वार्षिक प्रतिवेदन
ANNUAL REPORT
2015-16

भाकृअनुप–राष्ट्रीय लीची अनुसंधान केन्द्र

ICAR-National Research Centre on Litchi

मुशहरी प्रक्षेत्र, मुशहरी, मुजफ्फरपुर–842 002 (बिहार), भारत

Mushahari Farm, Mushahari, Muzaffarpur–842 002 (Bihar), India

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ICAR- NATIONAL RESEARCH CENTER ON LITCHI
(Indian Counsil of Agricultural Research)
Mushahari, Muzaffarpur - 842 002 , Bihar,
India

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Basic and Applied Research on Productivity, Quality and Utility of Litchi

Certificate Registration No. **QM 04 00368**
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ICAR-National Research Centre on Litchi

Mushahari, Muzaffarpur – 842 002, Bihar, India

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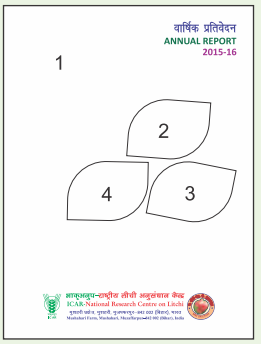

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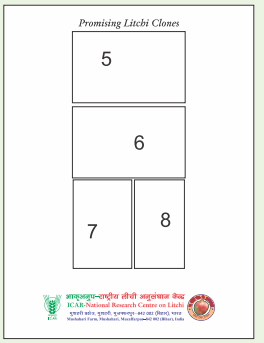

Back Cover Picture

Cover Photography by : Dr. Alok Kumar Gupta and Shyam Pandit

Cover Photograph details : 1.Young Litchi plants in full bloom 2. Honey bee pollinating litchi flowers 3. Close view of bifid stigma of litchi flower 4. Mature Litchi bunch on tree 5. Promising litchi cultivar Bedana 6. VNSDASU 7. Kasba 8. Yogda selection.

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Preface

The ICAR-National Research Centre on Litchi (ICAR-NRCL) has been striving to achieve milestones in litchi research and development since its inception in 2001. The centre is tasked with harnessing science and technology by interfacing research and extension activities for enhanced quality production, productivity, processing, and use diversification for sustained litchi production, industry and trade.

The centre is putting its best efforts in solving the problems, extending technical support, and assisting at policy and planning level. Consequently, tremendous change in the trend of litchi production and pricing has been taken place in recent years. Currently, India produces about 5, 85,300 MT from an area of about 84,200 ha.

ICAR-NRCL is focusing its activities in four research theme areas viz. genetic resource management and crop improvement, sustainable crop production, crop protection and post-harvest handling and value addition apart from outreach activities in tribal, non traditional and north eastern areas. In addition to planned research activities, the centre has also taken up externally funded projects from PPV&FRA, DBT, and ICAR network projects and has delivered quality results with highest degree of satisfaction.

The centre has been able to locate and exploit seasonality barrier in non-traditional areas where tremendous potential to produce winter season litchi to exits. The centre is in process of mapping such local ones with modern tool and striving to widen the gene pool through introductions of litchi germplasm, and related sapindaceous fruits viz. longan and rambutan. Besides, efforts are on to develop ideal cultivars through hybridization programme involving different parents. The centre is continually working towards refinement of sustainable production technologies through our studies on canopy architecture management, high-density planting, nutrient status, mycorrhizal association, shoot physiology in relation to flowering, and hormonal regulation of plant growth and yield. Our scientists are also working to protect plants and produce from different insect pests and diseases and reducing post harvest losses.

ICAR-NRCL has actively participated in programme of *Rajbhasha* and received first prize in implementation of official language. The Book Litchi (in Hindi) has been awarded with "इंदिरा गाँधी मौलिक पुस्तक लेखन पुरस्कार" by Hon'ble President of India during "Hindi Diwas Celebration" at New Delhi. ICAR-sports, *Kisan Melas/Kisan Gosthis,* exhibition and training to farmer all over the country have been regular feature at the centre. During the period, the centre has organised various litchi related programme and trainings in the litchi growing areas and extended its technical expertise to various stakeholders. This all has become possible with the whole-hearted support and co-operation by all the staff of the centre.

I would like to place on the record the guidance, support and encouragement received from Secretary, DARE and DG, ICAR, DDG (Horticultural Science), ICAR, Chairman, RAC and members of IMC from time to time.

Finally, it is my pleasure and privilege to present you the Annual Report of ICAR-NRC on Litchi, Muzaffarpur for the year 2015-16. It highlights our efforts and achievements, and provides a framework to march ahead to greater heights. I shall look forward to any suggestions or comment on the information contained in this report, which would greatly help us in formulating future strategies.

Muzaffarpur
25th June, 2016

Vishal Nath
Director

Contents

Executive Summary

ICAR-National Research Centre on Litchi (NRCL), established in the year 2001 has continued its momentum in conducting basic and applied research under multi-disciplinary programme covering different aspects of litchi *viz.,* genetic resource management and crop improvement, crop production, crop protection and postharvest management. Besides, the centre also conducts training, outreach programmes, and transfer of technology to improve knowledge and develop skills of different stakeholders. The salient achievements of the centre during 2015-16 are presented in brief.

Research Accomplishments

Genetic Resource Management and Crop Improvement

- Five accessions each from Uttarakhand and Assam states were collected to enrich the litchi germplasm.
- Out of 52 germplasm lines maintained, eight accessions showed flowering and characterized on the basis of floral characteristics. Accession IC-0615586 exhibited the earliest panicle initiation (3rd February) and IC-0615598 expressed delayed panicle initiation (26th February).
- Twenty five genotypes of litchi were evaluated for physico-chemical parameters of fruit. Bombai-II recorded heaviest fruit weight (20.69 g) and and highest TSS content was noted in Shahi (20.78°B).
- Explant responded to *in vitro* growing media containing 3.75 mg/*l* BAP + 1 g/*l* Activated Charcoal + 5 mg/*l* GA_3.
- IC numbers for nineteen litchi clones have been obtained from ICAR-NBPGR, New Delhi.
- Fifty two hybrids of litchi including Shahi, China, and Bedana as parentage were planted and maintained in the field. Shahi×Bedana cross combination recorded highest fruit retention (1.90%) followed by Shahi×China (0.87%), Rose Scented×Shahi (0.76%) and China×Shahi (0.65%), three weeks after crossing.

Crop Production

- The highest fruit yield in cv. Shahi (42.93 kg/plant) was obtained with 100:50:100g NPK/plant/year applied in two split during June and April months in 10 years old plant.
- Very poor flowering and fruit setting was observed during 2015 under organic management practices but, very good panicle emergence and flowering has been noticed during 2016 in the plants applied with 20 kg FYM + 2 kg Vermi-compost + 1 kg Neem cake + bio- fertilizers, (9 years after planting).
- China recorded least mortality (6.99%) followed by Trikolia (9.23%) and Mandraji (15.38%) after one year planting under organic package of practices. Faba bean grown as intercrops produced an average yield of 16.67 q/ha.
- Soil analysis before sowing of faba bean during *Rabi* season in organic block slightly declined soil pH and EC (8.49-8.22 & 0.22-0.13 dsm^{-1}, respectively) and increased organic carbon (0.16-0.23%) from upper to lower side of orchard. Available nitrogen content ranged from 94.36 kg/ha in upper side to 120.47 kg/ha in middle site.
- The maximum trunk girth and plant spread were observed in 6×4m spacing of Shahi litchi. Plant height was maximum in 2×2m and 4×4m densities. The highest fruit yield (8.75 kg/plant) was recorded in 6×6m spacing.
- Nitrogen deficient plants showed stunted growth with shorter inter-nodal length and reduced leaf size and yellowish colour. Zn-deficient plants expressed inter-veinal chlorosis in leaves and Cu-deficient plants showed narrowing of younger

leaves. Foliage becomes dark green and erect in P deficient plants and Fe deficient plants showed chlorosis on new leaves without spot.

- Application of 2% KNO_3 recorded increased shoot length while spray of 4.0 g PBZ reduced shoot lengths, brought resetting and showed maximum retention of chlorophyll content.
- Spray of 3.0 g PBZ reduced Chlorophyll a and total Chl contents (May and August). 1 % KNO_3 increased concentration of total chl contents. August month has maximum chl contents (a,b and total) than May *Chl a, b* and *total Chl* increased from FBD to flowering phase, with maximum values in control trees and least in trees receiving 2 % KNO_3.
- Photosynthetic rate (*Pn*) was recorded maximum in trees receiving 2.0 g PBZ and 2 % KNO_3. 4.0 g PBZ maintained maximum leaf temperature and leaf N content.
- Girdling of branches during September of China litchi recorded no new flush whereas un-girdled branches showed continue flush till December. All the girdled branches exhibited flowering panicles contrary to no flowering in un-girdled branches.
- The Maximum (95%) shoot flowered with 3 and 4 mm (75 % PB) girdling while ungirdled branches produced no panicle or few mixed inflorescence.
- In cv. China, floral shoot had higher *chlorophyll a* during May (over August) which further increased during November while Shahi showed continuous reduction from May onwards. The non floral shoots showed increasing trend of *Chl b*, *Total Chl* from May to November.
- In 'Shahi' litchi, floral shoots has reduced *Chl b* and *total Chl* status during November. 'Shahi' plants had more concentration of *Chl a* and *Chl b* in the leaves over cultivar'China'.
- China had lesser content of total carbohydrate (total CHO) and reducing sugar (RS) content than Shahi. The total CHO and RS content increased from FBD stage to flowering stage where as the proline and phenol content was reduced during same period.
- *Azotobacter chrococcum* + *Trichoderma viride* @100 g/ plant each produced highest root density on fresh weight basis (2503.8 g m^{-3}). Significant effect on fine root density was observed under various microbial treatments (up to 1288 g m^{-3}) compared to control (303 g m^{-3}). Ratio of thin: thick roots on fresh weight basis was highest (2.59) with arbuscular mycorrhizal fungi (AMF)@200 g/ plant+*Bacillus megatarium* @100 g/plant.
- The population dynamics of microbial inoculants revealed a higher population in co-inoculation than in individual microbial inoculants (10.92-11.87% and 2.97-7.35% after 1 month and 2 month, respectively) in case of *Azotobacter* and *Trichoderma* with AMF. Colonization of roots by AMF was between 79-93%.
- On pond bund of litchi based cropping system banana cv. Grand Naine yielded 41.0 t/ha with average bunch weight of 19.12 kg/plant. Similarly, papaya cv. Pune Selection-3 recorded fruit yield of 8-10 kg/plant with average yield of 18.2t/ha.
- Cowpea variety Kash Nidhi performed better with average yield of 14.53t/ha than Kashi Kanchan (9.65 t/ha). Maize produces average cob yield of 38.8 t/ha on pond bunds during kharif 2015.
- During *Rabi* season, the highest yield was recorded in cabbage (26.36 t/ha). followed by faba bean 2.37 t/ha, maize 16.2 t/ha and mustard 25 t/ha under different models on pond bunds.
- The highest average net return with banana + cabbage in model I (Rs 11.49/m^2) followed by banana+ maize (Rs 6.55/m^2) in model III and papaya+faba bean (Rs 5.84/m^2) in model II.
- China recorded least plant mortality (0-18.75%) after at one year of planting on raised and mound bed system of planting under low-lying conditions.
- Identification of potential litchi area of (Amravati and Bidar) Edaphic factor (Temperature) based

study showed that minimum temperature of both areas is higher than Muzaffarpur during November to January and hence these areas may not be very suitable for litchi cultivation because low temperature during this period is crucial for flowering of litchi.

Crop Protection

- *Alternaria alternata* caused disease at multiple phenophases of litchi viz., leaf blight in nursery and field, panicle/inflorescence and fruit blight in orchard, and fruit rot/decay at post-harvest stage.
- Morphological and molecular characterization of the four isolates (3 leaf blight and one fruit rot causing isolate) was done.
- The disease incidence of leaf blights in nursery plants ranged between 22.29 to 49.52% while PDI among infected plants ranged between 34.4-77.8%.
- Disease incidence of panicle blight in farmers' field ranged from 2.5-37.5% in cv. 'Shahi' and 24.0-88.9% in cv. 'China' while, fruit blight incidence varied from 40.0-78.9% in China at farmers' fields. Similarly, panicle blight in Shahi recorded 43.1-77.1% and fruit blight in cv. 'China' 14.3-66.7% at NRCL experimental farm.
- Two new minor leaf spot causing fungal pathogens viz., *Corynespora litchii* and *Pestalotiopsis versicolor* have been observed on litchi.
- Algal leaf spot of longan *caused by Cephaleuros virescens* Kunze has been identified. Disease incidence ranged from 20.0-37.5% in twig and 28.4-57.4% on leaflet. The disease was found prevalent during July to September during high humidity, warm and rainy weather.
- Out of twelve different fungicides, two antagonists and one defense activator evaluated against leaf blight disease in nursery plants, panicle and fruit blight on field condition caused by *Alternaria alternata,* difenoconazole (2ml/l), azoxystrobin (1ml/l) and thiophanate methyl (2g/l) found most effective to manage the diseases.
- Moisture and temperature *versus* viable *cfu* count in talc based formulation of NRCL Trichoderma has been standardized. The isolate NRCL T01 was found superior than commercially available product under *in-vitro* as well as in pot experiment in controlling *Fusarium solani* and *Alternaria alternata.*
- *Conopomorpha sinensis* Bradley has been confirmed as major fruit & shoot borer species of litchi using DNA barcode Sequences. It was confirmed that litchi is not a host plant for *Conopomorpha cramerella.*
- Among natural enemies' two coccinellids (Seven spotted beetle, *Coccinella septempunctata* and six-spotted zigzag ladybird, *Cheilomenes sexmaculata*) and one predatory bug *(Eocanthecona furcellata)* were identified as promising bio-agents in litchi ecosystem.
- Incidence of all major pests were observed almost throughout the year except (30th, 31st and 32nd std. week (litchi looper), 30th std. week (red weevil) and 30th std. week (leaf folder) with maximum and minimum population in the month of September-October and December-January, respectively.
- Diversity of insect pests associated with longan crop revealed that the insect pests' incidence was less as compared to litchi.
- Two spray of Thiamethoxam (12.6%) + lambdacyhalothrin (9.4%), (0.098%) during September and October found effective against ash weevil and red weevil.
- Integrated management of litchi mite can be done by pruning of affected twigs in July followed by two spraying of chlorfenapyr (10 EC) (0.03%) at 10 days interval and again pruning in October with one spraying of Chlorfenapyr (10 EC) (0.03%).

Postharvest Management and Value Addition

- Pre-harvest (one month after full bloom) spray of GA_3 + carbendazim gave maximum healthy fruits (89%) followed by GA_3 + *B. subtilis*@1 × 10^8cfu (82%).

- Chitosan (1%) + *B. subtilis*@1 × 10^8 cfu or carbendazim (0.2%) or salicylic acid (1%), has been found effective in maintaining the quality of fruits and enhanced shelf life up to 5th days at ambient condition and 18 days at refrigerated condition.
- The fruit weight in cv. Shahi increased from 0.85 g about 25 days after fruit set (corresponding to 13 April) to 21.29 g at harvest (26 May). Aril development commences about one month after fruit set (19 April).
- Soluble solids concentrate (SSC) increased from 11.2 °B to 19.5 °B while titratable acidity and total phenolics declined from 6.06 to 0.36% and 469.12 to 42.35 mg GAE/100g, respectively. The anthocyanins content of pericarp increased from 9.58 to 34.37 mg/100 g (FW) during fruit development and maturity.
- Litchi fruits hydro-cooled at 5 and 10°C recorded least PLW (5.10% and 7.14%) as compared to control (19%) and highest marketable fruits (54.74%, <50% browned fruit) after 16 days of storage. Hydro-cooling at 10 °C for 20 minutes was found to be a suitable temperature-time combination for effective hydro-cooling of litchi fruit.
- Postharvest dip treatment with salicylic acid (1.2 mM) stored under refrigerated conditions (6±1°C and 80-90% RH) maintains membrane stability and reduces pericarp browning and fruit decay in litchi cv. Shahi.
- Four strains of *Bacillus subtilis* and two isolates of antagonistic yeast were recovered from healthy fruit-plane of litchi. The identification of isolates has been done.
- Isolate NRCL BS-1 was found the best to check the fruit rot and enhancement of shelf life of litchi fruit.
- Out of 16 postharvest dip treatments, *Bacillus subtilis*, *Bacillus subtilis* + salicylic acid and *Bacillus subtilis* + carbendazim were highly effective in controlling litchi fruit rots as it showed 0% fruit rotting after 4th day, 5-10% rotting on 6th day and 25-40% rotting on 8th day after treatment as compared to 40.0% and 93.3% and 100.0% rotting after 4th, 6th and 8th day after treatment, respectively in the control.
- Preventive ability of antagonists against fruit rots of litchi showed that the isolate of *B. subtilis* BS-1 and *Trichoderma viride* isolate NRCL T-01 had completely controlled the pathogen (*Alternaria alternata*). In case of *Colletotrichum gloeosporioides,* isolate BS-4 and BS-5 significantly reduced fruit rot as well as PDI. In case of *Aspergillus flavus* isolate BS-1, most effective against *Aspergillus niger* which was at par with carbendazim (0.1 %).
- An integrated package consist of preharvest spray of boron @0.4 g/l (30-40 days after fruit set), GA_3 (100 ppm) + carbendazim (0.1 g/l) at 40-45 days after fruit set) and foliar spray of potassium sulphate (1%) 10 days before commercial harvest has been developed.
- Post harvest package consisting of bringing harvested fruits to the pack-house within 2 h, sorting, grading, precooling at low temperaturen (25 ^{0}C) followed by dip treatment with *B. subtilis* (1x10^8 cfu/ml) for 5 min or with chitosan (1%) for 10 min. followed by air drying and packing in perforated polythene bag (40 µm) and keeping in CFB Box (5, 7, or 9 ply) has been standardized for transport to distant market.
- Rapid and continuous loss in weight was recorded and 17.83 per cent loss in weight (PLW) was noticed within 48 hours in stored litchi fruit. The initial weight loss occurred from the pericarp and not from the whole fruit.
- The highest overall acceptability (9.22) of dehydrated litchi pulp with minimum hardiness (2853 g) and drying time (15.00 hrs) were recorded with pulp: stone ratio of 1:4 by osmotic dehydration at 60 °C.
- Influence of polyamines (putrescine, 0.5mM and spermine, 0.5 mM) on flowering and fruit set attributes of litchi cvs. Shahi and China studied and showed the promising response.

Improving knowledge and skill of stakeholders

- More than 3, 000 stakeholders and about 300 students were benefitted through various training and extension activities during the year.
- Under TSP, four additional tribal villages under Harnatand and Parsauni panchayat of West Champaran district of Bihar have been surveyed after which Bakwa Chandraul and Parsauni villages have been finally selected. Besides this there was plantation of mango and litchi at Bandel village of Rayagada district of Odisha.
- Training cum sensitization programmes on rejuvenation of old senile trees of litchi have been successfully organized in Tripura.

Externally Funded Projects

- Under DBT Sponsored National Database on Mango Project, one hundred and ten custodian mango farmers (cultivating more than 10 mango varieties) from northern and eastern parts of Bihar have been identified. Farmers are maintaing up to 36, 28, 25, 22 varieties of mango in one orchard of Samastipur, West Champaran, Katihar, East Champaran districts, respectively.
- Bakwa Chandraul and Parsauni women tribal village of West Champaran district of Bihar were selected and training cum awareness programme on "Importance of Kitchen Gardening and Value addition" has been organized at the village.
- Excellent performance of turmeric and potato has been recorded with average yield 11.62 t/ha and 14.06 t/ha, respectively.
- *Conopomorpha sinensis* Bradley is one of the major fruit and shoot borer species of litchi identified through molecular study.
- Biological study of litchi fruit and shoot borer revealed that adults are nocturnal and mating usually takes place during dusk and lay their eggs singly soon after mating on the under surface of the leaf or near the peduncle of litchi fruits.
- Minimum fruit infestation (19.0%) by litchi fruit borer was recorded with first spray of neem oil (3ml/l) before flower opening, second spray of diflubenzuron 25 WP (0.06%) at clove stage fruit size and third after 21 days of second spray.
- Among various organic products/ bio-enhancers tested against litchi fruit borer, *Panchgavya* 3% (30 ml/l) found to be the most effective (14.33%) for healthy and quality litchi production. Four sprays at 10 days interval after fruit attaining clove size kept the infestation below threshold level.
- Thirty two thousand air-layered plants of litchi was maintained and kept for sale to farmers and stake holders.

Linkages and Collaborations

The centre is working in close collaboration with other ICARs institutes and SAUs such as RAU, Pusa, Samastipur, BAU, Sabour, Bhagalpur, IGKVV, Raipur, JNKVV, Jabalpur, NHB, APEDA, State Agriculture/ Horticulture Departments, and other ICAR Institutes. The Centre has been identified as National Active Germplasm Site (NAGS) for Litchi by NBPGR, New Delhi and Distinctness, Uniquiness and Stable (DUS) centre for litchi by PPV & FRA, New Delhi. The NRCL has been recognized as one of the programme study centers of IGNOU, New Delhi for postgraduate diploma in plantation management and certificate course in organic farming.

Transfer of Technology

Effective and rapid transfer of litchi based technologies developed by the centre through off-campus and on-campus training programmes has been done. Field visits to farmers and stakeholders and timely advice through print and electronic media were taken during the year. The centre had organized Kisan Gosthi, Field Day, World Soil Day and 26 formal trainings including one MTC (model training course) sponsored by Ministry of Agriculture and Farmer's Welfare, New Delhi to farmers and extension functionaries of state agriculture department to upgrade their knowledge and skills. Centre has developed and distributed more than

200 soil health cards to litchi growers. The centre also participated in various Farmers' Fair to showcase and disseminate litchi technologies among stakeholders.

Other Activities

'Agricultural Education Day' was organized by the centre for school students on 5th September, 2015. The '*Hindi Chetna Maas 2015*' from 1st to 30th September 2015 was organized at ICAR-NRCL in which various competitions were held. The centre got first position in implementation of official language in day to day work and scientific writing by NARAKAS, Muzaffarpur. Beside this, regular Swachh Bharat Abhiyan, Vigilance Awareness and other official programes were observed at the Centre.

Infrastructural development

The Centre is developing the laboratory facilities for the molecular characterization and other biotechnological studies. Laboratory facilities for physiological and biochemical analysis, nutrient and elemental studies of plant and soil have been established. The facilities for plant protection and postharvest research have been strengthened. The centre has been connected to the national knowledge network (NKN) through Railtel. Visiting Scientist Home at the centre has been made functional. Residential quarters and other facilities in the campus are being developed for various categories of employees.

INTRODUCTION

The ICAR-NRCL is the premier national institute for conducting research and developments on litchi and provides leadership at national level. It also acts as a national repository of information on litchi production, processing, value addition, and provides consultancy services to end users.

Genesis and Growth

The establishment of ICAR-National Research Centre on Litchi (ICAR-NRCL) was approved on 24th May, 2001 at Muzaffarpur, the largest and most prominent city in North Bihar and known for litchi world wide. It is well connected by railways to major cities in the country. The Eastern corridor of the golden quadrilateral highway project also passes through Muzaffarpur. The nearest airport is located at Patna, about 100 km south. The centre is located at Mushahari, on Muzaffarpur-Pusa Road at 26°5'87" N latitude, 85°26'64" E longitude at an elevation of 210m above msl. It is about eight km from Muzaffarpur railway station. The research farm of the centre is spread over an area of 35 ha. The Centre started functioning from 2002 with budgetary allocation and the first batch of two scientists joining the Centre in March, 2002. The lease deed was signed on 25th June, 2002 between the ICAR and Government of Bihar to transfer 40 ha of land to the Centre at Mushahari, Muzaffarpur. Over the course of 15 years, the centre has grown in terms of staff strength, laboratory facilities, and infrastructural development. From a modest beginning, the centre now functions from the headquarters with state-of-the-art laboratory facilities, farm and experimental area and a brimming residential campus.

Mission

Harnessing science and technology by interfacing research and extension activities for enhanced quality production, productivity, processing and use diversification for sustained litchi production, industry and trade.

Mandate

- Applied and strategic research on genetic resources and production technologies for enhanced, sustained and safe production of litchi
- Transfer of technology and capacity building of stakeholders for enhancing and sustaining productivity of litchi

Functions

- To undertake basic, strategic and applied research for enhancing productivity, quality and utility of litchi
- To act as repository of genetic resources and scientific information on all aspects of litchi
- To undertake frontline demonstration in newer technologies and to impart training for upgrading scientific knowledge

Infrastructure Facilities

The research farm of the centre has a modern propagation structures, shade houses, glasshouses, irrigation networking and water sources. The research and development at the centre has been strengthened through procurement of equipments such as GCMS, AAS, UV-VIS spectrophotometer, HPLC, leaf area meter, portable photosynthesis meter, horizontal electrophoresis unit, colour difference meter, nitrogen analyzer, flame photometer, trinocular phase-contrast upright microscope, plant growth chamber, insectry lyophilizer, ultracentrifuge, modified atmospheric packaging unit, hydro-cooling system, forced-air cooling system, litchi grading machine, plastic strip sealing and packaging machine, litchi peeling machine, cool storage chamber, bottle washing machine, litchi harvester cum pruner, power sprayer and mist chamber. Some residential quarters have been developed and allotted to employees and efforts are on for further development. The visiting scientist home at the centre has become functional.

Library

It has more than 1960 books including recent editions of 450 reference books and Hindi literature in horticulture and allied subjects. The library has 16 encyclopedias and 30 vol. of Britannica. Currently, 13 Indian and 10 international journals are being subscribed. The centre has published 9 technical bulletins and 11 extension bulletins that are available in the library for researchers, extension workers and farmers.

Agricultural Knowledge Management Unit

The centre has an Agricultural Knowledge Management Unit (AKMU) to manage the knowledge database with software of international repute such as SAS, CAB abstracts, horticultural abstract, and other computing softwares. The centre has now installed server and LAN system for shared resources. The centre has been connected to the national knowledge network (NKN) through Railtel and Wi-Fi provision for internet access has been developed. Regular updating of website is being done and stakeholders can access the happenings at ICAR-NRCL by logging into the centre's website (www.nrclitchi.org). The centre is regulary publishing the NRCL news letter.

