hort.).

17th July, 2019

The second day of the QRT started with meeting at Dist. Agriculture Supdt. Office, Amravati. The following were present:

Dr. B.S. Chundawat, Dr. A.M. Goswami, Dr. P.B.S. Rajput, Dr. Y.S. Ahlawat, Dr. P.C. Sharma, Dr. S. R. Bhatt, Dr. M.S. Ladaniya, Dr. A.K. Srivastava, Dr. Dabke, Sh. Anil Ingle, Sh. A.S. Kharchan, Sh. U.R. Agarkar Sh. M.S. Patekar, Sh. S.J. Awadhale, Sh. D.P. Choudhari, Sh. M.R. Yawalkar, Sh. N.R. Wankhede, Sh. G.H. Dane, Sh. R.N. Nimkar, Sh.N.A. Niswade, Sh. S.S. Parode, Sh. V.S. Kuntawar, Sh. R.N. Dhande.

The issues which were discussed during the meeting comprised of: low rainfall, drought, marketing, transport facilities, unsuitable varieties for processing, plant material *Phytophthora*, in-sufficient technical know-how, post-harvest handling, subsidy on plastic crates and corrugated boxes, fresh juice parlour, export facility, DNA fingerprinting facility, training to farmers, fruit drop, drip irrigation, fertigation, subsidy on double line drip



irrigation, irregular flowering, nutrient management, organic production, water harvesting, drainage problem, fruit cracking, diagnostic visit, climate change-related issues, uncertainties associated with *Mrig bahar* etc.

Thereafter, another meeting with state government officials and prominent citrus growers was held at Achalpur Dist. Amravati. The following were present in the meeting:

Dr. B.S. Chundawat, Dr. A.M. Goswami, Dr. P.B.S. Rajput, Dr. Y.S. Ahlawat, Dr. P.C. Sharma, Dr. S.R. Bhatt, Dr. M.S. Ladaniya, Dr. A.K. Srivastava, Sh. P.J. Satav, Sh. R.K. Gupta, Sh. R.H. Bowe, Sh. S.N. Kulathe, Sh. A.R. Shelke, Sh. S.S. Shelke, Sh. N.H. Parokar, Sh. Sachin Bhosle, Sh. S. R. Jambhe, Sh. S.P. Shirsagar, Sh. Shubham Warne, Sh. Pravin V. Madghe, Ku. S.H. Uike, Sh. S.R. Bhagat, Sh. Bandu Wasankar, Sh. Nandu Madghe, Sh.Shyamsundar Agrawal.

The major issues which were prominently discussed have been: "*Waiwar*" disorder, citrus greening, fruit drop, disease-free planting material and field demonstration for "*Waiwar*" disorder management.

18th July, 2019

The third and last day of meeting was dedicated to finalization of the QRT report including the consolidated recommendations.

Finally the meeting ended with vote of thanks to the chair and QRT members by Member Secretary QRT, Dr. A.K Srivastava, Pr. Scientist (Soil Science).



Annexure - II

Important Meetings Conducted (2013-18)

Meeting	Dates	Total number of meetings
	15 th April, 2014	
Research Advisory	11 th August, 2015	4
Committee	6 th September, 2016	4
	11 th September, 2017	
	23-24 th April, 2013	
	25-26 th April, 2014	
Institute Research Council	16-17 th April, 2015	6
Institute Research Council	3-4 th May, 2016	0
	25-26 th April, 2017	
	25-26 th April, 2018	
	09 th April, 2013	
	26 th November, 2013	
Institute Management	23 rd June, 2015	6
Committee	14 th March, 2016	0
	30 th March, 2017	
	28 th March, 2018	
	4 th May, 2012	
	11-12 th July, 2012	
5 th QRT (2007-2013)	19-20 th December, 2012	5
	4-5 th February, 2013	
	9-10 th April, 2013,	



Annexure - III

Infrastructure developed (2013 – 18)

List of major infrastructure/ facilities developed with brief description

Year	Name of Work Done	Amount	Date of work Started	Date of work Completion
2014-15	Construction of intake well at Amabzari lake	Rs. 134 lakhs	19.02.2015	05.08.2017
2015-16	Construction of Farmers Hostel at ICAR-CCRI, Nagpur	Rs. 120 lakhs	17.03.2016	17.05.2018
2017-18	2x25 HP Pump supply of HT (High Tension) Electricity line	Rs. 27.10 lakhs	14.12.2017	Work in progress
2018-19	Construction of Septic tank and Pipe Line near ICAR-CCRI Residential quarters	Rs.10.89 Lakhs	11.05.2018	Work in progress

Major Equipment (Above Rs 5.00 Lakhs) Purchased (2013 -2018)

Year	Name of indenter	Name of Equipment	Amount
2013-14	Dr. D.K. Ghosh	Lenovo all in one 3 rd generation intel core in processer 25 No. Desktop PC's Funded by NAIP.	Rs.13,00,000/-
2014-15	Dr. Anjitha George	Lieca Microscope motarized sterio zoom with Digital Camera	Rs.17,64,743/-
2015-16	Dr. P. S. Shirgure	Air Blast Orchard Sprayer Orange Electrostatic	Rs. 7,25,000/-
2015-16	Dr. P. S. Shirgure	Orchard Sprayer Caffini Speedy Reserve	Rs. 7,10,000/-
2015-16	Dr. P. S. Shirgure	Mechanical tree prunner	Rs. 28,45,000/-
2015-16	Dr. D. K. Ghosh	Deep Freezer (-80°)	Rs. 5,61,050/-
2015-16	Dr. Dinesh Kumar	HPLC System	Rs. 27,98,500/-
2015-16	Dr. Dinesh Kumar	Reverse osmosis and ultra filtration unit	Rs. 24,75,000/-
2015-16	Dr. Kiran Bhagat	Portable Photosynthesis Measurement System	Rs. 28,70,000/-
2015-16	Dr. D. K. Ghosh	Nanodrop Spectrophotometer System	Rs. 6,27,079/-
2015-16	Dr. A. K. Das	Microscope with fluorescence attachment	Rs. 7,78,817/-
2015-16	Dr. R. A. Marathe	Fertigation and Irrigation System	Rs. 5,86,872/-
2015-16	Dr. C. N. Rao	UV-VIS Spectrophotometer	Rs. 5,45,625/-
2015-16	Dr. D. K. Ghosh	Gel Documentation System	Rs. 10,30,000/-



Year	Name of indenter	Name of Equipment	Amount
2015-16	Dr. Kiran Bhagat	Automatic Weather station with accessories	Rs. 6,50,000/-
2016-17	Dr. Kiran Bhagat	Purchase of Automatic Weather Station with Software.	Rs. 5,75,702/-
2016-17	Dr. R.A. Marathe	Purchase of Irrigation and Fertigation System	Rs. 5,86,872/-
2016-17	Dr. D.K. Ghosh	Water purification system;- Model - LW31305T	Rs. 7,71,919/-
2016-17	Dr. R. K. Sonkar	Micro irrigation system with Fertigation unit	Rs. 15,90,980/-
2017-18	Dr. D.K. Ghosh	Autoclave	Rs.7,79,216/-

New laboratory facilities /furniture/furnishing created

Sr. No.	Name of indenter	Name of Lab	Amount
1.	Dr. D. K. Ghosh	Plant Virology Lab	Rs.4,90,490/-
2.	Dr. C.N. Rao	New Entomology Lab	Rs.6,47,557/-
3.	Dr. R.A. Marathe	New Soil Science Lab	Rs.4,66,693/-
4.	Dr. A. A. Murkute	New Crop improvement Lab	Rs.6,34,999/-

Acquisition of equipments recommended /suggested for excellence in research

S. N.	Name of Equipment	Purpose
1.	Microscope with Karyotyping software	Karyotyping studies and ploidy analysis.
2.	Atomic Absorption Spectrophotometer / ICP	Analysis of micronutrient in soil/plant samples for soil health advisory
3.	Genetic / DNA analyzer	Diversity analysis and population structure of Citrus fungal and bacterial pathogens
4.	Gel documentation system with all accessories	Observation and documentation of pathogen specific DNA bands
5.	LC-MS	Identification and quantification of newly identified compounds in citrus fruits.
6.	Lyophilizer	Lyophilization of samples for antioxidant analysis
7.	Pressure plate apparatus	Soil moisture studies
8.	Diesel Generator 25 KVA including AMF Panel, DG Set protection shed and Cable work	Stand by power during Electricity shut down



