वार्षिक प्रतिवेदन
ANNUAL REPORT
2018-19

भा.कृ.अनु.प.–राष्ट्रीय लीची अनुसंधान केन्द्र

ICAR-National Research Centre on Litchi

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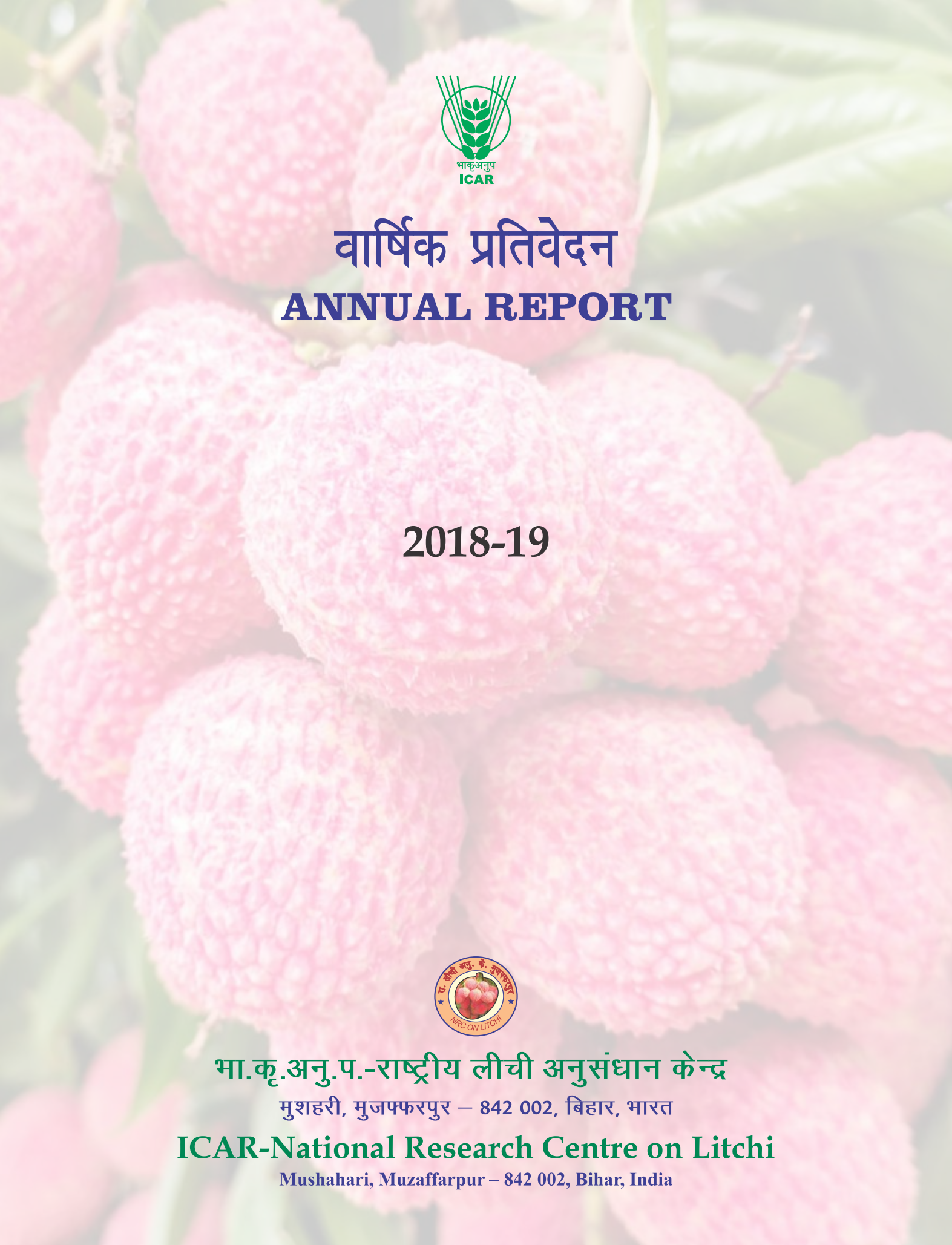
Mushahari Farm, Mushahari, Muzaffarpur–842 002, Bihar, India



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Preface

It is always a privilege to bring out the Annual Report. It gives us the opportunity to look back on the year that was, and provides a platform where one can reflect on the achievements with a sense of accomplishment and also pull up socks on challenges where continued efforts to improve are required.

With clear goals envisioned in the centre`s mandate, ICAR-NRCL, Muzaffarpur pushed forward with zeal and enthusiasm during the past year. Our scientists were able to collect some promising litchi germplasm, while also succeeding in characterization of several genotypes of litchi and longan available in the centre`s field gene bank. Fertilizer application is an important component of production system in litchi, and our study on standardization of fertilizer doses for more than a decade has finally taken the shape of a technology. Readers will be apprised of the progress with studies on girdling, planting densities and canopy management, litchi-based cropping system, mycorrhizal association, and shoot physiology in relation to flowering, and also be introduced to some new research programmes on DRIS norms, leaf nutrient dynamics, and microbial consortia. Disease incidence and severity of blight caused by Alternaria alternata have been studied, and NRCL Microbial Consortia, a carrier-based formulation, has been released as a technology. New molecules and their efficacy in management of litchi shoot and fruit borer and litchi mite have been tested successfully. Database generated on fruit growth and development in litchi cv. Shahi over the past years have been used to establish correct harvest maturity standards. A postharvest protocol to enhance shelf life of litchi has also been developed.

Living up to the expectations of litchi growers in different parts of the country, the centre made concerted efforts to reach out to farmers and stakeholders in litchi-growing areas all over the country. Several capacity building and training programmes were organized during the year and more than 5000 stakeholders were benefitted through our training and extension activities. MoU and licence transfer for litchi based beverages have been inked with three firms. The centre also participated in various Farmers` Fair to showcase and disseminate litchi technologies among stakeholders. With the aim of developing core competence and human resource development, the centre has continued to attract and train UG and PG students in agricultural research and education.

Development of infrastructural facilities continued during the year with the completion and allotment of nine more residential quarters and installation of rooftop solar power panels being the most significant.

I place on record, my sincere gratitude to the Dr, T. Mohapatra, Secretary, DARE and DG, ICAR, and Dr. A.K. Singh, DDG (HS) for their steadfast and wholehearted support to the centre. I thank the scientists and staff of ICAR-NRCL for the unwavering cooperation to take the centre forward.

The report in your hands is the fruit of our labour, and it is with great honour that I present the progress we have made in this journey towards fulfilment of our vision and mandate. I hope that you will find the content of this report informative and educative. I wind up soliciting your valuable feedbacks and suggestions, so as to help us serve and work with greater zeal and vigour.

Muzaffarpur
June, 2019

Vishal Nath
Director

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Executive Summary

ICAR-National Research Centre on Litchi has made commendable progress in 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. The centre also conducted training, organized outreach programmes, and transfer of technology activities to improve knowledge and develop skills of different stakeholders. A concise summary of salient achievements the centre has made during 2018-19 is presented below.

Research Accomplishments

Genetic Resource Management and Crop Improvement

- Five litchi germplasm from Assam and three germplasm from Meghalaya were collected of which 3 germplasm namely Tezpur Bilaiti, Tezpur Rongiya and Meghalaya Seedless have fruit weight more than 25 g.
- Two germplasm tolerant to fruit cracking were identified in Punjab.
- Thirty litchi genotypes were screened for dwarfing characters on the basis of morphological and bio active compounds.
- A total number of 18,135 crosses were made from four parental combinations. Twenty three hybrid fruits were harvested in 2018 and planted in protected nursery.
- Four genetic stocks in litchi *viz.*, NRCL 29, NRCL 85, NRCL 86 and NRCL 87 have been identified based on unique key characters.
- Six hundred seedlings were evaluated for abiotic stresses like drought based on leaf thickness.
- Screening of thirty litchi genotypes for dwarfing characters on the basis of morphological and bio active compounds revealed that plant height was negatively correlated with bark:wood ratio (-0.422). Correlation studies revealed that yield was negatively correlated with phenol content in pericarp (-0.41) and flavonoids in seed (-0.43).
- Evaluation of twenty litchi genotypes based on wax content in leaf revealed that wax content ranged from 3.07 to 31.08 mg/g leaf and 0.10 to 0.97 mg/cm^2 leaf.
- Twenty one fruited longan genotypes were evaluated and two genotypes recorded fruit weighing about 8.0 g.

Crop Production

- Significantly higher yield of 9.72 t/ha (67.50 kg/plant) was recorded with application of 100:50:750g NPK/plant/year age in 14 years old plants of litchi cv. Shahi. Fruit weight of 25.33 g was recorded with TSS of 20.4°B. N and K was applied 2/3rd after harvesting in month of June and 1/3rd at the time of clove size of fruit.
- The highest yield 15.84 t/ha (110 kg/plant) was recorded with application of 100:100 g and N and K with application of 2/3rd during June after harvesting and 1/3rd during mid April at clove size fruit stage on 12 years old litchi cv China plant.
- Application of 120 kg FYM+15 kg vermi-compost + 3 kg neem cake and 200g bio-fertilizer per plant yielded 68.87 kg fruit/plant (9.92 t/ha) with 20.51 °Brix TSS and 65.72% pulp recovery in 12 years old plants.
- Out of 6 planting densities, 6x4 m and 8x4 m recorded maximum yield of 20.11 and 19.77 t/ha, respectively.
- Significantly highest fruit yield of 49.75 kg/plant (10 year old plant) was recorded in 3 mm girdling covering 75% plant canopy.
- Litchi-based cropping system on pond bunds was executed with plantation of litchi on pond embankment along with other short duration fruit and seasonal crops comprised

with different models showed that about 20% plants of Shahi litchi exhibited flowering at 4 years of age.

- Performance of makhana crops grown in pond found to be a promising under Muzaffarpur condition.
- Nitrogen content in vermi-compost made up with banana pseudo stem varied from 1.92-2.18%, in litchi leaves 2.10-2.35%, in litchi peels 1.96-2.16% and in farm grasses 1.33-1.75%.
- Study on soil moisture status of ridge and mound system at various soil profile depth reveal that soil moisture content varied due to soil depth and situation (Ridge & mound).

Crop protection

- Disease incidence and severity of blights of leaf, panicle and fruits were recorded. The mean disease incidence of leaf blight was 13.22- 16.17%. The mean disease incidence of panicle blight was 16.32% in cv. 'Shahi' while in cv. 'China' it was 28.27%. The mean disease incidence of fruit blight on trees in farmers' orchard in Muzaffarpur, Bihar varied from 3.1-15.8% while the range was 2.0-17.4%
- Ecophysiology of *A. alternata* and epidemiology of the disease was studied. *A. alternata* was able to survive in prolonged stressing conditions of high and low temperature and humidity regime that increase the concern about this pathogen expecting higher levels of occurrence.
- Studies showed that application of mycorrhiza along with *Azotobacter* and *Trichoderma* was beneficial for growth of litchi, and influenced the fruit quality parameters positively.
- A technology *viz,* NRCL microbial consortium for enhanced growth, productivity and quality of litchi was released. This is is a carrier-based formulation of three microbes, Arbuscular mycorrhiza, *Azotobacter chroococcum* and *Trichoderma viride* isolate NRCLT-01.
- Spraying of flubendiamide 19.92% + thiacloprid 19.92% (0.48%), lambdacyhalothrin 5 EC (0.003%) and chlorantranilprole 18.5 SC (0.007%) were found to be effective against fruit & shoot borer.
- Among organic pesticides, few natural plant origin alkaloids (1.25-1.5 ml/l) along with neem oil 3 ml/l found to be the most effective against fruit & shoot borer.
- Pruning of affected twigs followed by two spraying of chlorfenapyr 10 EC (0.03%) or spiromesifen 22.9 SC (0.034%) at 15 days interval during July and one pruning in October with one spraying of any one above chemical were highly effective against litchi mite.

Postharvest management and value addition

- Fruit growth and development of litchi cv. Shahi was studied. Growth dynamics of peel, seed and aril were profiled on the basis of physical and biochemical parameters during fruit development stages. Based on database developed since 2010, maturity standards for litchi cv. Shahi were established.
- Pre-harvest application of senescence regulator (Ethrel@ 900 ppm) at colour break stage resulted in higher accumulation of anthocyanins (34.35 mg/100 g) and red colour formation (Hunter a – 31.22) in litchi pericarp.
- Salicylic acid (2-8 mM) applied as a pre-harvest prophylactic spray (2 days before anticipated harvest) could significantly reduce incidence of fruit decay during postharvest storage of litchi up to 18 days under refrigerated conditions.
- Postharvest treatment of litchi with Kojic acid at concentration ranging from 1-5 mM resulted in significant control of pericarp browning up to 21 days under refrigerated conditions.
- Superior retention of colour and firmness in minimally-processed litchi could be achieved through steam blanching for 3 minutes followed by treatment with 4-Hexylresorcinol @ 0.02% and ascorbic acid (0.5%).

- A postharvest protocol to enhance shelf life of litchi was developed

Improving knowledge and skill of stakeholders

- More than 25 formal trainings including five litchi Pathshala and a 'National Dialogue on Improving Productivity and Utilization of Litchi' were organized at the centre.
- Technology awareness programmes were regularly conducted in adopted villages under Mera Gaon Mera Gaurav (MGMG).
- During the year more than 5000 stakeholders were benefited through various training and extension activities.
- Provided 1000 litchi planting material of cv. Shahi and China to 400 beneficiaries of Khetauli Village in Shahdol district and 150 winter season vegetable kits were distributed among the farmers under TSP programme.
- Training and canopy management during initial plant growth stage as well as practical demonstration of preparing litchi-based beverages were conducted in Ngwalwa and Heningkunglwa villages in Peren district under NEH component.

Externally Funded Projects

- Under Farmers First Programme (FFP), 1200 litchi plants, 8 varieties of wheat, papaya (1800 plants), one each of lentil and mustard, 120 ducks of Indian Runner and Khaki Campbell, 3 bucks of Black Bengal have been distributed among project beneficiaries of eight identified villages in East Champaran, Bihar. The farmers were also empowered to improved livelihood by intervention of good practices in agricultural production system under four major modules, viz. crop, horticulture, livestock, and microenterprise-based modules.
- Under BRNS-funded project, preservation of litchi pulp up to six months without undesirable change in colour and aroma with the use of low temperature (-18°C) has been standardized. Combination treatment including acidification (up to 1%) using citric acid and different levels of sorbic acid to preserve litchi pulp has also been found to prevent spoilage of litchi pulp.
- Approximately 40000 air-layers were prepared during the period under the ICAR-sponsored Mega Seed project.
- Character detailing of 9 genotypes of litchi as per DUS guidelines has been done.
- Under NAIF project, five entrepreneurs were trained on rejuvenation, canopy management, beverage technology and more than seven demonstrations have been conducted in various states.
- Technology on bunch bagging and girdling of branches to induce fruiting in China litchi has been refined.
- FSSSI registration has been obtained and various litchi products are developed under RFS (PHT & Lab).
- Two cold room of 5 tonne capacity each has been developed under NHB project

Linkages and Collaborations

The centre is working on different aspects in close collaboration with other organizations such as Agricultural Universities (BHU, DRPCAU, IGKV, JNKVV, SHIATS, SKAUST, BAU, etc.), Central University (MGCUB), NHB, APEDA, BARC, State Agriculture/Horticulture Departments, and other ICAR Institutes. Under the MoU signed with DRPCAU, Pusa, the scientists of the centre have been actively involved in post-graduate education and research under collaborative mode. Five PG scholars are conducting research at the centre under the guidance of NRCL scientists. The centre also conducts regular summer training for UG and PG students from various universities and fulfills the training and HRD needs of students from different parts of the country. Altogether 32 students were part of such summer training and internship programmes during the year. As a study centre of IGNOU, New Delhi for postgraduate diploma in plantation management

and certificate course in organic farming, several students have registered for the courses.

Transfer of Technology

Three MoU were signed between ICAR-NRCL and Md. Hasnain Ariz Anwari Lodge Sadpura Milki Tola, Mithanpura, Muzaffarpur, Bihar, Md. Shohaib North Bihar Distributor Franchises of Ayurved products, Sadpura, Mithanpura, Muzaffapur, Bihar and Mr. Krishna Gopal Singh, M/S Vishvaksenah Agro & Dairy Pvt. Ltd. 2B/1, Plot No. 155, Road No-2, Tirhut Colony, Ahiyapur, Muzaffarpur, Bihar-842001 for 'Technology Transfer and Commercialization of process for preparation of litchi squash and RTS'. Initiatives for effective transfer of litchi based technologies, through off-campus and on-campus training to farmers, field visits, and timely advice through print and electronic media were taken. The centre also participated in various Farmers` Fair to showcase and disseminate litchi technologies among stakeholders.

Other Activities

Hindi Chetna Maas was organised and the use of official language in all communication is being attempted. Swachh Bharat abhiyan and International Day of Yoga was organised at the centre where personnel from the NRCL took part. Other activities where the centre joined the rest of the nation in commemorating included Vigilance Awareness Week, Field Day, World Soil Day, etc.

Infrastructural development

Construction of nine additional residential quarters was completed and allotted to scientists and staff. Solar rooftop installation was completed under RESCO model for generation of about 100kwh of clean energy. With financial grant from NHB, a facility was created with installation of cold rooms having capacity of 10 MT.

ICAR-NRCL

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

Genesis and Growth

The ICAR-National Research Centre on Litchi (ICAR-NRCL) was established on 6th June, 2001 under the aegis of the Indian Council of Agricultural Research. With the lease deed having signed on 25th June, 2002 between the ICAR and Government of Bihar to transfer 100 acres of land to the Centre at Mushahari, Muzaffarpur, ICAR-NRCL began its journey. The centre grew in strength and number in subsequent years as more scientists and staff were allotted from the council. The centre can boast today of having almost its full sanctioned scientific strength, modern laboratories with core equipment, a sprawling farm and experimental area, and a buzzing campus. 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 210 m. It is about eight km from Muzaffarpur railway station. The research farm of the centre is spread over an area of 35 ha.

Mission, Mandate and Functions

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 for stakeholders for enhancing and sustaining productivity of litchi

Infrastructure Facilities

The research farm of the centre has modern propagationstructures,screenhouses,glasshouses, irrigation networking and water sources. Modern analytical and diagnostic equipmentlike GCMS, AAS, UV-VIS spectrophotometer, HPLC, leaf area meter, portable photosynthesis system, horizontal electrophoresis unit, nitrogen analyzer, flame photometer, trinocular phase-contrast upright microscope, trinocular compound microscope, inverted phase contrast microscope, stereo binocular microscope, lyophilizer, ultracentrifuge, modified atmospheric packaging unit, hydro-cooling system, forced-air cooling system, litchi grading machine, plastic strip sealing and packaging machine, cool storage chamber, bottle washing machine, litchi harvester cum pruner, power sprayer and mist chamber, Hunter colour meter, Water Activity meter, CHN Analyzer, CO_2 analyzer, soil moisture meter, have been installed for different research and supportive activities. The centre has a processing workshop equipped with litchi peeling machine, twin litchi pulper, sulphitation unit, honey processing unit etc which is made available to interested users on custom-hire basis.

Library

NRCL Library has about 1874 books including recent editions of 400 reference books and Hindi literature in horticulture and allied fields. It has 16 encyclopedias and 30 vol. of Britannica. Currently, 14 Indian and 9 international journals are being subscribed. The centre has published 13 technical bulletins, two technical folders, nine extension folders and 25 extension bulletins that are available in the library for researchers, extension workers and farmers.

Agricultural Knowledge Management Unit (AKMU)

The centre has an Agricultural Knowledge Management Unit to manage the knowledge database with software of international repute such as SAS, CAB abstracts, horticultural abstract, and other computing software's. The centre has now installed server and LAN system for shared resources. Access to high speed internet is made available through the National Knowledge Network (NKN). The centre's website (www.nrclitchi.org) is regularly updated with the latest information and is visited by thousands of visitors from all over the world. The centre has also launched a mobile app (ICAR-NRCL) for android devices and is available for free download on Google Play Store.

Research and Development Activities

ICAR-NRC on Litchi carries out its research and development programmes under five main thematic areas:

- Conservation, characterization and utilization of genetic diversity for improvement of litchi
- Development and refinement of integrated production technologies for improved productivity of litchi
- Development and refinement of integrated crop protection technologies for improved productivity of litchi
- Integrated postharvest management to reduce losses, improve marketing and product diversification
- Improving knowledge and skill of stakeholders for increasing production of litchi

The centre has also undertaken two flagship projects taking into consideration the challenge of pericarp browning and understanding shoot physiology with respect to flowering and fruiting in litchi. In addition to these, the centre also has fourongoing externally funded projects to address issues and challenges in litchi production and utilization.

The centre regularly conducts training programmes and activities for transfer of technology to farmers and various stakeholders. Under the TSP and NEH component, the centre has laid out structured programmes for area expansion and technology dissemination in tribal belts and Northeastern hill regions of the country.

Staff Strength of the Centre

Staff	Sanctioned	Filled	Vacant
Scientific	15+1	13+1	2
Technical	8	7	1
Administrative	12	10	2
Skilled supporting staff	3	1	2

Financial Statement 2018-19

(Rs. in lakh)

Sl. No	Head-wise break up	RE 2018-19	BE 2018-19	Release	Expenditure
(A)	**Recurring:**				
	Establishment (including pension)	440.89	341.00	440.89	404.34
	T.A.	1.0	1.0	1.0	0.17
	Contingency	221.34	163.00	221.34	225.32
	HRD	2.0	2.0	2.0	0.63
	Loans and advances	32.0	32.0	32.0	31.82
	Total (A)	697.25	539.0	697.25	662.28
(B)	**Non-Recurring:**				
	Equipment	10.0	10.0	10.0	16.97
	Works	75.0	47.0	75.0	66.03
	Furniture & Fixture	7.0	7.0	7.0	6.75
	Library	3.0	3.0	3.0	5.23
	Total (B)	95.0	92.0	95.0	94.99
	Grand Total (A +B)	792.23	631.00	792.23	**757.26**

Resource Generation

(Rs. in lakh)

Sale of farm produce	13.38
Interest earned on short term deposits	2.46
Income generated from internal resources (including recovery of loans and advances)	2.72
Miscellaneous receipts	5.13
Total	23.69

Receipts and Expenditure Statement of Externally Funded Projects

(Rs. in lakh)

Source of Externally funded projects	Opening balance	Receipt	Expenditure
BRNS (BARC)	0.033	4.06	4.06
FFP (ICAR)	0.19	35.44	35.75
AICRP-F (ICAR)	0.019	12.00	12.01
NAIF (ICAR)	0.025	14.00	14.43
DUS (PPV&FRA)	0.255	5.50	5.24
RFS (Seed & Plant)	20.01	34.89	44.21
RFS (Post Harvest Lab)	0.00	2.67	0.55

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

Eight germplasm were collected during survey conducted in Assam and Meghalaya (Fig. 1.1.). Litchi variability in these areas is very limited and most plantations are confined on established varieties. Litchi in Meghalaya is confined to North and East Garo Hills and to the border areas of Ri-Bhoi and Khasi Hills adjacent to Assam and Bangladesh, respectively. Meghalaya Seedless is the most desirable genotype collected from North Garo Hills. In Assam, Sonitpur district was surveyed where Tezpur litchi is popularly grown. Bilaiti, Bombaiya, Rongiya and Elachi grown in Tezpur area of Assam exhibited good fruit size and quality. On the basis of fruit maturity, three broad maturity groups were observed. About 44% of germplasm falls under early maturing group while mid and late maturing groups comprised 28% each (Fig. 1.2.). In most of the

Fig. 1.1. Variability of litchi germplasm in Northeast India

genotypes from Tripura, fruit matures early in second week of May while in others, late maturing groups produce fruits upto last week of June. Four germplasm namely, TezpurBilaiti, TezpurRongiya, Meghalaya Seedless and Tripura Collection-2 have fruit weight more than 25 g (Fig. 1.3.) and pulp content more than 70% (Fig. 1.4.). Cluster analysis delineates these genotypes into a distinct cluster which was clearly differentiated from the rest of the genotypes (Fig. 1.5.). A PCA biplot based on PC1 and PC2 was constructed and revealed fruit weight and pulp content as most important traits in discriminating genotypes (Fig. 1.6.). Additionally, two germplasm tolerant to fruit cracking were identified in Punjab.

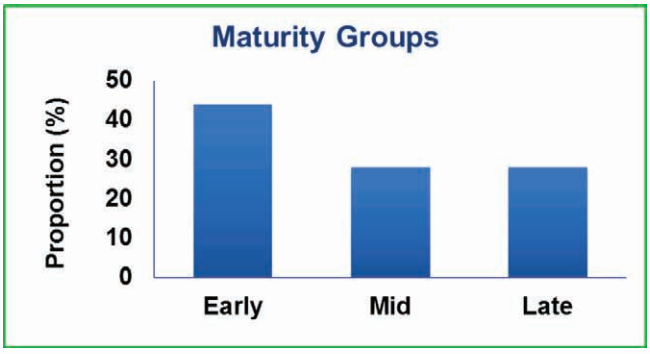

Fig. 1.2. Proportion of maturity groups among litchi germplasm in Northeast India

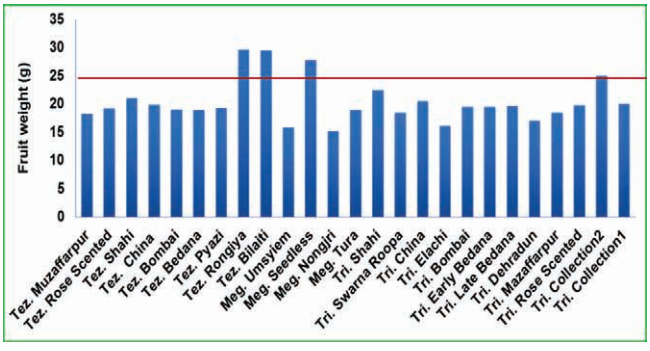

Fig. 1.3. Fruit weight of litchi germplasm in Northeast India

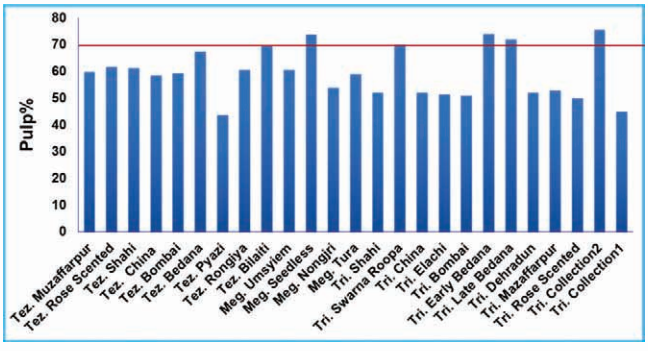

Fig. 1.4. Pulp content of litchi germplasm in Northeast India

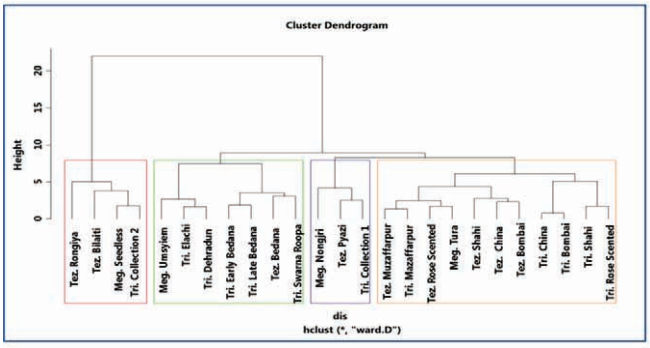

Fig. 1.5. Grouping of Northeast litchi germplasm based on fruit quality traits

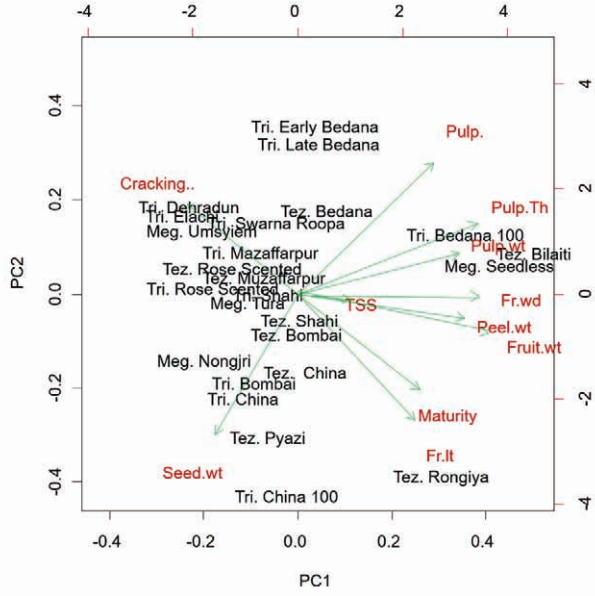

Fig. 1.6. Biplot graph depicting contributory traits based on PC1 and PC2

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

Thirty litchi genotypes were evaluated based on morphological and bioactive compounds for dwarfing characters. The correlation study revealed that plant height was positively

correlated with trunk girth (0.704), crown diameter (0.625), tree volume (0.935), rachis length (0.569), leaflet length (0.511), dry weight of leaf (0.387) and negatively correlated with bark:wood ratio (-0.422). Yield per plant exhibit a highly significant positive correlation with seed length (0.53), seed breadth (0.60), seed weight (0.47), chlorophyll A (0.58), chlorophyll B (0.49), total chlorophyll (0.57), anthocyanin in pericarp (0.65) and significant negative correlation with phenol in pericarp (-0.41) and flavonoids in seed (-0.43). The path coefficient analysis indicated that positive direct effect on yield were exhibited by crown diameter, tree volume, petiole length, leaflet length, duration of flowering, panicle length, days from fruit set to maturity, number of fruits per cluster, fruit diameter, aril weight, ascorbic acid, seed breadth, seed weight, chlorophyll A, B and total chlorophyll while negative direct effect on yield were exerted by plant height, trunk girth, number of leaflet per leaf, rachis length, leaflet width, panicle width, female flower per cent, fruit length, fruit weight, total sugar and seed length.