Farmers friendly Technology developed by NRCL

1) Rejuvenation of Senile Unproductive Litchi Trees

- Litchi trees become senile and unproductive after 60-70 years and the fruiting areas is shifted towards tip. The tree frame and root system can be utilized and the canopy can be rebuild by reiterative pruning and post pruning managements.
- During rejuvenation, the selected orchards are cut (prune) at 2m height during August-September. Cut ends are painted with copper fungicides. The trees are fertilized with recommended doses and plant health is maintained appropriately. Suitable sprouts are selected for canopy development by thinning unwanted shoots. Suitable intercrops are advised to cultivate to sustain the income of orchardists.
- If periodic orchard management operations are followed appropriately the plant starts bearing after three years otherwise in old and senile plantation, productivity of orchard declined drastically, fruit size gets reduced and plants become liability to the grower.
- While practicing this technology, approximately Rs. 5000/- is spent for performing the rejuvenation operation which can be met from the disposal sale of the pruned wood, maintenance cost of the orchard can be met from the income of intercrops and the benefit-cost ratio is 1:9.

2) Off-season propagation for regular availability of litchi planting material.

- Plants raised during traditional seasons (July-October) require a long period of care in the nursery leading to high cost of maintenance, with limited span of propagation period that is why off season propagation is required.

- Selection of non-bearing twigs of desired thickness during February-March and performing standard air-layering operations is the first step. Provide proper conditions to the mother tree through irrigation and protection from heat waves. Detaching the air-layers after rooting during April and maintenance in the nursery up to August is required. Disposal of plants is possible within six months. This is suited for all the litchi growing areas in the country for quality plant production.
- Apart from the cost of developing air-layered plants (Rs. 25/plant approximately), the additional cost of covering a special care to the mother tree is required. The benefit-cost ratio is 1:3.5.

3) Litchi based cropping system model

- Provides sustainable and regular income to orchardists by utilizing the vacant space in young developing orchard of litchi (1- 10 years). It improves the socio-economic and nutritional condition of farmers through cultivation of intercrops and also improves soil health and plant growth by integrating legumes in the interspaces.
- In young developing litchi orchard, 80 percent area remain vacant up to 5th year which gradually decreases as the plant growth increases. To utilize this area short duration remunerative crops has been standardized. [Model I: Litchi + 2 rows of banana (main + 2 ratoon crop), Model II : Litchi + high value crops in 80% area (Okra-Gladiolus; Cowpea – Potato and Onion), Model III: Litchi + Partial shade loving crops (Turmeric)] for new litchi orchard of Bihar, UP, West Bengal and Uttrakhand.
- This technology has C:B ratio for Model I = 1: 5.1; Model II= 1: 4.0 and Model III= 1: 2.62

4) Post cut dip solution to enhance nursery survival of litchi layers

- High mortality of litchi air-layers in nursery and poor development of secondary and tertiary roots are seen after transplanting in the field. After detachment of air-layers from mother plants it requires intensive care. The survival of layers depends on the initial care of air-layers and development of secondary and tertiary roots
- Post cut dip solution can be prepared by dissolving 10 ml Rhizobacteria/ litre of normal water and steering the solution to make it uniform. Dipping air-layers in the above solution for 3-5 minutes after detachment and remove polythene from root balls carefully.
- Planting of air-layers should be done in the enriched medium in poly bags containing RBS+ VC + vermiculite + cocopith + DAP and proper care needs to taken of air-layers in nursery.
- C/B ratio for this technology is 1: 2.29.

5) Improved varieties of litchi

- Productivity of litchi is much below the potential by cultivating the existing varieties. The pulp ratio of the existing varieties is also moderate with a number of problems related to regularity in bearing, yield potential and susceptibility to pest and disorders.
- Improved varieties of litchi have been developed and five new varieties have been recommended to the growers, *viz.*, 1. Shahi, 2. China, 3. VNSDASU, 4. Yogda, 5. Kasba
- **Shahi:** Higher yield, rosy flavor, early maturity and high yield potential (140-150 kg/tree); **China:** Heavy yielder, bigger fruit size, bright red colour, resistant to cracking and high yield potential (150-160 kg/tree); **Vnsdasu:** High pulp recovery (>83%), big fruit size (38 g), cracking resistant, pleasant aroma, and good yield potential (120-140 kg/tree); **Yogda:** Dwarf plant, small seeded fruit, late maturity, free from fruit borer, melting pulp with pleasant aroma and yield potential (70-80 kg/tree); **Kasba:** Late maturity, nutrient efficient, heavy yielder, bright red fruit colour with good yield potential (130-140 kg/tree).
- These varieties are suitable for all litchi growing areas especially Yogda is suitable for high density plantings and Kasba for low input management.
- These varieties has edge over the existing strains of litchi with more than 20% higher yield potential and better quality under



optimum management conditions. The B:C Ratio can be 1:7.5 (improved varieties) in place of 1:5 (existing varieties)

6) Integrated Management of litchi fruit & shoot borer

- Litchi fruit & shoot borer is a major pest responsible for fruit losses and shoot infestation to the tune of 24-48% and 7-70%, respectively. The insects damage the newly emerged shoot during the September - October resulting in failure of shoot to bloom. The maximum pest population on shoots during August and on fruits during April-May causes severe losses.
- It can be managed by setting of suitable pheromone traps in mid canopy during February and replacement of lures after 25 days. Spraying of neem oil (4 ml/l) before flowering and lufenuron 5 EC (1ml/l) or emamectin benzoate 5% SG (0.5ml/l) after fruit attained the clove size and repeat the same after 15 days and 30 days interval.
- Above practices are suitable for litchi plant health management in Bihar, UP, West Bengal, Uttrakhand and other litchi growing areas with C/ B ratio = 1: 7.22.

7) Integrated management of litchi mite

- Litchi mite is causing economical loss to a tune of 22- 38 %. Nymphs and adults damage the new leaves, inflorescence and young developing fruits. Severe infestation has been noticed during March - April and August – October. Twigs infested during August - October becomes unfruitful and yield is reduced.
- It can be managed by pruning and removal of infested twigs after fruit harvest and two spray of chlorfenapyr 10 EC (3ml/l) or propargite 57 EC (3ml/l) at 15 days interval during July.
- Pruning of new infested twigs during October and spray with chlorfenapyr 10 EC (3ml/l) or propargite 57 EC (3ml/l), Need based spray of above acaricides after panicle initiation are other control measures.
- It has C/ B ratio : 1: 5.67 and technology is suited for plant health management in Bihar, UP, West Bengal, Uttrakhand and other litchi growing areas.

8) Higher production through honey bee pollinators

- Litchi requires insect pollinator to insure optimum crop, proper pollination increases fruit set & size, fruit retention, fruit yield and produces uniform fruit shape, where in transfer of compatible pollen results in proper fertilization and formation of seeds.Flowers with proper fertilization produce bigger fruit, Honey bee has been identified as main pollinator insect for litchi.
- 10-12 honey bee colonies/ ha with 8-10 frames are required for effective pollination.
- It has C/ B ratio = 1: 10.50 and suited for all litchi growing states.

9) Management of litchi fruit & shoot borer using bio-enhancers

- Alternative to chemical control, an environment friendly technology with different organic products has been standardized on Shahi litchi cultivar.
- Panchgavya (30ml/l) locally made product, containing cow products, like ghee, urine, dung, curd, milk besides, banana and sugarcane juice and biodynamic pesticide (50ml/l) locally made with cow-urine, cow-dung, chopped leaves of neem/madar and water has been found most effective for healthy and quality litchi production. Four sprays at 10 days interval after fruit set checks infestation below the threshold level.
- Integration of orchard operations like pruning of infested twigs in June, manuring of plants with 4 kg castor-cake and 1 kg neem-cake in the 2nd week of June and spraying of neem based formulations improves the effectiveness.
- It has C/ B ratio = 1: 6.72 and technology is suited for Bihar, UP, West Bengal, Uttrakhand and other litchi growing areas.

10) Assured flowering and fruiting in litchi through girdling of primary branch

- Alternate bearing in China litchi is a major problem of litchi production and irregular bearing in juvenile litchi orchard (till 12 years age) is a major constraint in litchi cultivation.
- The main function of girdling is to stop or reduce the flow of sap via the phloem to the lower parts of the tree and roots. In this process carbohydrate is accumulated in the twigs, leaves and stem above the girdle portion of the branch. The technique discourages winter flushing in litchi and favour flower initiation. Ensure regular flowering and fruiting in litchi, increases fruit yield and quality as compared to untreated branches, girdled tree least affected by foliage pest.
- Perform the circular cut on 75% major limbs, ideal time of girdling is last week of August to first week of September i.e. after 2nd vegetative flushes. Girdling should be done by using sharp pruning saw/knife. Remove a strip of bark 2-3 mm wide in a circular ring around the selected primary branch.
- Subsequent girdling during next year to be performed at least 4-5 cm above the previous girdled section
- If main trunk has 2 branches (bifurcated) then girdle in one of the limbs. Similarly, if the tree has three main limbs (trifurcated), then girdle two of them and likewise four main limbs, girdle three of them. Avoid cut to wood portion.
- It is suited for all major litchi growing states with B/C ratio is 1: 3.03 (average of 3 years).

11) Potting media for raising healthy litchi plants

- High mortality of layers and poor growth in nursery, less field establishment is found due to uprooting jerk and well-developed rooted air layers after detaching from mother plant require proper care for their survival in nursery as well as in the field. Nursery survival depends on the quality roots and growth of saplings.
- Here, dip the root ball to fill up the cracks in thick slurry of clay and vermi-compost (1:1 ratio)
- The potting mixture containing RBS : VC (1:2) + vermiculite (50g/kg) + cocopith (50g/kg) + DAP 5g/kg mixture has been effective to improve survival. Prepare the mixture 10 days in advance during August.
- There after planting of air-layers is done in the enriched medium and maintain in the nursery. C/ B ratio is 1: 1.86.

12) Bagging litchi bunches for quality fruits

- Fruit maturity coincided with high temperature and blow of hot desiccating winds and low relative humidity, fruits burning followed by fruit cracking is the major problem.
- The main function of the bagging of litchi fruit bunches with non-oven poly propylene or perforated butter paper during fruit development stage helps in increasing the humidity and reducing the high temperature and providing shade resulting in improve quality and reduction in fruit borer infestation.
- Bagging of the fruit panicle containing 60-70 number of fruit during fruit development stage with above material in last 4th week of April, Tying of the one distal end of bag with inserted thread or hessian rope.
- Cut the fruit panicle along with bag, hasten the harvesting procedure and increases fruit quality as compared to control.Bagged fruit had 30% higher class-I fruit.
- This technology is suited for all major litchi growing states with B/C ratio: 1.26 (average of 3 years).



Staff Strength of the Centre

Staff	Sanctioned	Filled	Vacant
Scientific	15+1	13+1	02
Technical	14	3	11
Administrative	12	8	4
Skilled Supporting Staff	10	3	7

Financial Statement (2015-16)

(Rs. in lakh)

Head	Plan		Non-plan	
	Allocation	Utilization	Allocation	Utilization
Capital	225.50	225.50	5.00	4.57
Revenue				
Establishment Expenses	0.00	0.00	292.50	290.30
Travelling Allowance	7.00	6.98	2.50	0.82
Research and Operational Expenses	67.00	70.66	40.00	40.81
Administrative Expenses	45.50	41.88	54.00	54.91
Miscellaneous Expenses	0.50	0.48	2.00	1.98
Total	345.50	345.50	396.00	393.39

Resource Generation

(Rs. in lakh)

Sale of farm produce	7.87
Interest earned on short term deposits	2.19
Income generated from internal resources (including recovery of loans and advances)	2.31
Miscellaneous receipts	0.13
Total	12.50

Receipts and Expenditure Statement (Externally Funded Projects)

(Rs. in lakh)

Externally Funded Projects	Opening balance	Receipt during 2015-16	Expenditure
Total	-0.16	47.70	34.46

RESEARCH ACHIEVEMENTS

1. Conservation, Characterization and Utilization of Genetic Diversity for Improvement of Litchi

1.1. Collection of indigenous and exotic germplasm, their characterization, evaluation, documentation and utilization

Collection of litchi germplasm from indigenous and exotic sources

An exploration programme was conducted in Uttarakhand and Assam to collect promising germplasms of litchi. Five accessions each were collected from both the states.

Characterization of litchi germplasm based on morphological, biochemical and molecular markers

Fifty two germplasm lines are being maintained at the institute out of which eight accessions came to flowering. Accession IC-0615586 exhibited the earliest panicle initiation (3rd February) among the eight accessions evaluated, while IC-0615598 expressed delayed panicle initiation (26th February). Flowering duration ranged from 17 days in IC-0615603 to 24 days in IC-0615523 (Table 1.1.). Dark yellow flower colour was observed in IC-0615587, IC-0615611 and IC-0615595 whereas light yellow flower colour was noted in IC-0615593, IC-0615523, IC-0615598, IC-0615586 and IC-0615603. Flowering intensity was moderate in IC-0615593, IC-0615523, IC-0615587, IC-0615586 and IC-0615603, while sparse flowering was observed only in IC-0615595. Length of inflorescence varied between 12-32 cm, while width of inflorescence from 7-18 cm (Table 1.2.).

Twenty five litchi genotypes were evaluated for physico-chemical parameters of fruit. Most of the genotypes exhibited red fruit colour as a dominant character followed by light red colour. Light yellow fruit colour was observed only in Early Bedana. Significant variations were recorded among genotypes for fruit quality parameters. Heaviest fruit weight was recorded in Bombai-II (20.69 g) followed by Kasba (20.61 g), Rose Scented (20.34 g) and Shahi (20.12 g). The least seed weight was recorded in Bedana (2.03 g) and CSL-2 (2.15 g) whereas Shahi and China have the heaviest seed (4.45 g and 4.42 g, respectively). Pulp recovery

Table 1.1. Floral characteristics of litchi germplasm

Floral character	Litchi germplasm							
	IC-0615593	IC-0615523	IC-0615587	IC-0615611	IC-0615595	IC-0615598	IC-0615586	IC-0615603
Date of first panicle initiation	22.2.15	23.2.15	12.2.15	20.2.15	23.02.15	26.2.15	03.2.15	22.2.15
Date of opening of first and last male flower (Type-I)	19.3.15	21.3.15	11.3.15	21.3.15	18.3.15	16.3.15	18.3.15	18.3.15
	26.3.15	28.3.15	17.3.15	26.3.15	24.3.15	21.3.15	24.3.15	24.3.15
Date of opening of first and last female Flower (Type-II)	25.3.15	26.3.15	15.3.15	24.3.15	25.3.15	20.3.15	24.3.15	23.3.15
	2.4.15	4.4.15	23.3.15	5.4.15	04.4.15	30.3.15	03.4.15	01.4.15
Date of opening of first and last hermaphrodite functionally male flower (Type-III)	30.3.15	2.4.15	20.3.15	28.3.15	28.3.15	27.3.15	30.3.15	28.3.15
	9.4.15	14.4.15	30.3.15	12.4.15	10.4.15	05.4.15	08.4.15	05.4.15

Table 1.2. Floral characterization of litchi germplasm

Floral character	Litchi germplasm							
	IC-0615593	IC-0615523	IC-0615587	IC-0615611	IC-0615595	IC-0615598	IC-0615586	IC-0615603
Flower composition in inflorescence (F:M1:M2)	95:465: 380	98:450:350	52:410:270	120:240:565	48:420: 310	112:560:176	86:670:210	56:398: 263
Flower disc/ inflorescence colour	Light Yellow		Dark Yellow			Light yellow		
Flowering duration (days)	20	24	18	23	22	20	19	17
Flower size	Large	Medium		Large	Medium			Large
Inflorescence length (cm)	20	20	12	32	24	29	32	26
Inflorescence width (cm)	12	8	7	15	13	17	18	10
Abundance of flower	Moderate			Profuse	Sparse	Profuse	Moderate	

was highest in Bedana (69.12%) followed by Kasba (62.82%), Late Large (61.67%), Ajhauli (61.66%), and Shahi (60.82%). The highest TSS content was noted in Shahi (20.78°B) followed by Green (20.18°B) and Yogda Selection (19.52°B).

Standardization of tissue culture techniques for propagation and multiplication of litchi germplasm

Preliminary work on standardization of tissue culture techniques was initiated. Four to six week old immature zygotic embryo after fertilization were kept in MS medium to get germinated. Thereafter, transferred into MS medium containing various combination of BAP. Explant responded to *in vitro* growth media (plain MS media) as evidenced by greening of embryo and emergence of radicle. Further, cessation of root growth and elongation of shoot like structure at the axillary meristem region were observed when explants were transferred into growing media containing 3.75 mg/L BAP + 1 g/L Activated Charcoal + 5 mg/L GA3. (Fig. 1.1).

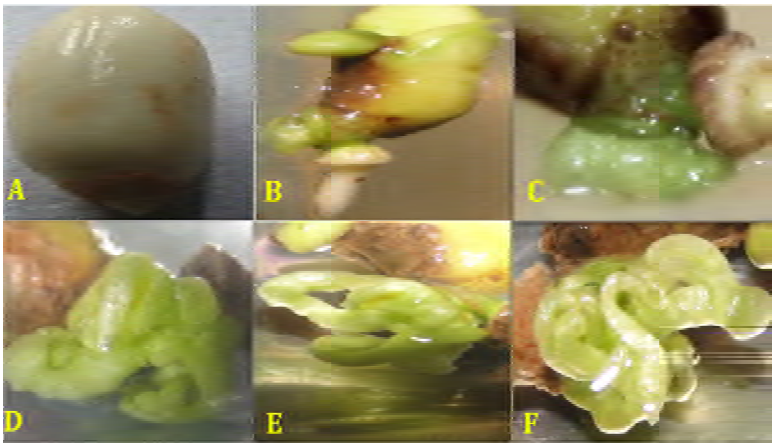


Fig. 1.1. Tissue culture in litchi cv. China A: Immature zygotic embryo; B: **Germination of embryo;** C: **Induction of shoot-like structure at axillary meristem region;** D: **Elongation of shoot-like structure;** E **and** F: **Further elongation of shoot-like structure**

Collection, characterization and evaluation of rambutan germplasm

Two germplasms (N-18 red type & E-35 yellow type) of rambutan were collected from Home Grown Nursery, Kanjirapally (Kerala) earlier and planted in nursery under protected condition but due to severe winter the plants died in the second year.

1.2. Development of improved cultivars in litchi

Clonal selection for improvement in commercial cultivars of litchi

IC numbers for nineteen clones were obtained from ICAR-NBPGR, New Delhi. Evaluation study revealed that IC-0614738, IC-0614775, IC-0614740, IC-0614736 and IC-0614735 showed lowest plant height, whereas plant vigour was highest in IC-0614728 (Fig. 1.2)

Development of improved hybrids of litchi

A total of 52 hybrids were obtained from cross combinations involving Shahi, China, and Bedana during 2015. The plants were transplanted and maintained in the field. Total number of 12835 flowers were crossed (Fig.1.3) using five cross combinations (Shahi, China, Bedana, Rose Scented and Kasba) on 378 panicles. The highest fruit set (53.93%) was observed in Shahi×China and lowest in Bedana×Shahi (17.74 %) at one week after pollination. Fruit retention declined in the second and third week after pollination. Shahi×Bedana cross combination had highest fruit retention (1.90%) followed by Shahi×China (0.87%), Rose Scented×Shahi (0.76%) and China×Shahi (0.65%) after three weeks. No fruit retention was observed in Bedana×China cross combination after third week of pollination.

Establishment and evaluation of segregating population of litchi

The segregating population of litchi are three years old. Maximum survival of plants (73.5%) was found in hybrid population and seedlings of selected clones. Plant height, canopy spread and survival % were recorded at regular intervals (Fig 1.4).

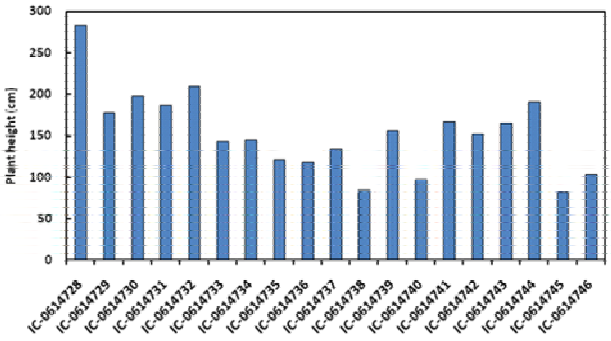


Fig.1.2. Variability in plant height among clonal population

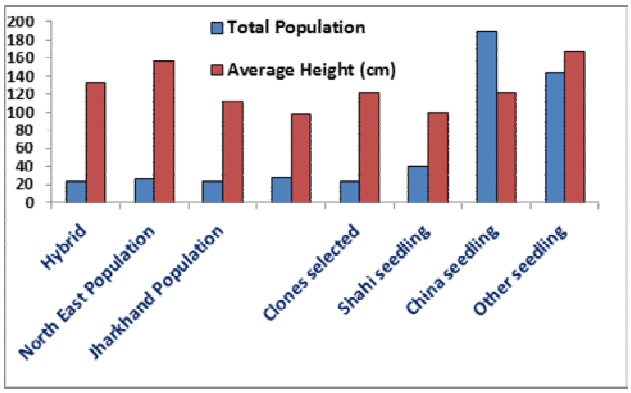


Fig. 1.4. Seedling population under evaluation

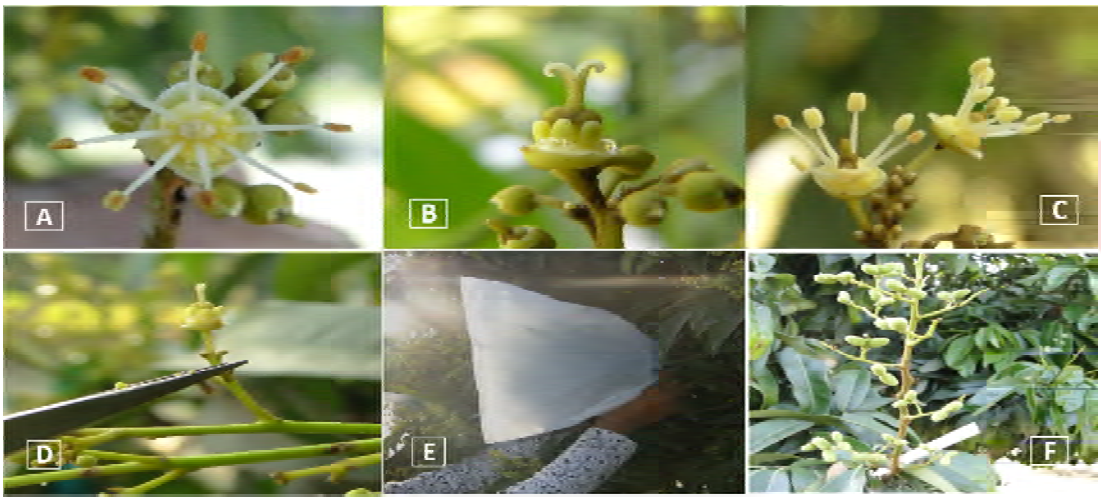


Fig. 1.3. Hybridization in litchi **A**: Functionally male flower (Type-I); **B:** Functionally female flower (Type-II); **C:** Hermaphrodite functionally male flower (Type-III); **D:** Emasculation; **E:** Bagging of pollinated flowers; **F:** Fruit set after pollination

2. Development and Refinement of Integrated Production Technologies for Improved Productivity of Litchi

2.1. Development and refinement of integrated technologies for improved productivity of litchi

Effect of graded level NPK on vegetative and reproductive character of 'Shahi' litchi

The litchi plants under experiment showed regularity in flowering and fruiting. Maximum 42.93 kg/plant yield was recorded with application of 100:50:100 g NPK/plant/year in 10 years old plant which was at par with all other combinations except N combination of 50g with 50, 75 and 100g K application per plant per year in two split and all other combination of 3 splits. Available N/ha increased with increasing dose of nitrogen and potassium and the highest available N (151.62 kg/ha) content was analyzed in treatment T_9M_2 (100:50:100g NPK/plant/year) and lowest (107.36 kg/ha) in T_2M_2 (50:50:50g NPK/plant/year) with 2 split application during June and April months. Whereas, same level of nutrient applied in 2 split during July and October recorded higher nitrogen content (95.73 to 209.75 kg/ha) than 3 splits.

Effect of graded level NPK on vegetative and reproductive character of China litchi

Litchi plant under the experiment showed irregularity in flowering with alternate tendency. During 2015 cropping season, no flowering was observed. However, in February and March, 2016 profuse panicle emergence followed by flowering has been noticed. The flowering per cent in different shoots varied from 70-90%.

Standardization of organic inputs for litchi production

Very poor flowering and fruit setting was observed during 2015 however, very good panicle emergence and flowering has been noticed during 2016 in the plants applied with 20 kg FYM + 2 kg Vermi-compost + 1 kg Neem cake + bio- fertilizers at 9 years after planting.

Development of package of practices for organic litchi production

One block of Shahi, China, Mandraji and Trikolia cultivars has been established in 1.6 ha area with 6x6 m spacing under organic management practices to study the response of different organic resources viz., FYM, vermi-compost, bio-fertilizers, bio-enhancers, green manures on growth performance of litchi. Plants mortality in litchi cultivars revealed that China recorded least mortality (6.99%) followed by Trikolia (9.23%) and Mandraji (15.38%) while Shahi recorded highest (24.18%) at one year after planting. Intercropping of faba bean was done in between two rows of organic litchi block during *Rabi* season. The average yield of faba bean was recorded 16.67 q/ha.

Soil samples were collected from organic block before sowing of faba bean in 2015 for analysis. Whole orchard was divided into 3 blocks as upper, middle and lower block as per the slope gradient. The data revealed that soil pH and EC slightly declined (8.49-8.22 & 0.22-0.13 dsm^{-1}, respectively) and organic carbon increased (0.16-0.23%) from upper to lower side. Available nitrogen content ranged from 94.36 kg/ha in upper side to 120.47 kg/ha in middle site.

High density planting in litchi cv. Shahi

Growth parameters recorded during September month showed significant differences in plant spread and trunk girth under different planting densities. Maximum trunk girth and plant spread were observed in 6×4m which was at par with 6×6m and 4×4m spacing. 2×2m and 4×4m densities were recorded maximum height.

