# वार्षिक प्रतिवेदन

# ANNUAL REPORT

## 2013-14

भाकृअनुप
ICAR

## राष्ट्रीय लीची अनुसंधान केन्द्र

मुशहरी, मुजफ्फरपुर – 842 002 (बिहार)

## National Research Centre on Litchi

Mushahari, Muzaffarpur – 842 002 (Bihar)

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मुशहरी, मुजफ्फरपुर – 842 002, बिहार

## National Research Centre on Litchi
**(Indian Council of Agricultural Research)**
**Mushahari, Muzaffarpur – 842 002 (Bihar)**

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## Cover Page Legend
1. Hybrid fruits set after pollination
2. A bunch of good quality fruits of cv. 'China'
3. Symptoms of leaf blight disease
4. Dehydrated litchi pulp

## Note


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# Preface

I feel privileged to bring out the Annual Report of NRC on Litchi (NRCL), Muzaffarpur for the year 2013-14. The report consists of various activities of the centre in the field of research, human resource development, transfer of technology, infrastructure development and other related activities of NRCL.

NRCL is located in the most important litchi production zone of the country. The region has pride of having the major share of litchi production and highest productivity, even though a lot of unsolved problems pose threats to litchi industry in the country. In recent years, possibility of growing litchi in non-traditional areas particularly in winter has shown a prospect for enhancing acreage under litchi. The production of litchi needs a strong infrastructure back up for post-harvest handling and marketing to realize its full potential.

NRCL is putting its best efforts in solving the problems extending technical support and helping at policy and planning level. As a result, tremendous change has been seen in trend of litchi production and its availability in domestic market.

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 some externally funded projects from Biodiversity International, DBT, NAIP and ICAR network projects, and has delivered quality results with highest degree of satisfaction.

NRCL has actively participated in programme of Rajbhasha, ICAR sports, Kisan Mela/ Kisan Gosthis, exhibition and training to farmers 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 at appropriate level.

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

I shall look forward for any suggestions or comment on the information contained in this report which would greatly help us in formulating future activities.

**Muzaffarpur**
30 June, 2014

**Vishal Nath**
Director

# Contents

# Executive Summary

National Research Centre on Litchi (NRCL), established in the year 2001 has continued its momentum in conducting basic and applied research under multidisciplinary programme covering different aspects of litchi *viz.,* genetic resource management and crop improvement, crop production, crop protection and post-harvest management, besides training and transfer of technology. The salient achievements of the Centre during 2013-14 are presented in brief.

## Research Accomplishments

### Genetic Resource Management and Crop Improvement

- Out of nine cultivars of litchi collected under FAO project, three cultivars *viz.* 'Kwai Mi', 'Sue Tong' and 'Tai So' finally survived and growing well in Nethouse.
- Five litchi germplasms were collected from indigenous sources and are being maintained in the Nethouse.
- Two germplasms of rambutan having distinct peel colour (red and yellow), bigger fruit size and easy to peel was collected from Kanjirapally district of Kerala.
- The morphological characterization of litchi germplasms planted in the Field Gene Bank was initiated and observations on plant height, girth, canopy spread, branching pattern, colour, shape and arrangement of leaflets were recorded.
- Out of 11 longan germplasm, the accession Lgc-9 had highest increase in plant height and girth. Only one accession, Lgc-6 flowered and bore fruits which had a TSS of 20.6$^0$ brix.
- Six litchi clones selected and planted in the field during March 2014.
- About 19,000 crosses were made in all possible combinations involving three parent cultivars *viz.*, 'China', 'Shahi' and 'Bedana'. Good fruit set was observed where cultivar 'China' was used as female parent.
- Among the seedling populations, 45 variants were characterized for panicle emergence, flowering, fruit set and fruit development.

### Crop Production

- Grafting as an alternative method for propagation of litchi was tried. Success of graft was about 46% under high humidity and low temperature conditions in the propagation chamber.
- Technology for effective utilization of interspaces in young bearing litchi orchards was developed. Intercrops having less completion to main crop and high economic return were elephant foot yam (*Amorphophallus paeoniifolius*), turmeric (*Curcuma longa)* and arvi (*Colocasia esculanta*).
- An experiment was conducted to evaluate efficacy of some post-cut dip solutions for growth and survival of plants in nursery. Air-layers dipped in rhizobacteria (1%) had the highest survival (90%) with maximum root: shoot ratio (0.95), root: plant ratio (0.49) and root colonization (root length/ root number) (1.91) of litchi sapling.
- Foliar spraying of ethrel (150 ppm) resulted in early colour breaking and early fruit maturity by 5 and 4 days, respectively while spraying with $GA_3$ (150 ppm) delayed fruit maturity by 7 days.
- Covering of tree canopy 15 days after fruit set with 30% green or 50% white shade-net was found effective in extending harvesting period of litchi cv. 'Shahi' by 16 days with better quality fruits.
- Studies on effect of vegetative flushing and shoot maturity on flowering and bearing behaviour revealed that July-August flushes had maximum contribution in flowering, fruit setting and fruit yield.

- Shoot physiology and biochemical parameters of litchi cv. 'China' was studied after spray with different concentration of paclobutrazol (PBZ) and potassium nitrate. Results revealed a concentration-dependent response (1 to 4 g a.i per $m^2$ canopy spread) of PBZ for flower induction and other parameters. PBZ (2 g a.i.) and $KNO_3$ (2%) produced significantly higher yield than unsprayed plants.
- Effect of application of arbuscular mycorrhizal fungi (*Glomus mosseae*), *Azotobacter chrococcum, Bacillus megatarium* and *Trichoderma harzianum* on growth and establishment of litchi was studied. Results indicated that all had positive effect on growth of plants. Higher increase in all the growth parameters was observed with application of mycorrhiza alone as well as in combination with other biofertilizer organisms. Preliminary observation showed a negative interaction between mycorrhiza and *Bacillus megatarium*. The mycorrhiza inoculated plants had good colonization of roots of litchi plants.

## Crop Protection

- The important pre-harvest diseases of litchi observed were leaf blight, twig blight, different types of leaf spots, sudden death or sudden wilting, parasitic lichens, and anthracnose on fruits. The causal organisms of these diseases were identified. Pathogen of wilt was identified as *Fusarium solani* while leaf blight pathogen was confirmed as *Alternaria alternata*.
- Except leaf blight, incidence and severity of other diseases were low. A detail study was carried out on leaf blight disease as it was the most important disease of litchi. Symptomatology and severity of the disease was studied. During March-April 2014, association of *A. alternata* with panicle blighting was also observed.
- The disease incidence, percent infected leaflets in nursery plants and percent disease severity index (PDI) of leaf blight in various nurseries during 2013 were 27.1-95.1%, 14.9-83.3% and 32.2-77.8%, respectively.
- Three distinct pathotypes was identified among population of *Alternaria alternata*.
- *Trichoderma viride* isolate 'NRCL T 01' isolated from rhizosphere of healthy plant was found very efficient in controlling soil borne pathogens particularly *Fusarium solani* under *in-vitro* condition and in potted plants under glasshouse conditions. It was mass multiplied and a talc based formulation was developed with minimum count $2x10^6$ cfu/g. Quality parameters and stability/viability of the product under storage conditions is being studied. On pilot basis, when applied in fields in 2013, the plants on the verge of wilting recovered with its application and improved their growth.
- Fruit borer, mite, leaf folder, looper, ash weevil, red weevil, bark eating caterpillar, shoot borer and stink bug was recorded as major pests while, mealy bug and bagworm as minor pests.
- Several promising natural enemies of pests *viz.*, praying mantis, *Chrysoperla carnea*, *Eocanthecona furcellata*, syrphid flies, coccinellids, *Trichogramma* sp. and braconids was observed during August 2013 to March 2014 in litchi ecosystem.
- Besides various species of *Apis viz., Apis dorsata*, *A. indica*, *A. mellifera,* other pollinators like hover fly, blue bot fly (*Calliphora* sp.), syrphid flies (*Metasyrphus* sp., *Eristalis tenax*) were also recorded.
- Maximum pest infestation was observed during October while minimum during January. Maximum population of leaf folder was in the 42nd standard week while that of looper in 43rd standard week.
- Borer infested fruit ranged between zero to 5%, however, late in the season after rains during last week of May 2013, borer infested fruits increased up to 80%.

## Post-harvest Management and Value Addition

- Pre-cooling (10$^0$C for 10 min.) of litchi fruits treated with carbendazim (250 ppm for 2 min.) + chitosan (1% for 5 min.) + citric acid (2% for 5 min.) and packed in perforated poly bag had reduced fruit rots and PLW in storage at ambient conditions Litchi fruits packed in perforated poly bag and kept at 8$^0$C + 80% RH had 47.6% fresh fruit up to 18$^{th}$ days of storage.
- Under modified atmospheric packaging, a gaseous composition having 12-18% $O_{-2}$ and 3-6% $CO_2$ resulted in 12-15 days shelf life under refrigerated conditions but at ambient conditions shelf life was only 5-6 days.
- The spray of Cropsil (40 ml/l) significantly reduced the cracking and sun burn over control followed by carbendazim (0.2%). The fruits sprayed with carbendazim had better shelf-life.
- Litchi fruits pre-cooled (2-4 hr at 4-5$^0$C) and packed in LDP bag and kept in thermocol box containing 3 silica gel ice pads could maintain quality up to 4$^{th}$ day of storage with only 2.48% discarded fruit.
- Losses in litchi at harvest and supply chain were quantified. At harvest, sunburn was 4.0-27.0%, cracked fruits were 0.0-14.0% and physically or mechanically damaged fruits during harvesting were 3.0-15%. The mean total loss observed at harvest in 2013 was 25.5%.
- The average loss at transport level in Delhi (wholesale) market was 8.9-17.2% and fruits having more than 50% browning were 10.6-23.3%. The average physiological loss in weight (PLW) was 7.07%. The improved packing methods in CFB boxes had reduced PLW (2.58%) and spoilage (4.3%).
- At retail level, losses varied from 3.0-38.3% in Delhi market and 2.1-5.8% in Muzaffarpur market during 2013. The fruits having high pericarp browning (>50%) in the Delhi market was in the range of 7.7-14.9% whereas in Muzaffarpur it was 2.2-19.6%.
- Mean cumulative loss from harvest to retail were mechanical loss 17.4%, browning (physiological loss) 27.1%, PLW 7.07% and pathological losses 17.9%.
- Among four fruit rot pathogens identified (*Alternaria alternata, Colletotrichum gloeosporiodis, Aspergillus niger* and *Aspergillus flavus)*, *A. alternata* was the dominant species.
- *Bacillus subtilis* isolate NRCL BS-01 was isolated from healthy fruit surface and evaluated for biocontrol efficacy against fruit rot pathogens.
- Litchi pulp pasteurized and treated with 1500 ppm KMS were acceptable in quality and colour up to 10 months when kept at low temperature (6±1$^0$C).
- A technique for preparation of litchi nuts was standardized.
- Osmo-mechanical method of drying litchi flesh pre-treated with sucrose solution of 40° brix at a ratio of 1:2 fruit to solution, and 60$^0$C as hot air drying resulted in highest overall acceptability of product with minimum hardiness and drying time.
- Bagging of litchi bunches at 40 days after anthesis with white butter paper bags were the best to improve quality and colour of fruits.

## Externally Funded Projects

- A total of 105 rhizospheric soil samples from litchi growing areas of Bihar *viz.* Muzaffarpur, Vaishali, Samastipur, East Champaran, West Champaran and Sitamarhi district were analyzed for spore density and root colonization by arbuscular mycorrhizal fungi (AMF), macro and micronutrient status, and diversity of AMF population.
- Soil pH of litchi orchards in various districts of Bihar was in the range of 7.42 to 9.53. The electrical conductivity of soil was in the range of 0.07 to 0.39 dSm$^{-1}$. In majority of the samples, organic

carbon was low (<0.5% in 48 samples) but nitrogen, phosphorus and potash was in the range of medium to high level.

- Spore count of AMF varied from 2-44 per two gram soil. The results revealed that all the root segments observed were colonized by AMF and the colonization was between 3.3% to 90.0%.
- In general, medium level of available phosphorus ($P_2O_5$) (13-28 kg/ha) had a positive effect on spore density and colonization of roots of litchi by AMF.
- Micronutrients in general, did not affected spore density of AMF in litchi rhizosphere (zero or a very weak linear correlation) but did affected root colonization by AMF in a negative linear relationship, the effect being more prominent above critical limits of the micronutrients.
- In almost all the samples *Glomus* species dominated the AMF population. Other genera found were *Acaulospora*, *Entrophosphora* and *Scutellospora*. Different AMF species identified were *G. mosseae, G. fasciculatum, G albidum, G. hoi, G. multicauli, Acaulospora scrobiculata,* and *Entrophosphora infrequens.*
- Sixteen germplasms of mango and 13 of pummelo were morphologically characterised and listed in fruit catalogue published by the centre. Eight mango germplasm were characterized using 10 primers by ISSR marker at division of Crop Improvement, CISH, Lucknow.
- 'Clone 77' was identified in *Bhuskaul* village of Samastipur district of Bihar as late maturing mango having bigger fruit size (308 g/ fruit). The clone is being multiplied for large scale distribution.
- Two community nurseries were established under UNEP-GEF/TFT Project and 12 custodian farmers identified from Pusa site. Mango diversity fair and training programmes on GAPs were organised during 2013.
- Under e-GRANTH project, server and KOHA software was installed. Data (English/Hindi) on books, encyclopedias, annual reports, dictionaries, newsletters, and Hindi books had been entered in excel sheet under 'Koha Implementation Programme' and migrated to KOHA.
- MoU with Shree Hari Fabricator, Kolkata was signed on 27 September, 2013 at NIRZAFT, Kolkata for commercialization of various litchi products *viz.* wine, nut, squash, pulp etc and development of machinery related to it.
- The centre had signed MoU with Reliance Industries Ltd., Kolkata for "testing the non-woven fabric made from RP for bagging of litchi bunches on quality and yield of litchi fruits".
- Under Revolving Fund scheme (RFS) 27,893 litchi saplings of cv. 'Shahi' and 'China' were made available to different indenters from state department and to other stakeholders. Revenue of Rs. 9,76,255 was generated during the year.

## 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. During 2013, NRCL signed MoU with SKUAS&T, Jammu, and the IGKV, Raipur for collaborative research and enrichment of faculty with advance research.

## 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" and eight formal training of farmers and extension functionaries of state agriculture departments. The centre had also participated in various farmers fair to showcase the technology and disseminate the information to actual stakeholders.

## Other Activities

'Agricultural Education Day' was organized by NRCL for school students on 6th September, 2013. Half yearly meeting of the *Nagar Rajbhasha Karyanwayan Samiti, Muzaffarpur* was held on 19th February 2014. The '*Hindi Chetna Maas 2013*' from 1st to 30th September 2013 was organized at NRCL in which various competitions were held and winners were awarded to encourage the use of Rajbhasha Hindi in day to day activities. Besides these, 'National Science Day' was organized at the Centre on 28th February 2014.

## Infrastructural development

The Centre is trying to develop its own laboratory facilities for molecular characterization and other biotechnological studies, and equipments and other facilities. Laboratory facilities for plant pathological and microbiological research, soil analysis and state of art facilities for post-harvest management were developed. MAP unit has been installed in post-harvest management laboratory. A common instrumentation facility at the centre has also been developed.

# NRCL

*The NRCL is premier national institute for conducting research and developments on litchi and provide 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 National Research Centre on Litchi (NRCL) was established on 6th June, 2001 under the aegis of the Indian Council of Agricultural Research. The Centre started functioning from 2002 with budgetary allocation and the first batch of two scientists joined 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 Mushahri. 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 $26^0$5'87" N latitude, $85^0$26'64" E longitude at 210 m asl. It is about eight km from Muzaffarpur railway station. The research farm of the centre is spread over an area of 35 ha.

## Mission, Mandate and Functions

### Mission

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

### Mandate

The centre has mandate to act as a repository of litchi plant genetic resource and to provide single window solution for crop production and post harvest 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.

## Infrastructure 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, leaf area meter, portable

photosynthesis meter, 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 has 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. It has broadband facility from BSNL for internet connectivity, and its website is being accessed worldwide by many stakeholders (*http://nrclitchi.org*).

## Significant Achievements

### Genetic Resource Management and Crop Improvement

- Fifty two accessions of litchi and allied species were collected from indigenous sources and were planted in the germplasm repository.
- Eight cultivars of litchi were collected from Spain under FAO Project
- Molecular characterization of 20 litchi cultivars was in progress in collaboration with CISH, Lucknow using RAPD and ISSR markers.
- Fifty six superior clones of litchi were identified and propagated.
- Developed hybrid progenies involving litchi cultivars 'Shahi', 'China', 'Bedana' and 'Kasba' and they are being evaluated.
- About 400 seedlings of *cv.* 'Shahi' and 'China' are under evaluation. Seedlings are also being raised from the selected clones.

### Crop Production

- Rejuvenation technique standardized for old senile orchard.
- In cultivar 'Shahi' application of 75:50:100 g NPK/ plant/year and in cv. 'China' 100:50:100 g NPK/ plant/year has been found most effective for vegetative growth.
- Inter-space utilization protocol for young non-bearing litchi orchards has been developed with (i) Litchi-Banana (ii) Litchi–Cowpea-Potato-Onion (ii) Litchi-Okra-Gladiolus models having a high B:C ratio of 2.38, 1.53 and 1.37, respectively.
- Foliar application of planofix @ 2.5 ml/10 litres or NAA 20 mg/ litre of water one week after fruit set checked fruit drop significantly.
- Two spray of $KNO_3$ (4% and 2%) after 20 and 30 days of fruit set delayed colour-break by 5 days in litchi cv. 'Shahi'.
- Bagging of individual litchi bunches in cv. 'Shahi' with perforated butter paper was found the best for production of class-I category fruits with reduced sun-burn and cracked fruits.
- Covering plants with 30% green and 50% white shade nets extended the harvesting period up to 16 days with slight decrease in TSS and acidity.

- Biodiversity of arbuscular mycorrhiza in litchi rhizosphere was studied. Three species of *Glomus* was the found predominantly associated with plants.

## Crop Protection

- Identified major pests of litchi prevalent in the area.
- Trichogramma @50,000 eggs/ha at flower initiation and Nimbicidine @0.5% at fruiting, Cypermethrin @0.005% and Nimbicidine @0.5% were effective in minimizing the damage caused by fruit borer.
- Three new pest threats in litchi were identified *viz*., red weevil (*Apoderus blandus)*, looper (*Perixera illepidaria)* and bagworm (*Eumeta crameri*).
- A 'twig blight' was observed, disease symptoms of which appeared as death of leaves on new shoots and leaf blight and tip dieback that was difficult to separate. The leaf blight appeared as tan spots on the leaves. The afflicted leaves look-like scorched from the sun.
- At post-harvest stage, fruit rot caused by several fungi (*Alternaria alternata Colletotrichum gloeosporioidis* and *Aspergillus flavus)* was found severe.

## Post-harvest Management and Value Addition

- Physico-chemical studies of litchi fruits during fruit development revealed that 3rd week onward of May is the best time for harvesting litchi *cv.* 'Shahi'.
- Combined spray of boric acid (0.2 and 0.5%) + carbendazim (0.1%) + $GA_3$ (50 and 100 ppm) + $KNO_3$ (2 and 4%) or $CaNO_3$ (1%) twice during fruit development stage gave higher yield and good quality with less sun-burn and cracked fruits in the *cv.* 'Shahi'.
- Thermocol packaging enhanced the shelf-life of litchi fruits by 6-8 days.
- Wine from litchi fruits having high nutritional value was produced by fermentation using wine yeast, *Saccharmoyces cerevisiae var.* bayamus.
- Good quality litchi nuts was produced by treating the fruits with KMS (0.1%) followed by citric acid (2%) and dried alternatively in sun/shade-oven-sun for specific periods.

## Externally Funded Projects

- Ten genotypes of pummelo and 14 of mango were identified from Pusa cluster.
- Good agricultural practices for litchi were demonstrated.
- Pollination behaviour in litchi was studied.
- Intercrops for grown up orchards were standardized.
- Biodiversity of arbuscular mycorrhiza in litchi was studied.
- Under RFS about 25,000 quality litchi saplings are being produced every year.

## Staff Strength of the Centre

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

## Financial Statement 2013-14

**(Rs. in lakh)**

| | Plan | | Non-plan | |
|---|---|---|---|---|
| | Allocation | Utilization | Allocation | Utilization |
| **Capital** | 224.35 | 224.43 | 3.00 | 3.03 |
| **Revenue** | | | | |
| Establishment Expenses | 0.00 | 0.00 | 183.27 | 182.7 |
| Travelling Allowance | 11.50 | 11.49 | 1.00 | 0.94 |
| Research and Operational Expenses | 71.00 | 70.84 | 5.00 | 7.16 |
| Administrative Expenses | 77.50 | 77.56 | 18.01 | 16.27 |
| Miscellaneous Expanses | 0.50 | 0.52 | 0.00 | 0.00 |
| **Total** | 384.85 | 384.84 | 210.28 | 210.10 |

## Resource Generation

**(Rs. in lakh)**

| | |
|---|---|
| Sale of Farm Produce | 5.74 |
| Interest Earned on Short Term Deposits | 13.52 |
| Income Generated From Internal Resources | 0.70 |
| Miscellaneous Receipts | 0.34 |
| Total | 20.30 |

## Receipts and Expenditure Statement of Externally Funded Projects

**(Rs. in lakh)**

| Externally Funded Projects | Opening balance | Receipt during 2013-14 | Expenditure |
|---|---|---|---|
| Total | 33.30 | 6.22 | 8.79 |

# 1. Plant Genetic Resources Management and Crop Improvement

## 1.1. Collection of indigenous and exotic germplasm, their characterization, evaluation, documentation and utilization (Awtar Singh, Rajesh Kumar, Amrendra Kumar and Narayan Lal)

### Collection of litchi germplasm from indigenous and exotic sources

Out of nine cultivars of litchi collected under FAO project, three cultivars *viz.* 'Kwai Mi', 'Sue Tong' and 'Tai So' finally survived and growing well in the Net house. These three cultivars were showing good vegetative growth, they could be multiplied by air layering. Fifteen litchi germplasm was collected from indigenous sources, which were being maintained in the net house. These germplasm will be planted in the germplasm block during July, 2014.

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

Morphological characterization of the litchi germplasms planted in the Field Gene Bank was initiated and observations on plant height, stem girth, canopy spread (North-South and East-West), branching pattern, colour, shape and arrangement of leaflet were recorded. Flowering was observed in ten litchi germplasm. However, very less number of flowers was noticed due to juvenile phase of plants.

**Table 1.1: Performance of litchi germplasm in Field Gene Bank (2013-14)**

| Cultivars | Percent fruit set |
|---|---|
| 'Bedana Sel. Pant' | 42.6 |
| 'Swarnaroopa' | 50.0 |
| 'Late Bedana' | 37.8 |
| 'Bedana Sel Sabour' | 32.0 |
| 'Late Large Red' | 32.4 |
| 'Bedana' | 74.0 |
| 'Yogda Sel.' | 63.5 |
| 'Calcuttia Late' | 72.1 |
| 'China' | 45.4 |
| '*Deshi*' | 32.7 |

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

This experiment could not be initiated laboratory facility is being created and the experiment will be initiated thereafter.

### Collection, characterization and evaluation of longan (*Dimocarpous longan*) germplasm

Out of eleven longan germplasms evaluated, the accession Lgc-9 had the highest plant height (5.2 m) and maximum girth (69.0 cm). The accession Lgc-6 recorded maximum fruit yield (6.6 kg/tree) but the maximum fruit weight recorded in the accession Lgc-7

**Table 1.2: Growth parameters and physicochemical characteristics of longan germplasm recorded during 2013**

| S.N. | Plant height (m) | Girth (cm) | Canopy spread (m) | | Fruit yield (kg/ tree) | Fruit weight (g) | TSS ($^0$Brix) |
|---|---|---|---|---|---|---|---|
| | | | E-W | N-S | | | |
| Lgc-1 | 3.0 | 47.0 | 3.4 | 3.6 | 3.80 | 3.8 | 19.6 |
| Lgc-2 | 2.1 | 26.2 | 2.2 | 2.3 | - | - | - |
| Lgc-3 | 2.9 | 26.0 | 3.4 | 2.9 | 1.60 | 1.6 | 20.2 |
| Lgc-4 | 3.9 | 60.0 | 6.2 | 6.2 | - | - | |
| Lgc-5 | 4.7 | 61.4 | 6.4 | 6.5 | - | - | |
| Lgc-6 | 3.1 | 53.0 | 3.5 | 4.5 | 6.62 | 6.5 | 20.6 |
| Lgc-7 | 4.1 | 51.0 | 5.4 | 4.9 | 6.46 | 6.7 | 20.2 |
| Lgc-8 | 3.9 | 51.0 | 5.6 | 4.6 | - | - | - |
| Lgc-9 | 5.2 | 69.0 | 6.0 | 6.1 | 1.82 | 1.8 | 18.8 |
| Lgc-10 | 1.9 | 43.0 | 1.7 | 2.2 | 1.46 | 1.4 | 19.8 |
| Lgc-11 | 3.1 | 59.0 | 3.9 | 3.7 | 3.62 | 3.6 | 20.2 |

(6.7 g/fruit). Panicle emergence in only one accession (Lgc-6) was observed in the first week of March and was earliest with respect to flowering and fruiting, while the four accessions *viz.,* Lgc-2, Lgc-4, Lgc-5, Lgc-8 had no flowering and fruit set. The highest TSS (20.6) was recorded in the accession Lgc-6, while it was lowest (18.8) in the accession Lgc-9. Further, survey and exploration visit for longan germplasm collection will be made in West Bengal.

### Collection, characterization and evaluation of rambutan germplasm

Two germplasm of rambutan was collected from Kanjirapally district, Kerala. They were having distinct peel colour (red and yellow), bigger fruit size and easy to peel. The vegetatively propagated plants were kept in the protected area during winter. Both the germplasms were surviving in the protected house.

## 1.2. Development of improved cultivars in litchi (Awtar Singh, Rajesh Kumar and Narayan Lal)

### Clonal selection for improvement in commercial cultivars of litchi

Six litchi clones were planted in the field during 2013-14 at a spacing of 8.25 m x 8.25 m. Five plants each in six clones were planted during March 2014. All clones survived and growing well in the field.

