वार्षिक प्रतिवेदन
ANNUAL REPORT
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भाकृअनुप–राष्ट्रीय लीची अनुसंधान केन्द्र
ICAR-National Research Centre on Litchi
मुशहरी प्रक्षेत्र, मुशहरी, मुजफ्फरपुर–842 002 (बिहार), भारत
Mushahari Farm, Mushahari, Muzaffarpur–842 002 (Bihar), India

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Preface

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

ICAR-NRCL is located in the major litchi-production zone of the country. The state of Bihar has pride in contributing 40% of total litchi production in the country from about 38% acreage. The centre is putting its best efforts in solving the problems, extending technical support, and assisting at policy and planning level. Consequently, tremendous change has resulted as evident in the trend of litchi production in recent years. Currently, India produces about 5,85,300 MT from an area of about 84,200 ha. ICAR-NRCL is focusing its research activities in four theme areas viz. genetic resource management and crop improvement, sustainable crop production, crop protection and post-harvest handling and value addition. Apart from planned research activities the, centre has also taken up few externally funded projects from Bioversity International, DBT, NAIP and ICAR network projects and has delivered quality results with highest degree of satisfaction.

The pressure on limited land resources notwithstanding, the centre has been able to locate and exploit seasonality barrier in non-traditional areas where there is tremendous potential to produce winter season litchi. The centre is striving to widen the gene pool through introductions of litchi germplasm, and of related sapindaceous fruits *viz.* longan and rambutan. Besides, efforts are on to develop ideal cultivars through our hybridization programme involving different cross combinations. The centre is continually working towards refinement of sustainable production technologies through canopy management, high-density planting, nutrient status, mycorrhizal association, shoot physiology with relation to flowering, and hormonal regulation of plant growth and yield. Our scientists are also involved to protect plants and produce from different insect pests and diseases. The centre is also involved in development of postharvest management and processing protocols for litchi.

ICAR-NRCL has actively participated in programme of Rajbhasha, ICAR-sports, KisanMela/KisanGosthis, exhibition and training to farmer all over the country. During the period, the centre has organised various litchi related programme and trainings in the litchi growing states of the country and extended its technical expertise to various stakeholders. This all has become possible with the whole-hearted support and co-operation by all the staff of the centre. The strengthening of scientific personnel in the past year has boosted our R & D efforts.

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

Finally, it is with pleasure and privilege that I present to you the Annual Report of ICAR-NRC on Litchi, Muzaffarpur for the year 2014-15. It highlights our efforts and achievements, and provides a framework to march ahead to greater heights. I shall look forward to any suggestions or comment on the information contained in this report, which would greatly help us in formulating future strategies.

Vishal Nath
Director

Muzaffarpur
25th June, 2015

Contents

Executive Summary

ICAR-National Research Centre on Litchi (NRCL), established in the year 2001 has continued its momentum in conducting basic and applied research under multi-disciplinary programme covering different aspects of litchi *viz.,* genetic resource management and crop improvement, crop production, crop protection and postharvest management. Besides, the centre also conducts training, outreach programmes, and transfer of technology to improve knowledge and develop skills of different stakeholders. The salient achievements of the centre during 2014-15 are presented in brief.

Research Accomplishments

Genetic Resource Management and Crop Improvement

- With the aim to increasing the varietal pool, the centre has introduced twelve litchi germplasm namely, Piyazi, Pickling, Early Bedana, Pant Selection, Ajhauli, Indira Sel-2, Hongkong, Dam Dam, Ambika Litchi-1, Bombay Sel, Pantnagar-1, and Rose Scented from Sabour, Bihar and Ambikapur, Chhattisgarh. These have successfully established under the net house. The earlier collections made from Pantnagar and Chhattisgarh have been planted in the field gene bank.
- Eight litchi germplasm have been characterized on the basis of morphological traits. The panicle length ranged from 21.5 cm in Shahi to 28.32 cm in Trikolia, whereas fruit set percentage varied from 30.48% in Shahi to 76.17% in Elaichi.
- Out of eleven longan germplasm evaluated, the accession Lgc-6 recorded maximum fruit yield (8.70 kg/tree) and TSS (20.6 °Brix), while accession Lgc-7 recorded maximum fruit weight (7.80 g/fruit).
- Poor survival of rambutan germplasm (N-18 red type and E-35 yellow type) has been recorded after seventeen months of planting under protected condition.
- Forty three new clones of litchi have been planted in the field gene bank to enrich the gene pool.
- Under crossing programme, only thirteen hybrid fruits (China x Shahi-5 nos. and China x Bedana-8 nos.) were harvested out of several crosses made during 2014.
- More than 18000 crosses were made during 2015 in all possible combination with five parent cultivars *viz.*, China, Shahi, Bedana, Rose Scented, and Swarnaroopa. The highest fruit set (87.63%) was observed in China x Bedana whereas, lowest in Swarnaroopa x Shahi (2.50%) after one week after pollination.
- Wide variation for plant morphological characters were noticed in seedling population (527 nos.) evaluated at 8th years of planting. Out of these, 134 seedlings (25.42%) recorded panicle emergence, flowering, fruit set and fruit development, and 62 seedlings finally bore fruits up to maturity.
- Evaluation of segregating population of litchi revealed that maximum plant survival (87.5%) was found in hybrid population and seedlings of selected clones.

Crop Production

- Wedge grafting performed during September showed maximum percentage of graft success (48%) with better graft union.
- Air-layers dipped in *Rhizobacteria* (2%) gave significantly higher plant weight (77.10g FW and 33.10g DW), root weight (28.24g FW and 14.66g DW) and root:shoot ratio on fresh and

dry weight basis (0.58 and 0.84, respectively). After 10 months of treatment, the highest available nitrogen content was found under *Rhizobacteria* (2%) (139.51kg/ha) followed by *Trichoderma* (1%) (137.28 kg/ha) in potting media of treated layers.

- Pruning at 2.0 m height plus 4 branches per trunk started bearing and gave maximum fruit yield (53.14 kg/tree) in 3rd year after reiterative pruning.
- Under high density trial, the highest yield (18.75 kg/plant) was obtained under 6x6 m density followed by 8x4 m (16.45kg/plant) and 8x 6 m (16.25 kg/plant) densities. TSS content in fruit was more in wider densities in comparison to closer densities.
- Deficiency symptoms in N-deficient litchi plants were expressed in older leaves of the plants, which turned yellowish in colour, while newly emerged leaves became light green in colour. Plant growth was stunted with shorter internodal length and reduced leaf size. The Zn-deficient plants showed inter-veinal chlorosis in leaves. The Cu-deficient plants expressed symptoms of narrowing of younger leaves, which became hard.
- Vegetative flush appeared in July-August transformed to maximum extent into panicle bearing shoots (74.0-88.0%). The late appearance of flushes gave rise to mixed type of inflorescences, contributing lesser towards flowering and/or sometimes remained vegetative only with reduced flowering and fruit yield.
- Spray of ethrel, NAA, MH and GA_3 did not express any residual effect on flower regulation and physico-chemical parameters of fruit even after one year.
- Application of 1.0 g PBZ (Paclobutrazol) and 2.0 % KNO_3 advanced flowering by one week with maximum opened flowers during April whereas, application of 2.0 and 4.0 g PBZ advanced colour turning by 5 days.
- TSS (17.74 ^{0}B) and average fruit weight (21.97 g) was improved due to application of 4.0 g PBZ. Application of 3.0 and 4.0 g PBZ encouraged cauliflorous growth in the trees and reduced leaf area.
- No vegetative growth was seen in girdled branches of China after September. All the girdled branches exhibited flowering but no flowering in ungirdled branches of the tree.
- All the bio-fertilizers had significant positive effect on growth parameters of litchi plants. AMF alone as well as in combination with other bio-fertilizers resulted in higher increase in all the growth parameters. Higher number of fibrous (feeder) roots, increment in canopy spread, leaf area, and chlorophyll 'a' was observed with AMF+AZ. The mycorrhiza inoculated plants also showed good colonization (up to 93.0%) in roots of litchi plants.
- Five ponds have been constructed and planting of litchi cvs. Shahi (30 nos.) and China (24 nos.) along with banana cv. Grand Naine (40 nos.) and papaya cv. Pune Selection-3 (42 nos.) have been done on pond bunds under litchi-based cropping system.
- The yield of maize, faba bean, knol khol, cabbage and pea crops grown as intercrops was relatively better than other crops.
- Litchi cvs. Shahi and China have been planted in raised and mound system under low-lying conditions.
- Non-floral shoots of 'Shahi' and 'China' litchi contained lesser amount of reducing sugar, total sugar, Chl *'a'*, Chl *'b'* and Total Chl than floral shoots.
- Chemical and nutrient status study of ICAR-NRCL farm revealed that soil pH ranged from

7.90-9.40, EC 0.08-0.48 dsm^{-1}, organic carbon 0.09-0.85%, N 40.21-188.24 kg/ha, P_2O_5 18.28-82.26 kg/ha and, K_2O 66.0-308.0 kg/ha. In general, organic carbon content in the farm soil is low to medium; nitrogen and phosphorus content is medium, and potassium content is low.

Crop protection

- *Alternaria alternata* was found to be a major pathogen causing disease in litchi at multiple phenophases (nursery, reproductive and postharvest stage). The incidence of panicle blight caused by *Alternaria alternata* ranged between 43.1-77.1% during 3rd week of April 2014 and fruit blight (2.9-12.9%) was observed in first week of June 2014 in cv. 'China'.
- *Trichoderma viride* isolate NRCL T 01 was found superior for tolerance to different temperature, pH and salt concentration against a reference strain NRCG T09. NRCL *Trichoderma* formulation was successfully stored at 4 °C up to 6 months without deterioration in the microbial count.
- Anatomical studies were conducted to ascertain the cause of mortality in air-layered plants in the nursery.
- Among the litchi pest, litchi fruit and seed borer, litchi shoot borer, leaf folder, litchi looper, ash weevil, red weevil, litchi mite and bark eating caterpillar have been observed as major pests while, bag worm, *Spodoptera litura, Spilosoma* sp., many lepidopteran defoliators and litchi bug as minor pests.
- Maximum and minimum pest population was observed in the month of September-October and December-January, respectively.
- Among natural enemies, *praying mantis*, *Chrysoperla carnea*, *Eocanthecona furcellata*, syrphid flies, coccinellids, *Trichogramma* sp. and braconids have been observed during study period.
- Besides *Apis* sp, some non *apis viz.*, hover fly, blue bot fly (*Calliphora* sp.), syrphid flies (*Metasysrphus* sp., *Eristalis tenax*) have been recorded as pollinators of litchi. Variety of coccinellids, damsel fly, and dragon fly had also recorded as visitors on litchi flowers.
- Pruning of twigs in last week of June and manuring the litchi trees with 4 kg of castor and 1kg of neem cake in first week of July followed by spraying of Novaluron 10 EC (0.015%) have been found effective against litchi looper and leaf folder.
- Spray of neem oil (3ml/l) before flower opening, second and third spray of Diflubenzuron 25 WP (0.03%) at clove stage of fruit and 21 days after second spray curbed the fruit and seed borer infestation effectively.

Postharvest management and value addition

- Irrespective of climatic variation during January and February, anthesis takes place in 2nd week of March, fruit set from mid-March and pulp development 40-44 days after flowering (DAF) in cv. Shahi.
- The proper maturity with >18 °Brix and 0.5% acidity were recorded at 75-78 DAF. Fruit weight increased exponentially from 35 DAF to approximately 70 DAF.
- Quantification of losses at different stages of fruits handling showed that loss at wholesale market of Mumbai was 42-46% on the 5thday after arrival of litchi from Muzaffarpur, whereas the loss at retail was about 56-65%.
- Postharvest dip treatments on fruit rots of litchi revealed that all the treatments *Bacillus subtilis* @ 1×10^8 cell/ml, Potassium silicate @ 0.5%, Chitosan @ 1%, Carbendazim @ 0.2%) were effective in controlling fruit rots up to 6th day as compared to 3 days in control.
- During evaluation for preventive ability of antagonists against fruit rots of litchi, the most

effective isolates against *A. alternata* were *B. subtilis* isolates BS-1 and BS-3, and *T. viride* NRCL T01; against *C. gloeosporioides* isolate BS-3, BS-4 and NRCL T01; against *A. flavus* isolate BS-1 and NRCL T01, and against *A. niger* BS-1 and yeast isolate Y2.

- *B. subtilis* isolate, NRCL BS-1 was found most effective as zero fruit rot incidence, and PDI was recorded as compared to control (100%) up to six days after dipping of litchi fruit.
- Pre-harvest spray of GA_3 (100 ppm) + Potassium sulphate (1%) significantly reduced fruit cracking (14%) and increased fruit weight by 15% in cv. Shahi. Fruits dipped in Chitosan (1%) + *B. subtilis* @1×10^8 cfu or Carbendazim (0.1%) was found effective in maintaining the quality and shelf life of the fruits up to five days under ambient condition and 18 days at refrigerated condition.
- Bagging of litchi bunches 40 days after anthesis with white butter paper bags gave the best result, followed by white non-woven PP bags. Bagged fruits recorded (30-35%) less damaged fruits (sunburned and cracked) and larger fruits (6-16%) over control.
- Litchi pulp pasteurized and treated with 1500 ppm KMS is acceptable in quality and colour up to 10 months when kept at low temperature (6±1 °C).
- Litchi flesh pre-treated with 50 °Brix osmotic sucrose solution in the pulp solution ratio of 1:2 gave highest overall acceptability (7.96) with minimum hardiness (2749.52 g) and drying time (15 hr) after 9 months of storage.

Improving knowledge and skill of stakeholders

- During the year more than 2000 stakeholders were benefitted through various training and extension activities.
- Under TSP, forty three acre area has been taken under plantation for mango and litchi at Bandel village of Rayagada district of Odisha.
- Canopy management (2 ha) and rejuvenation of old senile litchi trees (5 ha) have been successfully attempted in Nagaland and Assam under North-eastern region programme.
- Twenty eight thousand litchi plants cv. Shahi and China were multiplied and made available for commercial sale.

Externally Funded Projects

Duly filled performa for registration of farmers' varieties of mango (16 nos.) and pummelo (10 nos.) with PPV&FRA, New Delhi has been submitted.

Molecular characterization of 13 germplasm of pummelo and 16 of mango has been completed. Four community nurseries were established at the community level, which have become source of planting material of unique varieties of mango and pummelo.

Fifteen mango growing districts of Bihar were surveyed to collect information on mango diversity under DBT mango project.

First presence of litchi fruit borer was noticed in 7th standard week (4 adults/trap) and maximum number of adults (55 adults/trap) were observed in 14th standard week.

Linkages and Collaborations

The centre is working on different aspects in close collaboration with other organizations such as Agricultural Universities (RAU and BAU), NHB, APEDA, State Agriculture/Horticulture Departments, and other ICAR Institutes. The centre has also been recognized as one of the study centres of IGNOU, New Delhi for postgraduate diploma in plantation management and certificate course in organic farming.

Transfer of Technology

Initiative 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. During the year, the centre had organized All India Litchi Show and Kisan Gosthi, Field Day, and 19 formal trainings to farmers and extension functionaries of state agriculture department to upgrade their skills. The centre also participated in various Farmers' Fair to showcase and disseminate litchi technologies among stakeholders.

Other Activities

'Agricultural Education Day' was organized by the centre for school students on 5th September, 2014. The '*Hindi Chetna Maas 2014*' from 1st to 30th September 2014 was organized at NRCL in which various competitions were held. The centre got third place in implementation of official language in day to day work and scientific writing. Besides these, Swachh Bharat Abhiyan was also observed at the Centre on 2nd October, 2014 to keep office premises clean and hygienic.

Infrastructural Development

The Centre is trying to develop its own laboratory facilities for the molecular characterization and other biotechnological studies. Laboratory facilities for physiological and biochemical analysis, nutrient and elemental studies of plant and soil have been established including facilities for plant protection and postharvest research. The centre has been connected to the national knowledge network (NKN) through Railtel. Residential quarters (Type-II, III, V and VI) has also been completed and allotted to staff.

INTRODUCTION

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

Genesis and Growth

The ICAR-National Research Centre on Litchi (ICAR-NRCL) was established on 6th June, 2001 under the aegis of the Indian Council of Agricultural Research. The Centre started functioning from 2002 with necessary budgetary allocation and the first batch of two scientists joinined the Centre in March, 2002. The lease deed was signed on 25th June, 2002 between the ICAR and Government of Bihar to transfer 100 acres of land to the Centre at Mushahari, Muzaffarpur. The Centre was strengthened during 2005 and onwards for developing infrastructural facilities and to carry out research. 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

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

The centre has mandate to act as a repository of litchi plant genetic resource and to provide single window solution for crop production and postharvest management to the growers, industries and exporters in mission mode.

Functions

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

Infrastructural Facilities

The research farm of the centre has a good number of modern propagation structures, screen houses, glasshouses, irrigation networking and water sources. Many equipments such as 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, litchi peeling machine, cool storage chamber, bottle washing machine, litchi harvester cum pruner, power sprayer and mist chamber have been established for different research and supportive activities.

Library

It has more than 15,000 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, 11 Indian and 11 international journals are being subscribed. The centre has published 7 technical bulletins and 9 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 (formerly ARIS Cell) to manage the knowledge database with software of international repute such as SAS, CAB abstracts, horticultural abstract, and other computing softwares. The centre has now installed server and LAN system for shared resources. During the year, the centre has been connected to the national knowledge network (NKN) through Railtel and Wi-Fi provision for internet access. Regular updating of website is being done and stakeholders can access the happenings at ICAR-NRCL by logging into the centre's URL www.nrclitchi.org.

Significant Achievements

Genetic Resource Management and Crop Improvement

- Twelve litchi germplasm have been introduced from Bihar and Chhattisgarh. Another forty three new clones of litchi have been planted in the field gene bank to enrich the gene pool.
- Eight litchi germplasm have been characterized on the basis of morphological traits.
- Accession Lgc-6 has been found promising among different longan collections evaluated.
- Crosses were made with five parent cultivars *viz.,* China, Shahi, Bedana, Rose Scented, and Swarnaroopa in the hybridization programme.

Crop Production

- Application of 100:50:100 g NPK/plant/year produced high yield in 9 year old litchi cv. Shahi and 75:50:75 g NPK/plant/year in 7 year old litchi plant cv. China.
- Pruning at 2.0 m height plus 4 branches per trunk started bearing and gave maximum fruit yield (53.14 kg/tree) in 3rd year after reiterative pruning.
- Under high density trial, the highest yield (18.75 kg/plant) was obtained under 6x6 m density followed by 8x4 m (16.45 kg/plant) and 8x 6 m (16.25 kg/plant) densities.
- Application of 1.0 g PBZ (Paclobutrazol) and 2.0 % KNO_3 advanced flowering by one week.
- AMF alone as well as in combination with other bio-fertilizers resulted in higher increase in all the growth parameters of litchi plant.
- Organic carbon content in the farm soil found low to medium, nitrogen and phosphorus content is medium, and potassium content is low.

Crop Protection

- *Alternaria alternata* was found to be a major pathogen causing disease in litchi at multiple phenophases (nursery, reproductive, and postharvest stage).
- *Trichoderma viride* isolate NRCL T 01 was found superior for tolerance to different temperature, pH and salt concentration against a reference strain NRCG T09.
- Maximum and minimum pest population in litchi was observed in the month of September-October and December-January, respectively.
- Spraying of Novaluron 10 EC (0.015%) have been found effective against litchi looper and leaf folder. Spray of neem oil (3ml/l) before flower opening, second and third spray of Diflubenzuron 25 WP (0.03%) at clove stage of fruit and 21 days after second spray curbed the fruit and seed borer infestation effectively.

Postharvest Management and Value addition

- The proper fruit maturity with >18 °Brix and 0.5% acidity were recorded at 75-78 DAF in Shahi.
- *Bacillus subtilis* @ 1×10^8 cell/ml, Potassium silicate @ 0.5%, Chitosan @ 1%, Carbendazim @ 0.2% as postharvest dip treatment found promising in controlling fruit rots. *B. subtilis* isolates, NRCL BS-1 was found most effective to control fruit rot incidence up to six days after dipping of litchi fruit.
- Preventive and curative ability of antagonists against fruit rots of litchi has been studied.
- Pre-harvest spray of GA_3 (100 ppm) + Potassium sulphate (1%) significantly reduced fruit cracking and increased fruit weight in cv. Shahi. Fruits dipped in Chitosan (1%) + B. subtilis @ 1×10^8 cfu or Carbendazim (0.1%) was found effective in maintaining the quality and shelf life of the fruits up to five days under ambient condition and 18 days at refrigerated condition.
- Bagging of litchi bunches 40 days after anthesis with white butter paper bags gave the best result, followed by white non-woven PP bags.
- Litchi flesh pre-treated with 50 °Brix osmotic sucrose solution in the pulp solution ratio of 1:2 gave highest overall acceptability (7.96) with minimum hardiness (2749.52 g) and drying time (15 hr) after 9 months of storage.

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- During the year more than 2000 stakeholders were benefitted through various training and extension activities.
- Under TSP, forty three acre area has been taken under plantation for mango and litchi at Bandel village of Rayagada district of Odisha.
- Canopy management (2 ha) and rejuvenation of old senile litchi trees (5 ha) have been successfully attempted in Nagaland and Assam under North-eastern region programme.

Externally Funded Projects

- Proforma for registration of farmers' varieties of mango (16 nos.) and pummelo (10 nos.) with PPV&FRA, New Delhi has been submitted.
- Four community nurseries for unique varieties of mango and pummelo were established at the community level.
- First presence of litchi fruit borer was noticed in 7th standard week (4 adults/trap) and maximum number of adults (55 adults/trap) were observed in 14th standard week.
- Twenty eight thousand litchi plants cv. Shahi and China were multiplied and made available for commercial sale.

Staff Strength of the Centre

Staff	Sanctioned	Filled	Vacant
Scientific	15+1	14+1	1
Technical	14	3	11
Administrative	12	8	4
Skilled supporting staff	10	3	7

Financial Statement 2014-15

(Rs. in lakh)

Head	Plan		Non-plan	
	Allocation	Utilization	Allocation	Utilization
Capital	104.00	103.90	3.64	3.64
Revenue				
Establishment expenses	0.00	0.00	219.50	218.74
Travelling allowance	13.00	13.04	2.00	0.67
Research and operational expenses	58.25	58.26	9.35	9.35
Administrative expenses	44.00	44.05	37.01	38.34
Miscellaneous expenses	0.75	0.75	0.00	0.00
Total	220.00	220.00	271.50	270.74

Resource Generation

(Rs. in lakh)

Sale of farm produce	9.28
Interest earned on short term deposits	7.47
Income generated from internal resources (including recovery of loans and advances)	1.09
Miscellaneous receipts	0.00
Total	17.84

Expendeture incurred under non-plan from resource generation over non-plan grant released: 16.16

Receipts and Expenditure Statement of Externally Funded Projects

(Rs. in lakh)

Externally funded projects	Opening balance	Receipt during 2014-15	Expenditure
Total	28.87	16.48	45.52

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 (Vishal Nath, Narayan Lal, Neetu Singh Kushwah, Alok Kumar Gupta, Rajesh Kumar and Amrendra Kumar)

Collection of litchi germplasm from indigenous and exotic sources

Twelve litchi germplasm (Piyazi, Pickling, Early Bedana, Pant Selection, Ajhauli, Indira Sel-2, Hongkong, Dam Dam, Ambika Litchi-1, Bombay Sel, Pantnagar-1, and Rose Scented) have been collected from Sabour, Bihar and Ambikapur, Chhattisgarh, and four plants of each germplasm have been planted in net house during third week of August 2014. Germplasm collected from Pantanagar and Chhattisgarh have been planted in the field gene bank at the spacing 8.25 x 8.25 m.

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

Morphological characterization of litchi germplasm has been initiated and observation on growth, flowering and fruiting parameter of eight germplasm was recorded during 2014 (Table 1.1).

Table 1.1. Growth, flowering, fruiting and physico-chemical characteristics of litchi germplasm

Parameters	Germplasm							
	Swarna-roopa	Yogda Selection	Late Large Red	Bedana Selection Pant	Late Bedana	Bedana	Calcuttia Late	China
Duration of flowering (days)	22	20	19	20	24	18	17	23
Length of inflorescence (cm)	24	29	32	20	20	12	26	32
Width of inflorescence (cm)	13	17	18	12	8	7	10	14
Number of fruits/cluster	5	8.67	2.33	7.33	3.33	1.6	8.67	10.33
Fruit cracking	Slightly prone to cracking	Not prone to cracking	Prone to cracking	Not prone to cracking	Not prone to cracking	Not prone to cracking	Slightly prone to cracking	Not prone to cracking
Fruit weight (g)	13.14	10.27	10.40	15.53	21.37	17.18	17.12	16.97
Aril weight (g)	8.41	5.11	7.10	11.48	15.28	13.99	8.42	11.66
Aril colour	Creamy white	Creamy white	Dull white	Dull white	White	Creamy white	Creamy white	Dull white
TSS (°Brix)	16.87	17.20	18.80	16.73	21.53	19.60	15.97	17.67
Mature fruit colour	Reddish yellow	Reddish yellow	Greenish red	Red	Reddish yellow	Reddish yellow	Pinkish red	Dark red
Seed index	274	260	306	103	96	115	411	233

Observation on plant height, stem girth, canopy spread (North-South and East-West), branching pattern, colour, shape and arrangement of leaflet, emergence of panicle, length of panicle, flower disc colour, fruit set percentage were recorded during 2015. The panicle length ranged from 21.5 cm in Shahi to 28.32 cm in Trikolia, whereas fruit set percentage varied from 30.48% in Shahi to 76.17% in Elaichi.

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

Establishment of basic facilities for tissue culture work is in progress. An experiment on embryo rescue technique is being initiated.

Collection, characterization and evaluation of longan (*Dimocarpus longan*) germplasms

In an evaluation trial of eleven longan germplasms, the accession Lgc-9 recorded the highest plant height (5.4m) and Lgc-4 recorded maximum girth (110.0 cm). The accession Lgc-6 recorded maximum fruit yield (8.70 kg/tree), but the heaviest fruit weight was observed in the accession Lgc-7 (7.80 g/fruit). During the year under study, all the accessions recorded flowering and fruit set (Table 1.2). Accession Lgc-6 recorded panicle emergence in the first week of March and remained earliest for flowering and fruiting. The TSS was highest (20.6 °Brix) in accession Lgc-6 and lowest (16.8 °Brix) in accession Lgc-4.

Collection, characterization and evaluation of rambutan germplasm

Two germplasms (N-18 red type and E-35 yellow type) of rambutan were collected from Home Grown Nursery, Kanjirapally (Kerala) during 2013 and planted in nursery under protected condition. Poor survival has been noticed in both the germplasm but, some plants are still surviving at 17 months after planting (Fig. 1.1).

Fig. 1.1. A: Rambutan N-18, B: Rambutan E-35

Table 1.2. Growth characteristics and fruit yield of longan germplasms

Germplasms	Plant height (m)	Girth (cm)	Canopy spread (m)		Fruit yield (kg/tree)	Fruit weight (g)	TSS (°Brix)
			E-W	N-S			
Lgc-1	3.5	55.0	3.5	3.4	3.90	3.80	19.6
Lgc-2	2.1	30.0	2.4	2.3	1.00	2.80	17.0
Lgc-3	3.3	55.0	3.7	3.2	2.30	3.60	20.2
Lgc-4	3.9	110.0	6.3	6.5	0.40	3.60	16.8
Lgc-5	4.7	79.0	6.5	6.7	0.90	3.40	17.2
Lgc-6	3.6	53.0	3.7	4.5	8.70	7.20	20.6
Lgc-7	4.2	88.0	6.1	5.1	7.80	7.80	20.2
Lgc-8	4.0	69.0	5.7	4.6	0.80	3.60	18.4
Lgc-9	5.4	96.0	6.3	6.3	1.80	3.80	18.8
Lgc-10	2.0	32.0	1.7	2.2	1.10	2.60	19.8
Lgc-11	3.4	59.0	4.7	4.3	3.62	3.60	20.4

1.2. Development of improved cultivars in litchi (Vishal Nath, Alok Kumar Gupta, Narayan Lal, Neetu Singh Kushwah and Rajesh Kumar)

Clonal selection for improvement in commercial cultivars of litchi

Thirty five new litchi clones (2 plants each) have been planted in the field during first week of August, 2014 and 8 clones planted in clonal block during 2nd week of August, 2014. Observation on plant height, canopy spread and flower initiation were recorded in few clones (Table 1.3).

Development of improved hybrids of litchi

The several crosses were made to produce hybrid during 2014 and only thirteen hybrid fruits (China x Shahi -5 nos. & China x Bedana-8 nos.) were harvested and sowed in nursery.

More than 18000 crosses were made during 2015 in all possible combination with five parent cultivars *viz.,* China, Shahi, Bedana, Rose Scented, and Swarnaroopa. Good fruit set was observed in pollinated flowers after one week (2.5 -87.63 %). The highest fruit set (87.63%) was observed in China x Bedana whereas, lowest in Swarnaroopa x Shahi

Table 1.3. Plant growth and panicle emergence in litchi clones

Clones	Plant height (cm)	Canopy spread (cm)		Flower/Flush initiation	Planting year
		N-S	E-W		
NRCL-01	182	140	112	Panicle	2012
NRCL-02	125	170	155	Vegetative Flush	2012
NRCL-03	120	140	120	Vegetative Flush	2012
NRCL-04	110	130	120	Vegetative Flush	2012
NRCL-05	125	110	142	Vegetative Flush	2012
NRCL-06	130	160	150	Vegetative Flush	2012
NRCL-07	110	90	102	Vegetative Flush	2012
NRCL-08	40	-	-	Vegetative Flush	2014
NRCL-09	85	115	150	Mixes Panicle	2012
NRCL-10	95	90	80	Vegetative Flush	2012
NRCL-11	45	-	-	Vegetative Flush	2014
NRCL-12	120	120	110	Panicle	2012
NRCL-13	53	-	-	Vegetative Flush	2014
NRCL-14	145	170	120	Vegetative Flush	2012
NRCL-15	105	140	110	Vegetative Flush	2012
NRCL-16	155	172	160	Vegetative Flush	2012
NRCL-17	105	85	60	Vegetative Flush	2012
NRCL-18	40	-	-	Vegetative Flush	2014
NRCL-19	45	-	-	Vegetative Flush	2014
NRCL-20	32	-	-	Vegetative Flush	2014
NRCL-21	46	-	-	Vegetative Flush	2014
NRCL-22	88	-	-	Vegetative Flush	2014

(2.50%) at one week after pollination. However, most of the fruits were dropped after fifteen days of crossing (Table 1.4 & Fig. 1.2).

development. Out of these, only 62 nos. of plants among the population bore fruits up to maturity. Fruit weight varied from 2.54 g to 16.28 g.