Annexure- IV

PUBLICATIONS (1.4.2013 to 31.3.2018)

Research Papers (In Peer Reviewed Journals)

International Journals

- 1. Agegnehu, G., Srivastava, A. K., and Michael, I. Bird. 2017. The role of biochar and biochar-compost in improving soil quality and crop performance: A review. *Appl. Soil Ecol.* **119**:156-170.
- 2. Anavrat, V. 2013. Decision making pattern and motivational factors of Nagpur mandarin growers. *Eco. Environ. Conserv.* **19** (2):113-116.
- 3. Anavrat, V. and Mokde, M. 2015. Perception of growers on contract farming in Nagpur mandarin. *Int. J. Trop. Agric.* **33** (2):1501-1505.
- 4. Chidambaranathan, P., Jagannadham, P.T.K., Satheesh, V., Kohli, D., Basavarajappa, S.H., Chellapilla, B., Kumar, J., Jain, P.K. and Srinivasan, R. 2017. Genome-wide analysis identifies chickpea (*Cicer arietinum*) heat stress transcription factors (Hsfs) responsive to heat stress at the pod development stage. *J. Pl. Res.*131(3)pp.525-542
- 5. Das, A. K., Bawage, S., Nerkar, S. and Kumar, A. 2013. Detection of *Phytophthora nicotianae* in water used for irrigating citrus trees by *Ypt*1 gene based nested PCR. *Indian Phytopathol.* **66**(2): 132-134.
- 6. Das, A. K., Kumar, A., Nerkar, S. and Bawage, S. 2013. First report of *Phytophthora lacustris* in India. *J. Pl. Pathol.* **95**(2): 447.
- 7. Das, A. K., Nerkar, S., Bawage, S., and Kumar, A. 2014. Current Distribution of Huanglongbing (citrus greening disease) in India as Diagnosed by Real-Time PCR. *J. Phytopathol.* **162**: 402-406.
- 8. Das, A. K., Nerkar, S., Kumar, A. and Bawage, S. 2016. Detection, identification and characterization of *Phytophthora* spp. infecting citrus in India. *J. Pl. Pathol.* **98**(1): 55-69.
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- 10. Das, A. K., Nerkar, S. and Kumar, A. 2017. First report of *Phyllosticta citricarpa* causing citrus black spot on *Citrus sinensis* and C. *reticulata* in India. *Plant Disease*, https://doi.org/10/1094/PDIS-08-17-1248-PDN.



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- 12. George, A., Rao C.N., Ghike, S. and Dhengre, V. 2017. Relative susceptibility of citrus leaf miner (*Phyllocnistis citrella* Stainton) to commonly used insecticides in Maharashtra, India. *Econ. Entomol.* **110**(2):525-529.
- Ghosh, D. K., Bhose, S., Manimekalai, R. and Gowda, S. 2013. Molecular detection of *Candidatus* Phytoplasma spp. causing Witches' broom disease of acid lime in India. *J.Pl. Biochem. Biotechnol.* 22(3): 343-347
- 14. Ghosh, D. K., Bhose, S., Mukherjee, K., and Baranwal, V. K. 2013. Sequence and evolutionary analysis of ribosomal DNA from Huanglongbing (HLB) isolates of western India. *Phytoparasitica*. **41**(3): 295-305
- 15. Ghosh, D.K, Hose, S., Mukherjee, K., Aglave, B., Warghane, A.J., Motghare, M., Baranwal, V.K. and Dhar, A K. 2014. Molecular characterization of Citrus yellow mosaic badnavirus (CMBV) isolates revealed the presence of two distinct strains infecting citrus in India. *Phytoparasitica* 42(5): 681-689
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- 21. Kumar, P. S., Singh, Y., Nangare, D. D., Bhagat, K., Kumar, M., Taware, P.B., Anjali Kumari and Minhas, P.S. 2015. Influence of growth stage specific water stress on the yield, physico-chemical quality and functional characteristics of tomato grown in shallow basaltic soils. *Sci. Hort.* **197**: 261-271.



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- Ladaniya, M. S. 2015. Influence of maturity stage on the storage life and quality of 'Nagpur' mandarin fruit stored at chilling temperature with intermittent warming. *Acta Hort*.1065 (3): 1533 - 1540.
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- 25. Malik, S.K., Chauhan, R. and Singh, I.P. 2015. Management of citrus genetic resources in India : Approaches, applications and achievement. *Acta Hort*.1011:39-46
- 26. Mann, R.S., Rouseff, R.L., Smoot J., Rao, C.N., Meyer, W. L., Lapointe, S.L., Robbins P., Cha, D., Linn C., Webster, F.X., Tiwari S., Stelinski, L.L. 2013. Chemical and behavioral analysis of the cuticular hydrocarbons from Asian Citrus Psyllid, *Diaphorina citri*. *Insect Sci.* **20** : 367-378.
- 27. Marathe, R.A, Sharma, J., Murkute, A.A. and Kumar, D.B. 2017. Response of nutrient supplementation through organics on growth, yield and quality of pomegranate. *Sci. Hort.* **214**: 114-121.
- 28. Murkute, A.A. and Singh, I.P. 2015. Citrus improvement through selection and mutagenesis: Constraints and opportunities. *Int. J. Trop. Agric.* **33**(3): 2361-2366.
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Annexure - V

Transfer of Technology (Trainings / Kisan Melas/ Consultancies/ Exhibitions)

Trainings

i) Training programmes for citrus growers from other parts of the country

On – **Campus**

- 1. Summer School on "Advances in Citriculture" organised by ICAR-CCRI, Nagpur and sponsored by ICAR, New Delhi for 16 officers from 7-27th May, 2013.
- 2. Training on "Orange Squash Making" organised by ICAR-CCRI, Nagpur for 25 citrus growers on 29th May, 2013.
- 3. Training on "Citrus Production technology" organised by ICAR-CCRI, Nagpur for10 Sathgudi orange growers from 9-11th July, 2013.
- Training on Citrus virology for a scientist of Oman under Indo-Oman bilateral cooperation programme in Agriculture organised by ICAR-CCRI, Nagpur from 18-24th November, 2013.
- 5. Training on "Citrus orchard Management" organised by ICAR-CCRI, Nagpur and sponsored by NHB, Gurgaon for 20 mandarin growers from 3rd -5th December, 2013.
- Training on "Elite nursery stock production in citrus" organized by ICAR-CCRI, Nagpur for 11 Scientist/Associate Professor of ICAR and SAUs from states of Punjab, Maharashtra, Meghalaya and Manipur from 23rd June - 7th July, 2014.
- Training on "Nursery management in citrus, STG techniques and indexing of pathogens" organised by ICAR-CCRI, Nagpur for 2 scientists from CIAH, Bikaner from 7-9th October, 2014.
- Training on "Integrated Orchard Management in Citrus" organised by ICAR-CCRI, Nagpur and sponsored by Director (Hort.) Govt. of Odisha for 20 officers from 19-21th November, 2014.
- Training on "Citrus Production and Post-harvest management" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha for 28 SMS and Technical Officers from 9-13th March, 2015.
- 10. Training on "Citrus Orchard Management" organized by ICAR-CCRI, Nagpur and sponsored by ADH (Hort.), Alirajpur (M.P.) for 5 officers from 18-20th March, 2015.
- 11. Training on "Production of Disease-free planting material of citrus" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha for 36 citrus nurserymen from private from State Govt. nurseries on 15th September, 2015.
- 12. Winter School training on "Precision Citriculture for Sustainable Production and



Post-harvest Management" organised by ICAR-CCRI, Nagpur and sponsored by ICAR for 26 officers from 15th October - 4th November, 2015.