**Table 1.3: Litchi clones at NRCL Field Gene Bank**

| Clone | No. of plants | Date of planting |
|---|---|---|
| NRCL-01 | 4 | 29.08.2012 |
| NRCL-02 | 3 | 29.08.2012 |
| NRCL-03 | 1 | 29.08.2012 |
| NRCL-04 | 3 | 30.08.2012 |
| NRCL-05 | 3 | 30.08.2012 |
| NRCL-06 | 4 | 30.08.2012 |
| NRCL-07 | 2 | 30.08.2012 |
| NRCL-08 | 1 | 30.08.2012 |
| NRCL-09 | 2 | 30.08.2012 |
| NRCL-10 | 1 | 31.08.2012 |
| NRCL-11 | 1 | 31.08.2012 |
| NRCL-12 | 2 | 31.08.2012 |
| NRCL-13 | 2 | 31.08.2012 |
| NRCL-14 | 2 | 31.08.2012 |
| NRCL-15 | 4 | 31.08.2012 |
| NRCL-16 | 1 | 01.09.2012 |
| NRCL-17 | 5 | 05.03.2014 |
| NRCL-18 | 5 | 05.03.2014 |
| NRCL-19 | 5 | 05.03.2014 |
| NRCL-20 | 5 | 05.03.2014 |
| NRCL-21 | 5 | 05.03.2014 |
| NRCL-22 | 5 | 05.03.2014 |

### Development of improved hybrids of litchi

About 19,000 crosses were made in all possible combinations with three parent cultivars *viz.*, 'China', 'Shahi' and 'Bedana'. Good fruit set was observed in pollinated flowers after one week (13.4-26.2%) but after

**Fig. 1.1 Hybrid fruits set after pollination**

**Table 1.4: Hybridization programme undertaken during 2013-14**

| Cross | Flowers pollinated | Total fruit set after one week | Fruit set after one week of crossing (%) | Fruit set after two weeks of crossing (%) |
|---|---|---|---|---|
| 'Shahi' x 'Bedana' | 4646 | 1217 | 26.2 | 0.0 |
| 'Bedana' x 'Shahi' | 1253 | 168 | 13.4 | 0.0 |
| 'China' x 'Shahi' | 4356 | 905 | 20.8 | 2.5 |
| 'Shahi' x 'China' | 2519 | 455 | 18.1 | 0.0 |
| 'Bedana' x 'China' | 2714 | 622 | 22.9 | 0.0 |
| 'China' x 'Bedana' | 4254 | 834 | 19.6 | 3.0 |

two weeks most of the fruits dropped due to heavy wind velocity. Good fruit set was observed where cultivar 'China' was used as female parent (Fig. 1.1).

## Evaluation of seedling population of litchi for improved plant types

A total of 531 seedling populations were evaluated for plant morphological characters, *viz*., plant height, stem girth, leaf length and width, canopy spread and number of times new flush emerged and colour of flushes. A wide variation was observed for these parameters among the population. During 7$^{th}$ year under experimentation, observation was recorded in 45 variants (8.4% of total population) for panicle emergence, flowering, fruit set and fruit development. Out of these, only 22 bore fruits up to maturity. Fruit weight varied from 2.25 g to 17.46 g. The plant type showing distinct characteristics for plant height, stem girth, leaf length and width, canopy spread, panicle emergence, flowering, fruit set and fruit yield was being characterized.

## Establishment and evaluation of provincial populations of litchi

To establish the provincial population from different states, the seeds from the selected clones were sown individually in nursery in net house. 'Shahi', 'China' and other litchi cultivars were raised. Further, the seedlings exhibiting wide range of morphological variation were planted in the field (Table 1.5). The seeds of other litchi cultivars will also be collected from different states.

**Table 1.5: Provincial population of seedlings grown from selected plants' seeds**

| Category | Date of planting | No. of plants |
|---|---|---|
| Natural hybrid | 27.08.2013 | 24 |
| North East Population | 27.08.2013 | 26 |
| Jharkhand Population | 27.08.2013 | 24 |
| Segregating Population (Bihar) | 28.08.2013 | 28 |
| Clones selected | 29.08.2013 | 24 |
| 'Shahi' seedlings | 29.08.2013 | 40 |
| 'China' seedlings | 30.08.2013 | 190 |
| Other seedlings | 31.08.2013 | 144 |

# 2. Development of Sustainable Production Technology

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

### Standardization of grafting technique

About 2000 seedlings were raised for root stocks. The earlier raised seedlings of desirable stem thickness were selected and grafting operation (wedge and side grafting) was performed according to the technical programme. The wedge grafting showed maximum percentage of success (46%) with better graft reunion attempted in September month. The survivability of grafted plants was recorded up to 120$^{th}$ days from the date of grafting operation. The better success was observed under high humidity and low temperature conditions maintained in the propagation chamber (Table 2.1).

**Table 2.1: Survivability of grafted plants of litchi**

| Treatments | Survivability of grafted plants (%) | | | |
|---|---|---|---|---|
| | After 30 days | After 60 days | After 90 days | After 120 days |
| Grafting during July 2013 | | | | |
| $T_1$-$M_1S_1$ | 28 | 18 | 8 | 6 |
| $T_2$-$M_1S_2$ | 28 | 16 | 14 | 6 |
| $T_3$-$M_1S_3$ | 44 | 18 | 4 | 0 |
| $T_4$-$M_2S_1$ | 24 | 14 | 4 | 0 |
| $T_5$-$M_2S_2$ | 38 | 18 | 18 | 6 |
| $T_6$-$M_2S_3$ | 46 | 22 | 6 | 6 |
| Grafting during August 2013 | | | | |
| $T_1$-$M_1S_1$ | 18 | 10 | 8 | 0 |
| $T_2$-$M_1S_2$ | 24 | 18 | 12 | 0 |
| $T_3$-$M_1S_3$ | 24 | 18 | 18 | 18 |
| $T_4$-$M_2S_1$ | 24 | 12 | 10 | 4 |
| $T_5$-$M_2S_2$ | 32 | 20 | 12 | 4 |
| $T_6$-$M_2S_3$ | 28 | 18 | 18 | 18 |
| Grafting during September, 2013 | | | | |
| $T_1$-$M_1S_1$ | 46 | 32 | 32 | 28 |
| $T_2$-$M_1S_2$ | 46 | 38 | 34 | 32 |
| $T_3$-$M_1S_3$ | 52 | 46 | 46 | 46 |
| $T_4$-$M_2S_1$ | 44 | 36 | 32 | 32 |
| $T_5$-$M_2S_2$ | 58 | 38 | 34 | 24 |
| $T_6$-$M_2S_3$ | 48 | 44 | 44 | 44 |

$M_1$: 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

### Standardization of protocol for mound layering in litchi

The mound layering was tried by heading back of established plants at 15 cm height. Sprout emerged and shoot formed after attaining age of 180 to 240 days and length was 20 cm and above. The mounding of the stumps was done accordingly. The rooting took place in case of both girdled and normal matured shoots in the mounded portion. The separation of the rooted stems and survival as a propagated plant was negligible, as it did not tolerate operational and transplanting jerks and found economically unviable. Hence, this experiment was then concluded due to inconsistent outcome.

### Effect of various dip solutions on establishment of litchi gooties in nursery

An experiment was conducted to evaluate the efficacy of some post-cut dip solutions for growth and survival of plants in nursery. Freshly detached air-layers were dipped in various dip solutions *viz.*, carbendazim 0.2% ($T_1$), NRCL formulation 0.5% ($T_2$), NRCL

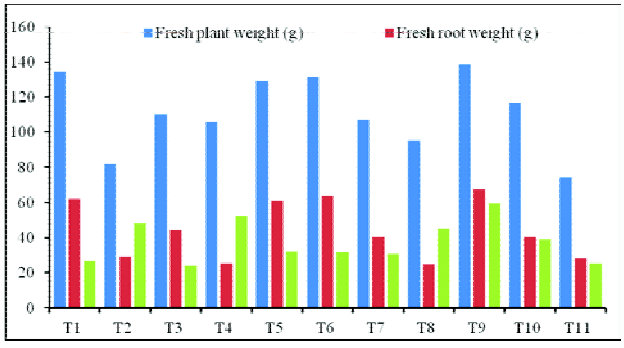


**Fig. 2.1: Effect of different root dip treatments on growth performance of air layers**

formulation 1.0% ($T_3$), NRCL formulation 1.5% ($T_4$), NRCL formulation 2.0% ($T_5$), soil + vermi-compost (VC) thick paste 2:1 ($T_6$), VC thick paste ($T_7$), *Trichoderma viride* 1% ($T_8$), rhizobacteria 1% ($T_9$), rhizobacteria 2% ($T_{10}$) and control (water dip, $T_{11}$). Observation was recorded up to 10 months after planting. The maximum survival of litchi air-layers (90%) was observed in treatment with rhizobacteria 1% ($T_9$) followed by $T_2$ (86.5%), $T_8$ (85%) and $T_{10}$ (85%) while, minimum was in control (65%).

Results also indicated that air-layers dipped in rhizobacteria (1%) had the highest fresh plant weight (138.5 g), root weight (67.5 g) and cumulative tertiary root length (59.5 cm) (Fig. 2.1). The maximum fresh weight of shoots (63.5 g), leaf weight (30.0 g), number of primary roots (36.5), secondary root (101.5) and tertiary roots (307.5) were noticed in $T_4$, $T_{10}$, $T_6$, $T_7$ and $T_2$, respectively (Fig. 2.2). Rhizobacteria (1%) treated air-layered plants also exhibited highest root-shoot ratio (0.95), root-plant ratio (0.49) and root colonization (root length/root number (1.91).

**Fig. 2.2: Growth performance of litchi air-layers in control (Left) in treatment with rhizobacteria 1% (Right)**

Microbial analysis of the rhizosperic soil of the experimental plants of treatments ($T_8$, $T_9$ and $T_{10}$) having *Trichoderma* and rhizobacteria, was done by counting colony forming units (CFU) after plating on suitable medium. The result on count is given in table 2.2.

**Table 2.2: Microbial analysis of rhizoshperic soil samples of various dip treatments**

| Treatment | CFU per gram soil | | | |
|---|---|---|---|---|
| | *Tricho-derma* sp. | Fluorescent pseu-domonds | Phosphate solubilizing bacteria | *Azoto-bacter* sp. |
| Trichoderma (1%) | $7.45 \times 10^5$ | - | - | - |
| Rhizobacteria (1%) | - | $1.3 \times 10^3$ | $3.65 \times 10^3$ | 0.0 |
| Rhizobacteria (2%) | - | $1.85 \times 10^4$ | $7 \times 10^3$ | $2.3 \times 10^3$ |

## 2.2. Development of sustainable production techniques in litchi (S. D. Pandey, Amrendra Kumar, R. K. Patel and Kuldeep Srivastava)

### Effect of graded levels of N and K on growth, yield and quality of litchi cv. 'Shahi'

Observations recorded during May 2013 on yield and quality parameters revealed that application of 75: 50: 75 g NPK/plant/year had good flowering and fruiting and recorded the maximum fruit yield of 36.8 kg/plant and better quality fruits. TSS of the fruits was in the range of 17.6 to 18.4$^0$brix. The range of available nitrogen in soil analyses were 82-163 kg/ha. During March 2014, average 90% flowering and fruit set were observed in all treatments. Growth observations showed non- significant differences. Bark eating caterpillar and shoot borer incidence was noticed in all densities. This year also, mite infestation was not noticed. Less than 2% fruit borer infestation was noticed in different treatments.

### Effect of graded levels of N and K on growth, yield and quality of litchi cv. 'China'

Observations recorded on growth parameters showed non-significant differences. However, application of 75:50:100 g NPK/plant/year showed better growth response and plant girth. Spread N-S and E-W direction recorded were 53.8 cm, 5.5 m and 5.3 mm, respectively during Sep 2013. About 80% plants had flowering in March, 2014 and very good fruit set was recorded. Mite was not noticed in the field but bark eating caterpillar was noticed in the field.

## Standardization of organic inputs for litchi production

Maximum yield (18.6 kg) was recorded with application of 20 kg FYM + 2 kg vermi-compost + 1 kg neem cake + biofertilizers. Total four flushes were observed during period. Mite was not noticed in the field. Fruit borer infestation was noticed up to 9.8% whereas bark eating caterpillar was the major problem. Assay value of leaf N content was 1.52% in this treatment whereas in other treatment range of N was 1.41-1.44%.

## Development of package of practices for organic litchi production

To develop a package of practices for organic litchi production, one orchard block of litchi cv. 'Shahi' was planted in 0.5 ha area at 6 x 6 m spacing under organic management practices. Studies will be carried out to evaluate the response of different organic resources on growth performance of litchi plants.

## 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 second year of experimentation. The treatment having pruning at 2.0 m height + 3 branches/trunk recorded the maximum growth (1.29 m) in plant height. The maximum canopy spread was recorded in the treatment having pruning at 2.5 m height + 4 branches/trunk (1.77 m E-W, 1.28 m N-S). The maximum shoot length (44.2 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. The treatment of reiterative pruning at 2.0 m height plus 4 branches/trunk started bearing and gave maximum fruit yield (13.2 kg) (Table 2.3). All the treatments receiving pruning and training treatment recorded the phase change from vegetative to reproductive but fruit yield was negligible. The open space was utilized with intercrops of maize and mustard.

**Table 2.3: Vegetative growth, flowering and fruit yield in reiteratively pruned old senile litchi trees during 2013**

| Treatment details | Increase in height (m) | Increase in canopy spread (m) | | Shoot length (cm) | Flowering (%) | Number of fruits/ panicle | Fruit yield (kg/ tree) |
|---|---|---|---|---|---|---|---|
| | | E-W | N-S | | | | |
| Pruning at 2.0 m height | 1.19 (3.18) | 1.50 (3.03) | 1.64 (3.42) | 26.60 | 02.6 | 2.6 | - |
| Pruning at 2.0 m height + 3 branches/trunk | 1.29 (3.12) | 1.19 (3.66) | 1.37 (3.53) | 42.40 | 14.8 | 2.2 | 04.12 |
| Pruning at 2.0 m height + 4 branches/trunk | 0.97 (3.48) | 0.41 (4.29) | 1.05 (3.95) | 38.40 | 02.6 | 6.2 | 13.26 |
| Pruning at 2.5 m height | 1.20 (3.26) | 1.06 (4.05) | 1.23 (3.65) | 38.20 | 02.6 | 1.6 | 02.12 |
| Pruning at 2.5 m height + 3 branches/trunk | 1.16 (3.34) | 1.25 (3.88) | 1.05 (3.53) | 44.20 | 08.0 | 2.4 | 04.16 |
| Pruning at 2.5 m height + 4 branches/trunk | 0.92 (3.78) | 1.77 (3.98) | 1.28 (4.52) | 38.6 | 02.8 | 1.4 | 01.82 |
| Unpruned tree (Control) | 0.42 (3.68) | 0.48 (3.32) | 0.74 (3.42) | 21.20 | 89.0 | 8.6 | 28.22 |

*Figures in parenthesis are actual value of parameters*

### Studies on effective utilization of interspaces in young bearing litchi orchards for income and soil health improvement

In a 9-year old orchard, the yield of various intercrops *viz.,* elephant foot yam (230 q/ha), turmeric (142 q/ha) and *arvi* (112 q/ha) were recorded. Litchi plants covered 62.34% of the total area (68.1 $m^2$). No adverse effect on main crop due to intercrops were found. Soil samples were analyzed for available nitrogen and their values in different crop combination were 142.9, 144.3 and 134.3 kg/ha in elephant foot yam, turmeric and *arvi*, respectively. The soil pH in elephant foot yam, turmeric and *arvi* grown plots were 8.1, 8.3 and 8.2, respectively. Heavy fruit bearing had been observed in the system.

### High density planting in litchi cv. 'Shahi'

Observations were recorded on growth parameters during September 2013 showed significant differences. The maximum girth and spread was observed in planting densities 6 x 4 $m^2$, 6 x 6 $m^2$ and 4 x 4 $m^2$, whereas in 2 x 2 $m^2$ and 4 x 4 $m^2$ densities maximum height was recorded. During 2014, in 4 x 4 $m^2$ planting density nearly 75% plants flowered followed by 6 x 6 $m^2$ and 6 x 4 $m^2$ (60%). Fruit set was also very good in flowered plants.

### Standardization of pruning intensity in high density planting of litchi

The pruning intensity in two high densities planting is being standardized. Preliminary information is presented below:

1. 2 x 2 m planting density: Height-1 m, 1.5 m and 2.0 m, 2. Pruning intensity: 25% and 50% of annual shoot growth back pruning one time during June.

   Good flowering and fruit set was observed in the plants of 50% of annual pruning during next year.

2. 4 x 4 m planting density: 1. Height- 2 m, 2.5 m and 3.0 m, 2. Pruning intensity: 25% and 50% of annual shoot growth back pruning one time during June.

Very good flowering and fruit set was observed in all the height and pruning intensity.

## 2.3. Investigation and establishing the physiological and biochemical relations for improved litchi production (Amrendra Kumar, S.D. Pandey, Rajesh Kumar, Sushil Kumar Purbey and Sanjay Kumar Singh)

### 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. The natural flushes of July-August transformed to maximum (up to 88%, 74%) extent in the panicle bearing shoots while November-December flushes transformed to the lowest extent (up to 26%, 24%). 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 from September onwards, not only ensured their maximum contribution in flowering but also resulted in 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 2.4: Vegetative and reproductive growth in natural and forced flushes in litchi

| Treatment | Type of flush | Length of the flush (cm) | Times of extension growth | No. of branched shoots | Total length of shoot at the time of flowering (cm) | Total length of panicle at the time of first flowering (cm) |
|---|---|---|---|---|---|---|
| July 2013 | Natural | 5.52 | 3.44 | 3.66 | 48.2 | 88 |
| | Forced | 4.34 | 1.66 | 3.26 | 43.6 | 44 |
| Aug. 2013 | Natural | 6.12 | 3.56 | 3.26 | 44.6 | 72 |
| | Forced | 4.65 | 1.60 | 3.26 | 36.6 | 42 |
| Sept. 2013 | Natural | 4.25 | 3.46 | 3.16 | 44.8 | 68 |
| | Forced | 4.15 | 1.66 | 2.32 | 26.4 | 26 |
| Oct. 2013 | Natural | 5.25 | 3.12 | 2.56 | 44.6 | 56 |
| | Forced | 4.54 | 1.66 | 2.12 | 26.8 | 22 |
| Nov. 2013 | Natural | 4.65 | 1.66 | 2.42 | 32.8 | 26 |
| | Forced | 3.55 | 1.26 | 1.66 | 18.8 | 21 |
| Dec. 2013 | Natural | 4.85 | 1.54 | 1.86 | 16.6 | 24 |
| | Forced | 3.65 | 1.22 | 1.12 | 14.2 | 23 |

Table 2.5: Flowering, fruit set and fruit yield in natural and forced flushes in litchi

| Treatment | Type of flush | No. of branched shoots which bore panicles | No. of flowers/ panicle | Proportion of Male:Hermaphrodite: Female flowers | Fruit set/ panicle | Fruit yield (g/panicle) | Fruit yield (kg/tree) |
|---|---|---|---|---|---|---|---|
| July 2013 | Natural | 96.3 | 1230 | 724:110:396 | 11.6 | 266.6 | 47.3 |
| | Forced | 49.6 | 366 | 203:37:126 | 5.7 | 119.6 | 21.3 |
| Aug. 2013 | Natural | 89.6 | 1186 | 702:108:376 | 8.6 | 183.3 | 36.6 |
| | Forced | 49.3 | 578 | 340:70:168 | 6.1 | 116.6 | 18.3 |
| Sept. 2013 | Natural | 89.3 | 888 | 548:48:292 | 8.6 | 177.6 | 34.3 |
| | Forced | 26.3 | 320 | 146:72:102 | 6.6 | 116.3 | 14.3 |
| Oct. 2013 | Natural | 76.6 | 690 | 418:96:176 | 7.6 | 168.6 | 26.6 |
| | Forced | 26.3 | 676 | 326:106:244 | 5.3 | 094.3 | 12.6 |
| Nov. 2013 | Natural | 66.3 | 818 | 502:152:164 | 5.0 | 086.6 | 11.3 |
| | Forced | 78.3 | 760 | 460:80:220 | 3.6 | 056.6 | 06.6 |
| Dec. 2013 | Natural | 34.3 | 760 | 446:96:218 | 3.6 | 064.3 | 06.3 |
| | Forced | 78.3 | 510 | 296:76:138 | 3.6 | 070.3 | 08.3 |

## Effect of plant growth regulators (PGR) on yield, maturity and quality of litchi fruits cv. 'Shahi'

Experiment was conducted to study the effect of plant growth regulators on regulation of bearing, yield and fruit quality in 9-10 years old litchi orchard (junior bearing stage). Twelve different PGRs in the treatment included NAA (15, 25 and 40 ppm), $GA_3$ (25, 50 and 75 ppm), ethrel (100 and 150 ppm), MH (15, 20 and 25 ppm) and control (water spray). Three spraying of NAA, ethrel, MH along with control and two spraying of $GA_3$ was applied at pre-flowering stage from 1st week of October at 30 days interval while 3rd spraying of $GA_3$ was given after fruit set. Results revealed that most of the shoots treated with PGRs showed >90% flowering inflorescence shoot except MH 15 ppm and control (76.7% each). Ethrel (100 and 150 ppm) and MH (20 and 25 ppm) consistently resulted in >90% flowering

inflorescence every year however, spray of $GA_3$ and NAA lead to flowering inflorescence in alternate year. Highest number of female flower/twig (103) and sex ratio (44.6) were recorded in MH 25 ppm whereas, lowest female flower/twig was noticed in control (49.0) and sex ratio in NAA 40 ppm (30.7) (Fig. 2.3). Ethrel 150 ppm resulted in early colour breaking and early fruit maturity by 5 and 4 days, respectively as compared to control. However, $GA_3$ 150 ppm and MH 25 ppm extended the harvesting period delaying the fruit maturity by 7 and 4 days, respectively (Fig. 2.4 and 2.5).

All the treatments showed significant effect on fruit and fruit quality attributes except fruit weight and TSS. The highest fruit weight (22.7 g), pulp weight (14.8 g), fruit volume (21 cc) and TSS (20.99$^0$ brix) were recorded in ethrel 100 ppm while least seed weight (3.3 g) in NAA 15 ppm and peel weight (2.12 g) in NAA 25 ppm. The

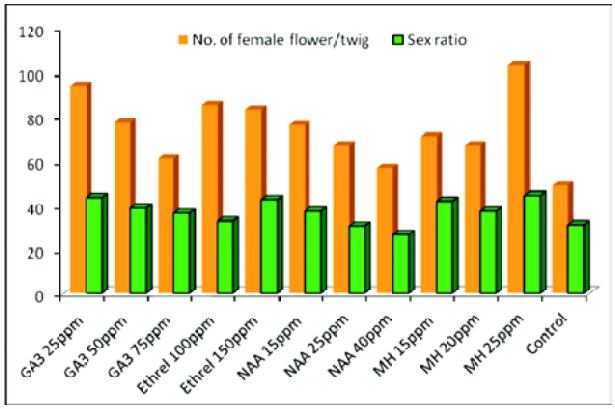


**Fig. 2.3: Effect of PGRs on number of female flower and sex ratio in litchi**

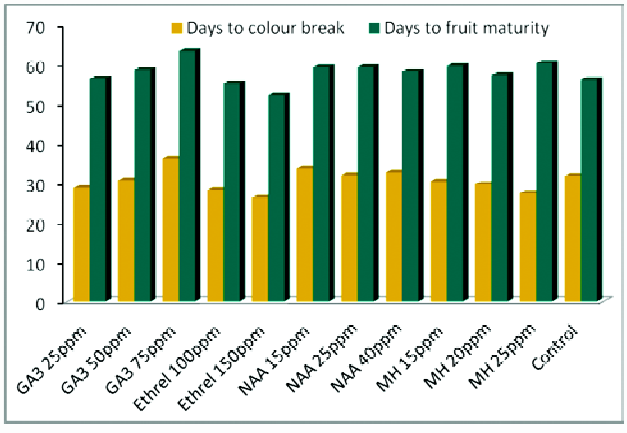


**Fig. 2.4: Effect of PGR on days taken to colour break and fruit maturity**

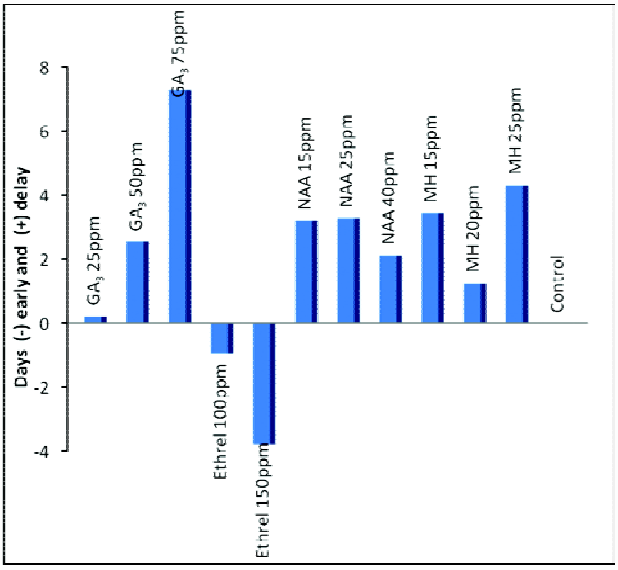


**Fig. 2.5: Effect of PGR spray on fruit maturity**

maximum fruit yield of 34.4 kg/plant was obtained in ethrel 100 ppm followed by $GA_3$ 25 ppm (30.2 kg/plant). Micro nutrient content in leaf samples were analyzed and their level varied in different treatments *viz.* zinc (20-30 ppm), copper (30-300 ppm) and manganese (15-52 ppm).

## Applications of Prohexadione-Calcium, Paclobutrazol and Potassium Nitrate in influencing flower induction, shoot physiology and biochemical status of litchi cv. 'China'

Investigation were undertaken during 2012-14 to explore the possibility of improving growth, shoot physiology, and flowering in cultivar 'China' of litchi. Paclobutrazol (PBZ) @ 1.0, 2.0, 3.0 and 4.0 g a.i per $m^2$ canopy spread was applied as soil injection (TSLP) method and $KNO_3$ @ 1.0 and 2.0 percent was applied as foliar spray during October months. The results indicated a concentration-dependent response. PBZ was found to be more effective to check vegetative growth as less number of growth flushes was observed during winter months. November flush was delayed by one week (23$^{rd}$ November) in the tree treated with PBZ @ 3.0 g and 2.0 g. Control tree had flush as usual (16$^{th}$ November). Spray of 1.0 g PBZ significantly improved number of new shoots/branch, number of new leaves/

branch, chlorophyll *a* and total chlorophyll contents but higher dose (4.0 g PBZ) caused highest chlorophyll b content in leaves. The maximum flowering was recorded in the tree treated with PBZ @ 4.0 g a.i per $m^2$ canopy spread followed by 2.0% $KNO_3$. Emergence of new flush in August month was inhibited by 4.0 g PBZ, while reducing sugar (RS) content in leaf increased due to application of 2% $KNO_3$. Later dose led to 100% flowering in trees (in second year) and had maximum fruit yield (18.0 kg/plant) and pulp weight but the highest TSS was recorded in the tree receiving 1.0 g PBZ. The maximum relative water content relative water content (RWC) of leaf was observed after application of 1.0 g and 3.0 g PBZ (84.1%). Compared to other treatments, 1.0% $KNO_3$ reduced RWC in leaves. The fruit weight was highest in the tree receiving 2.0 g PBZ which was at par with tree sprayed with 2.0% $KNO_3$. Application of PBZ and high concentration of $KNO_3$ prevented flush emergence in second consecutive year during December month. Untreated trees had maximum number of vegetative flushes. Morphactine and Prohexadion-Ca could not be procured procure due to unavailability with the local suppliers.

## Extending the harvesting period of litchi

Experiment was conducted at the research farm of NRCL to evaluate the effect of various shade-nets on fruit retention, maturity and fruit quality of litchi, cv. 'Shahi'. Litchi trees were covered 20-25 days after fruit set with shade-net (white and green). Nine treatments combination having two shading percentages (30 and 50%) and one uncovered control were evaluated. The results showed that irrespective of colour and percent shading, shade-nets had a significant effect on fruit weight, percentage of class-I fruits, reduction in discarded fruits, and extended the harvesting period in comparison to control (uncovered) (Fig. 2.6). The 30% and 50% green shade-net extended the harvesting period by 14-16 days followed by 50% and 30% white shade net (10-12 days) with slight decrease in TSS and acidity. With the shade net treatments there were about 35% more class-I fruits, and 7-9% discarded fruits as compared to 32% in the control. During adverse climatic conditions shade-net treatments had about 50% higher fruit retention and almost 40% less sunburn and cracked fruits and extended the harvesting period by almost 7-12 days compared to open trees. During 2013, due to periodic cloudy weather, shade nets had less effect on extending the harvesting period, however, the discarded fruit percentage was about 5-10% and fruit retention increased by 28% compared to the control. These results indicated that shading with 30% green or 50% white shade-net can be commercially utilized to improve fruit quality and overall appearance as well as to extend the harvesting period in litchi, cv. 'Shahi'.