Table 1.4. Hybridization programme in litchi during 2015

Cross	Flower pollinated	Fruit set after one week	Fruit set after two week	Fruit set after three week	Fruit set after four week	Fruit set after five week
Shahi x China	3491	1106 (31.68)	322 (9.22%)	14	9	9 (0.25%)
Shahi x Bedana	2338	607 (25.96%)	370(15.82%)	7	0	-
China x Bedana	2134	1870 (87.63%)	40	8	5 (0.23%)	
Bedana x China	1574	912 (57.94%)	47 (2.99%)	1	0	-
Bedana x Shahi	1170	337 (28.80%)	27	7	4	4 (0.34%)
China x Shahi	2919	2141 (73.34%)	57	16	11 (0.37%)	
Swarnaroopa x Shahi	1439	36 (2.50)	21	21	21 (0.014)	
Shahi x Rose Scented	1758	605 (34.41%)	33	1	0	-
Rose Scented x Shahi	2304	1891 (82.07%)	322	13	11 (0.47 %)	7 (0.30)

Fig. 1.2. Fruit set, A: After pollination, B: After five weeks

Evaluation of seedling population of litchi for improved plant types

Seedling population (527 nos.) evaluated, which showed a wide variation for plant morphological characters, *viz.,* plant height, stem girth, leaf length and width, canopy spread and number of times putting forth flushes and colour of flushes. During 8th year under experimentation, the observation recorded in 134 nos. (25.42%) of seedlings for panicle emergence, flowering, fruit set and fruit

The plant types exhibited distinct variation in plant height, stem girth, leaf length and width, canopy spread, panicle emergence, flowering, fruit set and fruit yield.

Establishment and evaluation of segregating population of litchi

The litchi seedling had been planted in the field during August, 2013. The maximum survival of plants (87.5%) found in hybrid population and

seedlings of selected clones. The maximum average plant height (92.57 cm) was recorded in other group of population (Table 1.5).

Table 1.5. Seedling population under evaluation

Category	No. of plant planted	Survival	Plant height (cm)
Hybrid	24	21 (87.5 %)	90.00
North East population	26	18 (69.23 %)	81.66
Jharkhand population	24	19 (79.16 %)	74.16
Segregating population (Bihar)	28	21 (75 %)	70.42
Clones selected	24	21 (87.5 %)	60.62
Shahi seedling	40	23 (57.5 %)	70.40
China seedling	190	72 (37.89 %)	68.16
Other seedling	144	105 (72.91)	92.57

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

2.1. Plant propagation and nursery management in litchi (Rajesh Kumar, Amrendra Kumar, S.D. Pandey, Vinod Kumar, R.K. Patel)

Standardization of grafting technique

About 1000 litchi seedlings were raised for seedling stocks during the year 2014. The earlier raised seedlings of desirable stem thickness were selected and grafting operation (wedge and side grafting) was conducted. Under grafting operation, wedge grafting showed maximum percentage of success (48%) with better graft union attempted in September month. The survivability of grafted plants was recorded up to 120 days from the date of grafting operation (Table 2.1, 2.2, 2.3).

Table 2.1. Survivability of litchi grafted plants (grafted operation during July, 2014)

Treatment	Nos. of seedlings grafted	Survivability of grafted plant after 30 days (nos.)	Survivability of grafted plant after 60 days (nos.)	Survivability of grafted plant after 90 days (nos.)	Survivability of grafted plant after 120 days (nos.)
T_1-M_1S_1	50	11	04	03	03
T_2-M_1S_2	50	13	07	05	02
T_3-M_1S_3	50	19	03	01	01
T_4-M_2S_1	50	08	03	01	01
T_5-M_2S_2	50	07	04	03	02
T_6-M_2S_3	50	06	04	02	02

Table 2.2. Survivability of litchi grafted plants (grafted operation during August, 2014)

Treatment	Nos. of seedlings grafted	Survivability of grafted plant after 30 days (nos.)	Survivability of grafted plant after 60 days (nos.)	Survivability of grafted plant after 90 days (nos.)	Survivability of grafted plant after 120 days (nos.)
T_1-M_1S_1	50	09	05	04	00
T_2-M_1S_2	50	09	09	06	00
T_3-M_1S_3	50	09	09	09	07
T_4-M_2S_1	50	09	06	05	04
T_5-M_2S_2	50	08	08	06	03
T_6-M_2S_3	50	11	09	09	03

Table 2.3. Survivability of litchi grafted plants (grafted operation during September, 2014)

Treatment	Nos. of seedlings grafted	Survivability of grafted plant after 30 days (nos.)	Survivability of grafted plant after 60 days (nos.)	Survivability of grafted plant after 90 days (nos.)	Survivability of grafted plant after 120 days (nos.)
T_1-M_1S_1	50	18	16	14	14
T_2-M_1S_2	50	18	16	11	11
T_3-M_1S_3	50	28	26	24	24
T_4-M_2S_1	50	23	19	17	16
T_5-M_2S_2	50	17	14	07	02
T_6-M_2S_3	50	22	20	11	09

M_1: Wedge grafting, M_2: Side grafting, S_1: Scion with leaf, S_2: Scion defoliated 7 days before grafting, S_3: Scion defoliated 15 days before grafting

Plant propagation and growth physiology of vegetatively propagated plants in litchi

Effect of various dip solutions on establishment of litchi gooties in nursery : Nursery trial conducted on root dipping of freshly detached air-layers in various solutions *viz.,* Carbendazim 0.2% (T_1), Mixture-1@ 0.5% (T_2), Mixture-1@ 1.0% (T_3), Mixture-1@ 1.5% (T_4), Mixture-1@ 2.0% (T_5), Soil+ vermi-compost (VC) thick paste 2:1 (T_6), VC thick paste (T_7), *Trichoderma viridae* 1% (T_8), *Rhizobacteria* 1% (T_9), *Rhizobacteria* 2% (T_{10}) and Control (water dip, T_{11}) to study the effect on growth performance at 10 months after planting. Study revealed that air-layers dipped in *Rhizobacteria* 2% (T_{10}) gave significantly maximum fresh plant weight (77.10g), dry weight (33.10g), root fresh (28.24g) & dry weight (14.66g) and root shoot ratio on fresh and dry weight basis (0.58, 0.84, respectively) (Fig. 2.1 & 2.2). Significantly higher fresh shoot weight (49.75g) was recorded in T_7, dry shoot weight (23.85g) and dry stem weight (17.76g) in T_4, fresh stem weight (38.20g) in T_3 and fresh leaf weight (16.73g) in T_5. Number of primary and secondary roots per plant and root length did not showed any significant variation due to various root dipping treatment. However, the highest number of primary roots (12) counted in T_{10} and secondary roots (52.25) and longest root length (38.68 cm) in *Rhizobacteria* (1%).

Fig. 2.1. Vigorous root growth with *Rhizobacteria* treated air-layers

The potting media of different treatments were analyzed for available nitrogen content at termination of experiments (10 months after planting). The nitrogen content in potting media varied significantly due to dipping of root in dip solutions. The highest available nitrogen (139.51 kg/ha) was found in *Rhizobacteria* 2% (T_{10}) followed by *Trichoderma* 1% (137.28 kg/ha).

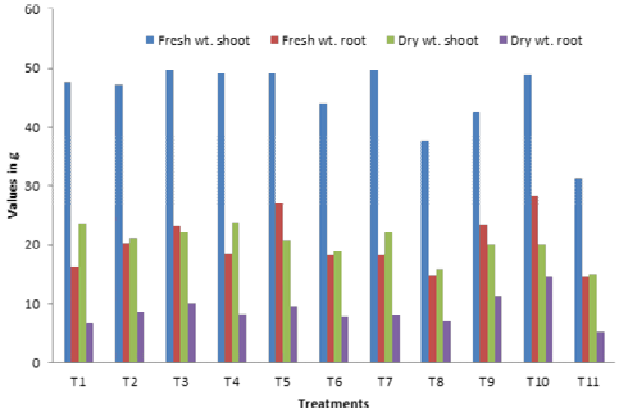


Figure 2.2. Effect of root dip treatment on performance of air-layers

2.2. Development and refinement of integrated technologies for improved productivity of litchi (S.D. Pandey, Vishal Nath, Amrendra Kumar, R.K. Patel and K. Srivastava)

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

The information obtained on effect of various treatment combination of NPK on growth, yield and quality parameters of Shahi litchi revealed non-significant differences for growth parameters, fruit weight, fruit length, fruit breadth and TSS. However, substantial variation in yield and pulp recovery percentage was observed. Maximum 55 kg/plant yield was recorded with application of 100:50:100 g NPK/plant/year in 9 year old plant which was at par with 75:50:75 g NPK application per plant per year. Growth data was recorded during September month. Initial information indicates response of Shahi variety towards high nutrient requirement.

Soil samples were collected from active root zone of the tree upto 20 cm depth during January

months before flowering. Data revealed that nitrogen availability in soil increased with increasing dose of nitrogen and potassium. The highest N (197.61 kg/ha) content was analyzed in treatment T_9M_1 (100:50:100g NPK/plant/year) and lowest (93.62 kg/ha) in T_1M_1 (50:50:50g NPK/plant/year) with 3 split application during July, October and April months. Whereas, same level of nutrient applied in 2 split during July and October recorded higher nitrogen content (95.73 to 209.75kg/ha) than 3 splits.

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

Different treatment combination of NPK showed significant response on flowering, yield, fruit length, TSS and ascorbic acid, whereas, fruit weight, fruit breadth, acidity and pulp recovery percentage showed non-significant. Maximum fruit yield (32.21 kg/plant) was recorded with application of 75:50:75 NPK/plant/year in 7 year old plant. Time of application did not show any significant response. Results indicate initially response of China variety to medium nutrient requirement. Higher TSS values were recorded in treatment where lower dose of nitrogen was applied.

Standardization of organic inputs for litchi production

Maximum 27.27 kg yield/plant was recorded with application of 20 kg FYM + 2 kg vermi-compost + 1 kg neem cake + bio-fertilizers with in treatments of organic inputs at 8 year after planting. In comparison of organic inputs, recommended dose of NPK recorded higher yield (34.36 kg/plant). Effect of organic inputs and NPK application on fruit quality showed non-significant difference. Spraying of vermi-wash and nimbicidine or neem-based products were done to manage the pest and disease incidence. Four flush in a year was observed during reporting period. Mite was not noticed in the field while, bark eating caterpillar was the major problem. Nitrogen content in leaf was 1.52% in 20 kg FYM + 2 kg vermi-compost + 1 kg neem cake + bio-fertilizers whereas, in other treatments it ranged from 1.41–1.44 %.

Development of package of practices for organic litchi production

An experiment on study the response of different organic resources *viz.,* FYM, vermi-compost, bio-fertilizers, bio enhancers, green manures on growth performance of litchi has been initiated. One block of Shahi, China, Mandraji and Trikolia cultivars has been established in 1.6 ha area at 6x6 m spacing under organic management practices.

Survival of litchi plants ranged from 84.62% in Mandraji to 95.80% in China cultivar at eight to twelve months after planting. China recorded the least mortality (4.20%) of plants (Table 2.4).

Intercropping of faba bean was done in between two rows with litchi during *Rabi* season. Good crop of bean was recorded particularly towards the down side slope of the orchard with average yield of 25-30 q/ha.

Soil samples were collected from organic block before planting. Whole block was divided into 4 blocks and each block was sub divided into three blocks (Upper, Middle & Lower) as per the slope gradient. Sampling was done up to 20 cm depth from different blocks. The data revealed that soil pH

Table 2.4. Planting of different cultivars of litchi under organic production system

Cultivars	Quantity	Survival (%)	Mortality (%)
Shahi	182	89.01	10.99
China	143	95.80	4.20
Mandraji	39	84.62	15.39
Trikolia	65	87.69	12.31

ranged from 8.34 to 8.71, EC 0.09 to 0.18 dsm^{-1}, organic carbon 0.12 to 0.33%, N 69.46 to 143.55 kg/ha, P_2O_5 18.28 to 27.42 kg/ha, K_2O 67 to 219 kg/ha. The micronutrient contents also varied within block (Table 2.5).

Table 2.5. Physical and chemical properties of soil of experimental block before planting

Plots		pH	EC (dsm^{-1})	Organic Carbon (%)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)	S (ppm)
I	U	8.34	0.12	0.18	104.53	22.85	67	0.31	0.32	3.15	1.29	1.25	33.44
	M	8.34	0.09	0.21	143.55	18.28	81	0.31	0.33	2.91	0.97	1.25	15.43
	L	8.35	0.10	0.24	99.84	22.85	103	0.18	0.44	2.98	0.89	1.41	15.43
II	U	8.34	0.09	0.15	100.17	22.85	94	0.26	0.26	2.79	1.11	1.41	25.72
	M	8.35	0.09	0.24	122.20	27.42	98	0.26	0.41	3.21	1.13	1.56	15.43
	L	8.51	0.11	0.18	99.42	27.42	112	0.17	0.32	2.68	0.86	1.56	15.43
III	U	8.33	0.18	0.12	69.46	18.28	100	0.32	0.18	3.00	1.68	1.88	36.01
	M	8.48	0.10	0.18	117.75	18.28	95	0.33	0.42	3.30	1.19	2.19	36.01
	L	8.57	0.11	0.18	89.77	27.42	130	0.23	0.36	2.36	0.90	2.19	20.58
IV	U	8.53	0.18	0.24	107.14	22.85	219	0.50	0.37	2.21	0.90	1.56	30.86
	M	8.62	0.10	0.21	103.05	22.85	118	0.38	0.43	2.69	0.91	2.19	25.72
	L	8.71	0.13	0.33	99.90	27.42	142	0.29	0.40	2.63	0.95	1.88	30.86

U= Upper, M= Middle & L= Lower

Effect of reiterative pruning and canopy rebuilding of old senile litchi trees for rejuvenation and enhanced quality fruit production

The parameters pertaining to vegetative and reproductive growth phases were recorded during the third year of experimentation. The treatment having pruning at 2.0 m height + 3 branches/trunk recorded the maximum growth (1.12 m) in plant height. The canopy spread was recorded maximum in the treatment having pruning at 2.5 m height + 4 branches/trunk (1.11m E-W; 1.14 m N-S). The maximum shoot length (57.90 cm) under thinned branches was recorded in the treatments consisting of pruning at 2.5 m height + 3 branches/trunk to the canopy. The flowering percentage and fruit set was also recorded in almost all the treatments, but highest (91.2%) in the treatment having pruning at 2.0 m height + 4 branches/trunk. The treatment of reiterative pruning at 2.0 m height plus 4 branches per trunk started bearing and gave maximum fruit yield (53.14 kg/tree) at 3rd years after treatment. All the treatments receiving pruning and training recorded the phase change from vegetative to reproductive and bore quality fruits with high yield (Table 2.6). The left over open space was utilized with intercrops of maize and mustard in succession and economic feasibility analysis was also done.

High density planting in litchi cv. Shahi

Significant differences were observed for growth parameters recorded during September month due to planting densities. The maximum plant height (4.56 m) was recorded in 8 x 4 m planting density followed by 2x2 m (4.37 m) and minimum in 8x8 m (3.84 m) planting density. Plant girth (49.96 cm) and plant spread (5.56 m) in east west direction was found maximum in 6 x 4 m whereas, 10x10 m plant density attributed highest plant spread (5.31 m) in north south direction. Plant density 2x2 m recorded lowest plant girth (38.57 cm) and plant spread in both directions (3.62 &3.60 m). Flowering percentage, fruit yield, TSS and acidity were significantly influenced due to densities, however fruit weight, fruit length, fruit breadth, ascorbic acid and pulp weight recorded non-significant differences. Highest 18.75 kg/plant yield was obtained in 6x6 m density followed by 8x4 (16.45kg/plant) and 8x6 m

Table 2.6. Vegetative growth, flowering and fruit yield in reiteratively pruned old senile litchi trees during 2014

Treatment details	Increase in height (m)	Increase in canopy spread		Shoot length (cm)	Flowering (%)	Number of fruits/ panicle	Fruit yield (kg/tree)
		E-W(m)	N-S(m)				
Pruning at 2.0 m height	0.89 (4.37)	1.03 (4.53)	0.91 (5.06)	25.53	67.2	3.1	36.56
Pruning at 2.0 m height + 3 branches/ trunk	1.12 (4.41)	0.92 (4.85)	1.01 (4.90)	51.30	84.8	3.8	47.12
Pruning at 2.0 m height + 4 branches/trunk	0.79 (4.45)	0.39 (4.70)	0.81 (5.00)	44.54	91.2	4.3	53.14
Pruning at 2.5 m height	0.81 (4.46)	0.85 (5.11)	0.89 (4.88)	43.54	76.4	4.1	42.12
Pruning at 2.5 m height + 3 branches/ trunk	0.86 (4.50)	0.93 (5.13)	0.73 (4.58)	57.90	78.2	3.1	41.16
Pruning at 2.5 m height + 4 branches/ trunk	0.74 (4.70)	1.11 (5.75)	1.14 (5.80)	56.35	87.7	4.1	47.82
Unpruned tree (Control)	0.37 (4.10)	0.34 (3.80)	0.56 (4.16)	18.23	78.0	3.4	23.22

(16.25 kg/plant) densities. TSS content in fruit was more in wider densities in comparison to closer densities. 8x8 m density recorded highest TSS (20.57 °Brix) and acidity content (0.75%).

Nutrient deficiency symptoms in litchi plants

A pot experiment was conducted to study the nutrient deficiency symptoms of three macro (N, P, K) and four micro (Fe, Cu, Zn, B) nutrient elements in litchi plants. The treatment comprised of T_1 (Full nutrient solution), T_2 (All nutrients except N), T_3 (All nutrients except P), T_4 (All nutrients except K), T_5 (All nutrients except Zn), T_6 (All nutrients except Cu), T_7 (All nutrients except Fe), T_8 (All nutrients except B) and absolute control (Without nutrients). The deficiency symptoms started 90 days after planting in N-deficient plants. The older leaves of the plants turned yellowish in colour and newly emerged leaves became light green in colour. Plant growth was stunted with shorter internodal length and reduced leaf size. The Zn-deficient plants showed inter-veinal chlorosis in leaves. The Cu-deficient plants expressed symptoms as narrowing of younger leaves, which become hard (Fig. 2.3). The plants under absolute control showed stunted growth with less number of leaves that too were pale yellow in colour.

Fig. 2.3. A: Nitrogen deficit plant, B: Zn deficit plant, C: Cu deficit plant

2.3. Investigation and establishing the physiological and biochemical relations for improved litchi production (Amrendra Kumar, Vishal Nath, S.D. Pandey, Rajesh Kumar, S.K. Purbey, Kuldeep Srivastava, Sanjay Kumar Singh, Evening Stone Marboh, and Swati Sharma)

Effect of vegetative flushing and shoot maturity on flowering, bearing behaviour, fruit yield and quality of litchi

The flushing and age of shoot were found to influence the overall floriferousness of the litchi trees. There was higher percentage of panicle emergence with mature shoots of earlier emerged flushes either natural or forced, while there was a sharp decline in the intensity with the less mature shoots resultant of the emerged flushed during October, November and December (Table 2.7). As observed that the July-August appeared natural flushes transformed to maximum (up to 88.0%, 74.0%) extent in the panicle bearing shoots. November-December month's flushes to the lowest extent (up to 26.0%, 24.0%).The age of shoot and growth rate was very well monitored by the time of appearance of flushes with the interaction of climatic factors. So, monitoring the appearance of sufficient flushing during July-August, with the gradual decline in flushing capacity

Table 2.7. Effect of vegetative and forced flushing in litchi

Treatment details	Length of the flush (cm)	Times of extension growth	No. of branched shoots	Length of shoot at flowering (cm)	Panicle length at first flowering (cm)
July 2014	4.64	3.44	3.66	48.2	88
	4.34	4.12	3.26	43.6	44
August 2014	5.22	3.56	3.26	44.6	72
	4.65	4.60	3.26	36.6	42
September 2014	4.28	3.46	3.16	44.8	68
	4.15	3.14	2.32	26.4	26
October 2014	4.45	3.12	2.56	44.6	56
	4.54	4.08	2.12	26.8	22
November 2014	4.84	3.66	2.42	32.8	26
	3.55	4.26	1.66	18.8	21
December 2014	4.45	3.54	1.86	16.6	24
	3.65	3.66	1.12	14.2	23

from September onwards, not only ensured their maximum contribution in flowering but also caused to give higher fruit setting and fruit yield. The late appearance of flushes gave rise to mixed type of inflorescences, contributing lesser towards flowering and/or sometimes remained vegetative only with reduced flowering and fruit yield (Table 2.8).

color turning by 5 days. TSS (17.74 °B) and average fruit weight (21.97 g) was improved due to application of 4.0 g PBZ. Application of 3.0 and 4.0 g PBZ encouraged cauliflorous growth in the trees and reduces leaf area. During flower bud differentiation (FBD), the leaf area was maximum in the treatments receiving 1 to 2% KNO_3 followed

Table 2.8. Effect of vegetative and forced flushing in litchi

Treatment	No. of shoots bore panicles	No. of flowers/panicle	Fruit set/ panicle	Fruit yield (g/panicle)	Fruit yield (kg/tree)
July 2014	96.3	1230 (724:110:396)	11.6	266.6	47.3
	49.6	366 (203:37:126)	5.7	119.6	21.3
August 2014	89.6	1186 (702:108:376)	8.6	183.3	36.6
	49.3	578 (340:70:168)	6.1	116.6	18.3
September 2014	89.3	888 (548:48:292)	8.6	177.6	34.3
	26.3	320 (146:72:102)	6.6	116.3	14.3
October 2014	76.6	690 (418:96:176)	7.6	168.6	26.6
	26.3	676 (326:106:244)	5.3	94.3	12.6
November 2014	66.3	818 (502:152:164)	5.0	86.6	11.3
	78.3	760 (460:80:220)	3.6	56.6	06.6
December 2014	34.3	760 (446:96:218)	3.6	64.3	06.3
	78.3	510 (296:76:138)	3.6	70.3	08.3

Effect of PGR sprays on yield and quality of litchi fruits

To regulate the flowering in juvenile stage of litchi cv. Shahi, spray of ethrel, NAA, MH and GA_3 were applied consecutively for 5 years. Results revealed that these chemicals did not express any residual effect on flower regulation and physico-chemical parameters of fruits even one year after experimentation.

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

Application of 1.0 g PBZ (Paclobutrazol) and 2.0% KNO_3 advanced flowering by one week with maximum opened flowers during April, 2014 whereas, application of 2.0 and 4.0 g PBZ advances

3g PBZ. Application of 3 g PBZ led to reduction in leaf area, chlorophyll 'b', total chlorophyll content and reducing sugar. However, 4.0 g PBZ led to highest phenol content while un-treated trees recorded least phenol content. Spray of 2% KNO_3 increased maximum reducing sugar content in the leaves (Table 2.9). There was no flowering panicle during March 2015 in any treatments.

Improving bearing potential though use of girdling cv. China (Observational trial)

In order to obtain fruit yield every year in litchi cv. China, which has the tendency of biennial bearing nature, a field experiment has been executed on 3 levels of girdling (2, 3 and 4 mm) on 3 levels of primary branches (25, 50 and 75 per cent). The girdling treatments were imposed during the months of September. There was no vegetative growth seen

Table 2.9. Effect of paclobutrazol and KNO_3 on morpho-physiological parameters of 'China' litchi

Treatments	Leaf area (cm^2)	Chl 'a' (mg/100 g)	Chl 'b' (mg/100 g)	Total Chl (mg/100 g)	Total sugars (mg/100g fw)	Reducing sugars (mg/g)	Phenols (mg/100g)	Proline (mg/g)
1.0 g PBZ	29.36	3.87	1.46	5.34	5.0	12.09	5.74	6.35
2.0 g PBZ	31.08	2.65	1.85	4.50	6.0	15.43	10.82	6.73
3.0 g PBZ	26.69	4.00	0.72	4.72	5.0	14.62	8.44	6.48
4.0 g PBZ	28.16	3.81	1.46	5.27	6.0	25.42	12.25	5.97
1 % KNO_3	29.97	3.82	1.44	5.26	5.6	28.50	7.12	5.85
2 % KNO_3	26.44	3.94	0.81	4.75	5.8	54.59	8.94	6.07
Control	28.36	3.34	1.51	4.86	5.4	32.78	3.19	6.48

Fig. 2.4. Flowering in girdled branches

in girdled branches. All the girdled branches exhibited flowering panicles (Fig. 2.4) but, no flowering was noticed in un-girdled branches of the tree.

2.4. Investigation on mycorrhizal association and role of bio-fertilizers for sustainable production of litchi (Vinod Kumar)

Studies on effect of application of mycorrhiza and other bio-fertilizer inoculants on growth and establishment of litchi

Studies were undertaken on the experimental plants that were plantedin field during 2011 in a randomized block design with twenty treatments having components such as consortium of arbuscular mycorrhizal fungi (AMF) @ 200 g/plant, *Azotobacter chrococcum* (AZ) @100 g/plant, *Trichoderma viride* (TR) @100g/plant and *Bacillus megatarium* (BM) @100 g/plant along with their combination treatments, which was compared with recommended dose of fertilizers (RDF; Urea=150 g, SSP=150g, MOP=100g/plant) and control plants as check.Three replications (one plant in each) were maintained under each treatment. Vermi-compost was applied in all the treatments @1 kg/plant. Some of the plants in each treatment died and gap filling was done. In such cases, mean of other replication was considered.

Observations were recorded at different interval during the year on various growth parameters *viz*., girth, height, plants spread, shoot length, leaf area and chlorophyll content in leaves, and percent increase was computed over the interval. The data indicated that all the bio-fertilizers had significant positive effect on growth parameters of plants. AMF alone as well as in combination with other bio-fertilizers resulted in higher increase in all the growth parameters. AMF combined with BM had negative interaction but was synergistic with AZ. Higher number of fibrous (feeder) roots was observed with co-inoculation of AMF and AZ (Fig. 2.5). This interaction was also confirmed by pot experiment.

Effect on plant spread (canopy): The observation was recorded on 28th December 2013, 1st April 2014 and 7th November 2014 after which plants were undergone pruning and training operation for developing desired tree architecture. The data revealed that increment in canopy spread

Fig. 2.5. Development of greater number of feeder roots with co-inoculation of mycorrhiza and *Azotobacter chrococcum*

of plants over the baseline value of December 2013 found maximum with AMF+AZ (34.1%) followed by AMF +TR (27.6%) and least in control (8.0%). The increase in canopy spread by application of bio-fertilizers were also significantly (p=0.05) higher than RDF (11.7%). Similar trend were observed when increment was computed in November 2014 over the canopy spread value of April 2014. The maximum increment was observed with application of AMF+AZ (97.5%) followed by AMF (82.2%) and AMF+TR (80.8%) compared to control (31.0%) (Fig. 2.6 & 2.7).

Fig. 2.6. Effect of application of mycorrhiza on plant spread of litchi

Effect on chlorophyll content of leaves: The observation on chlorophyll content (Chl 'a', Chl'b' and total Chl) of leaves was recorded in November 2014. Significantly higher chlorophyll content was recorded with application of AMF and other bio-

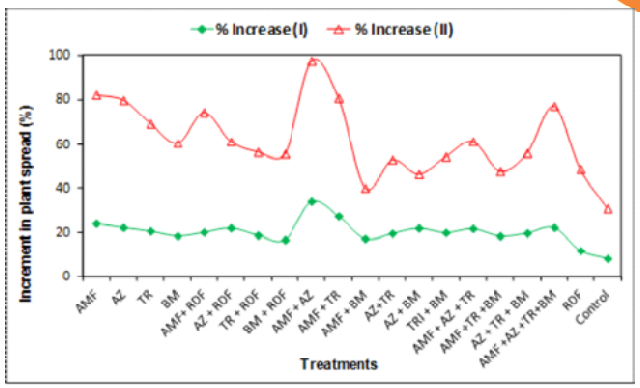


Fig. 2.7. Effect of application of mycorrhiza and other bio-fertilizer inoculants on plant spread (Increase I: Between Dec. 2013 to April 2014; Increase II: Between April to Nov. 2014)

fertilizers compared to control and RDF (Fig. 2.8). The maximum Chl 'a' in leaves was recorded with application of AMF+AZ (2.0 mg) while least was in control (0.97 mg). With respect to Chl 'b' effect of most of the bio-fertilizers were at par but significantly higher than control. The 'total Chl' was maximum (2.38 mg) in the treatment AMF+AZ followed by AMF+RDF (2.10 mg) and minimum with AMF +BM (1.20 mg) that was at par with control (1.22) (LSD=0.56 at p=0.05).

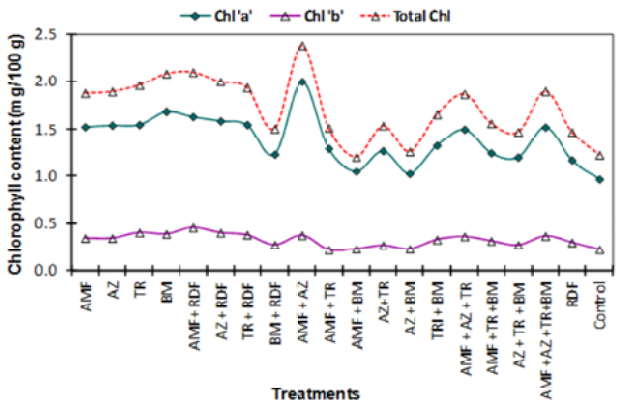


Fig. 2.8. Effect of application of mycorrhiza and other biofertilizer inoculants on chlorophyll content of leaves (Nov. 2014)

Effect on leaf area: The highest leaf area in plants was observed with application of AMF+AZ (37.48 cm^2) followed by AZ+RDF (35.46 cm^2) and TR+BM (35.30 cm^2) while it was least in control

(22.03 cm^2). In the mycorrhiza alone (AMF) treatment, the average value of leaf area was 33.30 cm^2. The effect was found statistically significant at p=0.05 (LSD = 3.15, SEm± 1.09). The data revealed a synergistic effect of AMF+AZ while a negative interaction was observed with AMF+BM (Fig. 2.9).

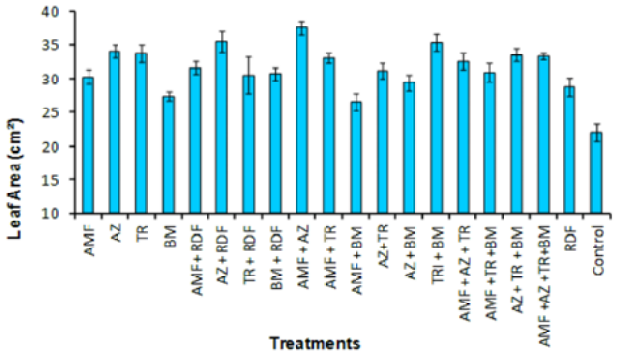


Fig. 2.9. Effect of application of mycorrhiza and other bio-fertilizer inoculants on leaf area (Nov. 2014)

Studies on dynamics of inoculated microflora in experimental plots

AMF spore was enumerated by wet sieving and decanting while other microflora was enumerated by serial dilution technique. The microbial population was monitored after inoculation at four months interval. Results indicated that the population of AMF spores, *T. viride, A. chrococcum* and *B. megatarium* was increased over the period but decreased after rainy season. The mycorrhiza inoculated plants also showed good colonization (up to 93.0%; gridline intersect method) of roots of litchi plants. Lesser number of AMF spores in rhizosphere, and colonization of roots of plants were observed with combined application of AMF+ BM indicating a negative interaction. Early first new flush and a higher increase in number of leaves and girth of air-layered plants were observed with AMF in pot experiment under glasshouse condition.