Twenty litchi genotypes were also screened based on wax content in leaf and observed that wax content ranged from 3.07 to 31.08 mg/g leaf and 0.10 to 0.97 mg/cm^2 leaf (Fig. 1.7.).

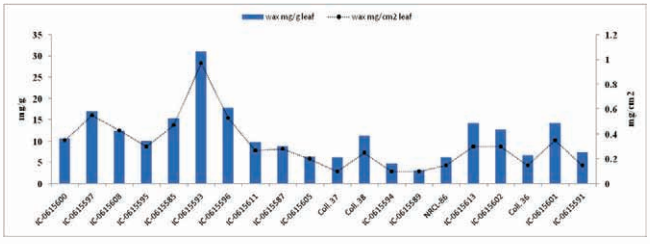

Fig. 1.7. Wax content in leaves among twenty genotypes of litchi

1.2. Development of improved cultivars in litchi

Clonal selection for improvement in commercial cultivar of litchi

Different clones of variable age, maintained at clonal block were evaluated for their fruiting potential. Of the 23 clones, flowering and fruiting was observed only in 9 clones. The fruit retention per panicle were recorded and observed that IC – 0614732 registered maximum fruit retention (Fig 1.8.).

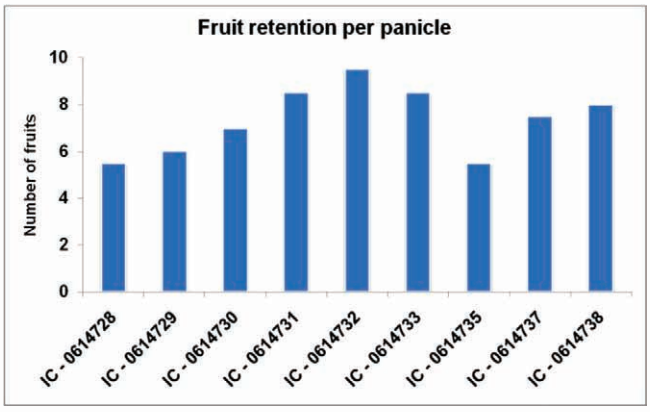

Fig. 1.8. Fruit retention in different litchi clones

Development of improved hybrids of litchi

A total number of 18,135 crosses were made using four parental combinations (Shahi, China, Bedana and GandakiLalima). In general, maximum fruit set was obtained in GandakiLalima and was higher in crosses when China and Bedana was used as male parents. Lowest seed weight (2.20 g) and high pulp content (82.0%) was obtained in GandakiLalima x Bedana while GandakiLalima x China resulted in maximum seed weight and lowest pulp content (65.0%). In other crosses, a significant amount of fruit drop was observed which is due to embryo abortion during the early stage of fruit growth (Fig 1.9). Overall, 23 hybrid

Fig. 1.9. Aborted fruitlet

fruits were harvested in 2018 and planted in protected nursery.

In beheaded seedling population, the number of new emerged shoots with respect to girth and bark:wood ratio was assessed for evaluating the coppicing ability of seedling genotypes. It was observed that number of emerged shoots had a very strong negative correlation with bark:wood ratio but was positively correlated with trunk girth.

Identification of promising genetic stock in litchi

Four genetic stocks in litchi *viz*., NRCL 29, NRCL 85, NRCL 86 and NRCL 87 have been identified based on unique key characters as detailed below:

NRCL-29: It is a selection made from open pollinated seedlings. It is characterized by precocious flowering (flowering in 3rd year of planting), dwarfing and drooping growth habit. Panicles are compact and fruits are easy to peel. Fruits contain high amount of pericarp anthocyanin (94.35 mg/100 g).

NRCL-85: It is fast growing, possess very rough trunk surface with high fruit bearing intensity (30-40 fruits/cluster). Fruits are tolerant to cracking with acidic and juicy pulp highly suitable for processing industries. It does not show hunger symptoms on leaf and seem to be a nutrient efficient genotype.

NRCL-86: It is comparatively dwarf, regular and heavy bearer, high content of pulp (72%) with significant presence of chicken tongue seeds (6.9%). It is tolerant to sun burning and fruit cracking.

NRCL-87: Regular and heavy yielder, high fruit weight (29.69-38.45 g) and pulp content (>70%) and tolerant to sun burning and fruit cracking.

Evaluation of seedling population of litchi for improved plant types

Six hundred seedlings were evaluated for drought tolerance based on leaf thickness. The thickness of litchi leaf varied from 0.098 to 0.612 mm and seedlings with higher leaf thickness were relatively healthy and developed good canopy.

For developing pre-selection criteria to screen out dwarf seedling(s) at early stage, 235 litchi seedlings more than 6 years old were evaluated on the basis of trunk and bark traits (Table 1.1). Plant height was negatively correlated with bark area (-0.488) and bark:wood ratio (-0.393).

Out of six hundreds seedling evaluated, $R_{19}P_1$ started flowering after 7 years and showed good fruiting (18 fruits per bunch).

Table 1.1. Evaluation of seedling population of litchi

Traits	Plant height	TC	BT	TD	TTA	XD	XTA	BTA	Bark area	Wood area	Bark:wood ratio
Plant height	1	.800**	.335**	.800**	.731**	.800**	.728**	.711**	-.488**	.488**	-.393**
TC		1	.436**	1.000**	.938**	.999**	.935**	.904**	-.553**	.553**	-.455**
BT			1	.436**	.406**	.406**	.385**	.711**	.218**	-.218**	.147*
TD				1	.938**	.999**	.935**	.904**	-.553**	.553**	-.455**
TTA					1	.938**	1.000**	.907**	-.383**	.383**	-.294**
XD						1	.935**	.892**	-.569**	.569**	-.467**
XTA							1	.896**	-.386**	.386**	-.295**
BTA								1	-.295**	.295**	-.255**
Bark area									1	-1.000**	.955**
Wood area										1	-.955**
Bark:wood ratio											1

TC= Trunk Circumference, BT=Bark thickness, TD=Trunk diameter, TTA= Trunk transversal area, XD=Xylem diameter, XTA=Xylem transversal area, BTA=Bark transversal area

Table 1.2. Physico-chemical characters of longan genotypes

Genotypes	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Aril weight (g)	Seed weight (g)	TSS (°B)
NRCL 6	6.04	19.85	21.65	4.11	1.18	18.74
NRCL 7	6.35	20.17	21.76	4.18	1.24	17.65
NRCL 10	6.88	22.18	23.26	5.42	1.39	19.75
NRCL 11	6.86	22.12	22.69	5.18	1.47	21.37
NRCL 12	6.22	20.22	22.48	4.22	1.30	19.86
NRCL 13	7.05	22.65	23.28	4.85	1.52	20.90
NRCL 14	6.48	20.16	22.28	5.19	1.42	18.30
NRCL 15	6.94	23.12	23.39	5.64	1.52	19.33
NRCL 17	6.86	20.92	22.14	5.05	1.40	20.30
NRCL 18	6.81	21.44	22.26	4.92	1.50	20.05
NRCL 62	6.88	22.36	22.24	5.22	1.68	19.40
NRCL 75	6.85	22.59	22.31	5.26	1.55	20.40
NRCL 81	6.688	22.29	21.89	4.48	2.01	18.60
NRCL 85	6.864	22.47	22.61	4.87	1.13	21.60
NRCL 94	**8.194**	23.25	24.55	5.88	1.28	19.38
NRCL 99	6.72	21.88	21.35	4.49	1.52	20.46
NRCL 103	6.08	21.46	21.46	4.88	1.35	21.80
NRCL 107	**7.884**	23.14	23.75	5.35	1.38	20.40
NRCL 112	6.41	21.9	21.95	5.48	1.35	22.10
NRCL 117	6.18	21.66	22.17	4.95	1.66	17.40
NRCL 124	7.28	22.05	22.27	5.86	1.57	17.22

1.3. Characterization, evaluation and utilization of Longan germplasm

Twenty-onelongan genotypes were characterized based on fruit morphological traits. Significant variation in fruit maturity,fruit weight, pulp per cent and TSS was recorded. The average fruit weight was 6.08 g while only two genotypes had fruit weighing almost 8.0 g (Table 1.2).

1.4. Molecular finger-printing in litchi cultivars through micro-satellite markers

Simple sequence repeat (SSR) markers are widely employed in molecular breeding programs in various crops including perennial fruit crops. Insufficient number of polymorphic molecular markers is an obstacle for current molecular breeding research in litchi, an important fruit crop. It becomes extremely essential to develop and validate more number of polymorphic SSR markers for its potential use in litchi improvement. Therefore, the present study was carried out to develop ESTs-SSRs from publically available EST (Expressed Sequence Tags) resources. In case of litchi, a total of 50512 EST sequences of *Litchi chinensis* were obtained from NCBI database (http://www.ncbi.nlm.nih.gov) available till June, 2018 (Fig. 1.10). The sequence information of 32 SSR markers available in the public domain was collected from publications of various research groups. The sequence information was used for similarity search within ESTs database. Candidate EST sequences were removed by using in house Perl script- Primer_search.pl.

Command line: >Perl Primer_search.pl <sequence. fasta>< file name having list of primers >

Pre-processing of ESTs caters to this need and reduces the overall noise in EST data, subsequently improving the efficacy of analyses. Thus, all ESTs were subjected to pre-processing by

1. SeqClean (Pertea*et al., 2003; http://http://sourceforge.net/projects/seqclean/files/*)and
2. Cross_match software (Gordon *et al.*, 1998) *with the following parameter:*

- Removal of low quality sequences shorter than 100 bp
- Removal of low-complexity region
- Trimming of reads containing poly A and poly T tracts of more than eight bases
- Removal of sequence ends rich in undetermined bases

Command line: >Perl Seqclean.pl <Sequence.fasta>

Command line: >cross_matchSequence.fasta vector -mismatch 10 -minscore 20 -screen >screen.out

As EST sequences from NCBI may contain such contamination of cloning vectors, adapters, linker sequence, Cross_match software (Gordon *et al., 1998)* was used with default parameter to remove impurity against the NCBI UniVec database *(http://www.ncbi.nlm.nih.gov/VecScreen/UniVec.html).*

Command line: >cross_matchSequence.fasta vector -mismatch 10 -minscore 20 -screen >screen.out

TGICL assembler Assembly and MIcroSAtellite (MISA) tools were used for Identification of EST-SSR and primer designing.

Command line: Perl tgicl<Sequence.fasta> -p 95 -l 50 -v 20 -s 10 000 –O '-p 95 -y 20 -o 50'.

Command line: Perl misa.pl <sequence.fasta>

Command line: Perl Extract_seq.pl <sequence.fasta><id file>

Total number of sequences examined:	**50512**
Total size of examined sequences (bp):	**38456641**
Total number of identified SSRs:	**3803**
Number of SSR containing sequences:	**3423**
Number of sequences containing more than 1 SSR:	**337**
Number of SSRs present in compound formation:	**142**

Fig. 1.10. Overview of microsatellite search using publicly available ESTs

Distribution to different repeat type classes

Unit size	Number of SSRs
2	2289
3	1513
4	1

Fig. 1.11. Distribution of different repeat types classes of SSRs

Repeats	5	6	7	8	9	10	11	12	Total
AC/GT -	160	92	61	44					357
AG/CT -	648	383	286	296	3	1	1		1618
AT/AT -	153	76	41	32	1				303
CG/CG	-	6	5						11
AAC/GTT	133	35							168
AAG/CTT	262	79							341
AAT/ATT	60	20							80
ACC/GGT	202	54	1						257
ACG/CGT	42	11							53
ACT/AGT	25	8	3	3					39
AGC/CTG	102	23							125
AGG/CCT	135	43							178
ATC/ATG	183	34							217
CCG/CGG	47	8							55
AACC/GGTT	1								1

Fig. 1.12. Frequency of classified SSR repeat types

A total of 2384 Novel EST based - SSR primers were designed. Thirty two randomly designed SSR primers used for functional validation in 39 genotypes of litchi. Four SSRs viz. SSR4, SSR5, SSR7 and SSR10 showed polymorphism during initial screening (Fig 1.11 & 1.12).

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 of NPK on vegetative and reproductive characters of Shahi litchi

Shahi variety showed regularity in bearing and fruiting. Significantly highest yield 9.72 t/ha (67.50 kg/plant) was recorded with application of 100:50:75g NPK/plant/year age in 14 years old plant. Fruit weight was recorded 25.33 g with TSS of 20.4°B. N and K was applied 2/3rd after harvesting in month of June and 1/3rdat the time of clove size of fruit. Application of graded level of N and K did not significantly influence the ascorbic acid content in Shahi cultivar; however it ranged from 43.81 to 63.97 mg/100g.

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

The litchi cv. China showed irregularity in bearing and fruiting. The highest yield 15.84 t/ha (110 kg/plant) was recorded with application of 100:100 g and N and K with application of 2/3rd during June after harvesting and 1/3rd during mid-April at clove size fruit stage on 12 years old plant. Fruit weight was recorded 23.59g with TSS of 19.80°B and 66.56% pulp recovery. Application of 1/3rd dose of N & K during June and 2/3rd during April exhibited more ascorbic acid content in fruits. The highest ascorbic acid content (80.65 mg/100g) was analyzed in 50:50 g NK/plant/ years of age (12 years old tree) followed by 50:75 g NK/plant (77.87 mg/100 g) applied in two split (1/3rd dose of NPK during June and 2/3rd during April).

Standardization of organic inputs for litchi production

Application of 120 kg FYM+15 kg vermi-compost + 3 kg neem cake and 200g bio-fertilizer per plant yielded 68.87 kg fruit/plant (9.92 t/ha) with 20.51°BTSS and 65.72% pulp recovery in 12 years old plants. Application of FYM in combination with vermi-compost showed little bit higher ascorbic acid than FYM alone which ranged from 27.52 to 38.23 mg/100g. One spray of vermi-wash and 3 spray of nimbicidine were given to manage the fruit borer.

Development of package of practices for organic litchi production

Litchi cvs.Shahi, China, Mandraji and Trikolia have been planted in 1.6 ha area with 6x6 m spacing under organic management practices. All the plants have been established and provided FYM, vermi-compost, bio-fertilizers, and green manures for soil nutrient management while insect-pest management has been done through application of organic pesticides. Few litchi plants survived after flood stress came into flowering in 2019. Faba bean has also been grown as intercrop in between two rows of organic litchi block during *Rabi* season with average yield of 1.48 t/ha.

High density planting in litchi cv. Shahi

Out of 6 planting densities 6x4 m and 8x4 m recorded maximum yield of 20.11 and 19.77 t/ha, respectively. Fruit size was recorded less than the normal planting. In 6x6m planting fruit size was recorded maximum 20.26 g. Pulp recovery were recorded more in 10x10 m planting density.

Nutrient deficiency symptoms in litchi plants

In air-layered plants of litchi K-deficient older leaves showed drying from leaf tip and leaf margin from all sides, cupping and rusty appearance. Nitrogen-deficient plant showed yellowing of older leaves, new leaves become short and green; premature defoliation of older leaves. In P-deficient plant pin discoloration of older leaves turning to dark green and dead patched on tip and margins coppery brown colour were exhibited. In iron-deficient plant, newly developed leaves showed whitish yellow coloration and later turn into yellowish green colour with loss of chlorophyll, and later on got bleached with necrosis. Zn deficiency symptoms appeared on new leaves with first appearance as interveinal chlorosis that persisted for longer time.

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

Different micronutrient treatment were imposed as per schedule. Marked diffrences has been observed in panicle emergence and flowering % of the shoot in those treatment where zinc was applied as foliar spray in comparison to control and soil apllication. The treatment where boron was given as soil and foilar spray has less fruit cracking. Leaf samples were collected for analyis of micronutrient content in leaf.

Doubling the productivity of litchi through advance approaches

A training trial has been started on support system (Y- trellis) to develop the frame work of plant in order to double litchi productivity in young bearing stage (less than 10 year). Frame work of plant completed as per the technical programme. Flowering panicle emergence has been recorded in the some plant having poor fruit set (1st year). Under Y-Trellis system, the effect of retained horns on growth of new shoots on lateral branches was studied and observed that the number of horns and new shoots on the horns exerts a strong negative correlation with number of new shoots emerging on the lateral branches.

Under Y-Trellis system, the effect of retained horns on growth of new shoots on lateral branches was studied and observed that the number of horns and new shoots on the horns exerts a strong negative correlation with number of new shoots emerging on the lateral branches (Table 2.1.).

Improving bearing potential though use of girdling cv. China

Marked changes in % shoot flowering has been observed in girdled branches/ area in comparison to control. Girdling size (width), level and their interaction had significant effect on healing of bark at girdled site and longer duration was observed in more width in case of trunk girdling. Girdling of 4 mm size in 75% Primary Branches and trunk girdling recorded longest healing duration (184.75 & 189.00 days, respectively). Comparatively smaller panicle length was recorded with trunk girdling. 4mm size girdling had significantly more number of female flowers in all the treatments. Panicle emergence varied with increasing the size of girdling. Girdling width size and different level did not influenced by branches girth. Significantly highest fruit yield of 49.75 kg/plant (10 year old plant) was recorded in 3mm girdling covering 75% plant canopy. However, 42.50kg/plant fruit yield was obtained in 3mm trunk girdling. Whereas, in case of girdling level 46.67kg/plant was obtained in 75% girdling.

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

Effect of application on percent female flowers

On each tree, 16 panicles, 4 from each direction were selected for the purpose of study. Date of initiation of flowering was recorded by visual observations of each tree by regular visits

Table 2.1. Correlation among vegetative growth parameters under Y-Trellis

Parameters	Main trunk girth	1st primary trunk girth	2nd primary trunk girth	Girth of arms	No. horns/ arm	No. new shoots/ arm	Average no. old shoots/ horn	Average girth of horns
Main trunk girth	1							
1st primary trunk girth	0.761**	1						
2nd primary trunk girth	0.563**	0.313NS						
Girth of arms	-0.130NS	-0.007NS	0.048NS	1				
No. horns/arm	0.656**	0.359NS	0.437NS	-0.150NS	1			
No. new shoots/arm	-0.141NS	0.192NS	-0.279NS	-0.003NS	**-0.618****	1		
Average no. old shoots/horn	0.760**	0.541*	0.506*	-0.104NS	**0.899****	**-0.532***	1	
Average girth of horns	0.244NS	0.143NS	0.392NS	0.029NS	0.726**	-0.387NS	**0.597****	1

during flowering time. Results showed that (Fig. 2.1) plants under different treatment bore higher percentage of female flowers (31-89 %) than control (11.7%).

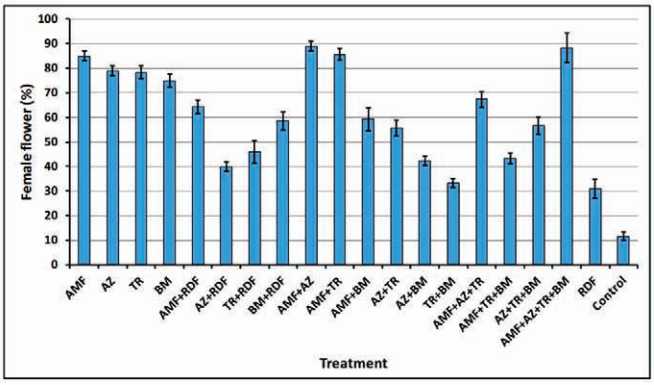

Fig. 2.1. Effect of application of microbial inoculants on percentage of female flowers borne on trees. The vertical bars indicate standard error (SE) of the mean.

Effect of application of AMF and other microbial inoculants on fruit quality parameters

The purpose of this study was to evaluate the effect of different microbial inoculants on fruit quality parameters such as TSS, titratable acidity, anthocyanin content, polyphenol oxidase (PPO) activity, peroxidase (POD) activity, and total phenolics. Harvested fruits were brought to laboratory and stored in perforated polybags at ambient conditions. Three replications, 30 fruits per replication, in each treatment were maintained. The values of different parameters were assessed at 0 day, 3rd day and 6th day of storage. Results showed that there was slight increase in TSS from day of harvest to 3rd day but a decrease on 6th day of storage was recorded in all the treatments including control. Differences among the treatments on a particular day of storage were, however, non-significant. The titratable acidity gradually decreased during the storage but the decline was significantly less in fruits obtained from trees receiving microbial inoculantsthan in control. With the lapse of storage time there was decline in anthocyanin content of the fruits in all the treatments. Not only significantly higher anthocyanin content than control was recorded at harvest but also the trees having microbial inoculation recorded significantly less decline in the anthocyanin content (Fig. 2.2.). Application of microbial inoculants influenced the antioxidant enzyme activity like PPO and POD in the litchi pericarp during storage of fruits. With the lapse of time, activity of these enzymes was enhanced. A significantly lesser values of the enzyme activity were recorded at 0 day, 3rd day and 6th day of storage in fruits obtained from tree receiving microbial inoculants compared to control fruits (Figs. 2.3. and 2.4.). Phenol content in fruits obtained from trees receiving microbial inoculants were higher than in control fruits. With the lapse of time a decrease in phenol content of fruits were observed in all the treatments including control but significantly less decline was noticed in fruits obtained from trees receiving microbial inoculants (Fig. 2.5.). Thus these results conclusively prove that application of microbial inoculants to litchi

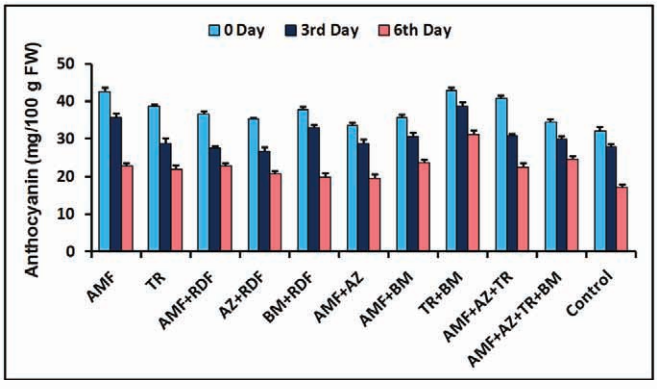

Fig. 2.2. Effect of application of microbial inoculants on anthocyanin content of fruits. The vertical bars indicate standard error (SE) of the mean.

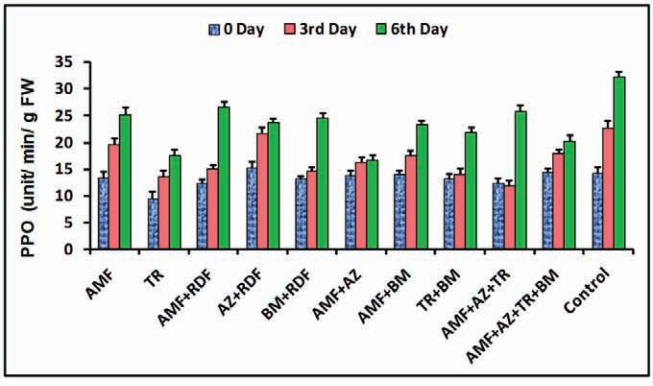

Fig. 2.3. Effect of application of microbial inoculants on polyphenol oxidase (PPO) activity in fruits. The vertical bars indicate standard error (SE) of the mean.

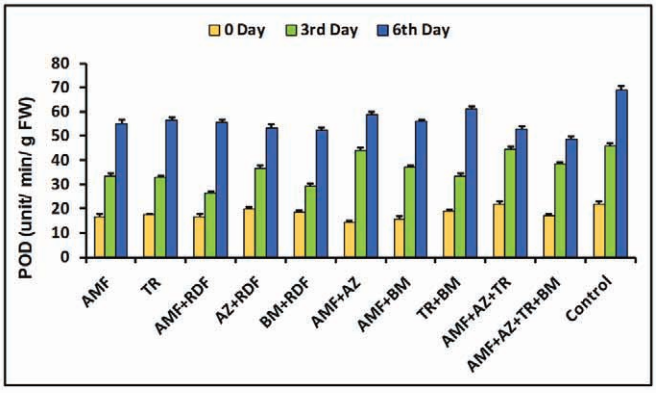

Fig. 2.4. Effect of application of microbial inoculants on peroxidase (POD) activity in fruits. The vertical bars indicate standard error (SE) of the mean.

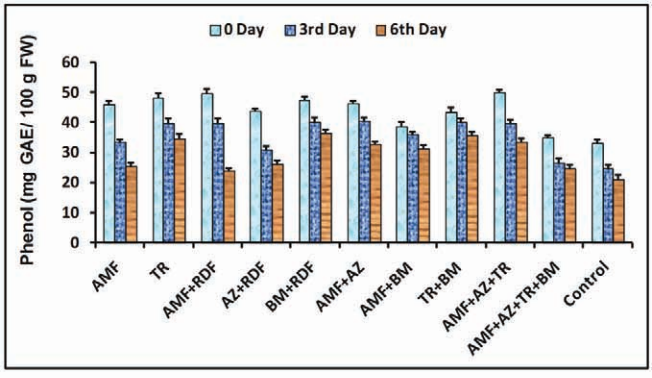

Fig. 2.5. Effect of application of microbial inoculants on total phenol content in fruits. The vertical bars indicate standard error (SE) of the mean.

trees improves fruit quality parameters and they have a positive influence on post-harvest life of fruits. A close perusal of the data showed that AMF + TR and AMF+AZ+TR had outperformed than other treatments/combinations.

Effect of application of AMF and other microbial inoculants on fruit diseases

The results showed that all the microbial inoculants had significant effect on reducing incidence of sunburn, cracking, and diseases like anthracnose and fruit blight. Not only they positively influenced the fruit size but also the percentage of good quality fruits was enhanced (69.0-82.3%) by these treatments as compared to control (51.2%).Incidence of anthracnose and fruit blight was 0.6-2.3% and 0.0-2.7%, respectively as against 8.0 and 6.9%, respectively in control. Zero percent incidence of fruit blight caused by *Alternariaalternata*was observed in some treatments *viz.*, TR, AMF+AZ and AMF+AZ+TR. These results indicated that applications of these microbes protected plants from foliar pathogens by means of activating systemic acquired resistance (SAR) regulating physiology of plants.