**Fig 2.6: Extension in maturity time due to different shade-nets; A. 50% Green shade-net, B. 30% Green shade-net, C. Without shade-net (Control), D. Fruit quality under shade-net (green fruits) and control (red fruits)**

## 2.4. Investigation on mycorrhizal association and role of biofertilizers for sustainable production of litchi (Vinod Kumar)

On the broader theme of mycorrhizal association and biofertilizers, there is an institute project and a network project on "Application of Microorganisms in Agriculture and Allied sectors (AMAAS) subproject "Harnessing arbuscular mycorrhizae for biofertilization in horticultural crops" as well. Most of the research work was undertaken under AMAAS project and hence presented elsewhere under externally funded project in this report. Results of the two ongoing experiment of this project are presented here.

### Studies on effect of application of mycorrhiza, biofertilizers and organic amendments on growth and establishment of litchi

Field experiment was laid out in a randomized block design with twenty treatments having components *viz.*, arbuscular mycorrhizal fungi (*Glomus mosseae*), *Azotobacter chrococcum, Bacillus megatarium* and *Trichoderma harzianum* along with combination treatments. Three replications (one plant in each) were kept under each treatment. Vermicompost 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 a fixed interval during the year on various growth parameters *viz.*, no. of branches, trunk cross sectional area (girth), height, spread and shoot length of litchi and percent increase was computed over the interval. The data indicated that all the biofertilizers had positive effect on growth parameters of plants. Arbuscular mycorrhiza alone as well as in combination with other biofertilizer organisms showed highest increase in all the growth parameters. However, the initial observation indicated that when mycorrhiza was combined with PSB (*Bacillus megatarium)* it showed reduced growth but even that was better than control. This interaction is being confirmed by having pot experiment.

### Studies on dynamics of microflora of mycorrhiza experimental plots

The microflora was enumerated by serial dilution technique (Fig. 2.7). The microbial population was monitored after inoculation at an interval of four months. Results indicated that population of *Trichoderma* and *Azotobactor* increased after each application but decreased after rainy season as it was a low lying plot. Later during October 2013, the soil level of plots was raised and drainage was improved by putting additional soil and spreading and labeling. The mycorrhiza inoculated plants also showed colonization of roots of litchi plants.

**Fig. 2.7: CFU count of *Trichoderma* on Trichoderma Selective Medium**

# 3. Standardization of Plant Protection Technology

## 3.1. Investigation and management of pre-harvest diseases of litchi (Vinod Kumar)

### Incidence and severity of pre-harvest diseases and their etiology

The pre-harvest diseases of litchi observed at farmers' field and NRCL farm were leaf blight, twig blight, different types of leaf spots, sudden death or sudden wilting (Fig. 3.1), parasitic lichens (Fig. 3.2), and anthracnose on fruits. The causal organisms of these diseases were identified (Table 3.1). However, except leaf blight incidence and severity of other diseases were low. Incidence of anthracnose was up to 10%. The incidence of the 'twig blight' disease was also less than 10% during 2013 at NRCL experimental farm. The percent infected leaflets in trees varied from 21 to 37 in different litchi blocks at NRCL farm. Incidence of twig blight was also low at farmers' fields. Sporadic occurrence of parasitic lichens was observed in some

**Table 3.1: Leaf spot symptoms and pathogens identified**

| Type | Symptom | Visual appearance | Pathogen identified |
|---|---|---|---|
| **Leaf Spot A** | Dark brown spots on young leaves with concentric growth rings |  | *Corynospora litchi* |
| **Leaf Spot B** | black spots irregular in size affecting older leaves |  | *Pestalatiopsis versicolor* |
| **Leaf Spot C** | Light brown marginal leaf blight starting from tip on young leaves |  | *Colletotrichum gloeosporioides* |
| **Leaf Spot D** | Dark brown marginal blight of older leaves |  | *Microdiplodia litchi* |

orchard trees having denser canopy and shades. Lichens resulted in weakening of tree branches. Wilt pathogen was identified as *Fusarium solani* (Mart) Sacc. Leaf blight pathogen was confirmed as *Alternaria alternata* (Fr.) Keissler. Since, leaf blight was most important disease, a detailed study was carried out on this disease. During March-April 2014, association of *A. alternata* with panicle blighting was also observed.

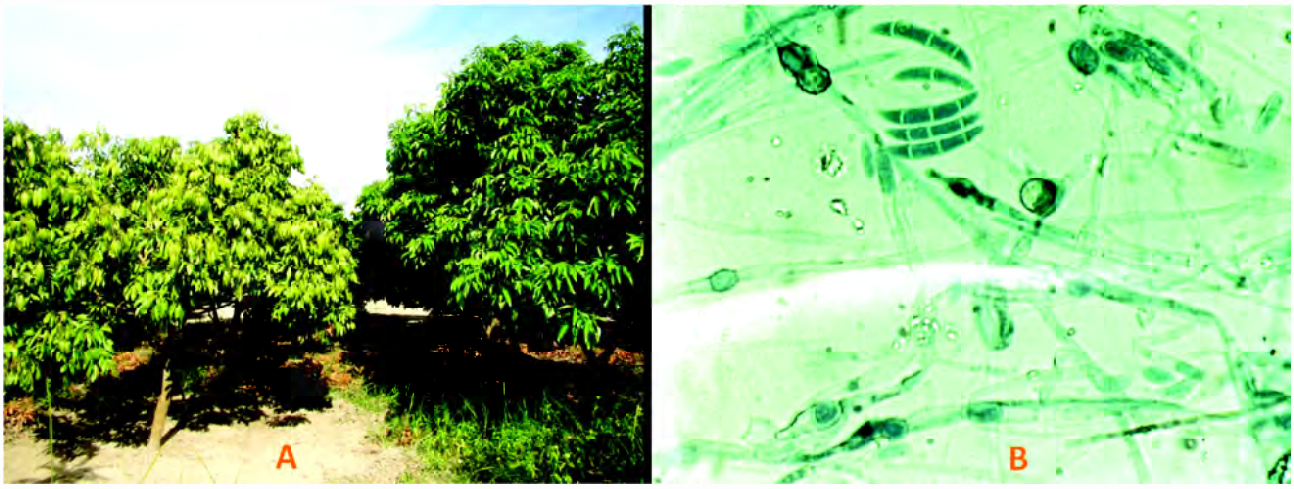


**Fig. 3.1: A. Tree with early symptoms of wilting (Left) and healthy tree (Right), B. Sclerotia and spore of *Fusarium solani***

**Fig. 3.2: Litchi tree branches, leaves and trunk affected by parasitic lichens**

## Symptomatology of leaf blight and pathogenic variability in *Alternaria alternata*

The incidence and severity of the leaf blight disease was assessed. 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 (Fig. 3.3). The pathogenicity test under glasshouse conditions was carried out and confirmed. The identification of the pathogen was confirmed by taxonomist as *Alternaria alternata.*

Variation in symptoms and cultural characteristics was apparent indicating intra-specific variability in the pathogen (Table 3.2, Fig. 3.4). Three distinct pathotypes identified had following characteristics:

**Fig. 3.3: Close up view of symptoms of leaf blight on nursery plants (Left) and orchard tree (Right)**

**Pathotype AA-L$_1$ (*NRCL Fungal Culture 5*)**: Symptoms appeared as marginal leaf necrosis that may or may not start from tip of the leaf lamina, colour of necrotic area dark brown, advanced to cause marginal blighting of lamina. Colony on PDA fast growing, circular with white smooth margin, front view greenish black with concentric growth rings, reverse view blackish with concentric growth rings; conidia oval to ellipsoidal, conidia formed in long, often branched chains, mean conidial dimension 34.5±5.6 µm with 3-8 transverse and 2-4 longitudinal or oblique septa, tapering gradually to form a short swollen beak at the apex; conidial length 15-49 µm, width at broadest part 6-16 µm and beak 0-14 µm.

**Pathotype AA-L$_2$ (*NRCL Fungal Culture 15*)**: Symptoms appeared as leaf necrosis starting from tip of leaf lamina, colour of necrotic area light brown. Colony on PDA slow growing, irregular, dark green with white margin, concentric growth rings absent, reverse view appeared blackish without growth rings, dark pink pigmentation; conidia oval to ellipsoidal, mean conidial dimension 29.8±4.3 µm with 2-6 transverse and 1-3 longitudinal or oblique septa, tapering gradually to form a short swollen beak at the apex; conidial length 16-40 µm, width at broadest part 4-13 µm and beak 0-10 µm.

**Pathotype AA-L$_3$ (*NRCL Fungal Culture 16*)**: Symptoms appeared as leaf necrosis starting from tip that advanced very fast leading to complete or partial blighting and scorching of leaves. The affected leaves soon withered and dropped off. Colony on PDA moderately fast growing compared to other two pathotypes, circular with smooth margin, front colour olivaceous green with smooth, white margin (resembling

**Table 3.2: Dimension and characteristics of litchi leaf isolates of *Alternaria alternata* from Bihar, India**

| Isolate | Conidial body | | | | | | Conidial septation | |
|---|---|---|---|---|---|---|---|---|
| | Length (µm) | | Width (µm) | | Beak length (µm) | | | |
| | Range | Mean± SD | Range | Mean± SD | Range | Mean± SD | Transverse | Longitudinal |
| AA-L$_1$ | 15-49 | 34.5±5.6 | 6-16 | 12.2±3.0 | 0-14 | 6.3±4.1 | 3-8 | 2-4 |
| AA-L$_2$ | 16-40 | 29.8±4.3 | 4-13 | 7.6±2.6 | 0-10 | 4.4±2.7 | 2-6 | 1-3 |
| AA-L$_3$ | 12-38 | 21.4±3.8 | 4-12 | 5.4±3.3 | 0-6 | 3.0±2.2 | 1-4 | 0-3 |

Among all the three pathotypes, AAL-3 appeared to be the most virulent.

to typical colony of *Aspergillus flavus*), reverse light pinkish without growth rings; conidia obclavate to oval, mean conidial dimension 21.4±3.8 µm with 1-4 transverse and 0-3 longitudinal or oblique septa, tapering gradually to form a short swollen beak at the apex; conidial length 12-38 µm, width at broadest part 4-12 µm and beak 0-6 µm. More number of shorter conidia was formed compared to pathotype AA-$L_2$.

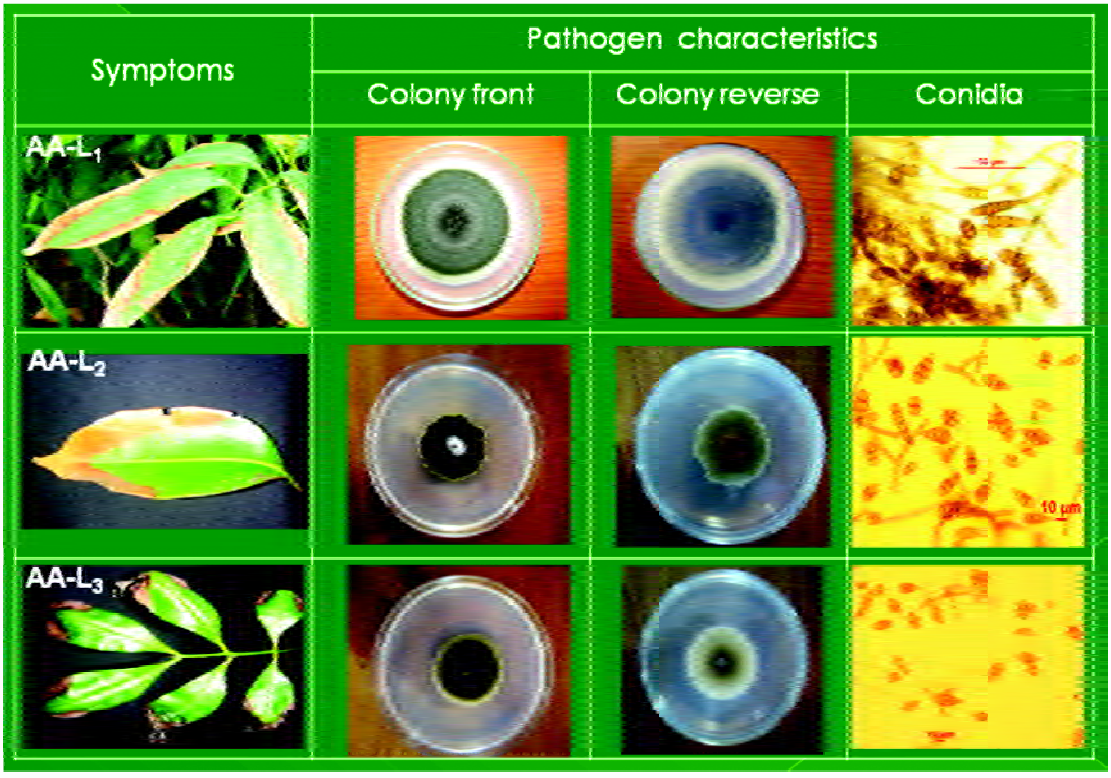


**Fig. 3.4: Symptoms and pathogenic variability in *Alternaria alternata* (Colony growth on 5th day after inoculation)**

## Assessment of severity of leaf blight disease

The severity of 'leaf blight' in nursery plants was recorded thrice during 2013 namely, April, September and December. Disease incidence was calculated based on number of plants showing blight symptoms on leaves. Further, ten plants were selected in each nursery to record percent infected leaflets, and for disease severity 30 leaves in a nursery was scored individually on a 9-point scale taking into account the percent leaf area damaged by the disease, where 1 = 0%, 2 = 1-5%, 3 = 6-10%, 4 = 11-20%, 5 = 21-30%, 6 = 31-40%, 7 = 41-60%, 8 = 61-80%, 9 = 81-100% disease severity. These grades were later converted into percentage disease severity index (PDI).

The results indicated that disease incidence, percent infected leaflets in nursery plants and percent disease severity index (PDI) in various nurseries during 2013 were 27.1-95.1%, 14.9-83.3% and 32.2-77.8, respectively. Seedling plants were more susceptible than air-layered plants.

## Evaluation of *Trichoderma* isolate NRCL T 01 (*T. viride*) for biocontrol potential and development of formulation for field application

The isolate of *Trichoderma viride,* NRCL T 01, isolated from NRCL Farm was found very efficient in controlling wilt pathogen, *Fusarium solani* under *in-vitro* condition as compared to four other isolates of *Trichoderma* spp. The inhibition of colony growth in dual

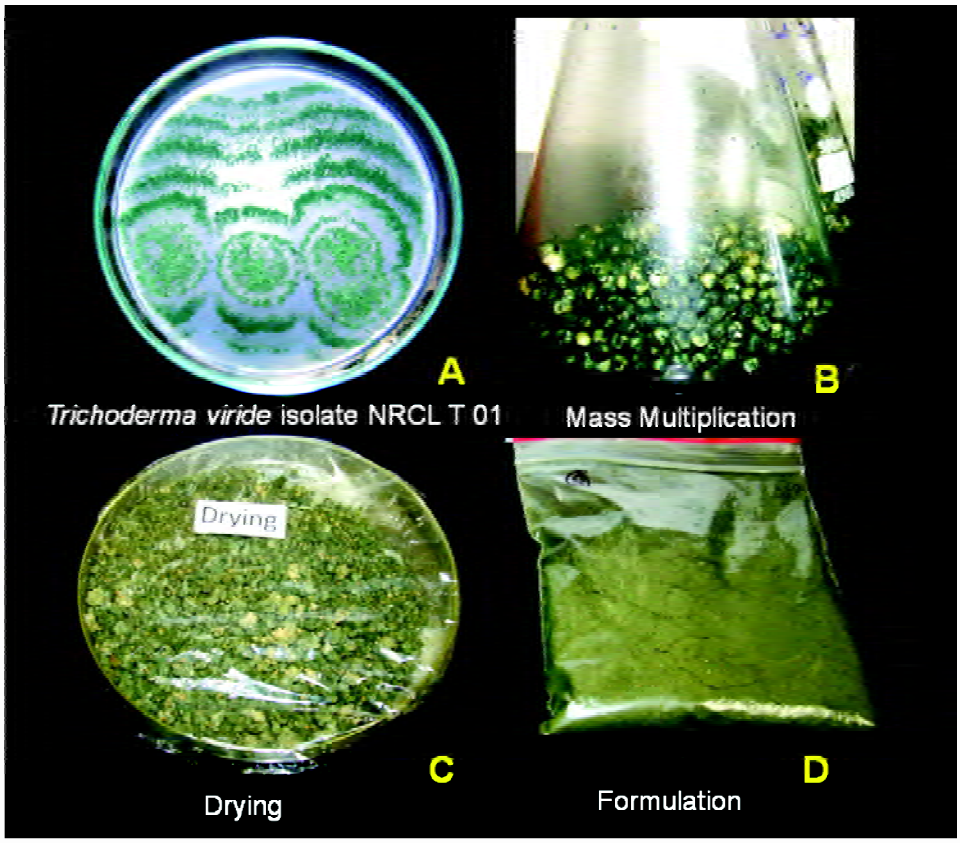


**Fig. 3.5: Mass multiplication and formulation of efficient *Trichoderma viride* isolate NRCL T01**

culture was 61.5% and the biocontrol agent completely overgrew the pathogen in 6 days (Table 3.3). Further, it was found effective in controlling the pathogen when tasted in potted plants under glasshouse conditions. Various liquid medium were tried for mass multiplication *viz.,* PD broth, molasses yeast broth and molasses soy broth. Molasses yeast broth yielded highest biomass and spore count. The solid medium, jowar grain medium was also found to be a good alternative but liquid state fermentation was better for talc based formulation (Fig. 3.5). A talc based formulation was developed with minimum count in final product 2 x $10^6$ cfu/g. Quality parameters and stability/viability of the product under storage conditions was being studied.

**Table 3.3: Antagonistic activities of *Trichoderma viride* isolate *NRCL T 01* against *Fusarium solani***

| Hours | Colony diam. in dual culture (mm) | | Colony diam. of *F. solani* in control (mm) | Inhibition of mycelial growth of *F. solani* (%) | % overgrowth of NRCL T 01 |
|---|---|---|---|---|---|
| | *Trichoderma viride* | *Fusarium solani* | | | |
| 24 | 36.0 | 18.3 | 32.3 | - | - |
| 48 | 54.7 | 34.3 | 61.7 | - | - |
| 72 | 61.3 | 34.7 | 76.7 | 54.8 | 17.3 |
| 96 | 70.0 | 34.7 | 86.0 | 59.7 | 42.3 |
| 120 | 83.7 | 34.7 | 90.0 | 61.5 | 81.7 |
| 144 | 90.0 | 34.7 | 90.0 | 61.5 | 100.0 |
| CD (*p=0.05*) | 2.5 | 1.4 | 2.3 | - | - |
| SEm± | 0.8 | 0.5 | 0.7 | - | - |
| CV (%) | 2.14 | 2.56 | 1.77 | - | - |

On pilot basis when, it was applied in field conditions at NRCL farm (July 2013) to the apparently sick trees that were on the verge of wilting, they became fully healthy after 20 days of application. The talc based formulation was applied after mixing with vermicompost. The population level of *Trichoderma* in rhizosphere of inoculated trees was assayed after 20 days showed a good population level (1.2-9.0 x $10^4$).

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

This project was under suspended animation till entomologist, Dr. Kuldeep Srivastava joined the centre in July 2013. Before him, one of the activity *i.e.* "Monitoring and surveillance of pest and diseases of litchi" was being undertaken under AICRP on subtropical fruits (Litchi Experiment 5.3.1) by Dr. Vinod Kumar (Pathologist).

### Investigation and documentation of insect pests and natural enemies

Fruit borer, mite, leaf folder, looper, ash weevil, red weevil, bark eating caterpillar, shoot borer and stink bug were recorded as major pests while, mealy bug and bag worm as minor pests (Table 3.4). Maximum population of looper and leaf folder was recorded during October and minimum in January. Besides, few other insect pests *viz. Lepropus lateralis* (Coleoptera: Curculionidae), *Thalassodes pilaria* (Lepidoptera: Geometridae), *Statherotis* sp. (Lepidoptera: Tortricidae) *Spodoptera litura* and *Spilosoma* sp. were also identified as minor pest in litchi. Several promising natural enemies of pests *viz.*, praying mantis, *Chrysoperla carnea*, *Eocanthecona furcellata*, syrphid flies, coccinellids, *Trichogramma* sp. and braconids were observed during August 2013 to March 2014 in litchi ecosystem. Besides various species of *Apis viz., Apis dorsata*, *A. indica*, *A. mellifera,* other pollinators like hover fly, blue bot fly

**Table 3.4: Taxonomic position and economic status of insect pests in litchi**

| S. No. | Common name | Scientific name | Order and Family | Economic status |
|---|---|---|---|---|
| 1 | Litchi Fruit borer | *Conopomorpha cramerella* Snellen | Lepidoptera: Gracillariidae | Major |
| 2 | Bark eating caterpillar | *Indarbela tetraonis* Moore | Lepidoptera: Metarbelidae | Major |
| 3 | Leaf roller | *Dudua aprobola* Meyrick | Lepidoptera: Tortricidae | Major |
| 4 | Leaf roller | *Statherotis* sp. | Lepidoptera: Tortricidae | Minor |
| 5 | Ash weevil | *Myllocerus undecimpustulatusn* Faust | Coleoptera: Curculionidae | Major |
| 6 | Red weevil | *Apoderus blandus* Faust. | Coleoptera: Curculionidae | Major |
| 7 | Ash weevil | *Lepropus lateralis* | Coleoptera: Curculionidae | Minor |
| 8 | Bag worm | *Eumeta crameri* Westwood | Lepidoptera: Psychidae | Minor |
| 9 | Looper | *Perixera illepidaria* | Lepidoptera: Geometridae | Major |
| 10 | Looper | *Thalassodes pilaria* | Lepidoptera: Geometridae | Minor |
| 11 | Litchi bug | *Tessaratoma javanica* Thunberg | Hemiptera: Pentatomidae | Major |
| 12 | Mealy bug | *Drosicha mangiferae* | Hemiptera: Coccidae | Minor |
| 13 | Litchi mite | *Aceria litchii* Keifer | Acari: Eriophyidae | Major |
| 14 | Tobacco Caterpillar | *Spodoptera litura* | Lepidoptera: Noctuidae | Minor/ Sporadic |
| 15 | Hairy caterpillar | *Spilarctia* sp. | Lepidoptera: Arctidae | Minor/ Sporadic |

**Table 3.5: Diversity of the major insect pollinators and visitors on litchi flowers**

| S. No. | Common name | Scientific name | Order: Family |
|---|---|---|---|
| 1 | Giant honey bee | *Apis dorsata* Fab. | Hymenoptera: Apidae |
| 2 | European honey bee | *Apis mellifera* L. | Hymenoptera: Apidae |
| 3 | Indian honey bee | *Apis cerana indica* Fab. | Hymenoptera: Apidae |
| 4 | Syrphid fly | *Eristalis tenax* L. | Diptera: Syrphidae |
| 5 | Syrphid fly | *Metasysrphus sp.* | Diptera: Syrphidae |
| 6 | Ladybird beetle | *Harmonia* sp. | Coleoptera: Coccinellidae |
| 7 | Ladybird beetle | *Cheilomenes sexmaculata* | Coleoptera: Coccinellidae |
| 8 | Ladybird beetle | *Cheilomenes* sp. | Coleoptera: Coccinellidae |
| 9 | Hover fly (Unidentified) | - | Diptera: Syrphidae |
| 10 | Blue bot fly | *Calliphora* sp. | Diptera: Syrphidae |

**Fig. 3.6: Predatory bug feeding on looper larvae, Syrphid fly-*Eristalis tenax*, Syrphid fly-*Metasysrphus* sp. (From left to right)**

(*Calliphora* sp.), syrphid flies (*Metasysrphus* sp., *Eristalis tenax*) were also recorded (Table 3.5, Fig. 3.6). Presence of these pollinators was observed throughout flowering period of litchi. Coccinellids, damsel fly and dragon fly were recorded as visitors on litchi flowers.

## Seasonal incidence of major pests

Seasonal incidence of major pests in litchi was recorded at weekly interval from August 2013 to March 2014. Incidence of all major pests was observed throughout the study period except first fortnight of January with maximum and minimum in the month of October and January, respectively (Table 3.6). Leaf folder population gradually increased and reached highest (14.33) in 42$^{nd}$ standard weeks and then declined to zero in 1$^{st}$ standard week. Population of leaf folder was again rose in the 3$^{rd}$ standard week (0.33) and mean reached to 3.33 in the second fortnight of March *i.e.* 12$^{th}$ standard week. Similar observation was noticed in case of looper, however, maximum population (13.33) was observed in 43$^{rd}$ standard week and after declining it again establish (0.33) in 2$^{nd}$ standard week. A fluctuating trend was observed in case of ash weevil with maximum (15.33) population in 40$^{th}$ standard week after that it declined to 6.00 in 47$^{th}$ standard week, subsequently no population was observed in first fortnight of January. Ash weevil population was again noticed in 4$^{th}$ standard week with corresponding value 1.33, while it again disappeared in 5$^{th}$ standard week. Again the fluctuating trend population of weevil reached up to 4.33 in second fortnight of March. Bag worm population was observed throughout study period in fluctuating trend with maximum 11.00 in 40$^{th}$ standard week and minimum 1.33 in first week of December.

**Table 3.6: Seasonal incidence of major insect pests in litchi**

| Fortnight | Standard Week | Mean no. of insects/ 30 cm shoot | | | |
|---|---|---|---|---|---|
| | | Leaf folder (*Dudua aprobola*) | Looper (*Perixera illepidaria*) | Ash weevil (*Myllocerus undecimpustulatus*) | Bag worm (*Eumeta crameri*) |
| August I | 32 | 6.0 | 3.0 | 7.3 | 3.3 |
| | 33 | 7.7 | 2.7 | 7.3 | 3.3 |
| August II | 34 | 9.3 | 4.7 | 9.3 | 4.7 |
| | 35 | 9.7 | 4. 67 | 10.0 | 5.0 |
| September I | 36 | 8.7 | 5.3 | 11.0 | 6.3 |
| | 37 | 9.3 | 6.0 | 12.3 | 7.0 |
| September II | 38 | 10.3 | 7.3 | 13.0 | 10.0 |
| | 39 | 10.7 | 8.7 | 13.7 | 10.3 |
| October I | 40 | 11.3 | 9.3 | 15.3 | 11.0 |
| | 41 | 14.0 | 9.7 | 12.3 | 9.0 |
| | 42 | 14.3 | 12.7 | 9.0 | 6.7 |
| October II | 43 | 11.7 | 13.3 | 8.7 | 3.3 |
| | 44 | 5.3 | 9.3 | 5.0 | 2.3 |
| November I | 45 | 5.0 | 8.7 | 3.7 | 2.7 |
| | 46 | 1.7 | 7.0 | 1.7 | 2.3 |
| November II | 47 | 2.0 | 1.3 | 6.0 | 2.3 |
| | 48 | 0.7 | 0.3 | 1.3 | 1.7 |
| December I | 49 | 0.7 | 0.3 | 1.0 | 1.3 |
| | 50 | 0.7 | 0.0 | 0.7 | 2.0 |
| December I | 51 | 0.3 | 0.7 | 0.7 | 2.0 |
| | 52 | 0.3 | 0.7 | 0.7 | 3.0 |
| January I | 1 | 0.0 | 0.0 | 0.0 | 2.3 |
| | 2 | 0.0 | 0.3 | 0.0 | 2.3 |
| | 3 | 0.3 | 0.3 | 0.0 | 2.7 |
| January II | 4 | 0. 33 | 0.0 | 1.3 | 2.7 |
| | 5 | 1.7 | 0.3 | 0.0 | 2.3 |
| February I | 6 | 1.3 | 1.0 | 0.7 | 2.3 |
| | 7 | 2.7 | 1.7 | 1.7 | 3.3 |
| February II | 8 | 2.0 | 2.0 | 2.3 | 2.7 |
| | 9 | 5.3 | 2.7 | 3.0 | 3.7 |
| March I | 10 | 1.3 | 3.3 | 2.7 | 4.7 |
| | 11 | 200.0 | 3.7 | 3.7 | 3.3 |
| March II | 12 | 3.3 | 4.3 | 4.3 | 3.3 |
| | 13 | 2.7 | 4.0 | 7.7 | 3.7 |

## Incidence of fruit borer in litchi

Data was collected on infestation of fruit borer in litchi at harvest from farmers' field in Muzaffarpur district of Bihar. In 15 samples examined at farmers' field in harvested lots, borer infested fruit ranged between 0.0-5.0%. However, late in the season after rains during last week of May 2013, borer infested fruits increased up to 80.0%, 22.2-40.0% fruits having physical presence of larvae and 40.0-42.2% had only presence of larval excreta.