2.5. Litchi based cropping system for low lying conditions

Litchi based cropping system for pond/low land

Experiment on litchi based cropping system for low lying area has been initiated. Five ponds have been constructed and planting of litchi cvs. Shahi (30 nos.) and China (24 nos.) along with banana cv. Grand Naine (40 nos.) and papaya cv. Pune Selection-3 (42 nos.) have been done on pond bunds (Table 2.10). Intercropping of pea, faba bean, maize and other vegetables have also been done with litchi planted on pond bunds during *Rabi* season. The cropping system in bunds includes three tier model of litchi cum banana/papaya and crop/vegetables based system comprised (Fig. 2.10) with 5 bunds model (Bund I: Two row of litchi & banana + vegetables as intercrops, Bund II: Two row of litchi & papaya + annual crop as intercrop, Bund III: Two row of litchi + banana in between two litchi plants

Fig. 2.10. View of litchi-based cropping system in pond bunds

Table 2.10. Planting/sowing of crops with litchi on pond bund

Crops	Varieties	Quantity (nos.)
Litchi	Shahi	30
	China	24
Banana	Grand Naine	40
Papaya	Pune Selection-3	42

Table 2.11. Performance of different crops/ vegetables grown as intercrops with litchi on pond bund

Crops	Varieties	Area (m^2)	Yield (kg/plot)	Yield (q/ha)
Pea	Golden GS & Azad Pea-1	75	13.17	17.56
Faba bean	Local	90	16.79	18.65
Maize	Gold Dekale Hybrid	120	180.0	150.0
Vegetables	Potato	9.5	10.85	114.21
	Cabbage	6.38	11.5	180.25
	Cauliflower	8.0	4.75	59.38
	Knol khol	1.62	4.19	258.64
	Tomato	8.0	13.5	168.75
	Chilli	8.0	-	-
	Brinjal	8.0	-	-

& intercrop, Bund IV: Two row of litchi + papaya in between two litchi plants & intercrop and Bund V: Two rows of litchi). The yield of different inter-crops revealed that the performance of maize, faba bean, knol khol, cabbage and pea crops was relatively better than other crops (Table 2.11).

An experiment on litchi based cropping system for low land situation has been started with litchi cvs. Shahi and China under three planting situations (PS I: raised bed 3 m width, PS II: raised bed 2.5 m width & PS III: mound). Planting of litchi was done in the month of September 2014 at 8.25x4m spacing (Table 2.12).

Table 2.12. Litchi planting on raised bed and mound

Planting situation	Cultivars	Quantity (nos.)
PS I (Raised bed 3x1.5x2.5 m BWxHxTW)	Shahi	14
	China	15
PS II (Raised bed 2.5x1.5x2 m BWxHxTW)	Shahi	16
	China	16
PS III (Mound 1.5x1.5x1 BDxHxTW)	Shahi	18
	China	18

BW: Bottom width, H: Height, TW: Top width, BD: Bottom diameter

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 (Vinod Kumar)

Studies on *Alternaria* disease of litchi

Alternaria alternata was found to be a major pathogen causing disease in litchi at multiple phenophases. In nursery, it caused leaf blight, the initial symptoms of which resembled potassium deficiency. The typical symptoms started from tip of the leaf as light brown to dark brown necrosis that advanced towards both the margins of the leaf leading to complete necrosis of the affected leaves that dried up subsequently. In orchard trees, it caused leaf blight typical of nursery stage, and at reproductive phase caused blighting of panicle and fruits, which was first noticed during April-June, 2014. At postharvest stages, it was found to be a dominant pathogen causing fruit rots. Survival of the pathogen was through conidia on fallen leaves and on senescing leaves under tree canopy.

Fig. 3.1. Symptoms of panicle blight; A. healthy panicle with fruit set, B. Diseased panicle with no fruit set

Fig. 3.2. Symptoms of fruit blight of litchi; Left - Field view, Right- Close up of diseased fruits

The incidence of panicle blight (Fig. 3.1) at ICAR-NRCL experimental farm during 3rd week of April 2014 ranged between 43.1-77.1%. The data on distribution of trees in various severity levels of panicle blights revealed that trees in <20%, 20-40%, 40-60%, 60-80% and >80% disease severity range were 19.1-27.0%, 9.5-32.3%,16.2-42.9%, 9.5-23.8% and 2.4-10.8%, respectively. Observation on incidence of fruit blight (Fig. 3.2) was recorded on 8th June 2014 in the cultivar 'China' at ICAR-NRCL experimental farm. The disease incidence varied from 2.9-12.9%. The distribution of blighted fruits in the tree in four cardinal directions (North, South, East, and West) showed no correlation with the particular direction.

Molecular identification and characterization of pathogenic variability in *Alternaria alternata*

Molecular variability among pathotypes of *A. alternata* that causes diseases at multiple phenophases of litchi was completed (Table 3.1). The identity of all the four pathotypes was confirmed as *Alternaria alternata*. The ribosomal ITS region was amplified using the universal primers ITS1 (5'-TCCGTAGGTGAACCTGCGG-3') and ITS4 (5'- TCCTCCGCTTATTGATATGC-3'). Consensus sequences of the ITS region of pathotypes and reference sequences downloaded from Genbank were aligned using the multiple sequence alignment program Clustal W. Based on the study four unique sequence were identified that was submitted to GenBank.

Table 3.1. Details of the pathotype and sequence of *Alternaria alternata*

Pathotype	Isolation source	NRCL Ref No.	Gene Sequence	No. of base pairs	Genbank accession No.
AA-L1	Infected litchi leaf	NRCL Fungal Culture 5	5.8S Ribosomal RNA	556 bp	Bankit1816896 seq5 KR149264
AA-L2	Infected litchi leaf	NRCL Fungal Culture 15	5.8S Ribosomal RNA	527 bp	Bankit1816896 seq15 KR149265
AA-L3	Infected litchi leaf	NRCL Fungal Culture 16	18S ribosomal RNA	540 bp	Bankit1816896 seq16 KR149266
AA-F1	Infected fruit	NRCL Fungal Culture 3	18S ribosomal RNA	567 bp	Bankit1816896 seq3 KR149264

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

Twelve different fungicides (Copper oxychloride, Mancozeb, Thiophanate Methyl, Carbendazim, Difenoconazole, Hexaconazole, Propiconazole, Propioneb, Chlorothalonil, Azoxystrobin, Metiram+Pyraclostrobin, and Mancozeb+Carbendazim), two antagonists (*Trichoderma viride* isolate NRCL T01 and *Bacillus subtilis*) and two defense activators (Salicylic acid, Chitosan) were evaluated under glasshouse conditions for management of leaf blight in nursery plants caused by *A. alternata*. Due to unforeseen constraints in maintaining required temperature and humidity conditions, however, the disease severity was too low even after artificial inoculation. The experiment is being repeated. Also, same set of treatments is being applied under field conditions to manage panicle and fruit blight caused by *A. alternata*.

Studies on novel characteristics of NRCL *Trichoderma viride* isolate NRCL T01

Novelty of the *Trichoderma viride* isolate NRCL T01 was studied with respect to a reference strain NRCG T09 for tolerance to different temperature, pH and salt concentration. The isolate NRCL T01 found superior in all the parameters tested. This isolate exhibited unique growth habit, tolerance to a wide temperature regime (15-40 °C), pH (4.0-9.0) and salinity (can grow up to a salt concentration of 1.5 M NaCl), and also for production of volatile and non-volatile compounds inhibitory to pathogens. Production of non-volatile compounds inhibitory to pathogens is one of the multiple modes of action of *Trichoderma*. The results of *in-vitro* bioassay showed that at a concentration of 75%, isolate NRCL T01 could inhibit up to 75.0% growth of *A. alternata* and 37.71% of *Fusarium solani*. No further increase in growth of the pathogen was observed till 15th day of incubation (Fig. 3.3, 3.4 & 3.5).

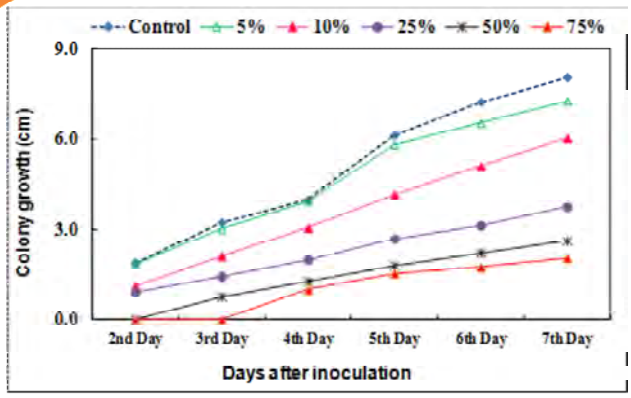


Fig. 3.3. Effect of non-volatile compounds produced by *Trichoderma viride* isolate NRCL T01 on growth of *Alternaria alternata*

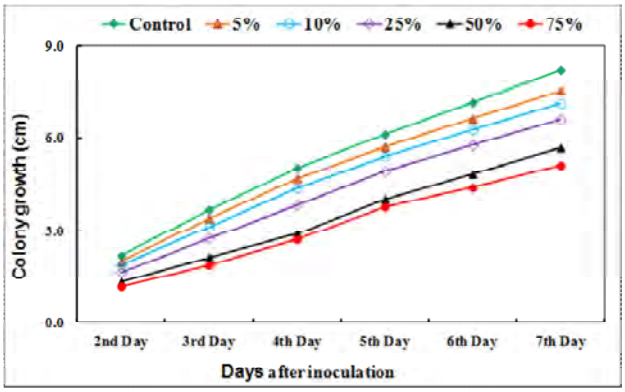


Fig. 3.4. Effect of non-volatile compounds produced by *Trichoderma viride* isolate NRCL T01 on growth of *Fusarium solani*

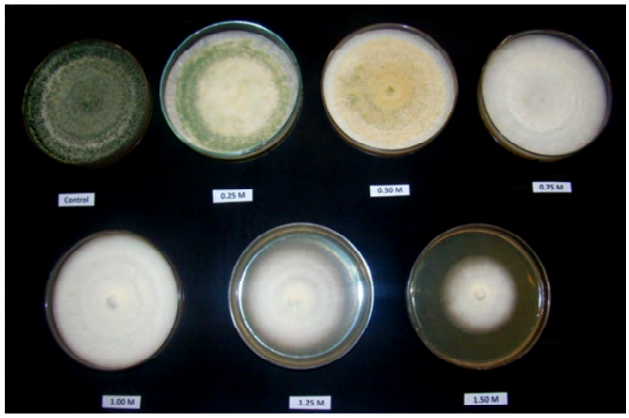


Fig. 3.5. Growth and colony morphology of *Trichoderma viride* isolate NRCL T01 at different NaCl salt concentration (Left to right: Top row- Control, 0.25 M, 0,50 M, 0.75 M; Bottom row-1.0 M, 1.25 M, 1.50 M)

Storage studies of NRCL *Trichoderma* formulation

The isolate of *Trichoderma viride,* NRCL T 01 isolated from rhizosophere of litchi at ICAR-National Research Centre on Litchi, Muzaffarpur has been found panacea for managing wilt caused by *Fusarium solani*. Besides controlling soil-borne pathogens, it has a good plant growth promotion activity and help air-layers to establish in field. A talc-based formulation was developed with minimum count in final product $2x10^6$ cfu/g (Fig. 3.6). Storage study and quality parameters of NRCL *Trichoderma*

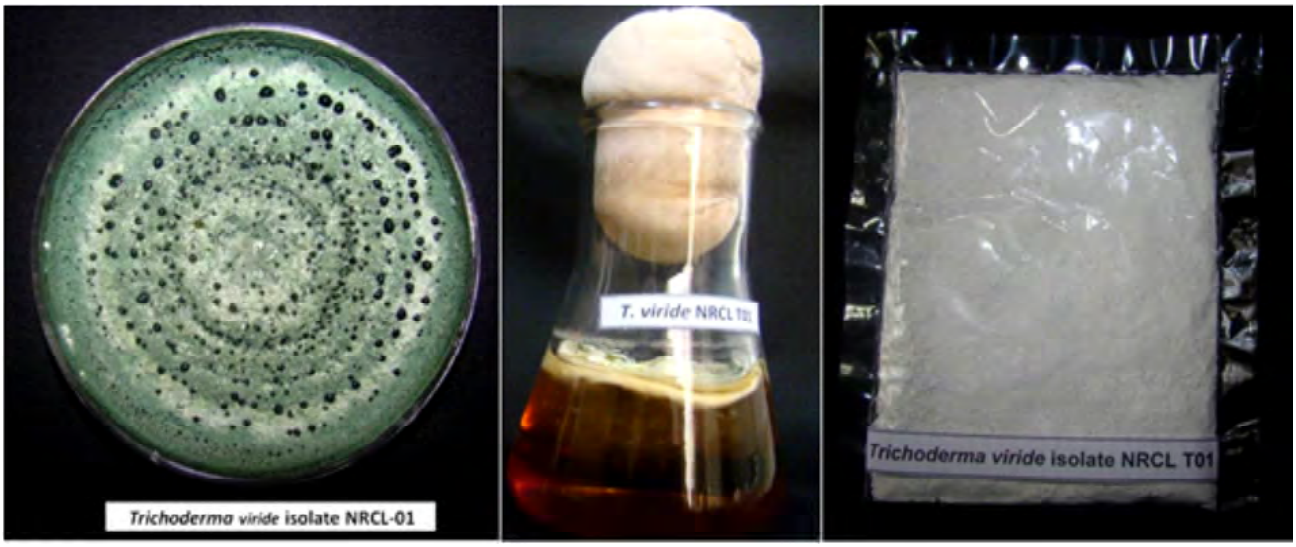


Fig. 3.6. Mass multiplication and formulation of efficient *Trichoderma viride* isolate NRCL T01

formulation was assayed after keeping it at 4 different temperature *viz.,* ambient condition, 28 °C, 4 °C and -15 °C. Initial count and moisture content were $5x10^6$ cfu/ml and 10% respectively, which remained almost constant at 4 °C but declined at other temperature when monitored at monthly interval for 6 months. No contaminants were found in the assay.

Studies on etiology of mortality of air-layered plants in nursery

The incidence of mortality (wilting) of air-layered plants in nurseries was up to 10%. Preliminary studies on etiology revealed that the initial roots developed in air-layers were white, puffy or inflated having fine secondary root and numerous root hairs that in due course degenerated with the development of fibrous root system in healthy plants. The root hairs of litchi were bi-layered with rippled wall. No root hairs were found on inflated roots of healthy plants. The diseased plants failed to develop fibrous root system (Fig. 3.7). A marked difference in cortex region was observed. The cortical cells in healthy roots were systematically arranged like white pebbles without any discolouration. In the diseased plant roots, cortex region had black discolouration (Fig. 3.8) and cells were loosely packed. Endodermis were multilayered in healthy with well-organized cells in vascular region while in diseased, endodermis was single layered with disorganized cells in vascular region. Though from the rhizosphere soil *Fusarium solani* was isolated, there was no evidence of plugging of vascular bundle by fungal hyphae. Primary reason of mortality appeared to be due to failure of plants to develop fibrous root system. A detail study of root anatomy and pathogencity test may lead to confirmation of etiology of mortality of plants in nursery.

Fig. 3.7. A: Wilting of air layered plants in nursery (Left) and healthy plant (Right), B: Initial roots of diseased (Left) and healthy (Right) plants, C: Fibrous root system developed in healthy air-layered plant (3 months old) in nursery

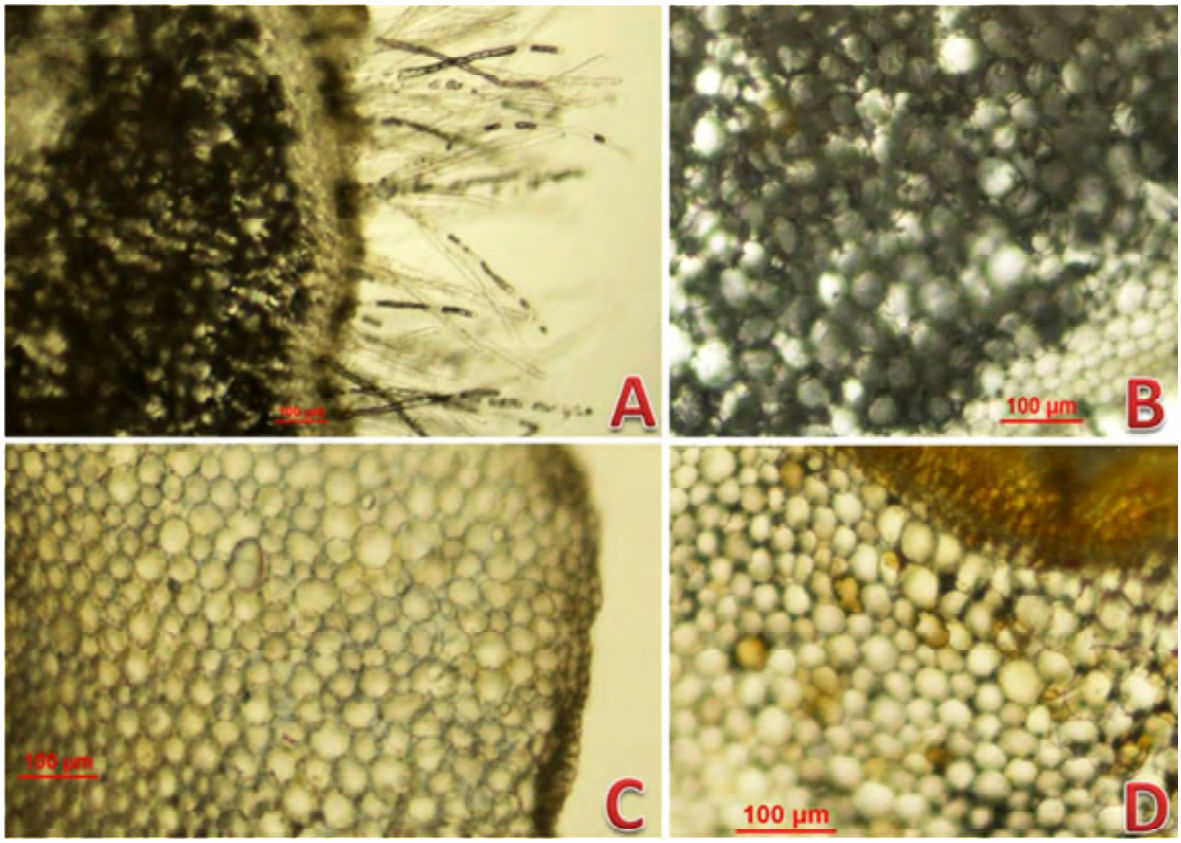


Fig. 3.8. Transverse section of inflated root of diseased and healthy air-layered plants. A: Epidermis and root hairs of diseased root, B: Cortex of diseased root, C: Epidermis in healthy root lacking root hairs D: Cortex in healthy roots

Studies on plant parasitic nematodes associated with litchi

Samples from five separated litchi experimental blocks of NRCL were analyzed for presence of plant parasitic nematodes with the help of nematologist at CISH, Lucknow. Analysis revealed the presence of three species in all the samples *viz*., ring nematode *Hemicriconemoides mangiferae*, lance nematode *Hoplolaimus indicus* and spiral nematode *Helicotylenchus dihystera*. Out of these, *Hemicriconemoides mangiferae* was the most prominent nematode species. The population density ranged between 0.0 to 1.8 nematodes/g soil which is far less than the pathogenic level of 6 nematodes/g soil. Nematodes at this population density can not cause economic damage to litchi plants and hence does not require any nematicide application.

3.2. Investigation and management of insect-pests complex in litchi (Kuldeep Srivastava and R.K. Patel)

Investigation and documentation of insect pests and natural enemies

Litchi fruit and seed borer, litchi shoot borer, leaf folder, litchi looper, ash weevil, litchi mite and red weevil have been recorded as major pests during 2014-2015 while, *Spodoptera litura*, *Spilosoma* sp., some unidentified lepidopteran defoliators, bag worm, litchi bug as minor pests. Several promising natural enemies' *viz*., *Praying mantis*, *Chrysoperla carnea*, *Eocanthecona furcellata*, syrphid flies, coccinellids, *Trichogramma* sp. and braconids have been observed during April 2014 to March 2015 in litchi ecosystem. Among pollinators, *apis viz., Apis dorsata*, *A. indica*, *A. mellifera* and non *apis viz*.,

hover fly, blue bot fly (*Calliphora* sp.), syrphid flies (*Metasysrphus* sp., *Eristalis tenax*) were recorded as pollinators of litchi. Presence of these pollinators was observed throughout the flowering period of litchi. Different species of coccinellids, damsel fly and dragon fly were also recorded as visitors on litchi flowers.

Seasonal incidence of major pests

Seasonal incidence of major pests in litchi was recorded from April 2014 to March 2015 at weekly interval (Table 3.2). Results revealed that incidence of all the major pests were observed throughout the study period except some std. weeks; 27th, 30th, IInd std. week in case of litchi looper, Ist std. week in case of ash weevil and 29th, 30th, 51st, 52nd, 1st std. week in case of red weevil with maximum and minimum population in the month of September-October and December-January, respectively. Leaf folder population showed fluctuating trend with minimum population (6.00) in 25th std. week (SW) and maximum (43.00) in 43rd SW. In case of litchi looper, no population was noticed in 27th SW and in fluctuating trend it reached up to 43.00 in 39th SW. Population of ash weevil was 4.00 in 14th SW while highest (50.00) in 42nd SW. In decreasing tune population of ash weevil reached 0.00 in 1st SW and again figured 4.33 in 12th SW. Red weevil population was 4.00 in 14th SW and reached up to 46.00 in 41st SW and again no population was observed from 51st SW to 1st SW.

Table 3.2. Seasonal incidence of major insect pests in litchi ecosystem

Std. week (SW)	Mean no. of insects/30cm shoot			
	Leaf folder (*Pletypeplus aprobola*)	Litchi looper (*Perixera illepidaria*)	Ash weevil (*Myllocerus undecimpus tulatusn*)	Red weevil (*Apoderus blandus*)
		2014		
14	15.00	0.33	2.33	4.00
15	15.00	1.00	10.00	16.00
16	13.33	10.33	10.66	5.33
17	14.33	13.33	5.33	5.33
18	19.33	11.66	6.66	8.66

Biology of litchi bug

Biology of litchi stink bug, *Tessaratoma javanica* (Thunberg) (Hemiptera: Tessaratomidae) was studied in field cages under natural field conditions (Fig. 3.9). In the field cages, one pair of adult bugs (one male and one female) was kept for recording data on fecundity and egg period, longevity and other biological parameters. Mating of the adults started from the second week of February, 2015. First egg mass was observed on the lower surface of tender leaves. A single egg cluster consisted mostly of 14 eggs. Normally, the adult female was found prefer to lay eggs on the lower surface of the young leaves but, egg laying was also found on upper surface of leaves and cages. The newly laid eggs were globular in shape, pink in colour but their colour became slightly blackish before hatching. The eggs were hatched in around 13 days. The mean developmental period of first instar was around 12 days. Parasitization by the unidentified hymenopteran egg parasitoids was also observed during investigation.

Fig. 3.9. Biology of litchi bug, A: Mating of adults, B: Egg cluster, C: Nymphs, D: Eggs parasitized

Biology of red weevil

Biology of red weevil was studied in field cages. Maximum incidence of adult weevils was observed in the month of September and October. Female adults laid eggs on tip of tender leaf and just after egg laying adults weevil rolled the entire leaf. In rolled leaves 1-3 yellowish colour eggs were observed. Moreover, eggs/grubs could not hatched/survived in open air (Fig. 3.10). Total life cycle was completed within 30-35 days in rolled leaves. Further study has to be conducted to observe biological parameters separately.

Fig. 3.10. A: Red weevil infestation, B: Red weevil grub

Development of IPM modules against lepidopteran defoliators

Field trials were conducted to manage lepidopteran defoliators using various IPM modules. Treatment$_1$ (Pruning of twigs in June) and Treatment$_2$ (T_1 + manuring the litchi trees with 4 kg of castor cake and 1 kg of neem cake) were imposed in last week of June and first week of July, respectively. First spraying was done on 15th September, 2015 and second spraying on 16th October, 2015. One day before spray, average minimum looper population (20 nos.) was noticed with treatment having manuring the litchi trees with 4 kg of castor cake and 1 kg of neem cake against 38 nos. in control (Table 3.3). Three days after spray, no population was noticed in all insecticidal treatments against 40.33 nos. in control. During 5th day observation, mostly treatments registered 0.00 looper population except T_3 and T_6 sprayed with Fipronil 5 SC (0.01%). Minimum looper population was observed with T_{11} i.e. spraying of Novaluron 10 EC (0.015%) at 15 days after spray. Similar trend was also observed during second spraying. In case of leaf folder similar trend was observed however, these molecules were less effective against leaf folder in comparison to litchi looper. Leaf folder population found minimum (10 nos.) in T_2 + Novaluron 10 EC (0.015%) against 78.67 nos. in control (Table 3.4).

Table 3.3. Effect of different IPM module against litchi looper

Treatments	Mean no. of litchi loopers (larvae/30 cm shoot)							
	First spray				Second spray			
	1st day before	3rd day after	5th day after	15th day after	1st day before	3rd day after	5th day after	15th day after
T_1- Pruning of twigs in June	26.67	27.67	28.00	35.00	46.67	56.33	62.33	69.33
T_2: T_1 + manuring the litchi trees with 4 kg of castor and 1 kg of neem cake	20.33	19.33	17.67	19.33	39.00	41.00	36.67	50.33
T_3: T_1 + Fipronil 5 SC (0.01%)	21.67	0.00	0.33	6.33	41.33	0.00	1.00	2.67
T_4: T_1 + Spinosad 45 SC (0.014%)	20.33	0.00	0.00	3.33	34.00	0.00	0.00	1.67
T_5: T_1 + Novaluron 10 EC (0.015%)	22.00	0.00	0.00	1.33	35.00	0.00	0.00	0.33
T_6: T_2 + Fipronil 5 SC (0.01%)	17.67	0.00	0.00	4.67	27.67	0.00	0.00	3.67
T_7: T_2 + Spinosad 45 SC (0.014%)	18.00	0.00	0.00	3.00	30.33	0.00	0.00	1.67
T_8: T_2 + Novaluron 10 EC (0.015%)	20.00	0.00	0.00	0.67	38.00	0.00	0.00	0.33
T_9: Spraying of Fipronil 5 SC (0.01%)	29.00	0.00	0.33	7.33	44.00	0.00	0.67	3.00
T_{10}: Spraying of Spinosad 45 SC (0.014%)	32.33	0.00	0.00	2.67	47.67	0.00	0.00	1.33
T_{11}: Spraying of Novaluron 10 EC (0.015%)	33.33	0.00	0.00	1.67	47.33	0.00	0.00	0.67
T_{12}: Control (no pruning, no spray)	38.00	40.33	45.33	56.00	62.00	72.33	77.67	80.33
CD (0.05)	5.04	2.99	2.59	2.60	6.38	3.33	2.42	3.31

Table 3.4. Effect of different IPM module against leaf folder

Treatments	Mean no. of leaf folder (larvae/ 30 cm shoot)							
	First spray				Second spray			
	1st day before	3rd day after	5th day after	15th day after	1st day before	3rd day after	5th day after	15th day after
T_1- Pruning of twigs in June	38.67	40.67	42.33	45.00	47.33	50.00	54.33	59.67
T_2: T_1 + manuring the litchi trees with 4 kg of castor and 1 kg of neem cake	36.33	39.00	40.67	48.00	42.67	45.33	48.33	52.00
T_3: T_1 + Fipronil 5 SC (0.01%)	38.67	14.00	11.33	14.00	40.00	13.33	11.67	14.67
T_4: T_1 + Spinosad 45 SC (0.014%)	40.00	16.33	13.00	16.67	38.00	12.00	8.00	13.33
T_5: T_1 + Novaluron 10 EC (0.015%)	41.33	20.00	16.33	22.00	34.33	15.00	10.33	17.67
T_6: T_2 + Fipronil 5 SC (0.01%)	36.00	12.00	10.67	15.00	34.67	10.33	9.00	16.67
T_7: T_2 + Spinosad 45 SC (0.014%)	34.33	10.33	9.00	14.67	30.33	8.33	6.33	12.33
T_8: T_2 + Novaluron 10 EC (0.015%)	34.33	7.67	7.67	10.00	29.00	9.00	6.00	14.00
T_9: Spraying of Fipronil 5 SC (0.01%)	49.00	38.00	37.67	46.33	40.67	30.00	25.67	32.67
T_{10}: Spraying of Spinosad 45 SC (0.014%)	54.33	47.33	40.00	48.67	49.67	40.33	29.67	38.67
T_{11}: Spraying of Novaluron 10 EC (0.015%)	54.67	46.00	41.00	45.67	51.00	42.33	30.00	45.00
T_{12}: Control (no pruning, no spray)	60.33	66.33	73.33	78.67	61.33	70.33	76.33	84.67
CD (0.05)	10.62	8.62	7.33	7.60	6.41	5.52	5.94	5.67

Development of IGRs based IPM modules against litchi fruit and seed borer

Experiment was conducted to manage litchi fruit & seed borer using different IGRs based modules *viz*., Lufenuron 5.4 EC 0.006%, Diflubenzuron 25 WP 0.03%, Buprofezin 25 SC 0.03% and Emamectin benzoate 5% SG 0.002% in combination with neem formulation (Table 3.5). Results showed that minimum fruit infestation (5.77%) was recorded with first spray of neem oil (3ml/l) before flower opening, second and third spray of Diflubenzuron 25 WP (0.03%) at clove stage fruit size and after 21 days of second spray against 45.8% in control, followed by Emamectin benzoate 5% SG 0.002% which registered 7.14% fruit infestation. Among IGRs, Buprofezin was least effective with 13.43% fruit infestation.

Table 3.5. Effect of different IGRs base IPM modules on litchi fruit borer infestation

Treatments	Fruit infestation (%)
Modules 1: Neem formulation 0.15% (3 ml/l) + Lufenuron 5.4 EC (0.006%)	8.50
Modules 2: Neem formulation 0.15% (3 ml/l) + Diflubenzuron 25 WP (0.03%)	5.77
Modules 3: Neem formulation 0.15% (3 ml/l) + Buprofezin 25 SC (0.03%)	13.43
Modules 4: Neem formulation 0.15% (3 ml/l) + Emamectin benzoate 5% SG (0.002%)	7.14
Control	45.8

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

Under organic farming, experiment was conducted for the management of litchi fruit & seed borer using various organic products and bio-pesticides *viz*. *Panchgavya* 3%, *Amrit Pani* 5%, biodynamic pesticides 5%, *Beauveria bassiana* 0.02% and *Metarhizium anisopliae* 0.02% (Table 3.6). Incidence of litchi fruit & seed borer in organic block was very less (8.56 % in control) may be due to initial utilization of different organic products. However, minimum fruit infestation (4.0%) was recorded with *Panchgavya* 3% followed by biodynamic pesticides 5% (4.35%).