2.3. Litchi based cropping system for low lying conditions

Litchi based cropping system for pond/low land

Performance of different fruits and seasonal crops grown with litchi based cropping system on pond bunds:Litchi based cropping system on pond bunds was executed with plantation of litchi on pond embankment along with other short duration fruit and seasonal crops comprised with different models (model I: three tier model of two rows of litchi cv. Shahi with banana cv. Grand Naine and seasonal crops, model II: three tier model of two rows of litchi cv. China with papaya cv. Red Lady and seasonal crops, model III: two tier model of two rows of litchi cv. Shahi with seasonal crops, model IV: two tier model of two rows of litchi cv. China with seasonal crops). Planting of 2 rows of banana cv. Grand Naine has been done in between two rows of litchi cv. Shahi planted on pond bunds leaving 2 m distance from litchi plants. Similarly, two rows of papaya cv. Red Lady were also planted between litchi cv. China on pond bund. About 20% plants of Shahi litchi exhibited flowering at 4 years of age.

During *kharif* season 2018, cowpea cv. KashiKanchan and yam bean (*Pachyrrhizuserosus* (L.) Urban) has been grown in between banana and papaya planted with litchi on pond bunds under model I and II. Pod yield in cow pea ranged from 12.5-12.75 t/ha and seed yield of yam bean was recorded 0.55-0.75 t/ha (Fig. 2.6 &2.7). Whereas, during *rabi* season 2018, Different seasonal crops (cabbage, cauliflower and knol-khol in model I, lentil and faba bean in model II and mustard in model III) were grown in different models. Among the different seasonal crops, the highest yield was noticed in cabbage (28.93 t/ha) followed by cauliflower (27.85 t/ha) and knol-khol (22.02 t/ha) grown in model I while faba

Fig. 2.6. Litchi with banana and other seasonal crops on pond bund during *kharif* season. A: cow pea, B: yam bean

Fig. 2.7. A. Litchi + banana +cole crop; B: Litchi + papaya +lentil/faba bean on pond bunds during winter season

bean (2.52 t/ha) and lentil (1.24 t/ha) grown in model II and mustard (1.95 t/ha) in model III.

Performance of makhana crops grown in pond:The seeds of makhana shown in pond (120 m^2 area) during January 2017 maintaining about 2.5-3 foot water depth throughout the growing period. The harvesting of makhana seed was done during October month in 2018 (Fig. 2.8) and recorded 15.5 kg yield first timewhich found to be a promise crop under Muzaffarpur condition.

Nutrient contents in vermi-compost produced through crop waste utilization: Production of vermi-compost by using crop residues like banana pseudo stem, litchi leaves, litchi peels and farm grasses has been done. It has been observed that vermi-compost production from banana pseudo stem was faster than other residues due to easily decomposition and conversion into vermi-compost by the earth worm (*Eiseniafoetida*) followed by farm grasses, litchi peals and litchi leaves. Vermiwash was also produced during vermi-compost making. Nitrogen content in vermi-compost made up with banana pseudo stem varied from 1.92-2.18%, in litchi leaves 2.10-2.35%, in litchi peels 1.96-2.16% and in farm grasses 1.33-1.75%.

Litchi based cropping system for low land/wet land

Land shaping techniques has been executed for rehabilitation of low lying water logged area through converting the ridge and deep furrows system. Litchi based cropping system has

Fig. 2.8. A. View of makhana cultivation; B. Harvesting of makhana

been implemented under three planting system (PS I: Ridges 3 m bottom width, PS II: Ridges 2.5 m bottom width & PS III: mound 1 m bottom dia.). Litchi planted during October 2017 at 8.25x4 m spacing on ridge and mound systems showed that the vegetative growth in Shahi litchi was better over China at one year after planting. Banana cv. Grand Naine and papaya cv. Red Lady have also been planted on ridges in between litchi plants during 2018.

Performance of different seasonal crops grown in furrows system of low lying area:Cucurbitaceous vegetables (bottle gourd and pumpkin) and mung bean was grown in deep furrows of ridge and mound system during summer season 2018 after mustard and wheat crops. The highest yield was obtained in pumpkin (11.85 t/ha) followed by bottle gourd (10.8 t/ha) and mung bean 1.05 t/ha. Paddy-wheat/mustard/faba bean-mung bean/vegetables bean based cropping sequence was adopted in furrows system during *Kharif* , *Rabi* and summer season and compared with conventional paddy-wheat based cropping system. Paddy and wheat grown under furrows system (Fig. 2.9) produced better yield than grown under conventional system in normal low land. The yield obtained in paddy and wheat under furrows system was 3.28-3.35 t/ha

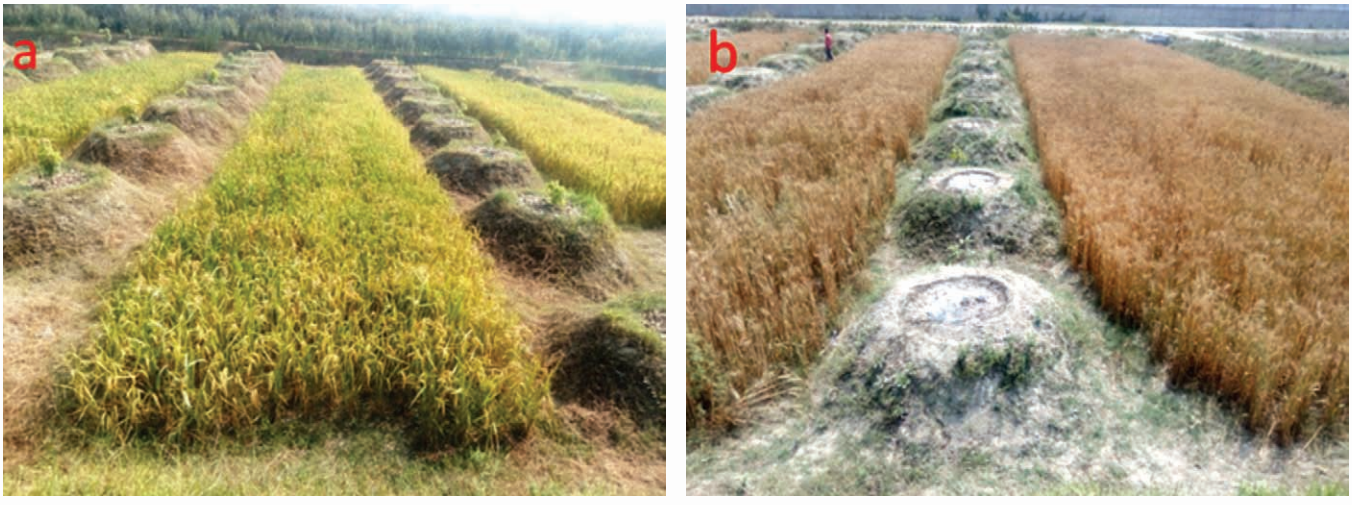

Fig. 2.9. Paddy (a)-wheat (b) cropping sequence adopted in deep furrows of litchi based cropping system in low lying area

and 2.49-2.58 t/ha, respectively while in normal low land condition it was 3.12 t/ha in paddy and 2.52 t/ha in wheat. However, mustard and faba bean were grown after paddy in furrows system gave the yield of 1.78-1.88 t/ha and 2.11-2.25 t/ha, respectively.

Fish culture in deep furrows of litchi based cropping system: The fingerlings of Indian carp (Catla, rohu andmrigal) have been released during November, 2018 in deep furrows of ridges system with stocking density of 7000 per hectare. The water in furrows is maintained at 1.25-1.5 m depth**.**

Study on soil moisture status of ridge and mound system at various soil profile depth: Soil moisture status of ridge and mound system at 10, 20, 30, 40, 60 and 100 cm soil profile depth was recorded during April 2018 to March 2019 at various intervals. Data reveal that soil moisture content varied due to soil depth and situation (Ridge & mound). The gradual increase in moisture content has been recorded with increased of soil profile depth during study period in most of the situation but in some cases upper 10 cm soil depth recorded higher moisture content than 20 cm depth.

2.4. Integrated soil health management for quality litchi production

The experiment was laid down as per treatment plan various organic and inorganic source of fertilizer were applied as per the treatment plan and observation recorded to identify best eco -friendly dose for quality litchi production. Fruit yield data ranged from 6 (T-8) to 34.8 kg (T-2) per plant. Five fruit weight ranged from 90.1 to 97.9 g. Soil respiration of soil was also recorded and found T-2 highest respiration rate 0.66 gram CO_2/Sq.m/hr.

2.5. Development of DRIS norms for nutrient management in litchi

A new project initiated to establish DRIS norm in Litchi for northern productive zone of Bihar. DRIS (Diagnosis and Recommendation System) is comprehensive system which can identify all the nutritional factors limiting crop production and has been successful in many crops. A survey of litchi orchard was conducted from eight districts of Bihar vizMuzaffarpur, EastChamparan, Sitamarhi, Samastipur, Darbhanga, Bhagalpur, Begusarai, Vaishali. Leaf and soil sample along with yield data were collected (Fig. 2.10).

Fig 2.10. Leaf Sampling from the selected orchard for establishing DRIS norm.

2.6. Leaf nutrient dynamics in Litchi

A new experiment has been laid down at Research Farm ICAR-NRCL to study seasonal effect on Litchi leaf nutrient dynamics of genotype Shahi and China. Litchi plants were selected of similar age and phenotype from which whole leaflet were sampled at monthly interval. To standardize the leaf sampling time and position of leaf sampling were also done at the time of reproductive phase in litchi.

2.7. Screening of different microbial consortia for enhancement of productivity and quality of litchi fruits

A new consortia project was initiated at the centre. Many potential microbial consortia have been developed by many institutes*viz*. IIHR, CCRI, CSSRI, NRCL, RCER etc for specific crop/ soil/region/ special problem. In view of the recent development of consortia developed by different Institute evaluation need to be done to screen out best consortia available in ICAR system on litchi crop. The potential consortia developed by various institute collected and experiment has been laid down on Shahi genotype. The treatment observation like microbial respiration (carbon dioxide flux), TSS of fruit, fruit yield and fruit weight were recorded.

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

Disease incidence and severity of leaf, panicle and fruit blight

Monthly observation on incidence and severity of leaf blights disease in nursery plants are presented in Table 3.1. It is clear that July to September was the peak period for the blight disease development while November to January had low disease incidence and severity. In 2018, the mean disease incidence (DI) between July to October was higher and ranged between 13.22-16.17%. The range of mean percent infected leaves (IL) was 18.95 to 48.45%. The mean percent disease severity index (PDI) varied from 37.55-61.42. Congenial weather factors (high humidity and temperature) prevailed in nursery during these months which favoured the disease progress.

The higher DI, IL and PDI were recorded in July, August and September months, while it was lower in November to January. The study gives information about the peak period of the leaf blight in nursery, which is crucial for the management of disease in nurseries. The mean disease incidence of panicle blight was 16.32% in cv. 'Shahi' while in cv. 'China' it was 28.27% (Table 3.2). The data on mean distribution of trees in different levels of panicle blights on cv. 'Shahi' showed that trees in ≤20%, 21-40%, 41-60%, 61-80% and >80% blighted panicles in surveyed orchards were 85.08%, 13.67%, 1.25%, 0.0% and 0.0%, respectively. This indicates that the maximum numbers of trees were having less than 20% blighted panicles. Similar trend was observed in cv. 'China'. The mean disease incidence of fruit blight on trees in farmers' orchard in Muzaffarpur, Bihar varied from 3.1-15.8% while the range was 2.0-17.4% (Fig. 3.1).

Table 3.1. Prevalence of leaf blight disease among nursery plants at NRCL, Muzaffarpur during 2018

Months	Disease Intensity (DI) (%)	Infected leaves (IL) (%)	Percent disease incidence (PDI)
January	6.16 (14.33)	18.95 (25.72)	37.55 (37.68)
February	9.52 (17.83)	21.86 (27.77)	42.39 (40.58)
March	11.11 (19.44)	24.00 (29.27)	40.18 (39.30)
April	10.95 (19.29)	25.88 (30.52)	49.47 (44.67)
May	10.92 (19.21)	30.82 (33.60)	42.57 (40.70)
June	11.43 (19.68)	28.68 (32.30)	48.40 (44.07)
July	13.51 (21.52)	31.93 (34.37)	57.33 (49.22)
August	16.17 (23.68)	48.45 (44.09)	58.33 (49.79)
September	14.16 (21.80)	47.68 (43.65)	61.42 (51.61)
October	13.22 (21.29)	33.54 (35.36)	55.08 (47.90)
November	12.64 (20.81)	21.80 (27.81)	52.88 (46.64)
December	8.39 (16.76)	20.90 (27.10)	48.28 (44.00)
SEm (±)	0.65	1.68	2.34
LSD(P=0.05)	1.86	4.78	6.65

* Mean value of six nurseries
** Data in parentheses are angular transformed value

Table 3.2. Disease incidence and severity of panicle blight during 2018 season*

	Cultivar 'Shahi'						Cultivar 'China'					
Orchard no.	I	II	III	IV	V	Mean	I	II	III	IV	V	Mean
Disease incidence (%)												
	10.81	14.29	21.05	19.61	15.84	**16.32**	17.24	26.67	33.33	30.95	36.17	**28.87**
Percent distribution of trees in different level of blighted panicles												
≤ 20%	100.00	66.67	87.50	90.00	81.25	**85.08**	60.00	62.50	83.33	61.54	70.59	**67.59**
21–40%	0.00	33.33	12.50	10.00	12.50	**13.67**	40.00	25.00	0.00	23.08	11.76	**19.97**
41–60%	0.00	0.00	0.00	0.00	6.25	**1.25**	0.00	12.50	8.33	15.38	17.65	**10.77**
61–80%	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	8.33	0.00	0.00	**1.67**
> 81%	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	0.00	**0.00**

*Values in the table are based on observations taken on all the trees (n = 60-78) of the orchard

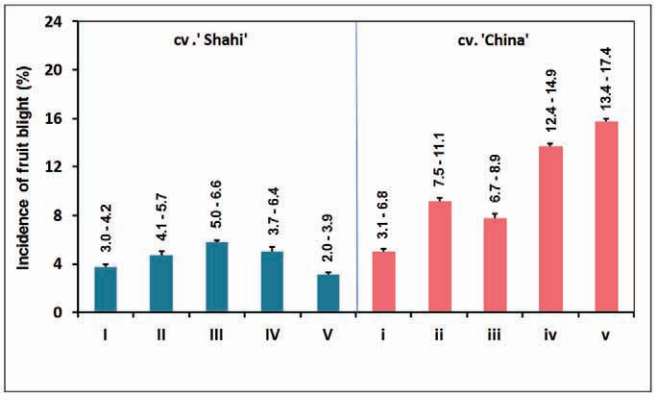

Fig. 3.1. Incidence of fruit blight disease during 2017 seasons recorded in June month on litchi *cvs.* 'Shahi' and 'China'on trees in farmers' orchard in Muzaffarpur, Bihar. Height of columns indicates the mean disease incidence, whereas the value above bars indicates the range in samples; the vertical bar indicates standard error (SE) of the mean. The least significant difference (LSD) at *P*=0.05 for disease incidence in 'Shahi' and 'China' are 1.19 (± 0.39) and 1.96 (± 0.45), respectively.

Frequency of association of *A. alternata* with blighted panicle

From each orchard, 20 different samples of blighted panicle were collected. A bit of infected tissue along with healthy portion was taken from the specimens and rinsed with distilled water followed by surface sterilization with 1%NaOCl for 2 min and finally rinsed twice with sterilized distilled water. After surface sterilization, these bits were longitudinally split into two pieces with the help of sterilized blade keeping in a sterile Petri dish under laminar flow. It was then transferred onto PDA plates and incubated at 27±1 °C. The results showed that extent of association of *A. alternata* with blighted panicle samples was 50.0-92.5% (mean 74%) (Fig. 3.2). The remaining had no pathogen growth and might have dried due to physiological or environmental stress.

Fig. 3.2. Mycelia growth of *Alternaria alternata* on infected bits taken from blighted panicles

Pathogenic variability in *A. alternata*

Distinct variability in pathogen was observed infecting different parts at different phenophases of litchi. Three leaf blight strain/pathotype (AA-L_1, AA-L_2 and AA-L_3), two panicle blightpathotype (AA-P_1, AA-P_2), one fruit blight pathotype (AA-

F_2)and two fruit decay pathotype (AA-F_1, AA-F_3) were identified, some of which were submitted to Genbank.Cross infectivity of the three leaf blight pathotypes for panicles and fruit infection was observed with varying severity, and conversely panicle and fruit blight pathotype caused leaf infection. toxigenic variability and variability at molecular level was studied.

Ecophysiology of *Alternaria alternata*

Studies were conducted to assess the effect of different medium, carbon source, pH, temperature, relative humidity and exposure to UV radiation on growth and sporulation of *A. alternata* under *in vitro* conditions. Results showed that the maximum mycelia growth rate was on Host Leaf Extract Dextrose Agar but sporulation was the maximum on Potato Dextrose Agar medium. The mycelia growth was more with dextrose as carbon source but the maximum dry weight was recorded in maltose amended medium. Optimum pH for mycelia growth was 6.0, and below or above this pH, mycelia growth was slow. It was evident that the maximum mycelia growth rate and germination of conidia were at 30 °C. The thermal death point of *A. alternata* was found to be 45 °C with 10 min. exposure. The maximum mean growth rate and germination percent was recorded at 100% relative humidity. The growth rate decreased with increasing exposure time to UV-B rays up to 20 min, but at exposure time 25 and 30 minutes, colony changed to profuse mycelia growth with smaller sporulating zone in the centre compared to untreated dishes.

Effect of relative humidity on the growth and conidial germination of *Alternaria alternata*

The result showed that *A.alternata*was able to grow well at all the relative humidity (RH) levels (60 to 100%) and rate of growth increased with increasing humidity (Fig. 3.3). The maximum mean mycelia growth rate (8.50 mm/day) and size of colony (8.80 cm) were recorded at 100 % RH. Similarly, the germination of conidia increased with increasing humidity (Fig. 3.4). Maximum germination (82.41 %) at 24 h and 97.42 % at 48 h of incubation was observed at 100 % RH. At 60% RH, mean mycelia growth rate was 4.88 mm/day, and germination at 24 h and 48 h were 44.18% and 63.79%, respectively.

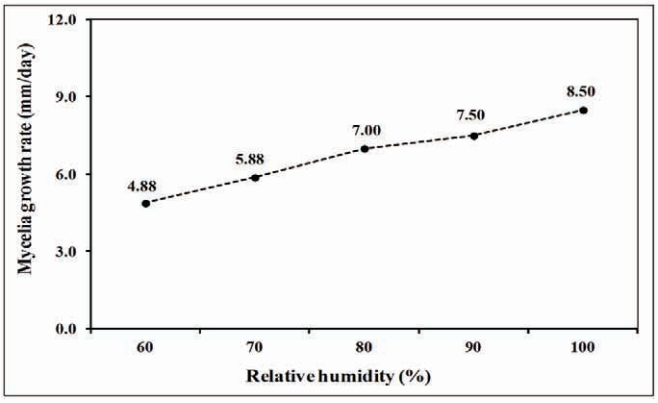

Fig. 3.3. Mycelia growth rate of *Alternaria alternata* on PDA medium at different relative humidity

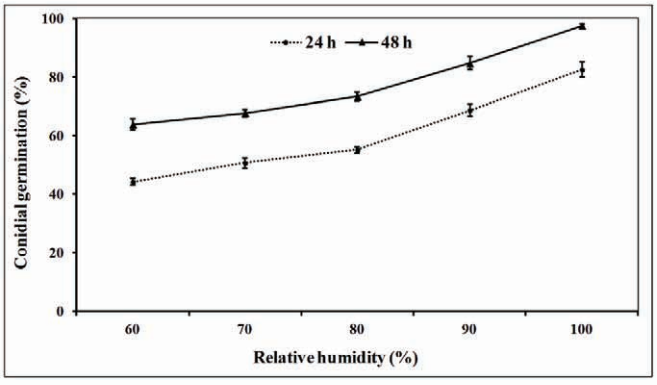

Fig. 3.4. Conidial germination of *Alternaria alternata* under *in vitro* conditions at different relative humidity. The vertical bar indicates standard error (SE) of the mean

Effect of UV-light on growth

The growth rate of *A. alternata* decreased with increasing exposure time to UV-B rays (wave length 254 nm) up to 20 minutes but beyond this, growth rate suddenly increased (Fig. 3.5 and 3.6). The maximum growth rate (10.54 mm/day) was observed in control dishes while the minimum (3.71 mm/day) was at exposure time 20 minutes. At exposure time 30 minutes, growth rate was 7.12 mm/day. With the increase in exposure time, colony size and mycelia growth rate reduced while sporulation increased, the white mycelium was visible only at periphery of the colony. At exposure time 25 and 30 minutes, colony changed to profuse mycelia growth with

smaller sporulating zone in the centre compared to control dishes.

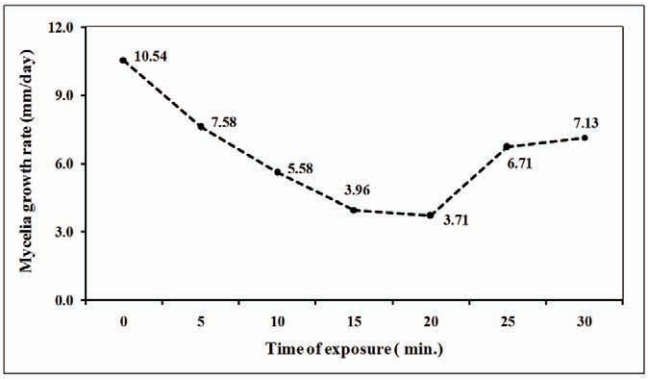

Fig. 3.5. Time dependent influence of UV-light on the growth rate of *Alternaria alternata*

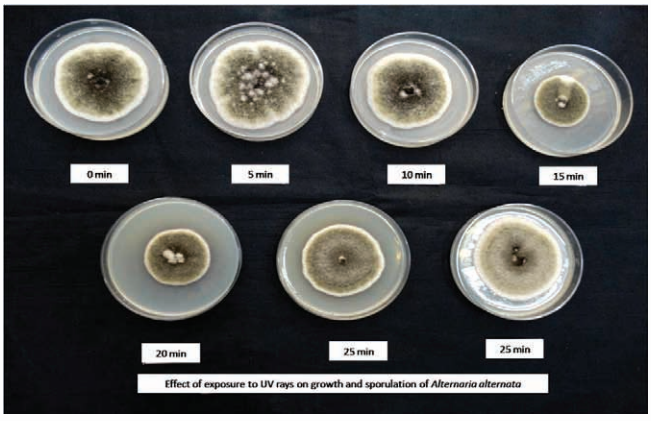

Fig. 3.6. Effect of UV- light on the radial growth of *Alternaria alternata*

Epidemiology

Survival and spread of pathogen

A. alternata propagules (conidia) were viable in infected leaves up to 7 month when stored in BOD incubator while at ambient conditions it remained viable only up to 5 month(Fig. 3.7). Another set of monitoring experiment revealed that in orchards, the pathogen survived throughout the year on infected leaves in lower canopy of trees and also on nursery plants. These acted as primary source of inoculum for the infection of panicles and fruits of litchi during fruiting season.

Spatial and temporal variation in number of air-borne conidia

Spatial and temporal conidial population of *A. alternata* in vicinity of tree canopy in orchards,

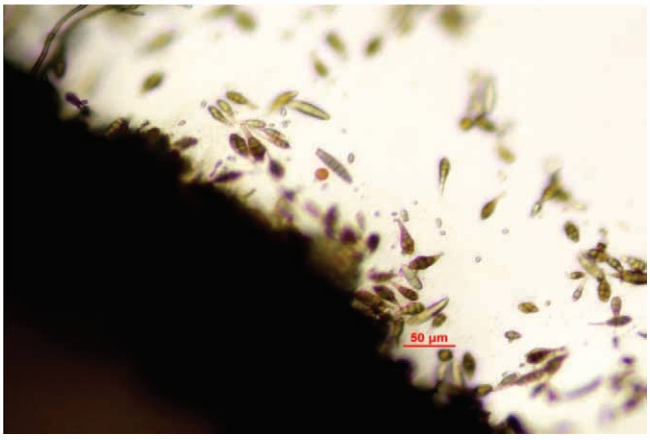

Fig. 3.7. *Alternaria alternata* in tissue of a fallen leaf under 20× objective of brightfield microscope

and in nurseries was monitored by air sampling. Petri dishes containing PDA amended with 0.5 mg/mL of streptomycin sulphate were exposed for 5 minute at different heights. Colonies which developed in plates were examined under a stereoscopic microscope to identify colony of *A. alternata* among them (Fig. 3.8). Results showed that the maximum numbers of conidia were present below tree canopy at 3-6 feet height. Temporal variation showed that the maximum conidia in air were present between 6.00-10.00 AM in morning hours.

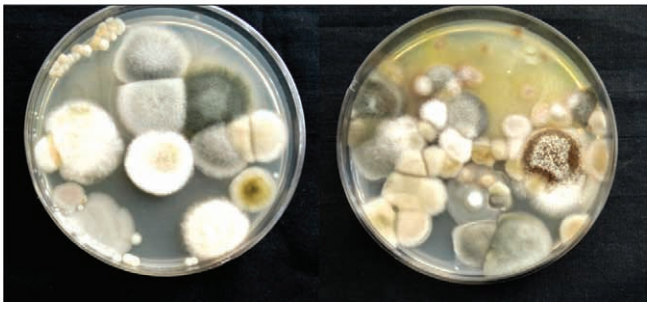

Fig. 3.8. Colony developed by airborne conidia of *Alternaria alternata* trapped on PDA in Petri plates

Weather parameters vis-à-vis disease

Weather parameters throughout flowering and fruiting period of litchi during 2014-2016 were: Tmax = 31.1-40.7°C, Tmin = 17.4-27.2°C, RHmax = 60.0-85.0%, RHmin = 23-57%. The analysis of prevailing weather conditions revealed that a temperature of about 28-30°C and humidity 60 to 85% were congenial for panicle and fruit

blight disease. Trendlines plotted on weather graph showed that the disease severity was more between Tmin 20-22°C and Tmax 32-35°C.

Disease management

Antifungal activity of some ethnomedicinal plant infusions

Biopesticidal properties of some ethnomedicinal plant infusions were explored as alternative management strategy for *Alternaria* disease of litchi. The preliminary results suggest that the leaf extracts of *Datura stramonium, Calotropis procera* and *Heliotropium indicum* possess antifungal compounds (Fig. 3.9) that can be harnessed for development of formulations or simply as a crude extract application for the management of *A. alternata.* Further experiments may focus on finding the bioactive constituents present in these plant infusions and feasibility of their application under field conditions.

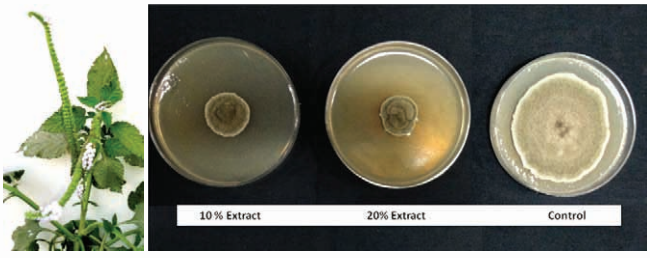

Fig. 3.9. Left- An Indian Heliotrope (*Heliotropium indicum)* plant, Right- Fungistatic effect of 10 % and 20 % aqueous extract of Indian Heliotrope plants on colony growthof *Alternaria alternata* compared to control (Distilled water)

Evaluation of fungicides for management of Alternaria disease

a) ***Greenhouse conditions:*** Twelve different fungicides (copper oxychloride, mancozeb, thiophanate methyl, carbendazim, difenoconazole, hexaconazole, propiconazole, propioneb, chlorothalonil, azoxystrobin, metiram + pyraclostrobin, and mancozeb + carbendazim) were evaluated under greenhouse conditions for management of leaf blight disease in nursery plants. Among plants of each treatment one infector plant was kept. To ensure sufficient disease pressure, spray application of conidial inoculum of *A. alternata*(1×10^6 conidia/ mL) was also done on plants. Results showed that among different treatments, thiophanate methyl (0.14%) or difenoconazole (0.025%) or azoxystrobin (0.023%) were very effective in controlling leaf blight disease, PDI being below 10.0% as against up to 89.6% in control plants.

b) ***Field conditions:*** The same set of treatments as in greenhouse conditions was tried against panicle and fruit blight disease under natural infection field conditions during 2018. Efficacy of these fungicides in controlling panicle and fruit blight disease were similar to efficacy against leaf blight disease observed on nursery plants. Mean incidence of panicle blight was below 3.0% in the effective fungicidal treatment as against up to 27.0% in control trees over the years. The disease incidence of fruit blight was 1.7- 3.6% in the effective fungicidal treatment as against up to 14.7% in control trees.