- 13. Training on "Entrepreneur Meet" organised by ICAR-CCRI, Nagpur for comercialization of technologies for 18 Entrepreneurs on 30th December, 2015.
- Training on "Advances in Production System of Citrus" organized by ICAR-CCRI, Nagpur and sponsored by Deputy Director (Horticulture), Distt. Mandi, (Himachal Pradesh) for 20 farmers from 3rd -9th February, 2017.
- 15. Training on "Integrated production and Post-harvest technology of citrus" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha for 28 farmers from 7-10th February, 2017.
- 16. Training on "Citrus Production and Post-harvest Management" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha under ASCI Qualification Pack of 200 hrs. for citrus fruit grower for 13 farmers from 1st -30th March, 2017.
- Training on "Commercial Citrus Production" organized by ICAR-CCRI, Nagpur and sponsored by Dy. Director, Mehsana, Gujarat for 23 citrus growers from 7-10th March, 2017.
- 18. Training on "Nursery management, Shoot-tip-grafting, fruit fly management, citrus greening and *Phytophthora* root rot management and virus and virus like diseases" organized by ICAR-CCRI, Nagpur and sponsored by Government of Nepal for 12 members delegation from 6-8th June, 2017.
- 19. Training on "Citrus Production and Post-harvest Management" organised by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha under ASCI Qualification Pack of 200 hrs. for citrus fruit grower for 17 candidates from 1st -30th August, 2017,.
- 20. Training on "Citrus Production and Post-harvest Management" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha under ASCI Qualification Pack of 200 hrs. for citrus fruit grower for 7 candidates from 1st -30th November, 2017.
- 21. Training on "Citrus Production and Post-harvest Management" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha under ASCI Qualification Pack of 200 hrs. for citrus fruit grower for 19 candidates from 2-30 December, 2017.
- 22. Training on "PCR based indexing of Citrus tristeza virus, *Candidatus Liberibacter asiaticus* (Citrus greening), Citrus yellow mosaic badna virus and Indian citrus ring spot virus" organized by ICAR-CCRI, Nagpur for 2 Officers from 4-5th December, 2017.
- 23. Training on "Citrus Production and Post-harvest Management" organized by ICAR-CCRI, Nagpur in collaboration with TMC for Vidarbha under ASCI Qualification Pack of 200 hrs. for citrus fruit grower from 15th January to 13th February, 2018, 15 candidates were benefited.
- 24. Training on "Citrus Production and Post-harvest Management" organised by ICAR-CCRI, Nagpur in collaboration with TMC for Vidarbha under ASCI Qualification



Pack of 200 hrs. for citrus fruit grower from 3^{rd} - 31^{st} March, 2018, 14 candidates were benefited.

Off – Campus

- 1. Training on "Development of value added products and their marketing" organized by ICAR-CCRI, Nagpur in collaboration with KVK, Badnera under UNEP/GEF Project at Jarud, Amravati site for 175 citrus growers on 16th September, 2013.
- 2. Training on "Management of *Ambia* crop of Nagpur mandarin" under project 'Conservation and sustainable use of cultivated and wild tropical fruit diversity' organized by ICAR-CCRI, Nagpur at Jarud, Amravati (MS) for 260 citrus growers on 16th December, 2013.
- Training on "Product Development from Local Fruit Diversity and Their Marketing" under UNEP project organized by ICAR-CCRI, Nagpur in collaboration with KVK, Badnera, Amravati at KVK, Badnera, Amravati (MS) for 25 citrus growers on 22nd January, 2014.
- 4. Training on "Management of *Mrig* crop of Nagpur mandarin" under UNEP/GEF project at Warud, Dist. Amravati (MS). This programme jointly organized by ICAR-CCRI, Nagpur; MOGA and Samarth Mahila Sanstha, Warud, Amravati for 130 citrus growers on 5th May, 2014.
- Training on "Development of Satpuda Santra Burfi and Marketing" organized by ICAR-CCRI, Nagpur in collaboration with KVK, Badnera, Amravati (MS) Under UNEP/TFT Project for 30 citrus growers on 23rd May, 2014.
- 6. Farmers Meet on "Management of Citrus Crops under Stress Conditions" organized by ICAR-CCRI, Nagpur at KVK Durgapur, Amravati (MS) for 270 citrus growers on 28th July, 2014.
- 7. Workshop for the Enumerators of DHAN Foundation to undertake Ex-post survey and FGD by ICAR-CCRI, Nagpur under UNEP-GEF project at Jarud, Amravati site for 86 citrus growers on 8th December 2014.
- Training on "Production Technology of Citrus" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha under Sansad Adarsha Gram Yojana at Pachgaon village, Nagpur for 100 citrus growers on 7th October, 2015.
- National "Workshop on Mandarin" organized by ICAR-CCRI, Nagpur in collaboration with State Institute of Agriculture Management, Jaipur at Jhalawar (Rajasthan) for 69 citrus growers from 1st -3rd February, 2016.
- Training on "Citrus Production and Post-harvest Management" organized by ICAR-CCRI, Nagpur in collaboration with TMC, Vidarbha at Susundari, Tah. Kalmeshwar, Dist. Nagpur for 118 citrus growers on 10th July, 2017.
- 11. Training on "PCR-based detection of CTV and citrus greening disease" organized by ICAR-CCRI, Nagpur at College of Horticulture and Forestry, Jhalawar, Rajasthan



for 5 Staff during 6-11th November, 2017.

12. Training on "Citrus cultivation practices" w.r.t. crop regulation, fruit drop, management of *Waiwar*, greening, insect-pest and disease management organized by ICAR-CCRI, Nagpur at Village, Pathrot, Tah. Achalpur, Dist. Amravati for 60 citrus growers on 2nd November, 2017.

ii) Training programmes for citrus growers of NEH region

On-Campus

- Training for Khasi mandarin growers from East Garo Hills, Williamnagar (Meghalaya) organized by ICAR-CCRI, Nagpur for 19 citrus growers on 8th April, 2013.
- Training on "Production Technology for enhanced productivity and improved fruit quality in Citrus" organized by ICAR-CCRI, Nagpur and sponsored by Centre for Agriculture and Rural Development (CARD) for 21 officer and farmers of Ri-Bhoi District of Meghalaya from 9-10th April, 2013.
- 3. Training for mandarin growers from Sikkim organized by ICAR-CCRI, Nagpur for 17 citrus growers from 27-29th August, 2013.
- Training on "Citrus Orchard Management in North-East Region" organized by ICAR-CCRI, Nagpur and sponsored by Centre for Agriculture and Rural Development (CARD), New Delhi for 13 citrus growers from 1st -2nd December, 2014.
- Training on "Post-harvest Management and Value addition of citrus fruits" organized by ICAR-CCRI, Nagpur and sponsored by NABARD and SDTT for 20 Nagaland citrus growers from 27-29th November, 2015.
- Training programme on 'Citrus Orchard Management in North-East Region' organized by ICAR-CCRI, Nagpur and sponsored by Directorate of Horticulture, Govt. of Mizoram for 11 Khasi mandarin growers from 11-13th January, 2016.

Off – Campus

- 1. Training on "Citrus Production Technology" organized by ICAR-CCRI, Nagpur in collaboration with Directorate of Horticulture and Soil Conservation, Agartala at Jampui Hills, Tripura for 57 citrus growers from 16-17th May, 2013.
- Training on "Citrus Production Technology" organized by ICAR-CCRI, Nagpur in collaboration with Directorate of Horticulture and Soil Conservation, Agartala for 57 citrus growers at Aizawl from 20th -22nd May, 2013.
- Training on "Production Technology of Citrus for NEH region" organized by ICAR-CCRI, Nagpur in collaboration with College of Horticulture and Forestry and Directorate of Horticulture, Govt. of Arunachal Pradesh for 78 Citrus Growers from 6-7th June, 2013 at College of Horticulture and Forestry, Pasighat, Arunachal Pradesh.