## Management of fruit borer in litchi

Two experiments on management of fruit borer was formulated *viz*., development of IPM modules using IGRs and new molecules (Lufenuron 5 EC 0.006%, Diflubenzuron 50 WP 0.06%, Buprofezin 25 SC 0.03%, Emamectin benzoate 5% SG 0.002%), and management of litchi fruit borer using various organic products (*Panchgavya* 3%, *Amrit Pani* 5%, biodynamic pesticides 5%, *Beauveria bassiana* 0.02%, *Metarrhizium anisopliae* 0.02%,). Both the experiments were in progress.

# 4. Post-harvest Management and Value Addition

## 4.1. Standardization of maturity standards, harvesting and post-harvest handling techniques for litchi fruits (Sushil Kumar Purbey, Sanjay Kumar Singh, Vinod Kumar and Alemwati Pongener)

### Post-harvest treatments to enhance the shelf life of litchi fruits

Experiment was conducted with six different treatment combination of sodium meta bi-sulphite, carbendazim, chitosan, water vapour and citric acid in which litchi fruits were dipped, dried, pre-cooled and kept in micro-perforated monopolymer bag and put in CFB box (2 kg). The results revealed that pre-cooling ($10^0$C for 10 min.) of litchi fruits treated with carbendazim (250 ppm for 2 min.) + chitosan (1% for 5 min.) + citric acid (2% for 5 min.) and packed in perforated poly bag had minimum percentage of discarded fruits (22.45 and 43.66) and PLW (1.3%) on 4$^{th}$ and 6$^{th}$ days after storage at ambient conditions (Fig. 4.1) maintaining the other quality parameters. Litchi fruits packed in perforated poly bag and kept at $8^0$C + 80% RH had 47.6% fresh fruit up to 18$^{th}$ days of storage (Fig. 4.2).

**Fig. 4.1: Treated (Left) and control (Right) fruits after 4$^{th}$ day of storage at ambient conditions**

**Fig. 4.2: Treated (Left) and control (Right) fruits after 18$^{th}$ day of storage at 6±2$^0$C and 85% RH**

### Development of modified atmospheric packaging technologies for extending the shelf life of litchi fruits

A trial on modified atmospheric packaging (MAP) for enhancing the shelf life of litchi fruits was carried out to find out the best gaseous composition and polyethylene film/bag for packaging. The results indicated that a gaseous composition having 12-18% $O_2$ and 3-6% $CO_2$ gave satisfactory shelf life (12-15 days) in refrigerated conditions but at ambient conditions shelf life was only 5-6 days. At gaseous composition of $O_2$ and $CO_2$ in a ratio of 18:6 resulted in minimum percentage of browning (16%) and fruit decay (12%) as compared to natural gaseous composition in LDPE packaging.

### Study on pre-harvest spray of various chemicals on quality and yield of litchi fruits

The litchi fruits were sprayed 40 days after full bloom with six different chemicals including PGR, anti-microbial and coating compound to study the effect on quality and shelf life. The spray of Cropsil (40ml/l) significantly reduced the cracking and sun burn (10% each) over control followed by carbendazim (0.2%). $GA_3$ spray gave the maximum percentage of fruit retention and thus maximum yield. The highest fruit weight, pulp and acidity were in carbendazim treatment. The fruits sprayed with carbendazim had also better shelf-life than others.

### Standardization of thermocol packaging

For confirmation of results of previous year, the experiment was carried out on thremocol packaging. It was found that litchi fruits pre-cooled (2-4 hr at 4-5$^0$C) and packed in LDP bag and kept in thermocol box containing 3 silica gel ice pads could maintain quality up to 4$^{th}$ day of storage with only 2.48% discarded fruits whereas 4 numbers of ice pad had enhanced the shelf life up to 6$^{th}$ day of storage with 5.80% discarded fruits. The results corroborate with the previous year findings.

**Fig. 4.3 Litchi fruits packed in LDP bag and kept in thermocol box**

## 4.2. Investigation and management of post-harvest losses in litchi (Sushil Kumar Purbey and Vinod Kumar)

### Studies on losses in litchi at harvest and supply chain

A detail studies was conducted to assess the extent of apparent losses at harvest, wholesale and retail levels during May-June 2013. Harvest level samples were collected from farmers' fields in Muzaffarpur district. Wholesale market samples were collected from Azadpur market in Delhi. Litchi (cv. 'Shahi') was also transported by truck from Muzaffarpur to Delhi in traditional wooden pack and in CFB boxes for the study. The retail samples were collected from vendors at different places in Delhi and Muzaffarpur market.

For assessing losses at farmers' field, about 100-150 fruits were randomly taken from the heap of harvested fruits and counted to determine percent loss in different categories of losses. A total of 15 samples from farmers' fields were studied. Samples at wholesale market consisted of three categories *viz.*, random market samples in traditional wooden box packing, transported samples in traditional wooden box packing, and transported samples in CFB packing. Two kg fruit sample were randomly drawn from random lots in wholesale and retail market whereas the complete lot of transported litchi was considered for this study. Ten samples were studied at wholesale and transport level.

**a. Losses observed at harvest**

The results indicated that sunburn was 4.0-27.0%, cracked fruits were 0.0-14.0% and physically or mechanically damaged fruits during harvesting were 3.0-15%. In some cracked fruits, there was visible mould colonization (0.0-2.5%). The incidence of fruit borer (0.0-5.0%) and anthracnose (0.0-5.0%) was low during 2013. However, later in the season fruit borer increased. When the fruit samples were observed in laboratory on 29 May 2013, it was found that the mean infestation of fruit borers were 67.9%, of which 28.7% had larval presence whereas 39.2% had no physical presence but only excreta was seen. There were 7.6% fruits which had both sunburn and infection by anthracnose pathogen.

Actually at harvest, only mechanical or physical loss occurs that was due to improper handling. The other losses apparent (sunburn, cracking, anthracnose and other infections, fruit borer infestation etc.) at harvest were actually due to non-adoption of good agricultural practices (GAPs) vis-à-vis climatic factors.

The comparison of the mean total loss observed at harvest revealed a higher loss in 2012 (30.4%) than 2013 (25.5%) (Table 4.1). The lower loss in 2013 was due to favourable weather factors *viz.*, lower average temperature and higher humidity during maturity phase of litchi fruits (Fig. 4.4). However, the high humidity after rain resulted in higher fruit borer infestation. The farmer's perception of damaged and discarded fruits on box basis while sorting and grading was 16.2% and 14.8% during 2012 and 2013, respectively that was quiet lower than the actual loss observed empirically.

**Table 4.1: Mean losses observed at harvest of litchi during 2012 and 2013**

| Sample No. | Sunburn (%) | Cracked fruits (%) | Cracked with visible mould (%) | Mechanical damage (%) | Anthracnose % | Fruit borer % | Total loss % | Damaged litchi on box basis (%)* |
|---|---|---|---|---|---|---|---|---|
| **2012** | | | | | | | | |
| Mean | 14.9 | 5.9 | 0.1 | 7.6 | 1.2 | 0.6 | 30.4 | 16.2 |
| Range | 1.5-44.5 | 0.5-14.0 | 0.0-1.0 | 0.0-17.5 | 0.0-10.0 | 0.0-5.0 | 8.5-51.5 | 5.0-33.3 |
| **2013** | | | | | | | | |
| Mean | 10.4 | 3.8 | 0.3 | 8.1 | 1.8 | 1.3 | 25.8 | 14.8 |
| Range | 4.0-27.0 | 0.0-14.0 | 0.0-2.5 | 3.0-15.0 | 0.0-5.0 | 0.0-5.0 | 11.0-51.0 | 6.7-25.0 |

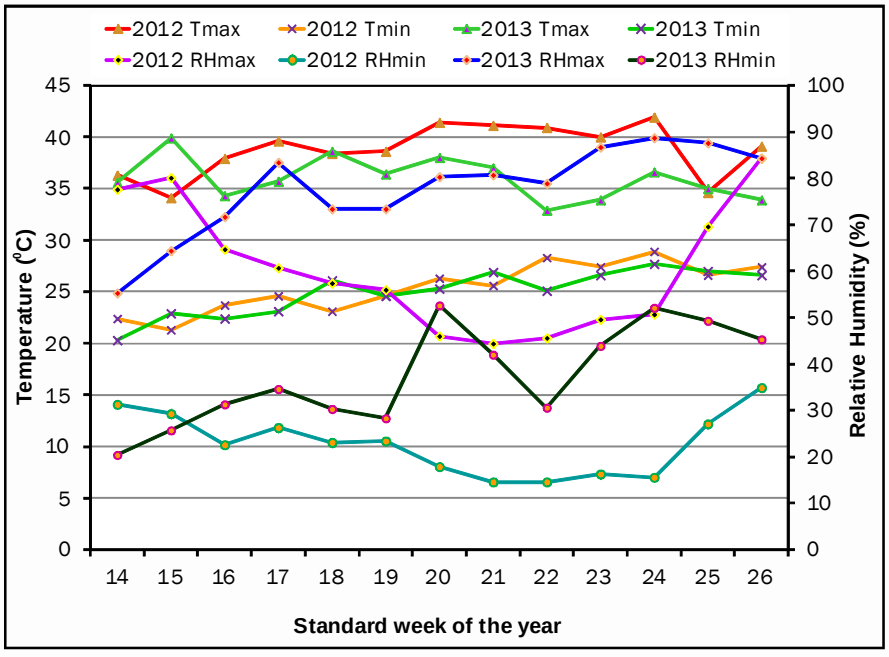


**Fig 4.4: Weather parameters during fruit development and maturity phase of litchi at Muzaffarpur during 2012 and 2013**

**Table 4.2: Cumulative loss in litchi from harvest to retail level**

| Stages of loss | Categories of losses | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | | | | 2013 | | | |
| | Mechanical/ physical loss† | Physiological loss | | Pathological losses§ | Mechanical/ physical loss† | Physiological loss | | Pathological losses§ |
| | | Browning¥ | PLW | | | Browning¥ | PLW | |
| Harvest* | 7.3 | - | - | - | 8.1 | - | - | - |
| Wholesale** | 9.3 | 24.6 | 9.42 | 6.5 | 7.1 | 15.5 | 7.07 | 5.3 |
| Retail | 3.7 | 12.9 | - | 16.7 | 2.2 | 11.6 | - | 12.6 |
| Total | 20.3 | 37.5 | 9.42 | 23.2 | 17.4 | 27.1 | 7.07 | 17.9 |

† Cracked /bruised and pressed ¥ Colour change § Rotten/ infected or diseased

*In Delhi wholesale market traders don't stock litchi fruits. Within 5-6 hrs of arrival of litchi it is taken by retailers. Hence the losses at wholesale are inclusive of handling and transport losses.

### b. Losses at wholesale level and during transportation

The results indicated that the average loss (cracked or pressed+ infected with visible mould growth) at transport level in Delhi (wholesale) market was 8.9-17.2% (mean 12.3%) and fruits having more than 50% browning was 10.6-23.3% (mean 15.5%) . The average physiological loss in weight (PLW) was 7.07%. The improved packing methods in CFB boxes had reduced PLW (2.58%) and spoilage (4.3%).

### c. Losses at retail level

At retail level losses varied from 3.0-38.3% (mean 14.7%) in Delhi market and 2.1-5.8% (mean 3.8%) in Muzaffarpur market during 2013. The fruits having high pericarp browning (>50%) in the Delhi market was in the range of 7.7-14.9% (mean 11.6%) whereas in Muzaffarpur it was 2.2-19.6% (mean 8.5%).

### d. Cumulative loss from harvest to retail

Cumulative loss from harvest to retail during last two years, 2012 and 2013 has been presented in table 4.2. The three types of losses viz., mechanical, physiological (browning and PLW) and pathological losses were higher in 2012 compared to 2013.

## Isolation and identification of pathogens and etiology of post-harvest fruit rots of litchi

A total of 12 storage samples were observed for fruit rots. Observation was taken after seven days of storage under ambient (temp.36±2$^0$C, R.H. 65±5%) and cold storage (temp. 6±2$^0$C, R.H. 85±5%) conditions. Results revealed that fruit rot was caused by four species of fungi *viz., Alternaria alternata, Colletotrichum gloeosporiodis, Aspergillus niger* and *Aspergillus flavus* (Table 4.3, Fig 4.5). Among these, *Alternaria alternata* was the dominant species. Etiology of these were confirmed by inoculating fresh fruits under *in vitro* conditions. Comparatively less fruit rotting was observed in storage of litchi under cold storage than ambient conditions after 7 days of storage.

**Table 4.3: Incidence of fruit rots in storage and frequency of different pathogens**

| Sample no.* | Fruit rot** (%) | Frequency of different fungal pathogens | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| 1 | 12.9 | 100.0 | 0.0 | 0.0 | 0.0 |
| 2 | 9.1 | 100.0 | 0.0 | 0.0 | 0.0 |
| 3 | 11.3 | 86.5 | 8.2 | 0.0 | 5.3 |
| 4 | 13.4 | 72.8 | 2.3 | 9.0 | 15.9 |
| 5 | 30.8 | 52.9 | 0.0 | 4.7 | 42.4 |
| 6 | 23.6 | 100.0 | 0.0 | 0.0 | 0.0 |
| 7 | 16.8 | 89.0 | 7.0 | 4.0 | 0.0 |
| 8 | 10.0 | 73.0 | 10.0 | 17.0 | 0.0 |
| 9 | 6.9 | 100.0 | 0.0 | 0.0 | 0.0 |
| 10 | 18.0 | 78.9 | 0.0 | 8.8 | 12.3 |
| 11 | 3.0 | 96.5 | 0.0 | 3.5 | 0.0 |
| 12 | 3.7 | 92.8 | 0.0 | 7.2 | 0.0 |

*Sample number 1-10 were from ambient conditions and sample 11-12 were from cold storage conditions; **observation taken after 7 days of storage

I: Light greenish black colour mat like growth on the surface of litchi fruits. Organism identified as *Alternaria alternata*. Colony was slow growing and conidia were small in size in comparison to the *Alternaria* isolated from the leaf blights.

II: Dark black fungal mycelium (powdery type) on the surface of litchi fruits identified as *Aspergillus niger*

III: White mycelium with abundant yellowish green sporulation identified as *Aspergillus flavus*

IV: White mycelial growth on the surface of litchi fruits identified as *Colletotrichum gloeosporioides*.


**Fig. 4.5: A. Post-harvest fruit rots caused by the four pathogens, *Alternaria alternata*, *Aspergillus niger*, *Aspergillus flavus* and *Colletotrichum gloeosporioides* (Left to Right), B. A sample of fruits fully colonized by *A. alternata***

## Pathological studies on spoilage of value added products

### a. Spoilage of litchi nuts

Observation on spoilage of litchi nuts during storage was recorded. Data revealed that spoilage was predominantly due to colonization by *Alternaria alternata* and *Colletotrichum gloeosporiodis* besides infestation of microscopic insects (Fig. 4.6).

**Table 4.4: Observation on litchi and longan nuts spoilage during storage**

| Cultivar | No. of nuts observed | Storage time | Spoiled due to moulds/ insect | Spoilage organism | | | |
|---|---|---|---|---|---|---|---|
| | | | | I | II | III | IV |
| 'Shahi' | 330 | 3 yr | 330 | 41.2 | 8.8 | 36.4 | 13.6 |
| 'China' | 340 | 3 yr | 330 | 28.2 | 25.8 | 38.5 | 7.6 |
| Longan | 330 | 2 yr | 330 | 10.0 | 6.7 | 76.7 | 6.7 |

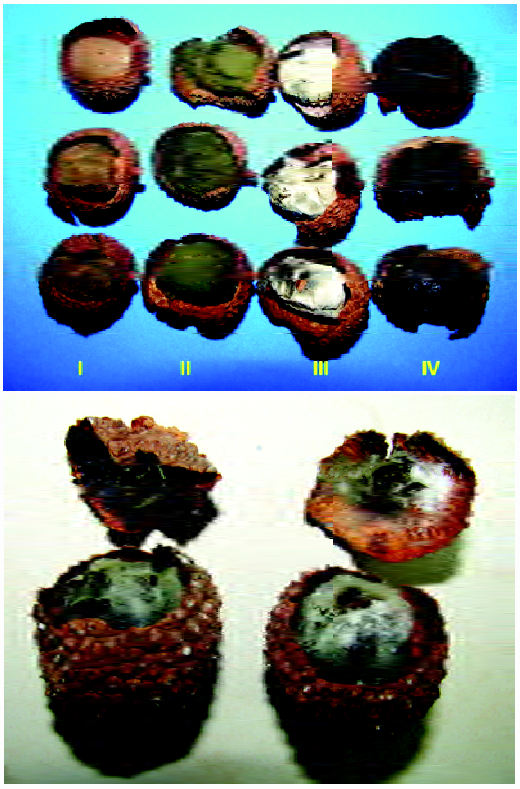


**Fig. 4.6: Top-I. Spoilage of litchi nuts due to colonization of microscopic insect, II. Green fungal growth of *A. alternata*, III. White fungal growth of *C. gloeosporioides* IV. Blackening of litchi nut but no visible fungal growth; Bottom-A close-up view of colonization by *A. alternata***

### b. Spoilage of canned litchi fruits

Litchi fruit canned in 30% sugar syrup was spoiled in storage after 18 days of storage in ambient condition (room temperature). The date of storage was 7th June 2013 and observation was taken on 25th June 2013. The pathogen associated with the spoilage was isolated and brought to axenic culture (Fig.4.7). It was identified as a yeast, the confirmation up to species level is yet to be done.

### c. Spoilage of litchi pulp

Samples were also taken from litchi pulp of cultivar 'China' which was preserved with 500, 1000 and 1500 ppm KMS. It was stored at room temperature (36±1.5$^0$C, 55±5% R.H.). Spoilage of pulp was observed after one month in some treatments. The pathogen was isolated and brought to axenic culture. It was found to be spoiled by a different kind of yeast species. The colony was dome shaped with creamy white in colour. When observed under microscope the cells were oval in shape (Fig. 4.7).

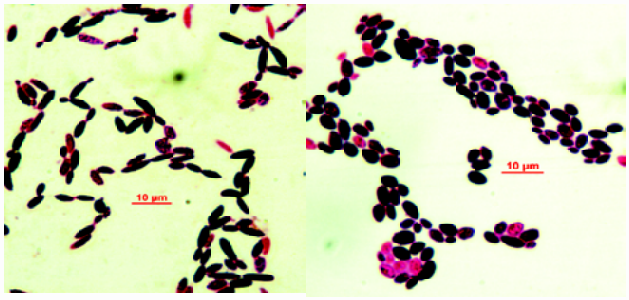


**Fig. 4.7: Photomicrograph of yeast isolated from canned litchi fruit (Left) and litchi pulp (Right)**

## Isolation of antagonists from healthy fruit surface

Healthy undamaged litchi fruit were taken from field and antagonist particularly isolation of *Bacillus subtilis* was tried. This was done by placing the four fruits in 250 ml Erlenmeyer flasks containing 100 ml sterile distilled water plus 25% Ringer's solution and shaking in an orbital shaker for 1 hour. Fruits were then removed and the liquid suspensions in the flasks were heat treated at 80$^0$C for 15 minutes in a water bath. Thereafter, serial dilution of $10^{-1}$, $10^{-2}$ and $10^{-3}$ was made before plating.

Aliquots of 0.2 ml were then poured onto tryptone soy agar (TSA) plates. Plates were incubated for three days at 28$^0$C, after which representative colonies were arbitrarily selected and streaked onto nutrient agar medium to obtain single cell colonies. One *Bacillus subtilis* isolate (NRCL BS-01) was recoved during 2013. The identification was confirmed by microscopic and biochemical studies (Fig. 4.8).

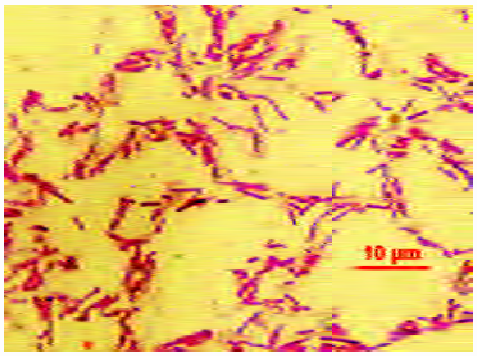


**Fig. 4.8: *Bacillus subtilis* isolate NRCL BS-01 isolated from litchi fruit plane**

## 4.3. Standardization of processing and value addition techniques in litchi (Sushil Kumar Purbey and Vinod Kumar)

### Studies on preservation of litchi pulp

The eight different combination treatments of potassium meta bi-sulphite (KMS) and heating was given to litchi pulp to study the shelf-life of pulp. It was found that litchi pulp pasteurized and treated with 1500 ppm KMS were acceptable in quality and colour up to 10 months when kept at low temperature (6±1$^0$C) but development of light brown colour started after 4 month of storage at ambient conditions (35 ±1$^0$C) without affecting the other quality. Whereas, untreated pulp (control) was spoiled just after 10 days of storage at ambient condition and 25 days at low temperature.

**Fig. 4.9: Litchi pulp stored at ambient conditions**

### Techniques for preservation of litchi flesh

A preliminary trial of litchi flesh dehydration was carried out using osmo-mechanical and mechanical method of drying after giving different pre-treatment to the litchi flesh. Osmo-mechanically (blanched) dried litchi flesh pre-treated with sucrose solution of 40° brix at a ratio of 1:2 fruit to solution and 60$^0$C as hot air drying gave highest overall acceptability (7.60) with minimum hardiness ( 24.26 N) and drying time (19.10 hr). Further studies need to be carried out to maintain the colour and flavour of dehydrated litchi flesh (Fig. 4.10, Fig. 4.11).

**Fig. 4.10: Osmo-mechanically dehydrated litchi flesh at 70°C and 60°C**

**Fig. 4.12: Mechanically dehydrated litchi flesh at 70°C and 60°C**

### Effect of various bagging materials on quality and yield of litchi fruits

Higher temperature and low humidity during fruit development period often cause higher sunburn and cracking of fruits. Considering these problems litchi fruit bunches were bagged with four different type of bagging material. 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. Results indicated that bagging of litchi bunches at 40 days after anthesis with white butter paper bags were the best followed by brown paper bags among the tested bags (Fig. 4.12).

**Fig. 4.12: Effect of bunch bagging on litchi fruits (Left- bagged, Right- Non-bagged)**

# Externally Funded Projects

## 1. Network project on "Application of Microorganisms in Agriculture and Allied Sectors (AMAAS) subproject "Harnessing arbuscular mycorrhizae for biofertilization in horticultural crops" (Vinod Kumar, Rajesh Kumar and Vishal Nath)

This project was concluded on 31st March 2014. Results based on the cumulative data are presented in this report.

### 1. Assessment of spore density of arbuscular mycorrhizal fungi (AMF) in litchi rhizosphere

#### 1.1. Survey and sampling

A total of 135 samples were collected from Muzaffarpur, Vaishali, Samastipur, East Champaran, West Champaran and Sitamarhi districts of Bihar. Besides the places, other variables considered while sampling was different age group of orchards (5-50 yr), cultivars, nutritional status (well managed vs. neglected or poorly managed), dry and damp places within the orchard and light or shady area. All the samples were analyzed for spore density and root colonization by AMF and 105 samples for nutritional parameters.

#### 1.2. Spore density of AMF in litchi rhizosphere

Spores of AMF were extracted from field samples and successive pot culture soils by the wet sieving and decanting technique. Total spore numbers of mycorrhizal fungi in the soil samples were estimated by taking two gram representative soil. Individual spores were picked up with the help of a needle and Pasteur pipette fitted with microtips under a stereo-binocular microscope. They were sorted out on the basis of hyphal attachments, colour and size and kept in water in watch glasses. From these samples, diagnostic slides were prepared for detail examination. It was possible to ascertain the genera at this level. Spores were then mounted onto a slide in Meltzer's reagent mixed with polyvinyl lactoglycerol (PVLG) (1:1, v/v).

The spore density ranged from 2 to 44 per two gram rhizospheric soil. In terms of average number of spores count/g soil, out of 105 samples, 58 samples had spores between 1.0-5.0, 35 samples had between 5.1-10.0, 9 samples had between 10.1-15.0, 2 samples had between 15.1-20.0 and only one sample had more than 20 (22 spores). Thus the results indicated a high level of spore density of AMF in rhizospheric soils of litchi (Fig. 5.1).

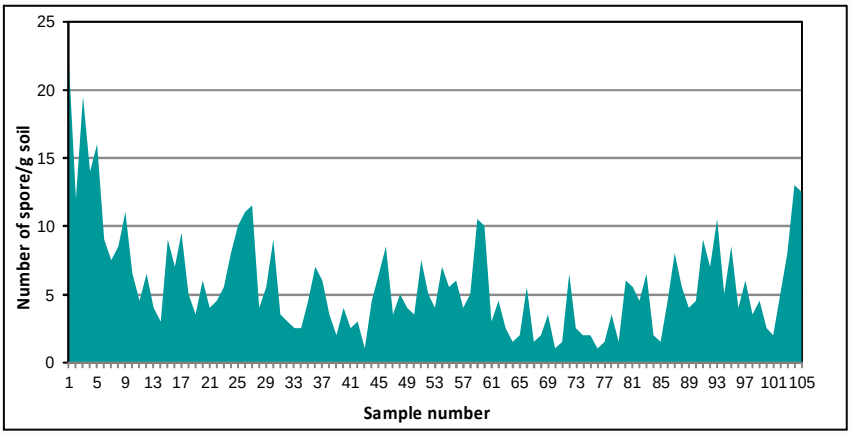


**Fig. 5.1: Average spore count of AMF in rhizospheric soil**

## 2. Assessment of extent of root colonization by AM fungi

### 2.1. Colonization of roots by AMF in litchi

To determine root colonization, root samples collected from different sites were washed in tap water and staining was done by the method of Phillips and Hayman (1970). The root samples were cut into pieces of 1 cm length and placed in 10% KOH solution, which was kept at boiling point (autoclaved at 15 lbs) for about 15 min. The KOH was then decanted and the root samples were bleached with freshly prepared alkaline hydrogen peroxide (3 ml of 25% ammonia solution + 30 ml of 6% $H_2O_2$ v/v) for 20-30 minutes. Roots were then treated with 1N HCl for about 10 min followed by keeping it overnight in 0.05% Trypan blue in lactic acid-glycerol. After removing from stain, roots were placed in lacto glycerol solution (destaining solution). The root specimen were then observed under microscope (10 root pieces/slide) for the presence or absence of hyphae, arbuscules and vesicles. A segment was counted as infected when hyphae, vesicles, or arbuscules were observed (Fig 5.2). The infection percentage was determined by method described by Giovannetti and Mosse (1980).