3.2 Investigation and management of insect-pests complex in litchi

Management of litchi fruit borer using combination of insecticides based IPM modules

Field trials was conducted to evaluate the different combination insecticides based IPM modules against litchi fruit borer *viz.*, Module 1: Neem formulation 0.15% (0.009%)+ Lambda cyhalothrin 5 EC (0.003%), Module 2: Neem formulation 0.15% (0.009%) + chlorantranilprole 18.5 SC (0.007%), Module 3: Neem formulation 0.15% (0.009%) + beta-cyfluthrin 8.49% + imidacloprid 19.81% (0.011%), Module 4: Neem formulation 0.15% (0.009%) + flubendiamide 19.92% + thiacloprid 19.92% (0.48%), Module 5: Neem formulation 0.15% (0.009%) + spirotetramat 11.01% + imidacloprid 11.01% (0.36%). First spray was given with neem oil before flower opening stage in all modules while second, third and fourth spray of different chemicals were applied as per modules at clove size fruit, cardamom size and after 10 days of third spray

(about 15 days before harvest), respectively. At early all the modules registered 0.00 borer population including control, while at mid stage no borer population was noticed in Module 4 and Module 5 followed by Module 3 with 5.88% fruit infestation against 47.78% in control.At harvest stage also minimum fruit infestation (3.88%) was recorded with spray of flubendiamide 19.92% + thiacloprid 19.92% followed by Module 1 with 7% fruit infestation against 95.14% fruit damage in control (Fig. 3.10 &Table 3.3.).

Fig. 3.10. Fruit & shoot borer infestation, A: Poor fruit setting due to infestation on 3rd flush; B: Infested fruits at maturity stage

Table 3.3. Efficacy of newer insecticides against litchi fruit borer

Treatments	Fruit infestation (%)		
	Early stage	Mid stage	Harvest stage
Lambda cyhalothrin 5 EC (0.003%)	0.00	6.67	7.00
Chlorantranilprole 18.5 SC (0.007%)	0.00	6.00	9.33
Beta-Cyfluthrin 8.49 %+Imidacloprid 19.81% (0.011%)	0.00	5.88	11.23
Flubendiamide 19.92% + Thiacloprid 19.92% 480 SC (0.48%)	0.00	0.00	3.88
Spirotetramat 11.01% + Imidacloprid 11.01% 240 SC (0.36%)	0.00	0.00	9.67
Control	0.00	47.78	95.14
SE(m)±	-	0.51	0.53
CD (5%)	-	1.64	1.68

Management of litchi fruit and shoot borer using organic pesticides

To evaluate the efficacy of various organic pesticides against litchi fruit and shoot borer, field trial was laid out in Randomized Block Design (RBD) with six treatments *viz*., Rovin (1.25ml/l),Fungole (1.5 g+ neem oil 3ml/l),Krimidote (3ml/l), Bio dose (1.25ml/l); Neem oil (4 ml/l), and Control (without spray) with three replicates. Four sprays at different intervals after fruit attained clove size were applied with the last spray 10 days before fruit harvest. Among various organic pesticides, Rovin (1.25ml/l) found to be the most effective with 4.72% fruit infestation at harvest stage against 83.22% in control followed by Fungole (1.5 g+ neem oil 3ml/l) which registered 21.69% fruit infestation (Table 3.4.).

Table 3.4. Efficacy of different organic pesticides on litchi fruit borer infestation (%)

Treatments	Fruit infestation (%)		
	Early stage	Mid stage	Harvest stage
Rovin (1.25ml/l)	0.00	1.33	04.72
Fungole (1.5 g+ neem oil 3ml/l)	0.00	6.0000	21.69
Krimidote (3ml/l)	0.00	16	41.24
Bio dose (1.25ml/l)	0.00	23.00	53.26
Neem oil (4 ml/l)	0.00	14.33	23.96
Control	0.00	31.58	83.22
SE(m)±	-	0.67	0.96
CD (5%)	-	2.13	3.06

Efficacy of spiromesifen against litchi mite

With an aim to evaluate the efficacy of various integrated approaches against litchi mite, an experiment was conducted comprising pruning of affected twigs (July & October) and spraying of miticides (chlorfenapyr 10 EC (0.03%) & spiromesifen 22.9 SC (0.034%) twice in July and once in October. Litchi mite infestation on shoots was recorded at initial stage and after imposition of the treatments. Mite infestation ranged between 25.00 to 32.67% at initial stage of observation before imposing treatments. Maximum reduction (0.67%) of litchi mite infestation was noticed with

spraying of chlorfenapyr combined with pruning of affected portion followed by spiromesifen combined with pruning (1.67%) during July when observations were recorded after 15 days of treatment against pruning alone (4.00 & 4.67%) and control (36.00%). Least infestation under the treatments of pruning of infested shoot along with chemical spray proved their efficacy to check the further spread of mite population. The observation in the month of October revealed that litchi mite infestation had gradually increased over July infestation on new flushes. The infestation level remained highest (44.67%) in untreated plant (control) followed by pruning treatment alone (10.67 & 11.67%) with lowest level in treatments namely, chlorfenapyr (3.33%, 3.67%) and spiromesifen (4.67%, 5.00%) before imposition of treatments in October month. Increase in level of mite infestation during October month over July under all the treatments might be due to population of mite left over coupled with prevalence of favourable weather condition along with emergence of new flush resulted in higher infestation. At 15 days after management schedule followed in October, no further infestation of litchi mite was noticed in miticides-sprayed plants combined with pruning in July and October against pruning in July (16.33%), pruning in July and October (1.67%) and control (46.00%) (Table 3.5.). Similar trends were observed at flowering and fruiting stage.

Table 3.5. Efficacy of spiromesifen 22.9 SC against litchi mite

Treatments	Litchi mite infestation (%)					
	Two spray in July at 15 days interval		One spray in October			
	Initial infes-tation	After July spray	Before spray	15th day after spray	At flowering stage	At Fruiting
Pruning of affected twigs in June	25.33	4.67	11.67	16.33	40.00	52.67
T_1 + Pruning in October	32.67	4.00	10.67	1.67	6.33	12.67
T_1 + Chlorfenapyr 10 EC (0.03%)	30.33	0.67	3.67	4.67	5.33	12.33
T_1 + Spiromesifen 22.9 SC (0.034%)	25.33	1.67	5.00	5.33	8.33	15.33
T_2 + Chlorfenapyr 10 EC (0.03%)	27.00	1.00	3.33	0.00	0.00	0.00
T_2 + Spiromesifen 22.9 SC (0.034%)	25.00	2.33	4.67	0.00	0.00	0.00
Control (no pruning, no spray)	29.00	36.00	44.67	46.00	72.00	80.67
SE (m)±	1.32	0.45	0.78	0.68	0.82	0.95
CD (5%)	4.10	1.42	2.43	2.10	2.56	2.96

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 fruits

Judging the optimum harvest maturity is an important part of successful harvesting and marketing in litchi. If litchi fruits are harvested early (immature) there is compromise on fruit quality parameters such as low TSS, higher acidity, and less red colour development in pericarp in addition to lower fruit weight. On the contrary, if harvesting operation is delayed, the fruits become over mature thereby adversely affecting postharvest quality and life.

Fruit growth and development of litchi cv. Shahi was studied. Growth dynamics of peel, seed and aril were profiled on the basis of physical and biochemical parameters during fruit development stages. Based on database developed since 2010, maturity standards for litchi cv. Shahi were established. Some reliable and accurate measures of optimum maturity and time of harvesting in litchi cv. Shahi are:

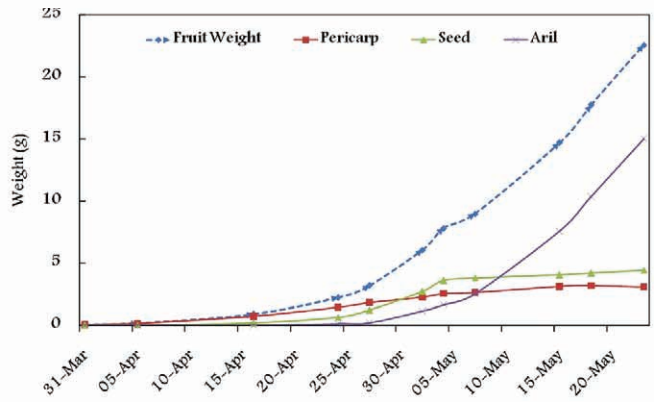

Fig. 4.1. Fruit growth and development in litchi cv. Shahi

- Total soluble solids (TSS) of fruit juice attain 18-20°B

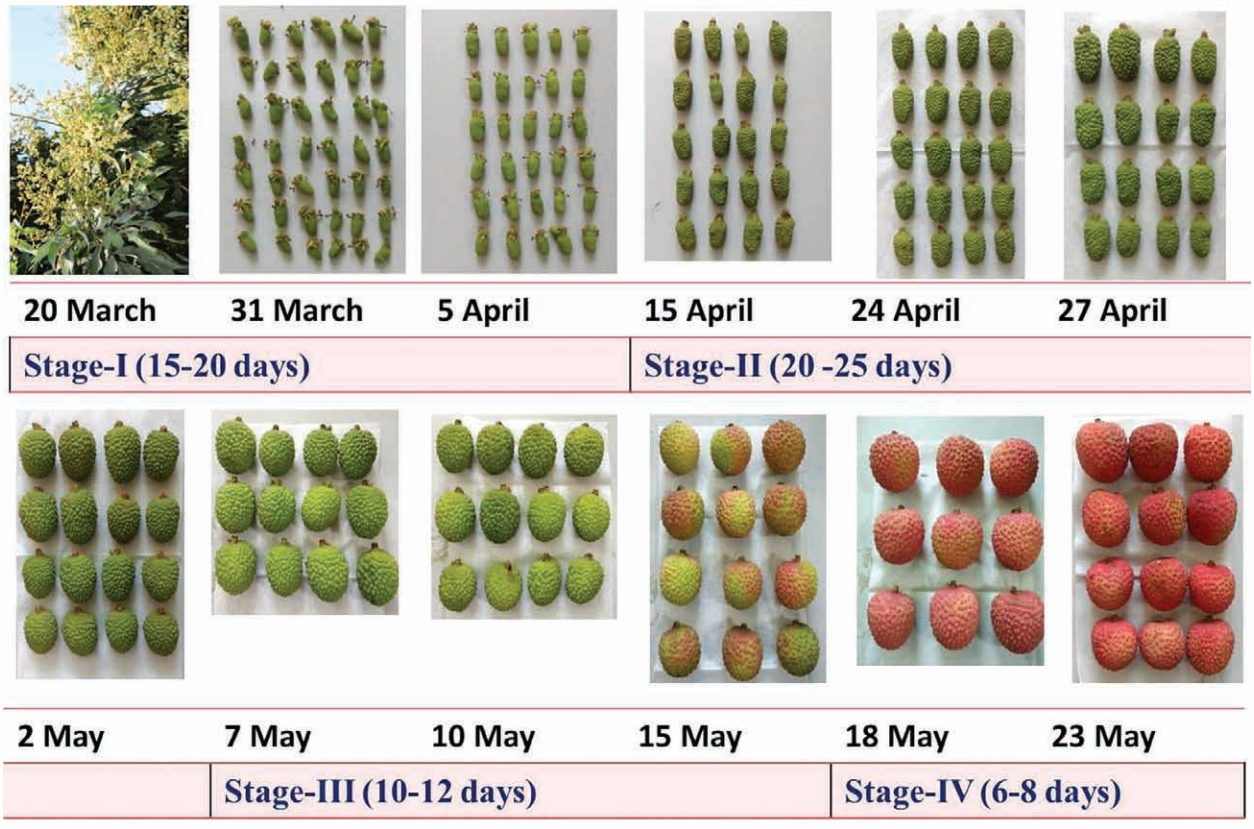

Fig. 4.2. Pictorial representation of different stages during fruit growth and development in litchi cv. Shahi

- Titratable acidity content below 0.5%
- TSS / Acid ratio more than 40
- The fruit has undergone growth and development period of about 62±2 days after fruit set
- Anthocyanins content in pericarp more than 30 mg/100 g (FW)
- Calendar dates: During the period under study, 20-25 May has been found the optimum period for harvesting in litchi cv. Shahi under Muzaffarpur conditions
- Early morning harvested fruits (before 6:00 AM) have thicker peel and high peel moisture content which ensure optimum fruit quality and postharvest life

4.2 Investigation and management of post-harvest losses in litchi

Pre-harvest application of senescence regulator (Ethrel) on colour development in litchi fruit

Fruit colour is one of the most important quality parameters in litchi. Litchi fruits are valued for its attractive colour which plays a key role in marketability, purchase decision among consumers and price realization for growers. Proper colour development is a problem in non-traditional areas as well as in shaded or inner portions of the tree canopy. In the preceding season, promising result had been obtained through use of senescence regulators i.e., ABA, and Ethrel. However, ethrel being the cheaper option and commercially available in the market, further studies were conducted with ethrel. Ethrel at different concentrations (300, 600 and 900 ppm) were applied as full cover foliar spray at colour break stage of fruit development. Treated fruits were harvested at optimum harvest maturity. Pre-harvest application of ethrel, irrespective of concentration, resulted in higher accumulation of anthocyanins in litchi pericarp in comparison to control. This also reflected in higher Hunter colour 'a' values in treated fruits. Anthocyanins content and Hunter colour 'a' in ethrel-treated litchi fruit increased in dose-dependent manner, with highest (31.22 mg/100g and 34.35, respectively) being recorded in fruits treated with 900 ppm (Table 4.1.). Ethrel-treated fruits were stored under refrigerated conditions (4±2°C and 85±5% RH) for 15 days. No adverse effects of ethrel treatment on fruit quality were recorded during storage period.

Table 4.1. Effect of Ethrel on colour development and anthocyanins content in litchi peel

Ethrel treatment	Colour (Hunter a)	Anthocyanins (mg/100 g)
900 ppm	31.22[a]	34.35[a]
600 ppm	27.39[b]	23.76[b]
300 ppm	25.43[b]	21.33[b]
Control	18.90[c]	13.52[c]

900 ppm 600 ppm 300 ppm

Fig. 4.3. Colour development in litchi fruit treated with different concentrations of ethrel

Effect of aqueous plant extracts on litchi shelf life and fruit decay

Effect of aqueous leaf/plant extract (20%) of eight different plants *viz*, Neem, Karanj, Calotropis, Datura, Guma, Catnip, Bhant, Indian helitrope were evaluated for their efficacy on litchi shelf life and fruit decay. Three replications each with 30 fruits each were treated by dip treatment for 5 minutes and air dried and packed in perforated polybags. Indian helitrope was found to enhance shelf life up to 5th day (without any fruit decay) while all the fruits in the control treatment were rotten on 4th day.

Effect of oxalic acid and citric acid treatment on shelf life litchi fruits

Post harvests dip treatment of citric acid (1%, 3% and 5%) and oxalic acid (1%, 3% and 5%) was evaluated for efficacy on shelf life and fruit decay of litchi fruits. Among these, 3% citric acid was found to extend shelf life, as on 7th day of storage

at ambient condition browning (26.6 %) and fruit decay (13.3%) wereless as compared to control (100%). Oxalic acid caused discolouration and burning effect on peel of fruits which increased with concentration.

Effect of *Bacillus subtilis* and other antagonists on quality and biochemical parameters of litchi

To validate earlier results, antagonists *viz.*, *Bacillussubtilis*(isolateNRCL BS-01, BS-02, BS-03, BS-04, and BS-05), and *Trichoderma* (NRCL T-01) were evaluated for their effect on litchi fruit shelf life. The concentration of postharvest dip solution with *B. subtilis*was 1×10^8 cell/mL. Thirty fruits in three replicates were taken for each treatment. Duration of dip treatments was 5 min followed by air drying. For control treatment, fruits were dipped in distilled water. Observations were recorded at 3 days interval. Results indicated that activity of PPO and POD enzymes increased significantly over time but less increase was observed with antagonists' treatment compared to control. Significantly,the lowest activity of PPO on 3rdday (13 unit/min/g FW) and 6th day (20 unit/min/g FW) of storage was observed in fruits treated with *Bacillus subtilis* NRCLBS-01 as compared to controlon 3rdday (18 unit/min/g FW) and 6th day (29 unit/min/g FW). Similarly, POD activity was the lowest in fruits treated with *Bacillus subtilis* NRCL BS-01 on 3rd day (23 unit/min/g FW) and 6th day (44 unit/min/g FW) thus indicating its efficacy in having better shelf life of fruits. Total soluble solids of litchi fruits increased marginally up to 3rd day of storage with dip treatment of antagonists but decreased significantly in chemicals dip and control treatments. However, from 3rd day to 6th day a decline in TSS of fruits was observed in all the treatments but between treatments, the differences were statistically non-significant. A non-significant decrease in titratable acidity of fruits was observed between different treatments. The anthocyanin contents in all the treatments declined with progress of time but significantly less reduction was observed with antagonists' treatment. Anthocyanin content just after treatment was significantly lower than other treatments including control fruits. Anthocyanin content in fruits treated with NRCL BS-01 on 3rd and 6th day after treatment was 30 and 21 mg/100 g FW compared to 26 and 19 mg/100 g FW, respectively. It was observed that fruits treated with carbendazim have a sort of bleach effect on colour of fruits. *Bacillus subtilis* isolate NRCL BS-01 was very effective in controlling fruit decay as significantly, less rotting was observed in these treatments compared to control. All the fruits in the control treatment were rotten on 4th day.

4.3 Processing and Value Addition in Litchi (*Litchi chinensis* Sonn)

Development of minimally processed RTE litchi pulp

With a view to bringing convenience in consumption of litchi, studies of developing a technique on minimal processing had been initiated. Different treatment combinations involving blanching (3-5 min), $CaCl_2$ (0.2%), ascorbic acid (0.2%), and potassium metabisulfite (1500 ppm) were tested in the preceding year with some encouraging results. Discolouration and leakage have been encountered as challenges in the study. Anti-browning chemicals, namely 4-Hexylresorcinol (0.015 and 0.02%) and Cystine (0.5%), were incorporated as treatments in minimal processing of litchi (Fig. 4.4.).

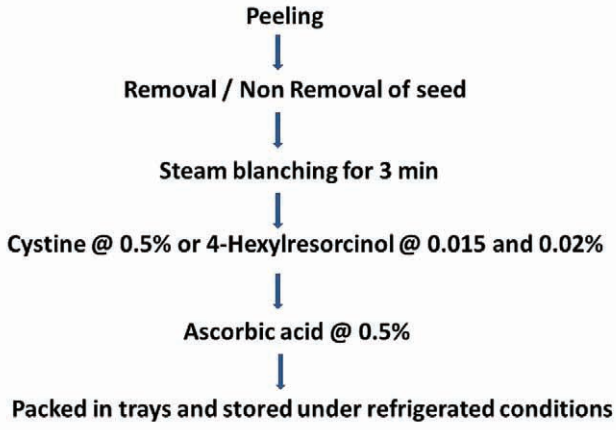

Fig. 4.4. Minimal Processing in Litchi

Significant colour retention was observed in litchi aril treated with 4-Hexylresorcinol @ 0.02% and ascorbic acid (0.5%) post steam blanching for 3 min. Retention of whiteness, as indicated by higher

Hunter 'L' value, and minimal discoloration, as indicated by lower Hunter 'a' values, were recorded under this treatment invonving 4-HR and ascorbic acid (Fig. 4.6.). Treatment involving 4-HR also retained higher firmness and absence of fungal growth during storage period of 10 days under refrigerated conditions (5±1°C).

Fig. 4.5. Minimally Processed Litchi

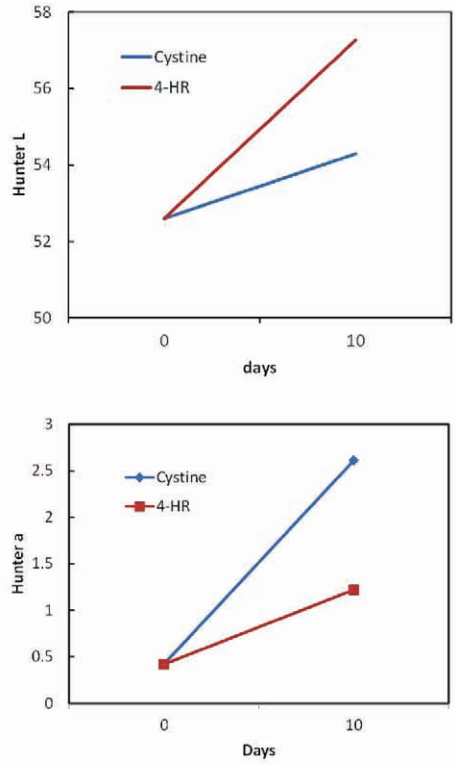

Fig. 4.6. Change in colour in 4-Hexylresorcinol and Cystine-treated minimally processed litchi

Refinement of litchi nut technology

Refinement in methodology for preparation of litchi nut was carried out to reduce shrinkage and browning of the product. Modification of existing technique included treatment in higher concentration of citric acid treatment (2.5%) for longer duration (20 minutes) and initial drying at solar dryer/ sun for one day followed by cabinet drying at 55-60°C.This has given 28% less shrinkage fruits and pinkish red litchi nut.

Refinement of osmo-dehydration of litchi pulp technology

The stickiness and dull appearance of dehydrated litchi pulp has been identified to be improved and in this regard a study was conducted. It has been found that the treatment of osmo-dehydrated litchi pulp with 4-Hexylresorcinol @ 0.015-0.02% and initial drying at 70 °C for 4 hrs then at 50-55 °C resulted in less sticky and brighter product.

Table 4.2. Refinement in litchi nut technology

Methods	Time taken (Hrs)	Dried nut wt. (g)	Sensory evaluation*			Shrinkage +damage %
			Colour	Taste	OA	
Shed + Sun + ED	36+7+30-32	4.84	7.45	8.00	7.83	12.79
Shade + Sun/ solar drying	36+48--52	4.80	8.20	8.30	8.25	8.67
*9 point hedonic scale						

Fig. 4.7. Litchi Nut prepared with earlier technology (Left). Litchi Nut prepared withrefinement of technology (Right)

Fig. 4.8. Litchi raisin prepared with earlier technology (Left). Litchi raisin prepared with refinement of technology (Right)

4.4. Fruit quality study of different commercial litchi orchards

Fruit quality study of four different commercial litchi orchard in Muzaffarpur district have shown that soil type and water sources like pond/ river bank nearby litchi orchard have impact on fruit quality of litchi fruits. It has been observed that orchard near water source and having loamy type of soil have less fruit cracking (50%) and more average fruit weight (6.5%) in comparison to orchard having loamy soil and do not having water recourses nearby. The orchards having sandy loam soil and nearby river bank have more sun burning (30%) but less cracking of fruits (30%) in comparison to orchard having loamy soil and do not having water recourses nearby.

Table 4.2.Fruit quality study of four different commercial litchi orchards in Muzaffarpur district

Location of Orchard	Soil type	Climatic condition during harvesting		Sunburn fruits (%)	Cracked fruits (%)	Avg. Fruit wt. (g)	T.S.S (°Brix)
		Temp (°C)	RH (%)				
I	Loamy	33.5	58	13.52	18.17	17.30	17.67
II*	Loamy	31.2	62	12.67	9.45	18.40	17.33
III*	Sandy Loam	32.6	66	17.33	10.10	17.85	16.50
IV*	Sandy loam	30.6	68	19.34	12.21	17.35	16.66

I – Sri Hira Singh, Rahua; II – Sri B. N. Jha, Jhapha; III – Sri Ganesh Sah, Balughat; IV – Sri Bhawani Shankar Bochhan

*Orchard having water body nearby

5. Improving Knowledge and Skill of Stakeholders for Increasing Production of Litchi

5.1. Tribal Sub Plan Project

In continuation of its efforts in the identified district of Shahdol in Madhya Pradesh, ICAR-NRCL continued its efforts in popularizing litchi and area expansion in the region. The centre provided 1000 litchi planting material of cv. Shahi and China to 400 beneficiaries of Khetauli Village in Shahdoldistrict (Fig. 5.1). In collaboration with KVK, Shahdol, 150 winter season vegetable kits were distributed among the farmers (Fig. 5.2). A one-day training programme on various aspects of nursery and orchard management was also conducted and the prospects of entrepreneurship development for improving livelihood and income of the farmers were addressed (Fig. 5.3.).

Fig. 5.1. Planting material of litchi being flagged off from ICAR-NRCL to Shahdol, M.P.

Fig. 5.2. Distribution of winter season vegetable kit to farmers in Shahdol, M.P.

Fig. 5.3. On-farm training programme being conducted at Shahdol, M.P. under TSP project

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

ICAR-NRCL had initiated plantation of litchi in four districts of Nagaland in the previous year in collaboration with ICAR RC NEH Region, Nagaland Centre, Medziphema, Nagaland. A team of scientists from the collaborating institutes visited the litchi plantation in Peren district of Nagaland on 18th February 2019 (Fig. 5.4). The team also interacted with the litchi growers in Ngwalwa and Heningkunglwa villages in Peren district (Fig. 5.5) and suggested measures for

Fig. 5.4. Team of scientists from ICAR-NRCL, Muzaffarpur and ICAR RC NEH Region, Nagaland Centre, Medziphema, Nagaland during their visit to the project plantation site at Ngwalwa village, Peren, Nagaland

Fig. 5.5. Interaction with litchi growers in Heningkunglwa village, Peren, Nagaland

successful establishment of young litchi plants in the field. Aspects of training and canopy management during initial plant growth stage as well as practical demonstration of preparing litchi-based beverages were conducted. With the NEH region emerging as a potential area for litchi production, modalities have been worked out for area expansion under the fruit in Meghalaya and Mizoram.