Yield attributing characters *viz.* flowering %, yield/plant (kg) and fruit quality (TSS and acidity) showed significant differences however, fruit weight, fruit length, fruit breadth, ascorbic acid and pulp weight found non–significant. Maximum 18.75 kg/plant yield was recorded in 6×6m density followed by 8×4m (18.38 kg) and 8×6 m (17.67kg) densities. Higher TSS was recorded in wider densities than closer densities.

Nutrient deficiency symptoms in litchi

A pot experiment was conducted with three macro (N, P, K) and four micro (Fe, Cu, Zn, B) nutrient deficiency symptoms. N-deficient plants showed deficiency symptoms after 90 days of planting. The older leaves turned yellowish in colour and newly emerged leaves became light green. Plant growth was stunted with shorter inter-nodal length and reduced leaf size. Zn-deficient plants showed inter-veinal chlorosis in leaves. However, in Cu-deficient plants expressed symptoms of narrowing of younger leaves, which become hard and brittle (Fig. 2.1). Under P deficient plant foliage becomes dark green and erect. In case of Fe deficiency, chlorosis on new leaves without spot had been observed. The plants under absolute control showed stunted plant growth produced less number of leaves with pale yellow in colour.

2.2. Investigation and establishing the physiological and biochemical relations for improved litchi production

Applications of paclobutrazol and potassium nitrate in influencing shoot physiology, flowering and leaf flushing of litchi cv. China

During 2015 and after application of paclobutrazol and KNO_3, the leaf area increased from May to August and maximum was found in un-treated tree and rate of increment reduced after August in all the trees. Maximum increase in shoot length was recorded in tree received 2 % KNO_3 and least was in control. Spray of 4.0 g PBZ reduced shoot lengths, brought rosetting and maximum was in un-treated trees (Table 2.1).

Fig. 2.1. Deficiency symptoms on litchi plant A: N deficient, B: Zn deficient, C: Cu deficient

Table 2.1. Effect of paclobutrazol and KNO_3 on morpho-physiological parameters of 'China' litchi

Treatment	Leaf area (cm^2)			Shoot length (cm)		
	May	Aug.	Nov.	May	Aug.	% Increase
1.0 g PBZ	39.75	47.69	48.34	8.45	13.25	56.80
2.0 g PBZ	31.44	41.19	50.24	7.41	12.09	63.15
3.0 g PBZ	37.97	48.28	40.60	6.12	10.71	75.00
4.0 g PBZ	27.55	38.10	42.32	4.98	8.85	77.71
1 % KNO_3	28.72	47.80	54.43	9.62	14.68	52.60
2 % KNO_3	40.10	49.69	53.45	7.62	16.24	113.12
Un-treated	37.54	55.37	56.38	11.58	15.85	36.87

Spray of 3.0 g PBZ reduced Chl a and total Chl contents (May and August). 1 % KNO_3 increased concentration of total chl contents August month has maximum chl contents (a,b and total) than May) *Chl a, b* and *total Chl* increased from FBD to flowering phase, but maximum in control trees and least in tree receiving 2 % KNO3. After spray of 4.0 g PBZ, there was maximum retention of chl a, b and total chl in litchi leaves (Table 2.2).

content and least due to 3.0 g PBZ, the later tree maintained maximum *Ci*. During floral phase, 1 % KNO_3 recorded maximum *Pn* and lowest *Ci*, untreated trees had lower *Pn* at both the stages but highest *E* during flowering. E and *Ci* were recorded least due to application of 4.0 g PBZ (Table 2.3).

Table 2.2. Effect of paclobutrazol and KNO_3 on leaf chlorophyll contents 'China' litchi

Treatment	Chl a (mg 100 g^{-1})				Chl b (mg 100 g^{-1})				Total Chl (mg 100 g^{-1})			
	May	Aug.	Dec.	Mar.	May	Aug.	Dec.	Mar.	May	Aug.	Dec.	Mar.
1.0 g PBZ	3.51	2.64	3.39	3.77	2.59	2.66	2.66	3.04	5.54	5.34	6.34	6.73
2.0 g PBZ	2.12	4.15	3.35	3.74	1.94	3.27	2.29	2.67	4.54	7.49	5.93	6.33
3.0 g PBZ	1.93	1.71	3.23	3.95	2.00	3.27	2.89	3.11	4.04	4.91	6.41	6.81
4.0 g PBZ	3.35	3.80	3.43	3.83	2.15	3.06	2.77	2.98	5.41	6.87	6.52	6.94
1 % KNO_3	5.05	3.91	3.41	3.80	1.61	3.61	2.77	2.87	6.82	7.44	6.43	6.81
2 % KNO_3	3.19	2.27	3.093	3.47	2.65	2.81	2.47	2.86	5.80	5.04	5.86	6.28
Un-treated	3.78	3.72	3.95	4.34	1.83	3.12	2.37	2.76	5.66	6.87	6.62	7.03

We had also measured various gas exchange parameters in '*China*' litchi and found that *Pn, E* and *Ci* were much higher during vegetative phase than reproductive phase. Photosynthetic rate (*Pn*) recorded maximum in tree receiving 2.0 g PBZ and 2 % KNO_3. The highest transpiration rate (*E*) was recorded with 2 % KNO_3 and least due to 4.0 g PBZ. 4.0 g PBZ maintained maximum leaf temperature and leaf N

Improving bearing potential though use of girdling cv. China

To regulate the bearing and to get fruit yield every year in China litchi a field experiment has been conducted on 3 levels of girdling size (2, 3 and 4 mm) on 3 levels of primary branches (25, 50 and 75 per cent) and control. The girdling treatments were imposed during the months of September. No new vegetative flush had

Table 2.3. Effect of paclobutrazol and KNO_3 on gas exchange parameters of 'China' litchi (after harvesting and during flowering)

Treatment	Photosynthetic rate (m mol CO_2) $m^{-1}s^{-1}$) (*Pn*)		Transpiration rate (m mol H_2O $m^{-1}s^{-1}$) (*E*)		Internal CO_2 Concentration (m mol CO_2 mol^{-1} air) (*Ci*)	
	Vegetative phase	Floral phase	Vegetative phase	Floral phase	Vegetative phase	Floral phase
1.0 g PBZ	6.76	1.96	7.00	1.03	341.66	210.00
2.0 g PBZ	7.63	2.70	7.30	1.73	332.66	254.00
3.0 g PBZ	5.80	1.96	6.56	0.83	359.00	224.00
4.0 g PBZ	7.13	2.16	6.36	0.80	321.00	174.00
1 % KNO_3	7.06	3.13	6.73	1.16	338.00	193.00
2 % KNO_3	7.33	2.26	8.50	1.00	357.00	281.00
Un-treated	5.60	2.03	6.60	1.96	359.66	250.00

been recorded in girdled branches however in ungirdled branches December flushes recorded. All the girdled branches exhibited flowering panicles but, no flowering was noticed in ungirdled branches of the tree (Fig. 2.2). In 4 mm girdling size 6-7 days delayed panicle emergence recorded in comparison to control. Maximum (95%) shoot flowered in 3 and 4 mm 75 % PB girdling while on the ungirdled branches no panicle or very few mixed inflorescence emerged. Physico-chemical analysis of fruit recorded showed non-significant differences in fruit quality (fruit weight, fruit length and pulp recovery) except TSS.

Fig. 2.2. Fruiting on girdled branches of China litchi

Effect of micronutrients on fruit yield and quality under cv. Shahi

As per the technical programme the leaf and soil samples were collected for base line information of the block of different micro- nutrient content in leaf and soil. Good flowering and fruiting has been observed and fruits are in the developmental stage.

2.3. Investigation on mycorrhizal association and role of bio-fertilizers for sustainable production of litchi

Studies on effect of application of mycorrhiza and other bio-fertilizer inoculants on root biomass, volume and density

Studies were undertaken on the experimental plants that were planted in field during 2011 in a randomized block design with twenty treatments having components

Fig.2.3. Growth response of litchi to microbial inoculants

such as consortium of arbuscular mycorrhizal fungi (AMF)@200 g/plant, *Azotobacter chrococcum* (AZ) @100 g/plant, *Trichoderma viride* (TR) @100 g/plant and *Bacillus megatarium* (BM)@100 g/plant along with their combination treatments, which was compared with recommended dose of fertilizers (RDF; Urea=150 g, SSP=150 g, MOP=100 g per plant) and control plants as check.

Data indicated that all the bio-fertilizers had significant positive effect on root volume, root weight, and root density of trees (Fig. 2.3). The highest root density on fresh weight basis (2503.8 g m^{-3}) was observed with application of AZ+TR followed by AMF (2466.3 g m^{-3}) and AZ (2436.3 g m^{-3}) as compared to control (847.5 g m^{-3}) trees. The highest root density (1370 g m^{-3}) on dry weight basis was observed with application of AMF followed by AZ+RDF (1332.5 g m^{-3}) and AZ+TR (1206.3 g m^{-3}) as compared to control (373.8 g m^{-3}) trees. Higher number of fibrous (feeder) roots was observed with co-inoculation of AMF and AZ.

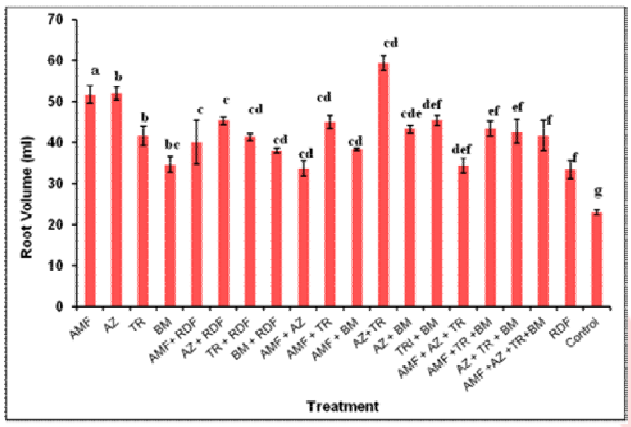


Fig. 2.4. Effect of application of microbial inoculants on root volume of trees; data sown is mean root volume per 20 cm^3 soil

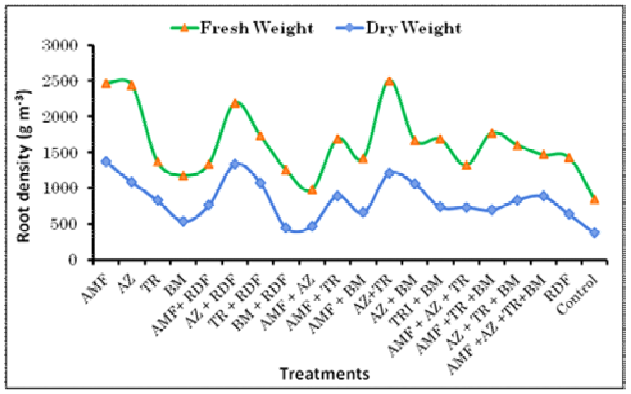


Fig. 2.4. Effect of application of microbial inoculants on root density of 5-yr age litchi trees

Significant effect on fine root density was observed under various microbial treatments (up to 1288 g m^{-3}) compared to control (303 g m^{-3}). Lesser number of AMF spores in rhizosphere, and colonization of roots of plants were observed with combined application of AMF+BM (Fig. 2.4).

On fresh weight basis, the ratio of thin to thick roots was highest (2.59) with AMF+BM followed by AMF+AZ+TR (2.30) and BM+RDF (2.02) as compared to control (0.56) and the lowest in AZ+RDF (0.24). On dry weight basis (Fig. 2.4), the ratio of thin to thick roots was highest (2.36) with AMF+AZ+TR followed by AMF+BM (2.59) and TRI+BM (1.86) as compared to control (0.60) and the lowest in AMF (0.26.). It was concluded that enhanced fine/fibrous root system of plants was one of the reasons for better growth promotion by microbial inoculants. Combined inoculation resulted in better root density.

Studies on population dynamics of arbuscular mycorrhizal fungi (AMF) and other microbes and their interactions

The population dynamics of microbial inoculants monitored after 1 week, 1 month and 2 month after inoculation in experimental plots (Table 2.4). AMF spore was enumerated by wet sieving and decanting while other microflora was enumerated by serial dilution technique. A higher population in co-inoculation than in individual microbial inoculants (10.92-11.87% and 2.97-7.35% after 1 month and 2 month, respectively) in case of *Azotobacter* and *Trichoderma* with AMF, but a decrease in population in case of co-inoculation of *B. megatarium* with AMF (-24.44%, -6.24% after 1 month and 2 month, respectively) was observed. Colonization of roots by AMF was between 79-93%.

2.4. Litchi based cropping system for low lying conditions

Litchi based cropping system for pond/low land

Experiment on litchi based cropping system in low land area has been initiated with construction of ponds and planting of various crops viz., banana, papaya, vegetables and seasonal crops with litchi based cropping system have been done on pond bunds. The cropping system in bunds includes three tier model of litchi cum banana/papaya and seasonal crops based system comprised with 5 models (Bund I: Two row of litchi & banana + vegetables, Bund II: Two row of litchi & papaya + annual crop, Bund III: Two row of litchi + banana in between two litchi plants + annual crop, Bund IV: Two row of litchi + papaya in between two litchi plants + annual crop and Bund V: Two rows of litchi). Data on plant mortality in different fruit crops was recorded at 12 months after planting (Table 2.6). Litchi cv. China showed least plant mortality (8.33%) followed by banana cv. Grand Naine (10%) and papaya cv. Pune Selection-3 (11.91%).

Table 2.5. Population of different inoculated organism in soil of experimental plots

Organism	After 1 month			After 2 month		
	Individual	Co-inoculation	Difference	Individual	Co-inoculation	Difference
T. viride	17.91	28.83	10.92	13.02	15.99	2.97
A. crococcum	30.99	42.86	11.87	25.81	33.16	7.35
B. megatarium	34.97	10.53	-24.44	18.62	12.38	-6.24

Table 2.6. Plant mortality in different fruit crops grown on pond bunds at twelve months after planting

Crops	Varieties	Quantity	No. of plants died	Mortality (%)
Litchi	Shahi	30 Nos.	8	26.67
	China	24 Nos.	2	8.33
Banana	Grand Naine	40 Nos.	4	10.00
Papaya	Pune Selection-3	42 Nos.	5	11.91

Performance of different fruits and seasonal crops grown with litchi based cropping system on pond bunds

Banana cv. Grand Naine planted under model I revealed bunch weight ranged from 11.9 to 26.94 kg with average weight of 19.12 kg/plant, fingers/bunch 67-131 Nos. and hands/bunch 6-8 Nos. with average yield 410 t/ha, however in model III bunch weight ranged from 10.8-21.5kg with average weight of 12.36 kg/plant, fingers/bunch 90-155 Nos. and hands/bunch 7-9 Nos. with average yield 300 t/ha in main crop. Similarly, papaya cv. Pune Selection-3 planted under model II recorded fruit yield of 8-10 kg/plant with average yield of 182 q/ha, 10-32 nos. fruit/plant and 0.92-1.25 kg fruit weight.

Fig. 2.6. A: Litchi + Banana + Cowpea during *Kharif* season; B. Litchi + Banana + Cabbage/Broccoli during *Rabi* season

Fig. 2.7. A: Litchi + Papaya + Faba bean; B: Litchi + Papaya + Mustard during *Rabi* season

Performance of chilli grown during *Rabi* season of 2015 in model I produced 43.75q/ha yield grown in between banana crops. Cowpea cvs. Kashi Kanchan and Kashi Nidhi were taken with banana in model I (Fig. 2.6) and maize with papaya in model II during *Kharif* 2015. Kashi Nidhi performed better with average yield of 145.33q/ha than Kashi Kanchan (96.54q/ha). However, Kashi Nidhi performed poor when grown in model IV with average yield of 63.75q/ha. Maize produces average cob yield of 38.75 q/ha.

Potato and cole crops (cabbage, broccoli & knol khol) were taken during *Rabi* season in model I, faba bean in model II, maize in model III and mustard in model IV. The highest yield was recorded in cabbage (263.6 q/ha) followed by knol khol (196.6 q/ha), potato (134.0 q/ha) and lowest in broccoli cvs. Palam Samridhi (117.0 q/ha) and Palam Vichitra (81.4 q/ha). The

Fig. 2.8. View of litchi plantation during rainy season; A: Raised bed, B: Mound system

average yield in faba bean was recorded 23.71q/ha, in maize 162 q/ha and in mustard 25 q/ha under different models (Fig. 2.7).

Economic analysis of banana and vegetables crops revealed that banana gave the highest net return (Rs 14.8/m^2) with B: C ratio (2.51) followed by cabbage (Rs 8.18/m^2 & 2.36), broccoli (Rs 4.96/m^2 & 1.83) and knol khol (Rs 4.33/m^2 & 1.79). Economic return analysis of papaya and faba bean grown in model II, banana and maize in model III and mustard in model IV also done. The highest net return among different crops was observed in banana (Rs 8.5/m^2) followed by papaya (Rs 7.56/m^2), maize (Rs 4.60/m^2), faba bean (Rs 4.11 / m^2) and mustard (Rs 3.56/m^2) whereas, the B: C ratio found maximum in faba bean (2.37) closely followed by maize (2.31), mustard (2.27), papaya (2.08) and banana (1.87). On the basis of overall economic analysis of different models, the highest average net return was obtained with banana+cabbage in model I (Rs 11.49/m^2) followed by banana+maize (Rs 6.55/m^2) in model III and papaya+faba bean (Rs 5.84/m^2) in model II.

Litchi based cropping system for low land/wet land

An experiment on litchi based cropping system for low lying condition was executed under three planting situations (PS I: raised bed 3 m width, PS II: raised bed 2.5 m width & PS III: mound). Planting of litchi was done during September 2014 at 8.25x4 m spacing (Fig. 2.8). Plant mortality in China was least (0-18.75%) as compared to Shahi cultivar (7.14-25%) at one year of plant age. Dhaincha was also grown in around the plant basin of mound system in the month of May, 2015 to protect the litchi plant during summer and also for green manuring purpose. Four harvesting of dhaincha has been recorded from June to September with 2.5-5kg plant biomass/ harvesting. Dhaincha leaves used for mulching of plant basin which took 25-30 days for full decomposition.

Performance of different seasonal crops grown in sunken beds of low lying area: Mustard, faba bean and maize crops have been cultivated in sunken beds of low lying area in Rabi season. Faba bean, maize and mustard crops grown under PS I produced better yield than the crops grown in other sunken bed of PS II and PS III. The highest cob yield was recorded in maize (170.0 q/ha). However, faba bean yield varied from 13.5-15 q/ha and mustard yield from 16-18 q/ha.

2.5. Edaphic factor based identification of potential litchi area in India

Litchi were primarily grown in plain adjoining foothills of Himalaya but its presence in many nontraditional areas and its income and employment generation potential-warrants closer attention and the project was envisaged tapping litchi potential in India. Identification of potential area in India is prerequisite for exploiting litchi potential of India. Edaphic factors including soils and climate. In first stage, climate of Muzaffarpur is being considered ideal for comparison

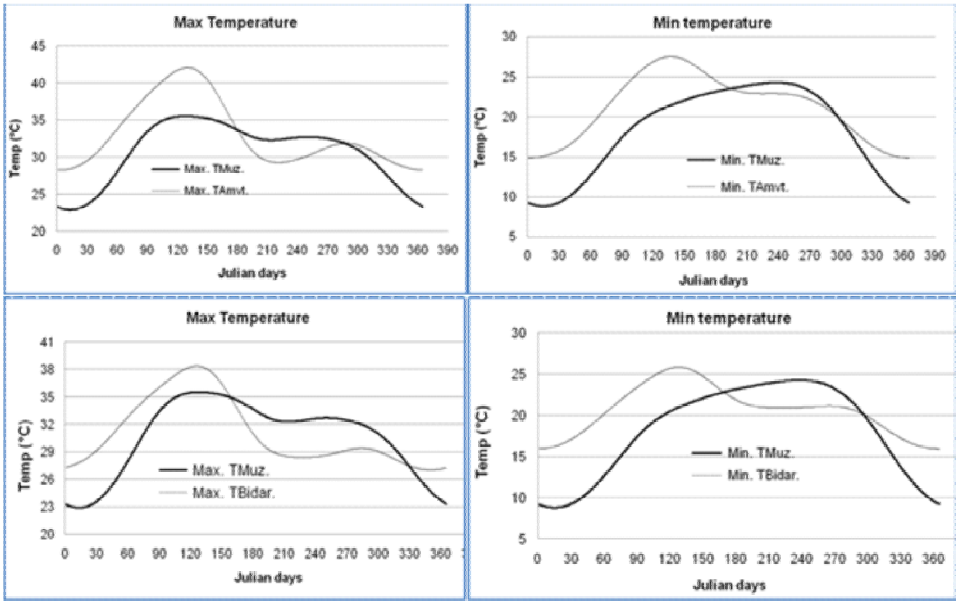


Fig. 2.9. Comparison of maximum and minimum temperature of Amravati and Bidar with Muzaffarpur

of any new location. However there is scope of defining multiple reference considering soil, slope and climatic factors. Minimum and maximum temperature of Amravati and Bider (Maharashtra) are compared with Muzaffarpur (Fig. 2.9).

At Amravati and at Bidar maximum as well as minimum temperature is higher than Muzaffarpur during November to January. Low temperature during this period is crucial for flowering of litchi therefore these areas may not be very suitable as per temperature. Further investigation is required to have assertive answer.

3. Development and Refinement of Integrated Crop Protection Technologies for Improved Productivity of Litchi

3.1. Investigation and management of pre-harvest diseases of litchi

Studies on *Alternaria* disease of litchi

Alternaria alternata caused disease at multiple phenophases of litchi viz., leaf blight in nursery and field, panicle/inflorescence and fruit blight in orchard, and fruit rot/decay at post-harvest stage. Morphological and molecular characterization of the four isolates (3 leaf blight and one fruit rot causing isolate) was done. Cross infectivity of these isolates at different phenophases was observed in the pathogenicity test, however the level of virulence differed. Disease incidence and severity of panicle and fruit blight vis-à-vis prevailing temperature and humidity in orchard, and viability of the pathogen on leaf debris at monthly interval was monitored.

Incidence and severity of leaf blights in nursery plants during February 2016 is given in Table 3.1. The disease incidence ranged between 22.29 to 49.52% while PDI among infected plants ranged between 34.4-77.8%. Disease incidence of panicle blight in farmers' field during 2015 was 2.5-37.5% in cv. 'Shahi' while in cv. 'China' it was 24.0-88.9%. Fruit blight incidence in cv. 'China' was 40.0 to 78.9% and percent diseased severity index (PDI) was 5.8-78.3 in farmers' fields. In four blocks of cv. 'Shahi' at NRCL experimental farm, 43.1-77.1% plants were found affected with panicle blight. The distribution of plants in various severity categories of panicle blight is given in Table 3.2. Incidence of fruit blight in cv. 'China' at NRCL experimental farm ranged between 14.3-66.7%

Table 3.1.Incidence and severity of leaf blight in nursery plants at NRCL, Muzaffarpur during February 2016

Nursery	Disease incidence (%)	Percent infected leaflets		PDI
		Mean*	Range*	
1	23.64	31.41	16.67 - 56.67	34.4
2	32.65	19.26	9.38 - 30.95	74.1
3	22.29	14.18	9.52 - 20.51	54.8
4	49.52	20.00	14.29 - 31.03	63.3
5	22.75	17.87	9.38 - 25.00	77.8

*Observations of 10 random plants

Table 3.2. Disease incidence and severity of panicle blight at NRCL Experimental Farm cv. 'Shahi' during 2015 season

Block	Disease incidence (%)	% Distribution of plants in various severity categories				
		< 20	20-40	40-60	60-80	> 80
I	77.1	27.0	24.3	16.2	21.6	10.8
II	65.6	19.0	9.5	42.9	23.8	4.8
III	67.2	27.9	30.2	30.2	9.3	2.3
IV	43.1	27.4	32.3	27.4	9.7	3.2

Occurrence of two new leaf spot causing fungal pathogens on litchi

Air-layers (planting material) of litchi raised in pots, and bearing trees in orchard at NRCL experimental farm were found to be infected with two different kinds of leaf spot pathogens, first time during April 2013. Since then, the incidence and severity of these two leaf spots were being monitored. Pathogens were isolated and identified as *Corynespora litchii* and *Pestalotiopsis versicolor*. While former affected younger leaves the latter affected older leaves. In pathogenicity test, disease was reproduced. The disease incidence among trees were between 10-90% and percent infected leaflets were between 1.2-8.0 in case of *Corynespora litchi,* while it was 10-30% and 0.0-3.55, respectively in case of *Pestalotiopsis versicolor*. Therefore, these remained as minor leaf spot pathogens of litchi.

Studies on algal leaf spot of longan

Between July to September of 2014 and 2015, leaves of longan trees were found infected by green algae in the NRCL experimental farm (Fig. 3.1& 3.2).

All the trees in orchard were found infected. Data revealed that percent infected twigs in trees were in the range of 20.0-37.5 while percent infected leaflet was 28.4-57.4. Though the PDI ranged from 13.3 to 20.2, the percent distribution of infected leaflets in different severity categories indicated that lesser number of leaves had more than 20 % of area damaged by algal pustules. The disease was found prevalent during July to September when maximum temperature was 31.7-35.4

Fig.3.1. Symptoms of algal leaf spot on leaves of a longan tree

Fig. 3.2. Photomicrograph of sporangiophores and sporangia (inset: enlarged view of a sporangium)

°C and minimum was 24.6-26.7 °C. Maximum humidity during the period was 82.6-93.6 % while minimum was 39.7-59.7%. It was most prevalent during high humidity, warm and rainy weather. The pathogens reproduced and survived in spots on leaves or stems and in fallen leaf debris. On the basis of morphological and

Table 3.3. Effect of different fungicides on incidence and severity of leaf blight disease under artificial inoculation condition in polyhouse during 2015

Treatment	Treatment details	Dose (in ml or g/l)	Active ingredient dose (%)	Percent infected leaflets		PDI
				Mean	Range	
T_1	Chlorothalonil (75%WP)	2.0	0.15	26.4	4.6-54.6	19.6
T_2	Thiophanate methyl (70 %WP)	2.0	0.14	39.0	0.0-100.0	11.9
T_3	Carbendazim (50%WP)	2.5	0.125	38.6	20.0-56.7	47.3
T_4	Copper oxychloride (50%WP)	2.0	0.10	33.4	0.0-64.7	37.0
T_5	Difenoconazole (25%EC)	2.0	0.05	21.0	0.0-53.4	10.4
T_6	Hexaconazole (5% EC)	2.0	0.01	38.2	23.8-66.7	37.3
T_7	Mancozeb (75%WP)	2.5	0.187	33.6	12.2-48.6	30.3
T_8	Propiconazole (25%EC)	2.0	0.05	27.9	17.6-48.0	42.9
T_9	Propineb (70%WP)	2.5	0.175	28.3	15.9-40.9	40.3
T_{10}	Azoxystrobin (23%SC)	1.0	0.023	24.0	3.2-46.9	10.8
T_{11}	Metiram+Pyroclostrobin (55%+5% WG)	1.0	0.055+0.005	25.1	4.2-50.0	27.3
T_{12}	Mancozeb +Carbendazim (63% +12% WP)	2.0	0.126+0.024	37.7	10.4-66.7	30.3
T_{13}	*Trichoderma viride* NRCL T-01	*	-	43.7	33.3-58.6	31.4
Control	Control (inoculums of *Alternaria alternata*	**	-	80.5	66.7-90.5	89.6

**Trichoderma viride* NRCL T-01@1x10^6 conidia/mL, **Control had inoculums of *Alternaria alternata only* @ 1 x10^6 conidia /mL spray suspension

microscopic characteristics, the algal species was identified as *Cephaleuros virescens* Kunze. Inoculums from naturally infected leaves reproduced typical reddish-rust coloured pustules but no infections occurred following inoculation with pure culture of *C. virescens*.