The results revealed that all the root segments observed were colonized by AM fungi and the colonization was between 3.3% to 90.0%. The roots having arbuscular, vesicular and both type of colonization was up to 50.0, 66.6 and 46.6, respectively (Table 5.1). The results also indicated that among different samples majority had vesicular colonization <20%, arbuscular colonization <20%, both arbuscular and vesicular colonization <10% and total root colonization <60%. Further, under zero arbuscular, vesicular, vesicular + arbuscular and total root colonization category there were 13.3, 1.9, 24.8, and 0.0 percent root samples, respectively. Considerable variation in percent root colonization and number of AMF spores in rhizospheric soil was observed. However, the data revealed that spore density and root colonization was not correlated with each other in a 'cause and effect' relationship. Distribution of root samples observed for colonization by AMF has been shown in figure 5.3.

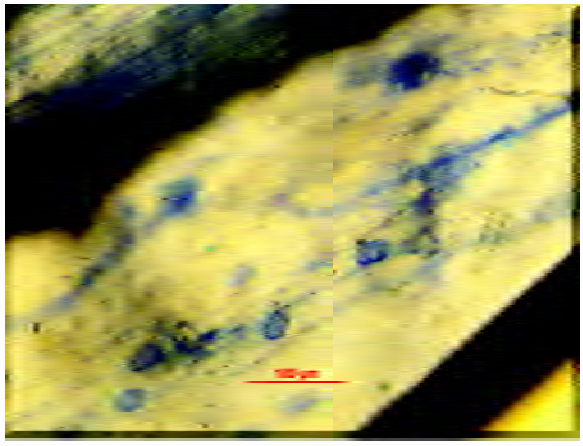

**Fig. 5.2: Vesicles and intraradial hyphae of AMF in a litchi root segment**

**Table 5.1: Distribution of root samples of litchi under different percent colonization category**

| | Arbuscular colonization | | Vesicular colonization | | Both vesicular and arbuscular colonization | | Total root colonization | |
|---|---|---|---|---|---|---|---|---|
| | No. of samples | % samples | No. of samples | % samples | No. of samples | % samples | No. of samples | % samples |
| Zero | 14.0 | 13.3 | 2.0 | 1.9 | 26.0 | 24.8 | 0.0 | 0.0 |
| 1-10 | 36.0 | 34.3 | 44.0 | 41.9 | 57.0 | 54.3 | 12.0 | 11.4 |
| 11-20 | 31.0 | 29.5 | 25.0 | 23.8 | 13.0 | 12.4 | 9.0 | 8.6 |
| 21-30 | 14.0 | 13.3 | 9.0 | 8.6 | 7.0 | 6.7 | 17.0 | 16.2 |
| 31-40 | 6.0 | 5.7 | 12.0 | 11.4 | 1.0 | 1.0 | 22.0 | 21.0 |
| 41-50 | 4.0 | 3.8 | 11.0 | 10.5 | 1.0 | 1.0 | 10.0 | 9.5 |
| 51-60 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 16.0 | 15.2 |
| 61-70 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | 6.0 | 5.7 |
| 71-80 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 5.7 |
| 81-90 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.0 | 6.7 |

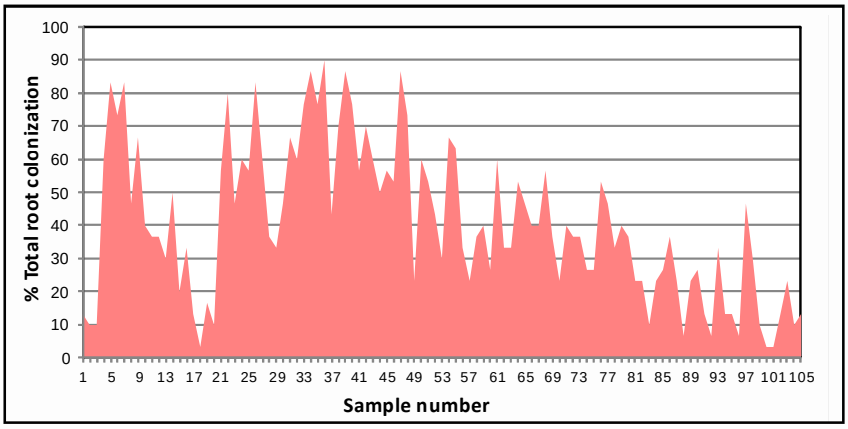


**Fig. 5.3: Total root colonization by AMF in the root specimens of litchi**

## 3. Physico-chemical properties of soil and mycorrhizal association in litchi

### 3.1. Soil chemical characteristics and nutritional status

The activity of the mycorrhizal fungi is affected by many factors including the physiological status of host plant and its ability to supply the fungus with organic nutrients. Soil chemical properties and nutrient content were assayed to know their effect on AMF population in rhizosphere, root colonization and their diversity. The different soil parameters considered were pH, electrical conductivity, organic matter content, nitrogen, phosphorus and potash. Besides these, micronutrients assayed were Zn, Cu, Fe, B, Mn and S. The result of the soil analysis is presented in table 5.2 and 5.3. It was evident that the soil pH of litchi orchards in various districts of Bihar was in the range of 7.42 to 9.53. The electrical conductivity of soil was in the range of 0.07 to 0.39 $dSm^{-1}$. In majority of the samples the organic carbon was low (<0.5% in 53 samples), nitrogen was high (>560 kg/ha in 96 samples) and available phosphorus (11-25 kg/ha in 58 samples) and potash (112-280 kg/ha in 91 samples) was in the medium range. Available phosphorus was high (>25 $P_2O_5$ kg/ha) in 43 samples.

**Table 5.2: Assay value of nutrients in the soil samples and distribution of samples in various categories**

| Nutrients | Assay value (range) in samples | | Critical range* and Number of samples | | |
|---|---|---|---|---|---|
| | Minimum | Maximum | Low | Medium | High |
| % Organic carbon | 0.02 | 1.05 | <0.5 | 0.5-0.75 | >0.75 |
| | | | 53 | 43 | 9 |
| % Organic matter | 0.21 | 1.81 | <2 | 2-4 | >4 |
| | | | 105 | 0 | 0 |
| % Nitrogen | 0.01 | 0.09 | <0.03 | 0.03-0.06 | >0.06 |
| | | | 7 | 89 | 9 |
| N(kg/ha) | 232 | 2027 | <280 | 280-560 | >560 |
| | | | 1 | 8 | 96 |
| Available $P_2O_5$ (kg/ha) | 4.57 | 137.1 | <10 | 11-25 | >25 |
| | | | 4 | 58 | 43 |
| Available $K_2O$ (kg/ha) | 69 | 293 | <112 | 112-280 | >280 |
| | | | 13 | 91 | 1 |

*Source: Koley, A. K., 1933; For each nutrients of column 4-6, the 1st row has assay value and second row has number of samples in that category

**Table 5.3: Assay value of micronutrients in the soil samples and distribution of samples in various categories**

| Nutrients | Assay value in samples (ppm) | | Critical** limit (ppm) | Number of samples | |
|---|---|---|---|---|---|
| | Minimum | Maximum | | < Critical limit | > Critical limit |
| Zn | 0.18 | 3.32 | 0.5 | 52 | 53 |
| Cu | 0.16 | 11.69 | 0.2 | 1 | 104 |
| Fe | 3.42 | 27.2 | 4.5 | 1 | 104 |
| Mn | 3.18 | 30.86 | 2.0 | 0 | 105 |
| B | 0.12 | 5.94 | - | - | - |
| S | 0.94 | 45.63 | 10 | 96 | 9 |

**Source: Lindsey and Norvell, 1978

## 3.2. Effect of pH, EC and organic matter content of soil on spore density and root colonization by AMF

The pH of the soil ranged from 7.42 to 9.53 and within this range spore density was not affected by pH. Data indicated that pH was positively correlated with root colonization by AMF but the correlation was weak ($r = 0.41$, $R^2 = 0.17$). Soil salinity in terms of electrical conductivity (EC) negatively affected spore density ($r = -0.34$, $R^2 = 0.11$) and root colonization ($r = -0.45$, $R^2 = 0.20$). The maximum spore density and root colonization were observed around EC value of 0.1 $dSm^{-1.}$ The organic matter content had a very weak correlation with spore density ($r = 0.17$, $R^2 = 0.03$) and root colonization by AMF ($r = -0.16$, $R^2 = 0.03$).

## 3.3. Effect of major nutrients on spore density and root colonization

### i) Nitrogen

The data reveled that the nitrogen content of soil did not have any influence on either spore density in rhizospere or root colonization by AMF.

### ii) Phosphorus

In general, medium level of available phosphorus ($P_2O_5$) (13-28 kg/ha) had a positive effect on spore density and colonization of roots of litchi by AMF. When the data was plotted on a scatterdiagram a negative linear correlation was apparent that was more strong with respect to root colonization by AMF ($r = -0.48$, $R^2 = 0.23$) than spore density ($r = -0.21$, $R^2 = 0.04$) (Fig. 5.4 and 5.5). The value of coefficient of determination ($R^2$) indicated that whereas 23% of the variability in extent of root colonization can be explained by level of available phosphorus, it was responsible for only 4% of the observed variability in spore density of AMF in rhizosphere.

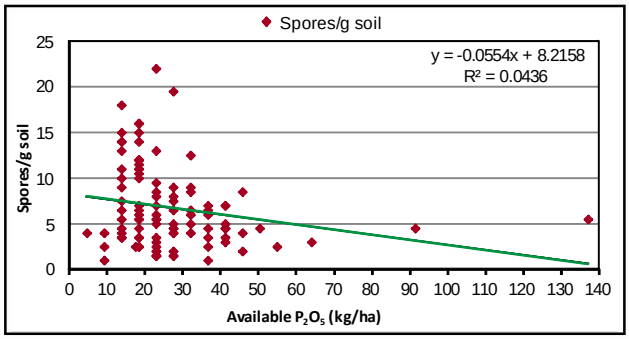


**Fig. 5.4: Available phosphorus and spore density of AMF in rhizospheric soils of litchi**

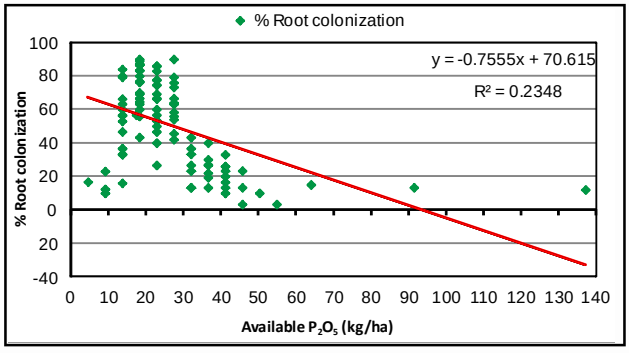


**Fig. 5.5: Available phosphorus and colonization of roots by AMF in litchi**

### iii) Potassium

The level of potassium ($K_2O$) in soil of litchi orchard in various districts of Bihar was in the range of 69-293 kg/ha. The maximum number of spores of AMF and root colonization was observed with medium level of potassum (112-200 kg/ha) in the soil. When the data was plotted on a scatterdiagram, no apparent correlation was found with spore density ($r = -0.05$, $R^2 = 0.00$) but a weak negative linear correlation was observed with respect to root colonization by AMF ($r = -0.28$, $R^2 = 0.08$) which was prominent at higher level of potash in the soil. Sreevani and Reddy (2004) also

observed similar observation who reported that a high level of potassium in the rhizospheric soil of tomato had the least number of spores whereas a greater number of spores were observed in the soils with low levels of potassium.

### 3.4. Effect of micronutrients on spore density and root colonization

Results indicated that micronutrients in general, did not affected spore density of AMF in litchi rhizosphere (zero or a very weak linear correlation) but did affected root colonization by AMF in a negative linear relationship, the effect being more prominent above critical limits of the micronutrients.

#### i) Zinc

Results indicated that zinc content around critical limit (0.5 ppm) in rhizospheric soil had a positive effect on spore density and root colonization and beyond this limit, it drastically affected both the parameters. When data was plotted on a scatterdiagram, the slope of the regression line was negative for both the parameters (r = -0.42 for spore density and -0.44 for colonization) (Fig. 5.6 and 5.7). The $R^2$ value indicated that Zn was responsible for 18-19% of the observed variability in the aforesaid parameters of AMF association in litchi.

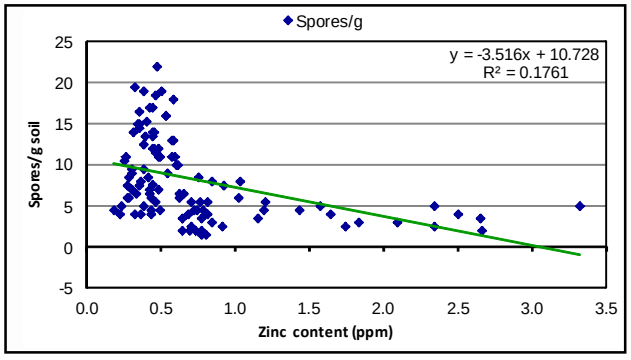


**Fig. 5.6: Zinc content and spore density of AMF in rhizospheric soils of litchi**

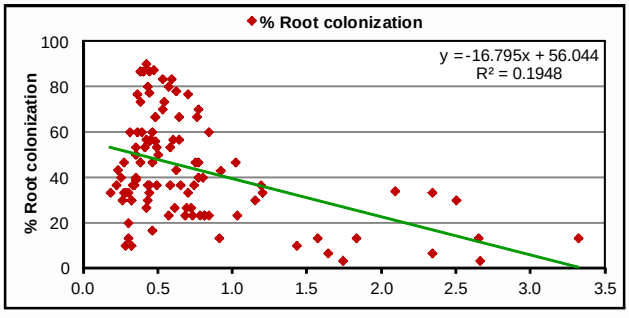


**Fig 5.7: Zinc content and colonization of roots by AMF in litchi**

#### ii) Iron

Data revealed that the soil samples having iron content between 5-12 ppm had higher number of spores of AMF. Similar trend was observed with respect to root colonization by AMF. Correlation and regression analyses indicated that iron content above critical limit was not conducive for mycorrhizal association in litchi as negative linear relationship (r = -0.44 for spore density and -0.49 for colonization) was evident (Fig.5.8 and 5.9).

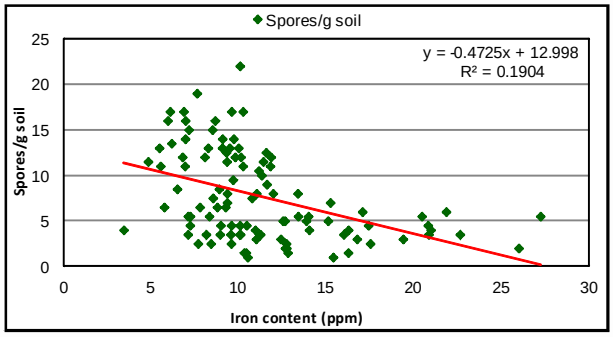


**Fig. 5.8: Iron content and spore density of AMF in rhizospheric soils of litchi**

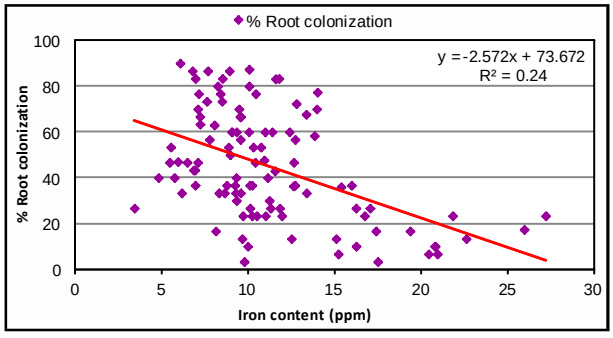


**Fig 5.9: Iron content and colonization of roots by AMF in litchi**

#### iii) Copper

Out of 105 samples, 104 were above critical limit (0.2 ppm). Data revealed that the level of copper in soil had no influence on spore density but negatively affected root colonization by AMF in litchi. The relationship of copper with these two parameters has been presented in scatterdiagram. It was evident that about 23% of the

observed variability in root colonization could be explained by copper content in soil rhizosphere.

### iv) Manganese

The data revealed that all the samples were above critical limit (2 ppm). The maximum number of spores and root colonization was observed between 5-8 ppm. Correlation and regression analyses revealed a similar effect of this micronutrient to that of copper on spore density and root colonization. The level of manganese in soil had no influence on spore density but negatively affected root colonization by AMF in litchi. The relationship has been presented in scatterdiagram. It was evident that about 27% of the observed variability in root colonization could be explained by manganese content in soil rhizosphere.

### v) Boron

Content of boron in soil rhizosphere had a positive effect on spore density of AMF but had a negative linear correlation with root colonization by AMF (Fig. 5.10 and 5.11). The maximum number of spores was observed between 3-4 ppm whereas maximum root colonization was observed between 0.5 to 4.0 ppm. Boron is essential for sugar translocation in roots. Dugger (1983) had indicated that the mycorrhiza themselves do not utilize boron. If the boron concentration in the soil rises above a certain level, it may become toxic for the roots. This may restrict the mycorrhizal activities and by doing so harm the plants indirectly or may cause them to die. This explains the results of our study. Ortas and

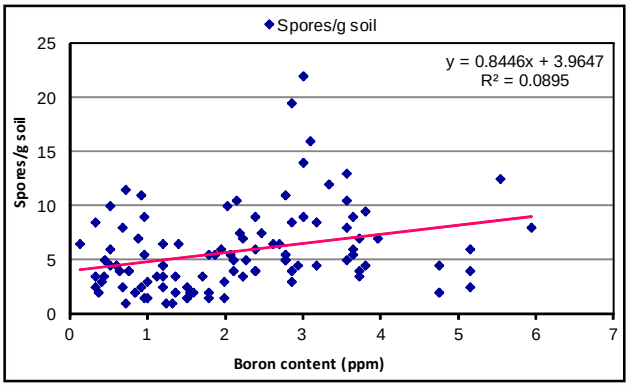


**Fig. 5.10: Boron content and spore density of AMF in rhizospheric soils of litchi**

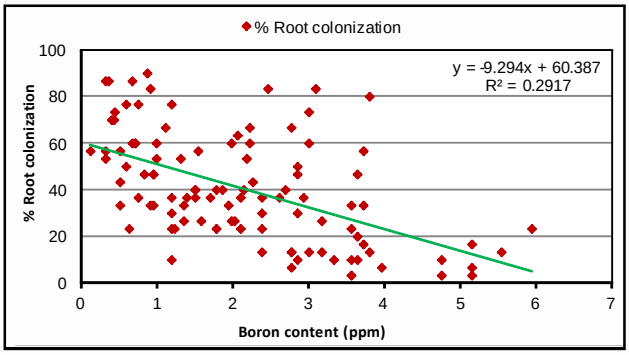


**Fig. 5.11: Boron content and colonization of roots by AMF in litchi**

Akpinar (2006) had also reported the negative effects of high soil concentration of boron on root AM colonization.

### vi) Sulphur

The maximum number of spores and colonization of roots by AMF was observed at sulphur content between 1.88 to 10.0 ppm. However, the data revealed that sulphur content in the rhizosphere soil had no effect on spore density and root colonization when plotted on a scatterdiagram. The value of correlation coefficients (r) was 0.08 and -0.06 for spore density and root colonization, respectively.

## 3.5. Age of litchi plantation vis-à-vis mycorrhizal association

The age of plantation did not have any influence either on spore density of AMF in the soil or root colonization by AMF.

## 3.6. Management status of litchi orchards vis-à-vis mycorrhizal association

Comparatively higher spore density of AMF and root colonization was observed in irrigated, well managed orchards where application of fertilizers and manures etc. were done than in non-irrigated, poorly managed orchards. This indicated that a minimum level of nutritional status and moisture regime of soil is required for this symbiotic organism to function.

### 3.7. Cultivar of litchi vis-à-vis mycorrhizal association

The soil samples were collected from orchards having two widely grown cultivars *viz.*, 'Shahi' and 'China'. A close perusal of the data revealed that cv. 'China' had higher root colonization than 'Shahi'. About 50% trees of cv. 'China' had root colonization above 50% whereas only 29.4% trees of *cv.* 'Shahi' had root colonization above 50%.

### 4. Diversity of AM fungal species in litchi rhizosphere

Diagnostic slides with spores/sporocarps were prepared using polyvinylalchol lactoglycerol (PVLG) as mountant. All the spores (including broken ones) were examined under fluorescent trinocular upright microscope. Taxonomic identification of spores up to species level was based on spore size, spore colour in Melzers' reagent, wall layers and hyphal attachments using the identification manual (Schenck and Perez, 1990) and the description provided on INVAM website (http://invam.caf.wvu.edu/). Spores were rolled or turned so that the hyphal attachment was not obscured by the spore. Some spores were pressed to break for the examination of wall layers as these are considered of much taxonomical value by several workers. Size of the spore was measured by imaging software by imaging software provided with Nickon camera model DS-Fi1 attached with fluorescence microscope, Nickon Model E50i.

The results revealed that in almost all the samples *Glomus* species dominated the AMF population. Other genera found were *Acaulospora*, *Entrophosphora* and *Scutellospora* (Fig. 5.12). Different AMF species identified were *G. mosseae, G. fasciculatum, G albidum, G. hoi, G. multicauli, Acaulospora scrobiculata,* and *Entrophosphora infrequens*. Wide occurrence of genus *Glomus* in the present study as well as reports of several workers suggested that genus *Glomus* has very wide ecological amplitude that is responsible for its adaptability and survival in different habitats. In the present study, *Gigaspora* was not detected in litchi rhizosphere.

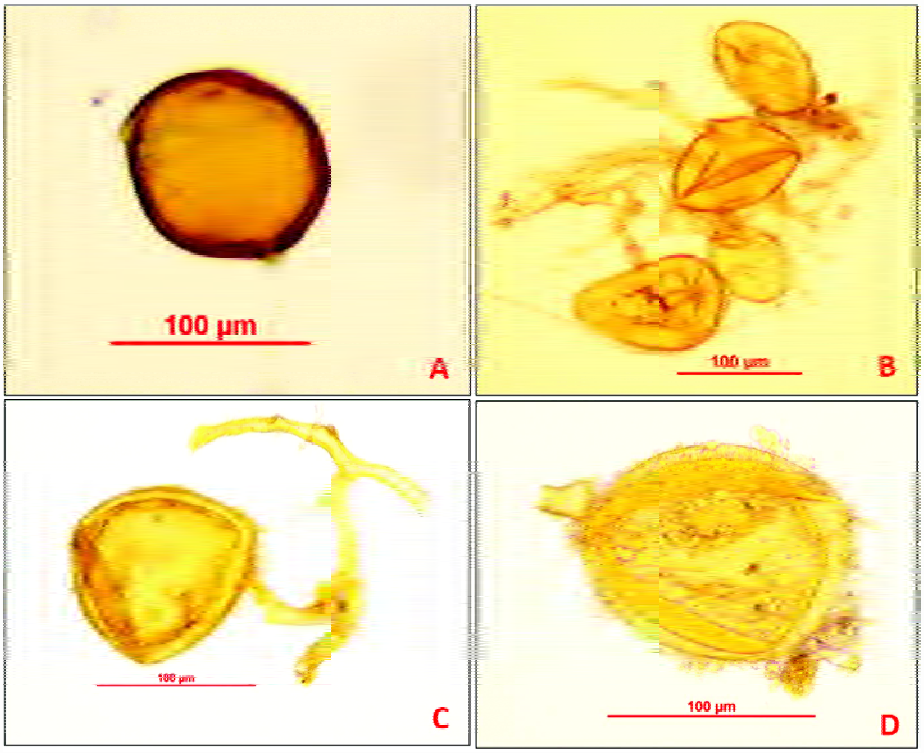


**Fig. 5.12: Spore of AMF; A. *Glomus mosseae*, B. *Glomus fasciculatum*, C. *Glomus multicauli* and D. *Glomus hoi***

## 2. "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services"-UNEP-GEF/TFT Project (Vishal Nath, Awtar Singh, Sanjay Kumar Singh and Narayan Lal)

The approved technical programme of the project was implemented and the progress made under this project is presented here in brief.

### Morphological characterization of mango and pummelo

Sixteen germplasm of mango and 13 of pummelo were morphologically characterised and listed in fruit catalogue published at the centre.

### Molecular characterization of mango germplasm

During 2013-14, following mango germplasm (8) were characterized using 10 primers by ISSR marker at division of Crop Improvement, CISH, Lucknow.

### Identification of late maturing mango clones at Pusa site

During the variability survey among the seedling population of mango, a very late- maturing seedling plant, 'Clone 77' was identified in *Bhuskaul* village of Samastipur district of Bihar. The tree was about 50 year old and bore big sized fruits (308 g/fruit). The farmer could never harvest its tree-ripened fruits (*Tapka*, a naturally ripened fruits falling from the tree first), because of late ripening. The fruits were analyzed for physico-chemical characteristics, which were excellent. It was almost similar to 'Maldah' but matured two months later than 'Maldah' and had TSS 19.64 °Brix that was a high TSS for the season. The late-maturing fruits could be sold at premier market price, besides widening the season of the availability of mango-fruits. A total of 150 grafted plants were made from this clone for detailed evaluation in replicated trials and for distribution among farmers of *Jagdishpur, Mahamada, Murliyachak* and *Dhobgama* in Samastipur district of Bihar.

### Establishment of community nursery

Two community nursery was established, used and being maintained.

### Distribution of sapling or plants

Seventy nine plants of elite germplasm of mango were distributed to community to establish 5 diversity orchards. Five plants of one variety were distributed to one farmer belonging to outside community villages.

**Table: Mango germplasm from Bihar characterized by ISSR marker**

| Name of collection of mango germplasm | Name of the farmer/ conservators | Contact address of farmer/ conservators |
|---|---|---|
| 'Sona Malda' | Shri Raghupati Prasad Singh | Vill. Mahamada, Pusa, Samastipur |
| 'Madukupiya Biju' | Shri Vinod Rai | Vill. Jagdishpur, Pusa, Samastipur |
| 'Kappuria' | Shri Triloki Prasad Singh | Vill. Mahamada, Pusa, Samastipur |
| 'Biju Mango' | Shri Kailash Prasad Singh | Vill. Jagdishpur, Pusa, Samastipur |
| 'Shukuliya Biju' | Shri Vinod Rai | Vill. Jagdishpur, Pusa, Samastipur |
| 'Biju Mango' | Shri Pranay Kumar Singh | Vill. Mahamada, Pusa, Samastipur |
| 'Sukul Biju' | Shri Uday Kumar Sharma | Vill. Dhobgama, Pusa, Samastipur |
| 'Alphonso Biju' | Shri Vinod Rai | Vill. Jagdishpur, Pusa, Samastipur |

### Consumption behaviour of tropical fruits and products at Pusa site

A survey was undertaken in five community villages of Pusa site having 10 farmers from each community. It was found that most of the people preferred seasonal fruits grown in the area. Watermelon, litchi and mango were the preferred fruits in the area during the season.