Table 3.6. Effect of different organic/ bio-pesticides on litchi fruit borer infestation

Treatments	Fruit infestation (%)
Panchgavya 3% (30 ml/l)	4.0
Amtit Pani 5% (50 ml/l)	5.0
Biodynamic pesticide 5% (5 ml/l)	4.35
Beauveria bassiana 0.02% (2 g/l)	6.90
Metarhizum anisopliae 0.02% (2 g/l)	6.50
Control	8.56

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 (Sushil Kumar Purbey, Sanjay Kumar Singh, Vinod Kumar and Alemwati Pongener)

Standardization of maturity standards and harvesting of litchi fruits

Fruit growth and development of litchi cv.Shahi was studied continuously for five years and it has been found that irrespective of climatic variation during January and February, anthesis takes place in 2nd week of March, fruit set from mid-March and pulp development 40-44 days after flowering (DAF). Fruit quality is highly dependent on the climatic conditions of April to first week of May. In general, even 4-6 days continuous high temperature (>38 °C), westerly winds and low humidity (<50%) during this period may cause about 25% sunburn and cracking. TSS was recorded in the range of 7-10 °Brix at 50 DAF to 15-17.5 °Brix at 70 DAF. Acidity dropped by 50% at same interval. The proper maturity with >18 °Brix and 0.5% acidity were recorded at 75-78 DAF. Fruit weight increased exponentially from 35 DAF to approximately 70 DAF. The taste and bright red colour started dull at 72-75 days after fruit set.

4.2. Investigation and management of postharvest losses in litchi (S.K. Purbey, Vinod Kumar, Alemwati Pongener)

Standardization of improved packaging technique

A study was conducted continuously for two years to see the effect of morning harvesting, CFB and polyethylene lining onpostharvest losses during 2012-14 (Fig. 4.1). Litchi fruits were harvested early in the morning (up to 7 AM), packed in CFB box (450 × 300 × 250 mm) of 7 ply with perforated polyethylene lining on top and brown craft paper lining on rest side. These boxes were sent to Delhi through road transport (by truck) along with traditional wooden box packed fruits. Samples at wholesale market consisted of three categories *viz.,* random market samples in traditional wooden boxes, transported samples in traditional wooden box packing and transported samples in CFB boxes packing. The result revealed that the average loss (cracked or pressed + infected rotten fruits) at wholesale market on 4th days after harvest was 8.9-17.2% (mean 12.3%) and fruit having more than 50% browning was 10.6-23.3% (mean 15.5%). The average physiological loss in weight (PLW) was 7.07% in wooden box packed fruits whereas in improved CFB box packaging PLW reduced to 2.58% and spoilage only 4.30% during 2013-14. During 2012-13 the

Fig. 4.1. A: Traditional wooden packaging, B: Improved CFB box packaging, C: Control

physiological and pathological losses were 34.02% and 6.5% respectively in traditional packaging whereas in improved packaging of CFB boxes it was 16.7% and 2.2% only. This might be due to high moisture content and less fruit temperature of early harvested fruit as well as reduced moisture loss due to polyethylene lining better cushioning in CFB boxes.

Quantification of losses at different stages of fruits handling

During 2014-15 survey of local orchards and perception of farmers of mechanical or physical loss was about 6-8%.The loss at wholesale market of Mumbai was 42-46% on the 5th day after arrival of litchi from Muzaffarpur to Wasimandi, Mumbai. The loss at retailer market of Mumbai was about 56-65%.

Isolation of potential antagonists from fruit-plane

Four isolates of *Bacillus subtilis* and two isolates of antagonistic yeast were isolated from healthy fruit-plane during May 2014. These were later screened for their antagonistic potential both for prevention and curative ability against fruit rot pathogens *viz.*, *Alternaria alternata, Colletotrichum gloeosporioides, Aspergillus flavus* and *A. niger*.

Studies on management of postharvest losses

Effect of postharvest dip treatment on fruit rots of litchi: A laboratory experiment was conducted to evaluate various postharvest dip treatments to manage fruit rots (fruit decay)of litchi. A totalof 12 treatments with *Bacillus subtilis* (1×10^8 cell/ml), Potassium silicate (0.5%), Chitosan (1%), Carbendazim (0.2%) and their different combinations in three replicates (each having 30 fruits) were considered for the study of effect of postharvest dip treatment on fruit rots of litchi. Duration of dip treatments was 1 min. In control, fruits were dipped in distilled water. After the treatments, fruits were stored in aerated polythene bags at 32±2 °C temperature and 65±2% R.H. in the laboratory. Observations were recorded up to 10th days. The data on cumulative rotting revealed that all the treatments were effective in controlling fruit rots up to 6th day. Fruits in control treatment started rotting on 3rd day (68.3%) and completely rotten on 4th day (Fig. 4.2 & 4.3).

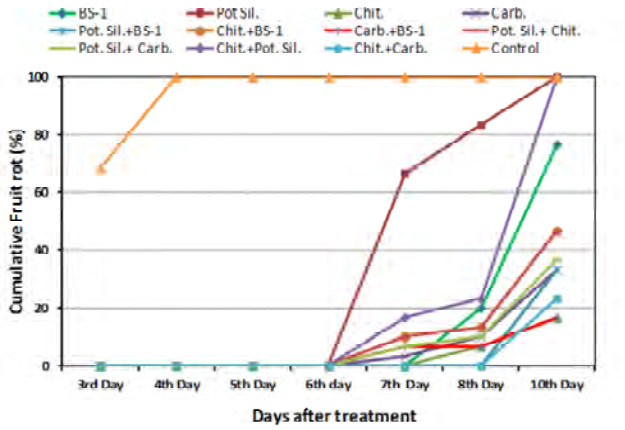


Fig. 4.2. Effect of various postharvest dip treatments on fruit rots

Fig. 4.3. Effect of postharvest treatments of fruits after six days of storage at ambient conditions (Left: Control, Right: Treated with *Bacillus subtilis* BS-1)

Evaluation for preventive ability of antagonists against fruit rots of litchi: A total of 8 antagonists (five *B. subtilis*, two yeasts and one *T. viride*) isolates were assayed for their preventative action against the four fruit rot pathogens of litchi. Litchi fruits were treated by dipping them into 70% alcohol for one minute, dried, and then dipped into a suspension of antagonist cells (1×10^8 cells /ml) for 1 minute. Three hours after drying, each fruit was sprayed with one ml of a conidial suspension of the

pathogen species at 1×10^6 conidia/ml, adjusted using a haemocytometer (Fig. 4.4). Two controls were maintained, in positive control fruits were sprayed with conidial suspension of pathogen and in the negative control fruit were sprayed with 1 ml of sterile distilled water. Fruits were kept in laboratory at ambient conditions (32±2 °C temp., 65±2% R.H.) for 10 days and observations were recorded on incidence of fruit rot, percentage surface area of the fruit covered by mycelium (PDI). The results showed because of the inoculums load of pathogen being too high, the antagonists could only partially overcome the pathogen. The most effective isolates against *A. alternata* were *B. subtilis* isolates BS-1 and BS-3, and *T. viride*NRCL T01; against *C. gloeosporioides* isolate BS-3, BS-4 and NRCL T01; against *A. flavus* isolate BS-1 and NRCL T01, and against *A. niger* BS-1 and yeast isolate Y2 (Fig. 4.5). The experiment will be repeated in ensuing season with reduced inoculums.

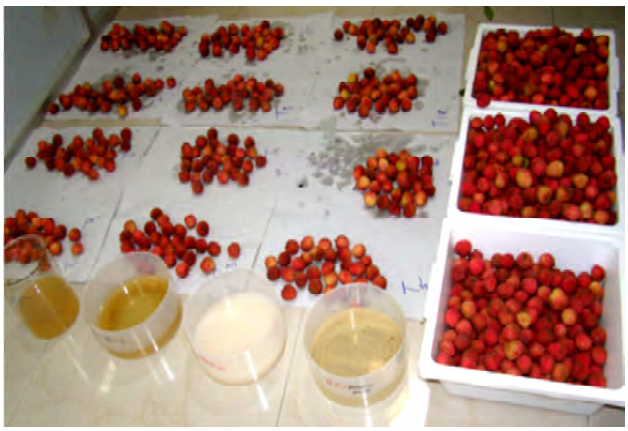


Fig. 4.4. Dip treatment of fruits for assay of preventive ability of antagonists to control fruit rots

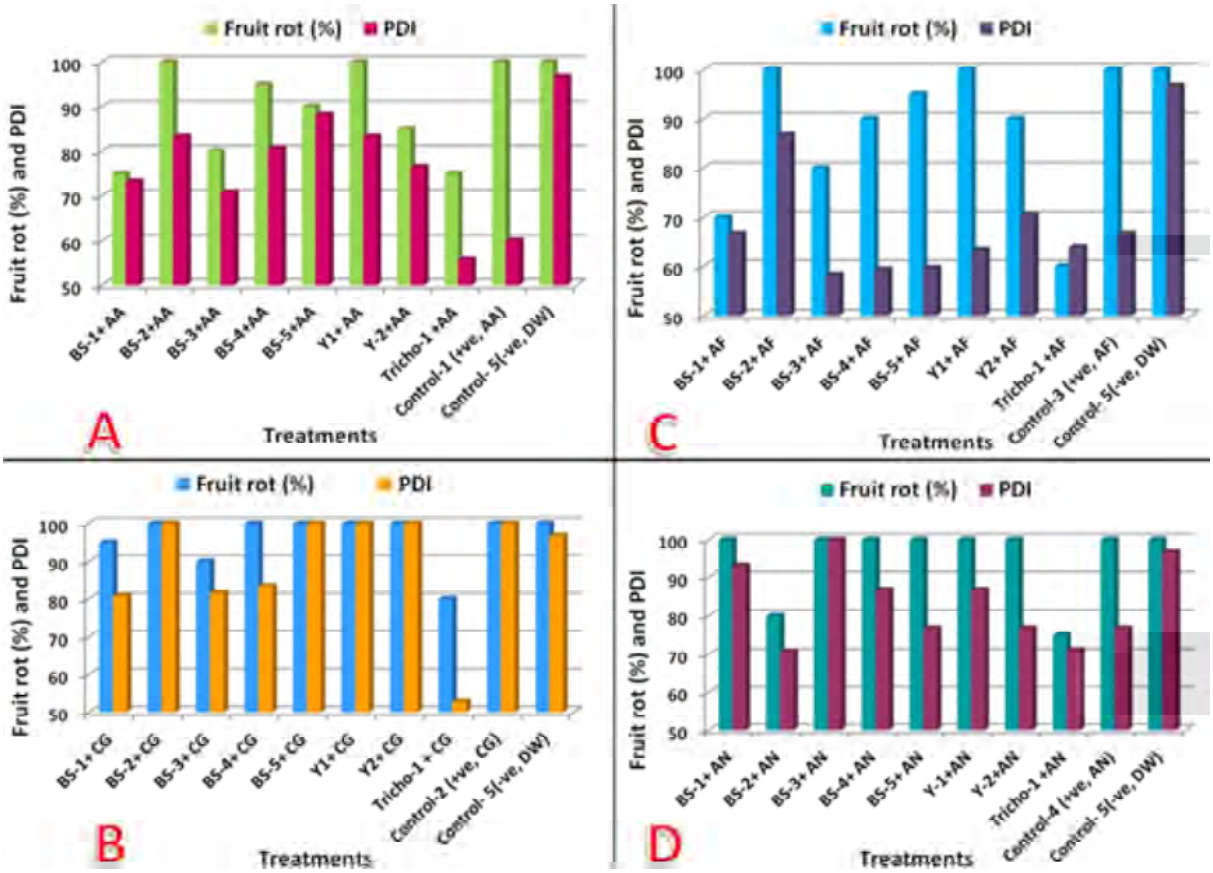


Fig. 4.5. Preventive ability of antagonists to control fruit rot pathogens *viz. A. alternata* (AA), *C. gloeosporioides* (CG), *A. flavus*(AF), and *A. niger* (AN)

Evaluation for curative ability of antagonists against fruit rots of litchi: Similar procedures, as described for preventive ability were followed. However, litchi fruit was dipped in suspension of pathogen cells (1×10^6 cells/ml) before treatment with each antagonist. After the fruits had dried for three hours, it was sprayed with one ml of the test organisms (*Bacillus,* yeast or *Trichoderma* at 1×10^8 cells/ml). The results of the study indicated that all the antagonists were effective against *A. alternata* reducing incidence as well as PDI. For *C. gloeosporioides*, *B. subtilis* isolate BS-5 and *T. viride* NRCL T01 was most effective while for *A. flavus,* all the isolates of *B. subtilis* and yeast were effective though the level of control was only up to 45%. None of the isolates could control incidence of rotting by *A. niger,* however, a reduced PDI was observed with the treatments. The results of the study clearly showed that use of a combination of antagonists will be a better option and hence in the ensuing season combination of antagonists will be assayed for their efficacy to manage fruit rots.

Effect of postharvest dip of antagonists on fruit rots and shelf life of litchi: Individual antagonist was tested by dip treatment to control fruit rots arising out of natural inoculums at ambient conditions. Among all, *B. subtilis* isolates, NRCL BS-1 was found most effective as zero fruit rot incidence and PDI was recorded as compared to control (100%) up to six days after treatment (Fig. 4.6).

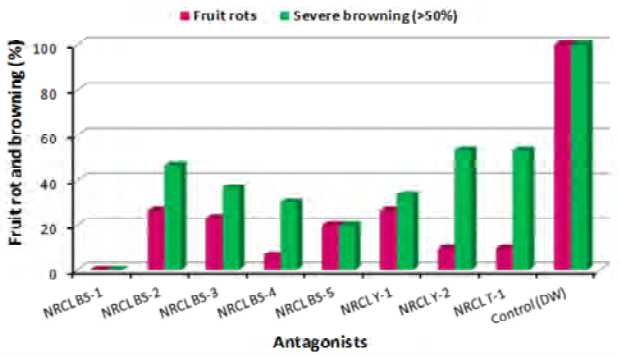


Fig. 4.6. Effect of dip treatment on incidence of fruit rots and browning of litchi fruits

Evaluation of non-woven polypropylene (PP) bags to study the effect of fruit bagging to improve litchi fruit quality

A test trial was conducted to evaluate the effect of non-woven polypropylene (PP) bags on litchi fruit quality. Fruit bunches of litchi were bagged with seven different types of bagging material (Fig. 4.7). The results showed that irrespective of bagging date and type, there was significant decrease in fruit borer infestation, sunburn, spotted and cracked fruits, with slight decrease in TSS and acidity. The physical appearance, weight and ascorbic acid content of fruit were significantly improved under all types of bags compared to un-bagged (control) fruits (Fig. 4.8). Results indicated that bagging of litchi bunches 40 days after anthesis with white butter paper bags gave the best result, followed by white

Fig. 4.7. Bagged fruits

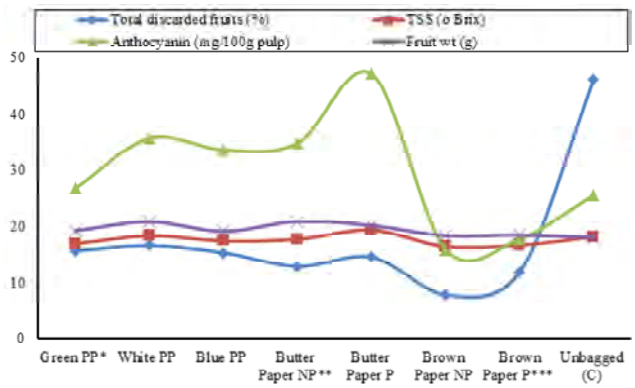


Fig. 4.8. Effect of bagging on fruit quality of litchi

non-woven PP bags. Bagged fruits recorded 30-35% less damaged fruits (sunburned and cracked) in comparison to control. Bagged fruits produced comparatively heavy and larger fruits with 6-16% more weight over control.

4.3. Processing and Value Addition in litchi (S.K. Purbey, Vinod Kumar and Alemwati Pongener)

Studies on preservation of litchi pulp

Litchi pulp was first pasteurized then treated with different levels of potassium metabisulfite (KMS) and kept at ambient and refrigerated conditions. This year again the same trend of result were observed. It was found that litchi pulp pasteurized and treated with 1500 ppm KMS is acceptable in quality and colour up to 10 months when kept at low temperature (6±1 °C) but light brown colour development started after five months of storage at ambient condition (35±1 °C) without affecting the other quality parameters (Table 4.1).Whereas, untreated pulp (control) spoiled just after 20 days of storage at ambient condition and 40 days at low temperature. A decreasing trend of TSS and increasing trend of acidity has been observed over a period of storage. Similarly, pulp colour turned dark brownish with increase in storage period. OD value at 420 nm showed the non-enzymatic browning index.

Table 4.1. Effect of preservation method on quality of litchi pulp over period of storage

Treatment	OD (420 nm) Storage period in months				Sensory evaluation after 9 month of storage		
	0	3	6	9	Colour	Aroma	Acceptability
T1	0.058	0.330	-	-	Dark brown	Fermented smell	-
T2	0.058	0.306	-	-	Brown	Fermented smell	-
T3	0.058	0.144	-	-	Brown	Fermented smell	-
T4	0.058	0.157	0.345	0.513	Brown	Fermented smell	6.70
T5	0.058	0.09	0.122	0.163	Light Yellowish	Rosy aroma	7.65
T6	0.058	0.07	0.102	0.124	Creamish	Rosy aroma	8.94

T_1 Litchi pulp pasteurised + AC, T_2 Litchi pulp pasteurised, + RC, T_3 Litchi pulp + 1000 ppm KMS + AC*, T_4 Litchi pulp + 1000 ppm KMS + RC**, T_5 Litchi pulp + 1500 ppm KMS + AC, T_6 Litchi pulp + 1500 ppm KMS + RC

Optimization of osmo-mechanical dehydration techniques for litchi pulp

An experiment was conducted on osmo-mechanical dehydration of litchi flesh pre-treated with sucrose solution of 30 to 60 °Brix in the fruit to solutionratio of 1:2 and 1:4comprising of eight treatments (T1- 1:4 + 60 °Brix; T2- 1:2 + 60 °Brix; T3- 1:4 + 50 °Brix; T4- 1:2 + 50 °Brix; T5- 1:4 + 40 °Brix; T6- 1:2 +40 °Brix; T7- 1:4 + 30 °Brix; T8- 1:2 + 30 °Brix), and were finally dried at 50±5 °C in hot air oven. The highest overall acceptability (7.96) with minimum hardiness (2749.52g) and drying time (15 hr) was recorded with T_4 followed by T_3, T_6 and T_5 after 9 months of storage (Fig. 4.9).Whereas, litchi flesh pre-treated with sucrose solution of 30 °Brix gave the minimum overall sensory score (5.66) with maximum hardiness (4192g) after same period. There was no significant effect of 40 and 50 °Brix strength solution and there fruit to solution ratio on quality parameters except the drying time and solute gain.

Fig. 4.9. Osmo-mechanical dehydrated litchi pulp, A: 1:4 pulp: osmotic solution, B: 1:2 pulp: osmotic solution

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

5.1. Tribal Sub Plan Project (S.D. Pandey)

Kashipur block of Rayagada district of Orissa located in the interior forest (at 500 km away from Bhubaneswar) was chosen as the location for the R&D activities where 86% of the population is rural, out of which 55.71% belongs to Scheduled Tribes and 13.95% Scheduled Caste. The economy of tribals in target area is based on output from shifting cultivation and forest including some other alternative livelihood options. Agriculture and forest, being important livelihood options, a significant proportion of tribal is engaged in such practices. More than 60% lands in the target area are high lands. The agro-climate of target area is very favourable for long (mango, litchi, cashew) and short duration (papaya and pineapple) fruit crops. February to late April is the months when food is sufficient to cater the need of many families. Normally, most of the families face food scarcity in the month of May to mid August. Mango and litchi comes under maturity from mid May to mid July in the area. As an age old tradition, horticultural crops are key assets during food shortage period in the area.

Objectives of the project

- To provide holistic growth of the horticulture sector through an area based regionally differentiated strategies which include research, technology promotion, extension and marketing.
- To enhance horticulture production, improve nutritional security and income support to farm households.
- To establish convergence and synergy among multiple on-going and planned programmes for horticulture development.
- To create opportunities for employment generation for skilled and unskilled persons, especially unemployed youth.

Planned strategies

- Ensure an end-to-end holistic approach covering production and marketing to assure appropriate returns to growers/producers.
- Enhance acreage, coverage, and productivity through:
  a) Diversification, from traditional crops to plantations, orchards and vegetable production.
  b) Extension of appropriate technology to the farmers for high-tech horticulture cultivation.
- Promote capacity-building and human resource development to stake holders and undertake evidence based research on various development themes.

Schedule of activities

- Identification of suitable area/villages for proposed activities in Kashipur block of Rayagada district.
- Establishing the fruit crop based model with suitable intercrops in the livelihood of tribals.
- Identification of critical food shortage period for scope of interventions.
- Technological support for area expansion and maintenance of existing new plantations under fruit crops.
- Soil and water conservation and plant health management.
- Development of marketing channel for local and distant market.

Progress report

Forty three acre area has been taken under plantation for mango and litchi at Bandel village of Rayagada district of Odisha. Mango plantation has been done and litchi plantation will be done in July 2015. Infrastructure of irrigation facilities and fencing has been created at the site.

5.2. North Eastern Hill (NEH) Component (Rajesh Kumar)

During the year 2014-15 two states, Nagaland and Assam, were undertaken for the strategic activities under the NE Region R&D project. Accordingly, the researchable issues and technological implementations to enhance litchi production and productivity were initiated and the progress report submitted. Interactions with scientists, PG students (Horticulture), and officials held through specific deliberations on technical aspects. The various meetings for strategic technological interventions/implementations of canopy management (2 ha), rejuvenation of old senile trees (5 ha) have been successfully attempted in Nagaland and Assam. Exhaustive discussions and strategic planning took place to initiate for strategic researchable issues and technological implementations through projects on litchi particularly at Assam Agricultural University, Jorhat, Assam. Survey visits and interactions/ meetings were held with the farmers at important litchi growing areas (Sonitpur and Tezpur) of Assam state.

Flagship Projects

6.1. Post harvest management with respect to pericarp browning and fruit decay (S.K. Purbey, Vinod Kumar, Alemwati Pongener, Swati Sharma, Evening Stone Marboh)

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

The litchi fruits were sprayed one month after full bloom with two different PGRs namely, GA_3 and Cytokinin, and 2nd spray was done one week before commercial harvesting date with four different anti-microbial compounds to study the effect on quality and shelf life. The spray of GA_3 (100 ppm) + potassium sulphate (1%) significantly reduced fruit cracking (14%) and fruit weight by 15% followed by cytokinin (6 ppm) + potassium sulphate (1%) and GA_3 (100 ppm) + potassium silicate (0.5%) or Carbendazim (0.1%) over control (Fig. 6.1 & 6.2). Minimum fungal infection (2.06%) was found with GA_3 (100 ppm) + Carbendazim (0.1%). Under postharvest dip treatment, Chitosan (1%) + *B. subtilis* @1 × 10^8cfu or Carbendazim (0.1%) was found effective in maintaining the quality of the fruits, along with enhancement of shelf life up to five days under ambient condition and 18 days at refrigerated condition.

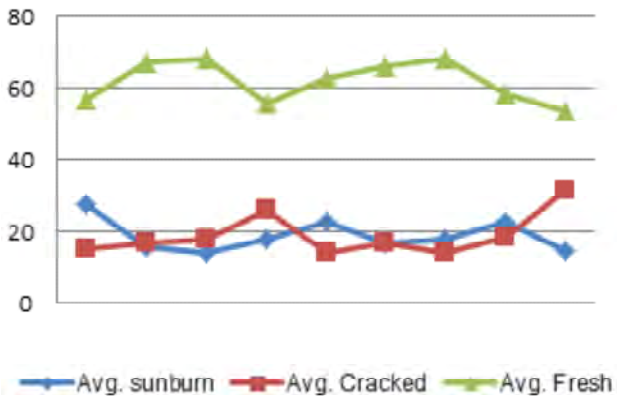


Fig. 6.1. Effect of variuos treatment on quality of litchi fruits

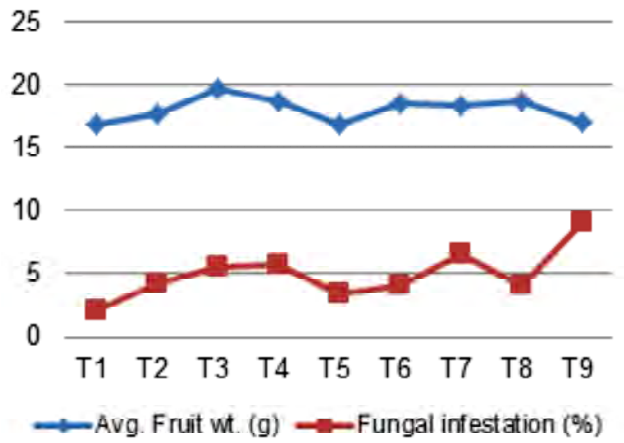


Fig. 6.2. Effect of various treatments on fruit quality

6.2. Shoot physiology in relation to flowering and fruiting of litchi (Sanjay Kumar Singh, Amrendra Kumar, Swati Sharma, and Evening Stone Marboh)

Analysis of shoot buds/leaves of floral and non-floral branches revealed that non-floral shoots of 'Shahi' and 'China' litchi recorded lesser content of reducing sugar, total sugar, Chl *'a'*, Chl *'b'* and Total Chl than floral shoots. The total phenol content of non-floral shoots exceeds over floral shoots (Table 6.1).

Table 6.1. Variation in biochemical parameters in floral and non-floral shoots during flowering in litchi cvs. Shahi and China

Variety	Shoot type	Leaf area (cm^2)	Total sugars (mg/100g fw)	Chl *'a'* (mg/100 g)	Chl *'b'* (mg/100 g)	Total Chl (mg/100 g)	Phenols (mg/100g fw)	Reducing sugars (mg/g)	Proline (mg/g)
Shahi	Floral	27.93	6.80	3.56	1.73	5.30	8.76	5.70	7.87
	Non floral	27.76	5.60	2.95	1.73	4.68	15.32	4.50	6.62
China	Floral	30.82	6.80	3.38	1.57	4.95	11.52	5.55	7.48
	Non floral	28.11	5.20	3.77	1.50	5.27	11.34	7.06	7.0

Externally Funded Projects

7.1. UNEP-GEF/TFT Project: Conservation and sustainable use of cultivated and wild tropical fruit diversity: promoting sustainable livelihoods, food security and ecosystem services: Pusa Site, Bihar (Vishal Nath, Sanjay Kumar Singh, Narayan Lal)

Registration of farmers' varieties of mango and pummelo with PPV&FRA, New Delhi

The duly filled proforma of farmer's variety (with farmers signature and endorsed by Director Research, RAU Pusa, Samastipur and Director, ICAR-NRC on Litchi, Muzaffarpur) on mango (16 nos.) and pummelo (10 nos.) identified at Pusa Site, Bihar under UNEP-GEF/TFT Project has been submitted to PPV&FRA, New Delhi as per following details:

Crop	Name	Candidate variety denominated as	Name of farmers'	Name of village
Mango (*Mangifera indica* L.)	Pusa Mango - 1	*Lal Pari*, Biju	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 2	*Madhukupia*, Biju	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 3	*Sukulia*, Biju	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 4	*Lali*, Biju	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 5	*Biju*, Mango	Sh. Upendra Thakur	Bhuskaul, Pusa
	Pusa Mango - 6	*Biju, Mango*	Sh. Kailash Prasad Rai	Jagdishpur, Pusa
	Pusa Mango - 7	*Alphanso, Biju*	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 8	*Malda, Biju*	Sh. Gaya Prasad Sharma	Bhuskaul, Pusa
	Pusa Mango - 9	*Sona Malda, Biju*	Sh. Raghupati Prasad Singh	Mahmada, Pusa
	Pusa Mango - 10	*Sipia, Biju*	Sh. Ramji Mahto	Mahmada, Pusa
	Pusa Mango - 12	*Sipia, Biju*	Sh. Rajesh Thakur	Malinagar, Pusa
	Pusa Mango - 13	*Biju Mango*	Sh. Ramrekha Thakur	Dhobgama, Pusa
	Pusa Mango - 14	*Sukul Selection*, Biju	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 15	*Malda, Biju*	Sh. Vinod Rai	Jagdishpur, Pusa
	Pusa Mango - 16	*Biju Mango*	Sh. Rajneshwar Thakur	Dhobgama, Pusa
	Pusa Mango - 17	*Madhuchinia, Biju*	Sh. Umesh Kumar Rai	Dighra, Pusa
Pummelo (*Citrus grandis*)	Pusa Pummelo - 1	-	Sh. Ram Kumar Rai	Narayanpur , Pusa
	Pusa Pummelo - 2	-	Sh. Jagdish Das	Narayanpur , Pusa
	Pusa Pummelo - 3	-	Sh. Upendra Pathak	Malinagar, Pusa
	Pusa Pummelo - 4	-	Sh. Kamal Rai	Mahmada, Pusa
	Pusa Pummelo - 7	-	Sh. Ramesh Rai	Narayan Pur, Pusa
	Pusa Pummelo - 8	-	Sh. Arun Kr. Rai	Mahmada, Pusa
	Pusa Pummelo - 9	-	Sh. Shankar Baitha	Malinagar, Pusa
	Pusa Pummelo - 10	-	Sh. Manoj Thakur	Malinagar, Pusa
	Pusa Pummelo - 11	-	Sh. Madan Thakur	Bhuskaul, Pusa
	Pusa Pummelo - 12	-	Sh. Dewendra Thakur	Malinagar, Pusa

So far, Pusa site has received acknowledgement of 12 mango varieties for registration from Registrar, PPV&FRA, New Delhi.

Identification of Custodian farmers and publication of their profiles

Profile of 12 Custodian farmers has been published and their varieties as farmer's varieties are under process to get registration with PPV&FRA, New Delhi.

Molecular characterization and publication of passport data of mango and pummelo germplasm as heirloom varieties

Thirteen germplasm of pummelo and 16 of mango is being characterized at IIHR Bangalore.

Imparting training on plant propagation, GAPs, plant protection measures and value addition for on-farm conservation

Training programme on 'Pickle making of seedling mango for value addition' was conducted at Malinagar Community, Pusa, Samastipur, Bihar, India, on 19th June, 2014, and on "Capacity building on good agricultural practices (GAPs) for mango diversity, livelihood and ecosystem services" at Malinagar, Pusa on 6th August, 2014 and at Madanpur-Malinagar, Pusa on 19th October, 2014.

Promotion and marketing of value added products of mango and pummelo by SHGs

Inputs for pickle making was given to three women SHGs. Ninety six kilogram (96 kg) of three types (wet, dry and mixed) of mango pickles prepared by four SHGs (Fig 7.1) has been promoted as a premier product. Mango pickles were successfully marketed in the local and district market, and were also sold at *kisan melas*/exhibitions.

Major cities such as Hyderabad, Mumbai, Chennai, Bangalore were identified as potential market for pummelo fruit. Three thousand pummelo fruits were sold in Secunderabad/Hyderabad market by members of two SHGs of Malinagar community and profit earned up to 30-35 per cent.

Fig. 7.1. A: Indigenous method of mango pickle preparation by the community; B: Member of women SHGs

Establishment of community nursery and diversity orchards

Four community nurseries (Jagdishpur, Bhuskaul, Mahamada and Dighra community) were established at the community level, which have become source of planting material of unique varieties of mango and pummelo (Fig. 7.2). Seven diversity plots containing local varieties of TFTs have also been established at five places in association with SHGs members.

Mass multiplication and distribution of mango and pummelo saplings/plants

Through the community nurseries and nursery at the resource centre, 380 plants of mango and 80 plants of pummelo were distributed to 30 farmers of five communities (Fig. 7.2). Eight plants of two mango varieties were also distributed to three farmers belonging to outside community villages.