Evaluation of fungicides, botanicals, antagonists, novel defense activators for management of leaf blight disease caused by *Alternaria alternata*

Twelve different fungicides (copper oxychloride, mancozeb, thiophanate methyl, carbendazim, difenoconazole, hexaconazole, propiconazole, propioneb, chlorothalonil, azoxystrobin, metiram + pyraclostrobin, and mancozeb + carbendazim), two antagonists (*Trichoderma viride* isolate NRCL T01 and *Bacillus subtilis*) and one defense activator (chitosan) were evaluated under polyhouse for management of leaf blight caused by *A. alternata* in nursery plants. One infector plant among plants of each treatment were kept as well as application of conidial inoculums of *A. alternata* ($1x10^6$ conidia/ mL) on plants were done to ensure sufficient disease pressure. Results showed that among the different treatments difenoconazole, azoxystrobin and thiophanate methyl and were most effective having PDI in the range of 10.4-11.9 as against 89.6 in control plants (Table 3.3).

The same set of treatments was tried against panicle and fruit blight disease under field conditions. Similar observations were apparent in their efficacy in controlling fruit blight disease .The disease incidence of fruit blight was 2.73-4.38% in the effective fungicidal treatment as against 22.4% in control trees under natural infection field conditions.

Studies on novel characteristics of *Trichoderma viride* isolate NRCL T-01 standardization of parameters for talc based formulation

Irradiation of conidia of the isolate NRCL T-01 with UV light (40 W, 256 nm) showed that the exposition time up to two minute did not affected viability and growth characteristics. Moisture and temperature *versus* viable *cfu* count in talc based formulation of NRCL Trichoderma was studied and standardized. Initial count and moisture content were $5x10^6$ c.f.u/ml and 10% respectively, which remained almost constant at 4 °C but declined at other temp. when monitored at monthly interval for 6 months. No contaminants were found in the assay. Further, an assessment of biocontrol efficacy of NRCL Trichoderma isolate vis-à-vis commercially available formulation was conducted. The isolate NRCL T01 was found superior than commercially available product under *in-vitro* as well as in pot experiment in controlling *Fusarium solani* and *Alternaria alternata*.

3.2. Investigation and management of insect-pests complex in litchi

Investigation and documentation of insect pests and natural enemies

Conopomorpha sinensis Bradley has been confirmed as major fruit and shoot borer species of litchi using DNA barcode Sequences, while litchi is not a host plant for *Conopomorpha cramerella* which was earlier considered as major fruit borer species of litchi. Among natural enemies' two coccinellids (Seven spotted beetle, *Coccinella septempunctata* and six-spotted zigzag ladybird, *Cheilomenes sexmaculata*) and one predatory bug, *Eocanthecona furcellata* were identified as promising bio-agents in litchi ecosystem.

Seasonal incidence of major pests in litchi

Seasonal incidence of major pests in litchi was recorded from April 2015 to March 2016 at weekly interval. Results revealed that incidence of all major pests were observed throughout the study period except some std. weeks (30^{th}, 31^{st} and 32^{nd} std. week) in case of litchi looper while 30^{th} std. week in case of red weevil and 30^{th} in case of leaf folder with maximum and minimum population in the month of September-October and December-January, respectively. Further, litchi looper and leaf folder population in 2015-16 was comparatively less than 2014-15. Bag worm population was also negligible. Moreover, outbreak of litchi mite was observed during survey at farmer's field and therefore, regular observation is needed for further study.

Seasonal incidence of major pests in longan

A field trial was conducted to study the diversity of insect pests associated with longan crop. Study revealed that the insect pests' incidence was less as compared to litchi. However, litchi fruit borer, *Conopomorpha sinensis*; litchi leaf folder, *Platypeplus aprobola*; litchi looper, *Perixera illepidaria*; ash weevil, *Myllocerus undecimpustulatus* and red weevil, *Apoderus blandus* was observed regularly with fewer population. Some unidentified lepidopteran defoliators, beetles and weevils were also observed during investigation. Interestingly, no infestation of bark eating caterpillar, *Indarbela* sp. and litchi mite, *Aceria litchii* was observed on longan crop, needs to be conformed through further study.

Development of IPM modules against litchi weevils

Among litchi defoliators besides lepidopteran (litchi looper and leaf folder) weevils (ash weevil, *Myllocerus undecimpustulatus* and red weevil, *Apoderus blandus*) are also causing serious damage to litchi leaves, especially in growing orchards. Ash weevil preferred older leaves while red weevil newly emerged leaves and therefore more severe than ash weevil. Hence, field trial was conducted to develop the eco-friendly approaches for managing litchi weevils. Spray of chemicals was done during September and October. In case of ash weevil, thiamethoxam 12.6% + lambdacyhalothrin 9.4% (0.098%) was highly effective with 0.00 population against 10.67 in control followed by chlorfenapyr 10 EC (0.03%) and imidacloprid 17.8 SL (0.0089%) as registered 0.33 and 1.67 weevil population, respectively after three days of spraying. Similarly, thiamethoxam 12.6% + lambdacyhalothrin 9.4% (0.098%) was also highly effective against red weevil with 0.00 population against 11.33 in control followed by chlorfenapyr 10 EC (0.03%) and imidacloprid 17.8 SL (0.0089%) as registered 0.67 and 1.33 weevil population respectively after three days spraying.

Integrated management of litchi mite

A field trial was conducted at farmers' field for management of litchi mite. Seven treatments comprising pruning of affected twigs (July & October) and miticides (chlorfenapyr & propargite) sprayed twice in July and once in October were imposed to evaluate the efficacy of various integrated approaches. Results revealed that reduction over initial infestation ranged from 49.67 to 97.0%. Highest reduction of mite over initial observation (97.0%) was recorded in pruning of affected twigs followed by two spraying of chlorfenapyr 10 EC (0.03%) at 10 days interval during July and again pruning in October with one spraying of Chlorfenapyr which was closely followed by spraying of propargite 57 EC (0.17%).

4. Integrated Postharvest Management to Reduce Losses, Improve Marketing and Product Diversification

4.1. Investigation and management of postharvest losses in litchi

Isolation of potential antagonists from fruit-plane

Four *Bacillus subtilis*, two isolates of antagonistic yeast were recovered from healthy fruit-plane of litchi during 2015. The identification was based on colony growth on specific medium, microscopic observations and physiological characteristics consulting with published Keys and Monograph. The cells of *B. subtilis* were rod-shaped, Gram positive. The colony was circular, with ragged edges, cream or white in colour. The bacteria spread out from the centre, keeping the ragged circular shape of the colony. It was catalase-positive and did not hydrolyze casein. It formed endospores and was a facultative aerobe. The colony of isolates of yeasts were white, creamy ovoidal. They showed a positive reaction for lipase activity. All yeast isolates showed budding as their mode of asexual reproduction. The yeast counts obtained in this study were relatively high (10^4 to 10^6 CFU/fruit). The axenic culture of these is being maintained in Plant Pathology laboratory at NRCL, Muzaffarpur

Effect of antagonists on fruit rots and shelf life of litchi

Individual antagonist was tested by dip treatment to control fruit rots arising out of natural inoculums at ambient conditions (36±2 °C temperature and 76±6% R.H.) during 2015. The treatments were same as previous year except three new combination treatments *viz.*, BS-1+ BS-2 + BS-3 + BS-4+ BS-5, Y-1+Y-2, and BS-1+ Y-1+ NRCL T-1 (Fig. 4.1). The results indicated that though all the antagonists could significantly inhibit pathogen development (fruit rots and PDI) as well as they checked browning of fruits. Treatment with antagonists also resulted in lower fruit rot, decay and percent disease index. Among these antagonists, against

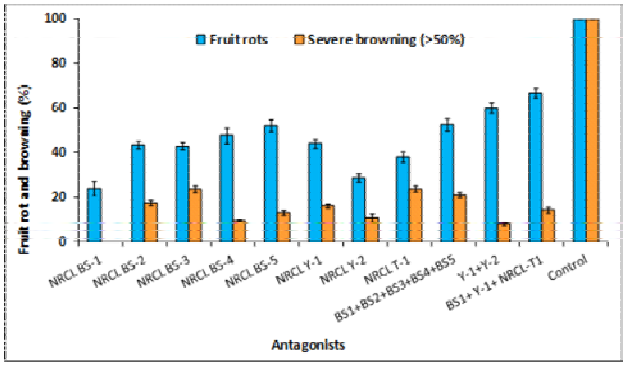


Fig. 4.1. Effect of treatments with antagonists on fruit rots and browning of litchi fruits during 2015; data presented is cumulative values six-day after treatment

B. subtilis isolate NRCL BS-1 was found the best. The combination treatments of antagonists were not found superior to individual treatments.

Effect of various postharvest dip treatments on fruit rots of litchi

Since *Bacillus subtilis* isolate NRCL BS-1 proved to be superior it was further tasted in combination with other postharvest treatment during 2015 for their efficacy in controlling fruit rots and shelf life. The same experiment of previous year was repeated and one more defense activator, salicylic acid with three combination treatments was evaluated. Results of experiment showed that out of 16 treatments, T_1 [*Bacillus subtilis*] T_{12} [*Bacillus subtilis* + salicylic acid] and T_8 [*Bacillus subtilis* + carbendazim] were highly effective in controlling litchi fruit rots as it showed 0% fruit rotting after 4th day, 5-10% rotting on 6th day and 25-40% rotting on 8th day after treatment as compared to 40.0% and 93.3% and 100.0% rotting after 4th, 6th and 8th day after treatment, respectively in the control (Fig. 4.2). Results showed that various dip treatments had not only significantly reduced the fruit rot incidence but also percent fruit area covered by the pathogen *i.e.* PDI was reduced. In absence of the biocontrol treatment, usually *Alternaria alternata* has been a dominating pathogen of fruit decay. The

pathogen frequency data showed that treatment with *Bacillus subtilis* had more effectively controlled *A. alternata* and hence occurrence of other pathogens (frequency) were more, particularly *C. gloeosporioides*.

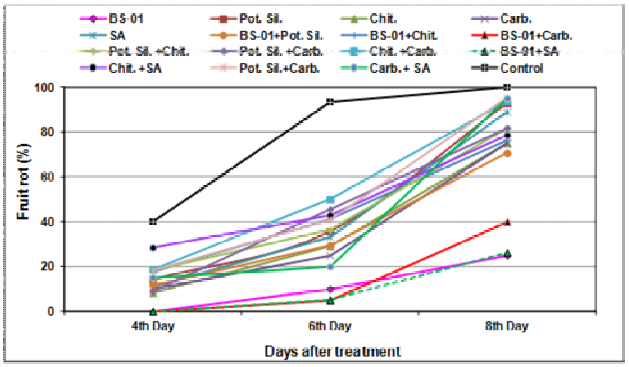


Fig. 4.2. Effect of various postharvest dip treatments on litchi fruit rots during 2015

Evaluation for preventive ability of antagonists against fruit rots of litchi

Litchi fruits were treated by dipping them into 70% alcohol for one minute, dried, and then dipped into a suspension of antagonist cells (1×10^8 cells /ml) for 1 minute. Three hours after drying, each fruit was sprayed with one ml of a conidial suspension of the pathogen species at 1×10^6 conidia/ml, adjusted using a haemocytometer. Two controls were maintained, in positive control fruits were sprayed with conidial suspension of pathogen and in the negative control fruit were sprayed with 1 ml of sterile distilled water. The results showed that though all the antagonists had reduced the incidence of fruit decay (fruit rot) caused by *A. alternata*, the isolate of *B. subtilis* BS-1 and the *Trichoderma viride* isolate NRCL T-01 had completely controlled the pathogen as zero percent incidence and PDI was observed as against 100 % in control treatments. The other antagonists could only partially overcome the pathogen because the inoculums load of pathogen being too high. In case of *Colletotrichum gloeosporioides,* isolate BS-4 and BS-5 significantly reduced fruit rot as well as PDI. In case of *Aspergillus flavus* isolate BS-3, BS-5, Y-2 and combination treatments (BS1+ BS2 + BS3+ BS4 + BS5), (Y-1+Y-2) showed good result and inhibited fruit rot and PDI significantly. The most effective isolates against *Aspergillus niger* were BS-1, BS-2, BS-3 and Y-1.

Evaluation for curative ability of antagonists against fruit rots of litchi

Similar procedures, as described for preventive ability were followed however; litchi fruit were dipped in suspension of pathogen cells (1×10^6 cells/ml) before treatment with each antagonist. The results of the study indicated that all the antagonists were effective against *A. alternata* reducing incidence as well as PDI, the most effective isolate being BS5 and yeast isolate (Y1+Y2) (Fig. 15). Against *C. gloeosporioides*, *B. subtilis* isolate BS5, yeast Y1 and Y2 was most effective while for *A. flavus,* all the antagonists were effective though the level of control was low except in combination treatment of *B. subtilis* viz., (BS1+ BS2 + BS3+ BS4 + BS5) and yeast isolate Y2. None of the isolates could completely control fruit rot (decay) incidence by *A. niger* but significantly reduced fruit rot and PDI as compared to control. The results of the study clearly showed that use of a combination of antagonists will be a better option to manage fruit decay of litchi.

Evaluation of pre and postharvest treatments for enhancing quality and shelf life of litchi fruits

An integrated package was evaluated for improving quality and shelf life of litchi fruits. Better shelf life and less fruit rots were observed with treatment of *B. subtilis* isolate BS-1 which was at par with carbendazim (0.1 %). Based on the results of last two years, an integrated packagae was developed which consisted of preharvest spray of boron @0.4 g/L (30-40 days after fruit set), GA_3 (100 ppm) + carbendazim (0.1 g/L) at 40-45 days after fruit set) and foliar spray of potassium suphate (1%) 10 days before commercial harvest. At post harvest stage package included bringing harvested fruits to the pack-house within 2 hrs, sorting, grading, precooling followed by dip treatment with *B. subtilis* ($1x10^8$ cfu/ml) for 5 min or with chitosan (1%) for 10 min. followed by air drying and packing in perforated polythene bag (40 µm) and keeping in CFB Box (5, 7, or 9 ply) for transport to distant market.

Postharvest storage behaviour of litchi

Delay in postharvest interventions can have drastic repercussions on fruit quality. The present experiment was conducted to study the consequence of delay in management techniques after fruit harvest. Harvested litchi fruit were stored under ambient conditions (32±3°C; 80±5% RH) and storage behaviour of the fruit and related physico-biochemical changes were studied. Rapid and continuous loss in weight was recorded and within 48 hours stored litchi fruit had 17.83 per cent loss in weight (PLW). The initial weight loss occurred from the pericarp and not from the whole fruit. Therefore, the 1.66% PLW after two hours in actual sense represented a loss of 11.22% from the pericarp (Fig. 4.3 & Table 4.1). Subsequently, representative PLW from pericarp after 24 hours was 104.08% indicating moisture loss from aril tissue has commenced. An 11.22% representative PLW from pericarp tissue could therefore explain desiccation and rapid browning of litchi after harvest. Such high level of desiccation was further evident in quick decline of membrane stability index (MSI). Fresh harvested litchi fruit recorded an MSI of 82.15 which dropped through 78.81 after 10 hours to 39.58 after 24 hours (Fig. 4.4). Postharvest interventions aimed to reduce loss of fruit quality should begin immediately after fruit harvest.

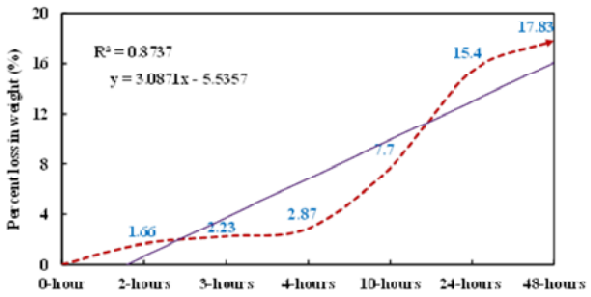


Fig. 4.3. Effect of time on PLW after harvest

Table 4.1. Effect of time after harvest on PLW, AWL and % weight of pericarp

Time after harvest (h)	PLW (%)	Actual weight loss (g)	% weight of pericarp
2	1.66	0.35	11.22
3	2.33	0.49	15.75
4	2.87	0.61	19.40
10	7.70	1.63	52.04
24	15.40	3.27	104.08
48	17.83	3.79	120.51

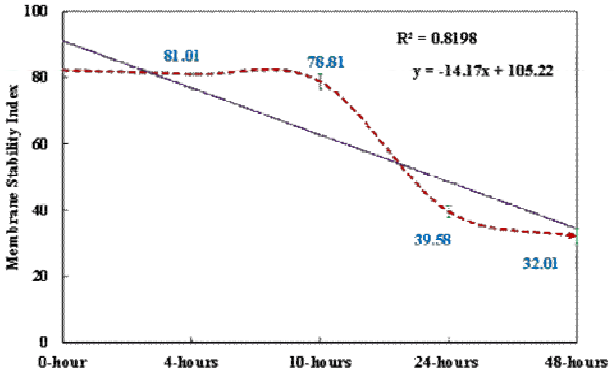


Fig. 4.4. Effect of time on membrane stability index after harvest

4.2. Processing and value addition in litchi studies on preservation of litchi pulp

Optimization of osmo-mechanical dehydration techniques for litchi pulp

The highest overall acceptability (9.22) with minimum hardiness (2853 g) and drying time (15.00 hrs) were recorded with T4 (pulp: soln. ratio of 1:4, osmotic dehydration at 60 °C) followed by T5 (9.08). Under these treatments the water loss rate was high and dehydration time was also found less as compare to other treatments. .

4.3. Influence of polyamines on pheno-physiological attributes and fruit quality of litchi

The 'Shahi' and 'China' litchis were sprayed with putrescine (0.5mM) and spermine (0.5 mM) at three stages i.e. one month before anthesis, full bloom stage and initial fruit set stage.The average length of panicle of Shahi litchi cultivar (45 cm) and China litchi cultivar (30 cm)was not significantly influenced by the putrescine (0.5 mM) and spermine (0.5 mM) treatments. The initial fruit set was as high as 90 and 60 fruits per panicle in Shahi and China litchi cultivars. However, the high fruit drop rate during the initial period resulted in about 10 and 15 fruits per panicle, respectively in Shahi and China litchis. The approximate number of total flowers in the panicles of 'Shahi' and 'China' litchi cultivars ranged from 700 to 1100 and 500 to 800, respectively.

5. Improving knowledge and skill of stakeholders for increasing production of litchi

5.1. Tribal Sub Plan Project

Kashipur block of Rayagada district of Orissa was chosen as the location for the R&D activities where 86% of the population is rural out of which 55.71% belongs to Scheduled Tribes and 13.95% Scheduled Caste. The economy of tribals in target area is based on output from shifting cultivation and forest including some other alternative livelihood options. Agriculture and forest, being important livelihood options, a significant proportion of tribal is engaged in such practices. More than 60% lands in the target area are high lands. The agro-climate of target area is very favourable for long (mango, litchi, cashew) and short duration (papaya and pineapple) fruit crops. February to late April is the months when food is sufficient to cater the need of many families. Normally, most of the families face food scarcity in the month of May to mid August. Mango and litchi comes under maturity from mid May to mid July in the area. As an age old tradition, horticultural crops are key assets during food shortage period in the area.

Forty three acre area has been taken under plantation for mango and litchi at Bandel village of Rayagada district of Odisha. Mango and litchi plantation has been done in selected village of the project. Infrastructure of irrigation facilities and fencing has been created at the site. Four additional tribal villages under Harnatand and Parsauni panchayat of West Champaran district of Bihar have been surveyed after which Bakwa Chandraul and Parsauni villages have been finally selected. Interaction programme has been held in collaboration with personnel of state department of agriculture and baseline data related to socio-economic and agro-techniques has been generated.

5.2. North Eastern Hill (NEH) Region: R&D project on litchi

Tripura, Nagaland, and Assam were undertaken for the strategic activities under the NE Region R&D project. Interactions with scientists, and state officials held on technical aspects of litchi area expansion and rejuvenation of old senile orchards. Various meetings for strategic technological interventions/ implementations of canopy management, rejuvenation of old senile trees have been successfully organised in Tripura.

6. Flagship Projects

6.1. Postharvest management with respect to pericarp browning and fruit decay

Evaluation of pre and postharvest treatments for enhancing quality and shelf life of litchi fruits cv. Shahi

The litchi fruits were sprayed one month after full bloom with two different PGR namely, GA_3 and Cytokinin and 2nd spray was done one week before commercial harvesting date with four different anti-microbial compounds to study the effect on quality and shelf life. Pre-harvest spray of GA3 + carbendazim gave maximum healthy fruits (89%) followed by GA3 + B. subtilis@1 × 10^8cfu (82%). Whereas, control gave only 43% healthy fruits. Under postharvest dip treatment, Chitosan (1%) + *B. subtilis*@1 × 10^8 cfu or carbendazim (0.2%) or salicylic acid (1%), has been found effective in maintaining the quality of the fruits and enhanced shelf life up to 5th days at ambient condition and 18 days at refrigerated condition.

Studies on physical, anatomical, physiological, and biochemical basis of pericarp browning in litchi

Growth and development of litchi fruit was recorded in litchi cv. Shahi throughout the fruit development period. Continuous growth of fruit was reflected in increase of fruit weight from 0.85 g about 25 days after fruit set (corresponding to 13 April) to 21.29 g at harvest (26 May). At initial fruit development stage, litchi fruit is composed of pericarp and seed measuring on an average 1.28 g and 0.41 g, respectively. Aril development commences about one month after fruit set (19 April), and aril growth is slow for the initial 10-12 days after which there is exponential growth of the aril tissue. There is increase in weight of pericarp from 1.28 g one month after fruit set to 3 g at harvest; the corresponding figures for aril and seed being 0 to 13.64 g and 0.41 g to 4.66 g, respectively. The contribution of pericarp to fruit weight at harvest is about 14.09%, a sharp decline from the initial 76%. Due to rapid growth of seed during the initial fruit development period the contribution of seed towards fruit weight increases from 24.10% to 50.03% between 30 and 40 days after fruit set. Thereafter, the per cent contribution of seed towards fruit weight decreases gradually to settle at 21.86% at harvest. From the commencement of aril formation until harvest, there is increase of about 13.64 g which reflects continuous increase in per cent contribution up to 64.05% of total fruit weight. Fruit length increases up to 3.75 cm and fruit width (diameter) up to 3.15 cm in Shahi fruit (Fig. 6.1 & Fig. 6.2).

Soluble solids concentrate (SSC) increased from 11.2 °B to 19.5 °B while titratable acidity declined from 6.06 to 0.36% during fruit development and maturity. Thus, the SSC/Acidity value increases from 1.85 at initial stage to about 53 at harvest stage of the fruit. Total phenolics in litchi pulp decreased from 469.12 to 42.35 mg GAE/100 g (FW) whereas the anthocyanins content of pericarp increased from 9.58 to 34.37 mg/100 g (FW) during fruit development (Fig. 6.3). Anthocyanins biosynthesis and accumulation in pericarp tissue commenced around 20-25 days after fruit set. Chlorophyll 'a', in pericarp reduced from 0.83 to 0.43 mg/g and total carotenoids also decreased from 0.29 to 0.15 mg/g during fruit development. Degradation of chlorophyll and accumulation of anthocyanins at later stage of fruit development are, therefore, responsible for loss of green colour and reddening of litchi skin.