## Identification of custodian farmers

Three more custodian farmers from outside community villages were identified at Pusa site making the total 12 custodian farmers identified from Pusa site. The name of custodian farmers identified at Pusa site is as follows:

- Shri Vinod Rai, Jagadishpur, Pusa, Samastipur
- Shri Kailash Prasad Rai, Jagadishpur, Pusa, Samastipur
- Shri Ravindra Nath Sharma, Jagadishpur, Pusa, Samastipur
- Shri Arvind Kumar Thakur, Dhobgama, Pusa, Samastipur
- Shri Vijay Kumar Sharma, Basuary, Malinagar, Pusa, Samastipur
- Shri Awadesh Thakur, Malinagar, Kalyanpur, Samastipur
- Shri Rajinder Thakur, Malinagar, Kalyanpur, Samastipur
- Shri Sanjay Sharma,Malinagar, Kalyanpur, Samastipur
- Shri Umesh Rai, Dighra, Pusa Samastipur
- Shri Ramnath Thakur, Bathua, Pusa, Samastipur

## Organizing Mango Diversity Fair

Mango diversity fair was organized at Dhobgama, Pusa site on 4th July, 2013 to know the extent of variability in mango seedling population and to identify the superior mango clones under the project. Dr. BMC Reddy, National Project Coordinator of UNEP/GEF Project, Dr. Gopal Ji Trivedi, former Vice-Chancellor, RAU, Pusa, Smt. Bimla Singh, Chairman, Lt. Amit Singh Memorial Foundation, New Delhi and Dr. Vishal Nath, Director, NRCL addressed the gathering of the farmers.

A huge response was received from the farmers and a total of 176 farmers registered with their entries in the mango diversity competition. Many seedling types (147) were exhibited in addition to commercial mango varieties. Many new types were observed in seedling population of mango, which had future potential. Twenty prizes were given to superior entries in five different groups. All the selected 21 entries were analyzed for physico-chemical parameters at NRCL laboratory. Positive response and keen interest in biodiversity conservation was shown by the farmers in the fair. Dr. Awtar Singh, earlier Site Coordinator of Pusa site under the project took lead to organize this programme and scientists of NRCL, Muzaffarpur, RAU, Pusa, and IARI RS, Pusa, Samastipur were present in the function along with State Horticultural Officers, local NGO's and media persons.


**Fig. 5.13: A panoramic view of mango diversity fair and diversity of mango fruits**

## Training programme on GAPs

Training programme was conducted on 21st December, 2013 in two batches for 'Capacity Building on Good Agricultural Practices for Mango Diversity, Livelihood Security and Ecosystem Services' at Dhobgama in forenoon and Jagdishpur village in afternoon at Pusa site comprised of two SHGs from each of the villages.

About 25 mango growers at each location had participated and got hands on experience on methods of planting/pit digging and filling, improved practices of water and nutrient application and monthly calendar operation adopted in mango orchard.

Printed literature on how to establish new mango orchard, GAPs for mango orchard and monthly calendar operation to be adopted in mango orchard were distributed to each of the members of SHGs. Interaction of SHGs with farmers on objective and function of SHGs (formed by DHAN foundation RS Gaya] in different village of Pusa Site took place and it was clear that the function of such SHGs can ease production and marketing problems. Growers felt marketing constraints during the season to dispose their produce from the field. The experts in the training programme were Dr. S.D.Pandey, Principal Scientist (Hort.) NRCL, Muzaffarpur and Dr. P.L.Saran, Senior Scientist (Hort.), IARI-RS, Pusa, Samastipur

## 3. "Development of National Database on Mango" Sponsored by Department of Biotechnology, GOI, New Delhi (Vishal Nath, Sanjay Kumar Singh, Kuldeep Srivastava and Alemwati Pongener)

The project was sanctioned by Department of Biotechnology, Government of India in February, 2013 but work was stated during financial year 2013-14. The objectives of the prioject are:

- Passport data collection, morphological charcterization of genetic resources of mango germplasm of Bihar and Jharkhand.
- Digitization of information on on-farm conservation
- Charcterization of extant and farmers varieties.
- Data collection on regional varieties
- Updating information on tradtional knowledge (TK), usage database, package of practices, nutritiuonal value, medicinal values, diseases and pests, status of field gene bank, production and post-harvest technology etc.

After discussion with Nodal officer, CISH, Lucknow, Director, NRCL, Muzaffarpur and with Head, CHES (regional centre of IIHR Bangalore), Bhubaneshwar, following districts of Bihar and Jharkhand were earmarked for preparation of mango database under the project. NRCL will be taking data from following districts of Jharkhand besides all districts Bihar:

**Bihar:** Araria, Aurangabad, Banka, Begusarai, Bhagalpur, Bhojpur, Buxar, Darbhanga, Gaya, Gopalganj, Jamui, Jehanabad, Kaimur, Katihar, Khagaria, Kishanganj, Lakhisarai, Madhepura, Madhubani, Munger, Muzaffarpur, Nalanda, Nawada, Paschim Champaran, Patna, Purbi Champaran, Purnia, Rohtas, Saharsa, Samastipur, Saran, Seohar, Sheikhpura, Sitamarhi, Siwan, Supaul and Vaishali (38 districts).

**Jharkhand:** Chatra, Garhwa, Giridih, Kodarma, Palamu, Ranchi, Lohardaga, Gumla, Latehar, and Hazaribag (10 districts).

During 2013-14, data was collected from following institution working on mango located in Bihar and Jharkhand. The details are as follows:

| Name of the institution | No. of mango varieties/ accessions maintained and conserved |
|---|---|
| NRCL, Muzaffarpur | 12 |
| RAU, Pusa, Samastipur, Bihar (Main Campus) | 21 |
| RAU Research Station, Madhopur, West Champaran, Bihar | 11 |
| KVK Birauli, RAU Pusa, Samastipur | 29 |
| ICAR Research Complex for Eastern Region (ICAR-RCER), Patna | Nil |
| ICAR-RCER, RS, Plandu, Ranchi | 127 |
| Bihar Agricultural University, Sabaur, Bhagalpur | 179 |
| Birsa Agricultural University, Ranchi | 20 |

After the survey of mango orchards in Bihar during 2013-14, varieties maintained by 5 farmers of Muzaffarpur and 15 farmers of Samastipur district were enlisted. Most of the orchard had infestation of plant hopper and mealy bugs and drying of branches was a prominent problem in the mango cultivar '*Sipia*' in the area.

## 4. NAIP sponsored e-GRANTH project: "Strengthening of Digital Library and Information Management under NARS" (Sanjay Kumar Singh)

Following work was carried out under this project during 2013-14 at this centre.

- Questionnaire for Status of Libraries and Catalogue Information of NRCL Muzaffarpur was submitted.
- *Debian 7.3.1* and *Koha LS 3.14* was installed and customization of KOHA-OPAC was completed. Data on books (1675 + 10 statistical CDs) and journals (1105 in No.) of NRCL Library was entered and taken for Centralized Koha Implementation at IARI, New Delhi.
- Conversion of Hindi font *Krutidev* 010 to Unicode of database on Hindi books was done and also migrated to KOHA.
- User IDs was issued to users of library and issuance of books was started.
- Data (English/Hindi) on books, encyclopedias, annual reports, dictionaries, newsletters, and Hindi books had been entered in excel sheet under 'Koha Implementation Programme' and migrated to Koha.
- Installation of Standalone Server (Proliant ML 350 G6) was completed in AKMU (formerly ARIS Cell) at NRCL.
- CCPI and SRFs attended workshop cum review meeting of KOHA implementation at ANGRAU, Hyderabad and ICAR-RCER Patna in last week of October, 2013 and February, 2014 respectively.
- National Workshop on "Automated Library & e-Resource under NARS" at IVRI, Izzatnagar, Bareilly, UP was attended by two SRFs during 16-17 December, 2013.

## 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 Sushil Kumar 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. During 2013-14 following two developments took place at the centre.

- MoU with Shree Hari Fabricator, Kolkata was signed on 27 September 2013 at NIRZAFT, Kolkata for commercialization of various litchi products *viz.* wine, nut, squash, pulp etc and development of machinery related to it.
- The centre had signed MoU with Reliance Industries Ltd., Kolkata for "testing the non-woven fabric made from RP as bagging of litchi bunches on quality and yield of litchi fruits" on 27.12.2013. As a technical advisory consultancy/paid up trial an amount of Rs. 1, 00,000/ (Rupees one lakh only) for the period of one year was paid.

## 6. Revolving Fund Scheme (RFS) (Vishal Nath and Amrendra Kumar)

Under the MSP-RFS project on Agriculture Crops and Fisheries Including Horticulture, a mother block

of 1.2 ha comprising of nine commercial cultivars of litchi *viz.,* 'Shahi', 'Rose scented', 'Longia', 'China', 'Mandraji', 'Swarnrupa', 'Purbi', 'Bedana' and 'Yogda selection' is being maintained at the Centre. To make available quality planting material to the farmers, state departments and other agencies, centre had produced quality planting material through air-layers (gooties). During 2013-14, 42,260 numbers of gooties were made, out of which 40,080 successful gooties were cut from mother block and raised in the polyethylene bags inside the net house. Finally 27,893 numbers of litchi saplings of cv. 'Shahi' and 'China' were made available to different indenters from state department and to other stakeholders. Revenue of Rs. 9,76,255 was generated during the year. During the period the centre could refund the money share of Rs. 2,00,000 with intimation to the DSR, Mau.

**Fig. 5.14: Director, NRCL after signing of MoU with the Executive of Shree Hari Fabricator, Kolkata**

# Other Research and Development Programmes

In the EFC of 12th Five Year Plan (2012-2017) of the centre separate provision with allocation of fund was made for the North-Eastern hill region and Tribal sub plan as mandatory R & D activities. Further, in continuation of the concluded NHB sponsored project at this centre research activity on honeybee was carried out with the infrastructure and resources created during the project. A brief report on these activities is presented here.

## Tribal Sub Plan Project

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% belong 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

In Bandel village of Rayagada district, 70 acre land was identified for plantation of mango and litchi. Besides new plantations, nearly 10000 new plantation (1-3) year old planted by HARPAL NGO also associated in this programme for extending local facilities was acquired. During 2013-14, fencing of area and irrigation network facilities had been created at the site. Planting material of litchi and mango were reserved for planting during the ensuing season. A sum of Rs 11.79 lakh was been spent to create the facilities. Activities proposed are planting of different models, maintenance of new plantation and providing training to the stake holders on good agricultural practices o different fruit based models.

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

The researchable issues and technological intervention to enhance litchi production and productivity in NEH region was planned. In the first phase, Tripura was selected to implement the planned activities. The strategic activities started and a progress report was submitted. Interactions with scientists, officials for strategic technological interventions/ implementations of new plantation (2 ha), canopy management (2 ha), rejuvenation of old senile trees (5 ha.) was successfully attempted. In the next phase, Nagaland, Assam, Manipur, Mizoram, Meghalaya and Arunachal Pradesh will be covered to initiate strategic researchable issues and technological implementations under this project.

## Honey-Bee Foraging Study

An apiculture unit (containing 120 boxes with honey-bee colonies) was created after the termination of the National Horticulture Board sponsored project entitled "Assessment and refinement of technology for improving productivity of litchi by enhancing pollination and honey production with processing for employment and income generation" during 2012. This resource is now being utilized for foraging studies.

### Survey and surveillance of pollinators

Honeybee keeping, foraging study out of season and in main season was carried out. The recorded observation showed that foraging bees were dominant between 06.00-12.00 hr and were less active in the afternoon from 14.00-16.00 hr. There movement (tracking) and other behaviour were recorded up to 18.00 hr. Other pollinating insects visited the blooming field crops/ litchi flowers mostly between 6.30 -14.00 hr. The pollination benefits and fruit production in litchi was recorded that revealed more fruit set in the trees having nearer placement 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 crop in bloom.

# Human Resource Development

## Participation of scientists/ staffs in Conference/ Seminar/ Symposia/ Workshops/ Training/ Meetings during 2013-2014

| Sl. No. | Title | Venue and Date | Name of the Participant |
|---|---|---|---|
| 1. | Management Development Programme on Stress Management | NAARM, Hyderabad, 21-24 January, 2014 | Dr. S. D. Pandey |
| 2. | Participation in XXI Annual Workshop and Group Workers Meeting of AICRP on Subtropical Fruits at BSKKV, Dapoli, Maharashtra | Dapoli, 22-25 January, 2014 | Dr. Vishal Nath<br>Dr. Rajesh Kumar<br>Nodal scientist)<br>Dr. S. K. Purbey<br>Dr. Amrendra Kumar<br>Dr. Kuldeep Srivastava |
| 3. | National Seminar on "Climate Change and Indian Horticulture: Exploring Adaptation and Mitigation Strategies for Expeditious Resilience" | Sabour, Bhagalpur, 25-27 May, 2013 | Dr. Rajesh Kumar<br>Dr. Sanjay Kumar Singh |
| 4. | International Conference on "Water Management for Climate Resilient Agriculture" organized by Lt. Amit Singh Memorial Foundation, New Delhi | Jalgaon, Maharashtra, 28-31 May, 2013 | Dr. Rajesh Kumar<br>Dr. Amrendra Kumar<br>Dr. Sanjay Kumar Singh |
| 5. | National Seminar cum Workshop on Canopy Management and High Density Planting in Subtropical Fruit Crops, Organized by PFDC and CISH, Lucknow | Lucknow, 22-24 October, 2013 | Dr. Rajesh Kumar |
| 6. | Management Development Programme on Leadership Development (Pre- RMP Cadre) | NAARM, Hyderabad, 26 November - 07 December, 2013 | Dr. Rajesh Kumar |
| 7. | National Seminar on "Climate resilient Horticulture: Adaptation and Mitigation Strategies, held at BAU, Sabour, Bhagalpur, Bihar | Sabour, 15-17 February, 2014 | Dr. Rajesh Kumar |
| 8. | National Seminar on Breeding for Abiotic Stresses: Problems and Prospects, Ranchi, Jharkhand | BAU, Kanke, Ranchi, 23-24 February, 2014 | Dr. Rajesh Kumar |
| 9. | Seminar on "Environment and Horticulture" Organized by Tirhut Udyan Bikas Samiti, Muzaffarpur | Maripur, Jaitpur campus, Muzaffarpur, 9 March, 2014 | Dr. Rajesh Kumar |
| 10. | Brain storming session on "Farm Mechanization, Processing technology and Value addition for enhancing Profitability", organized by Faculty of Engg., RAU, Pusa | Veterinary College, Patna, 6 April, 2013 | Dr. S. K. Purbey |
| 11. | Training programme on "*Prashikshak Karyakarta Abhyas Varg Programme*" at Vaishali Garh, Vaishali organized by *Jaivik Kheti and Jaivik Khad Samiti*, Muzaffarpur | Muzaffarpur, 10 April, 2013 | Dr. S. K. Purbey |
| 12. | Participated in annual workshop of ITMU's and BPD unit organized by ZTMU and BPD unit NIRJAFT, Kolkata | Kolkata, 26-27 September, 2013 | Dr. S. K. Purbey |
| 13. | Participated in annual workshop on "Supply Chain Management in Agriculture" organized by NAARM, Hyderabad | NAARM, Hyderabad, 7-12 October, 2013 | Dr. S. K. Purbey |
| 14. | Participated in the conference on "*Kaushal Vikash Mission* (Skill Development Training Programme)" organized by Director Agriculture, Govt. of Bihar | Patna, 13 November, 2013 | Dr. S. K. Purbey |
| 15. | Seminar on Seed/Sapling production, Seed processing, Storage and Marketing- Challenges and Opportunities. Organized by BAMETI, Patna (Bihar) | Patna, 23-24 August, 2013 | Dr. Amrendra Kumar |

| | | | |
|---|---|---|---|
| 16. | MDP workshop on PME Agricultural Research Projects organized by NAARM, Hyderabad | NAARM, Hyderabad, 19-23 November, 2013 | Dr. Amrendra Kumar |
| 17. | Review Meeting of ICAR Seed Platform | IIHR, Bangalore, 22 February, 2014 | Dr. Amrendra Kumar |
| 18. | Meeting of RFD Nodal officers of RSC under Horticulture Division at KAB-II, Pusa, New Delhi for half-yearly review of progress of RFD | Pusa, New Delhi, 23 October 2013 | Dr. Vinod Kumar<br>Dr. Sanjay Kumar Singh |
| 19. | 8th NPSC Meeting of the project "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services" | Chittoor, A.P., 11-12 May, 2013 | Dr. Sanjay Kumar Singh |
| 20. | Mid-term Review of e-GRANTH Project at DOR, Hyderabad | Hyderabad, 25-26 October, 2013 | Dr. Sanjay Kumar Singh |
| 21. | National Workshop on 'Strategies for strengthening NARS Libraries under *e-Granth*' IARI, New Delhi | IARI, New Delhi, 5 -6 July, 2013 | Dr. Sanjay Kumar Singh |
| 22. | One day Seminar on '*Separation and Detection equipment*' Manufactured by M/s Agilent Technologies at Hotel Patliputra Ashok, Pune | Patna, 25 January, 2014 | Dr. Sanjay Kumar Singh |
| 23. | Attended "Koha implementation and customization' under *e-Granth* Project at ICAR Research Complex for Eastern Region, Patna | Patna, 20-22 February, 2014 | Dr. Sanjay Kumar Singh |
| 24. | 9th NPSC Meeting of the project "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services" | Nagpur, 13-14 February, 2014 | Dr. Sanjay Kumar Singh |
| 25. | National symposium entitled "Recent Advances in Beneficial Insects" | Ranchi, 27-29 November 2013 | Dr. Kuldeep Srivastava |
| 26. | Refresher Course on Agricultural Research Management at NAARM, Hyderabad | Hyderabad, 3-15 February 2014 | Dr. Kuldeep Srivastava |
| 27. | Professional Attachment Training on Application of Molecular Biology on Crop Improvements | NABI, Mohali<br>6th June to 10th September, 2014 | Shri Narayan Lal |
| | | | |
| 28. | Training on "MAS for Molecular Breeding in Fruit Crops" | CISH, Lucknow<br>11-24th November, 2014 | Shri Narayan Lal |
| 29. | Interactive meet to Review progress and future course of Action on "Conservation of Mango and Pummelo"under UNEP-GEF project | Pusa Site, Samstipur<br>24th April, 2014 | Dr. S.D. Pandey<br>Dr. Sanjay Kumar Singh<br>Dr. R.K. Patel<br>Sh. Narayan Lal |

## Other human resource development activities

- A one week training programme on "Post harvest handling and processing of litchi fruits" was organized from 8-15 June, 2013 for B.Sc. (Ag). students in which 12 students from B.H.U., Varanasi and the Deemed University Naini, Allahabad participated. The programme was coordinated by Dr. S.K. Purbey, Senior Scientist (Hort.) of the Centre.
- Excursion/ Exposure visits were organized at NRCL for school students on 7th December, 2013. About 250 students of class 9th and 10th from Holly Mission Sr. Sec. School, Muzaffarpur and about 150 students of class 7th and 8th of Rajkiye Utkramit Madhya Vidyalaya, Mushahari, Muzaffarpur visited during the programme. The programme was coordinated by Dr. S.K. Purbey, Senior Scientist (Hort.) of the Centre.
- Dr. Vinod Kumar acted as resource person and delivered lecture on "Pest and disease management in litchi" and "Mycorrhizal association in litchi" during training programme on "Post-harvest handling and processing of litchi fruits" held for B.Sc. (Ag.) students at NRCL, Muzaffarpur from 8-15th June 2013.
- Dr. Rajesh Kumar delivered lectures in the training programme of UG students on the topic "Introduction to litchi" on 10.06.2013; Rejuvenation of old senile litchi orchards on 12.06.2013 and Climate change and litchi production on 13.06.2013.

# Visits Abroad

## Dr. Vishal Nath, Director, NRCL visited Thailand

Dr. Vishal Nath, Director, NRCL visited Thailand during 26 May -1 June, 2013 to gain knowledge of the litchi production and post-harvest practices followed in the country. From the visit to various places it was observed that Chiang Mai and Fang was the best litchi producing areas. 'Chakapat' and 'Hung Huay' were the leading varieties, and crop regulation by cincturing and optimum nutrient management was the best production practices. A shift in research focus from litchi to longan was observed in Thailand. The timely and specific post-harvest practices and better infrastructure helped in efficient litchi marketing and trade in Thailand. The techniques such as canopy management, centre opening of trees, rejuvenation of trees, sod culture, bunch thinning and cincturing of shoots could be of significance in Indian context. The following action points emerged as a result of the study tour:

- The constant efforts should be made to obtain the varieties like 'Chakapat', 'Huang Huay', 'Khm' and 'O-Hio' from Thailand.
- The improved technique like centre opening, cincturing, bunch thinning, bagging of bunches to improve size and quality of fruits should be popularized among farmers.
- The method of packing fruits in special types of crates with iron hooks should be introduced for domestic and distant transportation.
- The cool chain system should be established as model unit at NRCL for generating sufficient data on handing and transportation.

## Dr. Vishal Nath, Director, NRCL visited USA

Dr. Vishal Nath, Director, NRCL, attended a NAIP sponsored training programme during 23-28 June, 2013 at Harvard Kennedy School, Harvard University, USA. The course was very useful in optimizing the performance of the organization. The lesson learnt from the training could be summarized were as follows:

- The decisions should be made based on the facts.
- We must try to change the situations at the work environment rather than changing people
- Calculated risks could be taken at work place and the judgment should be based always on the data/ facts
- One must prepare to handle work pressure much ahead- slow down and analyze carefully.

The learning of the training was shared among the scientist and staff of the Centre.

# Meeting, Workshops and Events

## Foundation Day

NRCL celebrated its 13th Foundation Day on 6th June 2013. Shri K. P. Ramaiyya, the Commissioner, Tirhut Division was the Chief Guest and Dr. Gopalji Trivedi, former Vice-Chancellor, Rajendra Agricultural University, Pusa, Bihar presided over the function. Dr. Vishal Nath, Director of the centre welcomed the guests and briefed about NRCL activities. A "Litchi Exhibition" and "*Kishan Gosthi*" were organized at the centre on this occasion.

The Chief Guest along with scientists and farmers visited the experimental farm and laboratories. Speaking on the occasion Shri Ramaiyya described the relationship of farmers and scientists as 'mutualistic' and their concerted effort would lead to accelerated development of agriculture. Dr. Trivedi advocated the need for bringing litchi under the crop insurance scheme by the Government.

More than 200 farmers from Muzaffarpur, Vaishali, Samastipur, Sitamarhi, and West Champaran district of Bihar were present on this occasion. About 100 farmers brought their litchi for exhibition. The cultivars in the exhibits were Shahi, China, Bedana, Kasailia, and Kasaba. Prizes for best exhibits in each category were conferred to farmers to encourage the production of good quality litchi. The largest fruit size of the litchi cultivar China in the exhibits weight up to 39 g. During the *gosthi* farmers interacted with the scientists who provided the answers to queries and vice-versa.

On this occasion, four publications of the centre viz. "The World Litchi Cultivars", *Litchi Ko Keeton avam Rogon se Bachayein* (in Hindi)", "*Litchi Mein Chhatrak Prabandhan* (in Hindi)" and "NRCL- at A Glance" was also released.


**A panoramic view of Inaugural Session of the Foundation Day celebration**

## Mango Diversity Fair

Mango diversity fair was organized at Dhobgama, Pusa site on 4th July 2013 under the UNEP/GEF TFT Project "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services". The fair was organized by NRCL in collaboration with Lt. Amit Singh Memorial Foundation, New Delhi and sponsored by Biodiversity International, New Delhi. Dr. BMC Reddy, National Project Coordinator of UNEP/GEF Project, Dr. Gopalji Trivedi, former Vice Chancellor, RAU, Pusa, Samastipur, Smt. Bimla Singh, Chairman, Lt. Amit Singh Memorial Foundation, New Delhi and Dr. Vishal Nath, Director, National Research Centre on Litchi, Muzaffarpur addressed the gathering of the farmers.

A total of 176 farmers registered with their entries in the mango diversity competition. Many seedling types (147) were exhibited in addition to commercial mango varieties. Twenty prizes were given to superior entries in five different groups.

## Agricultural Education Day

Agricultural Education Day was organized by NRCL for school students at St. Xavier's Senior Secondary School, Muzaffarpur on 6th September, 2013. 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 and Dr. Vinod Kumar.

## Hindi Chetna Maas

*Hindi Chetna Maas* was celebrated at NRCL from 1st to 30th September 2013 with an aim to promote use of *rajbhasha* Hindi in day to day official work. Various programmes such as essay writing in Hindi, *Srutilekhan*, translation and *Shabdakshari* were organized during the month. All the staffs participated in the programme with great enthusiasm. Prizes were distributed on the concluding day.

## Meeting of *Nagar Rajbhasha Karyanwayan Samiti*

Half yearly meeting of the *Nagar rajbhasha Karyanwayan Samiti* was organized on 19th February 2014 at NRCL in which about 45 delegates including *Rajbhasha Adhikari* and Incharges, Hindi Cell had participated. Delegates expressed their views on promoting adoption of Hindi as a national language during comprehensive discussion in the programme. Prize distribution ceremony was also done on this occasion.


**Half yearly meeting of the *Nagar Rajbhasha Karyanwayan Samiti***

## National Science Day

National Science Day was organized at the Centre on 28th February 2014. During the programmes, debate on topic "Is science a threat to humanity" and general speech on "Role of science in growth and development of the country" were organized. Twenty five staff members had actively participated in the programme. The programme was coordinated by Dr. R. K. Patel.

# Distinguished Visitors

## Visit of Shri Tariq Anwar, Minister of State for Agriculture and Food Processing Industries, Govt. of India

Shri Tariq Anwar, Minister of State for Agriculture and Food Processing Industries, Government of India, visited National Research Centre on Litchi, Muzaffarpur on 16th September, 2013. He visited the research farm, experimental fields and laboratories of the centre and interacted with the Director and scientists of the centre. After visiting the centre, Shri Anwar expressed his pleasure on centre's ongoing works. He appreciated the recent efforts of the centre being made in development of facilities for central instrumentation, pre-cooling, MAP, improved packaging and value added products.

In a formal meeting, the Dr. Vishal Nath, Director, NRCL briefed the minister and gathering about the ongoing research activities of the centre under the different theme areas viz., gemplasm management and crop improvement, crop production, crop protection and post- harvest and value addition. A short video on "post-harvest management in litchi" covering the research and recent developments at the centre was also played on the occasion.

Scientists, senior officials, progressive farmers, other stakeholders and media persons were also present on this occasion.

## Visit of Dr. N. K. Krishna Kumar, DDG (Hort.)

Dr. N. K. Krishna Kumar, the honourable DDG (Hort.), had made one day visit to NRCL on 21st September 2013. On this occasion, Dr. K.K. Kumar, former Director, NRCL was also present.

The DDG visited the Farm, Experimental Fields and Laboratories of the centre. During the formal interaction with the scientist, he had taken stock of the achievements, ongoing research and development activities at the centre. During presentation of research activities by Dr. Vishal Nath (director), the DDG critically reviewed each research project and programme of the centre and offered his comment. The mandate and objectives of the centre was also critically discussed and


**The Honourable Minister interacting with scientists and media persons**

he suggested its suitable wording and modification. During the discussion he emphasized the need for increasing production and quality of litchi through improved cultivars, water, nutrients and pest management. He emphasized small seed size characteristics for basis of selection of clones and efforts directed towards breeding such cultivars of litchi. He further said that biointensive management for fruit borers and stink bug is very much needed.