Documentary on project accomplishment activities

Two documentary videos (one each in English and Hindi) were made on project accomplishment of various activities of Pusa site, including indigenous methods of pickle preparation by the women SHGs.

Fig. 7.2. A: Establishment of community nursery; B: Distribution of grafted/budded plants of mango/pummelo

Community mobilization and formation of SHGs

The DHAN Foundation has established 40 SHGs till date for mango, pummelo production, and its value-addition. Each SHG has own CBM funds to run the same. Micro credit to SHGs was facilitated through DHAN Foundation personnel.

Documentation of Traditional Knowledge (TKs) on *on-farm* conservation

Three TKs was documented through information gathered through community and validated by Mr. B.S. Somashekhar, Tumkur, Karnataka based expert on TK documentation as

a) Conservation of pummelo in home stead through *Chhat* Puja

b) Multi fruits home stead garden and

c) Multi-varieties mango orchard

Exposure visits of farmers and participation in diversity fairs

Identified custodian farmer have been motivated to conserve maximum number of biodiversity through exposure visit to various institutions and imparting training programmes. Eight custodian farmers were taken on an exposure trip to IIHR, Bangalore, College of Forestry, Sirsi,

Fig. 7.3. Felicitation of custodian farmers of the country at IIHR, Bangalore (First from right, Mr. Vijay Kumar Sharma from Pusa, Bihar)

Karnataka (Fig. 7.3) and Chittoor Site, Andhra Pradesh. Two farmers took part in mango show at BAU, Sabour, Bhagalpur on 9th and 10th June, 2014. Four farmers participated in mango diversity show at CISH, Lucknow on 28th and 29th June, 2014.

Stakeholders' meets conducted on conservation on mango and pummelo diversity

An interactive meet was organized under the chairmanship of Dr. V.A. Parthasarathy, National Project Co-ordinator of the project at Malinagar, Pusa, and cross talk/ interaction with farmers, traders, DHAN Foundation personnel was held. Project personnel interacted with DHAN Foundation personnel, KVK, Birauli; RAU, Pusa, Samstipur; ATMA, Samastipur; DDM, NABARD, Samastipur; DAO, Samastipur, and DHO, Samastipur on 4th July 2014.

Ex-post survey through focussed group discussion (FGD)

Project personnel participated in training programme at Mohammadpur Talukedari of Malihabad Site for FGD (FCA and MSC) as part of ex-post survey. This was done at five communities with two FGD in each village with FCA method at Pusa Site.

7.2. DBT Sponsored Project: Development of National Database on Mango (Vishal Nath, Sanjay Kumar Singh)

Fifteen districts of Bihar (Banka, Begusarai, Bhagalpur, Buxar, Darbhanga, Gopalganj, Khagaria, Muzaffarpur, Nawada, Samastipur, Saharsa, Shekhpura, Supaul, Vaishali, and West Champaran) were surveyed to collect district level information like name of farmers who grows and maintains more than ten mango varieties in their orchard, information on fruit usage, methods of value addition, medicinal usages and cultural practices followed in the orchard. Information on medicinal practices and TKs was also collected from various districts. The database on major diseases and pests of mango including prevalent protection measures, harvesting season, harvesting and packaging methods were also collected under the project.

List of major mango growers and varietal diversity at different locations in some of the orchards was obtained from the concerned District

Table 7.1. Major commercial, unique, pickle purpose, sucking and table varieties of mango in 15 districts of Bihar

Sl. No.	District	Block	Major mango varieties	Major unique varieties	Important pickle varieties	Important sucking varieties	Important table varieties
1.	Begusarai	Matihani, Cheria, Bariarpur, Bakhri, Naokothi, Bachhwara	Malda, Bombai, Amrapali, Dashehari	Malda	Sukul	Bombai, Jarda	Malda
2.	Banka	Barahat, Amarpur,Bausi, Katoria	Malda, Bombai, Sukul, Sipia, Amrapali	Malda, Paharpur Sinduria	Sipia, Sukul	Bombai, Jarda.	Malda
3.	Bhagalpur	Pirpainti, Naugachhia, Kahalgaon, Nathnagar, Bihpur, Kharik, Narayanpur, Gopalpur	Malda, Bombai, Jarda	Jardalu	Gulabkhas, Jardalu.	Bombai, Jarda	Amrapali, Dashehari

4.	Buxar	Buxer Sadar, Dumraon, Itari	Sukul, Chausa, Sipia, Dashehari, Amrapali, Bombai	Lal Pari,	Sukul	Bombai, Amrapali	Malda, Chausa
5.	Darbhanga	Keoti, Benipur, Madhepur, Darbhanga Sadar, Manigachi, Singhwara	Malda, Bambai, Kishanbhog, Calcuttia, Paharpur Sinduria, Sukul, Zardalu, Amrapali, Dashehari, Gulabkhas	Malda, Bambai, Kishanbhog, Calcuttia, Dashehari,Gulabkhas	Kishanbhog, Calcuttia, Sukul, Sipia	Sukul	Dashehari, Langra, Chausa
6.	Gopalganj	Kuchaikot, Barauli, Sidhwaliya, Fulwaria, Thawe, Manjha, Gopalganj Sadar	Malda, Culcuttia Malda, Bombai, Chausa	Sabja, Chausa, Himsagar, Baramasi, Sindhu	Sukul, Bombai	Jarda, Bijju	Sabja, Sipia
7.	Khagaria	Parbatta,Gogri,Chautham,Khagaria,Beldaur,Mansi	Malda, Bombai, Amrapali, Dashehari	Malda	Sukul	Bombai, Jarda	Malda
8.	Muzaffarpur	Aurai ,Bandra,Sakra, Bochaha, Gaighat, Marwan	Malda , Bombai Green Jarda Kishanbhog,	Malda	Sukul	Malda	Sipia, Kishanbhog
9.	Nawada	Narhat, Akbarpur , Gobindpur,Hisua.	Malda, Bombai, Amrapali, Dashehari	Malda.	Sukul	Bombai, Jarda	Malda
10.	Samastipur	Kalyanpur, Pusa, Samstipur Sadar, Vidyapati nagar, Dalsingh sarai	Malda, Bombai, Kishanbhog, Paharpur Sinduria, Sukul	Malda, Chinia, Madhukupia	Bathua Calcuttia, Sukul	Sukul	Malda, Sukul, Sipia
11.	Saharsa	Simri Bakhtiyarpur, Labhatta, Sanbarsa, Patarghat	Malda, Jarda, Gulab Kash, Bombai	Malda	Fazli	Bombai, Jarda	Malda
12.	Shekhpura	Shekhpura, Barbigha	Malda,, Dashehari , Bambay, Amrapali	Malda	Sukul	Bombai	Malda
13.	Supaual	Supaul, Pipra, Kishanpur, Saraigargh,Partapganj, Basantpur, Nirmali	Malda, Bombai, Gulabkhas	Malda	Calcuttia, Malda, Beeju	Bombai	Malda
14.	Vaishali	Mahua, Raja Pakar, Jandaha, Patepur, Lalganj, Vaishali, Goraul, Bhagwanpur	Malda, Bombai, Sukul, Sipia,Amrapali	Malda, Paharpur Sinduria	Sipia, Sukul	Bombai, Jarda	Malda
15.	West Champaran	Maintara ,Gaunaha, Ram Nagar, Nautan Bairia	Malda (Danka), Sabuja Sukul, Sipia Bambai, Amrapali	Malda	Sukul	Sukul, Beeju	Malda

Horticultural Officers of various districts. In most of the districts, Jarda and Bombai are considered as the main sucking varieties, Malda as major table variety, Sukul and Fazli as varieties preferred for pickle-making. Malda exists as unique variety in 8 districts (Begusarai, Khagaria, Muzaffarpur,

Samastipur, Nawada, Saharsa, Shekhpura and Supaul) and Jardalu in Bhagalpur (Table-7.1). Darbhanga, Samastipur, Muzaffarpur, East Champaran, Vaishali, Bhagalpur and West Champaran are main mango producing districts of Bihar (Table 7.1).

During the survey, 86 farmers of seven districts of Bihar (Darbhanga, Gopalganj, Madhubani, Muzaffarpur, Samastipur, West Champaran and Vaishali) were questioned with set of questionnaire to update database on aforesaid parameters. Feedback of farmers of 21 blocks of seven districts of Bihar indicated that, maximum varieties of mango is grown and maintained by Sh. Vinod Kumar Rai, Jagdishpur, Samastipur (36 nos.) and Sh. Abdul Rahim, Kumarbagh, West Champaran (28 nos.). Sh. Vijay Kumar Sharma of Basuari, Samastipur is maintaining 20 varieties of mango, while Sh. Wasi Akhtar of Dharmparsa, Gopalganj, Sh. Harsh Ranjan of Hasanpur Vajhi, Muzaffarpur, and Sanjay Sharma of Malinagar, Samastipur are maintaining 19 varieties each in their orchard. Maximum number of varieties in an orchard (more than 10) is being maintained by mango orchardists (25 nos.) of Darbhanga district. Among all the districts surveyed, thirteen orchardists have maintained more than 15 varieties in their orchard (Table 7.2).

Table 7.2. List of mango orchardists of seven districts of Bihar maintaining more than 10 varieties

District	Block	Village	Name of orchardists	Varieties maintained
Vaishali	Goraual	Katarmala	Sh. Vipin Kumar Pandey	10
			Sh. Amrendra Pandey	11
			Sh. Shivchandra Pandey	12
			Sh. Madhusudan Pandey	10
	Lalganj	Namidih	Sh. Jitendra Singh	13
			Sh. Ashok Kumar Singh	14
			Sh. Manoj Kumar Singh	10
		Ghataro	Sh. Vijay Kumar Singh	12
			Sh. Baleshwer Singh	14
		Dhanushi	Sh. Anant Kumar Singh	14
			Sh. Dewendra Singh	13
			Sh. Pramod Kunwar	13
			Sh. Mithilesh Singh	14
		Ranipokhar	Sh. Kapildev Singh	14
Muzaffarpur	Mushahari	Nayagaon	Sh. Arun Kumar Tiwari	12
	Kanti	Shahbajpur	Sh. Ram Naresh Shahi	13
			Sh. Shailendra Kumar Shahi	13
			Sh. Pankaj Kumar Shahi	13
			Sh. Uma Shankar Prasad Singh	16
	Muraul	Vishunpur Bakhari	Sh. Sudhir Kumar Pandey	16
			Sh. Naval Kishor Prasad Singh	17
		Sambhu Nathpur, Dholi	Sh. Vishwanath Chaudhary	15
			Sh. Krishna Kumar Chaudhary	12
		Raini	Sh. Ashok Kumar Thakur	12
			Sh. Rajesh Jha	12
		Murliyachak	Sh. Lalbabu Thakur	10
	Sakra	Hasanpur Vajhi	Sh. Harsh Ranjan	19

Darbhanga	Bajitpur	Bajitpur	Sh. Mantun Thakur	10
	Biraul	Benk	Sh. Mannu Acharya	11
	South Jale	Jale	Sh. Dileep Kr. Dheer	10
			Sh. Prem Kr. Dheer	10
			Sh. Santikanandan Verma	10
	Darbhanga Sadar	Ranipur	Sh. Chandrashekhar Chaudhary	10
			Sh. Gobind Narayan Chaudhary	10
			Sh. Jay Kumar Jha	10
		Subhankar Pur	Sh. Ganpati Jha	10
	Keoti	Keoti	Sh. Abhiram Jha	10
			Sh. Ram Prasad Gupta	12
			Sh. Shyam Prasad Gupta	13
			Sh. Shristi Narayan Jha	10
	Benipur	Lavni	Sh. Dilip Kumar Jha	10
	Ashapur	Ashapur	Prof. Bimlendu Mishra	11
	Singhwara	Rampura	Sh. Amrendra Prakash Chaubey	10
		Hanuman nagar	Sh. Suresh Thakur	10
	Manigachhi	Chanaur	Sh. Dhiraj Kumar Singh	11
		Chak Raje	Sh. Pramod Nath Singh	16
		Gangauli	Sh. Baidya Nath Jha	10
			Sh. Gopal Jha	10
		Raje West	Sh. Braj Nath Chaudhary	10
			Sh. Hemneshwar Chaudhary	10
			Sh. Ram Chandra Rai	10
			Sh. Upendra Yadav	10
Madhubani	Jhanjharpur	Araria	Sh. Baidya Nath Jha	10
	Rajnagar	Shivipatti	Sh. Bimlendu Pathak	10
	Phulparas	Phulparash	Sh. Chiranjeev Jha	10
	Sakri	Kanhauli	Sh. Biplav Kumar Mishra	10
			Dr. A P Thakur	10
	Pandaul	Gangaur	Sh..Manoj Kumar	10
	Khajauli	Maharajpur	Sh. Nathuni Kumar	10
		Pali	Sh. Ramchandra Mishra	10
	Benipatti	Akaur	Sh. Ramashish Yadav	11
Samastipur	Pusa	Shrirampur	Sh. Ashwini Kumar	10
		Jagdishpur	Sh. Vinod Kumar Rai	36
			Sh. Kailash Prasad Rai	14
			Sh. Ravindra Nath Sharma	12
		Dhobgama	Sh. Arvind Kumar Thakur	13
			Sh. Rajneshwar Thakur	16
			Sh.Uday Kumar Sharma	10

		Bathua	Sh. Shivnath Thakur	10
		Mahmada	Sh. Pranay Kumar Singh	10
			Sh. Triloki Prasad Singh	11
		Dighra	Sh. Umesh Kumar Rai	12
	Kalyanpur	Basuari	Sh. Vijay Kumar Sharma	20
		Malinagar	Sh. Awadhesh Thakur	12
			Sh. Rajinder Thakur	15
		Bargama,	Sh. Sanjay Thakur	15
		Malinagar	Sh. Sanjay Sharma	19
		Dariha	Sh. Vijay Kumar Rai	10
	Dalsingh Sarai	Kewta	Dr. Chandra Kant Chaudhary	10
			Sh. Prabhat Kumar Chaudhar	10
			Sh. Uday Kumar Chaudhary	11
			Sh. Ujjawal Kumar Chaudhary	10
	Vidyapatinagar	Sahita-Tajpur	Sh. Arvind Kumar Singh	10
		Mirzapur	Sh. Prabhat Kumar Rai	10
Gopalganj	Majhagarh	Dhrma Parsa	Sh. Washi Akhtar	19
	Sidhwalia	Sher	Sh. Harendra Rai	12
West Champaran	Bettiah Sadar	Kumar Bagh	Sh. Abdul Rahim	28

7.3. ATMA Sponsered Project : Studies on feasibility of intercropping under partial shade of litchi (Amrendra Kumar, S.D. Pandey and R.K. Patel)

Turmeric, amorphophallus and colocassia were grown as intercrops in young litchi orchard consecutively for three years during 2012-14. The total yield (litchi + intercrops) was in increasing trend. Regular flowering and fruiting were obtained in litchi with fruit yield 32.56, 48.96 and 70.48 q/ha. The yield of turmeric was excellent in all the years which gave average yield of 156.42, 144.63 and 137.57 q/ha during 1st, 2nd and 3rd year, respectively.

The soil physical properties and nutrient status were improved in respect of soil pH (8.13), EC (0.15 dsm^{-1}), organic carbon (0.41%), available phosphorous (25.22 kg/ha), available potassium (134 kg/ha) and available nitrogen (146.33 kg/ha) over a period of 3 years as compared to initial status of soil pH (8.23), EC (0.08 dsm^{-1}), organic carbon (0.39%), available phosphorous (15.37 kg/ha), potassium (109 kg/ha) and nitrogen (91.38 kg/ha).

7.4. Consortia Research Platform (CRP) on borers (Kuldeep Srivastava and R.K. Patel)

Monitoring of litchi fruit borer was carried out using pheromone trap. First presence of litchi fruit borer was noticed in 7th standard week (4 adults/trap) and maximum number of adults (55 adults/trap) were observed in 14th standard week. Experiment on management of litchi fruit borer has been synthesized using five modules, *viz*., Module 1: Neem formulation 0.15% (3ml/l) + Chlorantranilprole 18.5% (0.006) , Module 2: Neem formulation 0.15% (3ml/l) + Chlorantranilprole 18.5% (0.007), Module 3: Neem formulation 0.15% (3 ml/l) + Neem formulation 0.15% (3 ml/l), Module 4: Neem formulation 0.15% (3 ml/l) + Release of arboreal *Trichogramma* and Module 5: Farmers practice.

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

(Vishal Nath and Dr. S.K. Purbey)

To implement IPR guidelines at the institute level, this scheme was sponsored by ICAR. The processes and technologies developed by various ICAR institutes need to be protected by some law after their registration with the Government bodies. The plant wealth available with the farmers also need some protection and for the owners of this wealth, the owners rights have also to be protected, so that they can have some benefit sharing from the material they owned.

Other Research and Development Programmes

8.1. Survey and surveillance of pollinators

The second year of foraging study with the apiculture unit (containing 120 boxes with honey bee colonies), has been completed. This was in continuity for maintenance and revenue generation along with research on foraging behavior including periods of out of season and main season. The recorded observation showed the similar trend and foraging bees were dominant between 06.00 am and 12.00 Noon and less active in the afternoon (2 to 4 PM). Bee movement (tracking) and other behaviors were recorded up to 06.00 PM. The difference was critically observed on odd weather days as seasonal variation. Other pollinating insects visit the blooming field crops/litchi flowers mostly between 6.30 am and afternoon. Honeybee pollination in litchi bloom has been found to influence the fruit-set significantly. Pollination benefits and fruit production in litchi, which have been recorded earlier, were confirmed as more fruit set was observed in the trees within the vicinity of honey bee boxes. The litchi orchard having no access of honeybees recorded late flowering and delay in fruit setting. The honey production efficiency was more in case of mustard crop as compared to litchi and vegetable crops.

8.2. Chemical and nutrient status of soil at research farm of ICAR-NRCL

A chemical and nutrient status study of research farm soil was conducted. Whole farm area was divided into different blocks and each block was sub divided into three blocks (Upper, Middle & Lower) as per the slope gradient and block size. Soils in ten replicates were sampled at a depth of 20 cm of each sub block and pooled together into a composite sample. Altogether 100 composite soil samples were collected for analysis in the laboratory. The data showed considerable varied soil condition in different blocks. Soil pH ranged from 7.90-9.40, EC 0.08-0.48 dsm^{-1}, organic carbon 0.09-0.85%, N 40.21-188.24 kg/ha, P_2O_5 18.28-82.26 kg/ha and, K_2O 66.0-308.0 kg/ha. In general, organic carbon content in the farm soil found low to medium; nitrogen and phosphorus content is medium, and potassium content is low.

8.3. Outreach activites for promotion of litchi

During the period, attempts were made to expand the area *viv-a-vis* knowledge of litchi in different states. After the responsibility of

Fig. Visit and interaction with scientists and farmers at A: Dhaulauan, B: Dehradun

monitoring litchi research work under AICRP fruits as Technical Co-ordinator, visits were made to different potential states and research centres. In this endeavour, visits were made to CHES, Chettali, FRS Pathankot, Mango and Litchi Research Station, Nagrota (H.P.), RHRC, Dhaulakuan, and IISWC, Dehradun. A brief report on such outreach activites is given as under.

Following a perusal of climatic regimes, a survey in the litchi growing areas in Southern India (Karnataka, Tamilnadu and Kerala), having higher attitude (more than 900 m altitude) was carried out in collaboration with IIHR-CHES, Chettali, Karnataka. The litchi plants are doing exceptionally well and demonstrated the possibility of area expansion in the region. The region has been identified as one of the potential areas for production of winter season litchi with at par quality of North India.

Visits were also made to Nagrota and Dhaulakuan in Himachal Pradesh where sizeable plantations of Shahi and China varieties of litchi exists. In Dhaulakuan, the fruit maturity time varies from 20th June to mid July, while in Nagrota the fruit matures by mid July. The research station at Dhaulakuan caters to the research needs of HP, plains of Uttarakand, Saharanpur in UP, and Yamunanagar of Haryana.

Human Resource Development

Participation of Scientists/Staff in conference/Seminar/Symposia/Workshop/Training/ Meeting during 2014-2015

Sl. No.	Title	Venue and Date	Participant (s)
1.	International Conference on Horticulture for Nutritional, Livelihood and Environmental Security in hills: opportunity and challenges	Kalimpong, Darjeeling 22-24thMay, 2014	Dr. Vinod Kumar
2.	Global Conference on Climate Smart Horticulture	NAU, Navsari, Gujarat, 28-31st May, 2014	Prof. (Dr.) Vishal Nath Dr. Rajesh Kumar Dr. Amrendra Kumar Dr. R.K. Patel Dr. Kuldeep Srivastava
3.	National Symposium on plant Pathology in Genomic era and the 66th Annual meeting of Indian Phytopathological Society, New Delhi	Raipur, 26-28th May, 2014	Dr. Vinod Kumar
4.	National Seminar Cum Workshop on Physiology of Flowering in Perennial Fruit Crops	ICAR-CISH, Lucknow, 24-26th May, 2014	Dr. Sanjay Kr. Singh
5.	Mango Diversity Fair and recognition functions of custodian farmers of different sites under UNEP-GEF Project	ICAR-IIHR, Bangalore 3rd June, 2014	Dr. Sanjay Kr. Singh
6.	Foundation day of National Academy of Agricultural Sciences (NAAS)	NASC, New Delhi, 5th June, 2014	Prof. (Dr.) Vishal Nath
7.	74th Research Council Meeting	RAU, Pusa on 24th June, 2014	Prof. (Dr.) Vishal Nath
8.	Annual workshop of ITMU's and BPD unit organized by ZTMU and BPD unit NIRJAFT, Kolkata	Kolkata, from 27-28th June, 2014	Dr. S.K. Purbey
9.	TRPM meeting and 10th NPSC Meeting of the project "Conservation and sustainable use of cultivated and wild tropical fruit diversity: Promoting sustainable livelihoods, food security and ecosystem services"	Bangalore, 10-12thJuly, 2014	Prof. (Dr.) Vishal Nath Dr. Sanjay Kr. Singh
10.	EFC meeting chaired by DG, ICAR with members of Finance ministry, Planning Commission	Krishi Bhawan, New Delhi, 14thJuly, 2014	Prof. (Dr.) Vishal Nath Dr. Sanjay Kr. Singh
11.	National symposium on natural resource management and sustainable hill farming system for food security	SKUAST, Jammu, J&K, 23-24th July, 2014	Dr. Kuldeep Srivastava Dr. R.K. Patel

12.	National Seminar on quality honey production for livelihood security	BAU, Sabour, Bhagalpur, Bihar, 05-06th August, 2014	Dr. Rajesh Kumar
13.	Workshop on CRP on borers in Network mode	IIHR, Bengaluru, 18-19th August, 2014	Dr. Kuldeep Srivastava
14.	International Training Programme on Pest Risk Analysis jointly organized by NIPHM and USDA	NIPHM, Hyderabad, 1-5th September, 2014	Dr. Kuldeep Srivastava
15.	'Writesop' under UNEP-GEF Project at Coorg, Karnataka and Indian Institute of Horticultural Research, Bangalore	ICAR-IIHR, Bangalore 1-6th September, 2014	Dr. Sanjay Kr. Singh
16.	International Conference on Pollinators Health and Use of Pesticides in Agriculture-global Perspective	CropLife, India New Delhi, 2nd September, 2014	Dr. Rajesh Kumar
17.	One day Review meeting of Externally Funded Projects	KAB-II, New Delhi, 23rd September, 2014	Dr. Sanjay Kr. Singh
18.	83rd Meeting of Board of Management	RAU, Pusa, Samastipur, Bihar on 27th September, 2014	Prof. (Dr.) Vishal Nath
19.	Krishi Vijay, 2014 organized by Dayal Group	Gwalior, 27-29th September, 2014	Prof. (Dr.) Vishal Nath
20.	National conference organized by "Sarvodaya Sarwa Sewa Sangh" through Sarvodya Samiti, Muzaffarpur and Muzaffarpur Vikas Mandal	Muzaffarpur , 11-12th October, 2014	Dr. Rajesh Kumar
21.	41st Foundation Day of ASRB	Pusa, New Delhi, 1st November, 2014	Prof. (Dr.) Vishal Nath
22.	Winter school on Hi-tech Intervention in fruit production for Enhancing the Productivity, Nutritional Quality and Value addition	ICAR-CIAH, Bikaner, 5-25th November, 2014	Sh. Narayan Lal
23.	6th Indian Horticulture Congress organized by the Horticultural Society of India	Coimbatore, Tamil Nadu, 6-9thNovember, 2014	Prof. (Dr.) Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Vinod Kumar
24.	Meeting of RFD Nodal officers of RSC under Horticulture Division at NASC, New Delhi for Half-Yearly Review of progress of RFD	NASC, New Delhi, 24th November, 2014	Dr. Vinod Kumar
25.	Discussion meeting on VISION-2050	Krishi Bhawan, New Delhi 26-27th November, 2014	Prof. (Dr.) Vishal Nath
26.	International Conference on Changing Scenario of Pest Problems in Agri-Horti Ecosystem and their Management organised by Entomological Research Association	MPUAT, Udaipur, Rajasthan, 27-29th November, 2014	Dr. Kuldeep Srivastava

27.	National Conference on Harmony with Nature in Context of Environmental issues and challenges of the 21st Century	Udaipur, 28-30thNovember, 2014	Dr. Amrendra Kumar Dr. Kuldeep Srivastava
28.	National Seminar on Pomegranate for Nutritional, Livelihood Security and Entrepreneurship Development	ICAR-NRCP, Sholapur, Maharashtra 5-7th December, 2014	Dr. Rajesh Kumar
29.	State level seminar and exhibition on "Uttarakhand mein audyanik vikas: wartman paridrisya awam sambhawanayen	Dehradun, Uttarakhand, 18-19th December, 2014	Dr. Rajesh Kumar
30.	Silver jubilee Symposium on Strategic Approach for Horticulture research, Education and Development-Way Forward	NASC, New Delhi, 26-27th December, 2014	Prof. (Dr.) Vishal Nath
31.	84th meeting of Board of Management	RAU, Pusa, Samastipur, Bihar 10th January, 2015	Prof. (Dr.) Vishal Nath
32.	Brain Storming Seminar on Accomplishment and Challenges in Tuber Crops Research in Bihar	TCA Dholi, 14th January, 2015	Prof. (Dr.) Vishal Nath
33.	Training cum Demonstration of tools and techniques of ex-post survey, FGD (GCA and MSC) for Pusa Site	Lucknow, 31st January, 2015	Dr. Sanjay Kr. Singh
34.	12th Agricultural Science Congress	NDRI, Karnal, 3-5th February, 2015	Prof. (Dr.) Vishal Nath
35.	National Entomologist Meet	IINRG, Ranchi, Jharkhand, 5-7th February, 2015	Dr. Kuldeep Srivastava
36.	International Conference on Technological Interventions in Agricultural Sciences for Enhanced Productivity, Nutritional Quality and Value addition (TIAS-2014)	CIH, Medziphema, Nagaland, 17-19th February, 2015	Dr. Rajesh Kumar
37.	Acute Encephalopathy outbreak investigations in Muzaffarpur outcome meeting	Nirman Bhawan, New Delhi, 27th February, 2015	Prof. (Dr.) Vishal Nath
38.	XXII Annual Workshop and group workers meeting of AICRP on fruits	MPUAT, Udaipur, Rajasthan, 26thFebruary-1stMarch, 2015	Prof. (Dr.) Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. Amrendra Kumar Dr. Kuldeep Srivastava
39.	State Level Seminar on Prospect of Horticulture Development in Eastern UP organized by District Horticulture Mission	Gorakhpur, 11th March, 2015	Prof. (Dr.) Vishal Nath

Meetings, Workshops and Events

Fish Farmer's Meet

Hon'ble Union Agriculture Minister Sh. Radha Mohan Singh inaugurated Fish Farmer's Meet on 26th December, 2014 at ICAR-NRCL Campus Muzaffarpur. About 1500 farmers from three Divisions comprising of 13 districts of Bihar participated in the Meet. The event was organized by ICAR-CIFE, Mumbai in coordination of NFDB, Hyderabad, and Fisheries Resources Department, Govt. of Bihar. ICAR-NRCL, Muzaffarpur being partner in Farming System Research, hosted the event. Minister in his address highlighted the vision of Govt. of India for overall development of agriculture in the country with special reference to agriculturally resource-rich state like Bihar. He stressed that effective and timely implementation of the schemes and larger participation of farmers can bring prosperity in the state. The Hon'ble Minister also released fingerlings of "Jayanti Rohu" at NRCL fish pond and appreciated the approach of litchi-based IFS model being developed at the Centre. A farmer-scientist interaction session was also organized on this occasion where the representative from NFDB, CIFE, Fish Resource Department, ICAR-RCER, Patna and College of Fisheries RAU, Pusa answered the queries of farmers.

Hon'ble minister of agriculture addressing the gathering

14th Foundation day 2014

On the occasion of 14th Foundation day celebration, an "All India Litchi Show, 2014 and Kisan Gosthi" was organized by the centre on 6th June, 2014. In the show, more than 70 entries of fresh litchi fruits (Shahi, China, Longia, Bedana, Mandraji) and packing of fruits, processed products like (Dried nut, Litchi squash, Litchi chutney, Litchi Khir, etc) were displayed by the progressive litchi growers of Muzaffarpur, Samastipur, Vaishali, East Champaran and Sitamarhi districts of Bihar. Among the entries, best litchi fruit displayed by the growers were awarded with prize and certificate in different categories. The centre has also displayed its various

A: Prof. Vishal Nath addressing the gathering on the occasion of 14th Foundation day; B: Dr. R.K. Mittal, VC, RAU, Pusa, inspecting the Litchi Show

processed products and litchi fruits of different varieties. In Kisan gosthi, about 200 progressive farmers including women farmers participated and took active part in the discussion. The Litchi Show was inaugurated by Dr. R. K. Mittal, Hon'ble VC, RAU, Pusa, Samastipur. One progressive farmer from each district was felicitated with memento, shawl and *Litchi Ratna* for their contribution in development of litchi in Bihar through adoption of improved litchi technology. The programme was coordinated by Dr. Amrendra Kumar, Dr. S.K. Purbey and Dr. R.K. Patel.

Hindi Chetna Maas

Hindi Chetna Maas was observed at ICAR-NRCL during 1-30th September, 2014. Various competitions were organized for popularizing usage and adoption of Hindi. Two Karyashala and four RKS meeting were organized during this period. The Centre received the third prize for commendable performance in implementing the official language policy of the union during year 2013-14 by Town Official Language Implementation Committee (**NRAKAS**), Muzaffarpur on 21.08.2014.

Swachh Bharat Abhiyan

Along with the rest of the country, the centre observed the *Swachh Bharat Abhiyan* on 2nd October, 2014. Prof. Vishal Nath recalled the ideals of Mahatma Gandhi towards cleanliness and hygiene, and later administered the oath of cleanliness to the staff of the centre. He encouraged the gathering to

ICAR-NRCL observing Swach Bharat Abhiyan on 2nd October, 2014

adopt cleanliness in every walk of life. He also motivated the staff and stressed on devoting time towards cleaning the surroundings. All the staff of the centre participated in cleaning the office premises and residential quarters.