6. Flagship Projects

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

Pre-harvest application of salicylic acid on postharvest quality of litchi fruit

Postharvest treatment with aqueous solutions of chemicals remains one of the most practiced methods to control decay pathogens during storage of litchi. Incomplete/improper surface drying post treatment can, however, result in aggravated incidence of decay due to presence of moisture on fruit surface. Besides, lack of infrastructural facilities limits the practicality of adopting postharvest dip treatments, especially among small and marginal farmers. Salicylic acid as a pre-harvest application was tested with the hypothesis that it can be used as a prophylactic treatment to reduce fruit decay during postharvest storage. Application of salicylic acid, at concentrations ranging from 2-8 mM, was done two days before harvest. Harvested fruits were sorted before being packed in polythene bags, and stored under refrigerated conditions (5-8°C and 80±5% RH). Pre-harvest application of salicylic acid resulted in significant reduction of fruit decay during storage compared to control. Untreated fruits recorded 10% decay incidence after 15 days, while the corresponding figure was 1.72% in fruits treated with salicylic acid @ 2.0 mM. Salicylic acid-treated fruits also retained

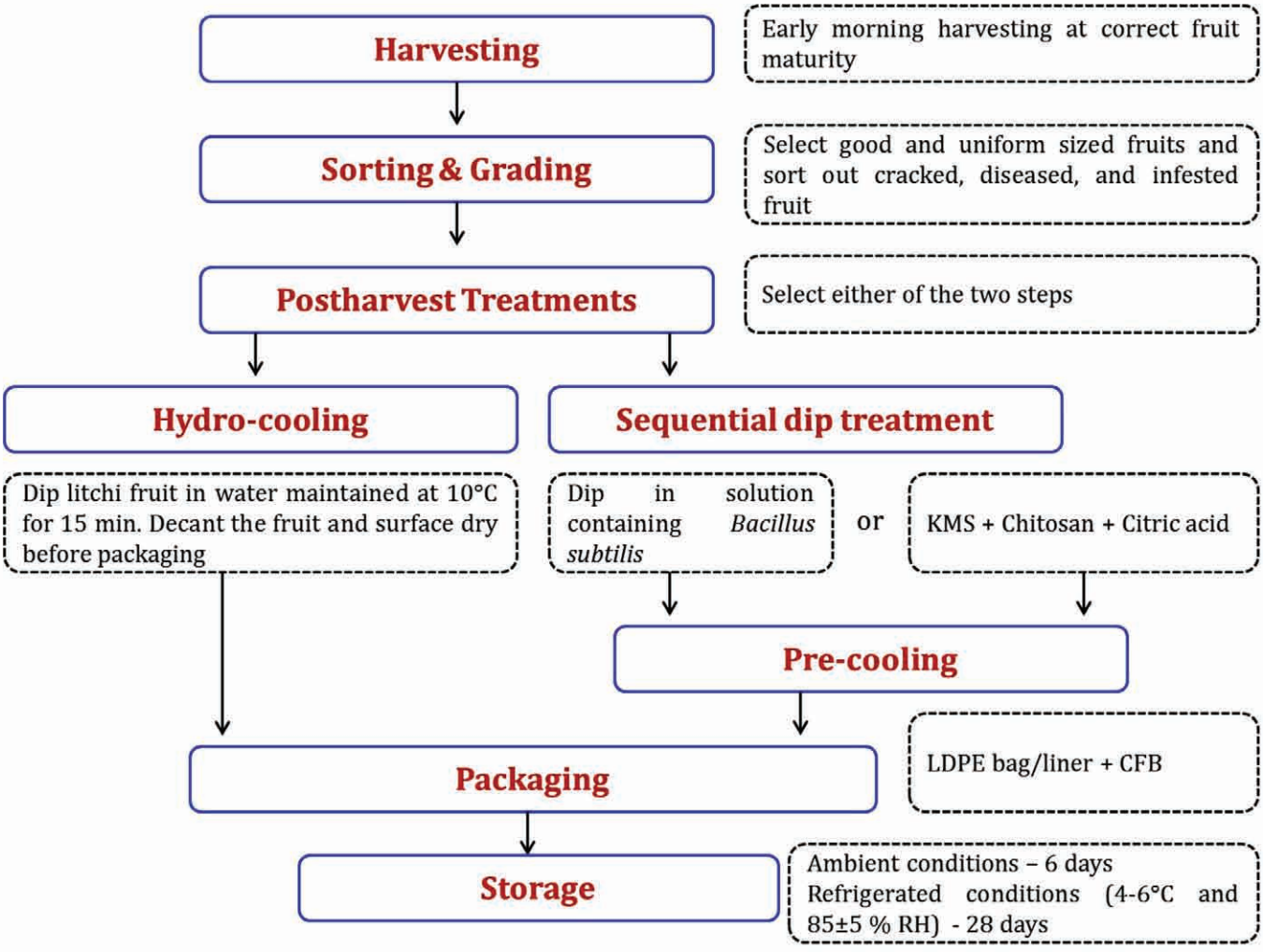

Fig. 6.1. Flow diagram depicting postharvest protocol for enhancing shelf life of litchi fruit

higher Hunter 'a' (30.43) compared to control (21.96), thereby indicating the positive role of salicylic acid in reducing pericarp browning during postharvest storage of litchi.

Response of litchi fruit to postharvest treatment with Kojic acid and Methionine

With the aim to reduce pericarp browning in litchi, anti-browning agents were tested for their efficacy. Kojic acid (1-10 mM) and Methionine (0.1-0.8%) were used as a postharvest dip treatment in litchi cv. Shahi. Treated fruit were stored under refrigerated conditions 5±1°C and 80-90% RH and observed for pericarp browning and fruit quality parameters. Postharvest treatment of litchi with Kojic acid at concentration ranging from 1-5 mM resulted in significant control of pericarp browning up to 21 days under refrigerated conditions.

Postharvest protocol to enhance shelf life of litchi

Litchi is highly perishable, and presents a huge challenge and growers and traders due to rapid pericarp browning and decay in the supply chain. The centre has standardized important components of postharvest management in litchi including correct harvest maturity, sorting and grading, pre-cooling, postharvest treatments, packaging etc. Such components have been integrated into a complete postharvest protocol, validated and released as a technology. Schematic representation of the protocol is depicted in Figure 6.1.

6.2 Shoot Physiology in Relation to Flowering and Fruiting of Litchi

Inhibition of winter flushed due to paclobutrazol and potassium nitrate

Application of 4.0 g paclobutrazol and KNO_3 (1.0 %) in every year completely inhibited winter flushes against control (305 flushes per tree). If applied in alternate year, it led to less no. of winter flushes against other treatment and potassium nitrate and untreated trees could not show winter flushing during November but immediate shooting up in number of new flushes during December month. Without application of PBZ or KNO_3 flowering was completely inhibited and highest no. of panicles was recorded in tree received 4.0 g PBZ. It was observed as per Table 1 that there was complete cessation of flush emergence during November-December if paclobutrazol applied every year but if PBZ applied in alternate years, highest no. of panicles per tree (265 panicles per tree was observed in tree with 4. 0 g PBZ); Although no flushes are emerged in control trees during winter but also we could not get any floral panicles (Table 6.1).

Table 6.1. Application of paclobutrazol and KNO_3 [every year and alternate year] affecting flushing pattern and flowering in litchi cv. China

Treatments	No. of winter flushes				No. of panicles per tree	
	#Every year		Alternate year		Every year	Alternate year
	November	December	November	December		
1.0 g PBZ	0	0	55	255	0	155
2.0 g PBZ	0	0	0	55	210	13
3.0 g PBZ	3	4	80	305	75	17
4.0 g PBZ	0	0	0	48	3	265
1 % KNO_3	0	0	0	275	25	37
2 % KNO_3	40	40	0	425	0	9
Un-treated	0	305	0	0	0	0

#application year of PBZ and KNO_3

Table 6.2. Changes in morphology of litchi cv. China after crop regulating practices

Treatment	Tree height (m)		% change	Tree girth (cm)		% change	TCA (cm^2)		% change
	I	II		I	II		I	II	
Control	3.23	3.53	9.28	59.00	59.66	1.11	280.03	286.30	2.23
2% KNO_3	3.16	3.21	1.58	61.00	61.66	1.08	299.16	305.70	2.18
ProhexadionCa	3.83	4.20	9.66	68.00	68.00	0.00	371.91	371.91	0.00
Paclobutazol (2.5g)	3.58	3.86	7.82	58.00	58.66	1.13	270.78	276.89	2.25
Girdling	3.46	3.73	7.80	56.33	58.33	3.55	255.21	273.65	7.22
Salicylic acid (2000 ppm)	3.40	3.66	7.64	57.33	58.00	1.16	264.30	270.46	2.33
KH_2PO_4(0.5%)	4.15	4.26	2.65	66.66	67.66	1.50	357.28	368.07	3.02
Spermidine (1g)	3.50	3.90	11.42	60.00	60.66	1.10	289.43	295.86	2.22
C.D.	0.54	0.43	-	3.00	2.56	-	29.18	25.43	-
SE(m)	0.17	0.14	-	0.98	0.83	-	9.52	8.30	-
C.V.	8.64	6.51	-	2.79	2.35	-	5.52	4.70	-

I: Before application of treatment; II: After two month of treatment

Combating alternate bearing in litchi plants by evolving methods that influence flowering mechanism

To combat alternate bearing tendency in litchi cv. China with inclusion of best treatment which [hitherto] seems to bring regular flowering in litchi. The details of treatment were, foliar spray of KNO_3 (2.0%), prohexadione calcium (0.5 g a.i. /L), paclobutrazol (2.5 g a. i. /canopy diameter), girdling with 3 mm intensity practiced in 75% branches, spray of salicylic acid @ 2000 ppm, KH_2PO_4 @ 0.5%, and spermidine @ 0.01Mm. Under morphological parameters (Table 6.2), it was found that tree height increased merely 1.58% due to KNO_3 (2%) while it showed 9.28% in control and Pro-Ca has been found to be less effecting for controlling tree height. Similarly, no increase in tree girth was recorded in tree with Pro-Ca (sas it had increased maximum height) but due to girdling the tree girth was increased by 3.55% after two month of application. Untreated tree had shown rate of increase in height and tree girth (9.28% and 1.11%, respectively) more than treated trees. Over all trunk cross sectional area (TCA) had highest increase (7.22%) in girdled trees and Pro-Ca treated trees had not shown any increment in TCA after two month of application of various crop regulation measures.

It was found that most of the tress flowered this year (2019) with varying intensity. During the winter season, we have also measured soil moisture and temperature and we found that soil temperature don't varied with treatment given for bringing regularity of flowering in litchi cv. China, but highest no. of panicles per tree (256.66) was recorded with 2% KNO3 while least in control

Table 6.3. Flushing pattern in litchi cv. China affecting by soil moisture and temperature

Treatments	Soil moisture (%)	Soil temperature (°C)	No. of flushes $tree^{-1}$	No. of panicles $tree^{-1}$
Control	7.5	13.8	225	3
KNO_3 (2.0 %)	9.4	13.4	17	256.66
Prohexadion Calcium	5.6	13.7	90	170.66
Paclobutazol (2.50 g)	3.2	13.5	80	7.33
Girdling	4.6	13.5	210	211.66
Salicylic acid (2000 ppm)	4.3	13.5	18	62.33
KH_2PO_4 (0.5%)	6.0	13.8	175	7.66
Spermidine (1.0 g)	0.5	13.4	75	8.33

trees (3.0). Rather girdling in 75% branches with 3 mm intensity proved better over other treatment to bring 211.66 numbers of panicles per tree (Table 6.3).

Gaseous exchange parameter affective by paclobutrazol in litchi cv. Shahi

As the data depicted in Table 6.4, leaf gaseous exchange parameters in litchi cv. Shahiwas measured,and it was found that highest P_N (net photosynthetic rate) (14.0 m mol CO_2 m^{-2} s^{-1}) was recorded with PBZ @2.0 g which also had highest no. of panicles per tree (1134) against control (356). Application of 2.0 g PBZ is now also increased panicles no. per tree against other treatments and has positive influence on stomatal conductance and efficient use of CO_2 by reducing internal CO_2 concentration. Thepaclobutrazol @ 1.0 or 2.0 g in litchi cv. Shahi can bring regularity with high yield. The panicle length could not deter due to application of PBZ, but had highest panicle length (32.20 cm) in tree having 2.0 g PBZ, which was almost 50% longer than control (19.60 cm) and no. of fruit per panicle was also found to be almost doubled over control plant. In 2018, also, 2.0 g PBZ performed excellently well for fruit yield against control and other treatment.

Leaf gaseous exchange parameters of four cultivars (Shahi, China, Bedana and Rose Scented) were also recorded and it was found that Shahi trees had highest P_N, *chlorophyll b* content. Amongst the various cultivars of litchi, the total chlorophyll content was lowest in 'Bedana' while highest in 'Shahi' litchi (17.39 mg/g leaves) followed by 'China' litchi (Table 6.5).

Table 6.4. Leaf gaseous exchange parameters, flowering and fruiting affected by application of paclobutrazol in litchi cv. Shahi

Treatment	Photosynthetic rate (*A*) (m mol CO_2) m^{-2} s^{-1})	Transpiration rate (*E*) (m mol H_2O $m^{-2}s^{-1}$)	Internal CO_2 Concentration (µ mol CO_2 mol^{-1} air)	Stomatal Conductance (*gs*) (m mol (H_2O) $m^{-2}s^{-1}$)	No. of panicles per tree	Panicle length (cm)	**No. of fruits per panicle (2019)	No. of fruits per tree (April 2018)	No. of fruits per tree (May 2018)
PBZ@ 3.0 g per m canopy diameter	0.5	2.8	370	65	110	29.00	10.00	310	22
PBZ @2.0 g	15.80	3.8	218	164	195	32.20	23.60	1440	1134
PBZ @ 1.0 g	9.20	3.8	268	138	105	24.80	28.40	365	36
Un-treated	7.0	3.8	318	154	30	19.60	14.00	1056	356

Table 6.5. Inherent characters of litchi cultivars in terms of gaseous exchange parameters and flowering attributes

Name of cultivars	*A*	*E*	*Ci*	*gs*	*Chl a*	*Chl b*	*Total Chl*	Panicle length (cm)	No. of fruits $panicle^{-1}$
Shahi	14.0	2.80	310	158	6.32	11.08	17.39	35.84	21.00
Bedana	0.3	2.60	365	69	4.38	7.99	12.37	20.040	8.80
China	1.80	0.70	316	153	6.73	5.78	12.51	0	0
Rose Scented	1.80	3.80	338	104	10.37	6.83	17.20	0	0

7. Externally Funded Projects

7.1. Improved livelihood through good practices in agricultural production system (Farmers FIRST programme)

Details of capacity building/HRD interventions (trainings, visits, workshops, interfaces, extension activities etc.) conducted for farmer-scientist interface	• 80 farmers of four villages participated in Scientist-Farmer Meeting during Agriculture Fair 2018 at Zila School, Motihari (13-15th April, 2018) • 10 farmers took part in 'National Seminar on Current Scenario and future strategies for augmenting productivity of small ruminants' organised at Bihar Animal Science University, Patna. • 250 farmers of 6 villages attended Gosthi on Production of Horticultural Crops at High School Areraj, Motihari (20 September, 2018). • 'World Soil Day' was organised at Chintamanpur, East Champaran on 5th December, 2018. • 100 farmers took partin Pashu Arogya Mela at KVK, Pipra Kothi, East Champaran on 25th December, 2018. • 10 farmers from 4 project villages participated in 'National Seminar on Current Scenario and future strategies for augmenting productivity of small ruminants' organised at Bihar Animal Science University, Patna on 16th February, 2019.
Details of identification of farm innovators and grooming them as technology agents	• Sri. Rambachan Kumar of BakhariNazir (Mangrahi Bazar), Mehsi, produced 20 kg of Oyster Mushroom and 5 kg of Milky Mushroom this year. • Sri. Vikash Misra of Damodarpur, Mehsi, East Chamaparan started production of Oyster, Milky and Botton Mushroom at the tune of 20 kg per day.
Details of input/technology provided to farmers	• 1200 litchi air layered plants have been distributed in three villages of Mehsi Block, East Champaran on 5th August, 2018. • 8 varieties of wheat, 2 each of papaya and lentil and one of Mustard was demonstrated during 1-3rd November, 2018. • 120 ducks of Indian Runner and Khaki Campbell has been demonstrated in Bakhari Nazir, Mehsi to 25 women farmers on 31st January, 2019. • 3 bucks of Black Bengal has been demonstrated to 3 SHGs of Chintamanpur and Bakhari Nazir Village, Mehsi, East Chmaparn on 12th March, 2019. • 1800 plants of papaya cv. Red Lady have been distributed to selected beneficiaries of FFP for demonstrations of improved production technologies of papaya cultivation at the farmers' field. Farmers were also trained on production technology of papaya cultivation.

Details of involvement of multi-stakeholders to create inter-face with the farmers	• A Field Day was on 12th April, 2018 was organised at Kothi-aHariram (Kankati), Mehsi, East Champaran. During this programme tools of Good Agricultural Practiced for mango and litchi were taught, a 50 no. of farmers participated in the event. • A Regional Workshop on 'Management of Litchi stink Bug' on 16th May, 2018 at Mirzapur, Mehsi, East Champaran on 16th May, 2018 where 65 farmers took part from all three villages and interacted with scientists and District Horticulture Officer, Block Agricultural Officer and local representative. • One day training on Botton Mushroom was conducted at Damodarpur, Mehsi, East Champaran on 24th October, 2018. • During Animal Health Camp at Ramgarhwa, East Champaran, total no. of 280 animals have got treatment with the help of experts from BASU, Patna on 6th January, 2019. • One day training on pickle preparation from Seasonal Vegetables was organised at Bishunpur-LalaTola, Pipra on 12th March, 2019, • Another Animal Health Camp has been organized at Bakhari Nazir, Mehsi, East Champaran on 15th March, 2019 and 220 animal were treated. • One day training on *Zero Budget Natural Farming* was conducted on 26th March, 2019 at Ujhilpur, Mehsi, East Champaran, 65 farmers participated.

Crop Based Module

Ten farmers of each village (total of 70 farmers) were involved in experimentation of rice varieties Rajendra Sweta, Rajendra Bhagwati, Sugandha-5, MTU-7029, Swarna Sub 1, and found that Rajendra Bhagwati and Sugandha-5 was best for high yield. The total area of under rice has been expanded to 11.70 ha under newer varieties. We have tested the genetic bio-fortified (enhanced zinc content) wheat variety (BHU-31) given by SHDA, Gorakhpur, UP and supported by Harvest Plus project of CIMMYT and the International Centre for Tropical Agriculture, funded by the Bill & Melinda Gates Foundation. 25 farmers had planted the wheat seed in 10 ha. The yield they have receivedupto 16 quintal per acre against 10.00 quintal/acre by growing PBW-343. This year 710 farmers had conducted trail on improved variety of wheat (HD-2967, PBW-154, HD-2733 and HD-2985) seed in 180 acres and the farmers received 16.50 quintal per acre with HD-2967 against UP-262 (10 quintal per acre).

Hundred farmer also got 200 kg of improved seed of mustard var. Pusa Bold, recorded low yields due to severe aphid attack. Demonstration of improved variety of Lentil (Pusa Shivalik, Pusa Vaibhav), Green Gram (Pusa Vishal, HUM-16, IPM 2-3), Maize (Maharaja) and Fodder Sorghum has been accomplished in 4 villages within area of 12 ha.

Livestock Based Module

The farmers of Damodarpur village have produced 50 eggs of adult bater, sold 'Vanaraja' chicks @ Rs. 800-1000. They have also sold 10 adult quail @Rs. 60/-. The survival rate was 75% which needs to be increased by enhancing winter protection and supply of recommended feed. Two types of night shelters house (two floor and 3 floor made up of bamboo) were demonstrated in 2

villages and 5 farmers came forward to adopt it by investing and improving the way they are rearing chicks. Mortality of chicks has been reduced by 70%. Duck breed Khaki Campbell (100 in no.) and Indian Runner (20 in No.) has been demonstrated in Bakhari Nazir village.

Four number of she-goat and one no. of the goat (buck) were also given to 5 youths of Damodarpur Village, Mehsi, East Champaran and 3 buck of Black Bengal breed in Chintamanpur, and Bakhari Nazir village has been given to 3 women SHGs (Fig 7.1 & 7.2). The group comprising of 10 participants including 5 women were provides 1 days training on goatary, back yard poultry management and quail farming.

Horticulture Based Module

For increasing diversity of orchard, early establishment of orchard, 1200 plants of litchi, 1500 plants of papaya, was planted in 500 farmers field, however mortality was recorded to be very high, Therefore, consortia kit having trichoderma strain was demonstrated which lead to improvement in survival percentage. The Turmeric variety 'Rajendra Sonia' has been planted in 5.0 ha of two villages as intercrop in Mango and litchi orchard. To increase varietal diversity in kitchen garden and encouraging commercial vegetable growing, the Garden pea var. Azad Matar-3, Okra var. Kashi Kranti, cow pea variety Kashi Kanchan, radish variety Kashi Sweta, Palak var. Arka Anupama, Sponge gourd var. Pusa Sneha has been demonstrated in 20 ha area. The bitter gourd variety Palee, a hybrid variety of East West seed International is very popular in the area due to Early to fruit and 50% high yield. Due to our effort the replacing seed with public sector variety with seed replacement rate of 25% has been successful and yield has been increased by 20% by replacement of only variety (local variety). The pre-harvest bagging of litchi bunches increased 30 percent more export quality fruits attributed to minimized damage by sun burn, cracking (8% against 26% in un-bagged bunches) and insect pest attack.

For control of fruit drop due to Stink Bug in litchi, Triazophos 40% EC @1.5 ml L^{-1} +lambda-cylothrin @0.5 ml L^{-1}+ 0.3 ml sticker solution L^{-1}has been tested and found effective.

Microenterprises Based Module

Training on Button Mushroom at Damodarpur, Bakhari Nazir was conducted and 10 kg have been produced every day by Mr. Vikas Misra and 5 kg by Mr. Ripuraj Kumar Singh of Damodarpur village. The 5 farmers have also started production of Dudhia Mushroom and Oyester Mushroom (at Damodarpur and Vishunpura LalaTola) and selling to their neighbours @ Rs. 200 per kg. 15 women farmers of Vishunpura Lalatola are also started growing Milky Mushroom initially with 5 kg per day (Fig. 7.2).

Training and initial kit demonstration on mixed pickle making have been demonstrated to two villages and it was found that drying of vegetable was the major obstacle. We had demonstrated low cost solar drier to respective villages. After hands on training, initial kit for small scale pickle making was provided to women participants. Two group of women farmers (of *Damodarpur* and *Ujhilpur* village) prepared pickles of mixed vegetables and now they are contemplated for commercial production.

NRM Based Module

To encourage organic farming in project villages, 70 farmers of Ujhilpur and Chintamanpur, East Champaran were trained on '*Zero Budget Natural Farming*.

Integrated Farming System (IFS) Module

Two farm pond of BakhariNazir is being developed for IFS module including Duckery. Vegetables and turmeric (cv. Rajendra Sonia) have been planted in mango and litchi orchard for initial income till tree starts bearing. An IFS model at ICAR-NRC on Litchi has also been developed.

Fig. 7.1. Demonstration of Vanaraja Chicks, Khaki Campbel duck and egg produced of Japanese quail at Bakhari Nazir and Damodarpur, Mehsi East Champaran

Fig 7.2. Raising black bengal goat and training on Milky Mushrrom Production

7.2. Development of synergistic hurdles for preservation of litchi pulp and products

This project has been funded by the Board of Research in Nuclear Sciences (BRNS), DAE, Govt of India. The main emphasis of the project is to develop synergistic hurdles and techniques for preservation of litchi pulp and products with a view to finding safer alternatives to use of conventional preservatives. Under the project the following results have been achieved:

- Use of low temperature (-18°C) as a means of preserving litchi pulp for up to six months without undesirbale change in colour and aroma
- Combination treatment including acidification (up to 1%) using citric acid and different levels of sorbic acid to preserve litchi pulp
- A mild heat treatment for preservation of litchi pulp

7.3 Mega Seed project on Seed production in Agricultural crops and Fisheries

Maintenance of the mother block: Severe pruning was made in the mother block for developing the ideal canopy after removal of the rooted air-layers. Apart from litchi, mother block of guava cv. Lalit (50 plants) for taking the scion/ bud wood and cutting for propagation of planting materials was also maintained.

Propagation of quality planting material: Altogether 50,000 air-layering was made using soil less rooting media (vermi-compost, coco-pith and vermiculite in1:1:1 ratio and *Trichoderma viride* during June to August. 45100 well rooted air-layers were detached and planted in the nursery from which 40100 sapling are ready for sale to farmers and stake holders.

7.4 Developing national repository and facilities for DUS testing in Litchi

Morphological diversity of 9 litchi genotypes *viz.*, CHL-4,CHL-7, SARGUJA Sel- I, CSL-1, CSL-2, CSL-3, CSL-4, CSL-5 and CSL-6 were evaluated at field gene bank of Litchi at ICAR-NRC on Litchi, Muzaffarpur, Bihar in a randomized block design with three replications. The spacing adopted was 8m×8m. Twenty five DUS character were observed from nine genotypes during 2018-19 and considerable variations were recorded among 9 litchi genotypes for various morphological characters. Variation across the genotypes was observed with respect to growth habit, bearing habit, leaf, floral, fruit and seed characteristics etc. Development of morphological descriptor in Litchi for DUS testing will be useful for varietal identification, registration, characterization, documentation etc. The detailed descriptor will be useful for creating plant genetic resource database.

Human Resource Development

Participation of scientists/ staff in conference/ seminar/ symposia/ workshop/ training/ meeting during 2018-2019

Sl. No.	Title	Venue and Date	Participant (s)
1.	National Conference on Enhancing Productivity of Oilseeds in Changing Climate Scenario (NCOS-2018)	ICAR-DGR, Junagadh 7-9 April 2018	Dr Abhay Kumar
2.	Review of the coordinated programme of Mango, Guava and Litchi under AICRP Fruits by QRT	ICAR-CISH, Lucknow 11-13 April 2018	Dr Vishal Nath Dr Amrendra Kumar Dr ES Marboh
3.	Round table Conference	Department of Agriculture, Govt. of Bihar at Patna 27th April 2018	Dr SD Pandey Dr Amrendra Kumar
4.	Review meeting of Farmers'First Project at ATARI, Kolkata	ATARI, Kolkata 28 April 2018	Dr SK Singh
5.	National Conference on Intensification and Diversification in Agriculture for Livelihood and Rural Development	Dr RPCAU, Pusa 28-31 May 2018	Dr Vishal Nath Dr S D Pandey Dr Amrendra Kumar Dr K Srivastava Dr ES Marboh Dr Alok K Gupta
6.	National Conference on Strategies and challenges in doubling farmer's income through horticultural Technology	ICAR-CISH, Lucknow 21-22 June 2018	Dr SK Singh
7.	Workshop on "Regional Group Leaders and Guide Teachers orientation programme" in 26th National Children's Science Congress 2018	Science for Society, Bihar; SCERT; BCST; NCSTC; DST, GOI Jila High school, Muzaffarpur 27 July 2018	Dr SK Purbey
8.	National Famers Science Congress-2018	BAU, Sabour 5-7 Aug 2018	Dr Vishal Nath
9.	Doubling Farmers Income for Sustainable and Harmonious Agriculture	IINRG, Ranchi 11-12 Aug 2018	Dr K Srivastava
10.	Awareness of Krishi Road Map and Horticulture Scheme in Bihar	BAMETI, Patna 11 Aug 2018	Dr Vishal Nath
11.	Pension and Retirement Benefit	ICAR-CIFRI, Kolkata 3-4 Sept 2018	Sh Dileep Kumar Sh Pawan Kumar

12.	10 days training course on Increasing Farmers Income And Livelihood Security: Role of Agriculture Diversification and Value Addition	SKUAST, Srinagar 3-12 Sept 2018	Dr SK Singh
13.	ICAR- Regional Committee Meeting	ICAR-IINRG, Ranchi 14-15 Sept 2018	Dr Vishal Nath Dr K Srivastava
14.	Stress Management	ICAR-NAARM, Hyderabad 17-20 Sept 2018	Dr SD Pandey
15.	Workshop on Doubling Farmer Income	ICAR-IIHR, Bengaluru 17-19 Sept 2018	Dr ES Marboh
16.	Training programme on Stress Management	ICAR-NAARM, Hyderabad 17-20 Sept 2018	Dr SD Pandey
17.	ICAR East Zone Sports Meet	ICAR-IINRG, Ranchi, Jharkhand 5-8 Oct 2018	Dr SD Pandey Dr Amrendra Kumar Dr RK Patel Dr Kuldeep Srivastava Dr Alok Kumar Gupta Dr Evening Stone Marboh Dr Alemwati Pongener Sh Abhishek Yadav Sh Ramji Giri Sh Ramasish Kumar Sh Sawan Kumar Sh Dharmendra Kumar
18.	26th State Level Children's Science Congress-2018	Science for Society, Bihar; SCERT; BCST; NCSTC; DST, GOI 25-27 October 2018	Dr SK Purbey
19.	District Level Children's Science Congress	Niteshwar College, Muzaffarpur, Science for Society, Bihar; SCERT; BCST 28 October 2018	Dr SK Purbey
20.	Workshop on "Eradicate Corruption-Build a New India"	ICAR-NRC on Litchi, Muzaffarpur 30 Oct 2018	All staff
21.	National Conference on Arid Horticulture for Enhancing Productivity and Economic Empowerment	ICAR-CIAH, Bikaner 27-29 October 2018	Dr Vishal Nath Dr SK Singh