The DDG interacted with administrative, finance and technical personnel of the centre during his visit. He also inaugurated the recently constructed "Litchi Handling and Processing Workshop" of this centre. He briefed about the current prospects of litchi in India and abroad to the media persons present on this occasion.

**DDG (Hort.) interacting with the director and scientists in the nursery of NRCL**

**DDG (Hort.) interacting with the Director and scientists in the experimental farm of NRCL**


**DDG (Hort.) interacting with the director, scientists and administrative staff in a formal meeting**

Besides visits of Shri Tariq Anwar, Minister of State for Agriculture, and the visit of Dr. K.K. Krishna Kumar, DDG (Hort.), following were also among the distinguished visitors during 2013-14.

| Sl. No. | Date of visit | Name | Designation/affiliation |
|---|---|---|---|
| 1. | 19.04.2013 | Dr. S.L. Mehta | Former DDG (Edu.) & FormerVC, MPUAT |
| 2. | 24.04.2013 | Dr. S.P.Ghosh | Former DDG (Hort.) & FAO Expert |
| 3. | 25.04.2013 | Dr. G.S. Prakash | Former Head, Fruit Crops, IIHR, Bangalore |
| 4. | 25.04.2013 | Dr. D.K. Shahi | Chief Scientist & Chairman, Deptt. of Soil Science, BAU, Ranchi |
| 5. | 13.06.2013 | Shri U. Venkateswarlu | IAS, Joint Secretary, Ministry of Food Processing Industries, GOI |
| 6. | 13.06.2013 | Dr. Umesh Srivastava | Former ADG (Hort.) ICAR, KAB, New Delhi |
| 7. | 04.07.2013 | Dr. B.M.C Reddy | Former Director, CISH, Lucknow, U.P. |
| 8. | 06.07.2013 | Dr. H.P. Singh | Chairman, Confederation of Horticultural Association of India (CHAI) |
| 9. | 27.08.2013 | Ram Awadh Ram | Pr. Scientist (Hort.), CISH, Lucknow |
| 10. | 14.12.2013 | Prof. S.K. Mitra | Prof. BCKV, Mohanpur, West Bengal |
| 11. | 23.12.2013 | Dr. K.L. Chadha | Former DDG (Hort.), New Delhi |

**Shri U. Venkateswarlu, Joint Secretary, Ministry of Food Processing Industries, GOI interacting with scientists during visit of laboratories**

**Dr. K.L. Chadha, Former DDG (Hort.) interacting with scientists during visit of laboratories**

# Transfer of Technology

Dissemination of litchi technologies was done through training to farmers, delivering lectures, organizing *kisan gosthi* and interaction with farmers. The details formal training and other programmes pertaining to transfer of technology is given in tabular form as under:

| Sl. No. | Title | Venue and Date | Participating Scientist | No. of Participants / Farmers |
|---|---|---|---|---|
| 1. | Master Trainers Training Progarmme on "Good Agriculture Practices in Litchi" for SMS sponsored by NHM Govt. of Bihar (Four trainings for 2 days duration each). | NRCL, Muzaffarpur 2-9 May, 2013 | Dr. S.D. Pandey<br>Dr. Rajesh Kumar<br>Dr. S.K. Purbey<br>Dr. Amrendra Kumar<br>Dr. Vinod Kumar<br>Dr. Sanjay Kumar Singh | 194 |
| 2. | All India Litchi Show cum Kisan Gosthi | NRCL, Muzaffarpur<br>6 June, 2013 | Dr. Vishal Nath<br>Dr. S.D Pandey<br>Dr. Awtar Singh<br>Dr. Rajesh Kumar<br>Dr. S. K. Purbey<br>Dr. Amrendra Kumar<br>Dr. Vinod Kumar<br>Dr. Sanjay Kumar Singh | 230 |
| 3. | GAP in Litchi, Organized by Dayal Fertilizer Ltd. | Korlahia, Saidpur, Sitamarhi, 24 August, 2013 | Dr. S.K. Purbey | 140 |
| 4. | Training programme on Rejuvenation and canopy management in Litchi | NRCL, Muzaffarpur, 1 November, 2013 | Dr. S. K. Purbey | 26 |
| 5. | *Krishi avam Udyan Pradarshani* organized by RAU on the occasion of its Foundation Day and Silver Jubilee | TCA, Dholi, 3 December, 2013 | Dr. Vinod Kumar | 120 |
| 6. | *Kisan Mela*, organized by Directorate of Seed, Mau, U.P. | Mau, U.P., 14 February 2014 | Dr. S. K. Purbey<br>Dr. Kuldeep Srivastava | 90 |
| 7. | *Kisan Mela* organized by BAU, Sabaur Bhagalpur | Sabour, 15-17 February, 2014 | Dr. S. K. Purbey | 200 |
| 8. | Growers Scientist interface and Animal health Camp, Katihar, Bihar | Katihar, 24 February, 2014 | Dr. S. K. Purbey | 450 |
| 9. | *Kisan Mela* , Katihar, organized by NIFTEM, Haryana | Katihar, 3 March, 2014 | Dr. S. K. Purbey | 120 |
| 10. | *Litchi Udhyamita Vikas Hetu* "Post harvest handling and value addition in litchi" | NRCL, Muzaffarpur, 3 and 5th May, 2013 | Dr. S. K. Purbey | 25 |

| | | | | |
|---|---|---|---|---|
| 11. | *Vaigyanik Krishak Warta sah Pashu Swasthya Shivir* at Katihar jointly organized by ICAR-RCER, Patna and NRCL | Katihar, 24-25 December 2013 | Dr. Rajesh Kumar | 150 |
| 12. | Good Agricultural Practices in Fruit Production | Betia, West Champaran, 01-02 March 2014 | Dr. Rajesh Kumar | 225 |
| 13. | Good Agricultural Practices in Fruit Production | Motihari, East Champaran, 3-4 March, 2014 | Dr. Rajesh Kumar | 150 |
| 14. | Horticulture show at RAU, Pusa, Samastipur | RAU, Pusa, 8 March, 2014 | Dr. R.K. Patel<br>Dr. Kuldeep Srivastava | |
| 15. | Mango diversity fair at Pusa Site, Samastipur under UNEP-GEF Project | Pusa, 4 July, 2013 | Dr. Sanjay Kumar Singh | |
| 16. | "Good Agricultural Practices' (GAPs) for mango diversity, livelihood and ecosystem services" under UNEP-GEF project | Pusa, 23 March, 2014 | Dr. Amrendra Kumar, Dr. Sanjay Kumar Singh Shri Narayan Lal | |

## Lectures delivered as resource person/ participation in programmes outside organization in individual capacity

### Dr. S.D. Pandey

1. Organized and participated in farmers training programme at Sonvasa on 10th June, 2013.
2. Organized an interaction meeting on GAP with Programme Co-ordinator of KVK. RAU and delivered a lecture on Good Agricultural Practices in Litchi.
3. Acted as resource person on farmers training programme on Good Management Practices in Litchi on 17th October 2013 at Bhubneswar, Odisha.
4. Organized a farmers training programme at Ramcola, Kushinagar on 25th October 2013 and delivered lecture on good agriculture practices and practical methodology of gooti preparation.
5. Organized a farmers training programme at Ramcola, Kushinagar on 9th February 2014.
6. Acted as resource person in farmers' training programme on "Good Management Practices in Litchi" on 18.12 .2013 at Pipra Kothi (Motihari), and delivered a lecture on High Density Planting.
7. Organized farmers' interaction cum training programme at Katermala (Vaishali) and Bakhari (Muzaffarpur).

### Dr. Rajesh Kumar

1. Coordinated and imparted training as nodal scientist and expert for "Rejuvenation of old senile fruit orchards" at all the commissionery of Bihar state in the series organized on dates and venue as: 16.08.2013 at Patna (Danapur), 19.08.2013 at Magadh (Gaya), 20.08.2013 at Saran (Chhapra), 21.08.2013 at Tirhut (Muzaffarpur), 22.08.2013 at Darbhanga, 24.08.2013 at Koshi (Saharsha), 26.08.2013 at Purnea, 27.08.2013 at Bhagalpur. All these training included the theory and practical session (on-site demonstration) organized by Bihar Agricultural Management Education and Training Institute (BAMETI), Patna Bihar and the Directorate of Horticulture, Ministry of Agriculture, Government of Bihar, Patna.
2. Delivered one talk on "Rejuvenation and Canopy Management in Litchi" at College of Agriculture, Agartalla, Tripura on 27.09.2013. A total of 65 students and 07 faculty members participated.
3. Participated in Interactive Meeting organized for discussion and making frame work for forthcoming Group workers meeting of All India

Coordinated Research Projects (Fruits)" organized at IIHR, Hesargatta, Bangalore, Karnataka from 28-29 October, 2013.

4. Imparted one day on-site training to District Horticulture Officers and Project Directors, ATMA of all district of Bihar on 01.11.2013 in the conference hall of NRC on Litchi, Muzaffarpur and organized by Directorate of Horticulture, Govt. of Bihar, Patna.

5. Participated as Chief Guest and delivered an invited talk on the topic in one day seminar on "Badalte Mausam Mein Krishi Aur Bagwani" on 23.12.2013 at Jubba Sahni Park, Mithanpura, Muzaffarpur organized by Muzaffarpur Development Agency, J.P. Path, RK Ashram, Muzaffarpur, Bihar.

6. Imparted one-day onsite training (theory and practical) on Rejuvenation and canopy management of fruit trees (litchi and mango). It was also highlighted the importance of aftercare at DHO office, Purnea on 12.12.2013 organized by DHO, Purnea.

7. Participated and imparted training (theory and practical) on "Rejuvenation and canopy management in litchi" at Horticulture Department Nursery Premises at Piprakothi, East Champaran on 18.12.2013 organized by DHO, East Champaran (Motihari).

8. Imparted on-site training (theory and practical) on Rejuvenation of fruit trees and importance of aftercare at Horticulture Nursery, DHO office, Madhubani on 22.12.2013 organized by DHO, Madhubani.

9. Visited Babhangaon village of Lakhisarai area on 30.12.2013 and interacted with honeybee keepers and also did the foraging study with the surrounding crops of nearby area and visiting frequency of our Honeybee unit kept over there.

10. Participated in *Krishak Vaigyanik Wartalap* organized by ATMA, Gopalganj and also imparted training in Field Demonstration Programme on "Rejuvenation of Fruit Trees" on 16.01.2014 at Hort. Nursery organized by DHO, Gopalganj.

11. Imparted one-day training to the 50 numbers of farmers/fruit growers under Exposure visit from Gopalganj, visiting National Research Centre on Litchi, Muzaffarpur. The team of farmers arranged and sent by Project Director, ATMA, Gopalganj on 6 February, 2014.

12. Participated in the *Kisan Mela-2014* of Rajendra Agricultural University, Pusa, Samastipur on 8 March, 2014.

### Dr. S. K. Purbey

1. Delivered a lecture on "Prospects of litchi based processing units in Bihar" in the conference on "Opportunities for Food processing industries in Bihar" organized by ASSOCHAM and MOFPI, Govt. of India, New Delhi on 25 February, 2014.

### Dr. Amrendra Kumar

1. 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 01.03.2014 at Samastipur.

2. Acted as resource person on farmers training programme on Good Management Practices in Mango under Biodiversity International on 23.03.2014 at Mahamada and Bathua village of Samastipur district.

### Dr. Vinod Kumar

1. Delivered lecture on "*Litchi Mein Akikrit Keet Avam Vyadhi Prabandhan*" and provided *hands on training* to participants on "Practical: Methods of preparation of spray solution of fungicide/ insecticides and its spraying" in the Master trainer's programme of SMS on Good Agriculture Practices in Litchi of 6 districts from 2-9 May, 2013.

2. Acted as resource person and delivered lecture on 'Pest and disease management in litchi' in the training programme held at NRCL, Muzaffarpur on 1st September 2013 on "Rejuvenation and Canopy management in litchi" for trainees from State Agril. Dept., Govt. of Bihar.

### Dr. Sanjay Kumar Singh

1. Delivered a lecture on '*Orchard establishment, monthly calendar operation in mango orchard for mango diversity, livelihood and ecosystem services'* at Dhobgama (9.30-10.30 AM) and Jagadishpur (12.30-2.30 PM) on 21.12.2013 under UNEP-GEF Project.

### Dr. R.K. Patel

1. Delivered lecture during trainers training on "Nursery management & quality planting material production of important fruit crops (citrus, passion fruits & litchi)" organized by CIH, Medziphema, Nagaland during 29-30 January, 2014.

## Radio and T.V. Talks

### Rajesh Kumar

- Phone-in-Live Programme - Doordarshan (Patna): Date of Broadcasting 22.07.2013 (Time 06.00 PM to 06.30 PM). Topic.: *Jalwayu pariwartan ka bagwani phasalon par prabhav.*
- Programme- Doordarshan (Muzaffarpur): Date of Broadcasting - 05 .03.2014 (Time 06.00-06.30 PM). Topic: *Litchi mein samsamayik krishi kriyanyen, Litchi mein poshan and sinchai prabandhan, Litchi ki phasal suraksha.*
- Phone-in-Live Programme - Doordarshan (Patna): Date of Broadcasting – 10.03.2014 (Time 05.30-06.00 PM). Topic: *Aam Avam litchi ke pereon ki dekhbhal.*

# Outreach Programmes by NRCL

## Exploring the potential areas for off-season litchi production

Traditionally, litchi is being cultivated in the northern plains of the country starting from Tripura to Jammu & Kashmir. Litchi matures from 3rd week of April to 1st week of July in these states. An analysis of climatic and edaphic features in these regions was made at NRCL revealed that some of the places in southern India having elevation 900-1000 m asl and modest climate resembled with the countries located in southern hemisphere such as South Africa, Madagascar and Australia that could produce good quality litchi during December-January. Potential off-season litchi production identified were Madkeri area of Kodagu district in Karnataka, Ambalavayal, Meppadi, Kalpetta and Vythiri areas of Wayanad in Kerala, Ootakmand area of Ooty in Tamil Nadu. Visits of a team of scientists in these areas consecutively during 2012-2013 revealed that the yield potential of a tree was more than 200 kg. The colour development and pulp quality were at par with main season crop with added advantage of low temperature ($32 \pm 2^0$C) and high relative humidity (70-80%).

The major research backup and dissemination of information to growers was being provided by Central Horticultural Experiment Station (CHES), Chettalli (IIHR) and Regional Research Station, Ambalavayal (KAU). The NRCL in collaboration with IIHR and KAU developed a programme to support the growers with respect to suitable varieties, sustainable production techniques and post-harvest handling of litchi fruits. Some of the farmers who were growing litchi as hobby were interacted during the visit and one of the farmer, Mr. Joseph Kurbila of Meppadi, who had good number of bearing trees of litchi since last 25 years, told that he was spreading litchi in that area by propagating from his mother trees. He had been a source of inspiration and pioneer in this regard. During the interaction with the scientists at Chettalli and Ambalavayal it was found that due to luxuriant vegetative growth in the area birds and bats were major problem for which netting of whole tree was being practiced. Due to vigourous growth of tree and unmanaged canopy this operation was also very labour and cost intensive. One of the farmer at Medkari was suggested by the NRCL scientist to do bagging of litchi bunches with locally available material preferably butter paper bag which had been found promising in protecting fruits and improving quality.

After overall analysis of the situation and current scale of planting, it was concluded that the region had immense potential of growing litchi with very good quality and market price (Rs. 350 per kg) but systematic orcharding by adopting an appropriate variety and canopy management practices coupled with nutrition and water management was required. In this context, Mr. Ahemad Kutty, a progressive farmer in Meppadi could be a role model who had taken 5000 plants from NRCL and planted in 5 acre area. He also received training on crop management practices at NRCL. For further strengthening of research, inclusion of CHES, Chettalli and RRS, Ambalavayal as one of the voluntary Centre was proposed in the AICRP on fruits.

**A tree at Chettalli laden with good quality fruits (Left) and fruits in close-up view (Right)**

# Research Programmes and Projects

## A. Institutional Projects

| Programmes and Projects | Title | Principal Investigators (PI) | Associates (Co-PI) |
|---|---|---|---|
| **Programme 1. Plant genetic resources management and crop improvement in litchi** | | | |
| Project 1.1. | Collection of indigenous and exotic germplasm, their characterization, evaluation, documentation and utilization | Dr. Awtar Singh | Dr. Rajesh Kumar<br>Dr. Amrendra Kumar<br>Shri. Narayan Lal |
| Project 1.2 | Evolving improved cultivars in litchi | Dr. Awtar Singh | Dr. Rajesh Kumar<br>Shri. Narayan Lal |
| **Programme 2. Development of sustainable production technology in litchi** | | | |
| Project 2.1 | Plant propagation and growth physiology of vegetatively propagated plants in litchi. | Dr. Rajesh Kumar | Dr. Amrendra Kumar<br>Dr. S.D. Pandey<br>Dr. Vinod Kumar |
| Project 2.2 | Development of sustainable production techniques in litchi | Dr. S. D. Pandey | Dr. Amrendra Kumar<br>Dr. R. K. Patel<br>Dr. Kuldeep Srivastava |
| Project 2.3 | Investigation and establishing the physiological and biochemical relations for improved litchi production | Dr. Amrendra Kumar | Dr. S.D. Pandey<br>Dr. Rajesh Kumar<br>Dr. Sushil Kumar Purbey<br>Dr. Sanjay Kumar Singh |
| Project 2.4 | Studies on mycorrhizal association and role of biofertilizers for improved litchi production | Dr. Vinod Kumar | - |
| **Programme 3. Standardization of plant protection technology for litchi** | | | |
| Project 3.1 | Investigation and management of pre-harvest diseases of litchi | Dr. Vinod Kumar | - |
| Project 3.2 | Investigation and management of insect-pests complex in litchi | Dr. Kuldeep Srivastava | Dr. R. K. Patel |
| **Programme 4. Post-harvest management and value addition** | | | |
| Project 4.1 | Standardization of maturity standards, harvesting and post harvest handling techniques for litchi fruits | Dr. Sanjay Kumar Singh | Dr. Sushil Kumar Purbey<br>Dr. Vinod Kumar<br>Dr. Alemwati Pongener |
| Project 4.2 | Investigation and management of Post-harvest losses in litchi | Dr. Sushil Kumar Purbey | Dr. Vinod Kumar |
| Project 4.3 | Standardization of processing and value addition techniques in litchi | Dr. Sushil Kumar Purbey | Dr. Vinod Kumar |

## B. Externally Funded Projects

| Sl.No. | Funding Agency | Title of the Project | PI and Co-PI |
|---|---|---|---|
| 1. | ICAR | Network project on "Application of Microorganisms in Agriculture and Allied Sectors (AMAAS), Subproject "Harnessing Arbuscular Mycorrhizae for Biofertilization in Horticultural Crops" | Dr. Vishal Nath<br>Dr. Vinod Kumar<br>Dr. Rajesh Kumar |
| 2. | UNEP/GEF, Biodiversity International, New Delhi | "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services" | Dr. Vishal Nath,<br>Dr. Awtar Singh, Site Coordinator*<br>Dr. Sanjay Kumar Singh, Site Coordinator<br>Shri Narayan Lal |
| 3. | Department of Biotechnology, Govt. of India | "Development of National Database on Mango" | Dr. Vishal Nath<br>Dr. Sanjay Kumar Singh<br>Dr. Kuldeep Srivastava<br>Shri Alemwati Pongener |
| 4. | NAIP | e-GRANTH Project: Strengthening of Digital Library and Information Management under NARS | Dr. Sanjay Kumar Singh |
| 5. | ICAR. XI Plan Scheme on Management and Information Services | "Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology scheme" | Dr. Vishal Nath<br>Dr. Sushil Kumar Purbey (Nodal Officer) |

**Dr Awtar Singh was site coordinator up to 3 December, 2013 and thereafter Dr. Sanjay Kumar Singh became site coordinator of the project*

# List of Publications

## Research Article


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Kumar, V., Reddy, P.V.R. and Anal, A.K.D. (2013). Report on the occurrence and biology of *Thalassodes pilaria* Guenée (Lepidoptera: Geometridae) on litchi (*Litchi chinensis* Sonn.) in Bihar, India. *Pest Management in Horticultural Ecosystems* **19** (2): 245-247.

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Kumar, A., Srivastava, K. Kumar, K.K. and Nath, V. (2014). Validation of IPM modules against insect pests of litchi. *Journal of Environmental Biology.*

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## Books

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Singh, G., Nath, V. and Pandey, S.D. (2013). Litchi (in Hindi). FAO, New Delhi, p.116.

## Book Chapters

Deshmukh, N.A., Patel, R.K., Verma, V.K., Firke, D.M. and Jha, A.K. (2013). Potential fruits and plantation crops of Meghalaya. Horticulture for Economic prosperity and Nutritional security in 21st Century (Hazarika and Nautiyal, eds.), Westville Publishing House, New Delhi (ISBN 978-81-85873-97-8), pp. 225-242.

Kumar, R. (2013). Rejuvenating old senile litchi trees-A remunerative venture (Success Story). *In*: *Canopy Management and High Density Planting in Subtropical Fruit Crops*, pp. 264-269.

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Kumar, V. (2014). Diagnosis and management of pests and diseases of litchi in India. *In:* "Realistic approaches in fruit pest management" (Pandey A., ed.) (*In press*).

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# Peer Recognition

## Dr. Vishal Nath

- Nominated as member of the Core Group for Jharkhand Agriculture Vision.
- Received appreciation letter from Principal Secretary (Agriculture), Govt. of Bihar, for production of Quality Planting Material in Litchi.
- Nominated as Subject Matter Experts, ARS-discipline of Horticulture, ICAR-RECER, Patna, dated 26.11.2013 by ASRB, New Delhi for DPC of Scientist.
- Participated in 72nd Research Council Meeting (*Kharif*)-2013 of RAU, Pusa, during 14-15th June, 2013.
- Participated in 73rd Research Council Meeting (*Rabi*)-2013 of RAU, Pusa, during 22-23rd November, 2013.
- Delivered key note address in National Seminar on "Protected Cultivation of Horticulture Crops and Value Addition" 29 -30 November, 2013.
- Guest of Honour in Farm Innovators Day at ICAR-RECER, Patna on 5th October, 2013.
- Invited for the meeting on Indian Horticulture: Imperatives to Enhance Trade on 30 October, 2013 at Hotel Le Meridien, New Delhi.
- Participated 59th Extension Education Council Meeting of RAU, Pusa, Samastipur on 25th November, 2013.
- Invited for World Piece Prayer & Kishan Sangosthi-2013 at Delhi.
- Co-chaired the session on "Nutrition" during GWM on AICRP on Fruits held at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli during 22nd to 25th January, 2014.
- Invited as an expert by BAU, Sabour for input on the subject "*Mausam Pariwartan Ke Paripekshya Mein Rajya Ke Krishi Vikash Ki Chunautiyan Avam Upaay*".
- Conducted Viva-voce exam of two M.Sc. (Ag) students.
- Conducted Viva-voce exam of one M.Sc. (Hort.) student of BAU, Ranchi on 1st February, 2014 at Ranchi.

## Dr. S.D. Pandey

- Reviewer of the paper for the journal "The Journal of Horticulture".

## Dr. Rajesh Kumar

- Member of the Editorial Board of "*Current Horticulture*", a research journal published under the aegis of Society for Horticultural Research and Development, Botany Department, MM (PG) College, Modinagar, Ghaziabad, U.P.
- Participated in Agricultural Technology Management Agency (ATMA) Administrative Council Meeting as Member- Governing Body on 07.05.2013 and suggested some of the recently developed technology implementation and adoption strategies as expert scientist.
- Attended a meeting called by the Agriculture Production Commissioner, Government of Bihar, Patna for implementation of programme on "Rejuvenation of old senile orchards in Bihar" on 10.07.2013, where proper and required input has been provided in this regard.
- Attended the Administrative Council Meeting as Member, Governing Body of Agricultural Technology Management Agency (ATMA) on 04.01.2014 and suggested about the need based technology implementation and adoption strategies as expert scientist.

- Participated and presented an invited paper on the topic "Resilient horticulture in changing seasonality scenario" in a one day State Level Workshop on Changing Seasonality in Bihar and Role of Disaster Risk Management on 31.01.2014 at Hotel Patliputra Ashoka, Patna as jointly organized by Disaster Management Department, Govt. of Bihar and Bihar Inter Agency Group, Patna with other Co-organizers.
- Participated and presented the work progress report as lead presenter for "Substrate dynamics under IPNM in litchi (*Litchi chinensis* Sonn.) in session III A (Nutrition) in Group workers meeting of "All India Coordinated Research Projects (Fruits)" organized at Dapoli, Maharashtra from 22-25 January, 2014.
- Participated and delivered an invited talk on the topic "Rejuvenating old senile litchi orchards for enhanced quantum of quality production" in one-day "Seminar on Environment and Horticulture" on 09.03.2014 at Jiattpur Campus, Maripur, Muzaffarpur organized by Tirhut Udyan Vikas Samiti, Muzaffarpur, Bihar.
- Participated and presented an invited paper on the topic "Strategies for developing abiotic tolerance/ resistance in litchi (*Litchi chinensis* Sonn.) in two days National Symposium on Genetic Improvement in Horticultural Crops held on 11-12 March 2014 at B.R.A. Bihar University, Muzaffarpur, Bihar.
- Attended the Assessment Committee Meeting of Functional Group of Horticulture at Central Research Institute of Jute and Allied Fibres at Barrakpore, Kolkata on 22.03.2014.
- Acted as Convener in session III A (Nutrition) and also acted as Rapporteur in the session for Finalization of proceedings (Technical Programme) in "All India Coordinated Research Projects (Fruits)" organized at BSKKV, Dapoli, Maharashtra from 22-25 January, 2014
- Invited as Chief Guest to inaugurate the Muzaffarpur Centre of GRAS Education and Training Services Pvt. Ltd., assisted by National Skill Development Corporation (NSDC), Ministry of Finance, Govt. of India at Mohammadpur, Muzaffarpur, Bihar on 20.07.2014.
- Acted as Co-Chairman in the technical session in IV" in National Seminar on "Climate Resilient Horticulture: Adaptation and Mitigation Strategies at Bihar Agricultural University, Sabour, Bhagalpur, Bihar held during February 15-17, 2014.
- Acted as Rapporteur in Technical Session – III of National Seminar cum Workshop on Canopy Management and High Density Planting in Subtropical Fruit Crops from October 22-24, 2013 at CISH, Lucknow.
- 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.
- Acted as Judge, for evaluation of exhibits in Horticulture Show-2014 during Kisan Mela of RAU, Pusa, Samastipur on 8 March 2014.
- Presented an invited paper on "Reiterative Pruning and Canopy Re-building of Old Senile Litchi Trees for Rejuvenation and Enhanced Quality Fruit Production. *In*: National Seminar cum Workshop on Canopy Management and High Density Planting in Subtropical Fruit Crops. October 22-24, 2013, organized by PFDC and CISH, Lucknow.
- Participated and presented lead paper in two days National Seminar on "Strategies for developing abiotic tolerance/resistance in litchi (*Litchi chinensis* Sonn.) in two days National Seminar on Breeding for Abiotic Stresses: Problems and Prospects. 23-24 February, 2014 at Birsa Agricultural University, Kanke, Ranchi, Jharkhand.

- Presented an invited paper on "Rejuvenating old senile litchi trees for enhanced quantum of quality production. *In*: Seminar on Environment and Horticulture. Organized by Tirhut Udyan Bikas Samiti, Muzaffarpur on 09.03.2014 at Maripur, Jaitpur campus, Muzaffarpur.