Field Day on Good Agricultural Practices (GAPs)

A field day cum training was organized at Marh village in Jammu district of J&K in collaboration with SKUAST, Jammu on 23rd February, 2015 on good agriculture practices in litchi. About 60 persons participated in the programme. Prof. (Dr.) Virendra Kaul, Head, Department of Entomology, SKUAST inaugurated the programme. Dr. R.K. Gupta, Department of Entomology, SKUAST apprised the gathering on the area expansion under litchi in Jammu region and motivated the farmers to adopt good agricultural practices for improving

productivity. Dr. S.D. Pandey, Principal Scientist (Horticulture) demonstrated the techniques of nutrient application, canopy management, and water management to the gathering. Dr. Kuldeep Srivastava delivered a talk on importance of plant protection measures and showed the attack of different litchi pests and their nature of damage. Dr. Amrendra Kumar coordinated the function.

Field day at Jammu

Another similar field day was organized at Pathankot (Punjab) in collaboration with PAU, Ludhiana on 24th February, 2015, in which 55-60 farmers participated. A team of scientists (S.D. Pandey, Amrendra Kumar and Kuldeep Srivastava) delivered lectures and demonstrated practical knowhow on different aspects of good agricultural practices in litchi. The experts also discussed in length about the problems raised by farmers during interaction session. Team of scientist and staff of KVK, Gurudaspur, PAU, Ludhiana also visited the farm of a progressive farmer. The visit was coordinated by Mr. Nav Prem Singh of KVK, Gurdaspur.

Agricultural Education Day

Agricultural Education Day was organized by NRCL for school students at Holy Mission Senior Secondary School, Muzaffarpur on 5th September, 2014. About 120 students attended the programme. Lectures were delivered on the importance of agricultural education for the development of nation. Some of the motivated students showed keen interest to have a career in agricultural research and education. The programme was coordinated by Dr. Rajesh Kumar, Dr. Vinod Kumar, and Dr. R.K. Patel.

ICAR-NRCL participated in the East Zone ICAR Sports Meet 2014

ICAR-NRCL sent a 11-member contingent to participate in the East Zone ICAR Sports Meet 2014 held at ICAR-CRIJAF, Barrackpore, Kolkata, from 13-17th October, 2014. The contingent was led by Dr. S.K. Purbey as the Chief-de-Mission, and Sh. Ramji Giri as the team manager. The team participated in various sports events *viz.,* badminton, chess, carrom, long jump, shot put, javelin, cycling, track and field events.

Participants of ICAR-NRCL in the East Zone ICAR Sports Meet 2014

Distinguished Visitors

Hon'ble Union Agriculture Minister Sh. Radha Mohan Singh, visited ICAR-NRCL on 26th December, 2014

Hon'ble Union Agriculture Minister Sh. Radha Mohan Singh visited ICAR-NRCL on the occasion of Fish Farmer's Meet on 26th December, 2014.The minister addressed the gathering and made a strong mention of fisheries development in the mound, chaurs, rivers and other water bodies in Bihar in collaboration with NFDB and State Fisheries Department to bridge the huge gap of fish production and demand.

Hon'ble Minister of Agriculture planting a longan sapling at the centre's farm

Dr. T. Janakiram, ADG (Hort.), ICAR, New Delhi visited the centre on 20th December, 2014

Hon`ble ADG (Hort.) Dr. T. Janakiram, visited the centre on 20th December 2014. The ADG visited the experimental farm, nursery, and the laboratories, during which he was apprised of the ongoing research projects and experiments of the centre. The ADG also inaugurated the security room and interacted with scientists, administrative, finance and technical personnel of the centre during his visit.

Fig: A: Dr. T. Janakiram, ADG (Hort) interacting with scientists during field visit, B: Inauguration of the security post

Dr. Arvind Kumar, DDG (Education), ICAR, New Delhi & VC, RLBCAU, Jhansi, Uttar Pradesh visited the centre on 25th January, 2015

The hon`ble DDG (Education) visited the centre on 25th January, 2015. He had a tour of the ICAR-NRCL research and experimental farms and appreciated the ongoing research programme at the centre. He also made a visit of the various laboratories of the centre.

Besides visits of Union Agriculture Minister, ADG (Hort.) and DDG (Education) the centre also hosted to following distinguished visitors during 2014-15.

Sl. No.	Date of Visit	Name	Designation/affiliation
1.	23rd April, 2014	Dr. H.P. Singh	Former DDG (Hort.), ICAR, New Delhi
2.	25th April, 2014	Dr. V.A. Parthasarathy	NPC, UNEP-GEF Project and Ex-Director, IISR, Calicut
3.	6th June, 2014	Dr. R. K. Mittal	VC, RAU, Pusa, Samastipur
4.	6th June, 2014	Dr. Manoj Kumar	Head, CPRS, Patna
5.	6th June, 2014	Dr. I.S. Solanki	Head, IARI RS, Pusa, Samastipur
6.	6th June, 2014	Prof. P.K. Ray	Head, Department of Horticulture, RAU, Pusa, Samastipur
7.	16th July, 2014	Prof. W.S. Dhillon	Director, PHPTC, PAU, Ludhiana
8.	31st July, 2014	Dr. S. P. Ghosh	Former DDG (Hort.), ICAR, New Delhi
9.	31st July, 2014	Dr. Ranvir Singh	Pr. Scientist, SMD (Hort.), ICAR, New Delhi
10.	31st July, 2014	Dr. D.K. Shahi	Chairman cum Head, Soil Sciences, BAU, Ranchi
11.	21st August, 2014	Dr. H.S. Singh	Head, CHES, Bhubaneshwar
12.	18th October, 2014	Dr. H.P. Maheshwarappa	Project Coordinator (Palm), AICRP on Palm, ICAR-CPCRI, Kasargod, Kerala
13.	9th December, 2014	Dr. S.D. Singh	ADG (Inland Fisheries), ICAR, New Delhi
14.	26th December, 2014	Dr. Gopalji Trivedi	Former VC, RAU, Pusa, Samastipur
15.	26th December, 2014	Dr. W.S. Lakra	Vice Chancellor, CIFE, Mumbai
16.	26th December, 2014	Dr. Nishat Ahmad	Director, Dept. of Fisheries Resources, Govt. of Bihar
17.	26th December, 2014	Dr. S.C. Rai	Principal Scientist, College of Fisheries, RAU, Pusa, Samastipur
18.	20th March, 2015	Dr. N. Kumar	Former Dean, COH, TNAU, Coimbatore

Dr. S.P. Ghosh, Chairman RAC, inspecting the exotic germplasm covservation efforts at the centre

Dr. W.S. Dhillon, Former ADG (Hort) interacting with NRCL scientists during laboratory visit

Transfer of Technology

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

Sl. No.	Programme	Venue and date	Participating/Resource persons	No. of beneficiaries
1.	Farm Innovators Day	Harshidhi, Meenapur, Muzaffarpur, May, 2014	Dr. S.K. Purbey	80
2.	Workshop on "GI for Muzaffarpur Litchi" sponsored by TIFAC, DST, New Delhi	ICAR-NRCL, Muzaffarpur, on 6th June, 2014	Prof. Vishal Nath Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Vinod Kumar	125
3.	All India Litchi Show and Kisan Gosthi	ICAR-NRCL, Muzaffarpur, 6th June, 2014	Dr. Rajesh Kumar Dr. S.K Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Dr. Sanjay Kr. Singh Sh. Narayan Lal Sh. Rajiv Ranjan Rai Dr. Shyamji Mishra	125
4.	Training programme on Post harvest handling and processing of litchi fruits for B.Sc. Ag. students from BHU, Varanasi and SHIATS, Naini, Allahabad	ICAR-NRCL, Muzaffarpur, 16-22nd June, 2014	Prof. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Dr. Sanjay Kr. Singh Sh. Narayan Lal Dr. A. Pongener Sh. Rajiv Ranjan Rai	12

5.	Pickle making of seedling mango for value addition under UNEP-GEF/TFT Project	Malinagar, 19th June, 2014	Dr. Sanjay Kr. Singh Sh. Narayan Lal	75
6.	Pickle making of seedling mango for value addition under UNEP-GEF/TFT Project	Jagdishpur and Malinagar, 7th July, 2014	Dr. Sanjay Kr. Singh Sh. Narayan Lal	75
7.	Integrated disease and pest management for mango orchard under UNEP-GEF/TFT Project	Malinagar, Pusa Site, Bihar, 6th August, 2014	Dr. S.D. Pandey Dr.Kuldeep Srivastava Dr. S.K. Singh Sh Narayan Lal	50
8.	Interaction meets on "GAP in litchi" with farmers of Usra Bajar, Deoria, U.P. by Exposure visit by NHM and NHRD programme	ICAR-NRCL, Muzaffarpur, 27th August, 2014	Dr. S.K. Purbey	35
9.	"GAP in Litchi" sponsored by ATMA, Muzaffarpur for officials of State Agriculture Department, Govt. of Bihar	ICAR-NRCL, Muzaffarpur, 2-4th September, 2014	Prof. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. R.K. Patel Dr. Vinod Kumar Sh. Narayan Lal Dr. Alemwati Pongener Sh. Rajiv Ranjan Rai Dr. Shyamji Mishra	35
10.	Trainers Training on Intensive Horticulture, Protected cultivation, mushroom cultivation, and bee-keeping	ICAR-NRCL, Muzaffarpur, 4–13th September, 2014	Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. R.K. Patel Dr. Alemwati Pongener	6
11.	Scientist-Processor-Growers-Industries Meet. Traders/ growers/ processors including representative from Reliance Polymer division participated	ICAR-NRCL, Muzaffarpur, 23rd September, 2014	Prof. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Dr. Sanjay Kr. Singh Sh. Narayan Lal Dr. Alemwati Pongener	30

12.	HDP in Litchi sponsored by ATMA, Sheohar	ICAR-NRCL, Muzaffarpur, 8-9th October, 2015	Dr. S.D. Pandey Dr. S.K. Purbey Dr. Amrendra Kumar	20
13.	Value addition in pummelo and their uses under UNEP-GEF/TFT Project	Dhobgama, Pusa Site, 19th October, 2014	Dr. Sanjay Kr. Singh Sh. Narayan Lal	390
14.	Propagation of mango and GAPs in mango orchard under UNEP-GEF/TFT Project	Madanpur, Pusa Site, 19th October, 2014	Dr. Sanjay Kr. Singh Sh. Narayan Lal	25
15.	GAP in Litchi sponsored by ADH, Muzaffarpur	ICAR-NRCL, Muzaffarpur, 11-12th December, 2014	Dr. S.D. Pandey Dr. S.K. Purbey Dr. Amrendra Kumar	25
16.	Excursion/exposure visit of 9th and 10th class students from ICCM, Narauli, Muzaffarpur	ICAR-NRCL, Muzaffarpur, 17th December, 2014	Dr. S.K. Purbey Dr. Amrendra Kumar Dr. R.K. Patel Dr. Alemwati Pongener Sh. Rajiv Ranjan Rai	65
17.	Trainers` training on Bagwani and Bag Prabandhan" organized by ATMA, Muzaffarpur	ATMA Sabhagar, Muzaffarpur, 19-24th December, 2014	Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. Vinod Kumar	20
18.	GAP in Litchi sponsored by ATMA, Samastipur	ICAR-NRCL, Muzaffarpur, from 22-23rd December, 2014	Prof. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Sh. Narayan Lal Sh. Rajiv Ranjan Rai Dr. Shyamji Mishra	70
19.	Matasya Kisan Gosthi organised by CIFE, Mumbai	ICAR-NRCL, Muzaffarpur, on 26th December, 2014	Prof. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K Purbey Dr. R.K. Patel Dr. Vinod Kumar Dr. Sanjay Kr. Singh Sh. Narayan Lal Sh. Rajiv Ranjan Rai Dr. Shyamji Mishra	900

20.	GAP in Litchi sponsored by ATMA, Madhubani	ICAR-NRCL, Muzaffarpur, 19-23rd January, 2015	Dr. S.D. Pandey Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Sanjay Kr. Singh Dr. Kuldeep Srivastava	30
21.	National Kisan Mela	ICAR-IIVR, Varanasi, 30th January, 2015	Dr. Kuldeep Srivastava	120
22.	GAP in Litchi sponsored by ATMA, Bhagalpur	ICAR-NRCL, Muzaffarpur, 5-10th February, 2015	Prof. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Vinod Kumar Dr. Sanjay Kr. Singh Sh. Narayan Lal Dr. Alemwati Pongener Sh. Rajiv Ranjan Rai Dr. Shyamji Mishra	20
23.	Regional Agricultural Fair for Eastern Region	CPRS (ICAR-CPRI) Patna 19-21st February, 2015	Prof. Vishal Nath Dr. S.D. Pandey Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava Dr. R.K. Patel Dr. Sanjay Kr. Singh Sh. Narayan Lal Dr. Shyamji Mishra	390
24.	ICAR-NRCL Farm visit of farmers from West Singhbhum, Chaibasa, Jharkhand sponsored by ATMA	ICAR-NRCL, Muzaffarpur, 21st February, 2015	Dr. S.K. Purbey	25
25.	GAP in Litchi sponsored by ICAR-NRCL, Muzaffarpur	Pathankot, Punjab, 22nd February, 2015	Dr. S.D. Pandey Dr. Amrendra Kumar Dr. Kuldeep Srivastava	75
26.	ICAR-NRCL participated in Kisan mela and gosthi on Pariwaric Kheti-need and potential organised by BAU, Sabour, Bihar	Sabour, 1-2nd March, 2015	Sh. Narayan Lal	135

27.	Workshop on advances in production technology of banana and litchi cum farmer's fair, sponsored by KVK, Sargatia, (IIVR)	Kushinagar, Uttar Pradesh, 26th March, 2015	Prof. Vishal Nath Dr. R.K. Patel Sh. Alok Gupta	160
28.	ICAR-NRCL Farm visit of farmers from Sheohar district	ICAR-NRCL, Muzaffarpur, 21st March, 2015	Dr. S.K. Purbey	20
29.	ICAR-NRCL participated in Kisan mela and horticulture show, organised by RAU, Pusa, Bihar	Pusa, Samastipur, 14-16th March, 2015	Dr. Rajesh Kumar Dr. S.K. Purbey Dr. Amrendra Kumar Dr. R.K. Patel Dr. Vinod Kumar	150

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

Dr. S.D. Pandey

- Delivered lecture on high density planting in litchi (200 farmers) organized by DHO, Vaishali from 11-12th December, 2014.
- Delivered lecture on "Recent advances made in production technology of litchi" during Regional Agriculture Fair for East Zone, organized by CPRI, Shimla at CPRS, Patna on 20th February, 2015.

Dr. Rajesh Kumar

- Organized training programme at Mahuawa (21st September, 2014) and Kahjua Bakhari (23rd September, 2014) of East Champaran district.
- Organized training on 'Good Agricultural Practices in litchi' at DHO office Campus-Betiah (West Champaran) on 11th December, 2014, and at DHO office Campus, Motihari (East Champaran) on 12th December, 2014.
- Participated and conducted Kisan Gosthi at three places *viz.,* Siswa Bazar, Kotuwa Bazar and Nawada, Sangrampur organized by District Horticulture Office and ATMA, East Champaran on 3rd January, 2015.
- Invited as Expert (scientist) to provide technical support and guidance for "Rejuvenation technology for old senile unproductive fruit orchards" for enhancing the quality fruit production by Directorate of Horticulture and National Horticulture Mission, Government of Bihar, Patna.

Dr. S.K. Purbey

- Acted as resource person in workshop on "Hamara jal, hamara jeevan" at Muzaffarpur Collectorate organized by Department of water resource, Muzaffarpur, Govt. of Bihar on 22nd February, 2015.

Dr. Amrendra Kumar

- Acted as resource person and delivered a lecture on "Good Agricultural Practices in Litchi" on farmers training programme organized by ATMA and District Horticulture Officer, Samastipur on 1st March, 2015.

Dr. Kuldeep Srivastava

- Delivered lecture on Insect Pests Management in litchi-based intercropping. In: District level orientation programme at Kushinagar organized by SHDA, Gorakhpur on 26th September, 2014.

- Delivered lecture on Insect Pests Management in Horticultural crops organized by DHO, Vaishali during 11-12th December, 2014.
- Delivered lecture on Insect Pests Management in litchi ecosystem. In: 8 days ICAR model training course on "Bio-rational and biological approaches for eco-friendly pest management under fragile hill ecosystem" at SKUAST-J, Jammu on 23rd February, 2015.

Dr. R.K. Patel

- Delivered lecture on GAP on litchi organized by DHO, Vaishali during 11-12th December, 2014.
- Delivered lecture on GAP of litchi during farmers fair cum Kisan Gosthi organized by KVK, Kushinagar, Uttar Pradesh on 26th March, 2015.

Dr. Vinod Kumar

- Coordinated programme and delivered lecture on "Disease and pest management in litchi" and "Application of bio-fertilizers in litchi" during training programme on *Kisan Vigyanik Vartalaap - Uttam Krishi Kriyaein (Litchi)'* at Mahuawa, East Champaran, on 21st September, 2014, and at Khajua Bakhari, East Champaran, on 23rd September 2014.
- Lectures delivered on the topic "Insect-pests and disease management in litchi" during training programme on "*Uttam Krishi Kriyaein-Litchi*" organized under the aegis of *Mukhyamantri Bagwani Mission,* Govt. of Bihar, at Dumra, Sitamarhi, from 17-18th December, 2014.
- Participated and played active role in mobilization of more than 800 farmers/ fishermens to participate in the Fish Farmer's Meet, organized on 26th December, 2014 in the premises of NRC on Litchi, Mushahari, Muzaffarpur, Bihar.

Dr. Sanjay Kumar Singh

- Delivered a talk on *'Aam ke bagiche me uttam krishi kriyaye'* during training programme on 'GAPs in Mango/litchi orchard' at Bettiah, West Champaran on 11th December, 2014.
- Delivered a talks on '*Aam ke bagiche me uttam krishi kriyaye*' and '*Litchi phalon ka kayik vicar evam uska nidan*' to farmers during 5 days training programme on Hi-Tech Horticulture sponsored by ATMA, Samastipur on 27th March, 2015.

Television and radio talk

Dr. Rajesh Kumar

- Phone in live programme of Doordarshan Kendra, Patna on the topic "*Litchi ki uttam krishi kriyayon ka kriyanwayan*" broadcasted live from 5.30 - 6.00 PM on 21st April, 2014.
- Participated in *Krishi Darshan* programme of Doordarshan Kendra, Patna on the topic, "Bahuwarshiya phalon mein chatrak prabandhan" on 21st March, 2015.

Dr. Sanjay Kr. Singh

- Delivered a talk on *"Bael, papita, aur jamun ki kheti*" on Doordarshan Kendra, Patna, recorded on 30th April, 2014 and broadcasted on 5.30-6.00 pm of 13th May, 2014.

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 indigeneous and exotic germplasm, their characterization, evaluation, documentation and utilization	Prof. Vishal Nath	Dr. Rajesh Kumar Dr. Amrendra Kumar Sh. Narayan Lal Sh. A. K. Gupta Dr. Neetu Singh Kushwah
1.2	Developing improved cultivars in litchi	Prof. Vishal Nath	Dr. Rajesh Kumar Sh. Narayan Lal Sh. A. K. Gupta Dr. Neetu Singh Kushwah
2	***Development and refinement of integrated production technologies for improved productivity of litchi***		
2.1.	Plant propagation and nursery management in litchi	Dr. Rajesh Kumar	Dr. S.D. Pandey Dr. Amrendra Kumar Dr. Vinod Kumar Dr. R.K. Patel
2.2.	Development of sustainable production techniques in litchi	Dr. S.D. Pandey	Dr. Amrendra Kumar Dr. R.K. Patel Dr. Kuldeep Srivastava
2.3.	Investigation and establishing the physiological and biochemical relations for improved litchi production	Dr. Amrendra Kumar	Dr. S.D. Pandey Dr. Rajesh Kumar Dr. S.K. Purbey Dr. S.K. Singh Dr. R.K. Patel
2.4.	Studies on mycorrhizal association and role of bio-fertilizers for improved litchi production	Dr. Vinod Kumar	-
2.5.	Litchi-based cropping system for low-lying areas	Dr. R. K. Patel	Dr. S.D. Pandey Dr. S.K. Purbey Dr. Amrendra Kumar Dr. Kuldeep Srivastava
2.6.	Nutrient deficiency symptoms in litchi	Dr. Amrendra Kumar	Dr. S.D. Pandey Dr. R.K. Patel Dr. I.S. Singh
3	***Development and refinement of integrated crop protection technologies for improved productivity of litchi***		
3.1.	Investigation and management of pre-harvest diseases of litchi	Dr. Vinod Kumar	-
3.2.	Investigation and management of insect-pests complex in litchi	Dr. Kuldeep Srivastava	Dr. R.K. Patel

4	***Integrated postharvest management to reduce losses, improve marketing and product diversification***		
4.1.	Standardization of maturity standards, harvesting and postharvest handling techniques for litchi	Dr. S.K. Purbey	Dr. 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	
5.2.	Strategic research on North-Eastern Hill region	Dr. Rajesh Kumar	-
6	***Flagship projects***		
6.1.	Postharvest management with respect to pericarp browning and fruit decay	Dr. S.K. Purbey	Dr. Vinod Kumar Dr. Alemwati Pongener Dr. Swati Sharma Dr. Evening Stone Marboh
6.2.	Shoot physiology in relation to flowering and fruiting in litchi	Dr. Sanjay Kr. Singh	Dr. Amrendra Kumar Dr. Swati Sharma Dr. Evening Stone Marboh

Externally Funded Projects

Sl. No.	Title	Funding agency	PI & Co-PI
1.	Conservation and sustainable use of cultivated and wild tropical fruit diversity: promoting sustainable livelihoods, food security and ecosystem services	UNEP-GEF, Bioversity International, New Delhi	Dr. Vishal Nath Dr. Sanjay Kr. Singh (Site Co-ordinator) Sh. Narayan Lal
2.	Development of National Database on Mango	DBT, New Delhi	Dr. Vishal Nath Dr. Sanjay Kr. Singh Dr. Kuldeep Srivastava Dr. Alemwati Pongener
3.	Studies on the feasibility of intercropping under partial shade of litchi	ATMA, Muzaffarpur	Dr. Amrendra Kumar Dr. S.D. Pandey Dr. R.K. Patel
4.	Consortia Research Platform (CRP) on borers	ICAR, New Delhi	Dr. Kuldeep Srivastava Dr. R.K. Patel
5.	Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology scheme	ICAR, New Delhi	Dr. Vishal Nath Dr. S.K. Purbey (Nodal officer)

List of Publications

Research Papers

Dinesh, M.R., Rajan, S., Singh, S.K., Singh, I.P., Ravishankar, K.V., Reddy, B.M.C., Parthasarathy,V.A., Sthapit, B., Rao, V.R., and Sandya, B.S. 2015. Heirloom/ Seedling mango varieties of India: Potentialities and future. *Indian Journal of Plant Genetic Resources* **28**:139-152.

Gajanana, T.M., Dinesh, M.R., Rajan, S., Vasudeva, R., Singh, S.K., Lamers, H.A.H., Parthasarathy, V.A., Sthapit, B., and Rao, V.R. 2015. Motivation for on-farm conservation of mango (*Mangifera indica*) diversity in India: a case study. *Indian Journal of Plant Genetic Resources* **28**:1-6.

Gajanana, T.M., Rajan, S., Singh, I.P., Dinesh, M.R., Vasudeva, R., Singh, S.K., Lamers, H., Parthasarathy, V.A., Sthapit, B., and Rao V.R. 2015. Fruit Diversity Fair and on-farm conservation: an Indian experience. *Indian Journal of Plant Genetic Resources* **28**: 80-86.

Gupta, R.K., Gani, M., Jasrotia, P., Srivastava, K., and Kaul, V. 2014. A comparison of infectivity between polyhedra of the *Spodoptera litura* multiple nucleopolyhedrovirus before and after passage through the gut of the stink bug, *Eocanthecona furcellata*. *Journal of Insect Science* **14**(96). Available online: http://www.insectscience.org/14.96.

Haider, P., Kishore, R., and Kumar, R. 2014. Application of expert system in the field of Horticulture. *International Journal of Advanced Biotechnology and Research* **5**: 725-730.

Kumar, A., Pandey, S.D., Patel, R.K., Rai, R.R., Srivastava, K., and Nath, V. 2014. Studies on feasibility of intercropping under litchi based cropping system. *The Ecoscan* **8**: 101-109.

Kumar, A., Pandey, S.D., Rai, R.R., and Nath, V. 2014. Evaluation of alternate media to potting mixtures for raising litchi quality planting material in polybags. *The Bioscan* **9**: 381-384.

Kumar, A., Srivastava, K., Patel, R.K., and Nath, V. 2014. Management of litchi fruit borer and litchi mite using bio-rational approaches under subtropics of Bihar. *The Ecoscan* **8**: 285-289.

Kumar, H., Kotoky, U., Lal, N., Kumar, J., Sinha, K., and Anal, A.K.D. 2015.Effect of drip fertigation on yield and productivity of guava (*Psidium guajava* L.). *Trends in Biosciences* **8**: 555-558.

Kumar, J., Phookan, D.B., Lal, N., Kumar, H., Sinha, K., Hazarika, M., Anal, A.K.D., and Kumar, R. 2015. Effect of organic manure and bio-fertilizers on yield and yield attributes characteristic of cabbage *(Brassica oleracea* L. *var. Capitata)* cv. Golden Acre. *Trends in Biosciences* **8**: 672-677.

Kumar, R. 2014. Economic feasibility of rejuvenation technology in litchi for enhancing quality fruit production and sustainability. *Journal of Community Mobilization and Sustainable Development* **9**: 134-139.

Kumar, R. 2014. Effect of pruning operation and nutrition on fruit yield and quality of litchi (*Litchi chinensis* Sonn.). *Indian Journal of Agricultural Sciences* **84**: 977-981.

Kumar, R. 2015. Rejuvenating old, senile orchards of tropical and subtropical fruits for enhanced production and improved quality: A review. *Indian Journal of Agricultural Sciences* **85**: 295-313.

Kumar, R. and Kumar, V. 2014. Impact of pollination by European honey bee, *Apis mellifera* L. on the yield and quality of litchi (*Litchi chinensis* Sonn.) fruits in India. *Pest*

Management in Horticultural Ecosystems **20**: 127-132.

Kumar, R., and Kumar, V. 2014.Impact of pollination by European honeybee, *Apis mellifera* L. on the yield and quality of litchi (*Litchi chinensis* Sonn.) fruits in India. *Pest Management in Horticultural Ecosystems* **20**: 127-132.

Kumar, V., Anal, A.K.D., and Nath, V. 2014. Prevalence of some threatening pests and disease of litchi (*Litchi chinensis* Sonn.) in Bihar state of India. *Journal of Applied Horticulture* **16**: 235-240.

Kushwah, N.S., Ahmad, I., and Ali, S. (2014). Characterization of promoter of terminal flower1 (*TFL1*) gene of *Arabidopsis*. *Research Journal of Biotechnology* **9**: 35-40.

Mandal, S., Rath, C., Gupta, C.K., Nath, V. and Singh, H.S. 2014. Probing occurrence of phenylpropanoids in *Morinda citrifolia* in relation to foliar diseases. *Natural Product Research*. 1-8.

Marboh, E.S., Singh, A.K., Dubey, A.K., and Prakash, J. 2015. Analysis of genetic variability among citrus (*Citrus* spp) genotypes using morphological traits. *Indian Journal of Agricultural Sciences* **85**: 203-211.

Patel, R.K., Meitei, S.B., Kumar, A., Srivastava, K., Deka, B.C., Deshmukh, N.A. and Verma, V.K. 2014. Effect of leaf and fruit thinning on yield and quality of peach cv. Flordasun. *The Ecoscan*, Special Issue (VI): 467-471.

Patel, R.K., Singh, A., Prakash J., Nath, A. and Deka, B.C. 2014. Physico-biochemical changes during fruit growth, development and maturity in passion fruit genotypes. *Indian Journal of Horticulture* **71**: 486-493.

Pongener, A., Sagar, V., Pal, R.K., Asrey, R., Sharma, R.R., and Singh, S.K. 2014. Physiological and quality changes during postharvest ripening of purple passion fruit (*Passiflora edulis* Sims). *Fruits* **69**: 19-30.

Sharma, D., Abrol, D.P., Ahmad, H., Srivastava, K., and Jamwal, V.V.S. 2014. Plants for bees Brankad: *Adhatoda vasica* Nees. *Bee World* **91**: 49-50.

Sharma, D., Ahmad, H., Srivastava, K., and Jamwal, V.V.S. 2014. Screening of rose cultivars against rose aphid, *Macrosiphum rosae* L. (Hemiptera: Aphididae). *Indian Journal of Entomology* **76**: 262-263.

Sharma, S., and Sharma, R.R. 2014. Nitric oxide inhibits activities of PAL and PME enzymes and reduces chilling injury in 'Santa Rosa' Japanese plum (*Prunus salicina* Lindell). *Journal of Plant Biochemistry and Biotechnology* DOI 10.1007/s13562-014-0271-9.

Singh, A. and Nath, V. 2014.Variability in fruit physico-chemical characteristics of litchi *(Litchi chinensis)* in Tripura and Assam. *Indian Journal of Agricultural Sciences* 85: 113-117.

Singh, D., Radhakrishnan, T., Kumar, V., Bagwan, N.B., Basu, M.S., Dobaria, J.R., Mishra, G.P., and Chanda, S. 2015. Morphological and toxigenic variability in the *Aspergillus flavus* isolates from peanut (*Arachis hypogaea* L.) production system in Gujarat (India). *Journal of Environmental Biology* **36**: 441-449.

Singh, D., Radhakrishnan, T., Kumar, V., Bagwan, N.B., Basu, M.S., Dobaria, J.R., Mishra, G.P., and Chanda, S. 2015. Molecular characterization of *Aspergillus* section Flavi isolates collected from a major peanut cropping system of India using AFLP. *Brazilian Journal of Microbiology* 46 (3) : xxx-xxxx DOI: http://doi.org/10.1590/51517-838246320131115.

Singh, S.K., Singh, A., Nath, V., Parthasarathy, V.A., Sthapit, B., Rajan, S., and Vinoth, S. 2015. Genetic diversity in seedling populations of mango. *Indian Journal of Plant Genetic Resources* **28**: 123-131.

Singh, S.K., Singh, A., Nath, V., Parthasarathy, V.A., Sthapit, B., Rajan, S., and Vinoth, S. 2015. Pummelo in homestead garden: conservation through family farming. *Indian Journal of Plant Genetic Resources* **28**: 132-138.

Singh, S.K., Singh, I.P., Singh, A., Parthasarathy, V.A., and Vinoth, S. 2015. Pummelo [*Citrus grandis* (L.) Osbeck] diversity in India. *Indian Journal of Plant Genetic Resources* **28**: 44-49.

Singh, S.P., Saini, M.K., Singh, J., Pongener, A., and Sidhu, G.S. (2014). Postharvest application of abscisic acid promotes anthocyanins accumulation in pericarp of litchi fruit without adversely affecting postharvest quality. *Postharvest Biology and Technology* **96**: 14-22.