- 4. Training on "Production Technology of Citrus for NEH region" organized by ICAR-CCRI, Nagpur in collaboration with College of Horticulture and Forestry and Directorate of Horticulture, Govt. of Arunachal Pradesh, Directorate of Horticulture Arunachal Pradesh and Regional Centre ICAR-Complex, Basar for 61 citrus growers at Regional Centre ICAR-Complex, Basar from 9-10th June, 2013.
- Training on "Citrus Production Technology" organized by ICAR-CCRI, Nagpur in collaboration with ICAR, Research Complex, Tadong for 120 citrus growers from East Sikkim district, Sikkim during 12-13th June, 2013.
- Training on "Citrus Production Technology" organized by ICAR-CCRI, Nagpur in collaboration with ICAR, Research Complex, Tadong for 120 citrus growers from North District, Sikkim from 14-15th June, 2013.
- 7. Training cum Awareness programme on "Protection of Plant Varieties and Farmers Right Act (2001) with Special Reference to Citrus" organized by ICAR-CCRI, Nagpur in collaboration with PPV and FRA; CIH, Medziphema; ICAR RC for NEH Region, Nagaland Centre and Department of Horticulture, Nagaland for 59 citrus growers at Mokokchung, Nagaland on 26th February, 2014.
- Training on 'Production Technology of Citrus for NEH Region' organized by ICAR-CCRI, Nagpur in collaboration with CIH, Medziphema; ICAR RC for NEH Region Nagaland Centre and Department of Horticulture, Nagaland for 130 citrus growers at Mokokchung, Nagaland from 27- 28th February, 2014.
- Training on 'Production Technology of Citrus for NEH Region' organized by ICAR-CCRI, Nagpur in collaboration with ICAR RC Manipur Centre, CAU, Imphal and Directorate of Horticulture Govt. of Manipur for 60 citrus growers at ICAR RC Manipur Centre, Imphal from 3rd -4th March, 2014.
- 10. Training on "Production Technology of Citrus for NEH Region" organized by ICAR-CCRI, Nagpur in collaboration with ICAR Research Complex for NEH Region, Mizoram centre, and District Horticulture office, Kolasib at ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib for 90 citrus growers from 17-18th October, 2014.
- 11. Training on "Production Technology of Citrus for Northeastern region" organized by ICAR-CCRI, Nagpur in collaboration with Citrus Research Station, AAU, Tinsukia at Citrus Research Station, Assam Agril. University, Tinsukia for 120 citrus growers from 21st -22nd November, 2014.

iii) Training programmes under TSP

On-Campus

 Training on "Production and nursery management in citrus" organized by ICAR-CCRI, Nagpur for 10 tribal farmers, field functionaries and horticulture officers from West Garo Hills, Tura (Meghalaya) from 10-13th January, 2017.



Off-campus

- Training on "Citrus Cultivation with Special Reference to Mandarins" of Directorate of Horticulture and Soil Conservation, Tripura organized by ICAR-CCRI, Nagpur for 100 citrus growers on 26th February, 2014.
- Training on "Citrus orchard management" organized by ICAR-CCRI, Nagpur in collaboration with KVK, Pratapgarh (Rajasthan) for 90 tribal farmers on 31st August, 2015.
- Training on "Production technology of Citrus" organized by ICAR-CCRI, Nagpur in collaboration with KVK, Nandurbar (MS) for 85 tribal farmers on 29th December, 2015.
- 4. Training on "Recent advances in production technology of Khasi mandarin" organized by ICAR-CCRI, Nagpur in collaboration with ICAR Research Complex for NEH region under TSP at ICAR RC for NEH region, Nagaland centre, Jharnapani, Medziphema for 50 officers of State Horticulture Department, Soil and Water Conservation Department, KVK, Universities and ICAR participated from 8-10th February, 2016.
- Training on "Citrus Production Technology" organized by ICAR-CCRI, Nagpur in collaboration with Department of Horticulture, Odisha and KVK, Gajapati under TSP for 70 tribal farmers at Paralakhemundi, Dist. Gajapati (Odisha) from 28-30th March, 2016.
- 6. Training on "Production Technology of Citrus" organized by ICAR-CCRI, Nagpur in collaboration with KVK, Banswara (Rajasthan) under TSP for 100 tribal farmers from five different notified tribal villages of Banswara on 15th July, 2016.
- 7. Training on "Production Technology of Citrus" organized by ICAR-CCRI, Nagpur in collaboration with KVK, Dhar (MP) under TSP for 80 tribal farmers from five different notified tribal villages of Dhar on 3rd November, 2016.
- Training on "Production Technology of Citrus" organized by ICAR CCRI, Nagpur in collaboration with TMC for Vidarbha and TMC for Chhindwara under TSP at Pandhurna, District Chhindwara (MP) for 100 tribal farmers on 30th December, 2016.
- Training on "Production Technology of Citrus" organized by ICAR CCRI, Nagpur under TSP in NEH region at RRCC, Assam for 80 citrus growers including 8 women citrus growers from 3 districts of Assam participated on 28th December, 2017.
- 10. Training on "Production Technology of Citrus" organized by ICAR CCRI, Nagpur in collaboration with KVK, Dhar (MP) for 100 tribal farmers organized at KVK, Dhar on 27th March, 2018.

iv) Rashtriya Kisan Melas Organized

• Rashtriya Kisan Mela on Citrus was organised during 30th -31st October, 2014 at ICAR-



CCRI, Nagpur, in which more than 1000 Citrus growers from five states viz. Maharashtra, Madhya Pradesh, Punjab, Andhra Pradesh and Rajasthan participated. A Citrus fruit show was organized in which more than 231 entries of fruit samples from different part of the country and as many as 1145 farmers and 98 students from 3 colleges of Nagpur visited the fair. There were in all 22 stalls from various ICAR institutes, SAUs and Private firms who showcased their technologies in the exhibition.

 ICAR-Central Citrus Research Institute, Technology Mission on Citrus for Vidarbha and ICAR-National Bureau of Soil Survey and Land Use Planning' Nagpur, jointly organised a Farmers Mela on 17th March, 2018 in which 1000 citrus growers participated. During the programme the Hon'ble Prime Minister's address to the farmers of the nation was directly web telecasted from New Delhi. In the Mela Central Citrus Research institute, Nagpur, felicitated 12 citrus growers for achieving higher yield by using ICAR-CCRI technology. This was followed by the technical session on Production of disease free planting material; Integrated Nutrient Management in citrus; Insect Pest Management; Disease management; STG technique on production of disease free planting material and Post-harvest Management.

v) Consultancy Offered

- Technology of RTS and Carbonated Drinks given to M/s. Paliwal Udyog Ltd. Kalmeshwar.
- Technology of Shoot-Tip-Grafting in production of disease free planting material of citrus given to M/s. H. U. Gugle Agrobiotech company, Ahmednagar through licensing.
- Consultancy on Storage of acid lime given to Mr. Suresh N. Mungalpara, Gujarat.
- Consultancy for analysis of Hesperidin and other compounds was given to Mr. Sanjiv Keshava, Orem Enterprises, Gurgaon, Haryana.
- Consultancy for establishment of mechanised packing line and cold store was given to ECS, Nagaland
- Technology of Hi-tech nursery management for production of disease-free planting material in citrus was given to Karunamaya Agrotech, Nagpur through licensing agreement.
- Technology of Shoot-tip-grafting and establishment of Citrus nursery for production of disease-free planting material was given to M/s. Seven Star Fruits Pvt. Ltd., Mumbai through licensing agreement.
- Technology of Microbudding propagation technique to shorten the Citrus nursery phase was given to M/s KJB Agro, Ootacamund, Tamil Nadu through licensing agreement.

vi) Participation in Exhibitions

1) 'Krishi-Vasant 2013' at Wardha, from 31st May - 2nd June, 2013.



- 2) 'Agro-Vision' at Reshimbag, Nagpur, from 26- 29th December, 2013.
- 3) 'Science Expo 2014' at Raman Science Centre, Nagpur, from 17-20^{th,} January, 2014.
- 4) Agro-exhibition at KVK Malegaon, Baramati, from 19-20th January, 2014.
- 5) 'Krishi-Vasant 2014' at CICR, Nagpur, from 9-13th February, 2014.
- 6) National Krishi Vigyan Mela, during 22-25th February, 2014, at premises of College of Agriculture, Indira Gandhi Krishi Viswavidyalaya.
- 7) '10th International Agriculture and Horti. Expo-2014' at Pragati Maidan, New Delhi, during 25-27th July, 2014.
- 8) '6th Agrovision' at Nagpur, during 4-7th December, 2014.
- 9) 'Agro-Tech 2014' at Dr. PDKV, Akola, during 27-29th December, 2014.
- 10) 'Agrovision 2014' at Reshimbag, Nagpur, on 6th December, 2014.
- 11) 'Science Expo 2014' at Raman Science Center, Nagpur, on 11th January, 2015.
- 12) 'Eastern Zone Farmers Fair' at CPRS, Patna, during 19th -21st February, 2015.
- 'Krishi Vigyan Mela 2015' at Office of Project Directorte ATMA, District Ratlam, Madhya Pradesh, during 1st -3rd March, 2015.
- 'Agri-Tech exhibition' in the Agricultural Science Congress at NDRI, Karnal, Haryana, during 3rd -6th March, 2015.
- 15) 'Agri Exhibition' at Savargaon, Tal. Narkhed, Distt. Nagpur, during 29-30th March, 2015.
- 16) Krushi Vikas Agriculture Expo-2015 organized by Krushi Vikas Pratishthan at Amravati, during 10-13th April, 2015. The scientists delivered lectures on Citrus Cultivation and Cold Chain Management.
- 17) State level Expo., Conference and Workshop Orange and Agriculture festival 2015 organised by Krushi Mitra during 1-4th October, 2015 at APMC Tah. Warud, Dist. Amravati, Maharashtra.
- 18) 7th AGRO-VISION exhibition at Reshimbag, Nagpur, during 11-14th December, 2015.
- 'Hort-Fair' exhibition at University of Horticultural Sciences, Bagalkot, Karnataka, during 19th -21st December, 2015.
- 20) "Agro Tech 2015" on the eve of 117th Birth Anniversary of Late Dr. Panjabrao Deshmukh at Dr. PDKV, Akola, from 27-29th December, 2015.
- 21) 5th Science Expo at Raman Science Centre and Planetorium, Nagpur, during 9-13th January, 2016.
- 22) 'Youth Empowerment Summit' at Nagpur, organized by Fortune Foundation during



30th January to 1st February, 2016.