22.	Winter School (21 days) on Innovative Approaches for Improvement of Perennial Horticultural Crops	ICAR-Indian Agricultural Research Institute, New Delhi 16 Nov-6 Dec 2018	Dr SK Singh
23.	New Paradigms of Plant Health Management: Sustaining Food Security under Climate Change Scenario (Indian Phytopathological Society) Annual Meeting	BAU, Sabour 17-19 Nov 2018	Dr Vinod Kumar
24.	International Conference on "Role of Soil and Plant Health in Achieving Sustainable Developmental Goals"	Bangkok, Thailand 21-25 Nov 2018	Dr Vinod Kumar
25.	International Seminar on Global Partnership in Agricultural Education and Research (CAP-2018)	Inst. Ag. Sc, BHU, Varanasi, U. P. 22-24 Dec 2018	Dr SK Purbey
26.	National Dialogue on Improving Productivity and Utilization of Litchi, ICAR-NRCL In collaboration with ICAR-AICRP (Fruits)	ICAR-NRC on Litchi, Muzaffarpur, 30 Nov - 1 Dec 2018	All Scientists
27.	Third Workshop of Officer In-charge, Data Management of KRISHI	NASC/IASRI, New Delhi 4-5 Dec 2018	Dr Vinod Kumar
28.	Management Development Programme on Leadership Development	ICAR-NAARM, Hyderabad 18-29 Dec 2018	Dr K Srivastava
29.	National Workshop on "Diseases of makhana: Challenges towards diagnosis and management"	Mandan Bharti Agriculture College, Agwanapur, Saharsa 11-12 Jan 2019	Dr Vinod Kumar
30.	8th Indian Horticulture Congress-2019, Shaping future of Indian Horticulture	IGKVV, Raipur, CG 17-21 Jan 2019	Dr Vishal Nath Dr RK Patel Dr Kuldeep Srivastava Dr Narayan Lal
31.	Workshop on 'Development of Food Processing Industries – Government Policies and Opportunities' organized by MOFPI, Govt of India under Operation Green Scheme	Bihar Industries Association, Patna 31 January 2019	Dr SD Pandey Dr Alemwati Pongener
32.	Development of EDP in Horticulture	NHB, New Delhi 5-6 Feb 2019	Dr Amarendra Kumar

33.	6th GD Meet of AICRP (Fruits)	AAU, Jorhat 14-16 Feb 2019	Dr Vishal Nath Dr SK Purbey Dr Amarendra Kumar Dr Kuldeep Srivastava Dr ES Marboh
34.	Expert Committee Meeting of ICAR-NASF, New Delhi on 'Research on Social Sciences'	NASC Complex, New Delhi 28 Feb 2019	Dr SK Singh

HRD target and achievements (2018-19)

A. Physical targets and achievements

S. No.	Category	Total No. of Employees	No. of trainings planned for each category during 2018-19 as per ATP	Total No. of employees undergone training during April 2018 to March 2019	% realization of trainings planned during 2018-19
1	Scientist	14	7	4	57.1
2	Technical	7	1	1	100
3	Administrative & Finance	8	2	2	100
4	SSS	1	1	0	0
	Total	30	11	7	

B. Financial targets and achievements (All employees)

S.No.	RE 2018-19 for HRD (Rs in lakhs)	Actual Expenditure up to 31 March, 2019 for HRD	% Utilization of allotted budget
1	2	2	100.00%

C. Category-wise trainings attended by employees during 2018-19

C1 Category: Scientists

S. No.	Name of employee	Designation	Discipline/ Section	Name of training programme attended	Actual Expenditure incurred (Rs)	Entered in ERP system (Yes/No)
1	Dr. S.K. Singh	Sr. Scientist	Crop Production	10 days training course on increasing farmers income and livelihood security: role of agriculture diversification and value addition.	paid by host institute	Yes

2	Dr. SD Pandey	Pr. Scientist	Crop Production	Stress management	33964/-	Yes
3	Dr SK Singh	Sr. Scientist	Crop Production	Innovative Approaches for Improvement of Perennial Horticultural Crops	paid by host institute	Yes
4	Dr Kuldeep Srivastava	Principal Scientist	Crop Protection	MDP on leadership Development	34529/-	Yes

C2	Category: Technical staff				
1	Mr Surender	T-1	Motivation,Positive thinking and communication skils for Technical Staff of ICAR at NAARM,Hyderabad	11544/-	Yes

C3	Category: Administrative staff				
1	Sh. Dileep Kumar	Assistant		7453	Yes
2	Sh. Pawan Kumar	Jr clerk		5881	Yes

C4	Category: SSS				
1	Nil	-	-	-	-

Meetings, workshops and events

National Dialogue on Improving Productivity and Utilization of Litchi

A programme on "National Dialogue on Improving Productivity and Utilization of Litchi" was organized at ICAR-National Research Centre on Litchi in collaboration with ICAR-All India Coordinated Research Project (Fruits) from 30th November - 1st December, 2018. The objective of the program is to address the issues and production problems with regard to improving litchi productivity, faced by farmers and litchi growers in major litchi belts of the country. The programme was facilitated by Dr. A.K. Singh, DDG (HS), ICAR, in presence of ADG (HS–I) ICAR, Dr. W.S. Dhillon, Dr. Gopalji Trivedi, Ex-Vice Chancellor, DRPCAU, Samastipur, Pusa, Dr. Prakash Patil, PC (AICRP – Fruits), Dr. Vishal Nath, Director, ICAR-NRCL, experts on litchi, scientists of AICRP (F) working on litchi at Chettalli (Karnataka), Himachal Pradesh, Mohanpur (West Bengal), Medziphema (Nagaland), Gangian (Punjab), Pantnagar (Uttarakhand), Ranchi (Jharkhand), Sabour (Bihar) and Muzaffarpur (Bihar), and development partners of State Government, progressive litchi growers and stakeholders.

18th Foundation Day

The 18th Foundation Day was celebrated on 6th June, 2018. Dr. Vishal Nath, Director of the centre welcomed the guests and briefed about achievement of NRCL since last 18 years. The development of three new varieties of litchi *viz,* Gandaki Sampada, Gandaki Lalima and Gandaki Yogita was highlighted in his speech. He also apprised about some of the newer technology developed by the Centre such as, good agricultural practices (GAP), girdling for regulating bearing, NRCL Trichoderma-a biological fungicide with plant growth promotion activity, NRCL microbial consortium for enhanced growth, productivity and quality of litchi, processed product of litchi especially osmo-dehydrated litchi, integrated pre and post- harvest management practices for minimizing losses and increasing shelf life of litchi were prominently highlighted the adoption of which will benefit litchi growers and processors in the region. Shri Nageswar Thakur, former District Horticulture Officer, Muzaffarpur was of the view that Foundation day of the centre should be organized in a grand manner and some farmer-friendly programmes could be organized. On this occasion, Shri Sanjeev Gupta, Horticulture Development Officer, Department of Horticulture, Jammu & Kashmir, present on the occasion apprised that J&K Government has plan to establish litchi village in plains of Jammu initially in 80 hectare land with the support of NRCL, Muzaffarpur. The programme was also attended by the farmers from Muzaffarpur, Vaishali, Samastipur, Sitamarhi, East Champaran and West Champaran districts of Bihar. The programme was coordinated by Dr. Vinod Kumar, Senior Scientist and was supported by all the scientists, administrative and technical staffs of the centre.

A glimpse of inaugural session of the 18th Foundation Day

Entrepreneurship Development Training Programme on Litchi-Based Beverage Unit

Preservation and processing of litchi into different products can help growers and entrepreneurs overcome glut and distress sale situation, because the processed products have long shelf life that allows for planned and organized distribution according to market demand. Processing and value addition can lead to generation of employment and addresses to achieve the Govt of India`s aim to double farmers` income by 2022. Litchi can be processed into various value-added products and offers huge potential for entrepreneurship in the food processing sector. With a view to promoting entrepreneurship among litchi growers and stakeholders, an 'Entrepreneurship Development Training Programme on Litchi-Based Beverage Unit' was conducted at the centre from 17-22nd December 2018. The training programme was conducted by Dr. S.K. Purbey as Course Director, and Dr. Vinod Kumar and Dr. Alemwati Pongener as Course Coordinators. The following entrepreneurs attended the training that included all modules related to technical knowhow, licensing, hands-on practicals, and establishment of litchi-based beverage unit and now engaged in business:

1. Mr. Ram Sarovar Singh, Ramsarowar Agro Food, Chhitrauli, Kudhani, Mariyani, Muzaffarpur

2. Mr. Pankaj Kumar, Muzaffarpur Agro, Krishanapuri, Kanhauli, Muzaffarpur
3. Mr. Krishna Gopal Singh, Vishvaksenah Agro & Dairy Pvt. Ltd., Ahiyapur, Muzaffarpur
4. Mr. Md. Shoaib, Sadpura, Near Central Public School, Mithanpura, Muzaffarpur
5. Mr. Hasnain Arij, Satpura, Mithanpura, Muzaffarpur

17th IRC Meeting

During the year, 17th Institute Research Council (IRC) meetings were held on 25-26 September 2018 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.

NHB-Sponsored Workshop

A one day workshop on "Sensitization of NHB schemes for enhancing litchi production and post harvest management of litchi orchards towards development of economic horticulture" sponsored by National Horticultural Board was organized at NRC on Litchi, Muzaffarpur from 20th July 2018. Several litchi growers, entrepreneurs and stakeholders took part in the training. Information on various schemes which can be taken up by the farmers were discussed in great details to the satisfaction of the audience. Officials from the NHB, Muzaffarpur Zone and Scientist of NRCL answered various range of issues raised by the litchi farmers.

ATMA-Sponsored three days Training Programme on Technological Innovations in Litchi Production and PHM for Doubling Farmers Income

A three-day training programme on technological innovations in litchi production and postharvest management sponsored by ATMA was organized at NRC on Litchi on 10-12 September, 2018. A total of 24 farmers from Begusarai district of Bihar were trained on various aspects of good agricultural practices in litchi production, management of pests and diseases, water and fertilizer management and it's processing towards export quality production of litchi. Special emphasis was given towards

minimizing losses during postharvest stages with the objective of maximizing economic returns. The programme was conducted by Dr. Kuldeep Srivastava, Principal Scientist (Entomology), Dr. R.K. Patel, Principal Scientist (Hort) and Dr. Alok Kumar Gupta, Scientist (Hort.). During the three day programme scientists and staff interacted with the farmers on diverse range of issues and concerns faced by the litchi growers.

Workshop on Water Management in Litchi Orchards

A two day workshop on "Water Management in Litchi Orchards" was organized at ICAR-NRC on Litchi under the aegis of *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) sponsored by ATMA, Muzaffarpur on 4-5 May, 2018. Several litchi growers, entrepreneurs and stakeholders took part in the training. Information on various aspects of water management, fertigation and new innovations in water management which can be taken up by the farmers were discussed in great details to the satisfaction of the audience. A lively discussion was led by Dr. Vishal Nath, Director of the centre and other scientists various queries were answered and solutions provided.

International Day of Yoga

ICAR – NRC on Litchi celebrated the 4th anniversary of "International day of Yoga" on 21st June 2018 as per common yoga protocol issued by Ministry of Ayush, Govt of India and ICAR's guidelines. Yoga is an invaluable gift of India's ancient tradition. The event was led by the Dr. S.D. Pandey, Principal Scientist and events were coordinated by Dr. Prabhat Kumar, Nodal Officer (Yoga Day) which was followed by talks on various topics including Yoga and consciousness. The yoga asanas were conducted under the supervision of trained yoga instructor, who apart from conducting the exercises also informed about the benefits of each asana. The instructor educated the participants about the importance of Yoga for stress free healthy living and healthy mind. A Yoga practice session was conducted in the morning session. The activity started with body setting exercises followed by routine yoga practices and postures. Scientists, Technical, Administrative and Skilled supporting staff of ICAR-NRCL enthusiastically participated in the Yoga celebration. The function ended with the pledge to do yoga regularly to live healthy life and contribute more in the progress of the nation.

World Soil Day

World Soil Day was celebrated on 5 December 2018 at farmer's field in village Chintamanpur, East Champaran, Bihar. Lectures on importance of soil health, integrated nutrient management were delivered to the farmers' audience. Soil Health Card was distributed to eighty farmers from the villagers of Khairwa Mahoba, Lalatola, Ramgadhwa and Chintamanpur of East

Champaran district of Bihar. Various activities were undertaken like training, demonstration were imparted to villagers and were sensitized to apply recommended dose of fertilizer to maintain the soil health. Farmers from nearby villages also participated this occasion and learned about soil health management techniques for sustainable production. The programme was coordinated by Dr. RK Patel and Dr. Prabhat Kumar.

Swachh Bharat Abhiyan

ICAR-NRC on Litchi celebrated *Swachhta Pakhwada* 16-31 Dec, 2018 spreading the awareness and cleanliness. During this fortnight various activities were undertaken to celebrate this occasion.

- Banner and poster were displayed at different places to create mass awareness towards cleanliness.
- Swachhta Pledge was organized involving NRCL staff, school children & teachers.
- Plantation of trees were also undertaken in campus and in near around adjoining villages.
- Digitization of the different office documents and forms, formats etc.
- Disposal of old furniture and waste material in lab and other junk material.
- Cleanliness drive in office, lab, corridor etc.
- Beautification of main entrance gate and corridor with flower pots.
- Cleanliness drive in residential colony, guest house, canteen area.
- Segregation of residential colony waste pit into decomposable and non-decomposable waste.
- Farm decomposition pit developed which will convert waste (farm) into valuable organic compost.
- Farmers were encouraged to adopt different composting technique and other green technologies, organic farming.
- School children were debated on swachhta and expressed their views, ideas to make clean and green India.

"Swachhta hi Sewa" was organised at NRCL during which various activities were undertaken. Cleanliness and awareness drive was organised at NRCL and nearby places. An essay writing and quiz programme was also

organised on *Swachha Bharat Abhiyan*. On 2nd Oct, 2018, Mahatma Gandhi 150th birth anniversary was celebrated at NRCL with full enthusiasm in which all employees performed *shramdaan*. On this occasion cleanliness drive was organised in public place, cleaning of road, pathway, parking shade etc. Director of the centre Dr. Vishal Nath administered "*Swachhta Pledge*" to the scientists and staff to bring the Mahatma`s dream into reality. In addition, several initiatives were taken for overall cleanliness of office building and premises, residential campus and research farm.

Commemoration of Vigilance Awareness Week

Vigilance awareness week was organized by ICAR-NRC on Litchi, Muzaffarpur from 29th October – 3rd November, 2017 with theme "Eradicate Corruption-Build a New India". An

oath towards Integrity Pledge was administered by the Dr. S.D. Pandey, Principal Scientist to all the staff of the centre acknowledging their commitment to uphold the highest standards of honesty and integrity. He extorted that the purpose of observing Vigilance Awareness Week is to educate the public at large about the corruption related practices and also educating them how to report about it. He said that it acts like a mass movement of involving people in saying no to corruption. A workshop on eradicating corruption was organized wherein debates was organized and speakers put forth their views on the topics. The programme was co-ordinated By Dr. Amarendra Kumar, Prinicpal Scientist (Horticulture).

ICAR-NRCL participated in the East Zone ICAR Sports Meet 2018

A 12-member contingent, led by Chief-de-Mission Dr. SD Pandey and Team Manager Dr. Kuldeep Srivastava, represented ICAR-NRCL at

Participants of ICAR-NRCL in the East Zone ICAR Sports Meet 2018

the ICAR Sports Tournament for Eastern Zone being held at ICAR-IINRG, Ranchi from 5-8 October, 2018. The team participated in various sports events, where Dr. Alok Gupta secured 3rd position in discus throw and the volleyball team secured the runners' up position in team event.

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संसाधन और संस्थान अनुसंधान परिषद (आईआरसी) के बैठक की निर्धारित तिथि के मद्दे–नजर केंद्र पर 14 सितंबर से 'हिन्दी सप्ताह' का आयोजन किया गया। इस दरम्यान कुल पाँच प्रतियोगिताएं नामतः प्रश्नोत्तरी, अनुवाद (अँग्रेजी से हिन्दी), निबंध लेखन, श्रुतिलेखन और आशुभाषण का आयोजन किया गया एवं उत्कृष्ठ प्रदर्शन करने वाले प्रतिभागियों को पुरस्कृत किया गया। हिंदी कार्यशाला सह पुरस्कार वितरण समारोह 10 अक्तूबर 2018 को आयोजित की गई। डॉ विनोद कुमार, वरिष्ठ वैज्ञानिक एवं केंद्र के राजभाषा हिन्दी प्रभारी ने हिन्दी के प्रगामी प्रयोग के मुद्दों पर चर्चा की और कार्यशाला में उपस्थित सभी सदस्यों को अवगत कराया कि केंद्र पर पहली छमाही के दौरान राजभाषा कार्यान्वयन समिति कि 2 बैठकें और 2 कार्यशालाओं का आयोजन किया गया। कार्यालय में हिन्दी में कार्य करने की प्रतिशतता निरंतर बढ़ी है।

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नगर राजभाषा कार्यान्वयन समिति (नराकास), मुजफ्फरपुर की पहली छमाही बैठक 21 अगस्त, 2018 को राष्ट्रीय लीची अनुसंधान केंद्र के सभागार में आयोजित की गई। समारोह का आरंभ दीप प्रज्वलन से हुआ। तत्पश्चात, डॉ विनोद कुमार, वरिष्ठ वैज्ञानिक और इस केंद्र के राजभाषा हिन्दी प्रभारी ने अतिथियों एवं विभिन्न कार्यालयों से आये हुये प्रतिनिधियों का स्वागत किया। डॉ कुमार ने अपने स्वागत भाषण में केंद्र पर राजभाषा हिन्दी के प्रगामी प्रयोग के मुद्दों पर चर्चा के साथ–साथ लीची अनुसंधान केंद्र के कार्यकलापों एवं हाल में विकसित तकनीकियों की भी संक्षिप्त जानकारी दी। समारोह के मुख्य अतिथि श्री नकुल बेहेरा, उपमहाप्रबंधक, बैंक ऑफ इंडिया एवं अध्यक्ष, नराकास, मुजफ्फरपुर थे। समारोह की अध्यक्षता डॉ विशाल नाथ, निदेशक, राष्ट्रीय लीची अनुसंधान केन्द्र ने की। श्री सुदीप सैनी, सचिव, नराकस, मुजफ्फरपुर ने हिन्दी के प्रचार–प्रसार में कम्प्युटर के योगदान पर प्रशिक्षण दिया एवं कार्यालयों में उपलब्ध सभी कम्प्युटर में यूनिकोड हिन्दी इन्स्टाल होने की अनिवार्यता पर जोर दिया। मुख्य अतिथि ने सभी विजेताओ को पुरस्कृत किया। अपने सम्बोधन में उन्होंने कहा कि हिंदी भाषा विविधता में एकता का प्रतीक है। हिन्दी पुरातन भी है और आधुनिक भी। हिन्दी भारतीयता की चेतना है। मंच संचालन डॉ संजय कुमार सिंह, मुख्य प्रबन्धक,

हिन्दी सप्ताह के उदघाटन सत्र में राजभाषा हिन्दी प्रभारी डॉ विनोद कुमार बैठक में उपस्थित सभी सदस्यों का स्वागत और उद्बोधन करते हुये

नराकास, मुजफ्फरपुर की पहली छमाही बैठक में मुख्य अतिथि एवं कार्यालय प्रमुख

एसबीआई ने किया और धन्यवाद ज्ञापन पंजाब नेशनल बैंक के प्रबन्धक श्री इंद्रजीत दास ने किया। समारोह में विभिन्न कार्यालयों से 47 प्रतिनिधि कार्यालय–प्रमुख एवं राजभाषा हिन्दी अधिकारियों ने भाग लिया।

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फार्मस फर्स्ट परियोजना के अंतर्गत किसान कल्याण सम्मेलन सह तकनीकी गोष्ठी का आयोजन दिनांक 14 अक्टूबर 2018 को चकिया के गाँधी मैदान में आयोजित किया गया। इस अवसर पर माननीय कृषि एवं किसान कल्याण मंत्री, भारत सरकार, श्री राधा मोहन सिंह, मुख्य अतिथि थे। माननीय पर्यटन मंत्री, बिहार सरकार, श्री प्रमोद कुमार ने कार्यक्रम की अध्यक्षता की तथा श्री श्यामबाबू यादव, माननीय विधायक, पीपरा कोठी, श्री सचीन्द्र प्रसाद सिंह, माननीय विधायक, कल्याणपुर एवं श्री राजेन्द्र गुप्ता, पूर्व विधान परिषद सदस्य, (बिहार) कार्यक्रम में विशिष्ठ अतिथि के रूप में भाग लेकर किसानों का सम्बोधित किया। इस अवसर पर परियोजना के अन्तर्गत चयनित ग्राम समूह चिंतामनपुर (लाला टोला), चिंतामनपुर (मलाही टोला) रामगढ़वा खैरयामहुआवा, ओझा टोला (बैयसहा), उझिलपुर, बखरीनाजिर एवंदामोदरपुर के परियोजना से जुड़े 1000 (एक हजार) परिवारों के साथ–साथ भारी संख्या में मक्का उत्पादक, सब्जी उत्पादक, फल उत्पादन, पशुपालन एवं मशरूम उत्पादन से जुड किसानों ने भाग लिया। कार्यक्रम में लीची सहित अनेक फलदार फसलों के उचित रख रखाव एवं प्रबंधन पर डॉ. एस. डी. पाण्डेय एवं अन्य वैज्ञानिकों ने अपने विचार रखें। डॉ. विशाल नाथ, निदेशक, भाकृअनुप–राष्ट्रीय लीची

अनुसंधान केन्द्र, मुजफ्फरपुर द्वारा अतिथियों का स्वागत किया गया। अपने उद्बोधन में माननीय कृषि मंत्री ने किसानों को उपलब्ध संसाधनों के अनुरूप समेकित कृषि प्रणाली को अपनाने का आह्वान किया। माननीय मंत्री जी ने उपस्थित किसानसमूह को विज्ञान पर कृषि तकनीकों को अपनाने और उससे अपनी आमदनी को दुगना करने की सलाह दी। अन्य गणमान्य अतिथियों ने कृषि में किये जा रहे वैज्ञानिक संसोधनों को अपनाने के लिए किसानों के प्रशिक्षण एवं ज्ञान कौशल वृद्धि के लिए समय–समय पर किसान गोष्ठियाँ एवं जागरूकता शिविरों के आयोजन पर बल दिया। इस अवसर पर बड़ी संख्या में जन प्रतिनिधि एवं कृषक उत्पादक संगठन (FPO) के सदस्य एवं उपादान विक्रेता भी मौजूद रहें। कार्यक्रम के अंत में मुख्य अतिथि एवं अन्यान्य अतिथियों का धन्यवाद ज्ञापन डॉ. एस.डी. पाण्डेय ने किया।

Distinguished Visitors

Dr. A.K. Srivastava, Chairman, Agricultural Scientists Recruitment Board, ICAR, New Delhi visited the centre on 29th May, 2018

Shri Chhabilendra Roul, Special Secretary, DARE & Secretary, ICAR visited ICAR-NRCL on 12th September, 2018

List of other distinguished visitors

S. No.	Distinguished Visitors	Affiliation	Date
1.	Sh. Surendra Nath	JDA, Muzaffarpur	4th May, 2018
2.	Dr. W.S. Dhillon	ADG, Hort-I, ICAR, New Delhi	30th Nov., 2018
3.	Dr. R.C. Srivastava	VC, DRPCAU, Pusa, Samastipur, Bihar	1st Dec., 2018
4.	Dr. G. Trivedi	Former VC, RAU, Pusa, Bihar	1st Dec., 2018
5.	Dr. A.K. Singh	DDG, Hort. Science, ICAR, New Delhi	1st Dec., 2018
6.	Dr. Awtar Singh	Pr. Scientist, Plant Breeding, IARI, New Delhi	30th Nov.-1st Dec., 2018
7.	Dr. Nav Prem Singh	PAU, Ludhiana	30th Nov.-1st Dec., 2018
8.	Dr. C.S. Maiti	Assoc. Prof. SASRD, NU, Medziphema, Nagaland	30th Nov.-1st Dec., 2018
9.	Dr. A.K. Singh	Prof. Hort, GBPUAT, Pantnagar	30th Nov.-1st Dec., 2018

Transfer of technology

Dissemination of technologies have been done through organizing training, demonstration, field day, *Kisan Gosthi*, delivering lectures, showcasing NRCL technologies in agriculture/farmers fair 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.

Outreach and extension activities

Programme	Venue and date	Participating/Resource persons	No. of beneficiaries
Advance training on rearing and distribution of quail and Chicks	Ujhilpur, Damodarpur, Chintamanpur of East Champaran 4 April 2018	Dr. S.K. Singh Dr. Vishal Nath	35
Kisan Mela & Kisan Gosthi	Narendra Deva University of Agriculture & Technology, Faizabad 5-6 April 2018	Dr. Alok Kr Gupta Dr. J.P. Verma	252
Training on Zero Budget Agriculture	Kankati, East Champaran 12 April 2018	Dr. Vinod Kumar Dr. S.K. Singh Dr. Swati Sharma Dr. S.K. Purbey	27
Showcasing of ICAR-NRCL technologies in State Level Agr. Fair cum Farmers –Scientists interaction	Jila School, Motihari 13-15 April 2018	Dr. S.D. Pandey Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Dr. S.K. Singh Dr. Alok Kr Gupta Dr. Abhay Kumar Dr. J.P. Verma Dr. Ramesh Kumar	175
Training on cultivation of turmeric and low cost drying techniques	Damodarpur, Chintamanpur, Ujhilpur of East Champaran 20 April 2018	Dr. S.K. Singh	25
Litchi Pathshala	Minapur, ATMA, Muzaffarpur 23 April 2018	Dr. S.D. Pandey Dr. Amarendra Kumar Dr. J.P. Verma	30
Litchi Pathshala	Laskaripur, Kanti, ATMA, Muzaffarpur 24 April 2018	Dr. R.K. Patel Dr. Alemwati Pongener	30

Litchi Pathshala	Bakhari, Dholi, Bihar 28 April 2018	Dr. Vinod Kumar	25
Training and demonstration on Bagging of litchi Bunches	Narsinghpur and Raghunathpur, Mushari, Muzaffarpur 28 April 2018	Dr. S.K. Singh	12
Litchi Pathshala	Bhatkauliya, Muzaffarpur 1 May 2018	Dr. Amarendra Kumar	25
Kisan Kalyan Karmshala organized by ATMA, Govt. of Bihar	Aurai, Muzaffarpur, Bihar 2 May 2018	Dr. Vinod Kumar	140
Management of Stink bug in litchi	Mehsi, Motihari, Bihar 16 May 2018	Dr. S.K. Singh Dr. Kuldeep Srivastava Dr. Vinod Kumar	60
Summer training on "Pre and Postharvest management of litchi" for UG students of BHU, Varanasi	ICAR-NRCL from 17-24 May 2018	Dr. S.D. Pandey Dr. Alemwati Pongener Dr. Swati Sharma	26
Farmers Field Visit	Muzaffarpur 25-27 May 2018	Dr. S.D. Pandey Dr. Prabhat Kumar	30
Training on advance technique of Rice cultivation on	Ujghilpur, Damodarpur, Motihari 7 June 2018	Dr. S.K. Singh	50
Training on advance technique of vegetable cultivation	Ujghilpur, Damodarpur, Motihari 13 June 2018	Dr. S.K. Singh	30
Litchi Pathshala	Punash and Bochaha, Muzaffarpur 14 June 2018	Dr. S.D. Pandey Dr. K Srivastava	30
Summer Training on "Laboratory analytical methods related to physiology and biochemistry of litchi fruit" for M.Sc. (Ag.) Horticulture students of BHU, Varanasi	ICAR-NRCL from 20th May to 20th June 2018	Dr. S.D. Pandey Dr. Swati Sharma Dr. Alemwati Pongener	02
Awareness programme on use of solar dryer for production of dehydrated products	Ujhilpur, Damodarpur and Chintamanpur village of East Champaran 10 July 2018	Dr. S.K. Singh	15