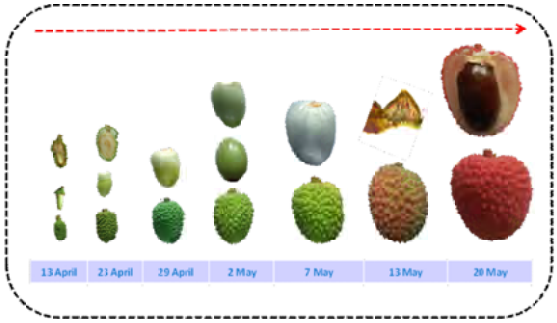


Fig. 6.1. Pictorial representation of fruit development in litchi cv. Shahi

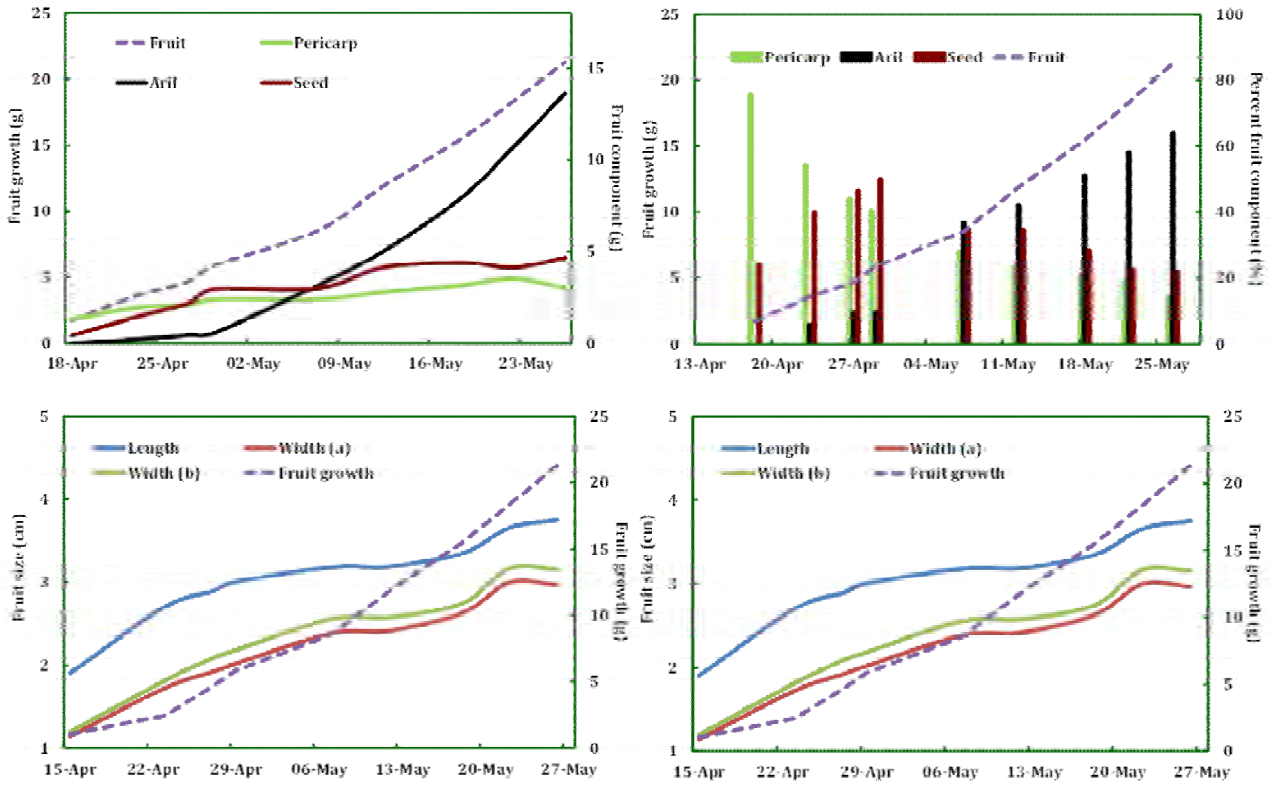


Fig. 6.2. Fruit growth dynamics in litchi cv. Shahi

Studies on hydro-cooling in litchi

An experiment was conducted to determine the optimum temperature and time for effective hydro-cooling to enhance shelf life and quality of litchi fruit. Litchi fruits were subjected to hydro-cooling treatments at 5 and 10°C for 30 min. Fruit that were not hydro-cooled constituted control. Freshly harvested litchi fruit were dipped into containers containing cold water at 5 and 10°C. Post treatment the fruit were surface-dried, packed in unsealed polymeric films, placed in plastic punnets and stored under refrigerated conditions (6±1°C, 80-90% RH). Fruit quality parameters were recorded at 0 and 16th day after storage. There was rapid initial decrease in pulp temperature, but in both cases further decline was not recorded after 15 min. Between 15-30 min, the temperature stabilized around 11°C and 13°C, respectively, for treatment at 5 and 10°C (Fig. 6.4).

Temperature reduction through hydro-cooling

Significant control of desiccation was observed in hydro-cooled fruits. The least PLW (5.10% and 7.14%) was recorded in fruits hydro-cooled at 5 and 10°C after 16 days of storage, whereas control fruits recorded 19% PLW. Fruit hydro-cooled at 5 and 10°C recorded significantly higher MSI, 66.90 and 65.88 respectively, compared to 31.42 in control on the 16th day of storage. The highest marketable fruits (54.74%, <50% browned fruit) was noticed in fruits hydro-cooled 10°C followed by those at 5°C (40.87%) after 16 days, while in control all fruit became unmarketable (>50% browned fruit surface). Fruit hydro-cooled at 5°C maintained significantly higher titratable acidity over control and fruit treated at 10°C during the storage period (Fig. 6.5). No significant differences were observed among treatments

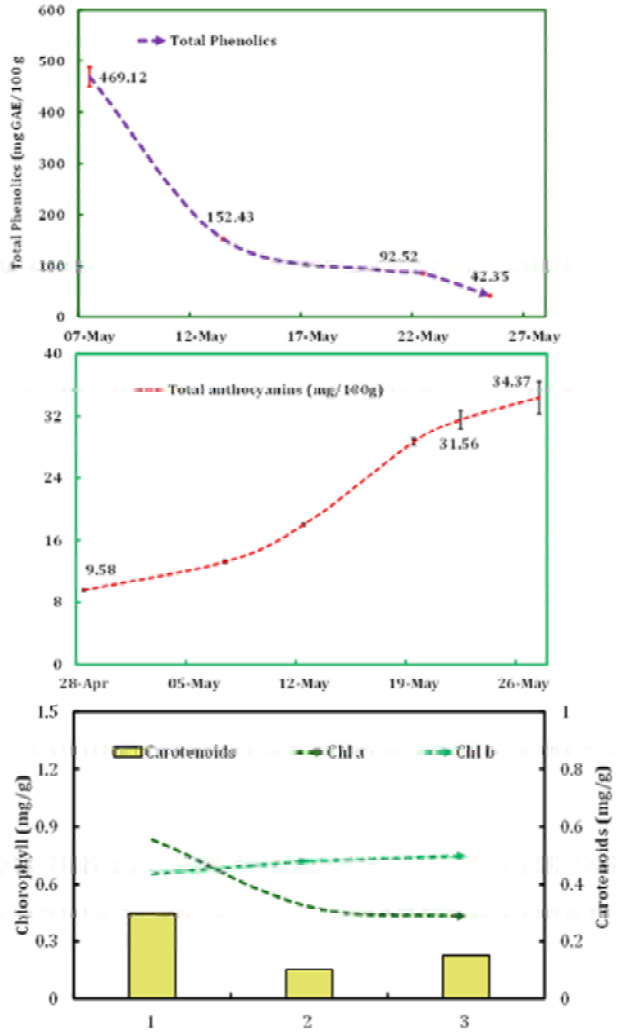


Fig. 6.3. Changes in total phenolics of pulp, total anthocyanins, chlorophyll a & b, and total carotenoids of litchi pericarp during fruit development of Shahi litchi

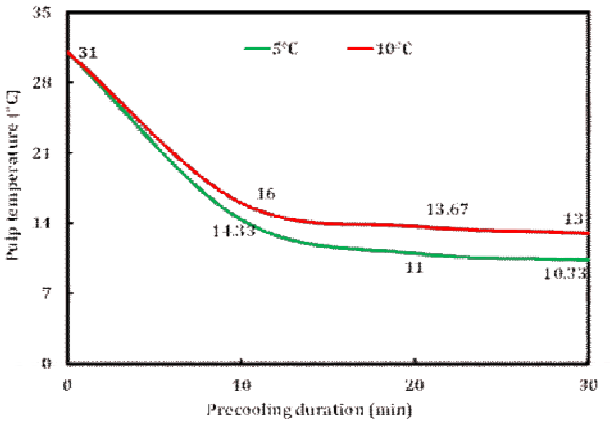


Fig. 6.4. Effect of precooling period on pulp temperature of litchi fruit

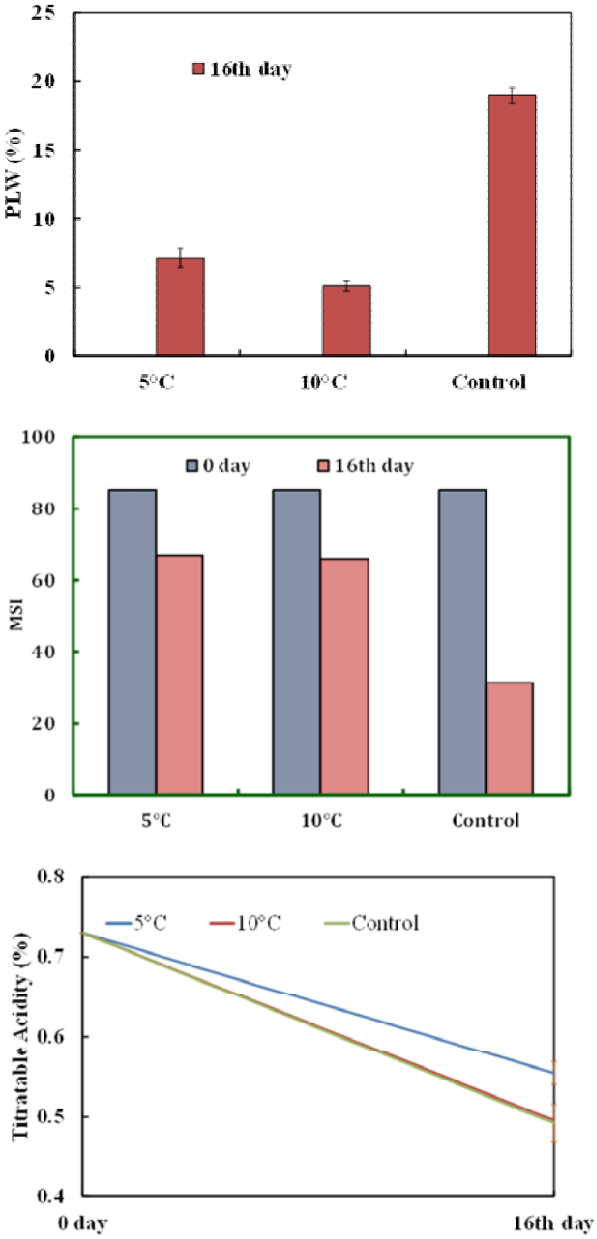


Fig. 6.6. Effect of storage temperature and period on PLW, MSI and acidity of litchi fruit

with respect to soluble solids concentrate (SSC), and total phenolics content of fruit pulp. Hydro-cooling at 10 °C for 20 minutes was found to be a suitable temperature-time combination for effective hydro-cooling of litchi fruit.

Salicylic acid maintains membrane stability and reduces pericarp browning in litchi

Rapid pericarp browning generates unmarketable litchi fruit leading to huge postharvest losses to growers and traders. Salicylic acid (SA) at three different concentrations (0.4, 0.8, and 1.2 mM) was tested as a postharvest dip treatment to ascertain the effect on fruit quality and storage behaviour of litchi. Freshly harvested litchi fruit cv. Shahi were dipped in the solutions, maintained at 10°C, for 20 minutes, and thereafter surface dried before packing in perforated and unsealed polythene bags. They were then stored under refrigerated conditions (6±1°C and 80-90% RH). SA-treated (1.2 mM) fruit maintained significantly higher membrane stability index (78.44) compared to control (67.64) over 22 days of storage. SA treatment also resulted in maintenance of higher anthocyanins content compared to control during storage. Untreated fruit had hardly 12.5% marketable fruits (Â 50% browning) after 18 days. The corresponding figure in case of SA-treated (1.2 mM) fruit was 68%, thereby indicating that SA treatment helps in reduction of pericarp browning in litchi. Also, the incidence of decay was only 6.25% in fruit treated with 1.2 mM SA, a significant reduction in decay from control (43.75%) after 18 days of storage. No significant differences due to SA treatment were recorded with respect to changes in fruit quality parameters such as soluble solids concentrate and titratable acidity. Salicylic acid @ 1.2 mM can be integrated as part of hydro-cooling of litchi fruit to reduce pericarp browning and fruit decay.

6.2. Shoot physiology in relation to flowering and fruiting of litchi

During 2015-16, we found that in 'China litchi', floral shoot had higher *chlorophyll a* during May over August and again increased during November ('Shahi' showed continuous reduction from May onwards). The non floral shoots had shown increasing trend of *Chl b*, *Total Chl* from May to November. In 'Shahi' litchi, floral

Table 6.1. Variation in biochemical parameters in floral and non-floral shoots during different growing period

Variety	Type of Shoots	Chlorophyll a (mg 100 g^{-1})			Chlorophyll b (mg 100 g^{-1})			Total chlorophyll (mg 100 g^{-1})		
		May	Aug.	Nov.	May	Aug.	Nov.	May	Aug.	Nov.
China	Floral	3.54	2.01	2.61	3.34	4.27	1.84	6.89	6.29	6.22
	Non Floral	2.45	3.38	3.26	2.11	2.17	2.18	4.57	5.56	6.51
Shahi	Floral	6.26	2.93	2.69	1.62	2.63	1.91	7.89	5.57	6.46
	Non Floral	5.04	1.97	3.26	1.93	2.80	1.97	6.99	5.78	6.70

Table 6.2. Variation in leaf gaseous exchange parameters in floral and non-floral shoots (after harvesting and flowering)

Variety	Type of Shoots	Photosynthetic rate (m mol CO2) m^{-2} s^{-1})		Transpiration rate (m mol H_2O ·m^{-2} ·s^{-1})		Internal CO_2 Concentration (m mol CO_2 mol^{-1} air)		Stomatal Conductance (m mol(H_2O) m^{-2}s^{-1})		Leaf temperature (^{0}C)	
		Vegetative phase	Floral phase	Vegetative phase	Floral phase	Vegetative phase	Floral phase	Vegetative phase	Floral phase	Vegetative phase	Floral phase
China	Floral	12.90	2.24	7.90	0.94	338.00	310.00	48.96	34.66	32.90	35.00
	Non Floral	9.70	2.36	8.90	1.35	357.66	199.00	51.90	27.13	33.36	33.95
Shahi	Floral	8.36	2.85	6.83	1.35	325.00	235.00	29.06	41.33	35.80	35.15
	Non Floral	7.60	2.29	5.60	1.04	319.66	238.00	29.23	42.83	34.56	34.75



shoots has reduced *Chl b* and *total chl* status during November month. The content of *Chl b* reduced during November month in floral and non-floral shoots. 'Shahi' litchi had more concentration of *Chl a* and *Chl b* in the leaves over cultivar'China' (Table 6.1).

While studying gaseous exchange parameters, it was found that 'China' litchi has lower photosynthetic rate (*Pn*), transpiration rate (*e*), internal CO_2 concentration (*Ci*) and stomatal conductance (*gs*) than 'Shahi' litchi. Leaf temperature (*TL*) found to be higher in 'Shahi' litchi than 'China' litchi, that latter had bushy appearance of terminal shoots. Floral shoots had more *Pn*, *e* but less *Ci*, *gs* over non-floral shoots in both the cultivars. The stomatal conductance had increased from vegetative phase to floral phase in '*Shahi*' litchi but there was reverse trend in 'China' litchi, like wise *Ci* reduced during floral phase over vegetative phase. The *Pn* and *E* drastically reduced during floral phase over vegetative phase in both the cultivars. (Table 6.2).

Leaves of floral and non-floral branches had reflected significant variation in bio-chemical status and it was observed that '*China*' litchi had lesser content of total carbohydrate (total CHO) and reducing sugar (RS) content than '*Shahi*' litchi. The total CHO and RS content increased from FBD stage to flowering stage but in contrast the proline and phenol content was reduced during same period (Table 6.3).

Table 6.3. Leaf biochemical status in floral and non-floral shoots (during FBD and Flowering stage)

Variety	Type of Shoots	Total Carbohydrate Content (%)		Reducing Sugar (%)		Proline content ($\mu g\ g^{-1}$)		Total Phenol Content (mg 100 GAE)	
		During FBD stage	Flowering stage	During FBD stage	Flowering stage	During FBD stage	Flowering stage	During FBD stage	Flowering stage
China	Floral	4.12	4.38	3.00	3.09	39.53	33.27	36.97	35.17
	Non Floral	4.19	4.41	3.04	3.27	39.93	32.94	38.98	35.11
Shahi	Floral	4.24	4.40	3.05	3.24	40.57	34.48	38.16	35.11
	Non Floral	4.21	4.40	3.06	3.23	39.91	34.61	38.19	36.03

7. Externally Funded Projects

7.1. Development of National Database on Mango

During 2015-16, the data was collected from different districts of Bihar and Jharkhand for district level information such as name of farmers who grow and maintain more than ten mango varieties in their orchard, fruit usage, methods of value addition, medicinal usages and cultural practices followed in the orchard. The database on medicinal practices and TKs, major diseases and pests of mango and prevalent protection measures, harvesting season and prevalent harvesting and packaging practices were also collected. The prescribed Part -1 and 2 format has been filled up for 10 district of Bihar (i.e. *Banka, Begusarai, East Champaran, Gopalganj, Jehanabad, Katihar, Purnea, Siwan,*and *West Champaran*) and 1 District of Jharkhand (Gumla).

So far 110 custodian farmers (cultivating more than 10 mango varieties) from northern and eastern parts of Bihar have been identified. Most of the custodian farmers were from 15 districts i.e. *Banka, Begusarai, Bhagalpur, Darbhanga, Gopalganj, Khagaria, Muzaffarpur, Katihar, Purnea, Samastipur, Saharsa, Supaual, Vaishali, West Champaran* etc. which shows intensive mango orcharding in the district.

No much variation in pests and diseases management practices and methods of processing practiced by farmers except varietal diversity has been recorded. There was limited use of fruits for medicinal purposes across the surveyed area. Blue Bull, dieback, mango malformation, Stem borers, mealy bugs, black tip, were major problems of mango orchard in the area. We had shared photographs of 10 commercial mango varieties grown in Bihar to the Nodal Office of the Project at CISH, Lucknow.

Mango growers of *Gumla* district of Jharkhand are practicing organic mango production where as at, other places both inorganic and organic inputs are common. '*Amrapali*' and '*Mallika*' is doing exceedingly well in the district (Table 7.1).

After detailed discussion with concerned District Horticultural Officers and Programme Co-ordinators KVKs of various districts as well as interaction with mango growers, a set of questionnaire was filled to update database on aforesaid parameters. It was found that *Jarda*, *Jardalu* and *Bombai* is the main sucking varieties, *Malda* is main table and *Sukul, Gulabkhas,* and *Fazli* are the main pickling varieties in the region. Malda (viz. Langra) is prominent variety in almost all 30 districts of Bihar and *Jardalu* is very popular in Bhagalpur district. 'Jarda', 'Maldah', 'Bombai', 'Kishanbhog' as early, 'Sipia' 'Kalkatia Malda (syn. 'Dalma')', 'Sabuja' (sweet at unripe), as mid and 'Bathua', 'Sukul' 'Fazli', as the late varieties are mainly grown by the farmers.

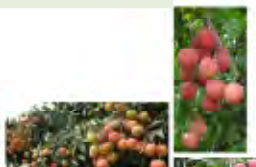
'Baelkhas' (fruit and leaves had *bael* flavour) and 'Raja' (sweet and easiest to digest), mango of *Gopalganj*, 'Kerwa' (large sized fruit), 'Tairia' (heavily fruited), 'Bhastara' (bearing twice in a year) mango of *Siwan*, 'Latkampu' mango of *East Champaran*, 'Hajipur Mithui' (thick peel, better shelf life), 'Madhukupia' and 'Baramasi' of *Samastipur* were observed as unique mango varieties in surveyed districts (Table 7.1). Up to 36, 28, 25, 22 varieties of mango are being maintained in one orchard of *Samastipur, West Champaran, Katihar, East Champaran districts*, respectively.

While surveying it was observed that young plant mortality, drying of 'Sipia' mango, dieback, mealy bug attack, were main reason for poor yield. There was no market for rare varieties and severe theft of fruits from the orchards. The irrigation facility is not available and small plants are grazed by goats. Labour scarcity for various agricultural operations was another area of concern.



Table 7.1. Custodian farmers of mango of various districts of Bihar and Jharkhand with unique local variety

Sl. No.	Name of District	Block	Village	Name of custodian farmer	No. of trees in his orchard	No. of mango varieties grown	Unique mango variety with remarks
				Bihar			
1.	Begusarai	Matihani	Badalpura	Sri. Ram Raghwendra Deo	105	10	Dhudhia Maldah (excellent demand in the market) Alphanso
2.				Sri. Aamnai Narayan Singh	90	11	Malda (dieback is affecting plantation)
3.				Sri. Sanjeev Kumar	110	10	Dhudhia Maldah (dieback is affecting plantation), Dashehari
4.				Sri. Rajnandan Rai	95	10	Jardalu, Jarda, Mallika, Dashehari
5.		Cheria Bariyarpur	Siuri	Sri. Mukaesh Kumar Rai	85	10	Himsagar, Chausa
6.			Manjhaul	Sri. Sandeep Prasad Singh	75	10	Alphanso, Himsagar, Dashehari
7.				Sri. Gajendra Pratap Singh	140	11	Dhudhia Maldah (dieback is affecting plantation) Jarda, Jardalu
8.		Nawa Kothi	Chhatauna	Sri. Pawan Kumar Singh	125	11	Navras (with 9 flavour) Mithua (unripe is also sweet)
9.	East Champaran	Sangrampur	Jalahan	Sri. Pankaj Kumar Singh	250	26	Bahufasali Aam (bear twice in a year)
10.		Kesaria	Sarotar Bazar	Sri Vikash Kumar Singh	500	11	Bahadura (big sized fruit) Sabja (Earliest)
11.				Sri. Raju Pandey	600	12	Dalma (Calcuttia Malda)
12.	Gopalganj	Uchkagaon	Dahibhata	Sri. Rajeev Nayan Tiwari	600	16	Baelkhas (flavour like bael) Rohinia (early maturity) Sabuja (earliest to mature) Raja (easy to digest)
13.	Katihar	Kodha	Rautara	Sri. Kalidas Banerjee	450	25	Chitranjan Jalmarai (late maturity), Lamba Bahadur (for size), Hilsa Peti (ideal sized)
14.		Hasanganj	Rampur Kamat	Sri. Sameer Kumar Jha	400	16	Esna (latest maturity) Chauria (early maturity) Navras (with 9 flavour)
15.		Katihar Sadar	Bhawara Kothi	Sri. Amresh Kumar	1500	17	Bael Khas (bael flavour), Kesar, Goa mankurad , Totapari
16.	Purnea	Jalalgarh	Chauhan Tola	Sri. Kumar Tarun	140	22	Suryapuri (Scented variety) Jethua (early maturity) Kaal Pahad (thin peel) Jingjing (sucking variety) Koitur ('Malda' like taste)
17.				Sri. Sanjeet Kumar	25	15	Jalmarai , Chitranjan , Suryapuri , Navras
18.	Siwan	Goriakothi	Sani Basantpur	Sri. Santosh Kumar Singh	80	12	Tairia (unripe fruits are also sweet) Kerwa (banana like shape) Baaljee
		Basant Pur		Sri. Ashok Kumar Singh	110	15	Bhastara (bearing twice in a year) Baramasi (obtained from Bangladesh)
				Jharkhand			
19.	Gumla	Ghaghra	Saranga Mohanpur	Sri. Shivbilas Uraon	140	10	'Gulabkhas' Dashehari, 'Mallika' under organic farming



7.2. Livelihood and Nutritional Improvement of Tribal Farm Women through Horticulture

Bakwa Chandraul and Parsauni tribal village of West Champaran district of Bihar were selected. Training cum awareness programme on "Importance of Kitchen Gardening and Value addition" has been organized at the village. On the basis of interaction with tribal women altogether 60 women farmers have been selected and base line survey of both the village and selected beneficiaries has been done. Kitchen garden kit containing seeds of summer vegetables viz. Cowpea (Kashi Kanchan/Nidhi), Bottle gourd (Kashi Ganga), Pumpkin (Kashi Harit), Okra (Kashi Pragati) were distributed to the selected tribal women. On-farm demonstration on land preparation, sowing technique of okra, bottle gourd and pumpkin has also been done.

Interaction of scientists with tribal farm woman

7.3. Studies on effective utilization of interspaces in young bearing litchi orchards for income and soil health improvement (ATMA)

Performance of main and intercrops: The crops in combination were undertaken during the *Kharif* and *Rabi* season of 2015. Excellent performance of Turmeric, Potato and Maize has been recorded. The good flowering and fruit set has been observed in the litchi fruits. The tuber yield of turmeric and potato were harvested 116.16 q/ha of and 140.62 q/ha, respectively.

7.4. Consortia research platform (CRP) on borers

Identification and phylogenetic analysis of fruit borer species using DNA barcode Sequences

One of the major constraints in formulating the management strategies against fruit borer in litchi is the difficulty of identifying the correct species because of low intraspecific variation among borer populations. In present study, partial cytochrome oxidase I (COI) sequences were used to understand the phylogenetic relationship among borer complex, and assess their usefulness to identify and classify unknown borer species collected from litchi orchards. In this respect, 150 specimens of litchi fruit borer from Bihar and Jharkhand were examined and 2 morphologically similar moths of each genus were used for further analysis. Sequence analyses revealed that the intraspecific and interspecific distances ranged from zero to 10.0% and 4.4 to 20.3%, respectively among fruit borer complex. The phylogenetic analysis showed that the borer insects used in this study clustered in to distinct species-groups designated as *Conopomorpha sinensis* Bradley, *C. litchiella* Bradley (Lepidoptera: Gracillaridae), *Cryptophlebia ombrodelta* (Lower) and *Gatesclarkeana* spp. (Lepidoptera: Tortricidae). Therefore, it may be concluded that, *Conopomorpha sinensis* Bradley is one of the major fruit& shoot borer species of litchi.

Biology of litchi fruit & shoot borer, *Conopomorpha sinensis* (Lepidoptera: Gracillaridae)

Adults are nocturnal and mating usually takes place during dusk and lay their eggs singly soon after mating on the under surface of the leaf or near the calyx of litchi fruits. Longevity of the adults varies from 3.23 to 6.80 days. The incubation period lasts for 4-5 ± 1 day. Newly hatched larvae are minute, milky white, slender, light brown head and minute setae present all over the body. Fully grown larvae come out of the fruit and pupate on the litchi leaf within oval shape cocoon (Fig. 7.1) .The total larval period and pupal period ranges from 8-9 days and 6-7 days, respectively.

Fig. 7.1. A**: Fruit & shoot borer damaged fruit;** B**: Pupae on leaves;** C**: Pupation on plastic crates;** D**: Adults**

Management of litchi fruit borer using IGRs based IPM modules

Minimum fruit infestation (19.0%) was recorded with first spray of neem oil (3ml/l) before flower opening, second and third spray of diflubenzuron 25 WP (0.06%) at clove stage fruit size and after 21 days of second spray followed by lufenuron (19.33%) as against 72.9% fruit damage in control.