- 23) 'Industries, Innovators, Entrepreneurs, Facilitators and Academia (IIEFA) Conference 2016' at VNIT, Nagpur, organised by All India Conference of IIEFA during 5-7th February, 2016.
- 24) Agribusiness Exhibition at National conference on UGC sponsored National Conference on Innovation in Agri-Biosciences at Dr. Ambedkar College, Nagpur, organized by Department of Botany, Biochemistry & Biotechnology during 26-27th February, 2016.
- 25) Krishi Unnati Mela at Indian Agricultural Research Institute, New Delhi, during 19th 21st March, 2016. A total of 8 farmers from Nagpur and Amravati District were sent by the Institute.
- 26) Krishi Vikas-2016 held at Science Ground, Amravati, during 10-13th April, 2016.
- 27) Farmers' fair at ICAR-Central Institute of Cotton Research, Nagpur, on 16th April, 2016 for creating awareness on the path breaking 'Pradhan Mantri Fasal Beema Yojna' and other agriculture schemes.
- 28) National Conference on "Fruit Breeding in Tropics and Sub-tropics (FBTST) : An Indian Perspective" during 27-29th April, 2016 at ICAR-IIHR, Bengaluru.
- 29) Agro Tech-2016 International Horti. and Agricultural Expo. at Pragati Maidan, New Delhi, during 22nd -24th July, 2016.
- 30) 8th Agri Tech India-2016 at Bangalore International Exhibition Center, Bangalore, during 26-28th August, 2016.
- 31) Agro-Vision-2016 at Reshimbagh Ground, Nagpur, during 11-14th November, 2016.
- 32) Maha Agro-2016 Exhibition at Ayodhyanagri ground, Aurangabad, (MS) from 24-27th December, 2016.
- 33) Agrotech 2016 : Krishi exhibition on the 118th anniversary of Dr. Punjabrao Deshmukh at Dr. PDKV, Akola, during 27-29th December, 2016.
- 34) 4th Agri-Horti show-2017 at Guwahati, Assam, during 6-9th January, 2017.
- 35) Science Expo at Raman Science Centre, Nagpur, from 18th -22nd January, 2017.
- 36) 'Kutuhal' exhibition organized by Vigyan Bharti at Dharampeth Science College, Nagpur, during 4-5th February, 2017.
- 37) Kisan Unnati Mela-2017 at ICAR-IARI, New Delhi, during 15-17th March, 2017.
- 38) International Symposium on 'Horticulture: Priorities and Emerging Trends' held at ICAR-IIHR, Bengaluru, during 4-7th September, 2017.
- 39) "State level Agri-Techniques Exhibition 2017" on the occasion of "Dhamma Chakra Pravartan Diwas" organised by Agriculture Department, Nagpur Division, Nagpur,



from 29th Sept., to 1st Oct., 2017.

- 40) "Agro-vision 2017" at Reshimbagh Ground, Nagpur, during 10-13th November, 2017.
- 41) "Krishi Vikas Parishad 2017" at Warud, during 7-10th December, 2017.
- 42) World Orange Festival 2017 at Suresh Bhatt Auditorium, Nagpur, during 16-18th December, 2017.
- 43) Agro Tech 2017 at PDKV, Akola, during 27-29th December, 2017.
- 44) "Science Expo 2018" at Raman Science Centre, Nagpur, during 17th -21st January, 2018.
- 45) North Zone Regional Farmers Fair, 23rd -25th February, 2018 at Trade Facilitation Centre, Varanasi, organized by ICAR-IIVR, Varanasi.
- 46) District Agriculture Festival/Exhibition organized by ATMA, Nagpur, 24-28th February, 2018 at Reshimbagh, Nagpur.
- 47) 5th Assam International Agri-Horti Show 2018 at Dibrugarh, Assam, 5-8th January, 2018 organized by Deptt. of Agri., Govt. of Assam, in association with Indian Chamber of Commerce and AAU, Assam.



Annexure - VI

Human Resource Development : Scientists, Technical and Other Staff

Trainings to the Institute's staff (01.4.2013 – 31.3.2018)

Name of the Personnel	Sponsoring agency/ Project	Title of the course	Place and duration
Scientists			
Dr Dinesh Kumar Pr Scientist (Hort.)	NAARM, Hyderabad	MDP workshop on 'Priority setting, Monitoring and Evaluation of Agricultural Research Project'	NAARM, Hyderabad, during 18 th -22 nd June, 2013.
Dr Vinod Anavrat Sr. Scientist (Ext.)	Ahmedabad Management Association	Train the Trainer workshop	Ahmedabad, during 6- 8 th August, 2013.
Dr. P. S. Shirgure Sr. Scientist (SWCE)	NAIP, New Delhi	Strengthening Statistical Computing in NAARS	CIFE, Mumbai, during 29-30 th August, 2013.
Anjitha George Scientist (Ento.)	ICAR, New Delhi	'Detection and Management of Insecticide Resistance including molecular aspects in insect pests'	NBAIR, Bengaluru, during 2 nd -11 th September, 2013
Dr. P. S. Shirgure Sr. Scientist (SWCE)	NNRMS (ISRO)	Winter School on Application of Remote sensing and GIS in Natural Resource management	NBSS&LUP, Nagpur, during 12 th November to 2 nd December, 2013.
Dr. A. D. Huchche Pr. Scientist (Hort.)	NAIP, New Delhi	'SAS for Developing Predictive Models in Agriculture, Animal and Aquaculture Research	CIFE, Mumbai, during 18 th -23 rd November, 2013.
All Scientific staff	ICAR, New Delhi	ManagementInformationSystemincludingManagementSystem	ICAR-CCRI, Nagpur, on 23 rd June 2014
Dr. M.S. Ladaniya Director	ICAR, New Delhi	ExecutiveDevelopmentProgrammeonLeadershipDevelopment	NAARM, Hyderabad, during 19 th -23 rd January, 2015
Dr. A.A. Murkute Sr. Scientist (Hort.)	ICAR – CCRI, Nagpur	Priority setting, Monitoring and Evaluation of Agri. Research Projects	NAARM, Hyderabad, during 2 nd -6 th June, 2015
Dr. D.K. Ghosh Pr. Scientist (Pl. Patho.)	ICGEB (Self-financed)	LAMP Technique for rapid detection of Phytoplasma	Nong Lam University, Vietnam, during 3 rd - 12 th August, 2015
Dr. C.N. Rao Pr. Scientist (Ento.) and Dr. A.A. Murkute Sr. Scientist (Hort.)	ICAR – CCRI, Nagpur	Analysis of Experimental Data	NAARM, Hyderabad, during 17 th -22 nd August, 2015