## Dr. S. K. Purbey

- Reviewer of paper for the journal "Indiam Journal of Horticulture" and "Horticulture Science"
- Attended the meeting called by APC, Govt. of Bihar on 19.07.2013 regarding preparation of roadmap for 'Skill development Training programme' under which about 20 million youth to be skilled in different sector and presented the training model in litchi on 26 August 2013.
- Delivered an invited lecture on "Pre- and Post-harvest technologies in Litchi" in the training programme on "Outreach programme in food processing for farmers and entrepreneurs" at Fatuha, Patna organized by IED, Bihar and NIFTEM, Kundli, Sonepat, Haryana on 10 August 2013.
- Delivered an invited lecture on " Post-harvest management and value addition in litchi" in two day training programmes on "Agriculture marketing" organized by BAU, Sabour, Bhagalpur and NIAM, Jaipur during 28-30 January, 2014 at Veterinary College Patna.

## Dr. Amrendra Kumar

- Reviewer of paper for the journal "Indian Journal of Horticulture".
- Elected as Zonal Councilor (East zone) AAPMHE by General Body of AAPMHE (Association for Advancement of Pest Management in Horticultural Ecosystem, IIHR, Bangalore) w.e.f. 26th April 2013 for a period of two years.
- Received letter of Appreciation from Secretary, Department of Agriculture, Govt. of Bihar for delivering lectures on Seed/ sapling production in Litchi during Seminar on "Seed/sapling production, seed processing, storage and marketing-challenges and opportunities" held on 23-24th August, 2013 at Patna, Bihar.
- Received letter of appreciation from NIFTEM for guiding the students in VAP during 2013.

## Dr. Vinod Kumar

- Delivered a guest lecture on the topic **"**Identification of major pests of litchi and their management" in a training programme of organized agricultural officers training programme under NHM at TCA, Dholi.
- Appointed as External Examiner for evaluation of M.Sc. (Ag.) thesis entitled "*Fungal flora in soils of some Krishi Vigyan Kendras of zone-1 of Bihar with special reference to population of Trichoderma species*" submitted to the Department of Plant Pathology, RAU, Pusa, Samstipur, Bihar.
- Reviewer for the three international journal *viz*., 1. "*Crop Protection*" (Manuscript no. CROPRO-D-13-00820), 2. "*International Journal of Applied Microbiology and Biotechnology Research*" (Manuscript No. IJAMBR-13-009), and 3. *African Journal of Microbiology Research* (Manuscript no. AJMR-10-155) and one national journal viz. "*Indian Phytopathology* (Manuscript no. 13929-29834-1-RV and 37474-86259-1-RV)

# Awards and Honours

- Dr. Vishal Nath, Director, NRCL received 'Rajendra Prasad Paroda Award' for outstanding contribution in field of Horticulture.
- Dr. Rajesh Kumar, Principal Scientist, received the Best paper presentation award in National Seminar cum Workshop on Canopy Management and High Density Planting in Subtropical Fruit Crops, 22-24 October, 2013 organized by PFDC and CISH, Lucknow at Central Institute of Subtropical Horticulture, Lucknow.
- Dr. Amrendra Kumar, Sr. Scientist was awarded Fellow of the Confederation of Horticultural Association of India (CHAI) in 2013.
- Dr. Kuldeep Srivastava, Sr. Scientist received best poster award at national symposium entitled "Recent Advances in Beneficial Insects" held at Ranchi during 27-29 November, 2013.
- Dr. R. K. Patel, Sr. Scientist received best poster presentation award as co-author in research paper entitled "Technology for doubling the production of grafted & budded plants of Khasi mandarin: a profitable option for nurseryman" authored by Deshmukh, N.A., Deka, B.C., Patel, R.K, Rymbai, H., Jha, A.K. and Kumar, A. *In*: National Seminar on Emerging Challenges and Prospective Strategies for Hill Agriculture in 2050, 23-25 January 2014, held at ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland, India.
- Dr. Sanjay Kumar Singh, Scientist SS, received CHAI Fellowship from Confederation of Horticultural Association of India (CHAI) on 29 May, 2013.
- NRCL Stall received Best Exhibit Award (3rd position) at Kisan Mela organized by BAU, Sabaur, 15-17 February, 2014.

# Compilation, Editing and Documentation

| Sl. No. | Title | No. of pages | Year of publication | Scientists involved |
|---|---|---|---|---|
| 1. | NRCL Annual Report, 2012-13 (English) | 58 | 2013 | Dr. Sanjay Kumar Singh<br>Dr. S.D. Pandey |
| 2. | NRCL Annual Report, 2012-13 (Hindi) | 70 | 2013 | Dr. Sanjay Kumar Singh<br>Dr. S.D. Pandey<br>Dr. S.K. Purbey |
| 3. | Mid-term Reports and Annual Progress Reports 2013-14 of AICRP (Fruits) , NRCL | - | 2013 | Dr. Rajesh Kumar |
| 4. | NRCL Technologies for business ventures in litchi and allied sector | 21 | 2013 | Dr. S.K. Purbey<br>Dr. Vishal Nath |
| 5. | 12th Plan EFC | 30 | 2013 | Dr. Vishal Nath<br>Dr. Sanjay Kumar Singh<br>Dr. S.D. Pandey |
| 6. | Vision 2050 | 36 | 2013 | Dr. Vishal Nath<br>Dr. Sanjay Kumar Singh<br>Dr. S.D. Pandey |
| 7. | HYPM, Quarterly Report, Monthly Cabinet Report | - | 2013-2014 | Dr. Sanjay Kumar Singh |
| 8. | RFD: Annual Draft, Monthly Report, Midterm Achievements, Annual Performance Evaluation; Citizen/Client Charter; Performance indicator | - | 2013-2014 | Dr. Vinod Kumar |
| 9. | News and uploads for NRCL Website and ICAR News | - | 2013-2014 | Dr. Vinod Kumar |

# Personnel

## A. Scientific (As on 31.3.2014)

| Name and Email | Designation | Area of Interest |
|---|---|---|
| Prof. (Dr.) Vishal Nath<br>nrclitchi@yahoo.co.in<br>director@nrclitchi.org | Director | Plant genetic resource management; Cabnopy archuitecture management; Disssemination of technology |
| Dr. S. D. Pandey<br>pandeynrcb@yahoo.com<br>sdpandey@nrclitchi.org | Pr. Scientist (Hort.) | High density planting; Canopy management; Nutrient management; Fertigation, Organic litchi production. |
| Dr. Rajesh Kumar<br>rajeshkr_5@yahoo.com<br>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<br>skpurbey_nrcl@yahoo.com<br>purbey@nrclitchi.org | Sr. Scientist (Hort.) | Post-harvest handling and packaging; Enhancement of shelf life of litchi; Value addition and processing; Utilization of litchi fruit waste through bio-processing. |
| Dr. Amrendra Kumar<br>amrendra_nrcl@yahoo.com<br>amrendra@nrclitchi.org | Sr. Scientist (Hort.) | Nursery management; Plant propagation and growth physiology of vegetatively propagated plants; Collection and characterization of rambutan germplasm. |
| Dr. R.K.Patel<br>rkpatelicar@gmail.com<br>rkpatel@nrclitchi.org | Sr. Scientist (Hort.) | Development of organic package of practices for litchi; Water management; Litchi based farming system. |
| Dr. Kuldeep Srivastava<br>Kuldeep.ipm@gmail.com<br>kuldeep@nrclitchi.org | Sr. Scientist (Ento.) | Management of insect pests of litchi; Insect pollinators of litchi. |
| Dr. Vinod Kumar<br>vinod3kiari@yahoo.co.in<br>vinod@nrclitchi.org | Sr. Scientist (Plant Path.) | Management of pre- and post-harvest diseases of litchi; Mycorrhizal association; Biocontrol and biofertilizers for sustainable production of litchi. |
| Dr. Sanjay Kumar Singh<br>sanjayhor@rediffmail.com<br>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 pumello. |
| Shri Narayan Lal<br>narayanlal.lal7@gmail.com<br>narayan@nrclitchi.org | Scientist (Hort.) | Collection and evaluation of litchi germplasm; Clonal selection; Development of hybrids; Molecular characterization of germplasm and cultivars. |
| Dr. Alemwati Pongener<br>alemwati@gmail.com<br>alemwati@nrclitchi.org | Scientist (Hort.) | Post-harvest handling techniques for litchi fruits; Management of post-harvest losses;<br>Processing and value addition; Pericarp browning. |

## B. Technical

| | | |
|---|---|---|
| Shri Rajiv Ranjan Rai<br>T7/T8 (Farm Incharge)<br>rrrainrcl@gmail.com<br>farmic@nrclitchi.org | Shri Shayamji Mishra<br>T3 (Farm)<br>shyam_lko_2004@yahoo.com | Ms. Pallavi<br>T3 (Lab Tech.)<br>library@nrclitchi.org |

## C. Administrative

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

# Recruitment, Promotion and Transfer

## Recruitments

- Shri Naryan Lal joined as Scientist, Horticulture (Fruit Science) on 11 April, 2013.
- Dr. Kuldeep Srivastava joined as Senior Scientist (Entomology) on 10 July, 2013.
- Dr. R. K. Patel joined as Senior Scientist (Horticulture) on15 July, 2013.
- Dr. Alemwati Pongener joined as Scientist (Horticulture) on 14 October, 2013.
- Dr. Sushil Kumar Purbey, Senior Scientist, Horticulture (Fruit Science) joined as Principal Scientist (Horticulture) on 27 January, 2014.

## Promotions

- Shri Rajiv Ranjan Rai, T-6 promoted to T-7/8 (Assistant Chief Technical Officer) with effect from 20 February, 2013.
- Shri Akshay Kumar Yadav, who had joined this centre on deputation, was regularized to the post of Assistant with effect from 26 August, 2013.

## Transfer

- Dr. Awtar Singh, Principal Scientist (Plant Breeding) was transferred to IARI, New Delhi. He was relieved on 3 December, 2013.


**NRCL family bidding farewell to Dr. Awtar Singh**

# Important Committees

## Research Advisory Committee

During 2013-14, 7th Research Advisory Committee (RAC) meeting was held on 24th April 2013. Constitution of the committee was as under:

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


**A glimpse of the 7th RAC meeting in progress**

## Institute Research Committee

The 9th Institute Research Committee (IRC) meeting was held on 6-7 September, 2013 under the chairmanship of Director, NRCL. During the meeting progress report of research projects along with technical programmes were discussed at length. The new research projects were also discussed and finalized. The following members attended the meeting:

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

## Institute Management Committee

The 8th Institute Management Committee (IMC) meeting was held on 12 November, 2013 at 11:00 AM in the Conference Hall of NRCL, Muzaffarpur. The following members attended the meeting and discussed the agenda items relevant to IMC of the Centre:

| | | |
|---|---|---|
| 1. | Dr. Vishal Nath,<br>Director, NRCL, Muzaffarpur | Chairman |
| 2. | Dr. I. P. Singh,<br>Pr. Scientist, National Research Centre on Citrus, Nagpur | Member |
| 3. | Director, Horticulture,<br>Directorate of Horticulture, Pant Bhawan, Patna | Member |
| 4. | Joint Director, Horticulture,<br>Government of Uttar Pradesh | Member |
| 5. | Shri Sudhir Kumar Pandey,<br>Village- Bhakari, P.O.- Bakhari, Muzaffarpur | Member |
| 6. | Sr. Finance & Accounts Officer,<br>Central Inland Fisheries Research Institute, Barrackpore, Kolkata | Member |
| 7. | Sh. Ramji Giri,<br>AAO, NRCL, Muzaffarpur | Member-Secretary |
| 8. | Chairman PME, NRCL, Muzaffarpur | Special Invitee |
| 9. | Chairman FMC, NRCL, Muzaffarpur | Special Invitee |

## Quinquennial Review Team

The Quinquennial Review Team (QRT) had meetings during 2013 to review the work done by NRCL during 1st April, 2007 to 31st March, 2012. Constitution of the team was as under:

| S.No. | Name and address | Designation |
|---|---|---|
| 1 | Dr. R. K. Pathak,<br>Former Director, CISH, Lucknow | Chairman |
| 2 | Dr. S. N. Pandey,<br>Former ADG (Hort.), Block I, Sector 41,Noida, Delhi | Member |
| 3 | Shri S. S. Mehta,<br>256, Advaitha Ashamam Road, Fair Lands, Salem | Member |
| 4 | Dr. R.D. Rawal,<br>Former Head, Plant Pathology, IIHR, Bangalore | Member |
| 5 | Dr. Prem Mathur,<br>South Asia Coordinator, Biodiversity International, Sector-7 Dwarka, New Delhi | Member |
| 6 | Dr. Babita Singh,<br>Professor of Horticulture, Institute of Horticulture,<br>Amity University, Noida | Member |
| 7 | Dr. S.D. Pandey,<br>Principal Scientist, (Hort.) NRCL, Muzaffarpur | Member Secretary |

Four meetings of the Quinquennial Review Team (QRT) were held during 2013 to review the work done by NRCL and to finalize the recommendations. Details about the meeting held during 2013 are as under:

| Meetings | Date | Visit and Reviews |
|---|---|---|
| Third | 14-16 May, 2013 | Murshidabad and Farakka Areas, BCKV; Research Farm and Instructional Farm at Mohanpur; Meeting with scientists, professors and the Vice Chancellor. |
| Fourth | 17-19 May, 2013 | NRCL, Mushahari, Muzaffarpur; I.G. International Agency, Patna; Progressive Farmers' village at Jhaphan; Kedia Processing Industries, Patahi, Mahamadpur Kothi and Progressive farmer Dr. G. Trivedi, village - Mutlupur, (Samastipur) |
| Fifth | 9-11 June, 2013 | G.B. Pant University, Pantnagar, Nainital and Ram Nagar; Kashipur areas of Uttarakhand |
| Sixth | 9-11 July, 2013 | Report writing in the office of Biodiversity International Office Block, NASC Complex, Pusa, New Delhi |

The report was finalized on 29th July 2013.

## Institute RFD Committee and RFD Cell

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

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

## Other Institutional Committees

The composition of other important institutional committee during 2013-14 was as under:

| SI. No. | Name of the Committee | Members of the Committee | |
|---|---|---|---|
| 1. | Priority setting Monitoring and Evaluation Committee (PME) | Dr. S.D. Pandey, Pr. Scientist | Chairman |
| | | Dr. Awatar Singh, Pr. Scientist (Publication*) | Co- Chairman |
| | | Dr. S.K Purbey, Sr. Scientist (Exhibition & Training-ITMU-IPR) | Member |
| | | Dr. Vinod Kumar, Sr. Scientist (RFD-AKMU, Publication) | Member |
| | | Dr. Sanjay Kumar Singh, Scientist SS (RPF-IRC,HYPM, PERMISNet) | Member-Secretary |
| 2. | Store & Purchase Advisory Committee (SPAC) | Dr. Rajesh Kumar, Pr. Scientist | Chairman |
| | | Dr. Kuldeep Srivastava, Sr. Scientist | Co- Chairman |
| | | Dr. Sanjay Kumar Singh, Scientist | Member |
| | | Assistant Finance &Account Officer | Member |
| | | Admn. Officer/Asstt. Admn. Officer | Member-Secretary |
| 3. | Works & Estate Committee | Dr. Amrendra Kumar, Sr. Scientist | Chairman |
| | | Dr. Narayan Lal, Scientist | Co- Chairman |
| | | Sh. Rajiv Ranjan Rai, Technical Officer | Member |
| | | Assistant Finance & Account Officer | Member |
| | | Administrative Officer | Member-Secretary |
| 4. | Farm Management Committee (FMC) | Dr. S.K Purbey, Sr. Scientist | Chairman |
| | | Dr. R.K. Patel, Sr. Scientist | Co- Chairman |
| | | Dr. Amrendra Kumar, Sr. Scientist | Member |
| | | Dr. Kuldeep Srivastava, Sr. Scientist | Member |
| | | Sh. Rajiv Ranjan Rai, Technical Officer | Member-Secretary |
| 5. | Price Fixation Committee | Dr. Amrendra Kumar, Sr. Scientist | Chairman |
| | | Dr. Sanjay Kumar Singh, Scientist | Co- Chairman |
| | | Sh. Subhanker Dey, AF&AO | Member |
| | | Sh. Ramji Giri, AAO | Member |
| | | Sh. Rajiv Ranjan Rai, Technical Officer & I/c Farm | Member-Secretary |
| 6. | Spot Purchase Committee (SPC) | Dr. S.D. Pandey, Pr. Scientist | Chairman |
| | | Dr. Vinod Kumar, Sr. Scientist | Co- Chairman |
| | | Sh. Rajiv Ranjan Rai, Technical Officer | Member |
| | | Sh. Subhanker Dey, AF&AO | Member |
| | | Sh. Ramji Giri, AAO | Member-Secretary |
| 7. | Library Committee | Dr. Sanjay Kumar Singh, Scientist SS | In charge |
| | | Dr. Narayan Lal, Scientist | Member |
| 8. | Security & Vehicle | Sh. Ramji Giri, Assistant Administrative Officer | In-charge |

*Till 3rd December, 2013

# Infrastructural Development

The centre is trying to develop its own laboratory facilities for molecular characterization and other biotechnological studies, and equipments and other facilities. Laboratory facilities for plant pathological and microbiological research, soil sciences and state of art facilities for post-harvest management were developed. MAP unit has been installed in post-harvest management laboratory. A common instrumentation facility at the centre has also been developed. Construction of the first floor of NRCL building was completed during 2013, and the administrative wing and laboratories were furnished.


**Nethouse for propagation of litchi saplings**

**Central Instrumentation Facility**

**Plant Pathology Laboratory**

**Post-harvest Management Laboratory**

**A view of nursery area and NRCL Experimental Farm**

An ariel view of NRCL

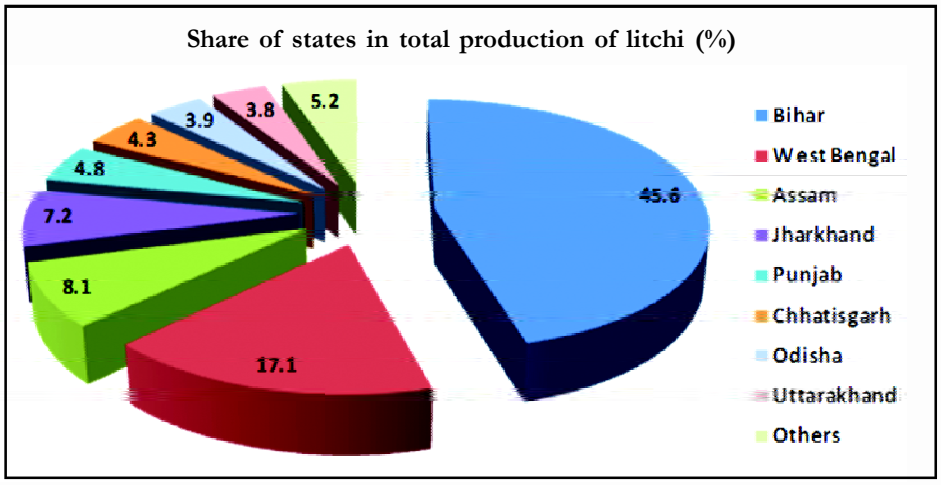
An interior view of NRCL

# Weekly weather data during 1st April 2013 to 31st March 2014

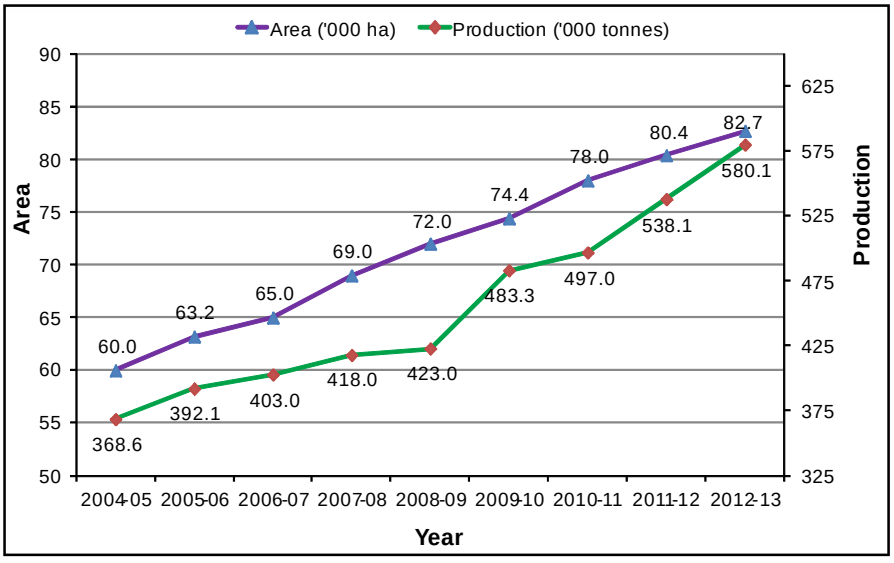
| Standard Week | Temperature (°C) | | Relative humidity (%) | | Rainfall (mm) | Sunshine hours | Wind velocity (km/h) |
|---|---|---|---|---|---|---|---|
| | Max. | Min. | 0700 hr | 1400 hr | | | |
| 14 | 35.9 | 17.4 | 67 | 28 | 0.0 | 9.7 | 6.0 |
| 15 | 38.6 | 21.3 | 68 | 31 | 1.2 | 7.6 | 5.1 |
| 16 | 32.0 | 20.4 | 86 | 61 | 12.0 | 6.7 | 8.2 |
| 17 | 34.5 | 23.3 | 87 | 51 | 0.0 | 9.0 | 5.0 |
| 18 | 39.2 | 23.5 | 77 | 42 | 0.0 | 9.3 | 6.7 |
| 19 | 35.2 | 24.4 | 85 | 61 | 0.0 | 7.4 | 9.2 |
| 20 | 35.3 | 24.2 | 77 | 54 | 6.6 | 10.3 | 9.3 |
| 21 | 34.1 | 25.9 | 87 | 65 | 26.4 | 5.2 | 9.1 |
| 22 | 31.1 | 24.5 | 88 | 69 | 85.3 | 4.5 | 9.6 |
| 23 | 33.3 | 26.5 | 89 | 70 | 0.0 | 4.0 | 8.1 |
| 24 | 36.1 | 27.1 | 82 | 69 | 16.2 | 6.3 | 7.5 |
| 25 | 33.5 | 26.5 | 88 | 70 | 36.9 | 3.2 | 5.0 |
| 26 | 31.9 | 26.3 | 91 | 77 | 170.8 | 3.8 | 7.9 |
| 27 | 33.1 | 27.2 | 90 | 74 | 4.3 | 3.9 | 5.5 |
| 28 | 33.3 | 26.2 | 90 | 70 | 24.3 | 4.5 | 6.6 |
| 29 | 33.4 | 27.3 | 90 | 70 | 1.2 | 5.0 | 7.4 |
| 30 | 34.5 | 26.9 | 86 | 62 | 6.0 | 8.6 | 8.9 |
| 31 | 33.9 | 26.6 | 88 | 66 | 30.7 | 8.2 | 7.1 |
| 32 | 31.9 | 25.7 | 91 | 71 | 66.6 | 5.1 | 7.0 |
| 33 | 33.0 | 25.9 | 91 | 72 | 15.0 | 5.1 | 4.6 |
| 34 | 33.4 | 26.4 | 85 | 65 | 3.1 | 7.4 | 7.5 |
| 35 | 32.5 | 25.9 | 91 | 72 | 15.6 | 3.3 | 5.6 |
| 36 | 33.1 | 25.5 | 88 | 65 | 105.7 | 5.8 | 4.9 |
| 37 | 34.8 | 26.3 | 89 | 59 | 0.0 | 8.6 | 3.6 |
| 38 | 34.3 | 25.9 | 87 | 60 | 1.8 | 7.8 | 5.2 |
| 39 | 34.3 | 25.2 | 87 | 65 | 3.6 | 6.5 | 4.3 |
| 40 | 30.17 | 24.2 | 90 | 72 | 16.3 | 1.7 | 7.0 |
| 41 | 31.3 | 23.6 | 89 | 65 | 18.9 | 7.3 | 7.5 |
| 42 | 28.4 | 22.1 | 92 | 72 | 5.6 | 2.9 | 5.5 |
| 43 | 31.1 | 21.2 | 93 | 63 | 0.0 | 7.0 | 2.9 |
| 44 | 28.2 | 19.8 | 94 | 68 | 0.0 | 3.2 | 3.1 |
| 45 | 28.9 | 14.8 | 90 | 44 | 0.0 | 6.5 | 1.6 |
| 46 | 28.2 | 13.0 | 88 | 36 | 0.0 | 8.1 | 2.1 |
| 47 | 27.4 | 11.1 | 89 | 37 | 0.0 | 6.5 | 1.8 |
| 48 | 27.2 | 13.0 | 91 | 46 | 0.0 | 2.9 | 1.6 |
| 49 | 27.2 | 11.1 | 90 | 41 | 0.0 | 6.7 | 1.5 |
| 50 | 24.4 | 10.3 | 91 | 49 | 0.0 | 2.5 | 1.8 |
| 51 | 22.9 | 11.2 | 89 | 59 | 0.0 | 0.6 | 2.3 |
| 52 | 18.8 | 9.7 | 93 | 77 | 0.0 | 0.0 | 2.9 |
| 1 | 21.3 | 9.0 | 87.1 | 57.8 | 0.0 | 3.6 | 3.5 |
| 2 | 18.5 | 9.0 | 91.1 | 67.0 | 5.3 | 1.0 | 3.4 |
| 3 | 18.8 | 9.5 | 91.0 | 74.2 | 4.2 | 2.2 | 3.6 |
| 4 | 19.7 | 10.5 | 92.0 | 66.1 | 0.0 | 2.7 | 3.9 |
| 5 | 17.6 | 8.9 | 90.9 | 74.7 | 0.0 | 1.1 | 3.8 |
| 6 | 24.2 | 10.4 | 88.4 | 50.6 | 0.0 | 7.0 | 3.8 |
| 7 | 20.4 | 10.8 | 89.4 | 61.6 | 29.6 | 5.3 | 4.9 |
| 8 | 24.0 | 10.8 | 90.0 | 54.7 | 1.4 | 6.0 | 2.9 |
| 9 | 24.7 | 14.3 | 90.0 | 64.3 | 1.7 | 3.5 | 3.7 |
| 10 | 26.7 | 11.7 | 87.6 | 41.6 | 0.0 | 7.2 | 3.7 |
| 11 | 30.3 | 15.0 | 88.1 | 41.1 | 0.0 | 9.0 | 3.3 |
| 12 | 31.7 | 16.6 | 80.7 | 39.3 | 0.0 | 9.0 | 4.0 |
| 13 | 34.6 | 18.3 | 70.3 | 28.1 | 0.0 | 9.4 | 6.8 |
| 14 | 35.0 | 19.1 | 78.4 | 35.9 | 0.0 | 7.8 | 4.8 |

# The Litchi Scenario

Litchi (*Litchi chinensis* Sonn.) is one of the most important subtropical fruit trees of the family Sapindaceae. India is the second largest producer of litchi in the world after China with an area and production of 82,000 ha and 5,80,100 tonnes, respectively during 2012-13. In India, Bihar, Jharkhand, West Bengal and Assam account for 78% of the total litchi production in the country. The other litchi producing states of India are in north western part of India, *viz.,* Uttarakhand, Chhattisgarh, Punjab, Odisha, Tripura, Himachal Pradesh and Jammu & Kashmir. The trends of area and production of litchi in India is given in the following figure.




**Leading litchi producing states of India, 2012-13**




**Trends in area and production of litchi in India**


# National Research Centre on Litchi

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