Management of litchi fruit borer using bio-enhancers and organic products

To overcome the ill effects of chemical control measures, different bio-enhancers *viz*., *Panchgavya* (3%), *Amrit Pani* (5%) , biodynamic pesticides (5%), *Beauveria bassiana* (0.02%) (2g/l), *Metarhizum anisoplea* (0.02%) (2g/l) and *Trichogramma chilonis* have been evaluated on *Shahi* variety. Among various organic products/ bio-enhancers, *Panchgavya* (3%) (30 ml/l) found to be the most effective (14.33%) for healthy and quality litchi production. Four sprays at 10 days interval after fruit attaining clove size kept the infestation below threshold level.

7.5. ICAR Seed Project- Seed production in agricultural crops and fisheries (RFS)

Propagation of quality planting material

35,000 (approx) air-layering in litchi was made using soil less rooting media containing vermi-compost, coco-pith and vermiculite (1:1:1 ratio) during June to August month, out of which, about 34,000 well rooted air-layers were detached and planted in the nursery. 32,000 nos. of quality planting materials of litchi was maintained and kept for sale to farmers and stake holders. Grafting was done in 300 numbers of litchi plants in cultivars Shahi and China out of which, 100 grafted plants survived and can be planted in the season. Mother block comprising 625 plants of 9 promising litchi cultivars viz. Shahi, Rose Scented, Longia, China, Mandraji, Purbi, Swarnroopa, Yogda Sel and Bedana in 1.2 ha area for large scale propagation of quality planting materials.

7.6. Intellectual Property Management and Transfer/Commercialization of Agricultural Technology scheme" (Up-scaling of existing component i.e. Intellectual Property Right (IPR) under ICAR Headquarters scheme on Management and information services

Under this project compilation and preparation of technology profile of the centre was done. Also participated in various exhibitions/conference/ mela for showcasing and commercialization of technologies. We also conducted/ organized several meetings with traders/processors/entrepreneurs for commercialization of technologies. Timely submission of monthly RFD related to ITMU.

INSTITUTIONAL ACTIVITIES

Human Resource Development, Training and Capacity Building

Participation of Scientists/Staff in Conference/Seminar/Symposia /Workshop/Training/ Meeting during 2015-2016

Sl. No.	Title	Venue and Date	Participant (s)
1.	*International Summer School on Plant Disease Epidemiology*	IGKVV, Raipur 30th March - 3rd April, 2015	Dr. Vinod Kumar
2.	Molecular Characterization of Mychorrhiza	IIHR, Bengaluru 6th-18th April, 2015	Dr. Vinod Kumar
3.	National Seminar on '*Importance of weather forecasting in Agriculture*'	RAU, Pusa, Samastipur 8th April 2015	Dr. Vishal Nath
4.	Agriculture Innovators Day-2015	Tetaria, East Champaran 30th April 2015	Dr S.D. Pamdey Dr. Rajesh Kumar Dr. Vinod Kumar Dr Sanjay Kumar Singh
5.	85th Meeting of Board of Management of RAU	RAU, Pusa, Samastipur 9th May 2015,	Dr. Vishal Nath
6.	VC's of AU's and Director's of ICAR Institutes Conference	NASC Complex, New Delhi 14-16th May 2015 and 23rd -24th January, 2016	Dr. Vishal Nath
7.	Brain Storming Session and exhibition on Avocado	CHES, Chettali, Karnataka 27th May 2015	Dr. Vishal Nath
8.	National Conference on '*Dynamics of Smart Horticulture for Livelihood and Rural Development*'	MGCGV, Chitrakoot, UP 28th - 31st May, 2015	Dr. Vishal Nath Dr. R K Patel Dr. Kuldeep Srivastava
9.	*All India Litchi Show cum Kisan Sangosthi 2015*	NRCL, Muzaffarpur, 6th June 2015	All Scientists of NRCL
10.	*3rd UP Agriculture Congress*	SHIAST, Allahabad 14-16th June 2015	Dr. Vishal Nath
11.	Inception workshop on collaborative project titled, "*Livelihood and nutritional improvement of tribal farm women through horticulture*"	ICAR-CIWA, Bhubaneswar 17-18th June 2015	Dr. Alemwati Pongener
12.	ICAR Short course on 'Digital Soil Mapping'	CAZRI Jodhpur 24th June – 3rd July, 2015	Dr. Gopal Kumar
13.	Foundation laying function of IARI, Jharkhand	Barhi, Hazaribagh, Jharkhand 28th June 2015	Dr. Vishal Nath
14.	One day workshop on "*Understanding Weather and Climate*'	Mukherji Seminary, Muzaffarpur 30th June 2015	Dr. S. K. Purbey
15.	Scientific Advisory Committee (SAC) Meeting	KVK, Saran, Bihar 1st July 2015	Dr. Vishal Nath
16.	East Kharif Kisan Mela awam Sangosthi	KVK, Sargatia, Kushinagar, UP 6th July, 2015	Dr. Amrendra Kumar
17.	National Seminar on *'Take it Farmers- The Farmer's rights through awareness'*	NASC Complex, New Delhi, 7th July 2015	Dr. Vishal Nath



18.	One day workshop on ''वैज्ञानिक संस्थानों में राजभाषा कार्यान्वपयन : प्रयोग एवम् प्रोत्साहन''	NASC, New Delhi 7th July 2015	Dr. S K Purbey
19.	IARI-Pusa Mango Day 2015	Division of Fruits and Hort. Technology, IARI, New Delhi 15th July 2015	Dr. Sanjay Kr. Singh
20.	ICAR Foundation Day and Award Ceremony and National Conference of KVK's	Sri Krishna Memorial Hall, Patna 25th July, 2015	Dr. Vishal Nath Dr. S. D. Pandey Dr. Rajesh Kumar Dr. S. K. Purbay Dr. Sanjay Kr. Singh
21.	The first Workshop of Nodal Officers of Knowledge Based Resources Information Systems Hub for Innovations in Agriculture (KRISHI)	NASC, New Delhi, 4-5 August 2015	Dr. Vinod Kumar
22.	Inaugural Function of ICAR-NRCIF, Mothihari cum Udyan Sangosthi	Motihari, 20th August 2015	Dr. Vishal Nath Dr. Rajesh Kumar Dr. S. K. Purbey Dr. Sanjay Kr. Singh Dr. Swati Sharma
23.	Outreach programme on "*Export Promotion of Agricultural and Processed Food Products from the State of Bihar*"	BAMETI, Patna 26th August 2015,	Dr. Vishal Nath Dr. Alemwati Pongener
24.	One day Training on STFR meter	W S Telemetics, New Delhi 15th September 2015	Dr. Gopal Kumar
25.	Stake Holders meeting of NRC on Integrated Farming Mothari	ICAR-RCER, Patna 17th September 2015	Dr. Vishal Nath
26.	21-days winter School on "*Irrigation Strategies to Improve Water Productivity in Hill and Plateau Region*"	ICAR-RCER, Ranchi 25th September–15th October, 2015	Dr. Evening Stone Morboh
27.	One day Workshop on *'Fruit Cracking and Soil Health Management in Pomegranate'*	ICAR-NRC on Pomegranate, Solapur, Maharashtra 03rd October, 2015	Dr. Sanjay Kumar Singh
28.	Two days training on AAS, HPLC	ICAR-NRC on Grapes, Pune 5-6th October 2015	Dr. Sanjay Kumar Singh
29.	Workshop on *'Identifying the production and technological gaps in Middle Ganatic Plains Region'*	ICAR-RCER, Patna 7th October 2015	Dr. Vishal Nath
30.	8th Convocation Ceremony of RAU Pusa, Samestipur	RAU, Pusa, Samastipur 30th October 2015	Dr. Vishal Nath
31.	42nd Foundation Day of ASRB	New Delhi 3rd November, 2015	Dr. Vishal Nath
32.	National Seminar on *'Temperate Fruits and Nuts'*	SKUAST, Srinagar 6-8th November, 2015	Dr. Vishal Nath
33.	*Golden Jubilee of Green Revolution in India*	IARI, New Delhi 27th November 2015,	Dr. Vishal Nath
34.	*77th Research Council Meeting, Rabi-2015*	RAU, Pusa, Samastipur 28th November 2015	Dr. Vishal Nath
35.	Awareness Programme on *off season Litchi cultivation in South India*	10th December 2015, CHES, (IIHR), Chettali	Dr. Vishal Nath

36.	*International Seminar on Indigenous Technologies for Sustainable Agriculture and Better Tomorrow*	Lucknow, 09-10th January, 2016	Dr. Kuldeep Srivastava Dr. R K Patel
37.	*International Extension Education Conference*	BHU, Varanasi, 27-30th January, 2016	Sh. Alok Kumar Gupta
38.	DST Sponsored one week training on "*Role of Scientist in Natural Resource and Environment Management*"	IIFM, Bhopal 8-12th February, 2016	Dr. Gopal Kumar
39.	Short Courses on '*Exploitation of Underutilized Horticulture Crops for Sustainable Production'*	CHES, Godhra, Gujarat 11-20th February, 2016	Dr. Sanjay Kr. Singh
40.	*Kishan-V aigayanik Samagam* Programme	Mutlupur, Muzaffarpur 15th February 2016	Dr. Vishal Nath Dr. Vinod Kumar
41.	Kisan Sangoshthi on Technical Knowledge for Economic development	Sitamarhi, Bihar 20th February 2016,	Dr. Vishal Nath
42.	*Foundation Day function and Kisan Mela*	ICAR-RCER, Patna 22nd February, 2016.	Dr. Vishal Nath Dr. Amrendra Kumar
43.	6th International Conference on "*Plant, Pathogen and People- Challenges in Plant Pathology to Benefit Humankind*"	NASC, New Delhi, 23-27th February 2016	Dr. Vinod Kumar
44.	One day seminar on *Analytical Solutions for today`s science*	Patna 24th February 2016,	Dr. Gopal Kumar Dr. Alemwati Pongener
45.	86th Meeting of Board of Management	RAU, Pusa, Samastipur 1st March 2016	Dr. Vishal Nath
46.	3rd Group Workers Meet of AICRP on Fruits	PAU, Ludhiana 3-6th March, 2016	Dr. Vishal Nath Dr. Amrendra Kumar Dr Kuldeep Srivastava
47.	One day workshop "*Brain storming g on Smart Horticulture"*	IARI, New Delhi 7th March 2016	Dr. Gopal Kumar
48.	National Conference on "*Rural Livelihood Improvement through Innovative Agriculture*	Patna, 12-13th March, 2016	Dr. Kuldeep Srivastava Dr. R.K. Patel
49.	Meeting on *Pradhan Mantri Fasal Beema Yojna* 2016	KVK, Saraiya, Muzaffarpur 31st March 2016	Dr. Vishal Nath

- Dr. Vinod Kumar guided a student Ms. Reshma Parween, B.Sc., (Industrial Microbiology), Patna Women's College, Patna for her short term (three month) Hands-on Training cum Project Work on "Isolation and Screening of Fruit-plane Antagonists to Manage Post-Harvest Fruit Decay of Litchi".

NRCL-Human Resource Development (HRD) Programme:2015-16

Name of the Institute:	ICAR-NRC on Litchi, Muzaffarpur, Bihar
Name of HRD Nodal Officer:	Dr. Kuldeep Srivastava



A. Physical targets and achievements

S. No.	Category	Total No. of Employees	No. of trainings planned for 2015-16 as per ATP	No. of employees undergone training during			% realization of trainings planned during 2015-16	Total no. of employees undergone training during
				April-September 2015	Oct. 2015 - March 2016	April 2015 - March 2016		April 2014 - March 2015
1	2	3	4	5	6	5+6=7	7/4 x 100=8	9
1.	Scientist	12	5	3	2	5	100%	2
2.	Technical	3	0	0	0	0	0	0
3.	Administrative & Finance	8	1	1	0	1	100%	4
4.	SSS	3	0	0	0	0	0	0
	Total	**26**	**6**	**4**	**2**	**6**	**100 %**	**6**

B. Financial targets and achievements (All employees)

S. No.	Total HRD allocation as per RE 2014-15	Actual Expenditure 2014-15 for HRD	% Utilization	RE 2015-16 for HRD			Actual Expenditure 2015-16 for HRD	% Utilization
				Plan	Non plan	Total		
	(Lakh Rs.)	(Lakh Rs.)	2014-15	(Lakh Rs.)			(Lakh Rs.)	2015-16
1	2	3	3*100/ 2=4	5	6	7	8	8*100/7=9
1	0.75	0.75	100	0.5	0	0.5	0.48	96%

Category-wise trainings attended by employees during 2015-16

A. Scientists

S. No.	Name of employee	Designation	Discipline/ Section	Name of Training Programme attended	Duration (days)	Organizing institution	Actual Expenditure incurred	Entered in ERP system
							(Rs)	(Yes/No)
1	Dr. Vinod Kumar	Sr. Scientist	Plant Protection	*Plant Diseases Epidemiology*	5	IGKV, Raipur	Paid by Organizer	Yes
2	Dr. Vinod Kumar	Sr. Scientist	Plant Protection	*Identification of Mycorrhiza isolate using Molecular Tools*	13	ICAR-IIHR, Bengaluru	Paid by Organizer	Yes
3	Dr Neetu Singh Kushwah	Scientist	Crop Improvement	*Novel genomic tools and modern breeding approaches for enhancing productivity and nutritional quality of pulse crops*	21	ICAR-IIPR, Kanpur	Paid by Organizer	Yes
4	Dr. Evening Stone Marboh	Scientist	Crop Production	*Recent Advances in Enhancing Water Productivity in Hill and Plateau Region*	21	ICAR-RCER, Ranchi	Paid by Organizer	Yes
5	Dr. Sanjay Kumar Singh	Scientist	Crop Production	*Exploitation of Underutilized Horticulture Crops For Sustainable Production*	10	ICAR-CHES, Godhara	Paid by Organizer	Yes
A.	**Administrative and Finance Wing**							
1.	Sri. Abhishek Yadav	Administrative Officer	Administration	*Training Program on Establishment Rules*	5	ISTM, New Delhi	Paid by Organizer	Yes

Meetings, Workshops and Events

14th Foundation Day

The centre had celebrated 'Foundation Day cum Litchi Day' on 6th June, 2015. On this auspicious occasion, Shri. Parasnath, IPS (Inspector General, Police, Muzaffarpur Range) was Chief Guest and Dr. Gopaljee Trivedi, Former Vice Chancellor, RAU, Pusa, Samastipur was guest of honour. He exhorted farmers and stake holders to be digitised and use ICT in litchi production, marketing and export. Dr. Vishal Nath was the Member Secretary of the functions.

Dignitories present on dias during Fondation Day Celebration; Stakholders raising queries

Farmer's Field Day

The Centre has organized Field Day-cum- Kisan Gosthi on show casing of the girdling techniques for regular bearing in China litchi at Katarmala, Garoul, Vaishali, on 25th May, 2015 in which more than 100 farmers participated. The programme was chaired by Director, ICAR-NRC on Litchi and the scientists of NRCL, Dr. Amrendra Kumar, Dr. R. K. Patel, Dr. Kuldeep Srivastava and other technical person given the hand on expertise on girdling techniques and its benefits to bring regularity in flowering. Litchi growers showed keen interest to adopt girdling technology especially on 'China' litchi after visiting the orchard and practicising girdling technology.

Field Day at Katarmala, Garoul, Vaishali

Round Table Conference on Litchi Borers

ICAR- NRC Litchi, Muzaffarpur, the nodal institute for litchi research in the country have organized a one day *'Round Table Conference on Litchi borers'* at ICAR-

Round Table Conference on Borers; visit of dignitaries to litchi orchard

National Research Centre on Litchi, Muzaffarpur, Bihar on December 4th, 2015. The meeting was attended by scientists, including entomologists and horticulturists, from NRC on Litchi - Muzaffarpur, IIHR - Bengaluru, CHES - Bhubaneswar and State Agricultural Universities who are part of AICRP on Fruits. Dr. A. Krishnamoorthy, former PS, IIHR and Ex-PI, CRP on Borers was the external expert. Dr. Vishal Nath, Director, NRC Litchi chaired the sessions. At the outset, delegates were welcomed by Dr. S.D. Pandey, Chairman, PME, and the session was started with Dr. P. V. Rami Reddy, Principal Scientist and PI-CRP on Borers, ICAR-IIHR, Bengaluru introducing the topic and presenting an outline of CRP on Borers and the essence of the Round Table Conference. Dr. Kuldeep Srivastava Sr. Scientist (Ag Entomology) presented the overview of litchi fruit borer.

World Soil Day

The ICAR-National Research Centre on Litchi, Muzaffarpur celebrated *'World Soil Day'* on 5th December 2015. The function was presided by Dr. Gopal Ji Trivedi, former Vice-Chancellor of RAU, Samastipur. The honourable Member of Parliament from Muzaffarpur Shri Ajay Nishad, was the Chief Guest of the function. Shri Suresh Sharma, Member of Legislative Assembly (MLA) from Muzaffarpur (city) was Special Guest on this occasion. Shri Ranjan Sahu, Member, IMC, and Farmer's representative was another dignitary in the function. About 100 farmers and staffs of ICAR-National Research Centre on Litchi attended the programme. At the outset, the Director, Dr. Vishal Nath, welcomed the guests and highlighted the importance of soil and appraised the gathering that 2015 has been declared as 'International Year of Soil' and 5th December is being celebrated as "World Soil Day". Dr. Trivedi in his presidential speech highlighted the importance of soil sampling and management for quality and assured litchi production. He also emphasized the need for close monitoring of Litchi plantations.

The chief guest, Shri Ajay Nishad (MP) appreciated the initiative of ICAR-NRCL in implementing Government of India scheme to provide soil health card to farmers on this occasion and suggested to strengthen the setup for reaching more farmers. Shri Suresh Sharma emphasized need to undertake research on effective insect pests management of litchi for assured income. At the end of function, soil health cards were distributed to the farmers of Muzaffarpur and Vaishali districts.

Distribution of soil health card to the farmers

Dignitaries present on dais on World Soil Day; presence of stakeholder of litchi

Periodical meetings of Nagar Rajbhasha Karyanwayan Samiti

NRC on Litchi Muzaffarpur, participated in NARAKAS meeting and workshops for implementation and extension of Rajbhasha Hindi. Centre as well as In-charge, Hindi cell got the First prize for commendable performance in implementing the Official Language Policy of the Union during year 2014-15 by Town Official Language Implementation ommittee (NARAKAS), Muzaffarpur on 27.08.2015.

हिन्दी कार्यशाला की छमाही बैठक

Agricultural Education Day

Agricultural Education Day was organized by NRCL for school students at D.A.V. Public School, Malighat, Muzaffarpur on 4th September, 2015. The objective of the programme was to promote the spirit of agriculture and allied subjects among the young minds. About 120 students attended the programme. Lectures were delivered on the importance of agricultural education for the development of nation. Dr. Rajesh Kumar delivered lecture on the topic "Agriculture as a science', whereas Dr. Vinod Kumar delivered lecture on the topic 'Challenges in agriculture vis-à-vis agricultural education'. Dr. Sanjay Kumar Singh highlighted the "Career opportunities in agriculture". Other scientists who participated in the programme and interacted with students were Drs. Alok Kumar Gupta, Ms. Swati Sharma, and Evening Stone Marboh. Some of the motivated students showed keen interest to have a career in agricultural research and education.

Agriculture Education Day, 2016 celebrated at D.A.V. Public School, Malighat, Muzaffarpur

Model Training on GAPs in litchi

The centre conducted Model Training Course (MTC) on *"Good Agricultural Practices in Litchi"* at ICAR-NRC on Litchi Muzaffarpur during 23-30th November, 2015. The training was aimed to provide recent technological knowledge and advance informations for improving productivity and quality of litchi in the country. During the Model Training, the aspects like varietal selection, orchard establishment and management, orchard floor management and crop diversification possibilities to enhance farm income, farming system and organic litchi production, IPM and IPNM for litchi, rejuvenation protocol for senile orchards, pre harvest management protocols to improve harvest life and help realize better price, etc. were covered by various eminent experts.

Participants of MTC receiving certificate

10th IMC Meeting

The 10th Institute Management Committee Meeting was held in the chairmanship of Dr. Vishal Nath, Director on 30th December, 2015 at 11:00 AM in the Committee Room of ICAR-NRC on Litchi, Muzaffarpur, other members were Dr. A. K. Mishra, Head, CISH, Lucknow, Dr. V. K. Gupta, Pr. Scientist, ICAR-RCER-Research Centre for Makhana, Darbhanga and Dr. I. S. Solanki, Principal Scientist & Head, ICAR-IARI, Regional Station, Pusa, (Bihar). Sh. Mukesh Kumar Sharma, Sh. Ranjan Kumar Sahu were the farmer's representative. The Members expressed their happiness on research activities, development of facilities and infrastructures in the farm as well as laboratory and office to undertake the advanced research in the field of Litchi. Members were also eager to know about the methods used by the Center to disseminate information related to research and development to the farmers and other stakeholders. Some concern was also raised about the

10th IMC at the Centre

litchi borer. The members expressed their satisfaction over the pace of research.

Mera Gaon Mera Gaurav

A 'Kisan Gaushthi' in the presence of Pradhan and Panchayat members was held in village Kankati (Kothia Hariram), Mehsi, East Champaran on 28.12.2015 in which large number of farmers from the adopted village participated and discussed their current farming practices and the problems they are facing in increasing the productivity. The farmers were provided the contact numbers of the team members to make available them the required information whenever needed. Farmers were made aware of their important role in meeting

Mera Gaon Mera Gaurav programme at Narauli, Muzafharpur

the challenges of food production and support of the Govt. of India and ICAR, Dept. of Agriculture to boost the production and making farming an economic pursuit. Importance of improved varieties of crops, control of weeds, diseases and pests was elaborated. Vill. Binda, of Mushahari Block of Muzaffarpur and Katarmala village of Goraul, Vaishali was also selected under the programme.

किसान व्यापारी संवाद

दिनांक 05 जनवरी 2016 को राष्ट्रीय लीची अनुसंधान केन्द्र पर वैज्ञानिकों, लीची उत्पादक किसानों एवं लीची से जुड़े हुए व्यवसायिओं के बीच एक विचार–विमर्श कार्यक्रम का आयोजन किया गया। कार्यक्रम की अध्यक्षता करते हुए केन्द्र के निदेशक ने लीची से जुड़े किसानों तथा उद्यमियों से अनुरोध किया कि इस राज्य की धरहोहर लीची फसल को राश्ट्रीय एवं अंतर्राष्ट्रीय फलक पर प्रमुख स्थान दिलाने के लिए सभी लोगों को मिलकर प्रयास करना चाहिए। निदेशक का यह मानना था कि लीची के उत्पादन में जितना महत्व किसानों का है, उतना ही जिम्मेदारी उससे जुड़े हुए व्यवसायिओं की भी है। क्योंकि लीची में फल लगने के बाद की सारी प्रक्रिया का अनुपालन मुख्य व्यवसायिओं द्वारा ही की जाती है इसलिए समय–समय पर संस्तुत कीट नाशकों एवं पादप हार्मोन का छिड़काव अत्यन्त आवश्यक होता है, जिससे लीची की गुणवत्ता एव पैदावार

केन्द्र में किसान व्यापारी संवाद

सुनिश्चित होती है। इस अवसर पर किसानों द्वारा अपनाये जाने वाले सिडयूल की जानकारी दी गयी।

Empanelment of Academic Counsellor for PGDPM/COF programme sponsored by IGNOU, New Delhi

IGNOU, Regional Centre Darbhanga has set up IGNOU Programme Study Centre, at NRCL, Muzaffarpur in which they will provide Self Instructional Material to learners and learners study and prepare themselves for examination. The course was started as Certificate Course on Organic Farming in which appointed counsellor will teach the courses on holidays.

Distinguished Visitors

Financial Advisor, DARE visited NRC on Litchi, Muzaffarpur, Bihar

Sri. S. K. Singh IAS, Additional Secretary cum Financial Advisor, DARE, New Delhi, visited NRC on Litchi, Muzafffarpur on 27th February, 2016. Director of the institute Dr. Vishal Nath, welcomed him and who also gave a brief presentation on research and developmental activities being undertaken by the Centre. Mr. Singh addressed the scientists and staff at the centre, and explained the value of money for agricultural research. He gave an insight into procedures and rules of finance release to the research institutes, agriculture universities and state departments. Mr. Singh also visited laboratories, experimental farms and campus development work at the Centre the various facilities and seen Shri. Singh expressed his satisfaction about the growth and functioning of the centre, and assured Director to provide all possible support to the centre to fulfill its mandate.

Interaction of Sh. S. K. Singh with scientisits of NRCL and visit of Laboratory

Besides visits of Sri. S K. Singh, following distinguished visitors visited the centre during 2015-16.

Sl. No.	Date of Visit	Name of Visitors	Designation with affiliation
1.	22nd May, 2015	Sri. Tieiman Ruan	Associate Scientist, South African Litchi Grower Association, Pretoria, SA
2.	17th June, 2015	Dr. Umesh Srivastava	Former ADG (Horticulture-I) ICAR, New Delhi
3.	17th June, 2015	Dr. K.K. Jindal	Former ADG(Horticulture), ICAR, New Delhi
4.	19th June, 2015	Dr. R. B. Deshmukh	Former Vice Chancellor, Mahatma Phule Krishi Vidyapeeth, Rahuri, Pune, MS
5.	27th November, 2015	Dr. G S Dubey	Ex- Director Research, BAU, Kanke, Ranchi
6.	4th December, 2015	Dr. A. Krishnamoorthy	Former Principal Scientist and Platform Coordinator- CRP on Borers, IIHR, Bengaluru
7.	11th December, 2015	Shri. Ratneshwari Prasad Singh	Member, Governing Body, ICAR, New Delhi
8.	27th February, 2016	Shri. S. K. Singh	AS&FA, DARE, ICAR, New Delhi
9.	19th march, 2016	Dr. H.P. Singh	Former DDG, Horticulture & Chairman, CHAI, New Delhi

Interaction of Sh. Ratneshwari Prasad Singh with NRCL staff and observing processed product of Litchi in PHM section

Transfer of Technology

Dissemination of technologies was done through organizing various training programmes and *Kisan Gosthi*, delivering lectures, showcasing NRCL technologies, and interaction with stakeholders. The details of formal training and other programmes pertaining to transfer of technology and human resource development activities are summarized below.