Kisan Pathshala	Minapur, Muzaffarpur 11 July 2018	Dr. S.D. Pandey Dr. Amarendra Kumar Dr. J.P. Verma	30
Kisan Pathshala	Lashkaripur, Kanti, Muzaffarpur 27 July 2018	Dr. R.K. Patel Dr. Alemwati Pongener	25
Training and interaction programme on litchi cultivation	Jammu, SKUA&T, Jammu; Marh, Jammu 30-31 July 2018	Dr. Vishal Nath Dr. Amarendra Kumar	30
Kisan Pathshala	Bakhari, Muzaffarpur 09 August 2018	Dr. Vinod Kumar Dr. Alok Kr Gupta Dr. J.P. Verma	25
Kishan Pathshala	Bhitaulia, Muzaffarpur 14 August 2018	Dr. Amarendra Kumar	25
Distribution of litchi plants to beneficiaries and organizing awareness camp under TSP component	Khetauli, Shahdol, MP 20 August 2018	Dr. S.D. Pandey Dr. Kuldeep Srivastava	50
Three days training programme on Technological innovations in litchi production and PHM for doubling farmers income as Course Coordinator sponsored by ATMA, Begusarai	ICAR-NRCL, Muzaffarpur 10-12 Sept 2018	Dr. R.K. Patel	27
On farm trial on canopy management and girdling	Urhuttu, Badmu, Jharkhand 16 Sept 2018	Dr. S.K. Singh	5
Three days training programme on rejuvenation and plant canopy management of litchi and mango	KVK, Birauli, DRPCAU, Pusa, 29 Sept - Oct 2018	Dr. Vishal Nath Dr. S.D. Pandey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Dr. Sanjay K. Singh	30
Interaction meet with farmers on *Rabi* crops	Damoderpur, East Champaran 05 October 2018	Dr. S.K. Purbey Dr. S.K. Singh	15
Krishi Kumbh International Convention & Exhibition	ICAR-IISR, Lucknow 26-28 October 2018	Dr. Alok Kr Gupta Dr. J.P. Verma	31

Method demonstration of improved techniques of button mushroom	Damodarpur, East Champaran 24 October 2018	Dr. Daya Ram, RPCAU Dr. S.K. Singh	42
Kisan Gosthi, field demonstration and awareness camps	Karnal and Yamuna nagar in Haryana and Meerut, Muzaffarnagar, Saharanpur and adjoining areas in western UP. 29 -30 October 2018	Dr. Vishal Nath	In mass
Kisan Mela	Ziradei, Siwan 3 October 2018		In mass
Method demonstration of zero budget natural farming	Chintamanpur, East Champaran 26 October 2018	Dr. Vinod Kumar Dr. S.K. Singh Dr. Prabhat Kumar	45
World Soil Day	Chintamanpur, East Champaran 5 December 2018	Dr. Prabhat Kumar Dr. R.K. Patel	50
Kisan Gosthi	Shahdol, MP 8-11 December 2018		150
Method of demonstration of Mustard, lentil and wheat variety	East Champaran 10-12 December 2018	Dr. S.K. Singh	100
Innovative Farm Management	Patna 13 December 2018	Dr. Amarendra Kumar	50
Entrepreneurship Development Training Programme on Litchi-Based Beverage Unit	17-22 December 2018	Dr. S.K. Purbey Dr. Vinod Kumar Dr. Alemwati Pongener	5
Kisan Diwas	ICAR-NRC on IFS, Motihari 23-25 December 2018	Dr. Vishal Nath Dr. S.D. Pandey Dr. R.K. Patel Dr. S.K.Singh Dr. Abhay Kumar Sh. Prabhat Kumar Dr. J.P. Verma Dr. Ramashish Kumar	45
Pashu Arogya Mela	ICAR- Mahatma Gandhi Integrated Farming Research Institute, Motihari 23-25 December 2018	Dr. R.K. Patel Dr.S.K. Singh Dr. Prabhat Kumar Dr. Abhay Kumar Dr. J.P. Verma Dr. Ramashish Kumar	In mass

Farm mechanization Fair	Block office Mushahari, Muzaffarpur 11-12 January 2019	Dr. Kuldeep Srivastava Dr. Narayan Lal Dr. J.P. Verma	In mass
Animal Health Camp (under Farmer FIRST Project)	Ramgarhwa, East Champaran 6 January 2019	Dr. Prabhat Kumar Dr. S.K. Singh Dr. Kuldeep Srivastava	80
Demonstration of improved seed of Okra, Bottle Gourd. Cow Pea and Pumpkin	Ujhilpur, Bakhari Nazir, Damodarpur, East Champaran 30 January 2019	Dr. R.K. Patel Dr. S.K. Singh	100
Demonstration of ducks (breed of Khaki Camel and Indian Runner)	Bakhari Nazir, East Champaran 31 January 2019	Dr. R.K. Patel Dr. S.K. Singh	15
Training Programme on pickle making in seasonal vegetables and its processing	Ramgardwah, East Champaran 3 January 2019	Dr. Prabhat Kumar Dr. S.K. Singh Dr. Kuldeep Srivastava Scientist of BASU, Patna	40
Kishan Kalyan Mela	Krishi Farm, Parsauni, Purvi Champaran, Bihar, 2-3 February 2019	Dr. Kuldeep Srivastava Dr. S.K. Singh Dr. J.P. Verma	37
Krishi Kumbh	Motihari, Bihar 9-11 February 2019	Dr. Abhay Kumar Dr. Narayan Lal Dr. J.P. Verma	71
Krishi Dham Expo	ICAR- CPRI, Regional Centre, Modipuram, Meerut, UP 15-17 February 2019	Dr. S.K. Singh Dr. J.P. Verma	96
Krishi Vikas Smannvit Mela	Agri Expo Madhibani, Bihar 17-19 February 2019	Dr. Narayan Lal Dr. JP Verma Sh. Surendra Rai	96
Visit of farmers to NRC on Litchi, Muzaffarpur. ATMA Sant Kabir Nagar, U.P.	ICAR-NRCL 20 February 2019	Dr. Kuldeep Srivastava Dr. J.P. Verma	19
Regional Agricultural Machinery Cum Subsidy Fair	Agriculture Department Mushahari, Muzaffarpur, Bihar, 21-22 February 2019	Dr. J.P. Verma Mr. Ajay Rajak	32
Farmers Training program on GAP in Litchi	Baitul, M.P. 22-23 February 2019	Dr. S.D. Pandey	300

Kisan Mela,-2019	BAU, Sabour, Bihar, 23-25 February 2019	Dr. Vinod Kumar Dr. J.P. Verma	290
Kisan Mela	KVK, Peepeeganj, Gorakhpur 2-3 March, 2019	Dr. Alok Kr Gupta Dr. J.P. Verma	140
"Litchi Utpadan ki Adhunik Taknik" Kisan Pathashala	Rajkhand, Muzaffarpur March 2019	Dr. S.D. Pandey Dr. Kuldeep Srivastava Dr. J.P. Verma	25
Demonstration of Buck on " Black Bengal'' to 3 group of woman(10 in each group)	Bakhari Nazir and Chintamanpur, E. Champaran 11 March 2019	Dr. S.K. Singh	30
Demonstration on Oyester Mashroom	3 villages of E. Champaran 08 March 2019	Dr. S.K. Singh	26
Demonstration of 600 chick, on "Vanaraja" and 100 Japanese quail to 40 farmers/rural youth	Bakhari Nazir, East Champaran 14 March 2019	Dr. S.K. Singh	40
Organization on Animal health camp	Bakhari Nazir, E. Champaran 16 March 2019	Dr. S.K. Singh	60
Demonstration of Methodology on Pickle preparation from seasonal vegetable.	Damodarpur, Vishunpura, Pipra, E. Champaran 16 March 2019	Dr. S.K. Singh	45
Visit and training under "Per Drop More Crop" under Pradhan Mantri Sichai Yojana	NRCL, Muzaffarpur 25 March 2019	Dr. Vishal Nath Dr. S.D. Pandey Dr. R.K. Patel Dr. J.P. Verma Dr. Ramashish Kumar	8
Organization field day and Method Demonstration: *Javik Kheti*	Ujheelpur, East Champaran 27 March 2019	Dr. Vinod Kumar Dr. R.K. Patel Dr. S.K. Singh Dr. Prabhat Kumar	62
Training on GAP in Litchi and Farm visit	NRCL, Muzaffarpur 27 March 2019	Dr. Vishal Nath Dr. S.D. Pandey Dr. R.K. Patel Dr. Kuldeep Srivastava Dr. Alok Kr Gupta Dr. J.P. Verma Dr. Ramashish Kumar	6

Commercialization/ licensing of technology

Name of Technology/ Know-How	IP Protection (Yes/No.)	Name of Contracting Party	Mode of Partnership	Date of Licensing
Process for preparation of Litchi Squash and RTS	No	Md. Hasnain Ariz, Anwari Lodge Sadpura Milki Tola, Mithanpura, Muzaffarpur, Bihar	Licensing/ Knowhow	22.12.2018
Process for preparation of Litchi Squash and RTS	No	Md. Shohaib, North Bihar Distributor Franchises of Ayurved products, Sadpura, Mithanpura, Muzaffapur, Bihar	Licensing/ Knowhow	22.12.2018
Process for preparation of Litchi Squash and RTS	No	Mr. Krishna Gopal Singh; M/S Vishvaksenah Agro & Dairy Pvt. Ltd. 2B/1, Plot No. 155, Road No-2, Tirhut Colony, Ahiyapur, Muzaffarpur, Bihar-842001.	Licensing/ Knowhow	22.12.2018

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

Dr. Vishal Nath

- Delivered a lecture on "Current status of litchi in India & Future possibilities" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.
- Delivered lectures on "Rejuvenation of old orchards for regaining productivity and profitability" and "Canopy management in fruit crops for enhancing production and marketable yield" during Winter School on Recent approaches in horticultural development for enhancing farm income in environmentally constraints ecosystem on 27 November- 17 December, 2018 at ICAR-CAZRI, Jodhpur, Rajasthan.
- Delivered lecture on "Enabling technologies for Hi-Tech Horticulture" during Workshop on Hi-Tech Horticulture on 07-08th March, 2019 at CHF, Jhalawar.
- Delivered lecture on "Recent development in fruit vegetable and flower production system" during National Seminar on Recent advances in agriculture for sustainable rural development-2019 on 15-17th March, 2019 at BAU, Sabour, Bihar.

Dr. S.D. Pandey

- Delivered lecture on "Good Agricultural Practices to obtain good fruits in litchin and banana, on 14-15 April, 2018 instate Agriculture fair at Motihari.
- Delivered lecture on Quality fruit development in litchi through GAP on 2 May, 2018 at Kisan Bhawan, Mushahari.
- Delivered lecture on possibilities of litchi cultivation in Eastern UP at Pindi Village Farmers Day on 19 May, 2018.
- Delivered a lecture on "Enhancing Efficiency and Behavioral Skills Through Positive Thinking and Time Management" in Summer Training on *"Litchi-based Integrated Farming System"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

- Delivered Lecture in litchi pathshala on nutrent and canopy management in litchi at Punash and Bhocha village of Muzaffarpur on 14 June, 2018 organized by NRCL and sponcered by ATMA, Muzaffarpur.
- Delivered lecture on nutrient management in litchi on 4 July, 2018 organized by Dayal fertlizers at NRCL, Muzaffarpur.
- Delivered lecture on canopy management in litchi at chintamanpur, East Champaran, Bihar on 12 July, 2018 organized by NRCL under FFP.
- Participated in Kissan mela at Piprakothi East champaran on 25 Sept, 2018 and delivered lecture nutrient and water management of litchi and also participated kisan gosthi.
- Delivered lecture on canopy management and Rejuvenation in litchi on 29 Sept, 2018 at DRPCAU, Pusa.
- Delivered lecture on Good Agricultural Practices in Enterpenureship development programme organized by ICAR-NRCL Muzaffarpur on 22 Dec, 2018.
- Participated in Chaupal Programme on 23 Dec, 2018 At Matalupur village and delivered lecture on how to double the income from litchi cultivation.

Dr. S.K. Purbey

- Delivered presentation of project related to Establishment of Model Pack House at ICAR-NRC on Litchi in front of Principal Secretary, Ag, Govt. of Bihar on 24 September, 2018.
- Invited and participated as resource person in workshop on "District level Project Orientation programme for Group Leaders and Guide Teachers" in 26th National Children's Science Congress 2018 organized by Science for society, Bihar in collaboration with BCST and SCERT, Bihar Catalyzed and supported by NCSTC-DST, Ministry of Science and Technology, GOI, held at Niteshwar College, Muzaffarpur, Bihar on 28 September, 2018.
- Delivered lectures entitled, 'Establishment of litchi-based beverage unit', 'Protocol for preparation of litchi pulp, squash and RTS', 'Some general considerations for litchi based beverage industry', and 'Detailed Project preparation for litchi-based beverage Industry' during "Entrepreneurship Development Training Programme on Litchi-based beverage Unit" organized at ICAR-NRCL, Muzaffarpur from 17-22 December 2018.
- Delivered a lecture on "High Density Planting and Canopy Management in Litchi" in a training programme "High Density Planting System in Horticultural Crops with Special reference to Banana" under Biotech-KISAN, funded by DBT and organized at ICAR-RC for NEH Region, Medziphema, Nagaland on18 February, 2019.
- Conducted hands on training and delivered lecture on "Preparation of Litchi Squash" to the entrepreneurs at ICAR-RC for NEH Region, Medziphema, Nagaland on 19 Feb., 2019.

Dr. Amrendra Kumar

- Delivered lecture on "GAP on Litchi and Insect Pest Management on litchi" organized by J&K State Horticulture Department for Horticultural Officers at Jammu on 30-31 July, 2018.
- Delivered a talk on GI tagging of litchi organized by Bihar Litchi growers association at Muzaffarpur on 1 Dec 2018.
- Delivered a lecture on "Ensuring regular bearing in litchi through girdling" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.
- Delivered a talk on Propagation of litchi quality planting materials and their management recorded on 06.07.18 and telecasted on 25.07.18 by DD Kissan, Patna, Bihar.

Dr. Kuldeep Srivastava

- Delivered lecture on "Organic Pest Management in Horticultural Crops" in National Seminar at NCOH Campus (BAU), Noorsarai, Nalanda, Bihar on 14 April, 2018.
- Delivered lecture on "Insect pests in Litchi and Their management" in in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.
- Delivered guest lecture on "Insect Pest Management in Litchi" at Institute of Agricultural Sciences, BHU, Varanasi, U.P. on 24 August, 2018.
- Delivered lecture on "Adopting Smart Pest Management Practices for Enhancing Farm Income" in ICAR sponsored Summer School on Business Incubation and Value Chain Integration for Doubling Farmers' Income at BAU, Sabour, Bihar on 1 September, 2018.
- Delivered lecture on "Doubling Farm Income Through Identification of Litchi Pests and Their Management " in training programme on Technological innovations in litchi production and PHM for doubling farmers income (10-12 Sept., 2018) at ICAR-NRC on Litchi, Muzaffarpur, Bihar on 11 September, 2018.
- Delivered lecture on "Pest and disease Management in Litchi" during Litchi Pathsala at Meenapur, Muzaffarpur, Bihar on 10 July, 2018.
- Delivered a lecture on "Insect-pests in Litchi and Their Management" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

Dr. R.K. Patel

- Delivered lecture on "Techniques of doubling far income through adoption of IFS" in training programme on Technological innovations in litchi production and PHM for doubling farmers income (10-12 Sept., 2018) at ICAR-NRC on Litchi, Muzaffarpur, Bihar on 12th Sept., 2018.
- Delivered lecture on "GAP in litchi" during Litchi Pathsala at Kanti, Muzaffarpur, Bihar on 27th April 2018.
- Delivered lecture on "Organic management practices in litchi" during internship programme (30 June-14 July 2018) at ICAR-NRC on Litchi, Muzaffarpur, Bihar on 5th July 2018.
- Delivered lecture on "Scope of converting organic litchi production through rejuvenation of orchards" in training programme on rejuvenation and plant canopy management of litchi and mango (29 Sept.-1 Oct., 2018) at KVK, Birauli, DRPCAU, Pusa, Bihar on 1st Oct., 2018.
- Delivered lecture on "Improved productivity of low lying area through land shaping techniques integrated with litchi based production system". *In:* 8th Indian Horticulture Congress-2019 organized by HIS, New Delhi at IGKV, Raipur, CG from 17-21 January, 2019.
- Delivered a lecture on "Litchi-based Integrated Farming System" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

Dr. Vinod Kumar

- Delivered lecture on ''माइकोरईजा का लीची उत्पादन में उपयोग एवं एकीकृत व्याधि प्रबंधन द्वारा लीची की खेती से लाभ बढ़ाना'' in ATMA, Begusarai sponsored programme on "Technological innovation in litchi production and PHM for doubling farm income" (10-12 September 2018).
- Delivered lecture on "Important diseases of litchi and their management" to Visiting Farmers and Horticulture Officer of Tamil Nadu State (16-18 July 2018).

- Delivered lecture on "Microbial Contamination of food and their management" in the Entrepreneurship Development Training Programme on Litchi Based Beverage Unit, held at NRCL, Muzaffarpur (22-27 October 2018).
- Delivered a lecture on "Diseases in litchi and their management" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

Dr. Sanjay Kumar Singh

- Delivered a talk on '*Management of Physiological Disorder of mango, litchi and seasonal Vegetables*' during Field Day-2018 at Kankati (Kothia Hariram), Mehsi, East Champaran under MGMG Programme (12 April, 2018).
- Deliver a talk on '*Recent technologies on GAPs for litchi orchard*' at Gaighat Block, Muzaffarpur during किसान कल्याण कर्मशाला sponsored by ATMA, Muzaffarpur (2 May, 2018).
- Delivered a talk on '*Physiology of Flowering and Fruiting in Litchi and Mango*' during meeting with Farmer and Horticulture Officer of Tamil Nadu State with ICAR-National Research Centre on Litchi, Muzaffarpur 842 002, Bihar (18th July, 2018).
- Delivered a talk on '*Management of alternate bearing and physiological disorder of litchi*' during one day training programme as लीची पाठशाला sponsored by ATMA, Muzaffarpur at Bakhari, Muraul, Muzaffarpur (9 August, 2018).
- ICAR-Delivered a talk on '*Prospects of litchi production in Western UP and GAPs tools for litchi farmers of tarai belt*' during *Krishidham Expo-2019* at ICAR-CPRS (CPRI, Shimla), Meerut, UP (16 February, 2019).
- Delivered a lecture on "Pursuing Higher Studies in Agricultural Sciences" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

Dr. Abhay Kumar

- Delivered a lecture on "Possibilities for application of biotechnology for perennial fruit crops" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

Sh. Prabhat Kumar

- Delivered a lecture on "Estimation of soil moisture in litchi orchard" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.

Dr. Alemwati Pongener

- Delivered a lecture on "Preparation of litchi beverages" in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.
- Delivered a lecture on "Preparation of Litchi Squash" and conducted hands-on training to the entrepreneurs at ICAR-RC for NEH Region, Medziphema, Nagaland on 19 Feb., 2019.
- Delivered a lecture on "Doubling income through value-addition in litchi" during ATMA sponsored training on Technological Innovations in Litchi Production & PHM for Doubling Farm Income" from 10-12th September 2018.
- Delivered a lecture on 'Postharvest management in litchi' during training programme on 'Cultivation practices and postharvest management of litchi' for farmers and horticulture officers of Tiruvannamali, Tamilnadu on 17th July 2018.
- Delivered lectures entitled, 'Establishment of litchi-based beverage unit', 'Principles and methods of food preservation', 'FSSAI registration and licensing', and 'Packaging, labeling, food additives, and storage of products' during "Entrepreneurship Development Training Programme on Litchi-based beverage Unit" organized at ICAR-

NRCL, Muzaffarpur from 17-22 December 2018.

- Delivered a lecture on "Processing and Value addition in Litchi" in a training programme "High Density Planting System in Horticultural Crops with Special reference to Banana" under Biotech-KISAN, funded by DBT and organized at ICAR-RC for NEH Region, Medziphema, Nagaland on18 February, 2019.

Dr. E.S. Marboh

- Delivered lecture and practical demonstration on Estimation of soil moisture in litchi orchard in Summer Training on *"Pre and Postharvest Management of Litchi"*, 17-24 May, 2018, ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar, India.
- Oral presentation on Genetic variability in qualitative traits of litchi in National Conference on *"Intensification and Diversification in Agriculture for Rural Livelihood and Development"*, DRPCAU, Pusa, 28-31 May 2018.
- Presented "Issues and Constraints of Litchi Production in Bihar during National Dialogue on Improving Productivity and Utilization of Litchi" ICAR-NRCL in collaboration with ICAR-AICRP (Fruits), 30 November - 1 December 2018.

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. A.K. Gupta	Dr. Amrendra Kumar Dr. Abhay Kumar Dr. Narayan Lal Dr. Evening Stone Marboh
1.2	Developing improved cultivars in litchi	Dr. Narayan Lal	Dr. Abhay Kumar Dr. A.K. Gupta Dr. Evening Stone Marboh
1.3	Characterization, evaluation and utilization of Longan germplasm	Dr. Evening Stone Marboh	Dr. Abhay Kumar Dr. A.K. Gupta Dr. Narayan Lal
1.4	Molecular finger-printing in litchi cultivars through micro-satellite markers	Dr. Abhay Kumar	Dr. Narayan Lal Dr. A.K. Gupta
2	***Development and refinement of integrated production technologies for improved productivity of litchi***		
2.1.	Development and sustainable production techniques in litchi	Dr. S.D. Pandey	Dr. Amrendra Kumar Dr. R.K. Patel Dr. Kuldeep Srivastava Dr. Evening S Marboh
2.2.	Investigation and establishing the physiological and biochemical relations for improved litchi production	Dr. Amrendra Kumar	Dr. S.D. Pandey Dr. S.K. Purbey Dr. S.K. Singh Dr. R.K. Patel Dr. Abhay Kumar Dr. Evening S Marboh
2.3.	Studies on mycorrhizal association and role of bio-fertilizers for improved litchi production	Dr. Vinod Kumar	Sh. Prabhat Kumar
2.4.	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 Sh. Prabhat Kumar

2.5.	Nutrient deficiency symptoms in litchi	Dr. Amrendra Kumar	Dr. S.D. Pandey Dr. R.K. Patel Dr. I.S. Singh
2.6.	Integrated soil health management for quality litchi production	Sh. Prabhat Kumar	Dr. Amrendra Kumar Dr. Vinod Kumar Dr. S.D. Pandey
2.7.	Development of DRIS norms for nutrient management in litchi	Sh. Prabhat Kumar	-
2.8.	Leaf nutrient dynamics in litchi	Sh. Prabhat Kumar	Dr. Evening S Marboh
2.9.	Screening of different microbial consortia for enhancement of productivity and quality of litchi fruits	Sh. Prabhat Kumar	-
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	Dr. Abhay 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. S.K. 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 Dr. Kuldeep Srivastava Dr. Alok K Gupta Dr. Evening Stone Marboh
5.2.	Strategic research on North-Eastern Hill region	Dr. S.K. Purbey	Dr. R.K. Patel Dr. Vinod Kumar Dr. Alemwati Pongener

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. Evening S Marboh
6.2.	Shoot physiology in relation to flowering and fruiting in litchi	Dr. S.K. Singh	Dr. Amrendra Kumar Dr. R.K. Patel Dr. Abhay Kumar Dr. Evening S Marboh

Externally funded projects

Sl. No.	Title	Funding agency	PI & Co-PI
1.	Improved livelihood through good practices in agricultural production system (Farmers FIRST programme)	ICAR, New Delhi	Dr. Sanjay Kumar Singh (PI) Dr. S.D. Pandey (Co-PI) Dr. S.K. Purbey (Co-PI) Dr. Vinod Kumar (Co-PI) Dr. Kuldeep Srivastava (Co-PI) Dr. Prabhat Kumar (Co-PI) **Scientist Associated** Dr. Amrendra Kumar Dr. R. K. Patel Dr. Abhay Kumar Dr. Narayan Lal Dr. Alemwati Pongener Dr. Alok K Gupta Dr. Evening S Marboh
2.	ICAR Seed Project–Seed Production in Agricultural Crops and Fisheries (RFS)	ICAR, New Delhi	Dr. Amrendra Kumar
3.	Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology scheme	ICAR, New Delhi	Dr. Vishal Nath Dr. Kuldeep Srivastava (Nodal officer)
4.	Developing national repository and facilities for DUS testing in Litchi	ICAR, New Delhi	Dr. Vishal Nath Dr. Alok K Gupta
5.	Development of synergistic hurdles for preservation of litchi pulp and products	BRNS, DAE, Mumbai	Dr. Vishal Nath (PI) Dr. S.K. Purbey (Co-PI) Dr. S. Gautam (PC) **Scientist Associated** Dr. Vinod Kumar Dr. Alemwati Pongener

List of Publications

Research papers

Gupta, A.K., Singh, M., Marboh, E.S., Nath, V. and Verma J.P. (2018). Pollen production, viability and in vitro pollen germination of different litchi (*Litchi chinensis*) genotypes. *Indian Journal of Agricultural Sciences* **88**(6): 884–888.

Kumar, A., Pandey, S.D., Purbey, S.K., Patel, R.K., Pongener, A. and Nath, V. (2018). Response of growth regulators on flower induction, fruit yield and quality of litchi 'Shahi'. *Acta Horticulturae*. **1211**: 29-34. DOI: 10.17660/Acta Hortic. 2018.1211.5.

Kumar, G., Kumar, R., Nath, V., Pandey, S.D., Marboh, E.S. and Kumar, P. (2018). Integrated Soil Management Technique for Young Growing Orchards of Litchi (*Lychee chinensis*). *International Journal of Current Microbiolology and Applied Sciences* **7**(9): 710-722.

Kumar, M., Narayan, D., Yadav, R.S., Kumar, P., Ranjan, R., Pramanik, M., and Kumar, R. (2018). Performance of aonla with *in-situ* moisture conservation techniques. *Indian Journal of Ecology* (2018) **45**(3): 654–658.

Kumari, P., Barman, K., Patel, V.B., Sharma, S. and Kole, B. (2018). Variability of bioactive properties and antioxidant activity in commercially grown litchi cultivars in India. *Indian Journal of Horticulture*. **75**(3): 369-375.

Lal, N., Pandey, S.K., Nath, V., Agrawal, V., Gontia, A.S. and Sharma, H.L. (2018). Total phenol and flavonoids in by-product of Indian litchi: Difference among genotypes. *Journal of Pharmacognosyand Phytochemistry* **7**(3): 2891-2894.

Lal, N., Pandey, S.K., Nath, V., Gontia, A.S. and Sharma, H.L. (2018). Evaluation of litchi (*Litchi chinenesis* Sonn.) genotypes for fruit quality attributes. *International Journal of Chemical Studies* **6**(3): 2556-2560.

Malhotra, S.K., Singh, S.K. and Nath, V. (2018). Physiology of flowering in litchi (*Litchi chinensis*): A review. *Indian Journal of Agricultural Sciences* **88** (9): 1319–1330.

Marboh, E.S., Gupta, A.K., Gyanesh, K., Singh, M., Singh, A. and Nath, V. (2018). Genetic variability, heritability and genetic advance in litchi (*Litchi chinensis*). *Indian Journal of Agricultural Sciences* **88**(10): 1510–1514.

Marboh, E.S., Gupta, A.K., Lal, N., Pandey, S.D. and Nath, V. (2018). An overview of differential response of litchi trees to water stress. *International Journal of Innovative Horticulture* **7**(1): 17–26.

Nath, V., Pandey, S.D., Pongener, A., Srivastava, K. and Marboh, E.S. (2018). Challenges and opportunities for improved productivity of litchi. *Acta Horticulturae* **1211**: 161–164.

Nawade, B., Mishra, G.P., Radhakrishnan, T., Dodia, S.M., Ahmad, S., Kumar, A., Kumar, A. and Kundu, R. (2018). High Oleic Peanut Breeding: Achievements, Perspectives, and Prospects. *Trends in Food Science & Technology* **78**: 107–19.

Pongener, A., Purbey, S.K., Nath, V., and Puja, K. (2018). Salicylic acid maintains membrane stability and reduces pericarp browning in litchi. *Acta Horticulturae* **1211**: 45–52.

Purbey S. K., Dev, R. and Vyas, S. P. (2018). Influence of Seed Age on Germination and Seedling Vigour of Aonla. *International Journal of Current Microbiolology and Applied Sciences* **7**(10): 1888–1891.

Purbey, S.K., Meena, S.L. and Dev, R. (2019). Influence of Soil Working Techniques and Planting methods on growth performance of fruit plants in Kachchh region of Gujarat. *International Journal of Current Microbiolology and Applied Sciences* **8**(1): 1874–1882.

Purbey, S.K., Pongener, A., Kumar, V. and Nath, V. (2018). Effect of time of harvest and packaging on quality and shelf life of litchi fruit. *Acta Horticulturae* **1211**: 65–70. DOI: 10.17660/ActaHortic.2018.1211.9.

Sharma, S., Sharma, A.K., Banerjee, K., Barman, K. and Nath, V. 2018. Evaluation of physico-chemical, nutritional quality and safety of imported raisin samples available in Indian market. *Journal of Pharmacognosy and Phytochemistry* **7**(5): 1246-1251.