Vasudeva, R., Sthapit, B., Salma, I., Changtragoon, S., Arsanti, I.W., Gerten, D., Dum-ampai, N., Rajan, S., Dinesh, M.R., Singh, I.P., Singh, S.K., Reddy, B.M.C., Parthasarathy, V.A., and Rao, V.R. 2015.Use values and cultural importance of major tropical fruit trees: an analysis from 24 village sites across South and South East Asia. *Indian Journal of Plant Genetic Resources* **28**:17-30.

Papers in Seminars/Symposia/Conferences

Kumar, R. 2014. Analysing economic feasibility of rejuvenation technology in litchi for enhancing quality fruit production and sustainability. In: The 6thIndian Horticulture Congress-2014 (6-9 November, 2014), Coimbatore, India. pp175.

Kumar, R. 2014. Litchi mein chatrak prabandhan awam jirnodhar: naveentam taknik. In: Souvenir, State Level Seminar and Exhibition on "Uttarakhand Mein AudyanikVikas: Wartman Paridrisya Awam Sambhawanayen" (18-19 December, 2014), State Horticulture Mission, Department of Horticulture and Food Processing, Dehradun, Uttarakhand. pp 51-56.

Kumar, R. 2014. Rejuvenating senile unproductive pomegranate orchards for enhanced quality fruit production.In: Souvenir, National Seminar on Pomegranate for Nutritional, Livelihood Security and Entrepreneurship Development (5-7 December, 2014), ICAR-NRCP, Sholapur. pp 108-113.

Kumar, R. 2014. Technological challenges in adoption of gaps in litchi (*Litchi chinensis* Sonn.). In: Sodh Chintan: Scientific Articles (Eds. Srivastava, A.K., Singh, B., Patel, N.L., Ahlawat, T.R., and Singh, A.), Global conference on climate smart horticulture, (28-31 May, 2014), ASM Foundation, New Delhi. pp 180-186.

Kumar, R. 2014. Unlocking mystery of phase change and flowering in litchi (*Litchi chinensis* Sonn.) cultivars. In: Physiology of Flowering in Perennial Fruit Crops. National Seminar cum Workshop (24-26 May, 2014). pp 250-256.

Kumar, R. 2014. Vegetative growth characteristics, panicle emergence and flowering in litchi (*Litchi chinensis* Sonn.). In: National Seminar cum Workshop on Physiology of Flowering in Perennial Fruit Crops (24-26 May, 2014)

Kumar, R. 2015. Intervention of rejuvenation technology for transforming old senile fruit trees into young production phase. In: Conference book and souvenir (TIAS-2014). International conference on technological interventions in agricultural sciences for enhanced productivity, nutritional quality and value addition (17-19 February, 2015) at CIH, Medziphema, Nagaland. pp 3-4.

Kumar, R. 2015. Litchi phalotpadan par jalwayu pariwartan ka prabhaw. **In:** *Badalta Mausam: Upyukt Vaigyanik Kheti* (ICN:H/145/2015), Published by ICAR-IARI Regional Centre, Pusa, Samastipur. pp 77-81.

Kumar, R. 2015. Refinement of traditional equipments and processes for production of processed foods in litchi for better quality, higher capacity, energy efficiency and reduced drudgery to workers. In: Study material for workshop on "Innovation for enhancing industrial and entrepreneurship development on food processing in litchi, makhana and forest produce" under A2K+Scheme by Institute of Entrepreneurship Development (IED), Patna. pp 10-12.

Kumar, V., and Anal, A.K.D. 2014. Leaf blight of litchi (*Litchi chinensis* Sonn.) caused by *Alternaria alternata* (Fr.) Keissler: An important disease of nursery plants. In: National symposium on plant pathology in genomic eraand the 66th annual meeting of Indian Phyto pathological Society (26-28 May, 2014), Raipur, India.pp 78.

Kumar, V., Kumar, R., and Anal, A.K.D. 2014. Arbuscular mycorrhizal association, species diversity and factors influencing association with litchi trees. In: The 6th Indian Horticulture Congress-2014 (6-9 November, 2014), Coimbatore, India. 281 pp.

Kumar, V., Purbey, S.K., and Anal, A.K.D. 2014.Losses in litchi at harvest and supply chain in India. In: International conference on horticulture for nutritional, livelihood and environmental security in hills: opportunity and challenges (22-24 May, 2014), Kalimpong, Darjeeling, India. H7-8pp.

Nath, V., and Singh, S.K. 2014. Physiology of flowering in litchi in relation to shoot maturity. In: Souvenir of National Seminar-cum-Workshop on physiology of flowering in perennial fruit crops (Ed. Ravishankar *et al.*). The Society for Development of Subtropical Horticulture (SDSH), ICAR-CISH, Lucknow, Uttar Pradesh. pp 173-181.

Nath, V., Kumar, A., Patel, R.K., and Pandey, S.D. 2014.Underexploited exotic fruit crops of India. In: Souvenir and Abs. International Symposium on Innovations in Horticulture for Nutritional Security, Conserving Biodiversity and Poverty Alleviation (16-18 October, 2014), Lucknow, Uttar Pradesh, India. pp 12-23.

Nath, V., Kumar, A., Patel, R.K., Pandey, S.D., Srivastava, K., and Karunakaran, G. 2014. Potential of off-season litchi cultivation in humid tropical zones of Western ghats. In: Souvenir and Abs. National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits (1-3 December, 2014), CHES, Chettalli, Karnataka, India. pp 175-183.

Nath, V., Purbey, S.K., Kumar, R., Pandey, S.D., Kumar A., and Kumar, V. 2015. Litchi vikas hetu nayi taknikein. In: Souvenir- Purwanchal Kchetriya Krishi Mela- Gramin Ajiwika Surakcha ke Liye Bagwani. (Published by ICAR-CPRS, Patna). pp 42-49.

Nath, V., Singh, S.K., Lal, N., and Pongener, A. 2014. Pusa me aam ki jaiva vividhita. In: National Conference on Mango Diversity, production, postharvest management and exports (Edited by Patel *et al.*) (9-11 June, 2014), Bihar Agricultural University, Sabour, Bhagalpur. pp 1-8.

Pandey, S.D., Kumar, A., Patel, R.K., and Nath, V. 2014. Integrated nutrient and water management of litchi in Southern climatic condition of India. In: Souvenir and Abs. National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits (1-3 December, 2014), CHES, Chettalli, Karnataka, India. pp 226-231.

Pandey, S.D., Srivastava, K., Kumar, A., Patel, R.K., and Nath, V. 2015. Badlte mausom men litchi utpadan awam kit prabandhan Badalta Mausom: Upayukta Vagyanik Kheti (TCN:

H/145/2015). IARI Regional Station, Pusa. pp 82-89.

Purbey, S.K., and Kumar, A. 2014. Pre-harvest spray of chemicals to enhance the quality of litchi fruits (Abstract numbers VII/283). In: The 6thIndian Horticulture Congress-2014, (6-9 November, 2014), TNAU, Coimbatore.

Purbey, S.K., and Pongener, A. 2014. Effect of postharvest treatments on storage behaviour of litchi fruits (Abstract number VII/282). In: The 6th Indian Horticulture Congress-2014 (6-9 November, 2014), TNAU, Coimbatore.

Technical and Popular Articles

Kumar, R. 2014. Nagaland: Tapping potential of litchi cultivation. *Indian Horticulture* (September-October) **59**: 31-34.

Kumar, R. 2015. Litchi Mein Dahik Vikar Ki Samasaya Awam Nidan. In: *Adhunik Kisan-Unnat Takanik : Labhakari Krishi* (January-March) **44**: 35-40.

Kumar, R. 2015. Rejuvenation technology in litchi is economical too. *Indian Horticulture* (January-February) **60**: 32-34.

Kumar, V., and Anal, A.K.D. 2015. *Jaivik paddhati se litchi ki bagwani* (in Hindi). *Adhunik Kisan* (January-March) **44**: 29-34.

Kumar, V., and Nath, V. 2014. Managing pests and diseases of litchi for quality production. *Indian Horticulture* 59(3): 17-21.

Lal, N., Singh, S.K. and Nath, V. 2014. Litchi mein phal jhulsan va phatan. *Mrida Darpan*, *Varshik Hindi Krishi Patrika*, ICAR-NBSSLUP, Nagpur pp 29-33.

Nath, V. 2014. Litchi farming. Agriculture & Industry Survey. 28-33 pp.

Nath, V., Purbey, S.K., Kumar, R., Pandey, S.D., Kumar, A., and Kumar, V. 2015. *Litchi vikas hetu nayi takneekein*. *Smarika*, Purvanchal Kshetriya Krishi Mela, Regional Station-Central Potato Research Institute, Patna, Bihar. pp 42-49.

Srivastava, K., Nath, V., Pandey S.D., and Mishra, D.S. 2014. Hampered pollination results in abnormal litchi-fruits. *ICAR News* **20**: 23-24.

Srivastava, K., Patel R.K., Kumar, V., and Nath, V. 2014. Litchi-looper affects litchi production. *ICAR News 20*: 7.

Srivastava, K., Patel, R.K., Lal, N., Kumar, R., and Nath, V. 2014. Litchi ke pramukh keet awam unka prabandh. *Ikshu* (IISR, Lucknow) **3**: 62-65.

Books/Book Chapters

Arora, N.K., Gill, M.I.S., Boora, R.S., Patel, R.K., and Deshmukh, N.A. 2014. Guava. In: Tropical and Sub tropical Fruit Crops: Crop Improvement and Varietal Wealth Part- I (Ed. Ghosh, S.N.). Jaya Publishing House, Delhi. pp 335-361.

Dinesh, M.R., Vasudeva, R., Rajan, S., Singh, S.K., Singh, I.P., Gajanana, T.M., Vinoth, S., Reddy, B.M.C., Parthasarathy, V.A., and Sthapit, B. 2014. Custodian of Tropical Fruit Tree Genetic Resources in India, National Project Management Unit (UNEP-GEF/TFT Project), ICAR-Indian Institute of Horticultural Research, Bengaluru. pp 1-33.

Kumar, R. 2015. Climatic issues affecting sustainable litchi (*Litchi chinensis* Sonn.). In: Climate dynamics in horticultural science- Impact, Adaptation, and Mitigation (Vol. – 2), (Eds. Choudhary, M.L., Patel, V.B., Siddiqui, M.W., and Verma, R.B.). Published by Apple Academic Press of CRC Press Group. pp 95-110.

Kumar, R. 2015. Soil and water resources management in Bihar. In: Management of Soil and Water Resources for Sustainable Agricultural Production (Ed. Sarkar, A.K.), Publisher-Image Print Media, Udaipur. pp 132-174.

Kumar, V., Prasad, A.S., and Ranjan, M. 2014. Sustainable agriculture practices to meet environmental challenges in India. In: Environment- Issues, Impact and Management (Ed. Sharma, V.R.), Research India Press, New Delhi.

Mahajan, B.V.C and Pongener, A. 2015. Pre and Postharvest Management. In: Chadha, K.L. and Pal, R.K. (eds). Managing Postharvest Quality and Losses in Horticultural Crops.Daya Publishing House, New Delhi. pp89-110.

Nath, V. and Purbey, S.K. 2015. Post-Harvest Management of Litchi for Domestic and International Market In: Post-harvest management in Horticultural Crops. Vol. 2 Fruit Crops (Eds. KL Chadha and R.K. Pal). Astral International Pvt. Ltd., New Delhi: 441-460.

Nath, V., Pandey, S.D., Kumar, A., Patel, R.K., and Srivastava, K. 2015. Litchi UtpadanKi UnnatTaknik. Krishi Men Sabjiyon DwaraVividhikaran (ISBN 978-93-5212-271-4), (Edited by Singh *et al.*), IVRI, Varanasi. pp 186-193.

Nath, V., Patel, R.K., and Purbey, S.K. 2014.Litchi technologies for sustainable production and rural development. In: Innovative and Modern Technologies for Sustainable Agriculture & Rural Development (Eds.Pandey, A.K., Pandey, G., and Pant, H.). Published by Society of Biological Sciences & Rural Development, Allahabad. pp 13-24.

Purbey, S.K. 2014. Supply chain management in litchi. In: Sivaramane, N., and Reddy, G.P (Eds) Supply Chain Management in Agriculture, NAARM, Hyderabad. pp 39-53.

Rajan, S., Dinesh, M.R., Ravishnkar, K.V., Bajpayee, A., Ahmed, I., Singh, A., Singh, S.K., Singh, I.P., Vasudeva, R., Reddy, B.M.C., Parthasarathy, V.A. and Sthapit, B. 2014. Heirloom varieties of important tropical fruits: a community initiative to conservation. ICAR-Indian Institute of Horticultural Research, Bengaluru.pp 33.

Singh, A., Nath, V., and Lal, R.L. 2014. Litchi. **In:** Tropical and Sub tropical Fruit Crops: Crop Improvement and Varietal Wealth Part- 2 (Ed. Ghosh, S.N.). Jaya Publishing House, Delhi. pp 405-431.

Singh, I.P., Dinesh, M.R., Gajanana, T.M., Rajan, S., Singh, S.K., and Vasudeva, R., 2014. Tropical Fruit Trees, Farmers Traditional Knowledge: Community Primer on Good Practices for Diversity Management (Scripted and supplementary information searched by Sh. B.S. Somashekhar). Bioversity International, Office of South Asia, National Agricultural Science Centre, Pusa Campus, New Delhi. pp 70.

Technical Bulletins/Manuals

Deka, B.C., Patel, R.K., Rymbai, H., Thirugnanavel, A., Deshmukh, N.A., and Ngachan, S.V. 2014. *Sohiong and Sohshang*: Two lesser known fruits of North-east India. Published by the ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland. pp. 25.

Purbey, S.K., Pongener, A., and Kumari, P. 2015. A laboratory manual for Postharvest analysis of fruits and products. Published by ICAR-NRC on Litchi, Muzaffarpur, Bihar. pp 100.

Singh, S.K., Pandey, S.D., Lal, N. and Nath, N. 2014. Aam ke bagiche me uttam krishi kriyanye. NRCL-Extension Bulletin-15, ICAR-National Research Centre on Litchi, Muzaffarpur. pp 40.

Singh, S.K., Singh, A., Nath, V., and Lal, N. 2014. Custodian of mango diversity: a case study of Pusa, Bihar. NRCL-TB-10: ICAR-National Research Centre on Litchi, Muzaffarpur. pp 50.

Singh, S.K., Srivastav, K., Lal, N., and Nath, N. 2014. Management of hoppers, mealy bug and

fruit fly in Mango orchard. NRCL-Extension Bulletin-14, ICAR-National Research Centre on Litchi, Muzaffarpur. pp 7.

Miscellaneous publications

Extension Folder

Singh, S.K., Singh, A., Lal, N., and Nath, N. 2014.Indigenous methods of pickle making from mango fruits at Pusa, Bihar. NRCL-Extension Folder-01, ICAR-National Research Centre on Litchi, Muzaffarpur. pp 6.

Singh, S.K., Kumari, A., and Lal, N. 2014. Aam ke kachche awam pake phalo se utapadan banana ke gharelu tarike. NRCL-Extension Folder-02, ICAR-National Research Centre on Litchi, Muzaffarpur. pp 4.

E-articles

Kumar, A., Pandey, S.D., Nath, V., Rai, R.R., and Patel, R.K. 2014. Role of plant growth regulators in litchi production. *Biotech Articles. http://www.biotecharticles.com.*

Kumar, A., Patel, R.K., Pandey, S.D., Srivastava, K., Purbey, S.K., and Nath, V. 2014. Tips for successful cultivation of litchi in India. *Biotech Articles.http:/www.biotecharticles.com.*

Kumar, V. 2015. Aflatoxins, their biosynthetic pathway and mechanism of action. http://www.biotecharticles.com/Agriculture-Article/Aflatoxins-their-Biosynthetic-Pathway-and-Mechanism-of-Action-3357.html.

Kumar, V. 2015. Estimation of aflatoxins in peanuts by indirect competitive ELISA. http://www.biotecharticles.com/Agriculture-Article/Estimation-of-Aflatoxins-in-Peanuts-by-Indirect-Competitive-ELISA-PDF-3362.html.

Kumar, V. 2015. Lab and field techniques for aflatoxin research in peanut. http://www.biotecharticles.com/Agriculture-Article/Lab-and-Field-Techniques-for-Aflatoxin-Research-in-Peanut-3358.html.

Kumar, V. 2015. Remove aflatoxin contaminated kernels from peanuts. http://www.biotecharticles.com/Agriculture-Article/Remove-Aflatoxin-Contaminated-Kernels-from-Peanuts-3356.html.

Rymbai, H., Patel, R.K., Deshmukh, N.A., Jha, A.K., Patel, R.S., and War, G.F. 2014. Nutrients variability in Sohiong (*Prunus nepalensis*) fruit. *Biotech Articles http://www.biotecharticles.com.*

Srivastava, K., Nath, V., Patel, R.K., and Sharma, D. 2014. Management of defoliator pest in litchi (*Litchi chinensis* Sonn.). *Biotech Articles, http://www.biotecharticles.com.*

Peer Recognition

Prof. Vishal Nath

- Chaired the poster presentation session in National seminar cum workshop on "Physiology of flowering in perennial fruit crops" at CISH, Lucknow on 25th May, 2014.
- Delivered lead lecture on "Technological Challenges in litchi production" and chaired the session on "Climate smart production technologies in fruit crops" in "Global conference on technological challenges and human resources for climate smart horticulture-Issues and strategies" at NAU, Navsari, Gujarat, India from 28-31st May, 2014.
- Chaired the session on "Postharvest management and export" and delivered lead lecture on "Strategies for mango diversity conservation and utilization" in National conference on mango diversity, production and post-harvest management and trade at BAU, Sabour, Bhagalpur, Bihar on 9th June, 2014.
- Chaired the session on "Modern approach for postharvest management in horticulture crops" and delivered lead lecture on "Approaches for improvement of litchi, citrus and grapes" during 2nd Uttar Pradesh Agricultural Congress at Lucknow, Uttar Pradesh on 16th June, 2014.
- Delivered lead lecture on "Hi-tech intervention in fruit production in eastern India" during winter school on hi-tech horticulture at CIAH, Bikaner from 5-25th November, 2014.
- Chaired the session on "Precision farming, protected cultivation and organic horticulture" and delivered lead lecture on "Underutilized exotic fruit crops of India" in International symposium on innovations in horticulture for nutritional security conserving biodiversity at BBA University, Lucknow, Uttar Pradesh on 17th October, 2014.
- Chaired a session on "Postharvest handling, food technology and value addition in horticulture crops" during International symposium on innovation in horticulture for nutritional security and conserving biodiversity on 18th October, 2014.
- Delivered lead lecture on "Canopy Management in Fruits crops" in 6th Indian Horticulture Congress at TNAU, Coimbatore, Tamil Nadu from 6-9th November, 2014.
- Delivered lead lecture on "Potential of off season litchi cultivation in humid tropical zones of Western ghats" and chaired the session on "Farmers-Scientist interaction" in National seminar on underutilized fruits at CHES, Chettali from 2-3rd December, 2014.
- Delivered lead lecture on "Litchi research and development- Way forward" during silver jubilee symposium on strategic approach for research and development in horticulture at NASC, New Delhi from 26-27th December, 2014.
- Delivered lead lecture on "New variety and advances in production technology in litchi" during "Farmers Day" organized by TAEF, Chennai at Patna on 13th February, 2015.
- Chaired the session on "Horticulture technology for use by the farmers" in the Regional Agriculture Fair- 2015 at CPRS, Patna, Bihar on 19th February, 2015.
- Invited for lead lecture on "Conservation of existing germplasm and exploration of underutilized sapindaceous fruit plants" during National Seminar on Hi-tech Horticultural

challenges and opportunity at BBA, University, Lucknow, Uttar Pradesh on 26th February, 2015.

Dr. Rajesh Kumar

- Presented keynote address on the topic "Technological challenged in adoption of GAPs in litchi" and lead paper in "Global conference on technological challenges and human resources for climate smart horticulture- Issues and strategies" at NAU, Navsari, Gujarat, India form 28-31st May, 2014 .
- Acted as Co-chairman in the technical session-I on "Recent advances in beekeeping", technical session- II on "Status, challenges and mitigation options" and presented a lead paper on the topic "Constraints of quality honey production in Bihar" in National seminar on "Quality honey production for livelihood security" organized at BAU, Sabour, Bhagalpur, Bihar from 5-6th August, 2014.
- Delivered an invited talk on "*Mausam, jalwayu awam krishi*" and acted as judge for evaluating team of students at Mukherjee Seminary School, Muzaffarpur on the occasion of 22nd Rashtriya Bal Vigyan Congress - 2014 on 20th August, 2014.
- Presented an invited paper on "Honeybee keeping and pollination benefits in fruit crops: constraints and management" in International conference on pollinators health and use of pesticides in agriculture-global perspective organized by CropLife, India at India International Centre, New Delhi, India on 2nd September, 2014.
- Presented an invited talk on "*Kisan ki khetibari awam swauwlamban*" in National conference organized by "Sarvodaya Sarwa Sewa Sangh" through Sarvodya Samiti and Muzaffarpur Vikas Mandal, Muzaffarpur on 11-12th October, 2014.
- Presented an invited paper in National seminar on pomegranate for nutritional, livelihood security and entrepreneurship development, organized by ICAR-NRC on Pomegranate, Sholapur, Maharashtra from 5-7th December, 2014.
- Acted as Co-chairman in the technical session-IV and presented an invited paper on the topic "Intervention of rejuvenation technology for transforming old senile fruit trees into young production phase" in International conference on "Technological interventions in agricultural sciences for enhanced productivity, nutritional quality and value addition (TIAS-2014)" at CIH, Medziphema, Nagaland from 17-19th February, 2015.
- Acted as Judge for evaluation of exhibits in Horticulture Show-2015 during Kisan Mela of RAU, Pusa, Samastipur on 14th March, 2015.
- Member of editorial board of "*Current Horticulture*" research journal published by Society for Horticultural Research and Development, Botany Department, MM (PG) College, Modinagar, Ghaziabad, U.P.
- Acted as referee in reputed research journals like Indian Journal of Agricultural Sciences, Current Horticulture, and HortScience.

Dr. S.K. Purbey

- Invited as guest speaker to deliver a lecture on "Postharvest management and value addition in litchi" at Veterinary College, Patna in programme "Agriculture marketing" organized by NIAM, Jaipur and BAU, Sabour, Bhagalpur during 11-12th February, 2015.
- Invited as guest speaker to deliver a lecture on "Litchi production and utilization" in 21 days training programme on "Sewakalin Prashikshan" at BB collegiate, Muzaffarpur on 25th June, 2014.

- Reviewed an article (Manuscript no. NASB-D-14-005314 and NASB-D-14-00571R1) for proceedings of the National Academy of Sciences, Indian Section B: Biological Sciences, Springer publication.
- Reviewed an article (Manuscript no. DES/ IJBAAR/ 2013/-175) for International journal of Basic and Applied Agricultural Research, GBPUA&T, Pantnagar.
- Acted as a judge to evaluate the exhibits received for the Horticulture Show at RAU, Pusa, Samastipur on 14th March, 2015.
- Attended the meeting of MSME, Muzaffarpur as technical advisor for development of Food Processing Cluster (Litchi Cluster) at MSME, Ministry of Commerce, Muzaffarpur on 25th June, 2014.

Dr. Amrendra Kumar

- Zonal councilor of Association for advancement of pest management in Horticultural ecosystem (AAPMHE), IIHR, Bangalore.
- Act as a convener of technical session-V on "Biotechnology, nanotechnology and bioinformatics in horticulture" In: Global Conference on technological challenges and human resources for climate smart horticulture- Issues and strategies at NAU, Navsari, Gujarat, India form 28-31st May, 2014.
- Conducted the Viva-voice examination of Ph.D. student, Department of Horticulture, BAU, Sabour, Bhagalpur on 12th February, 2015.
- Acted as member of Jury in the Horticulture Show organized by Department of Horticulture, RAU, Pusa, Samastipur on 14th March, 2015.

Dr. R.K. Patel

- Joint Secretary, Indian Association of Hill Farming, Indian Journal of Hill Farming, ICAR (RC) for NEH Region, Umiam, Meghalaya.
- Act as an Associate Editor of Hortflora Research Spectrum Journal published by Biosciences and Agriculture Advancement Society, Meerut, Uttar Pradesh.
- Act as a convener of technical session-7 on "Challenges to production technology of horticultural crops". In: Global Conference on technological challenges and human resources for climate smart horticulture- Issues and strategies at NAU, Navsari, Gujarat, India from 28-31st May, 2014.
- Act as a member of judging committee for evaluation of poster presentation In: National symposium on natural resource management and sustainable hill farming system for food security organized by SKUAST, Jammu, India on 24th July, 2014.
- Reviewed an article (JFST-D-14-01170) of *Journal of food Science and Technology,* Mysore.
- Reviewed an article (IJAS-34281) of *Indian Journal of Agricultural Sciences,* New Delhi.

Dr. Kuldeep Srivastava

- Nominated as Editor (plant Protection) in editorial board (2015) of HortFlora Research Spectrum Journal published by Biosciences and Agriculture Advancement Society, Meerut, Uttar Pradesh.
- Nominated as member, editorial board (2015), Journal of Agricultural Sciences, 1120 Finch Avenue West, Suite 701—309 Toronto, ON. M3J3H7 Canada.
- Convener of technical session-10 on "Technology for biotic stress management". In: Global conference on technological challenges and human resources for climate smart horticulture- Issues and strategies at NAU, Navsari, Gujarat, India from 28-31st May, 2014.

- Co-chaired, technical session on "Climate change and pest management". In: National Entomologist Meet organized by ICAR-IINRG, Ranchi, Jharkhand, from 5-7th February, 2015.

Dr. Vinod Kumar

- Acted as reviewer for two international journal *viz.,* Crop Protection (MS-CROPRO-D140409-006182) and Current Analytical Chemistry (MS-BSP-CAC-2015-390), and two national journal viz. Indian Phytopathology and Journal of Mycology and Plant Pathology.
- Delivered guest lecture on the topic **"**Disease and pest management in litchi" and "Application of bio-fertilizers in litchi" in the training programme organized for state agricultural officers under NHM at RAU, Pusa, Samastipur.

Dr. Sanjay Kumar Singh

- Appointed as question setter of course no. AHT 301 of B.Sc. Ag. IXth Semester of year 2010-11 by RAU, Pusa, Samstipur, Bihar during March, 2015.

Dr. Alemwati Pongener

- Reviewed an article (Manuscript No. WSFR-2014-0023) for International Journal of Fruit Science, Taylor and Francis publication.
- Reviewed an article (Manuscript No. AJB-30.10.14-14288) for African Journal of Biotechnology.

Awards and Honours

- Centre got the third prize for commendable performance in implementing the official language policy of the union during year 2013-14 by Town Official Language Implementation Committee (NRAKAS), Muzaffarpur on 21st August, 2014.
- ICAR-NRCL stall was adjudged the Best Exhibit Award (2nd position) at Farmers' fair cum Kisan Gosthi organized by KVK, Kushinagar (IIVR, Varanasi), UP on 26th March, 2015.
- ICAR-NRCL has been accredited as a programme study centre for "Post Graduate Diploma in Plantation Management (PGDPM)", and "Certificate in Organic Farming (COF)" by IGNOU, New Delhi.

Dr. Rajesh Kumar

- Received Manyata Puruskar from Muzaffarpur Vikas Mandal, Muzaffarpur, Bihar for the significant contribution in developing farmer's friendly technology and transfer for enhancing fruit production in the region on 11th October, 2014.
- Received "Scientist of the Year- 2014 Award" from Hi-Tech Horticultural Society, Meerut for the significant contribution in the field of horticulture on 19th February, 2015.
- Received the best paper presentation award in International Conference on Technological Interventions in Agricultural Sciences for Enhanced Productivity, Nutritional Quality and Value Addition (TIAS-2014) at CIH, Medziphema, Nagaland from 17-19th February, 2015.

Dr. S.K. Purbey

- Awarded Fellow of Confederation of Horticulture Association of India (CHAI), New Delhi in 2014.
- Awarded Commendation Certificate for admirable contribution to in implementing the official language policy of the union during year 2013-14 by Town Official Language Implementation Committee (NRAKAS), Muzaffarpur.

Dr. Amrendra Kumar

- Received best poster presentation award with co-authors; **S.D. Pandey and R.K. Patel** for paper entitled "Induction of flowering in litchi through chemical sprays". In: 6th Indian Horticulture Congress on Horticulture for inclusive growth organised by Horticulture Society of India at TNAU, Coimbatore, Tamil Nadu, India from 6-9th November, 2014.

Dr. R.K. Patel

- Received "Young Scientist Associate Award-2014" by Hi-tech Horticultural Society, Meerut, Uttar Pradesh.
- Received "Bioved Young Scientist Associate Award-2015" by Bioved Research Society, Bioved Research Institute of Agriculture & Technology, Allahabad, Uttar Pradesh, India.
- Awarded Fellow of Confederation of Horticulture Association of India (CHAI), New Delhi in 2014.

Dr. Kuldeep Srivastav

- Recipient of Fellow of Confederation of Horticulture Association of India, New Delhi in 2014.

- Recipient of Fellow of Entomological Society of India, New Delhi in 2014.
- Received best poster presentation award with Co-authors; **Amrendra Kumar and R.K. Patel** research paper entitled "Beneficial insect fauna associated with litchi (*Litchi chinensis* Sonn.)". In: National symposium on natural resource management and sustainable hill farming system for food security at SKUAST, Jammu, India from 23-24th July, 2014.
- Received best oral presentation award with co-authors; **Amrendra Kumar and R.K. Patel** for research paper entitled "Pollinators diversity and their impact on qualitative and quantitative yield parameters of litchi (*Litchi chinensis* Sonn.)". In: International conference on "Changing scenario of pest problems in agri-horti ecosystem and their management" organised by Entomological Research Association at MPUAT, Udaipur, Rajasthan, India from 27-29th November, 2014.
- Best poster presentation award as co-author in research paper entitled "Base line susceptibility of *Spodoptera litura* (Fab.) to fungicides and insecticides". In: National Entomologist Meet at IINRG, Ranchi, Jharkhand from 5-7th February, 2015.

Sh. Narayan Lal

- Awarded Fellow of the Confederation of Horticultural Association of India (CHAI), New Delhi in 2014.

Dr. Alemwati Pongener

- Awarded Fellow of Confederation of Horticulture Association of India (CHAI), New Delhi in 2014.