Name of the Personnel	Sponsoring agency/ Project	Title of the course	Place and duration
Dr. Kiran Bhagat Scientist (Pl. Physio.)	ICAR – CCRI, Nagpur	Winter School on 'Precision Citriculture for Sustainable Production and Post-harvest Management'	ICAR-CCRI, Nagpur, during 15 th October – 4 th November, 2015
Sh. Prasanth Tej Kumar Scientist (Agri. Biotech.)	ICAR – CCRI, Nagpur	Deputed for three months training under Dr. S. R. Bhatt, Pr. Scientist	NRCPB, New Delhi, w.e.f. 9 th November, 2015.
Dr. D.K. Ghosh Pr. Scientist (Pl. Patho.)	ICAR – CCRI, Nagpur	ManagementDevelopmentProgrammeonLeadershipDevelopment	NAARM, Hyderabad, during 30 th November to 11 th December, 2015
Dr. R. K. Sonkar Pr. Scientist (Hort.)	ICAR-DWR, Jabalpur	Advances in Weed management	ICAR-DWR, Jabalpur, during 12 th -21 st January, 2016
Dr. C. N. Rao Pr. Scientist (Ento.)	ICAR - CCRI	Competency Development for HRD Nodal officers	ICAR-NAARM, Hyderabad, during 10- 12 th February, 2016
Dr. A.A. Murkute Sr. Scientist (Hort.)	ICAR - CCRI	Awareness cum training programme on PPV and FRA and Interface with Nodal Officers of MGMG initiative	ICAR-ATARI CRIDA, Hyderabad, on 28 th March, 2016
All Scientist	NAIP, New Delhi	Indian Patenting Procedures: Commercialization of Patents PIS/RGNIIPM, Nagpur	ICAR-CCRI, Nagpur, on 11 th August, 2016
Dr. Kiran Bhagat Scientist (Pl.Physio.)	ICAR- NRCPB, New Delhi	Winter School on "Genomics and Phenomics for enhancement of Crop Nutrient use efficiency"	ICAR-NRCPB, New Delhi, during 1-21 st September, 2016
Dr. Dinesh Kumar Pr. Scientist (Hort.)	RGNIIPM, Nagpur	Indian Patenting Procedures, patent search, drafting and International filing	RGNIIPM, Nagpur, during 19 th -23 rd September, 2016
Dr. Dinesh Kumar Pr. Scientist (Hort.)	CSIR-CFTRI, Mysore	Spectrometric Techniques (GC- MS, LC-MS/MS, FT-IR and NMR) in food analysis	CSIR-CFTRI, Mysore, during 3 rd -7 th October, 2016
Sh. Kiran Kumar Kommu Scientist (Nematology)	ICAR-CCRI, Nagpur	One month orientation training at the various laboratories	ICAR-CCRI, Nagpur, during 19 th October, - 18 th November, 2016
Dr. Anjitha George Scientist (Ento.)	NAARM, Hyderabad	Training for Nodal Officers of the Public Authority related to RTI Online Portal of DoP&T i.e. RTI request /application & Appeal Management System (RTI-MIS)	NAARM, Hyderabad, on 25 th October, 2016
Dr. A. K. Das Pr. Scientist (Pl. Patho.)	NAARM, Hyderabad	'Bioinformatics Tools and Technique in Agriculture'	NAARM, Hyderabad, during 1 st -10 th November, 2016



Name of the Personnel	Sponsoring agency/ Project	Title of the course	Place and duration
Sh. Kiran Kumar Kommu Scientist, (Nematology)	ICAR- NRCPB, New Delhi	Professional training of entry level ARS	ICAR-NRCPB, New Delhi, w.e.f. 28 th November, 2016 for three months
Dr. R.A. Marathe Pr. Scientist (SSSP)	NAARM, Hyderabad	ManagementDevelopmentProgrammeonLeadershipDevelopment	ICAR-NAARM, Hyderabad, during 19- 30 th December, 2016
Dr. C. N. Rao Pr. Scientist (Ento.)	NAARM, Hyderabad	Competency Enhancement programme for Effective Implementation of Training Function by HRD Nodal officers of ICAR	ICAR-NAARM, Hyderabad, during 16-18 th February, 2017
Dr. C. N. Rao Pr. Scientist (Ento.)	NAARM, Hyderabad	Regional workshop on 'Skill Development in Agriculture'	MANAGE, Hyderabad, on 20 th February, 2017
Dr. N. Vijayakumari Pr. Scientist (Hort.)	ICAR – CCRI, Nagpur	Analysis of Ploidy level from the Shoot/root-tip of citrus samples	ICAR-IIHR, Bengaluru, during 24 th February to 3 rd March, 2018.
Technical			
Ms Lily Varghese, ACTO	NAARM, Hyderabad	'Competency Enhancement Programme for Technical Officers'	NAARM, Hyderabad, during 13 th -22 nd May, 2013
All technical staff	ICAR, New Delhi	Management Information System including Financial Management System	ICAR-CCRI, Nagpur on 23 rd June 2014
Sh. V. N. Dhengre, Sr. TO and Sh. A. B. Gadge, TA	ICAR, New Delhi	Organic Citrus Cultivation	SILC, Pune, during 9-13 th March, 2015
Sh. C.V. Bankar, ACTO	ICAR - CCRI	Capacity Building of Agriculture Library Professional in NARS	PJTSAU, Hyderabad, during 22 nd -31 st July, 2015
Sh. S.L. Shirkhedkar, Sr. T.O	ICAR - CCRI	Competence Enhancement Training programme for Technical Officers of ICAR	NAARM, Hyderabad, during 19-28 th August, 2015
Dr. Ashok Kumar, Sr. T. O.	ICAR - CCRI	Competence Enhancement Training Programme for Technical Officers	NAARM, Hyderabad, during 14 th –23 rd December, 2015
Sh. Santosh Khaire, Tech. Asstt	ICAR - CCRI	Hands on Advanced Instruments of Water Quality Testing	NIH, Roorkee, Uttarakhand, during 11-15 th January, 2016
Sh. Baljeet Singh, CTO (Farm), Sh. V. P. Baladhare, Sr. TA, Sh. B. G. Awari, Sr. TA (Farm),Sh. K. K. Ghaiwat, TA. (Farm) and Sh. P. R. Bagde, Tech, (Farm)	TMC, Vidarbha	Nursery, cultivation, rejuvenation and post-harvest handling of citrus fruits	TMC Vidarbha, Nagpur, during 14-17 th March, 2016



Name of the Personnel	Sponsoring agency/ Project	Title of the course	Place and duration
All Technical Officers	NAIP, New Delhi	Indian Patenting Procedures: Commercialization of Patents PIS/RGNIIPM, Nagpur	ICAR-CCRI, Nagpur, on 11 th August, 2016
Mrs. Jayshree S. Kolwadkar, Sr. T.O.	ICAR-IISS, Bhopal	Use and maintenance of Advanced Instruments in Soil and Plant analysis	ICAR-IISS, Bhopal, during 8-13 th August, 2016
Sh. M.P. Gorle, Sr. Tech. Asstt. and Sh. P. R. Bagde, Technician	ICAR-CIAE, Bhopal	Selection, Adjustment, Operation and Maintenance of Agricultural Implements for Field and Horticultural Crops	ICAR-CIAE, Bhopal, during 16-25 th August, 2016
Sh. C.V. Bankar, ACTO (Lib.)	NAU, Gujarat	Training-cum-Awareness workshop on J-Gate@CeRA for Western region	Navsari Agricultural University, Navsari, Gujarat, on 8 th October, 2016
Sh. Sunil Kumar U.T., ACTO	ICAR-CIAE, Bhopal	Winter School on Renewable Energy for Productive Uses in Rural Agro-Processing Sector	CIAE, Bhopal, during 9-29 November, 2016
Sh. C. V. Bankar ACTO (Lib.)	ICAR-CMFRI, Kochi	National workshop cum training on Digital Library Management	ICAR-Central Marine Fisheries Research Institute, Kochi, during 25-26 th November, 2016
Sh. R. D. Dhone Sr. Tech. Asstt.	ICAR-IARI, New Delhi	Fundamental Concepts and Methodologies for Agricultural Water Management'	ICAR-IARI, New Delhi during 19-24 th December, 2016
Sh. Manoj Sayam Tech. Asstt. (Driver)	ICAR-CIAE, Bhopal	Automobile maintenance, road safety and behavioural skills	ICAR-CIAE, Bhopal, during 20-24 th February, 2017
Sh. M. P. Gorle Sr. Tech. Asstt.	ICAR-CIAE, Bhopal	Automobile maintenance, Road Safety and Behavioral Skills	ICAR-CIAE, Bhopal, during 19 th -23 rd September, 2017
Shri C. V. Bankar ACTO (Library)	NAARM, Hyderabad	KOHA for Library staff of ICAR	NAARM, Hyderabad, during 5-9 th February, 2018
Mr. V. N. Dhengre Sr. Technical Officer and Mrs. Jayshree Kolwadkar, Technical Officer	ICAR-IASRI, New Delhi	Statistical techniques for Agricultural Data Analysis	ICAR-Indian Agricultural Statistics Research Institute, New Delhi, during 14 th -23 rd February, 2018