Sl. No.	Title of the Programme	Venue and Date	Participating/Resource persons	No. of beneficiaries
1.	Training programme on '*HDP in Litchi*'	ICAR-NRCL, Muzaffarpur 6th April, 2015	All scientists of NRCL	16
2.	*Horti-Sangam 2015*	Motihari, 10th April 2015	Dr. Vishal Nath Dr. S. D Pandey Dr. Rajesh Kumar Dr. S. K. Purbey Dr. Sanjay Kumar Singh Dr. Alok Kumar Gupta Dr. Evening Stone Marboh	300 farmers/ traders/ delegates
3.	Training on '*Food Processing and Preservation cum E &P*'	Institute of Entrepreneurship Development (IED), Muzaffarpur 18th April, 2015	Dr. S. K. Purbey	25
4.	Training on '*GAP in Litchi for Agriculture Co-coordinators*'	RAU, Pusa, Samastipur 28th April 2015	Dr. Vishal Nath Dr. S. K. Purbey	150 farmers/ traders/ delegates
5.	*Kisan Gosthi*	Kisan Club Repura, Kanti, Muzaffarpur 6th May, 2015	Dr. S. D. Pandey	82
6.	Training programme on '*GAP in Litchi and Mango and Post harvest Management of litchi fruits*'	Malinagar, Samastipur, 15th May, 2015	Dr. Sanjay Kumar Singh Dr. Kuldeep Srivastava Dr. Vinod Kumar Dr. Swati Sharma	45
7.	Field Day-cum- Kisan Gosthi on GAP, Girdling and IPM	Katarmala, Vaishali 25th May, 2015	Dr. Vishal Nath Dr. Amrendra Kumar Dr. R. K. Patel Dr. Kuldeep Srivastava	60
8.	Foundation Day cum Kisan Goshthi	ICAR-NRCL, Muzaffarpur, 6th June, 2015	All scientists of NRCL	160 farmers/ traders/ delegates
9.	Training program on '*Pre and Post harvest Handling of litchi fruits*'	ICAR- NRC L, Muzaffarpur, 15-21st June 2015.	All scientists of NRCL	19 UG Students of BHU, Varanasi
10.	State Level Pre-Kharif Kisan Sumelan	KVK, Baghara, Muzaffarnagar, UP 27th June, 2015	Dr. S K Purbey	55
11.	*Kisan Mela cum Udyan Sangoshthi*	Barahi, Hazaribag, Jharkhand 28-29th June, 2015	Dr. Vishal Nath Dr. Shyamjee Misra	1000 farmers, traders, delegates, state officials etc.
12.	Kisan Gosthi and Farmer's Field Day	Rampur, Bagaha, Kushi nagar, UP 7th July, 2015	Dr. Vishal Nath Dr. Amrendra Kumar	59
13.	Excursion/Exposure Visit of students of class Xth students	ICAR-NRCL, Muzafarpur 24th July, 2015	Dr. S K Purbey	30 students of Mother Teresa Vidyapeeth, Manika, Muzaffarpur



14.	Udyan-gosthi cum-inaugural Function ICAR-NRC on Integrated Farming System,	Piprakothi, Motihari 20-21st August, 2015	Dr. Vishal Nath Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Sanjay Kumar Singh Dr. Swati Sharma Dr. Evening Stone Marboh Dr. Alok Gupta Dr. Alemwati Pongener	300 farmers/ traders/ delegates
15.	Visit of IXth students	ICAR-NRCL, Muzaffarpur 3-5th Nov**ember** 2015	Dr. S K Purbey	257 students of Holly Mission Sr. Sec. School, Muzaffarpur
16.	Training on Rejuvenation and GAP on litchi	Narhan and Mathi, Samastipur, Bihar 4th November, 2015	Dr. S. K. Purbey Dr. Amrendra Kumar Dr. A. K. Gupta	30
17.	Model training course on Good Agricultural Practices in Litchi	ICAR-NRC on Litchi, Muzaffarpur. 23-30th Nov**ember**, 2015	All scientist of NRCL	State Ag. Officials and farmers (26)
18.	*World Soil Day cum Kisan Gosthi*	Muzaffarpur 5th December, 2015.	All scientist of NRCL	100
19.	*Jai Kisan - Jai Vigyan Week*	Kothia Hareram, East Champaran 28th December, 2015	Dr. Vishal Nath Dr. Rajesh Kumar Dr. Kuldeep Srivastava Dr. Sanjay Kr. Singh Dr. Alok Kumar Gupta	139
20.	*Kisan Vyapari Vaigayanik Varta*	ICAR-NRCL, Muzaffarpur, 5th January 2016	Dr. Vishal Nath Dr. S. K. Purbey	45
21.	*Kisan Gosthi cum Mera Gaon Mera Gaurav* Programme	Katarmala, Vaishali 6th February, 2016	Dr. S.D. Pandey Dr. Amrendra Kumar Dr. R. K. Patel Dr. Gopal Kumar Dr. Alemwati Pongier	60
22.	*Field Training and Kisan Gosthi on GAP and Canopy Management in Litchi*	Lakhminia, Begusarai 7th January, 2016	Dr. Vinod Kumar Dr. S. K. Purbey Dr. Amrendra Kumar Dr. Vinod Kumar	65
23.	National Farmer's Fair and Vegetable Show Casing'	ICAR- IIVR, Varanasi, UP 30th January, 2016	Dr. Sanjay Kumar Singh	400
24.	*"Farmers- Scientists interaction Meet"*	Matlupur, Muzaffarpur, 15th February 2016	Dr. Vishal Nath Dr. S. K. Purbey	130
25.	Training cum Awareness Programme	Binda, Narauli, Muzaffarpur 26th February, 2016	Dr. Vishal Nath	55
26.	Kisan Mela, 2016	BAU, Sabaur, Bhagalpur 4-6th March, 2016	Dr. Gopal Kumar	185
27.	Kisan Sambhodhan, by Union Minister of Ag.	ICAR-IISR Regional Centre, Motipur, Muzaffarpur 5th March, 2016	Dr. S.D. Pandey Dr. S K. Purbey	121
28.	Kisan Mela 2016,	RAU, Pusa, Samastipur, 5-7th March, 2016	Dr. Vinod Kumar Dr. Sanjay Kumar Singh	126
29.	*Unnati Krishi Mela* 2016	IARI, Pusa, New Delhi 19-21st March, 2016	Dr. S. K. Purbey	37

Lectures delivered as resource person participation in programme outside the organization in individual capacity

Dr. Amrendra Kumar

- Delivered a lecture on "Establishment of litchi orchard and intercropping in HDP" in the training programme '*High Density Planting for State Govt. Officers (Agricultural Coordinator)*' at ICAR-NRC on Litchi, Muzaffarpur 6th April, 2015.
- Delivered lecture on 'GAPs and Propagation in litchi during training programme for UG Students of BHU, Varanasi on 'Pre and post harvest handling of litchi fruits' (15-21st June, 2015) on 10th June, 2015.
- Delivered a lecture on "GAP in litchi" in the *East Kharif Kisan Mela awam Sangosthi* at IIVR, -KVK, Sargatia, Kushinagar, UP on 6th July, 2015.
- Delivered lecture on "Establishment of New Litchi Orchard, Intercropping in Litchi in new and juvenile orchard and coordinated practical session" in the *MTC on GAP in litchi* at ICAR-NRCL, Muzaffarpur (23-30th November. 2015).
- Delivered a talk on "Nursery Management in litchi" on field training and '*Kisan goshti on GAP and Canopy Management*' at Lakhminia, Choti Balia, Begusarai on 7th January, 2016.

Dr. Kuldeep Srivastava

- Delivered a lecture on "IPM in litchi with special reference to fruit borer Management" in '*Training on GAP-cum-Kisan Gosthi*' at Repura, Muzaffarpur on 6th May, 2015.
- Delivered expert lecture on "Integrated management of major pests of litchi" in *Training on GAPs in litchi* at Malinagar, Samastipur on 15th May, 2015.
- Delivered expert lecture on "IPM in litchi with special reference to fruit borer Management" in *Field day on Girdling: a technology for regular bearing in China litchi*' at Katarmala, Vaishali on 25th May, 2015.

Dr. R K Patel

- Delivered a lecture on 'Integrated farming system in litchi' during training programme for UG students of BHU Varanasi, on *Pre and Post harvest handling of litchi fruits* (15-21st June, 2015), at ICAR-NRC on Litchi, Muzaffarpur, Bihar on 19th June 2015.
- Delivered lecture on 'Fitting litchi in farming system of different topography and conditions' on during *Model training course (MTC) on Good Agricultural Practices (GAPs) in litchi* at ICAR-NRC on Litchi, Muzaffarpur, Bihar on 30th November, 2015
- Delivered a lecture on 'Nursery management on litchi' at ICAR-IARI Regional Centre, Pusa, Samastipur, Bihar on 18th March, 2016.

Dr. S. D. Pandey

- Delivered a talk on 'Establishment of litchi orchard and intercropping in HDP' under training programme on '*High Density Planting for State Govt. Officers (Agricultural Coordinator)*' at ICAR-NRCL, Muzaffarpur on 6th April, 2015.
- Delivered a talk on 'High density planting and canopy management' under training programme of UG Students of BHU, Varanasi on *Pre and Post Harvest handling of litchi fruits* at ICAR-NRCL, Muzaffarpur on 19th June, 2015.
- Establishment of plantation and high density planting for GAP in litchi' and coordinated practical session in the *MTC on GAP in litchi* at ICAR-NRCL, Muzaffarpur on 26th November, 2015.
- Delivered a talk on 'High Density Planting and Nutrient and Water Management in Litchi' on field training and '*Kisan goshti on GAP and Canopy Management*' at Lakhminia, Choti Balia, Begusarai on 7th January, 2016.

Dr. S K Purbey

- Delivered a lecture on 'Processing and value addition in Litchi' in training programme on "*Food processing and preservation for entrepreneurship development*"



organized by IED, Muzaffarpur on 20-21st April, 2015.

- Participated and delivered a lecture in Seminar cum workshop on "*Horticulture and food processing*", organized by CIA, APEDA and NHB at Dayalpur, Vaishali, during 22-24th May, 2015.
- Delivered a lecture on "Value addition and marketing of litchi" in All India litchi Show cum Kisan Sangosthi at ICAR-NRC on Litchi on 6th June, 2015.
- Delivered a lecture in Seminar on "*Bharat men vigyan: Bhut, Vartmaan and Bhavishya*" organized by Society for Science, Muzaffapur at Mahila Polytechnique College, Muzaffarpur on 28th February, 2016.

Dr. Sanjay Kumar Singh

- Delivered a lecture on 'Orchard establishment, monthly calendar operation in mango orchard for Mango and litchi diversity, livelihood and ecosystem services' during *Training on GAPs in litchi* at Malinagar, Pusa, Samastipur on 15th May, 2015.
- Delivered a talk on '*GAPs in Mango'* under training programme of UG Students of BHU, Varanasi on *Pre and Post Harvest handling of litchi fruits* at ICAR-NRCL, Muzaffarpur on 20th June, 2015.
- Delivered a talk on '*Career opportunities in Agriculture*' during 'Agriculture Education Day' at DAV Public School, Malighat, Muzaffarpur on 04th September, 2015.

Dr. Vinod Kumar

- Delivered a talk on 'Challenges in agriculture vis-à-vis agricultural education'during 'Agriculture Education Day' at DAV Public School, Malighat, Muzaffarpur on 04th September, 2015.
- Delivered a lecture on "Biofertilizers and micronutrients for quality litchi production" during *Model training course (MTC) on Good Agricultural Practices (GAPs) in litchi* at ICAR-NRC on Litchi, Muzaffarpur, Bihar on 23-30th November, 2015.
- Delivered a talk on "Disease and insect pest management in litchi" on field training and '*Kisan goshti on GAP and Canopy Management*' at Lakhminia, Choti Balia, Begusarai on 7th January, 2016.

Dr. Vishal Nath

- Delivered lead lecture on topic "Prospect and Utility of Weather Forecasting in Horticultural Crops" during '*National Seminar on Importance of weather forecasting in Agriculture*' on 8th April, 2015.
- Delivered Key note address on "Advances in Litchi Production for enhanced productivity and quality" during *3rd UP Agriculture Congress* at SHIAST, Allahabad on 16th June, 2015
- Delivered a lead lecture on "Litchi scenario in India and Varietal choices for farmers" during Awareness Programme on '*Off season Litchi cultivation in South India'* at CHES, (IIHR), Chettali, Karnataka on 10th December, 2015.

Radio and TV Talks

Dr. S. D. Pandey

- Delivered a TV talk on 'Nutrient and Water Management in Litchi' under ETV-Annadata programme, ETV, Bihar-Jharkhand broadcasted on 8th April, 2015.

Dr. Vishal Nath

- Delivered a TV talk on '*Litchi baag ki sthapna aur paudhon ki dekh-rekh'* under Krishi Darsan programme, Durdarshan, Patna broadcasted on 03rd September, 2015.

Research Programmes and Projects

Institutional Projects

Sl. No.	Programmes / Projects	PI	Co-PI (s)
1	***Conservation, characterization, and utilization of genetic diversity for improvement of litchi***		
1.1.	Collection of indigenous and exotic germplasm, their characterization, evaluation, documentation and utilization	Dr. Vishal Nath	Dr. Rajesh Kumar Dr. Amrendra Kumar Sh. Narayan Lal Sh. A. K. Gupta Dr. Neetu Singh Kushwah
1.2	Developing improved cultivars in litchi	Dr. Vishal Nath	Dr. Rajesh Kumar Sh. Narayan Lal Sh. A. K. Gupta Dr. Neetu Singh Kushwah
2	***Development and refinement of integrated production technologies for improved productivity of litchi***		
2.1.	Plant propagation and nursery management in litchi	Dr. Rajesh Kumar	Dr. S.D. Pandey Dr. Amrendra Kumar Dr. Vinod Kumar Dr. R.K. Patel
2.2.	Development and sustainable production techniques in litchi	Dr. S.D. Pandey	Dr. Amrendra Kumar Dr. R.K. Patel Dr. Kuldeep Srivastava
2.3.	Investigation and establishing the physiological and biochemical relations for improved litchi production	Dr. Amrendra Kumar	Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S. K. Purbey Dr. Sanjay Kr. Singh Dr. R. K. Patel
2.4.	Studies on mycorrhizal association and role of bio-fertilizers for improved litchi production	Dr. Vinod Kumar	-
2.5.	Litchi-based cropping system for low-lying areas	Dr. R.K Patel	Dr. S.D. Pandey Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava
2.6.	Nutrient deficiency symptoms in litchi	Dr. Amrendra Kumar	Dr. S.D. Pandey Dr. R.K. Patel Dr. I. S. Singh
2.7.	Edaphic factor based identification of potential litchi area in India	Dr. Gopal Kumar	Dr. S. D. Pandey Dr. Sanjay Kr. Singh, Sh. Alok Kr. Gupta Dr. Evening S. Marboh
3	***Development and refinement of integrated crop protection technologies for improved productivity of litchi***		
3.1.	Investigation and management of pre-harvest diseases of litchi	Dr. Vinod Kumar	-
3.2.	Investigation and management of insect-pests complex in litchi	Dr. Kuldeep Srivastava	Dr. R.K. Patel

4	***Integrated postharvest management to reduce losses, improve marketing and product diversification***		
4.1.	Standardization of maturity standards, harvesting and postharvest handling techniques for litchi	Dr. S. K. Purbey	Dr. Sanjay Kr. Singh Dr. Vinod Kumar Dr. Alemwati Pongener
4.2.	Investigation and management of postharvest losses in litchi	Dr. S. K. Purbey	Dr. Vinod Kumar Dr. Alemwati Pongener
4.3.	Standardization of processing and value-addition techniques in litchi	Dr. S. K. Purbey	Dr. Vinod Kumar Dr. Alemwati Pongener
5	***Improving knowledge and skill of stakeholders for increasing production of litchi***		
5.1.	Strategic research in Tribal Sub Areas	Dr. S.D. Pandey	Dr. Amrendra Kumar
5.2.	Strategic research on North-Eastern Hill region	Dr. Rajesh Kumar	-
6	***Flagship projects***		
6.1.	Postharvest management with respect to pericarp browning and fruit decay	Dr. S. K. Purbey	Dr. Vinod Kumar Dr. Alemwati Pongener Dr. Swati Sharma Dr. Evening Stone Marboh
6.2.	Shoot physiology in relation to flowering and fruiting in litchi	Dr. Sanjay Kr. Singh	Dr. Amrendra Kumar Dr. Swati Sharma Dr. Evening Stone Marboh

Externally Funded Projects

Sl. No.	Title	Funding agency	PI & Co-PI
2.	Development of 'National Database on Mango'	DBT, New Delhi	Dr. Vishal Nath Dr. Sanjay Kr. Singh Sh. Alok Kr. Gupta Dr. Kuldeep Srivastava
3.	Studies on the feasibility of intercropping under partial shade of litchi	ATMA, Muzaffarpur	Dr. Amrendra Kumar Dr. S.D. Pandey Dr. R.K. Patel
4.	Consortia Research platform (CRP) on borers	ICAR, New Delhi	Dr. Kuldeep Srivastava Dr. R.K. Patel
5.	ICAR Seed Project – Seed Production in Agricultural Crops and Fisheries (RFS)	ICAR, New Delhi	Dr. Amrendra Kumar
6.	National Agriculture Innovation Fund (NAIF) and Transfer/Commercialization of Agricultural Technology	ICAR, New Delhi	Dr. Vishal Nath Dr. S.K. Purbey (Nodal officer)

List of Publications

Research Articles

Adhikary P. P., Chandrasekharan, H., Dash Ch. Jyotiprava and Kumar, G. 2015. Hydrogeochemical investigation of groundwater quality in West Delhi, India, *Indian Journal of Soil Conservation,* 43(1): 15-23

Alam, N.M., Jana, C., Panwar, P., Kumar, G., Mishra, P .K., Sharma, N. K. and Tiwari, A.K. 2015. Weekly rainfall analysis for crop planning in rainfed Shivalik Himalayas of India, *Journal of Agrometeorology* 17 (2): 234-240

Gupta, A. K., Solanki, I. S., B. M. Bashyal, Y., Singh, Srivastava, K. 2015. Bakanae of rice -an emerging disease in Asia. *The Journal of Animal & Plant Sciences* 25(6): 1499-1514.

Jadon K.S., Thirumalaisamy P.P., Kumar V., Koradia V.G. and Padavi R.D. 2015. Management of soil borne diseases of groundnut through seed dressing fungicides. *Crop Protection* 78: 198-203.

Kumar A., Pandey, S.D., Patel R. K., Singh S. K., Srivastava K. and Nath V. 2015. Induction of flowering by use of chemicals and cincturing in '*Shahi*' litchi. *The Ecoscan Special Issue* VII: 493-496.

Kumar, A., Pandey, S. D., Purbey, S.K., Patel, R. K., and Nath, V. 2016. Effect of growth regulators on shoot maturity, flower induction and yield of litchi cv. Shahi . *HortFlora Research Spectrum*. 5 (1): 12-16.

Kumar, A., Pandey, S.D., Patel, R.K., Singh, S.K., Srivastava, K. and Nath, V. 2015. Induction of flowering by use of chemicals and cincturing in 'Shahi' litchi. *The Ecoscan Special Issue* VII: 493-496.

Kumar R. and Kumar V. 2016. Physiological disorders in perennial woody tropical and subtropical fruit crops. *Indian Journal of Agricultural Sciences* 86 (6): 703-717.

Kumar V., Kumar R. and Anal A.K.D. 2016. Spore population, colonization, species diversity and factors influencing the association of arbuscular mycorrhizal fungi with litchi trees in India. *Journal of Environmental Biology* 37(1): 91-100

Kumar V., Purbey S.K. and Anal A.K.D. 2016. Losses in litchi at various stages of supply chain and changes in fruit quality parameters after harvest. *Crop Protection* 79: 97-104.

Marboh E.S., Singh A.K., Dubey A.K. and Prakash J. 2015. Analysis of genetic variability among citrus (*Citrus* spp) genotypes using morphological traits. *Indian Journal of Agricultural Sciences* 85 (2): 203–11.

Nath, V., Sharma, S. and Barman, K. 2016. Acute Encephalitis Syndrome and its Alleged Litchi Connection: A Review and Status. *Indian Journal of Agricultural Sciences*. 86(3): 283-90.

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Kumar, A., Patel, R.K., Pandey, S.D. and Nath, V. 2015. Nursery Management in Litchi. *Biotech Articles. http:/www.biotecharticles.com.*



Peer Recognition

Dr. A.K. Gupta

- Best poster presentation award as author in research paper entitled "SWOT analysis and GAPs in litchi production system". *In:* International Extension Education Conference, Dept. of Agriculture Extension, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh, India (27-30th January, 2016).

Dr. Alemwati Pongener

- Acted as external examiner M.Sc. (Ag.) thesis for Bihar Agricultural University, Sabour, Bhagalpur.
- Acted as reviewer for journal 'CyTA-Journal of Food' during 2015.

Dr. Amrendra Kumar

- Acted as Zonal Councilor of Association for Advancement of Pest Management in Horticultural ecosystem (AAPMHE), IIHR, Bengaluru.
- Nominated as external examiner for evaluation of thesis of M. Sc. Ag. (Horticulture), BAU, Sabour, Bhagalpur.

Dr. Kuldeep Srivastava

- Nominated as Member, Editorial Board for Plant Protection Part of Journal 'HortFlora Research Spectrum' published by Biosciences and Agriculture Advancement Society, Meerut, Uttar Pradesh.
- Act as a convener of technical session-10: Farmers interaction workshop on potentiality of growing banana in north and eastern India". *In:* National Conference on Dynamics of Smart Horticulture for Livelihood and Rural Development at MGCGV, Chitrakoot (28th to 31st, May, 2016).
- Nominated as External Examiner for evaluation of M. Sc. (Ag.) thesis at SKUAST-Jammu, J&K.
- Co-chaired, Poster Presentation Session *In:* International seminar on "Indigenous Technologies for Sustainable Agriculture and Better Tomorrow" at NBRI, Lucknow on 10th January, 2016.
- Chaired the Technical Session-1: "Crop, Seed, Nutrient, Disease and Pests Management, livelihood improvement through innovative agriculture. *In:* National Conference on "Rural Livelihood Improvement through Innovative Agriculture" at ICAR-CPRS, Patna on 13th March, 2016.

Dr. R. K. Patel

- Act as an Associate Editor of *Hortflora Research Spectrum* journal published by Biosciences and Agriculture Advancement Society, Meerut, Uttar Pradesh.
- Empanelled as an Academic Counsellor for PGDPM/COF Programme for Course. MAM-004, BAP-001 BAPL-1, 2, 3 by Indira Gandhi National Open University, LNMU Campus, Darbhanga 846 004, Bihar
- Acted as a Chairperson (Session-3: Horticulture, Floriculture, Beekeeping, Mushroom, Innovation in Post-harvest Technology) *In:* National Conference on "Rural Livelihood Improvement through Innovative Agriculture" at ICAR-CPRS, Patna, on 13th March, 2016.

Dr. S D Pandey

- Empanelled as an Academic Counsellor for PGDPM/COF Programme for Course. MAM-004, BAP-001 BAPL-1, 2, 3 BY Indira Gandhi National Open University, LNMU Campus, Darbhanga 846 004, Bihar

Dr. S K Purbey

- Nominated as Member, Editorial Board, *Muz-Darpan,* Rajbhasha Patrika, NRAKAS, Muzaffarpur

- Nominated as Jury Member, Evaluation Committee, Science Projects during 3rd *National Bal Vygyan Congress* on 28th August, 2015 at Dwarka Nath High School, Muzaffarpur.

Dr. Sanjay Kumar Singh

- Nominated as Panel Member for Farmers-Scientist Interaction Session for "Institute Annual Day cum Foundation Day" on 6th June, 2015
- Nominated as Judge, Evaluation Committee for Exhibitions on Horticulture at Kisan Mela, 2016 at RAU, Pusa, Samastipur during 5-7th March, 2016.
- Empanelled as an Academic Counsellor for PGDPM/COF Programme for Course. MAM-004, BAP-001 BAPL-1, 2, 3 BY Indira Gandhi National Open University, LNMU Campus, Darbhanga 846 004, Bihar
- Nominated as a team member for effective implementation of *Mera Gaon, Mera Gaurav* Programme for East Champaran District of Bihar.

Dr. Swati Sharma

- Acted as External examiner of M.Sc. Thesis, Department of Horticulture (Fruits) for Bihar Agricultural University, Sabour, Bhagalpur.

Dr. Vinod Kumar

- Elected as Zonal Councilor (East Zone, 2015-17) of Association for Advancement of Pest Management in Horticultural Ecosystems (AAPMHE), Bengaluru, India.
- Nominated as Judge, Evaluation Committee for Exhibitions on Horticulture at Kisan Mela, 2016 at RAU, Pusa, Samastipur during 5-7th March, 2016
- Empanelled as an Academic Counsellor for PGDPM/COF Programme for Course. MAM-004, BAP-001 BAPL-1, 2, 3 BY Indira Gandhi National Open University, LNMU Campus, Darbhanga 846 004, Bihar
- Nominated as a team member for effective implementation of *Mera Gaon, Mera Gaurav* Programme for East Champaran District of Bihar

Dr. Vishal Nath

- Appointed as observer to ensure impartiality and fairness in conduct of Assistant (DR) Main Examination-2014 held on 18th October, 2015 for Patna Centre.
- Appointed as External Examiner to conduct comprehensive cum viva-voce examination of Ph. D and M.Sc. (Hort. - Fruit Science) at Bihar Agricultural University, Sabaur, Bhagalpur and BAU, Kanke, Ranchi, Respectively.
- Appointed as a Member of Security and Liaison Committee for the visit of Hon'ble Prime Minister of India for "87th Foundation Day and Award Ceremony of ICAR" at S K Memorial Hall, Patna.
- Nominated as an Expert on Litchi for presenting the case of litchi and its alleged involvement for the cause of AES at Nirman Bhawan, New Delhi.
- Appointed as Member of task force for validation of DUS guidelines on Guava and litchi by PPV&FRA, New Delhi.
- Empanelled as an Academic Councilor for PGDPM and COF Programme for course MAM-001 and 002, respectively by IGNOU, Regional Centre Darbhanga.
- Invited as technical expert on *Outreach Programme on Export promotion of Agriculture and Processed Food Products* from State of Bihar at BAMETI, Patna on 26th August 2015.
- Invited as Guest of Honor in '*Awareness programme on Off season Litchi Cultivation in South India*' at CHES (IIHR), Chettali, Karnataka on 10th January, 2016.