Compilation, Editing and Documentation

Sl. No.	Title	No. of pages	Year of publication	Scientists involved
1.	NRCL Annual Report, 2013-14 (English)	85	2014	Dr.Vinod Kumar
2.	ICAR-NRCL Annual Report, 2013-14 (Hindi)	86	2014	Dr.Vinod Kumar Dr. R.K. Patel Dr. Sanjay Kumar Singh
3.	Mid-term Reports and Annual Progress Reports 2014-15 of AICRP (Fruits) , ICAR-NRCL	-	2014	Dr. Rajesh Kumar
4.	HYPM, Quarterly Report, Monthly Cabinet Report	-	2014-2015	Dr. Sanjay Kumar Singh
5.	RFD: Annual Draft, Monthly Report, Mid-term Achievements, Annual Performance Evaluation; Citizen/Client Charter	-	2014-2015	Dr. Vinod Kumar Dr. Sanjay Kumar Singh
6.	News and updates for NRCL Website and *ICAR NEWS*	-	2014-2015	Dr. Vinod Kumar
7.	Strategic Plan Document (2012-2017)	21	-	Dr. Vinod Kumar
8.	7th RAC Proceedings, Recommendations of 8th RAC, Action Taken Report	-	2014-15	Dr. Rajesh Kumar

Personnel

A. Scientific

Name and Email	Designation	Area of Interest
Prof. (Dr.) Vishal Nath nrclitchi@yahoo.co.in director@nrclitchi.org	Director	Plant genetic resource management; Canopy architecture management; Dissemination of technology.
Dr. S. D. Pandey pandeynrcb@yahoo.com sdpandey@nrclitchi.org	Pr. Scientist (Hort.)	High density planting; Canopy management; Nutrient management; Fertigation, Organic litchi production.
Dr. Rajesh Kumar rajeshkr_5@yahoo.com rajesh@nrclitchi.org	Pr. Scientist (Hort.)	Rejuvenation of old senile litchi trees; Studies on horticultural traits of cultivars; Seedling variability of litchi and longan; Improved propagation methods; Canopy architecture; Climate variability vis-à-vis litchi production.
Dr. Sushil Kumar Purbey skpurbey_nrcl@yahoo.com purbey@nrclitchi.org	Pr. Scientist (Hort.)	Postharvest handling and packaging; Enhancement of shelf life of litchi; Value addition and processing; Utilization of litchi fruit waste through bio-processing.
Dr. Amrendra Kumar amrendra14d@gmail.com	Sr. Scientist (Hort.)	Nursery management; Plant propagation and growth physiology of vegetatively propagated plants; Collection and characterization of rambutan germplasm.
Dr. Kuldeep Srivastava Kuldeep.ipm@gmail.com kuldeep@nrclitchi.org	Sr. Scientist (Ento.)	Management of insect pests of litchi; Insect pollinators of litchi.
Dr. R.K. Patel rkpatelicar@gmail.com rkpatel@nrclitchi.org	Sr. Scientist (Hort.)	Development of organic package of practices for litchi; Litchi-based cropping system for low-lying areas.
Dr. Vinod Kumar vinod3kiari@yahoo.co.in vinod@nrclitchi.org	Sr. Scientist (Plant Path.)	Management of pre and postharvest diseases of litchi; Mycorrhizal association; Biocontrol and bio-fertilizers for sustainable production of litchi.
Dr. Sanjay Kumar Singh sanjayhor@rediffmail.com sanjay@nrclitchi.org	Scientist SS (Hort.)	Shoot physiology and biochemistry in relation to flowering and fruiting in litchi; Germplasm conservation and development of database on mango and pummelo.
Sh. Narayan Lal narayanlal.lal7@gmail.com narayan@nrclitchi.org	Scientist (Hort.)	Collection and evaluation of litchi germplasm; Clonal selection; Development of hybrids.
Dr. Alemwati Pongener alemwati@gmail.com alemwati@nrclitchi.org	Scientist (Hort.)	Pericarp browning; Postharvest management to reduce loss; Processing and value addition.
Sh. Alok Kumar Gupta alokguptabhu@gmail.com	Scientist (Hort.)	Collection and evaluation of litchi germplasm; Clonal selection; Development of hybrids.
Dr. Neetu Singh Kushwah neeturajawat@gmail.com	Scientist (Agri. Biotechnology)	Biotechnology.
Dr. Evening Stone Marboh esmarboh@gmail.com	Scientist (Hort.)	Water management and plant physiology.
Dr. Swati Sharma swtsharma92@gmail.com	Scientist (Hort.)	Postharvest management and plant physiology.

B. Technical

C. Administrative

Recruitment, Promotion and Transfer

New entry

1. Dr. Neetu Singh Kushwah joined as Scientist (Agricultural Biotechnology) on 13th October, 2014.
2. Dr. Evening Stone Marboh joined as Scientist (Horticulture-Fruit Science) on 13th October, 2014.
3. Sh. Pawan Singh Gurjar joined as Scientist (Horticulture-Fruit Science) on 13th October, 2014.
4. Dr. Alok Kumar Gupta, Scientist (Horticulture-Fruit Science) joined the centre on 15th January, 2015 on transfer from ICAR-CITH, Srinagar.
5. Dr. Swati Sharma (Horticulture-Fruit Science) joined the centre on 2nd March, 2015 on transfer from ICAR-CISH, Lucknow.

Promotion

1. Dr. Shyamji Mishra, T-3 (Field/Farm Technician) promoted to T-4 on 30th June, 2014.

Transfer

1. Sh. Pawan Singh Gurjar, Scientist (Horticulture-Fruit Science) was transferred to ICAR-CISH, Lucknow and relieved from the centre on 13th March, 2015.

Important Committees

Research Advisory Council (RAC)

During 2014-15, 8th Research Advisory Committee (RAC) meeting was held from 31st July to 1st August, 2014. Constitution of the committee was as under:

1.	Dr. S. P. Ghosh, Former DDG (Hort) & FAO Expert, 68, Qutab View Apartments, Near Kutub Hotel, Katwaria Sarai, New Delhi	Chairman
2.	Dr. G. S. Prakash, Principal Scientist (Hort), IIHR, Bangalore	Member
3.	Dr. R. K. Jain, Head, Division of Plant Pathology, IARI, Pusa, New Delhi	Member
4.	Dr. R. K. Pal, Director, NRC on Pomegranate, Sholapur, Maharashtra	Member
5.	Dr. D. K. Shahi, Chief Scientist cum Professor, BAU, Kanke, Ranchi, Jharkhand	Member
6.	Sh. Alok Kedia, Radha Krishna Implex, Sikandarpur, Muzaffarpur, Bihar	Member
7.	Sh. Bipin Kumar Pandey, Katarmala, Vaishali, Bihar	Member
8.	Sh. Sudhir Kumar Pandey, Village- Bakhari, Muzaffarpur, Bihar	Member
9.	Sh. Rajpal Singh, Village-Jaghata, Gujar, Sharanpur, U.P.	Member
10.	Dr. Vishal Nath, Director, NRCL, Muzaffarpur, Bihar	Member
11.	Dr. Rajesh Kumar, Principal Scientist, NRCL, Muzaffarpur, Bihar	Member Secretary

Institute Research Council (IRC)

During the year, 10th and 11th Institute Research Council (IRC) meetings were held on 16-17th April, 2014 and 21-22nd November, 2014, respectively. 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.

The 10th IRC meeting was attended by the following scientists:

1.	Prof. (Dr.) Vishal Nath	Director	Chairman
2.	Dr. S. D. Pandey	Pr. Scientist (Hort.)	Member
3.	Dr. Rajesh Kumar	Pr. Scientist (Hort.)	Member
4.	Dr. Sushil Kumar Purbey	Pr. Scientist (Hort.)	Member
5.	Dr. Amrendra Kumar	Sr. Scientist (Hort.)	Member
6.	Dr. Kuldeep Srivastava	Sr. Scientist (Ento.)	Member
7.	Dr. R.K. Patel	Sr. Scientist (Hort.)	Member
8.	Dr. Vinod Kumar	Sr. Scientist (Plant Path.)	Member
9.	Sh. Narayan Lal	Scientist (Hort.)	Member
10.	Dr. Alemwati Pongener	Scientist (Hort.)	Member
11.	Dr. Sanjay Kumar Singh	Scientist SS (Hort.)	Member Secretary

The 11th IRC meeting was attended by the following scientists:

1.	Prof. (Dr.) Vishal Nath	Director	Chairman
2.	Dr. S. D. Pandey	Pr. Scientist (Hort.)	Member
3.	Dr. Rajesh Kumar	Pr. Scientist (Hort.)	Member
4.	Dr. Sushil Kumar Purbey	Scientist (Hort.)	Member
5.	Dr. Amrendra Kumar	Pr. Scientist (Hort.)	Member
6.	Dr. Kuldeep Srivastava	Sr. Scientist (Ento.)	Member
7.	Dr. R.K. Patel	Sr. Scientist (Hort.)	Member
8.	Dr. Vinod Kumar	Sr. Scientist (Plant Path.)	Member
9.	Dr. Sanjay Kumar Singh	Scientist SS (Hort.)	Member
11.	Dr. Alemwati Pongener	Scientist (Hort.)	Member Secretary

10th and 11th IRC in progress at the centre

Institute Management Committee (IMC)

The 9th Institute Management Committee (IMC) meeting was held on 20th December, 2014 at the centre. The following members attended the meeting and discussed the agenda items relevant to IMC of the centre:

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

The 9th IMC meeting in progress

Institute RFD Committee and RFD Cell

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

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

Other Institutional Committees

The composition of other important institutional committees during 2014-15 was as under:

Sl. No.	Name of committee	Members of the committee	
1.	Priority Setting Monitoring and Evaluation Committee (PME Cell)	Dr. S.D. Pandey	Chairman
		Dr. Vinod Kumar	Co-chairman
		Dr. Sanjay Kumar Singh	Member
		Dr. Alemwati Pongener	Member Secretary
2.	Price Fixation Committee (PFC)	Dr. Rajesh Kumar	Chairman
		Dr. Sanjay Kumar Singh	Co-chairman
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member
		Sh. Rajiv Ranjan Rai	Member Secretary
3.	Works and Estate Committee	Dr. S.K. Purbey	Chairman
		Dr. Vinod Kumar	Member
		Sh. Rajiv Ranjan Rai	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member Secretary
4.	Farm Management Committee (FMC)	Dr. Amrendra Kumar	Chairman
		Dr. R.K. Patel	Co-chairman
		Dr. Kuldeep Srivastava	Member
		Sh. Abhishek Yadav	Member
		Dr. Shyamji Mishra	-
		Sh. Rajiv Ranjan Rai	Member Secretary

5.	Store and Purchase Advisory Committee (SPAC)	Dr. R.K. Patel	Chairman
		Dr. Kuldeep Srivastava	Co-chairman
		Sh. Narayan Lal	Member
		Sh. Subhankar Dey	Member
		Sh. Abhishek Yadav	Member Secretary
6.	Spot Purchase Committee (SPC)	Dr. S.D. Pandey	Chairman
		Dr. Kuldeep Srivastava	Co-chairman
		Sh. Rajiv Ranjan Rai	Member
		Sh. Subhankar Dey	Member
		Sh. Ramji Giri	Member secretary
7.	Training and Exhibition Cell	Dr. S.K. Purbey	Incharge
		Dr. Kuldeep Srivastava	Member (Museum)
		Dr. R.K. Patel	Member (IGNOU)
		Sh. Subhankar Dey	Member
		Dr. Shyamji Mishra	Member
8.	Central Instrumentation Facility	Dr. Amrendra Kumar	Incharge
		Dr. Alemwati Pongener	Alternate Incharge
		Smt. Pallavi	-
9.	Library Committee	Sh. Narayan Lal	Incharge
		Dr. Alemwati Pongener	Alternate Incharge
		Dr. Neetu Singh Kushwah	Member
		Smt. Pallavi	-
10.	Climate Change related matters and Weather Advisory Cell	Dr. Rajesh Kumar	Incharge
11.	Security Cell	Sh. Abhishek Yadav	Incharge
12.	Estate and Vehicle in-charge	Sh. Ramji Giri	Incharge
13.	Women Cell	Dr. S.D. Pandey	Incharge

Infrastructural Development

The centre is developing laboratory facilities for molecular characterization and biotechnological studies. Laboratory facilities for physiological and biochemical analysis, nutrient and elemental studies of plant and soil have been established. Facilities for research on plant protection including pathology, microbiology, and entomology have been developed. The centre also has a well-equipped laboratory for postharvest handling, processing, and value addition of litchi, including a workshop for honey processing and sulphitation chamber. The centre has been connected to the National Knowledge Network (NKN) through Railtel and Wi-Fi provision for internet access has been installed. In addition to these, a common instrumentation laboratory has been set up at the centre. Construction of four type-II and type-III, and one each of type-V and Type-VI residential quarters has been completed and allotted to the staff.

A view of nursery complex at the centre

Air layered plants under hardening stage

AAS, HPLC and GCMS in Central Instrumentation Facility

NRCL Staff using Library

Arial view of infrastructural facilities created at the centre

Annexure-I

Results Framework Document (RFD) of ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar for the period 2013-14

Section 1: Vision, Mission, Objectives and Functions

Vision

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

Mission

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

Objectives

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

Functions

To undertake basic, strategic and applied research for enhancing productivity, quality and utility of litchi.

To act as repository of genetic resources and scientific information on all aspects of litchi.

To undertake frontline demonstration in newer technologies and to impart training for upgrading scientific knowledge.

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

S. No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target /Criteria Value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1.	Production and post-harvest management in litchi	46	Development of improved production technology	Production technology developed	Number	18	3	2	1	-	-
			Development of post-harvest technology	Post-harvest technology developed	Number	10	2	1	-	-	-
			Production of quality planting materials	Saplings produced	Number	18	25000	24000	23000	22000	20000
2.	Plant genetic resources management and crop improvement in litchi	25	Collection of germplasm	Germplasm collected	Number	6	8	6	4	2	1
			Selection and establishment of clones	Clones selected and established in field	Number	8	10	8	6	5	4
			Hybridization	Hybrid seedlings produced	Number	5	40	35	30	25	20
			Characterization of seedling population	Seedlings characterized	Number	6	45	35	25	20	15
3.	Training and transfer of technology to stakeholders	18	Organization of training programmes for farmers and processors	Trainings organized	Number	18	8	6	5	4	3
	*Efficient functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May 15, 2013	May 16 2013	May 17 2013	May 20, 2013	May 21 2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	May 1, 2013	May 2, 2013	May 5, 2013	May 6, 2013	May 7, 2013
	*Administrative reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for Innovation	On-time submission	Date	2	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013
	* Improving internal efficiency /responsiveness / service delivery of Department/ Ministry	4	Implementation of *Sevottam*	Independent audit of implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

* = Mandatory objectives

Section 3: Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success indicators	Unit	Actual value for FY 2011-12	Actual value for FY 2012-13	Target value for FY 2013-14	Projected value for FY 2014-15	Projected value for FY 2015-16
1.	Production and post-harvest management in litchi	Development of improved production technology	Production technology developed	Number	2	2	2	3	3
		Development of post-harvest technology	Post-harvest technology developed	Number	1	1	1	1	2
		Production of quality planting materials	Saplings produced	Number	19074	23005	24000	25000	26000
2.	Plant genetic resources management and crop improvement in litchi	Collection of germplasm	Germplasm collected	Number	4#	2	6	8	-
		Selection and establishment of clones	Clones selected and established in field	Number	0	6	8	10	12
		Hybridization	Hybrid seedlings produced	Number	0	15	35	50	60
		Characterization of seedling population	Seedlings characterized	Number	0	125##	35	40	45
3.	Training and transfer of technology to stakeholders	Organization of training programmes for farmers and processors¥	Trainings organized	Number	9*	5	6	7	8
	†Efficient functioning of the RFD system	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date			May 16, 2013		
		Timely submission of Results for RFD (2012-13)	On-time submission	Date			[ay 2, 2013		
	†Administrative Reforms	Implement ISO 9001 as per the approved action plan.	% Implementation	%			95		
		Prepare an action plan for Innovation	On-time submission	Date			0/08/2013		
	†Improving internal efficiency /responsiveness / service delivery of Department/ Ministry	Implementation of *Sevottam*	Independent audit of implementation of Citizen's Charter	%			95		
			Independent audit of implementation of public grievance redressal system	%			95		

= Out of 8 collected, only four finally survived, ## = Morphological characterization was done; reproductive phase characterization in subsequent years, - = No programme during the year, ¥ = Minimum 50 farmers/beneficiaries, * = Out of 9, eight was sponsored training, † = Mandatory objectives

Section 4: Acronyms

S. No.	Acronym	Description
1.	NHB	National Horticulture Board
2.	NHM	National Horticulture Mission
3.	APEDA	Agricultural and Processed Food Products Export Development Authority
4.	SAU	State Agricultural Universities
5.	KVK	Krishi Vigyan Kendra

Section 4: Description and Definition of Success Indicators and Proposed Measurement Methodology

S. No.	Success indicator	Description	Definition	Measurement	General Comments
1.	Production technology developed	Development of production technology includes techniques to produce quality planting material, improved nutrient management, water management and pest management practices.	All those technologies that lead to increase in production and productivity are called production technology.	Number	This will help in enhancing litchi production.
2.	Post-harvest technology developed	Development of post-harvest technology includes diversified value added products, extention in shelf life and reduction in post-harvest losses including fruit rots through different packaging systems.	All those technology that minimizes post-harvest loss and results in value addition is called post-harvest technology.	Number	It will help in reducing losses of litchi and diversified value added products of litchi to consumers
3.	Saplings produced	Supply of quality planting material of litchi to various stakeholders.	It is a process of vegetative means by which new individuals arise without production of seeds	Number	In a wider sense, planting material arise from vegetative propagation methods such as air-layering and grafting in case of litchi
4.	Germplasm collected	Diverse germplasm is the basic requirement to bred new improved varieties	Germplasm is collection of cultivars, landraces, wild species etc. for conservation and utilization	Number	Germplasm material serve as base for utilization in crop improvement programs for breeding new varieties.
5.	Clones selected and established in field	Selection of intra-varietal variation to develop new cultivars.	Clones are progenies of a single vegetatively propagated plants	Number	This is a method of improving the existing variety.
6.	Hybrid seedlings produced	Through hybridization, the genetic base of a crop is broadened. It may help in improving various traits of fruit quality, shelf-life, extending harvesting period and overcoming irregular bearing habit in litchi.	Hybrids are progenies obtained through crossing of diverse plant varieties.	Number	This is a method of developing new cultivars.
7.	Seedlings characterized	The seedling progenies are highly variable and selection can be performed only after characterization.	Characterization of seedlings is systematic observation of useful vegetative and reproductive traits	Number	This is also a method of development of new cultivars.
8.	Trainings organized	Capacity building activities related to knowledge and skill improvement/development programmes conducted for farmers/ stakeholders, Technology developed at the centre particularly rejuvenation, intercropping and IPM in litchi is aimed will be disseminated among stakeholders.	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving productivity in an organization or enterprise	Number	

Section 5: Specific Performance Requirements from Other Departments

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this Organization	What happens if your requirement is not met.
State Government	Litchi growing states (Bihar,WB,UP, Uttarakhand, North Eastern states and new potential areas in Southern States	Department	Different States' Agricultural Department	Saplings produced	Indent for quantity (number) of litchi saplings	Variety-wise indent for litchi saplings	Quantity of saplings is produced as per indent	Less or more number of saplings will be produced

Section 6: Outcome/ Impact of activities of the Organization

S. No.	Outcome/ Impact of organization	Jointly responsible for influencing this outcome/ impact with the following organization(s)/ departments	Success Indicator (s)	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1.	Enhanced productivity and production of litchi	NHB, NHM, APEDA, State Departments of Agriculture, SAUs, KVKs etc.	Improvement in productivity*	%	3.0	4.5	6.0	7.5	8.0
2.	Enhancement in shelf life of fruits		Increased shelf life	Days	6	8	10	12	15

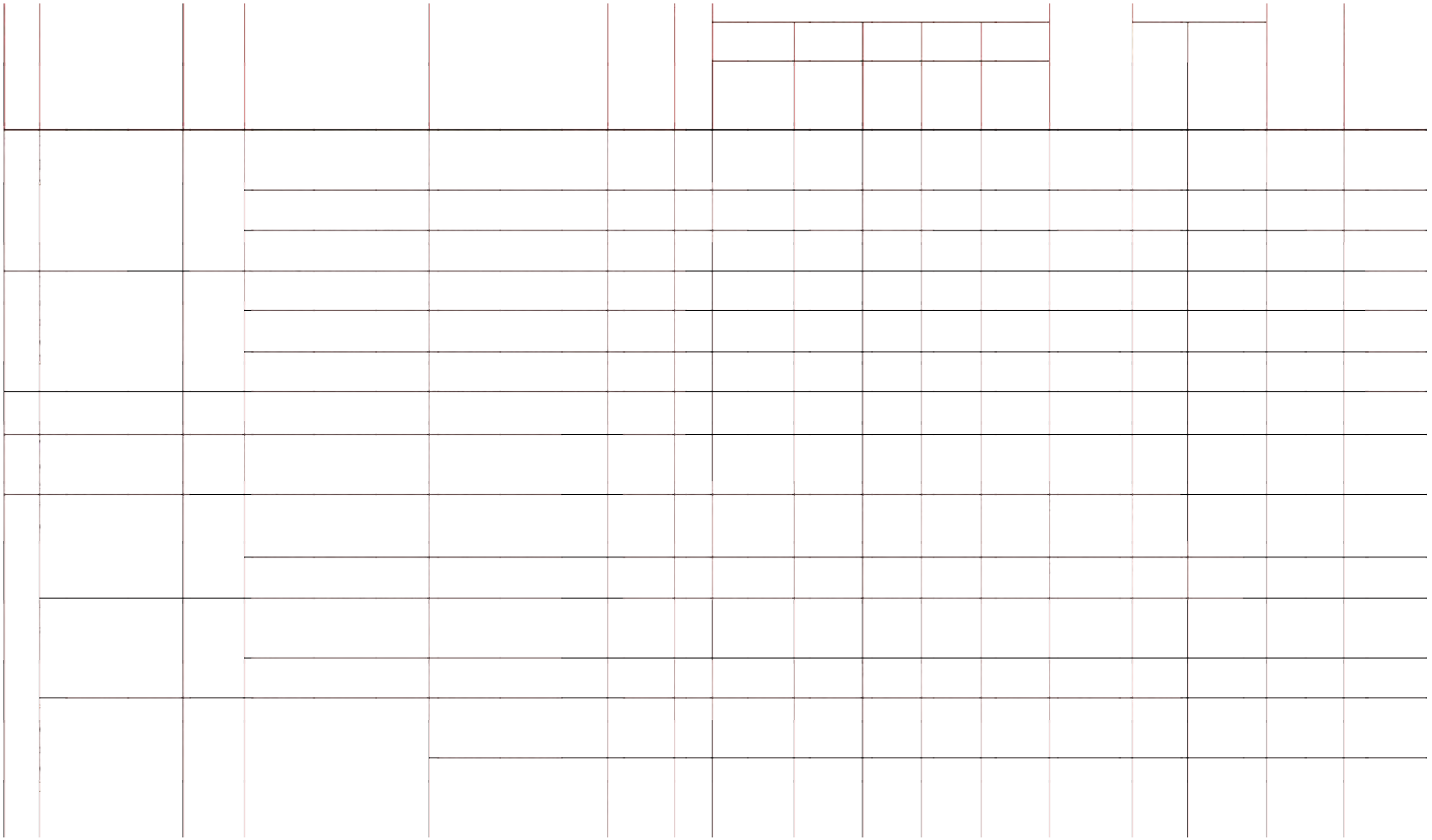
*Enhancement over the base year 2011-12

Results Framework Document 2013-14

Annexure-II

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014 of RSCs i.e. Institute

Name of the Division: Horticultural Science



*Mandatory objectives, # All the hybrid fruits destroyed by hailstorm, ** A letter of enquiry has been issued to the identified firm for ISO certification
NA= Not applicable, NA+ = Meets excellent target (100% col.), NA++ = Quantity produced was dependent on lifting of plants by the indenter/clients

Total Composite Score: 89.09
Rating: Very Good

Procedure for computing the Weighted and Composite Score
1. Weighted score of a success indicator= Weight of the corresponding success indicator x Raw score/100
2. Total composite score = sum of weighted score of all the success indicators

Weather Report

Weekly weather data during 1st April, 2014 to 31st March, 2015

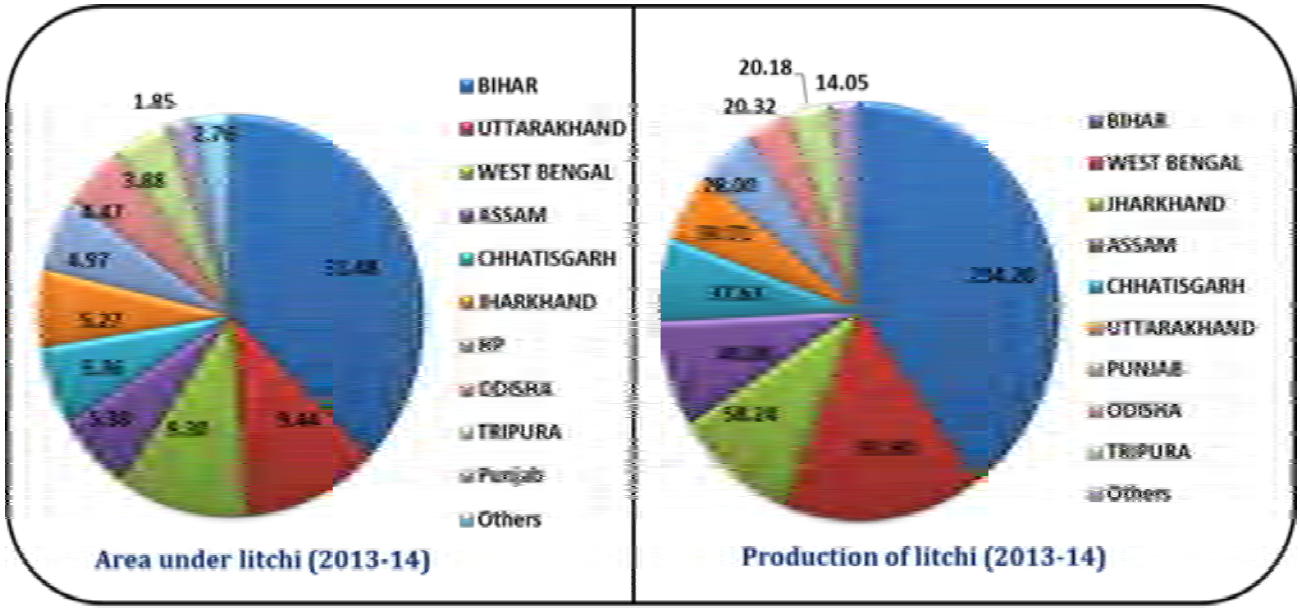
Standard Week	Temperature (°C)		Relative humidity (%)		Wind velocity (km/h)	Rainfall (mm)	Evaporation (mm)	Sunshine hours
	Max	Min	0700 hrs	1400 hrs				
2014								
14	35.0	19.1	78	36	4.8	0.0	5.2	7.8
15	36.8	17.4	65	28	4.4	0.0	6.0	9.6
16	37.8	20.3	61	23	4.9	0.0	7.0	9.7
17	38.9	21.1	69	24	5.7	0.0	7.8	9.9
18	36.2	23.9	76	51	8.2	1.3	5.5	8.3
19	40.5	24.3	63	27	5.9	0.0	7.5	9.0
20	40.7	24.5	65	25	6.9	0.0	9.1	10.8
21	37.3	25.0	78	38	5.3	11.1	7.1	8.8
22	32.4	23.7	83	57	7.3	51.6	4.3	6.8
23	37.2	27.2	85	57	8.0	24.6	5.2	7.2
24	37.1	26.4	77	52	5.0	10.2	5.0	8.8
25	34.5	25.6	86	66	4.8	30.4	3.5	4.7
26	35.2	26.7	86	68	5.5	28.0	4.3	5.2
27	31.3	25.8	91	76	4.8	114.0	3.3	5.8
28	34.5	27.6	88	70	6.1	1.4	3.4	4.6
29	32.5	26.5	88	77	8.5	82.3	2.9	4.1
30	31.6	26.0	89	68	5.6	44.9	2.4	6.9
31	34.7	27.3	86	67	7.5	8.0	4.4	8.1
32	33.1	26.7	90	79	6.1	45.4	3.6	4.7
33	30.2	25.3	94	82	3.9	255.0	2.0	1.6
34	32.7	25.8	91	78	3.9	43.5	2.7	2.4
35	33.4	25.9	68	38	10.8	52.1	5.9	5.7
36	33.6	26.1	89	65	6.5	9.0	4.0	8.8
37	31.7	25.0	94	74	5.8	50.8	3.1	3.7
38	33.0	24.8	92	71	4.6	48.4	3.4	5.4
39	32.2	24.5	91	65	3.8	18.8	2.8	5.4
40	32.8	23.6	91	62	1.7	36.2	2.8	7.7
41	33.0	24.1	91	65	3.9	7.2	2.7	5.3
42	30.1	19.3	91	52	3.9	38.2	3.5	7.9
43	30.5	19.6	90	53	1.7	0.0	2.0	6.0
44	30.0	18.3	91	53	1.9	0.0	1.9	3.5
45	30.7	17.0	89	45	1.5	0.0	1.9	7.1
46	28.5	13.2	84	35	2.2	0.0	1.9	5.6
47	27.7	11.6	86	34	2.0	0.0	1.6	6.0
48	26.0	11.7	88	55	1.5	0.0	1.0	2.4
49	20.6	13.6	94	76	2.3	0.0	0.5	0.7
50	21.6	12.0	91	67	2.6	2.2	0.9	1.1
51	20.9	08.5	92	61	3.3	0.0	1.2	4.5
52	15.3	07.8	91	77	3.9	0.0	0.4	1.1

2015								
1	21.0	12.1	86	72	4.2	1.0	1.0	1.3
2	18.1	08.6	88	73	3.5	0.0	0.7	1.6
3	16.2	07.1	89	71	3.9	0.0	0.6	1.7
4	21.6	09.4	89	58	3.3	0.0	1.2	5.3
5	21.1	09.5	88	52	2.7	0.1	1.5	5.5
6	22.9	09.6	89	52	4.0	0.0	2.2	6.6
7	24.9	13.0	88	55	3.8	0.1	1.8	2.7
8	27.9	15.9	93	63	2.4	0.0	1.6	1.2
9	24.4	14.8	88	59	4.3	1.6	2.2	4.5
10	28.4	12.0	77	38	3.8	0.0	3.8	8.9
11	29.2	15.2	85	48	5.4	0.3	3.8	7.3
12	33.7	17.6	82	43	3.0	0.0	4.3	9.4
13	32.2	20.7	89	59	6.2	4.9	4.3	4.4

The Litchi Scenario

In India, 585,300 metric tonnes of litchi is produced annually from 84,170 ha. Litchi, being exacting in climatic requirement, is confined to a few states of India with 40 per cent of production in Bihar. In Bihar, litchi is the source of livelihood for millions of people as it provides both on-farm and off-farm employment. Small and marginal farmers get additional income from litchi plants in their homesteads. Thus, litchi cultivation is a major source of livelihood security for a large population, especially in the state of Bihar. Presently it is grown in an area of 84,170 ha with a productivity 6.95 t/ha.Bihar occupies about 37.4% area and 40% production of litchi in India.

Litchi accounts for slightly more than one per cent of the total area under fruits crops in India but it has a definite economic significance in its growing areas. The harvesting period of litchi fruits is quite limited which extends from May to June in different parts of the country. Approximately 90 per cent of the produce is utilized as fresh of which at least 25 per cent goes to waste due to postharvest losses. Usually, there is abundance of fresh litchi fruit in the market due to very short period (45-60 days) of fruit maturity and harvesting in its growing regions from Tripura to Himachal Pradesh. Only a meager quantity of litchi is exported though there is great demand and scope to increase the quantum of export; more so because the harvesting season is quite different in other parts of the world.



Area (`000 ha) and production (`000 MT) of litchi in different states of India during 2013-14

भाकृअनुप–राष्ट्रीय लीची अनुसंधान केन्द्र

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