Name of the Personnel	Sponsoring agency/ Project	Title of the course	Place and duration
Administrative			
All administrative staff	ICAR, New Delhi	Management Information System including Financial Management System (FMS)	ICAR-CCRI, Nagpur on 23 rd June 2014
Sh. Yashwant Sorte AFAO and Sh. S. W. Ambekar, Asst	ICAR, New Delhi	Management Information System (MIS) including Financial Management System (FMS)	IASRI, New Delhi, during 22 nd -24 th December, 2014
Sh. Yashwant Sorte AF&AO	Min. of Fin., Deptt. of Exped., GoI	Management Development Programme on 'Public Procurement'	NIFM, Faridabad, during 31 st August – 5 th September, 2015
Mrs. Usha Dhanvijay, Sr. Clerk and Sh. Prakash Khobragade, Jr. Clerk	NAARM, Hyderabad	Implementation of NIC's e- Procurement solution through CPP Portal	NAARM, Hyderabad, during 27-28 th April, 2016
Sr. AO, AAO and AF&AO	NAIP, New Delhi	Indian Patenting Procedures: Commercialization of Patents PIS/RGNIIPM, Nagpur	ICAR-CCRI, Nagpur on 11 th August, 2016
Sh. Yashwant Sorte AF&AO	NIFM, Faridabad	Accrual Accounting in Govt./Autonomus Bodies	NIFM, Faridabad, during 26 th September to 1 st October, 2016
Sh. Yashwant Sorte AF&AO	Institute of Government Accounts & Fininace, New Delhi	Module of Public Finance Management System (PFMS)	VANAMATI, Nagpur 8-9 th March, 2017.
Sh. Yogesh Kadian, AO	ICAR-NIFM, Faridabad	Management Development Programme on 'Public Procurement'	NIFM, Faridabad, during 24-29 th April, 2017
Sh. Y.V. Sorte AF&AO	NAARM, Hyderabad	Refresher course for section officers, AAO's, AF&AO's and Assistants of ICAR	NAARM, Hyderabad, during 23 rd -29 th June, 2017
Shri Yogesh Kadian AO	ISTM, New Delhi	Organization specific programme on GFR-2017	ISTM, New Delhi, during 8-12 th August, 2017
Shri Yogesh Kadian AO	NAARM, Hyderabad	Administrative and Finance Management	NAARM, Hyderabad, during 1 st -7 th February, 2018



Name of the Personnel	Sponsoring agency/ Project	Title of the course	Place and duration
Skilled Supporting	ng Staff (SSS))	
Sh. D. N. Sambhare, Sh. D. S. Sardar, Sh. Dashrat Raut and Sh. N. K. Mohariya	Technology Mission on Citrus, Vidarbha	Nursery cultivation, rejuvenation and Post-harvest handling of citrus fruits	Technology Mission on Citrus, Vidarbha, Nagpur during 21 st -24 th June, 2016
Sh. Pramod Patil, Sh. Sunil Kharche, Sh. Namdeo Thakre and Sh. Anil Shaneshwar	Technology Mission on Citrus, Vidarbha	Nursery, cultivation, rejuvenation and Post-harvest handling of citrus fruits	TMC Vidarbha during 7-10 th February, 2017
Other Staff			
Dr. (Mrs.) Archana S. Khadse, Research Associate	ICAR-IIHR, Bengaluru	Intellectual Property Rights and Technology Management in Horticulture	ICAR-IIHR, Bengaluru during 29 Aug 3 rd September, 2016
Sh. Rupendra Kumar Jhade, SRF (NICRA Project)	M.P. Council of Science and Technology, Bhopal	'Advanced instrumentation methods'	$\begin{array}{c c} \text{M.P.} & \text{Council} & \text{of} \\ \text{Science} & \text{and} \\ \text{Technology,} & \text{Vigyan} \\ \text{Bhawan, Bhopal during} \\ 23^{\text{rd}} - 26^{\text{th}} \text{August, 2017.} \end{array}$



Annexure VII

List of abbreviations

AAO	=	Assistant Administrative Officer
AAU	=	Assam Agricultural University, Assam
ADG	=	Assistant Director General
ADO	=	Agriculture Development Officer
ADRP	=	Annual Direct Recruitment Plan
AF and AO	=	Assistant Finance and Accounts Officer
AGM	=	Assistant General Manager
AICRP	=	All India Coordinated Research Project
APEDA	=	Agricultural and Processed Food Products Export Development Authority
APMC	=	Agricultural Produce Market Committees
ASCI	=	Agriculture Skill Council of India
ATARI	=	Agriculture Technology Application Research Institute, Pune
ATMA	=	Agricultural Technology Management Agency
BNCA	=	Biswanath College of Agriculture, Biswanath
BUAT	=	Banda University of Agriculture and Technology, Banda
CAB	=	College of Agricultural Banking, Pune
CARD	=	Centre for Agriculture and Rural Development, New Delhi
CAU	=	Central Agricultural University, Imphal
CCRI	=	Central Citrus Research Institute, Nagpur
CEO	=	Chief Executive Officer
CEVd	=	Citrus Exocortis Viroid
CFTRI	=	Central Food Technological Research Institute, Mysore
CIAB	=	Center of Innovative and Applied Bioprocessing, Mohali
CIAE	=	Central Institute of Agricultural Engineering, Bhopal
CIAH	=	Central Institute for Arid Horticulture, Bikaner
CICR	=	Central Institute for Cotton Research, Nagpur
CIFE	=	Central Institute of Fisheries Education, Mumbai
CIH	=	Central Institute of Horticulture, Medziphema
CIPHET	=	Central Institute of Post-Harvest Engineering and Technology, Ludhiana
CISH	=	Central Institute for Subtropical Horticulture, Lucknow
CMBV	=	Citrus Mosaic Badna Virus
CMFRI	=	Central Marine Fisheries Research Institute, Kochi
CPP	=	Central Public Procurement Portal
CPRS	=	Central Potato Research Station, Shimla
CRIDA	=	Central Research Institute for Dryland Agriculture, Hyderabad
CRISPR	=	Clustered Regularly Interspersed Short Palindromic Repeats
CRP	=	Consortium Research Platform
CSIR	=	Council of Scientific and Industrial Research, New Delhi
CTV	=	Citrus Tristeza Virus
DAC and FW	=	Department of Agriculture Cooperation and Farmers Welfare. New Delhi
DBT	=	Department of Biotechnology, New Delhi
DHAN	=	Development of Humane Action
DNA	=	Deoxyribonucleic Acid
DOI	=	Digital Object Identifier
DRIS	=	Diagnosis and Recommendation Integrated System
DSS	=	Decision Support System
DUS	=	Distinctness. Uniformity and Stability
DWR	=	Directorate of Weed Research Jabalpur
ECS	_	Eleutheros Christian Society Nagaland
EFC	_	Expenditure Finance Committee
		Experience i munee commutee

EMBRAPA	=	Empresa Brasileira de Pesquisa Agropecuaria
ER	=	Evaporation Replenishment
ETL	=	Economic Threshold Level
FAO	=	Food and Agriculture Organization
FGD	=	Focus Group Discussion
FLD	=	Frontline demonstration
FMS	=	Financial Management System
FPO's	=	Farmers Producer Organizations
FSM	=	Fruit Sucking Moth
FSSAI	=	Food Safety and Standards Authority of India, New Delhi
FYM	=	Farm Yard Manure
GA	=	Gibberlic Acid
GAP	=	Good Agricultural Practices
GAU	=	Guiarat Agricultural University. Navsari
GBS	=	Genotyping-by-Sequencing
GCEAD	=	Gas Coupled Chromatography - Electroantennographic Detection
GFR	=	General Financial Rules
GI	_	Geographical Indication
GIS	=	Geographical Information System
GOI	_	Government of India
GPS	_	Global Positioning System
GRAS	_	Generally Recognized As Safe
GWAS	_	Genome-Wide Association Study
HDP	_	High Density Planting
HIR	_	Huanglonghing
HORTSAP	_	Horticultural Crop Pest Surveillance Advisory and Management Project
HDIC	_	High Performance Liquid Chromatography
HPD	_	Human Resource Development
HKD Uefe	_	Host Strass Transcription Easters
	_	Indian Agricultural Passarah Instituta, Naw Dalhi
	_	Indian Agricultural Statistics Passarah Institute, New Delhi
	_	Indian Council of Agricultural Passarah, New Delhi
ICAN	_	International Contra for Constita Engineering and Piotechnology, New Delhi
ICUED	_	Industively Coupled Plasma
ICPSV	_	Inductively Coupled Flasma
ICKSV	_	Indian Chius Kingspot Virus
	_	Indegrateu Disease Management
	_	Industrias, Innevistore, Entrepreneure, Escilitatore and Academia
	=	Industries, Innovators, Entrepreneurs, Facilitators and Academia
	=	Indian Institute of Forices Descende, Colingt
IISK	=	Indian Institute of Spices Research, Cancul
1155 UT	=	Indian Institute of Son Science, Diopar
	=	Indian Institutes of Vegestable Decession Vegestable
	=	Indian Institute of Vegetable Research, Varanasi
IMC	=	Institute Management Committee
	=	Integrated Nutrient Management
IPGKI	=	International Plant Genetic Resources Institute, Nairool, Kenya
IPM	=	Integrated Pest Management
IFINI IDD	=	International Plant Nutrition Institute, Gurgaon
	=	Interfectual Property Kignis
IKU	=	Institute Research Committee
	=	Insecucide Resistance Management
IKS	=	Indian Kemote Sensing
120	=	International Standards Organization
ISKU	=	Indian Space Research Organisation, Bengaluru
151M	=	Institute of Secretariat Training and Management, New Delhi