Singh, S.K., Srivastava, K., Pandey, S.D., Gupta, A.K. and Nath, V. (2019). Assessment of motivation factor for conservation of mango diversity and IPM practices. *Multilogic in Science* (Special issue) RTTEPSR 2019 NDUAT, Ayodhya, UP: 15-20.

Srivastava, K., Choudhary, J.S., Patel, R.K., Reddy, P.V.R. and Nath, V. (2018). Identification and phylogenetic analysis of fruit borer species of litchi using DNA barcode sequences. *Indian Journal of Horticulture* **75**(3): 415–422.

Verma, V., Jha, A.K., Patel, R.K. and Ngachan, S.V. (2018). Studies on storage life, and effect of temperature and pre-sowing seed treatments on germination behaviour and maturity indices in King-chilli (*Capsicum* spp). *Indian Journal of Agricultural Sciences* **88**(8): 1162–1167.

Verma, V., Jha, A.K., Verma, B.C., Babu, S. and Patel, R.K. (2018). Response of tomato (*Solanum lycopersicum*) to foliar application of micronutrients under low cost protected structure in acidic soil of Meghalaya. *Indian Journal of Agricultural Sciences* **88**(7): 998–1003.

Papers in seminars/symposia/conferences

Gupta, A.K., Marboh, E.S., Singh, M., Kumar, A., Verma, J.P. and Nath, V. (2018).*In vitro* studies on pollen viability and pollen germination in some litchi cultivars.*In:* National Conference on *"Intensification and Diversification in Agriculture for Livelihood and Rural Development"*, 28-31 May, 2018 DRPCAU Pusa (Samastipur) Bihar, pp. 72.

Kumar, A., Radhakrishnan, T., Singh, B.K., Mishra, G.P. and Dobaria, J.R. (2018). Heterologous expression of *BcZAT12* transcription factor greatly enhances drought stress tolerance in transgenic groundnut (*Arachis hypogaea* L.). *In*: India International Science Festival 2018 (5-8 Oct, 2018), Indira Gandhi Pratishthan, Lucknow, India, pp. 40.

Kumar, A., Radhakrishnan, T., Singh, B.K., Mishra, G.P. and Dobaria, J.R. (2018). Stress-inducible expression of *BcZAT12* transcription factor greatly improves drought stress tolerance in transgenic groundnut (*Arachis hypogaea* L.). *In*: 2nd National Conference on Doubling Farmers Income for Sustainable and Harmonious Agriculture DISHA-2018 (11-12 August, 2018), ICAR-Indian Institute of Natural Resins and Gums, Ranchi pp. 62.

Kumar, A., Radhakrishnan, T., Singh, B.K., Mishra, G.P. and Dobaria, J.R. (2018). Stress inducible expression of BcZAT12 transcription factor in transgenic groundnut (*Arachis hypogaea* L.) conferred tolerance to drought and salinity stress. *In*: National Conference on Enhancing Productivity of Oilseeds in Changing Climate Scenario (7-9 April, 2018) at ICAR-Directorate of Groundnut Research, Junagadh, India, pp. 11-12.

Kumar, V. and Anal, A.K.D. (2019). *Alternaria-alternata* - An emergent destructive pathogen of crop plants. *In:* The National Workshop on *"Diseases of makhana: Challenges towards diagnosis and management"* (January 11-12, 2019), Mandan Bharti Agriculture College, Agwanapur, Saharsa (Bihar), India, pp. 8-22.

Kumar, V., Anal, A. K. D. and Purbey, S. K. (2018). Alternaria disease – an emerging problem of litchi (*Litchi chinensis*) in India. *In:* International Conference on *"Role of Soil and Plant Health in Achieving Sustainable Development Goals"* (21-25 Nov., 2018) organized by Indian Phytopathological Society (IPS), New Delhi Asia-Pacific Association of Agricultural Research Institutions (APAARI) Bangkok, Thailand Department of Agriculture, Bangkok, Thailand.

Kumar, V., Anal, A.K.D. and Purbey, S.K. (2018). Alternaria disease- an emergent problem of litchi (*Litchi chinensis*) in India. *In:* International Conference on *"Role of Soil and Plant Health in Achieving Sustainable Developmental Goals"*

(November 21-25, 2018), Bangkok, Thailand, pp. 44.

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Peer Recognition

Dr. Vishal Nath

- Member Editorial board, Current Horticulture.
- Empanelled as Co-Advisor for Ph.D (Horticulture) students by JNKV, Jabalpur to guide on Characterization of Litchi genotypes.
- Act as reviewer of paper fort Indian Journal of Horticulture.

Dr. SK Purbey

- Conferred Fellow of Society for Scientific Development in Agriculture & Technology (SSDAT), Meerut (U.P.) for outstanding contribution in the field of Horticulture.
- Awarded Certificate of Appreciation by Science for Society, Bihar, Bihar Council of Science and technology, SCERT, Bihar during 2018 for acting as resource person and member of jury committee.
- Assoc. Editor of *Hortflora Research Spectrum*, an International Journal, Meerut, UP, India.
- Guest of honour on occasion of inauguration of ATAL Tinkering Lab. at Mother Teresa School, Narauli, Muzaffarpur on 24th July, 2018.
- Nominated as member of the Science project evaluation committee and resource person for Science Projects in District Level 26th National Children's Science Congress - 2018 held at Niteshwar College, Muzaffarpur, Bihar on 28.09.2017.
- Nominated as Jury Member of evaluation committee and resource person for Science projects in 26th State Level Children's Science Congress - 2018 held at Mt Litera Valley School, Begusarai, Bihar during 25-27 Oct., 2018.
- Acted as examiner for poster evaluation in session IV on 23rd afternoon in International Seminar on Global Partnership in Agricultural Education and Research (CAP-2018) on 23rd Dec., 2018.

Dr. Kuldeep Srivastava

- Associate Editor of International Journal of Life-Sciences Scientific Research, Barabanki, U.P., India.
- Reviewed research articles of Journal of Agricultural Science, Toronto, Canada.
- Evaluated and conducted *viva-voce*exam of M Sc (Ag.) Entomology Students BHU, Varanasi (01 No.); DRCAU, Pusa, Samastipur, Bihar (03 No.).
- Evaluated answer scripts of comprehensive examination (M. Sc/ Ph. D.) of SKUAST-Jammu, J&K and DRCAU, Pusa, Samastipur, Bihar.
- Paper setter of UG course (Ento-221) of SKUAST-Jammu, J&K

Dr. R.K. Patel

- Editor of *Hortflora Research Spectrum* journal published byBiosciences and Agriculture Advancement Society, Meerut, U.P.
- Reviewed research article of *Journal of Food Science and Technology* (JFST-D-18-02589).
- Reviewed research article of *Journal of Food Science and Technology* (JFST-D-18-01140).
- Reviewed research article of The Indian Journal of Agricultural Sciences (78480).
- Review research article of Indian Journal of Horticulture (MS No. 85377)
- Participated and act as member in judging committee of Horticulture show organised at DRCAU, Pusa, Samastipur on 4th Dec., 2018.

Dr. Vinod Kumar

- Editor in the Journal "SCREA Journal of Agriculture", Science Research Association (http://www.scirea.org/)
- Associate Editor in "*International Journal of Agriculture Sciences*", Bioinfo Publications, Pune, India.

- Reviewer in National and International journals during 2018-19, reviewed paper for the five journals *viz., Journal of Crop Research and Fertilizers, Crop Protection, Indian Phytopathology International Journal of Agriculture Science, Journal of Environmental Biology.*
- Acted as External Examiner to conduct *viva-voce* examination of one M.Sc. (Ag.) student at DRPCAU, Pusa

Dr. Sanjay Kumar Singh

- Appointed as Reviewer of *The Journal of Horticultural Science and Biotechnology*, Kent, London for the year 2018-19.
- Appointed as External Examiner for Thesis *viva-voce*of M.Sc. (Horticulture), PG College Ghazipur by Registrar, VBS Purbanchal University, Jaunpur, UP.
- Appointed as Question Setter for Session 2017-18 (Semester IV) for B Tech. (Hort.): FSC 202: Commercial Subtropical and Temperate Fruit Production (2 +1) by Controller of Examinations, TNAU, Coimbatore - 641 003, Tamil Nadu
- ICAR-NASF Concept Note No. 8-6220 entitled '*Improving rural livelihood security of tribal and resource constrained farmers of North Bihar through low cost technology of Animal Husbandry and Horticulture*' has been accepted by ICAR-National Agricultural Science Fund, New Delhi for detailed presentation during 2019-20
- Appointed as Examiner of Thesis of Ph.D. (Horticulture) for Session 2018-19 by Dean, PG Studies, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad – 211007, Uttar Pradesh

Dr. Abhay Kumar

- Appointed as External Examiner for Thesis *viva-voce* of M.Sc. (Genetics & Plant Breeding), College of Agriculture, Bihar Agricultural University, Sabour, Bhagalpur, Bihar.
- Reviewer for Journal of Plant Biochemistry and Biotechnology - Springer
- Reviewer for Proceedings of the National Academy of Sciences, Biological Sciences (NASB) –Springer

Dr. Evening S Marboh

- Appointed as external Examiner for setting of Question Papers (theory) for the Course 1st Semester of Academic Session 2018-19 for B.Sc (Hons) Horticulture, CAU, Imphal.

Awards and Honours

Awards and honours conferred to the centre

- ICAR-NRCL obtained 1st prize stall exhibit during farmers' fair held at BAU, Sabour, Bihar, 23-25 February 2019.
- ICAR-NRCL bagged 1st prize in stall exhibition during *Purvanchal Kishan Mela* held at KVK, Gorakhpur during 02-03 March 2019.

Dr. Vishal Nath

- Lifetime Achievement Award for outstanding contribution in field of horticulture by Society for Science and Nature.
- SDSH Fellowship for outstanding contribution in the field of horticulture by Society for development of subtropical horticulture, Lucknow.

Dr. Kuldeep Srivastava

- Received Distinguished Scientist Award from Science & Tech. Society for Integrated Rural Improvement, Telangana in 2018.

Dr. Abhay Kumar

- Received Young Scientist Award for outstanding contribution in the field of Plant Biotechnology during International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2018), 28-30 October, 2018 at Rajasthan Agricultural Research Institute, Jaipur, Rajasthan, India.

Dr. Narayan Lal

- Best Poster Presentation Award for poster presented on Diversity in total phenol and flavonoids among litchi genotypes during International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2018) during 28-30 October, 2018 at Rajasthan Agricultural Research Institute, Jaipur, Rajasthan.

Compilation, Editing, and Documentation

Sl. No.	Title	Year of publication	Scientists involved
1.	NRCL Annual Report, 2017-18 (English)	2018	Dr. R.K. Patel Dr. Kuldeep Srivastava Dr. Sanjay Kr. Singh Dr. Abhay Kumar Dr. Alemwati Pongener
2.	ICAR-NRCL Annual Report, 2017-18 (Hindi)	2018	Dr. R.K. Patel Dr. Kuldeep Srivastava Dr. Sanjay Kr. Singh Dr. Abhay Kumar Dr. Alemwati Pongener
3.	NRCL Newsletter Volume 4 Issue 1 & 2	2018	Dr. Abhay Kumar Dr. R.K. Patel Dr. Kuldeep Srivastava Dr. Sanjay Kr. Singh Dr. Alemwati Pongener
4.	News and updates for NRCL Website and *ICAR NEWS*	2018-19	Dr. Vinod Kumar
5.	Technology and Publication Repository (Database), KRISHI (Knowledge Based Resources Information Systems Hub for Innovations in Agriculture)	2018-19	Dr. Vinod Kumar
6.	HYPM, Quarterly Report, Monthly Cabinet Report	2018-19	Dr. Sanjay Kumar Singh
7.	ICAR-AICRP (Fruits) on Litchi Annual Report 2017-18; AICRP (F) QRT reports	2018-19	Dr. Evening Stone Marboh
8.	17th IRC Proceedings, and Action Taken Report	2018-19	Dr. Alemwati Pongener
9.	Compilation of Rajbhasa Hindi Patrika (Litchima)Vol 4 Issue 1	2018-19	Dr. S.D. Pandey Dr. Amarendra Kumar Dr. R.K. Patel Dr. Vinod Kumar Dr. J.P. Verma

Personnel

A. Scientific

Name and Email	Designation	Area of Interest
Dr. Vishal Nath nrclitchi@yahoo.co.in	Director	Plant genetic resource management; Canopy architecture management; Dissemination of technology
Dr. S.D. Pandey pandeynrcb@yahoo.com	Pr. Scientist (Hort.)	High density planting; Canopy management; Nutrient management; Fertigation, Organic litchi production.
Dr. Sushil Kumar Purbey skpurbey_nrcl@yahoo.com	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 amrendra_nrcl@yahoo.com	Pr. Scientist (Hort.)	Nursery management; Plant propagation and growth physiology of vegetatively propagated plants; Collection and characterization of rambutangermplasm
Dr. KuldeepSrivastava kuldeep.ipm@gmail.com	Pr. Scientist (Entomology)	Management of insect pests of litchi; Insect pollinators of litchi.
Dr. R.K. Patel rkpatelicar@gmail.com	Pr. 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	Sr. Scientist (Plant Pathology)	Management of pre- and postharvest diseases of litchi; Mycorrhizal association; Biocontrol and bio-fertilizers for sustainable production of litchi
Dr. Sanjay Kumar Singh sanjayhor@rediffmail.com	Sr. Scientist (Hort.)	Shoot physiology and biochemistry in relation to flowering and fruiting in litchi; Germplasm conservation and development of database on mango and pummelo
Dr. Abhay Kumar abhay.kumar1@icar.gov.in	Scientist SS (Biotechnology)	Molecular markers; diversity analysis and genetic transformation
Sh. Prabhat Kumar prabhat.ssac@gmail.com	Scientist (Soil Science)	Soil Science; climate change and climate resilient agriculture
Sh. Narayan Lal narayanlal.lal7@gmail.com	Scientist (Hort.)	Collection and evaluation of litchi germplasm; Clonal selection; Development of hybrids

Dr. Alemwati Pongener alemwati.pongener@icar.gov.in alemwati@gmail.com	Scientist (Hort.)	Postharvest management for loss reduction; 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. Evening Stone Marboh esmarboh@gmail.com	Scientist (Hort.)	Water management and plant physiology; Evaluation of longangermplasm

B. Administrative

Sh. AbhishekYadav Administrative Officer (Up to 4th Dec., 2018)	Sh. Ramji Giri Assistant Administrative Officer	Sh. Subhankar Dey Assistant Finance & Account Officer (On Deputation w.e.f 24th May, 2018)
Sh. Dileep Kumar Assistant	Sh. Akshay Kumar Yadav Assistant	Sh. Ranjit Kumar Assistant (up to 4th July, 2018)
Sh. Avinash Kumar Kashyap Sr. Clerk (UDC)	Sh. Pawan Kumar Jr. Clerk (LDC)	Sh. Sawan Kumar Jr. Clerk (LDC)
Ms. Ekta Jr. Clerk (LDC)	Sh. Ritesh Kumar Jr. Clerk (LDC)	Sh. Dharmendra Kumar Skilled Supporting Staff

C. Technical

Dr. Ramashish Kumar T-3 (Field/Farm)	Dr. J.P. Verma T-3 (TOT)
Ms. Upagya Sah T-3 (PME)	Sh. Ajay Kumar Rajak T-1
Sh. Surendra Rai T-1	Sh. Somesh Kumar T-1
Sh. Lokesh Kumar T-1	

Recruitment, Promotion and Transfer

New entry

1. Ms. Upagya Sah, joined as Technical Assistant (T-3) w.e.f. 29th October, 2018 on direct recruitment through ASRB/Council, New Delhi.
2. Mr. Somesh Kumar, joined as Technician (T-1 Trainee) w.e.f. 11th January, 2019 on direct recruitment through ASRB/Council, New Delhi.
3. Mr. Lokesh Kumar, joined as Technician (T-1 Trainee) w.e.f. 16th January, 2019 on direct recruitment through ASRB/Council, New Delhi.

Promotion

1. Mr. Ajay Kumar Rajak, SSS got promoted to Technician (T-1) with effect from 09th April, 2018
2. Mr. Surendra Rai, SSS got promoted to Technician (T-1) with effect from 27th June, 2018

Transfer, Deputation & Resignation

1. Dr. Swati Sharma, Scientist (Fruit Science) was relieved from the centre on 30th June, 2018 to join ICAR-IIVR, Varanasi on transfer posting.
2. Mr. Abhishek Yadav, Administrative Officer, was relieved from the centre on 4th December, 2018 to join as SAO, ICAR-IGFRI, Jhansi on promotion and transfer.
3. Mr. Subhankar Dey, AF&AO was relieved from the centre on 24th May, 2018 to join as FAO, AIIMS, Patna on deputation.
4. Mr. Ranjeet Kumar, Assistant resigned from ICAR service on 5th July, 2018.

Important Committees

Institute Research Council

During the year, 17th Institute Research Council (IRC) meetings were held on 25-26 September, 2018. The IRC meetings were held 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.

17th IRC meeting in progress

Institute Management Committee

The 13th Institute Management Committee (IMC) meeting was held on 1st December 2018 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, ICAR-NRCL, Muzaffarpur-842002 (Bihar)	Chairman
2.	Dr. W.S. Dhillon, Assistant Director General (Hort.-I) Indian Council of Agricultural Research, KAB-II, Pusa, New Delhi	Member
3.	Dr. Manish Mishra, Principal Scientist, ICAR-CISH, Rehmankhera, Po: Kakori, Lucknow- 226002 (UP)	Member
4.	Mr. Pawan Kumar, Deputy Director (Hort.), Govt. of Bihar, Patna (Bihar)	Member
5.	Dr. Baljit Singh, DHO, Representative of Director Horticulture Govt. of Uttar Pradesh, H&FP Department UP Udhyan Bhawan, Lucknow-226101	Member
6.	Dr. S.D. Pandey, Pr. Scientist, Chairman, PME, ICAR-NRCL, Muzaffarpur-842002 (Bihar)	Special Invitee

7.	Dr. Amrendra Kumar, Pr. Scientist, Chairman FMAC & RFS, ICAR-NRCL, Muzaffarpur-842002 (Bihar)	Special Invitee
8.	Dr. R.K. Patel, Pr. Scientist, ICAR-NRCL, Muzaffarpur-842002 (Bihar)	Special Invitee
9.	Dr. Kuldeep Srivastava, Pr. Scientist, Incharge TOT ICAR-NRCL, Muzaffarpur-842002 (Bihar)	Special Invitee
10.	Dr. Alemwati Pongener, Scientist & MS-PME, ICAR-NRCL, Muzaffarpur-842002	Special Invitee
11.	Mr. Ramji Giri, AAO, In-charge Estate, ICAR-NRCL, Muzaffarpur-842002 (Bihar)	Special Invitee
12.	Mr. Abhishek Yadav, Administrative Officer, ICAR-NRCL, Muzaffarpur-842002	Member Secretary

13th IMC meeting in progress

Other institutional committees

The composition of other important institutional committees during 2018-19 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. Kuldeep Srivastava	Member
		Dr. Vinod Kumar	Member
		Dr. Sanjay Kumar Singh	Member
		Dr. Evening Stone Marboh	Member
		Dr. Alemwati Pongener	Member Secretary

2.	Price Fixation Committee (PFC)	Dr. Vinod Kumar	Chairman
		Dr. Alok K Gupta	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member
		Dr. Ramashish Kumar	Member Secretary
3.	Works and Estate committee	Dr. Kuldeep Srivastava	Chairman
		Sh. Prabhat Kumar	Member
		Dr. Evening Stone Marboh	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member Secretary
4.	Farm Management and Advisory Committee (FMAC)	Dr. Amrendra Kumar	Chairman
		Dr. R.K. Patel	Member
		Dr. Kuldeep Srivastava	Member
		Dr. Vinod Kumar	Member
		Dr. Alok K Gupta	Member
		Dr. Evening Stone Marboh	Member
		Dr. Ramashish Kumar	Member Secretary
5.	Purchase and Store advisory committee (P&SAC)	Dr. R.K. Patel	Chairman
		Dr. Vinod Kumar	Member
		Dr. Abhay Kumar	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member Secretary
6.	Local Purchase Committee (LPC)	Dr. Kuldeep Srivastava	Chairman
		Dr. Evening Stone Marboh	Member
		Dr. Alemwati Pongener	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member Secretary
7.	HRD, ITMU & TOT	Dr. Kuldeep Srivastava	Chairman
		Dr. R.K. Patel	Member
		Dr. S.K. Singh	Member
		Dr. Abhay Kumar	Member
		Sh. Prabhat Kumar	Member
8.	Central Instrumentation Facility	Dr. Swati Sharma	Incharge
		Dr. Alemwati Pongener	Alternate Incharge
9.	Library Advisory Committee	Dr. Vishal Nath	Chairman
		Dr. S.D. Pandey	Member
		Dr. Kuldeep Srivastava	Member
		Dr. Alok K Gupta	Member
		Dr. Evening Stone Marboh	Member
		Sh. Abhishek Yadav	Member
		Sh. Subhankar Dey	Member
		Dr. Alemwati Pongener	Member Secretary & Incharge

10.	Security Cell	Sh. Abhishek Yadav	Incharge
11.	Estate and Vehicle Cell	Sh. Ramji Giri	Incharge
12.	Internal Complaints Committee	Dr. Swati Sharma	Incharge
		Smt. Sudha Devi, Representative of NGO	Member
		Dr. Abhay Kumar	Member
		Miss Ekta	Member
		Sh. Ramji Giri	Member Secretary
13.	ISO Management Committee	Dr. Amarendra Kumar	Chairman
		Dr. Abhay Kumar	Member
		Dr. Alok K Gupta	Member
		Sh. Shubhankar Dey	Member
		Sh. Abhishek Yadav	Member Secretary
14.	Guest House, Sports, and Extra-curricular Activity Committee	Dr. S.D. Pandey	Chairman
		Dr. Alemwati Pongener	Member
		Dr. Swati Sharma	Member
		Sh. Ramji Giri	Member Secretary
15.	Climate change related matter, weather advisory, farm digitization, Farmers First cell	Sh. Prabhat Kumar	Incharge
16.	RFD, AKMU, Krishi and Official Language Unit	Dr. Vinod Kumar	Incharge
		Dr. Sanjay Kumar Singh	Member
		Sh. Prabhat Kumar	Member
		Sh. Abhishek Yadav	Member Secretary
17.	Swachh Bharat Abhiyan	Sh. Prabhat Kumar	Incharge
18.	Publication Committee	Dr. R.K. Patel	Chairman
		Dr. Kuldeep Srivastava	Member
		Dr. Sanjay Kumar Singh	Member
		Dr. Abhay Kumar	Member
		Dr. Alemwati Pongener	Member
19.	Post Harvest Facility	Dr. R.K. Patel	In-charge
		Dr. Alemwati Pongener	Member
		Dr. Swati Sharma	Member
20.	Technical Evaluation Committee	Dr. Sanjay Kumar Singh	Chairman
		Dr. Abhay Kumar	Member
		Dr. Alemwati Pongener	Member
		Dr. Evening Stone Marboh	Member

Infrastructural Development

The centre continued its effort in infrastructural development during the year. Construction of nine residential quarters, including five Type-V and four Type-IV quarters, completed, and were eventually allotted to the scientists and staff. With this addition, the number of staff/families residing within the campus has gone up to 19, thereby, improving the social fabric and vibrancy of campus life.

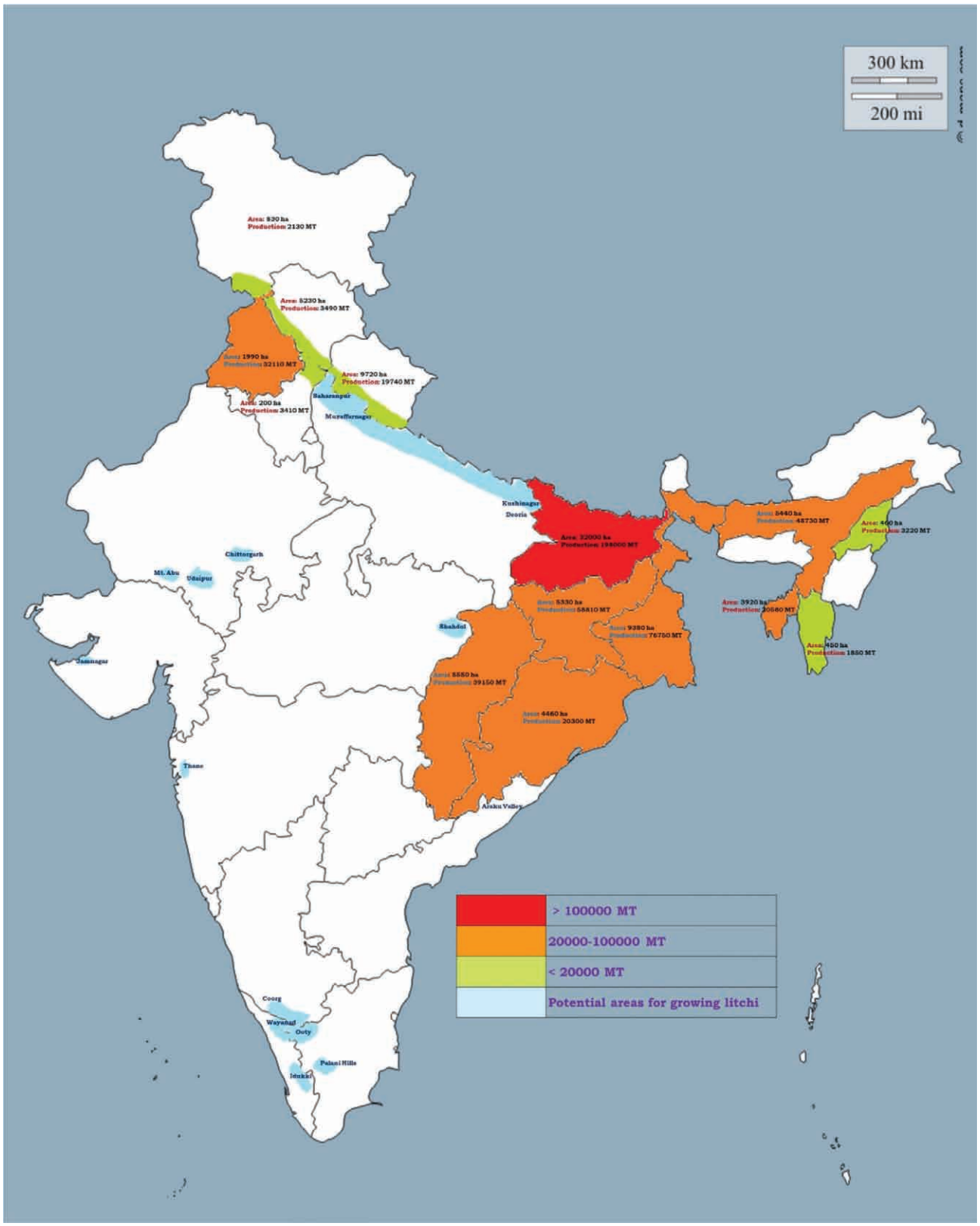
An aerial view of NRCL Residential campus

Another notable development was the installation of Rooftop Solar Power panels for generation of electricity. Aimed with the purpose of contributing to the generation of clean and green energy, rooftop solar panels were installed under RESCO model with a generation capacity of about 100 kwh. The facility was inaugurated by the Hon`ble DDG (Horticulture Science) Dr. A.K. Singh on 1st December 2018.

Left: Hon`ble DDG (HS) Dr. A.K. Singh inaugurating the Solar Rooftop facility on 1st December 2018; Right: Aerial view of the rooftop solar power facility at ICAR-NRCL

The National Horticulture Board (NHB) approved and sanctioned a proposal of ICAR-NRCL for establishment of cold rooms for technology development to enhance the shelf life of litchi and other horticultural produce grown in the state of Bihar. Consequently, a facility has been created with two cold rooms having a total capacity of about 10 MT.

Litchi Scenario



भा.कृ.अनु.प.–राष्ट्रीय लीची अनुसंधान केन्द्र

ICAR-National Research Centre on Litchi

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