Awards and Honours

- **Dr. Gorakh Singh, Dr. Vishal Nath and Dr. S.D. Pandey** received "*Indira Gandhi Maulik Pustak Lekhan Puruskar*" on book Litchi (Hindi) by Hon'ble President of India during *'Hindi Diwas Celebration'* at Vigyan Bhawan, New Delhi.
- Dr. Gopal Kumar, Senior Scientist (Soil Science), received best research paper award as co-author from Indian Association of Soil & Water Conservationists for the paper entitled "*Implications of optimal groundwater extraction for sustainable groundwater use in Indian semi-arid tropical watershed*" authored by V.C. Pande , R.S. Kurothe, D.R. Sena and Gopal Kumar.
- Dr. Kuldeep Srivastava, Sr. Scientist (Agricultural Entomology) awarded with *Fellow of Society of Plant Protection Sciences*, New Delhi during 2015.
- Dr. Kuldeep Srivastava, Sr. Scientist (Agricultural Entomology) and late Dr. Rajesh Kumar received best oral presentation award for paper entitled "Litchi (*Litchi chinensis* Sonn.) pollinators enhancing pollination efficiency and quality fruit production". *In:* International *Conference on Indigenous Technologies for Sustainable Agriculture and Better Tomorrow*, NBRI, Lucknow, India (9-10th January, 2016).
- Dr. Sanjay Kumar Singh, Scientist SS (Horticulture) received Third Prize for taking part in **वाद-विवाद प्रतियोगिता (पड़ोसी देशों से परस्पर संबंध)** and Second Prize for taking part in **शब्दाक्षरी प्रतियोगिता** under **हिन्दी चेतना मास 2015** organized at ICAR-NRC on Litchi, Muzaffarpur during 1-30th September, 2015.
- Dr. Vinod Kumar, Senior Scientist (Plant Pathology) conferred Honorary Life Membership by the "*Asian PGPR Society*", Auburn, Alabama, USA.

Director, NRCL receiving "इन्दिरा गांधी मौलिक पुस्तक लेखक पुरस्कार"at Vigyan Bhavan, New Delhi

Compilation, Editing and Documentation

Sl. No.	Title	No. of pages	Year of publication	Scientists involved
1.	NRCL Annual Report, 2014-15 (English)	85	2015	Dr. R. K. Patel Dr. Alemwati Pongener Dr. Sanjay Kumar Singh
2.	ICAR-NRCL Annual Report, 2014 -15 (Hindi)	86	2015	Dr. R.K. Patel Dr. S. D. Pandey Dr. Sanjay Kumar Singh Dr. Alemwati Pongener
4.	HYPM, Quarterly Report, Monthly Cabinet Report	-	2015-2016	Dr. Sanjay Kumar Singh
5.	Updation of PIMS-ICAR, Permisnet-II		2015-2016	Dr. Sanjay Kumar Singh
6.	RFD: Annual Draft, Monthly Report, Midterm Achievements, Annual Performance Evaluation; Citizen/Client Charter	-	2015-2016	Dr. Vinod Kumar
7.	News and updates for NRCL Website and news related to the centre	-	2015-2016	Dr. Vinod Kumar
8.	9th RAC Proceedings, Recommendations of 8th RAC, Action Taken Report	-	2014-15	Dr. S K Purbey



Personnel

A. Scientific

Name and Email	Designation	Area of Interest
Prof. (Dr.) Vishal Nath nrclitchi@yahoo.co.in director@nrclitchi.org	Director	Plant genetic resource management; Canopy architecture management; Dissemination of technology
Dr. S. D. Pandey pandeynrcb@yahoo.com sdpandey@nrclitchi.org	Pr. Scientist (Hort.)	High density planting; Canopy management; Nutrient management; Fertigation, Organic litchi production.
Dr. Sushil Kumar Purbey skpurbey_nrcl@yahoo.com purbey@nrclitchi.org	Pr. Scientist (Hort.)	Postharvest handling and packaging; Enhancement of shelf life of litchi; Value addition and processing; Utilization of litchi fruit waste through bio-processing
Dr. Amrendra Kumar amrendra14d@gmail.com amrendra@nrclitchi.org	Sr. Scientist (Hort.)	Nursery management; Plant propagation and growth physiology of vegetatively propagated plants; Collection and characterization of rambutan germplasm
Dr. Kuldeep Srivastava Kuldeep.ipm@gmail.com kuldeep@nrclitchi.org	Sr. Scientist (Ento.)	Management of insect pests of litchi; Insect pollinators of litchi.
Dr. R.K. Patel rkpatelicar@gmail.com rkpatel@nrclitchi.org	Sr. Scientist (Hort.)	Development of organic package of practices for litchi; Litchi-based cropping system for low-lying areas
Dr. Vinod Kumar vinod3kiari@yahoo.co.in vinod@nrclitchi.org	Sr. Scientist (Plant Path.)	Management of pre- and postharvest diseases of litchi; Mycorrhizal association; Bio-control and bio-fertilizers for sustainable production of litchi
Dr. Gopal Kumar gkcswcrti@gmail.com	Sr. Scientist (Soil Science)	Weather, agricultural meterology, soil survey and mapping, nutrient status of litchi soil
Dr. Sanjay Kumar Singh sanjayhor@rediffmail.com sanjay@nrclitchi.org	Scientist SS (Hort.)	Shoot physiology and biochemistry in relation to flowering and fruiting in litchi; Germplasm conservation and development of database on mango and pummelo
Sh. Narayan Lal narayanlal.lal7@gmail.com narayan@nrclitchi.org	Scientist (Hort.)	Collection and evaluation of litchi germplasm; Clonal selection; Development of hybrids
Dr. Alemwati Pongener alemwati@gmail.com alemwati@nrclitchi.org	Scientist (Hort.)	Pericarp browning; Postharvest management to reduce loss; Processing and value addition
Sh. Alok Kumar Gupta alokguptabhu@gmail.com	Scientist (Hort.)	Collection and evaluation of litchi germplasm; Clonal selection; Development of hybrids
Dr. Neetu Singh Kushwah neeturajawat@gmail.com	Scientist (Ag. Biotechnology)	Biotechnology, Molecular characterization, Germplasm conservation
Dr. Evening Stone Marboh esmarboh@gmail.com	Scientist (Hort.)	Water management and plant physiology
Dr. Swati Sharma swtsharma92@gmail.com	Scientist (Hort.)	Postharvest Management, and plant physiology

B. Technical

Sh. Rajiv Ranjan Rai Asst. CTO (Farm In-charge) rrrainrcl@gmail.com farmic@nrclitchi.org	Dr. J.P. Verma (T-3)	Sh. Ramashish Kumar (T-3)

C. Administrative

Sh. Abhishek Yadav Administrative Officer aonrclitchi@gmail.com ao@nrclitchi.org	Sh. Ramji Giri Assistant Administrative Officer aaonrcl@gmail.com aao@nrclitchi.org	Sh. Subhankar Dey Assistant Finance & Account Officer afao@nrclitchi.org
Sh. Dileep Kumar Assistant	Sh. Akshay Kumar Yadav Assistant	Sh. Avinash Kumar Kashyap Sr. Clerk (UDC) avinash_kgh@yahoo.com
Sh. Pawan Kumar Jr. Clerk (LDC)	Sh. Sawan Kumar Jr. Clerk (LDC)	Sh. Ajay Kumar Rajak Skilled Supporting Staff
Sh. Surendra Rai Skilled Supporting Staff	Sh. Dharmendra Kumar Skilled Supporting Staff	



Recruitment, Promotion and Transfer

New entry

- Dr. Gopal Kumar, Scientist (Ag. Physics) joined the centre as Senior Scientist (Soil Science) on 30th September, 2015.
- Sh. Jai Prakash Verma has been recruited for the post of Technical-3 (Field/Farm Technician) and joined on 15th July, 2015
- Sh. Ramashish Kumar joined as Technical-3 (Field/Farm Technician) and joined on 29th July, 2015

Promotion

- Dr. Shyamji Mishra, T-3 (Field/Farm Technician) has been promoted to T-4 with effect from 30th June, 2014.

Transfer

- Dr. Shyamjee Misra, T-3 has been transferred to ICAR-CSSRI Regional Centre, Lucknow and relieved from the centre on 22nd July, 2015.
- Smt. Pallavi, T-2 has been transferred to ICAR-IISR, Lucknow and relieved from the centre on 17th October, 2015.
- Dr. Neetu Singh Kushwah, Scientist, (Agricultural Biotechnology) was relived from centre on 26th December, 2015 to join at ICAR-Indian Institute of Pulse Research, Kanpur on transfer recommended by ICAR-HQ.

Important Committees

Research Advisory Committee (RAC)

9th Research Advisory Committee (RAC) meeting was held under the chairmanship of Dr. S. D. Shikhamany, Former VC, Dr. YSR Horticultural University, West Godavari, District, AP on 15th September, 2015 at ICAR-NRCL, Muzaffarpur. The constitution of the committee was as under:

1.	Dr. S.D. Shikhamany, Former VC, Dr. YSR Horticultural University, West Godavari District, AP	Chairman
2.	Dr. Manjit Singh. Former Director, ICAR-DMR, Solan, H.P	Member
3.	Dr. D.S. Khurdiya, Former Head, Division of Post Harvest Technology, IARI, New Delhi	Member
4.	Dr. V. V. Ramamurthy, Principal Scientist, IIHR, Bengaluru	Member
5.	Dr. S. K. Mitra, Former Dean, BCKVV, Kalyani, West Bengal	Member
6.	Dr. Jitendra Kumar, Director, ICAR-DMAPR, Anand, Gujarat	Member
7.	Sh. Mukesh Kumar Sharma, Muzaffarpur, Bihar	Member
8.	Sh. Ranjan Kumar Sahu, Muzaffarpur, Bihar	Member
9.	Dr. Vishal Nath, Director, ICAR-NRCL, Muzaffarpur, Bihar	Member
10.	Dr. S.K. Purbey, Principal Scientist, ICAR-NRCL, Muzaffarpur, Bihar	Member Secretary

9th Research Advisory Committee inprogress

Institute Research Council (IRC)

During the year, 12th and 13th Institute Research Council (IRC) meetings were held on 20-21st April, 2015 and 2-3rd December, 2015, respectively under the chairmanship of Director, ICAR-NRCL. During the meetings, progress report of research projects along with technical programmes was discussed in detail. The new research projects were also discussed and finalized. The 12th and 13th IRC meeting was attended by the following scientists:

1.	Prof. (Dr.) Vishal Nath	Director	Chairman
2.	Dr. S. D. Pandey	Pr. Scientist (Hort.)	Member
3.	Dr. Rajesh Kumar	Pr. Scientist (Hort.)	Member
4.	Dr. Sushil Kumar Purbey	Sr. Scientist (Hort.)	Member
5.	Dr. Amrendra Kumar	Sr. Scientist (Hort.)	Member
6.	Dr. Kuldeep Srivastava	Sr. Scientist (Ag. Entomology)	Member
7.	Dr. R.K. Patel	Sr. Scientist (Hort.)	Member
8.	Dr. Vinod Kumar	Sr. Scientist (Plant Pathology)	Member
9.	Dr. Sanjay Kumar Singh	Scientist SS (Hort.)	Member
10.	Sh. Narayan Lal	Scientist (Hort.)	Member
11.	Sh. Alok Kumar Gupta	Scientist (Hort.)	Member
12.	Dr Neetu Singh Kushwah	Scientist (Ag. Biotechnology)	Member
13.	Dr Evening Stone Marboh	Scientist (Hort.)	Member
14.	Dr Swati Sharma	Scientist (Hort.)	Member
15.	Dr. Alemwati Pongener	Scientist (Hort.)	Member Secretary

13th IRC meeting in progress

Institute Management Committee (IMC)

The 10th Institute Management Committee (IMC) meeting was held on 30th December, 2015 at the centre. The following members attended the meeting and discussed the agenda items relevant to IMC of the Centre.

1.	Dr. Vishal Nath, Director, NRCL, Muzaffarpur	Chairman
2.	Dr. T. Janakiram, ADG (Hort.-I), ICAR, New Delhi	Member
3.	Dr. I. S. Solanki, ADG (F & FC), ICAR, New Delhi	Member
4.	Dr. A. K. Mishra, Pr. Scientist, ICAR-CISH, Lucknow	Member
5.	Dr. V.K. Gupta, Pr. Scientist, ICAR-RCER Research Centre for Makhana, Darbhanga, Bihar	Member
6.	Sh. Ranjan Kumar Sahu, Muzaffarpur	Member
7.	Sh. Mukesh Kumar Sharma, Muzaffarpur	Member
8.	Dr. S.D. Pandey, Chairman PME, ICAR-NRCL, Muzaffarpur	Special Invitee
9.	Dr. S. K. Purbey, Pr. Scientist, ICAR-NRCL, Muzaffarpur	Special Invitee
10.	Dr. Amrendra Kumar, Chairman FMC, NRCL, Muzaffarpur	Special Invitee
11.	Sh. Subhankar Dey, AF&AO, ICAR-NRCL, Muzaffarpur	Special Invitee
12.	Sh. Ramji Giri, AAO, ICAR-NRCL, Muzaffarpur	Special Invitee
13.	Sh. Abhishek Yadav, AO, ICAR-NRCL, Muzaffarpur	Member-Secretary

Institute RFD-Committee and RFD-Cell

For successful implementation of committed plan of work under Results Framework Document (RFD) and monitoring of success indicators, the centre has 'Institute-RFD Committee' and 'RFD-Cell', the constitution of which is as under:

Institute RFD Committee		RFD Cell	
Dr. Vishal Nath (Director)	Chairman	Dr. Vinod Kumar	Nodal Officer
Dr. Vinod Kumar	Nodal officer	Dr. Sanjay Kumar Singh	Co-Nodal officer
Dr. S.D. Pandey	Member	Sh. Abhishek Yadav	Member
Dr. Sanjay Kumar Singh	Member	Sh. Subhankar Dey	Member
Sh. Abhishek Yadav	Member		

Other Institutional Committees

The composition of other important institutional committees during 2015-16 was as under:

Sl. No.	Name of committee	Members of the Committee	
1.	Priority Setting Monitoring and Evaluation Committee (PME Cell)	Dr. S.D. Pandey	Chairman
		Dr. Vinod Kumar	Co-Chairman
		Dr. Sanjay Kumar Singh	Member
		Dr. Alemwati Pongener	Member Secretary
2.	Price Fixation Committee (PFC)	Dr. Rajesh Kumar	Chairman
		Dr. Sanjay Kumar Singh	Co-Chairman
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member
		Sh. Rajiv Ranjan Rai	Member Secretary

3.	Works and Estate Committee	Dr. S. K. Purbey	Chairman
		Dr. Vinod Kumar	Member
		Sh. Rajiv Ranjan Rai	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member Secretary
4.	Farm Management Committee (FMC)	Dr. Amrendra Kumar	Chairman
		Dr. R.K. Patel	Co-chairman
		Dr. Kuldeep Srivastava	Member
		Sh. Abhishek Yadav	Member
		Dr. Shyamji Mishra	-
5.	Purchase and Store Advisory Committee (PS&AC)	Dr. R.K. Patel	Chairman
		Dr. Kuldeep Srivastava	Co-Chairman
		Sh. Narayan Lal	Member
		Sh. Subhankar Dey	Member
		Sh. Abhishek Yadav	Member Secretary
6.	Spot Purchase Committee (SPC)	Dr. S.D. Pandey	Chairman
		Dr. Kuldeep Srivastava	Co-chairman
		Sh. Rajiv Ranjan Rai	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member Secretary
7.	Training and Exhibition Cell	Dr. S.K. Purbey	In-charge
		Dr. Kuldeep Srivastava	Member (Museum)
		Dr. R.K. Patel	Member (IGNOU, PPV & FRA)
		Sh. Subhankar Dey	Member
		Dr. Shyamji Mishra	Member
8.	Central Laboratory Facility	Dr. Swati Sharma	In-charge
		Dr. Alemwati Pongener	Alternate In-charge
		Smt. Pallavi	-
9.	Library Committee	Sh. Narayan Lal	In-charge
		Dr. Alemwati Pongener	Alternate In-charge
		Dr. Neetu Singh Kushwah	Member
		Smt. Pallavi	-
10.	Climate Change related matters and Weather Advisory Cell	Dr. Rajesh Kumar	In-charge
11.	Security Cell	Sh. Abhishek Yadav	In-charge
12.	Estate and Vehicle Cell	Sh. Ramji Giri	In-charge
13.	Women Cell	Dr. Swati Sharma	In-charge

Annual (April 1, 2014 to March 31, 2015) Performance Evaluation Report in respect of RFD 2014-2015 of RSCs i.e. Institutes

Name of the Division : Horticulture Science
Name of the Institution : National Research Centre on Litchi, Muzaffarpur
RFD Nodal Officer of the RSC : Dr. Vinod Kumar

1.	Production and post-harvest management in litchi	48	Development of improved production technology	Production technology developed	Number	22	4	3	2	1	0	4	100	22	133.3	NA+
			Development of post-harvest technology	Post-harvest technology developed	Number	11	2	1	0	0	0	2	100	11	200.0	NA+
			Production of quality planting materials	Saplings produced	Number	15	34000	28000	22000	16000	10000	24245	83.75	12.56	86.6	R_1
2.	Plant genetic resources management and crop improvement in litchi	17	Collection of germplasm	Germplasm collected	Number	5	12	10	8	6	4	12	100	5	120.0	NA+
			Selection and establishment of clones	Clones selected and established in field	Number	4	8	7	6	5	4	8	100	4	114.3	NA+
			Characterization of seedling population	Seedlings characterized	Number	8	150	125	100	75	50	125	90	7.2	100.0	NA
3.	Training and transfer of technology to stakeholders	15	Organization of training programmes for farmers and processors	Trainings organized[#]	Number	15	10	8	6	4	2	11	100	10	137.5	NA+

produced but only 24,245 were taken by various indenter/clients

*	Publication/Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	3	2	1	0	0	5	100	3	250.0	R_2
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30.06.2014	2.07.2014	04.07.2014	07.07.2014	09.07.2014	28.06.2014	100	2	NA	NA
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90	98.70	100	2	102.8	NA+
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014	April 30, 2014	100	2	NA	NA
			Timely submission of Results for 2013-2014	On time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014	April 30, 2014	100	1	NA	NA
*	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80	100	100	2	NA	NA
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80	100	100	1	NA	NA

	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	Nov.2 2014	Nov.3 2014	Nov.4 2014	Nov.5 2014	Oct. 10 2014	100	2	NA	NA
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	90	80	70	60	100	100	1	NA	NA
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80	0	0	0	NA	R_3
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60	100	100	2	NA	NA

Total Composite Score: 89.76

Rating: Very Good

Procedure for computing the Weighted and Composite Score

1. Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100
2. Total Composite Score = Sum of Weighted Scores of all the Success Indicators

Results-Framework Document (RFD) for National Research Centre on Litchi (2014 - 2015)

Address: Mushahari, Muzaffarpur- 842002 (Bihar)
Website ID: http://www.nrclitchi.org

Section 1: Vision, Mission, Objectives and Functions

Vision

Developing the National Research Centre on Litchi as a centre of excellence in the field of research, extension and training.

Mission

Harnessing science and technology by interfacing research and extension activities for enhanced quality production, productivity, processing and use diversification for sustained litchi production, industry and trade.

Objectives

1. Production and post-harvest management in litchi
2. Plant genetic resources management and crop improvement in litchi
3. Training and transfer of technology to stakeholders

Functions

- To undertake basic, strategic and applied research for enhancing productivity, quality and utility of litchi.
- To act as repository of genetic resources and scientific information on all aspects of litchi.
- To undertake frontline demonstration in newer technologies and to impart training for upgrading scientific knowledge.

Section-2: *Inter se* priorities among Key Objectives, Success Indicators and Targets

1.	Production and post-harvest management in litchi	48	Development of improved production technology	Production technology developed	Number	22	4	3	2	1	0
			Development of post-harvest technology	Post-harvest technology developed	Number	11	2	1	0	0	0
			Production of quality planting materials	Saplings produced	Number	15	34000	28000	22000	16000	10000
2.	Plant genetic resources management and crop improvement in litchi	17	Collection of germplasm	Germplasm collected	Number	5	12	10	8	6	4
			Selection and establishment of clones	Clones selected and established in field	Number	4	8	7	6	5	4
			Characterization of seedling population	Seedlings characterized	Number	8	150	125	100	75	50
3.	Training and transfer of technology to stakeholders	15	Organization of training programmes for farmers and processors	Trainings organized[¥]	Number	15	10	8	6	4	2
*	Publication/Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	3	2	1	0	0
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30.06.2014	02.07.2014	04.07.2014	07.07.2014	09.07.2014
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90

Section-2: *Inter se* priorities among Key Objectives, Success Indicators and Targets

*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014
			Timely submission of Results for 2013-2014	On-time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014
*	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80
*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	Nov.2 2014	Nov.3 2014	Nov.4 2014	Nov.5 2014
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	90	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60

Section-3: Trend Values of the Success Indicators

1.	Production and post-harvest management in litchi	Development of improved production technology	Production technology developed	Number	2	3	3	3	3
		Development of post-harvest technology	Post-harvest technology developed	Number	1	2	1	1	1
		Production of quality planting materials	Saplings produced	Number	25000	27893	28000	30000	32000
2.	Plant genetic resources management and crop improvement in litchi	Collection of germplasm	Germplasm collected	Number	8	5	10	12	15
		Selection and establishment of clones	Clones selected and established in field	Number	8	6	7	-?	-?
		Characterization of seedling population	Seedlings characterized	Number	125	45	125	200	250
3.	Training and transfer of technology to stakeholders	Organization of training programmes for farmers and processors	Trainings organized	Number	5	8	8	10	12
*	Publication/Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	Number	1	1	2	3	4
		Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	-	-	02.07.2014	-	-
*	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	100	99.98	96	100	100

*

Section-3 : Trend Values of the Success Indicators

*	Efficient Functioning of the RFD System	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	-	-	May 16, 2014	-	-
		Timely submission of Results for 2013-2014	On-time submission	Date	-	-	May 2, 2014	-	-
*	Enhanced Transparency / Improved Service delivery of Ministry/ Department	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
*	Administrative Reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	Nov.2, 2014	-	-
		Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC).	% of implementation	%	-	-	90	-	-
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs).	% of implementation	%	-	-	90	-	-

Section 4(a): Acronyms

1.	NHB	National Horticulture Board
2.	NHM	National Horticulture Mission
3.	APEDA	Agricultural Produce Export Development Authority
4.	SAU	State Agricultural Universities
5.	KVK	Krishi Vigyan Kendra
6.	IPM	Integrated Pest Management

Section 4(b): Description and definition of success indicators and proposed measurement methodology

1.	Production technology developed	Development of production technology includes techniques to produce quality planting material, improved nutrient management, water management and pest management practices.	All those technologies that lead to increase in production and productivity are called production technology.	Number	This will help in enhancing litchi production.
2.	Post-harvest technology developed	Development of post-harvest technology includes diversified value added products, extention in shelf life and reduction in post-harvest losses including fruit rots through different packaging systems.	All those technology that minimizes post-harvest loss and results in value addition is called post-harvest technology.	Number	It will help in reducing losses of litchi and diversified value added products of litchi to consumers.
3.	Saplings produced	Supply of quality planting material of litchi to various stakeholders.	It is a process of vegetative means by which new individuals arise without production of seeds.	Number	In a wider sense, planting material arise from vegetative propagation methods such as air-layering and grafting in case of litchi.
4.	Germplasm collected	Diverse germplasm is the basic requirement to bred new improved varieties.	Germplasm is collection of cultivars, landraces, wild species etc. for conservation and utilization.	Number	Germplasm material serve as base for utilization in crop improvement programs for breeding new varieties.
5.	Clones selected and established in field	Selection of intra-varietal variation to develop new cultivars.	Clones are progenies of a single vegetatively propagated plant.	Number	This is a method of improving the existing variety.
6.	Seedlings characterized	The seedling progenies are highly variable and selection can be performed only after characterization.	Characterization of seedlings is systematic observation of useful vegetative and reproductive traits.	Number	This is also a method of development of new cultivars.
7.	Trainings organized	Capacity building activities related to knowledge and skill improvement/development programmes conducted for farmers/ stakeholders. Technology developed at the centre particularly rejuvenation, intercropping and IPM in litchi will be disseminated among stakeholders.	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving productivity in an organization or enterprise.	Number	It will facilitate the adoption of improved technology.

Section 5: Specific performance requirements from other departments that are critical for delivering agreed results

State Government	Litchi growing states (Bihar,W.B.,U.P., Uttarakhand, North Eastern states and new potential areas in Southern States)	Department	Different States' Agricultural Department	Saplings produced	Indent for quantity (number) of litchi saplings	Variety-wise indent for litchi saplings	Quantity of saplings is produced as per indent	Less or more number of saplings will be produced

Section 6: Outcome/ Impact of activities of the Department/Ministry

1.	Enhanced productivity and production of litchi	NHB, NHM, APEDA, State Departments of Agriculture SAUs, KVKs, etc.	Improvement in productivity*	%	3.0	4.5	6.0	7.5	8.0
2.	Enhancement in shelf life of fruits	-do-	Increased shelf life	Days	6	8	10	12	15

Weather Report

Monthly Weather Data (1st April, 2015 to 31st March, 2016)

Month	Av. Temperature (°C)		Av. Relative humidity (%)		Total Rainfall
	Max	Min	Max	Min	Days
2015					
April	33.29	21.22	84.22	40.11	3
May	37.53	25.92	79.15	35.53	5
June	36.03	26.50	75.39	37.64	4
July	33.25	26.09	89.87	54.35	19
August	33.75	26.10	91.42	51.39	10
September	33.80	25.71	90.47	51.23	9
October	33.71	22.00	89.00	36.54	2
November	29.52	17.86	89.56	38.43	0
December	24.27	12.34	90.58	42.41	0
2016					
January	22.89	9.27	91.62	43.96	1
February	26.40	12.96	88.40	38.62	2
March	32.22	18.37	85.48	34.92	3



ICAR - National Research Centre on Litchi

(Indian Council of Agricultural Research)

Quality Policy : NRCL

National Research Centre on Litchi is committed in developing as a Centre of excellence in the field of research, extension and training.

Towards this, we shall,

- Implement a Quality Management System to international standards
- Continually improve our performance by periodical review of quality objectives and RFD documents
- Actively involve and adequately empower all personnel

Dated: 12th January, 2015

Director

Promising Litchi Clones

भाकृअनुप
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भाकृअनुप–राष्ट्रीय लीची अनुसंधान केन्द्र

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