ITMC	=	Institute Technology Management Committee
ITMU	=	Institute Technology Management Unit
ITS-RFLP	=	Internal Transcribed Space – Restriction Fragment Length Polymorphism
JNKVV	=	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
KAB	=	Krishi Anusandhan Bhavan
KJB	=	Mr. Kenneth Jason Blades
KMS	=	Potassium meta-bisulphite
KVKs	=	Krishi Vigyan Kendra
LAMP	=	Loop-mediated Isothermal Amplification
LC-MS	=	Liquid Chromatography Mass Spectrometry
LDPE	=	Low Density Polyethylene
LSP	=	Light Saturation Points
MANAGE	=	National Institute of Agricultural Extension Management, Hyderabad
MAS	=	Marker Assisted Selection
MAU	=	Marathwada Agricultural University, Parbhani
MDST	=	Multi-Disciplinary Site Team
MGMG	=	Mera Gaon Mera Gauray
MIS	=	Management Information System
MLST	=	Multilocus Sequence Typing
MOGA	=	Maharashtra Orange Growers' Association
MOU	_	Memorandum of Understanding
mPCR	_	multiplex Polymerase Chain Reaction
MPKV	_	Mahatma Phule Krishi Vidyapeeth Rahuri
MSAMB	_	Maharashtra State Agriculture Marketing Board Pune
NAARM	_	National Academy of Agricultural Research Management Hyderabad
NAAS	_	National Academy of Agricultural Sciences New Delbi
NABARD	_	National Reducting of Agriculture and Rural Development. Mumbai
NAID	_	National Agricultural Innovation Project
NAPAKAS	_	Nagar Raibhacha Karyanyayan Samiti
NARA	_	National Agricultural Research Project
NARS	_	National Agricultural Research System
NAU	_	National Agricultural University, Newseri
NRAID	_	National Bureau of Agricultural Insect Resources, Bangaluru
NDAIN	_	National Bureau of Plant Constic Posources, New Delbi
NBSS and LUD	_	National Bureau of Soil Survey and L and Utilization Planning, Nagnur
NCIDM	_	National Contro for Integrated Past Management, New Dolhi
NDDI	_	National Deiry Bassarah Institute, Karnal
	_	National Horticulture Roard, New Dalhi
	_	National Initiative on Climate Desiliont Agriculture, New Delhi
NICKA	_	National Institute of Einensiel Menagement, Feridehad, Harvene
	_	National Institute of Financial Management, Fanuadau, Haryana
	=	National Natural Decourses Management System
ININKINIS NDCC	=	National Natural Resources Management System
NPSC	=	National Project Steering Committee
NRCC	=	National Research Centre for Chrus, Nagpur
NKCPB	=	National Institute for Plant Biotecnnology, New Deini
PAK	=	Photosynthetically Active Radiation
PAU	=	Punjab Agricultural University, Ludniana
PCK	=	Polymerase Unain Reaction
PDKV	=	Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
PET	=	Polyetnylene Terephthalate
PFMS	=	Public Finance Management System
PHT	=	Post Harvest Technology
PIS	=	Patent Information System
PJTSAU	=	Professor Jayashankar Telangana State Agricultural University, Hyderabad
РРА	=	Power Purchase Agreement

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PPV and FRA	=	Protection of Plant Varieties and Farmers Rights Authority, New Delhi
qPCR	=	quantitative Polymerase Chain Reaction
QRT	=	Quinquennial Review Team
QTL	=	Quantitative Trait Loci
RAC	=	Research Advisory Committee
RARS	=	Regional Agricultural Research Station, Lakhimpur, Assam
RBI	=	Reserve Bank of India
RDF	=	Recommended Doses of Fertilizer
RGNIIPM	=	Rajiv Gandhi National Institute of Intellectual Property Management, Nagpur
RH	=	Relative Humidity
RMP	=	Research Management position
RNA	=	Ribonucleic Acid
RRCC	=	Regional Research Centre for Citrus, Biswanath Chariali, Assam
RTI	=	Right to Information Act
RTMNU	=	Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
RTS	=	Ready To Serve
SAARC	=	South Asian Association for Regional Cooperation
SAUs	=	State Agricultural Universities
SCAR	=	Sequence Characterized Amplified Region
SFE	=	Supercritical Fluid Extraction
SILC	=	Sakal International Learning Centre, Pune
SMD	=	Subject Matter Division
SOPs	=	Standard Operating Procedures
SRF	=	Senior Research Fellow
SSNM	=	Site-Specific Nutrient Management
SSR	=	Simple Sequence Repeats
SSS	=	Skilled Supporting Staff
STG	=	Shoot Tip Grafting
SWCE	=	Soil and Water Conservation Engineering
TMC	=	Technology Mission on Citrus
TNAU	=	Tamil Nadu Agricultural University, Coimbatore
TOT	=	Transfer of Technology
TSP	=	Tribal Sub-Plan
TSS	=	Total Soluble Solids
UAE	=	United Arab Emirates
UNDP	=	United Nations Development Programme
UNEP and GEF	=	United Nations Environment Programme and Global Environmental Facility
UV-VIS	=	Ultraviolet–Visible Spectroscopy
VANAMATI	=	Vasantrao Naik State Agricultural Extension Management Training Institute, Nagpur
VDB	=	Vidarbha Development Board, Nagpur
VIGS	=	Virus Induced Gene Silencing
VNIT	=	Visvesvaraya National Institute of Technology, Nagpur
VRF	=	Variable Rate Fertilization



12. Photo Gallery





QRT team visiting at Institute Nursery



QRT meeting in Progress



Joint committee meeting of IMC with QRT members



QRT team visiting at HDP orchard of Nagpur mandarin at Nimji village, Nagpur



Team visiting at Mr. Junghare's Farm, Hatla Village, Nagpur





QRT team visiting at Private Packing Unit at Tah. Warud, Dist. Amravati (MS)



QRT team visiting Experimental Farm of RRCC, Assam



Meeting and interaction with staff at RRCC, Assam





Meeting with Staff of B. N. college of Agriculture, AAU, Biswanath, Assam



Team visiting Khasi mandarin orchards at Ri-bhoi and Govt. Nursery at Dwalie, Ri-bhoi, Meghalaya



Team visiting Govt. Nursery at Dwalie, Ri-bhoi, Meghalaya



Interactive meeting with Scientific staff of ICAR RC for NEH region, Barapani and officials of State Deptt. of Horti. Meghalaya.




Interactive meeting with District Supt. Agri. Officer, staff and citrus growers at Amravati



Maharashtra State Govt. Officials, interacting with QRT of ICAR-CCRI, Nagpur



A citrus grower interacting with QRT of ICAR-CCRI, Nagpur



QRT of ICAR-CCRI alongwith citrus growers of Achalpur, Amravati



View of interactive meeting of QRT with citrus growers of Achalpur, Amravati



View of final report writing at ICAR-CCRI, Nagpur

'Nagpur' mandarin







ICAR - CENTRAL CITRUS RESEARCH INSTITUTE (INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

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