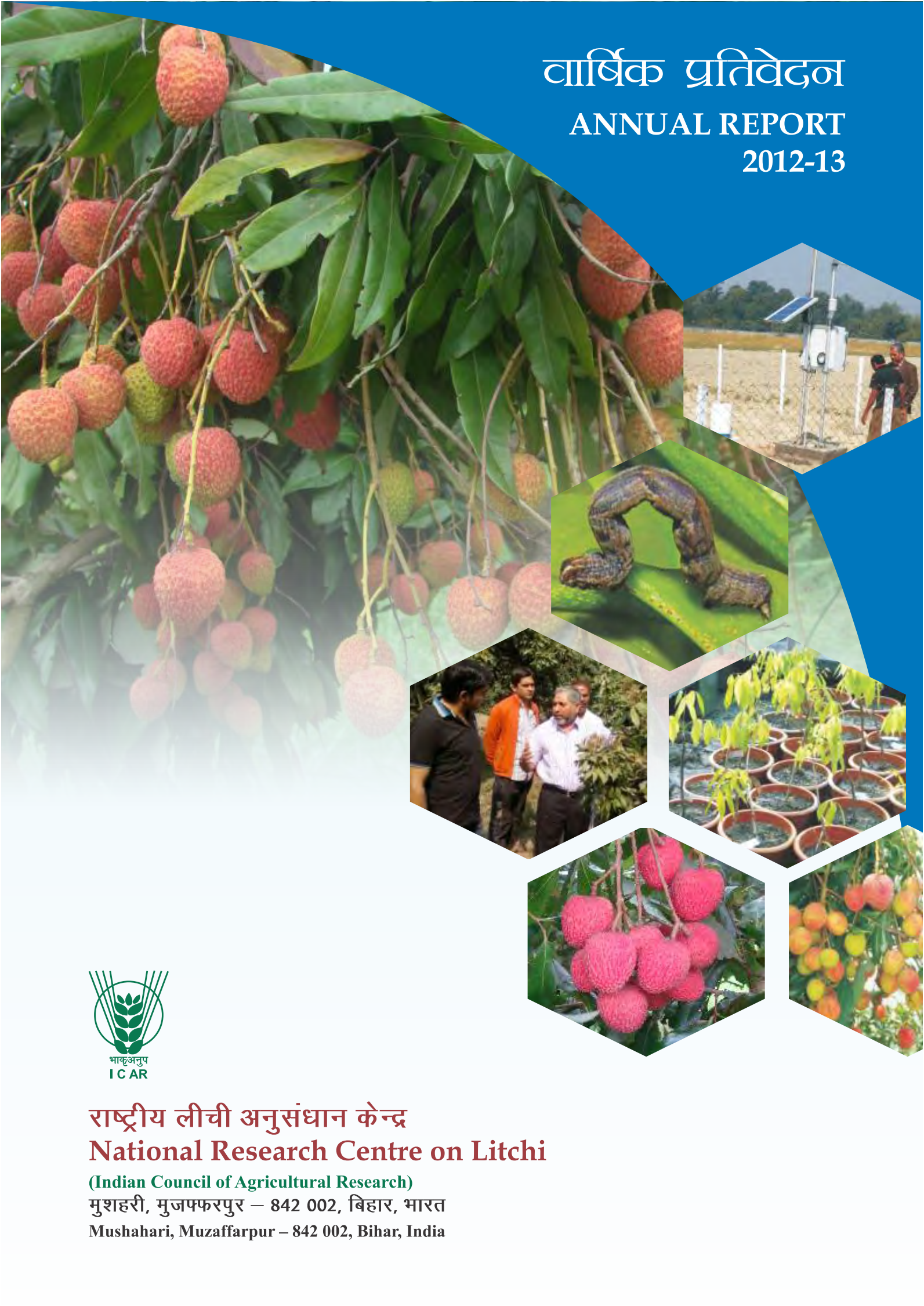


# वार्षिक प्रतिवेदन ANNUAL REPORT 2012-13



## राष्ट्रीय लीची अनुसंधान केन्द्र National Research Centre on Litchi

(Indian Council of Agricultural Research)  
मुशहरी, मुजफ्फरपुर – 842 002, बिहार, भारत  
Mushahari, Muzaffarpur – 842 002, Bihar, India



वार्षिक प्रतिवेदन  
ANNUAL REPORT

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## *Preface*

I feel privileged to bring out the Annual Report of NRC on Litchi, Muzaffarpur for the year 2012-13. The report consists of various activities of the centre in the field of research, transfer of technology, human resource development and other related activities of National Research Centre on Litchi, Mushahari, Muzaffarpur.

The centre is situated in the major litchi hub of the country. The region has pride of having the major share on litchi production and highest productivity, even though a lot of unsolved problems pose threats to litchi industry in the country. In recent year a possibility of growing litchi in non traditional area particularly in winter has thrown a ray of hope to improve its tally of acreage. The production of litchi needs a strong infrastructure back up for post harvest handling and marketing to realize the full potentials.

The NRCL with a team of scientist, technicals, administrative and other staff putting its best efforts in solving the problem, 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.

The centre is focusing its research activities as per the pre laid out mandate and objective. The entire research at the centre is focused towards 4 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 externally funded projects from FAO, Bioversity International, DBT, NAIP and ICAR network projects.

NRC on Litchi has taken active part in programme of Rajbhasha, ICAR sports, Kisan Mela/ Kisan Gosthis, exhibition training to farmer all over the jurisdiction area. During 2012-13, NRCL has organised various litchi related programme and visits in the litchi growing states of the country and extended its technical expertise to various stakeholder. This all has become possible with the whole-hearted support and co-operation by all the staff of centre at appropriate level.

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

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

July, 2013

  
**Vishal Nath**  
Director









## Executive Summary

National Research centre on Litchi, Muzaffarpur made steady progress in the field of research and extension under multidisciplinary programme covering the different aspects of mandate i.e., genetic resource management, crop production, crop protection and post harvest management. The salient achievements of the year 2012-13 are summarized below.

### Research Accomplishments

#### 1. Genetic Resource Management and Crop Improvement

Out of nine cultivars of litchi, collected last year under the FAO project, five cultivars, viz. Tai So, Kwai Mi, Sue Tong and Kwai Mai Pink are surviving and growing well in the net house. Morphological characterization of the field planted (new) litchi germplasm indicated flowering in seven litchi cultivars and one longan, but very less fruit set was seen due to juvenile phase of these plants. Microsatellite allele sizes were determined at six loci in 20 litchi genotypes. Pairwise comparison of the microsatellite data led to the identification of unambiguous nomenclature and established differences between two litchi cultivars, Dehradun and Dehrrase, previously thought of as identical. The results also pointed to several unique alleles in cultivar Kasba, Madraji, Late Large Red, Yogda Selection and Seedless late. A survey was undertaken in Samastipur, Bihar to identify the superior clones of litchi. The fruit colour varied from green to dark red and fruit weight of >25g was recorded in two clones, whereas in three clones, the fruit weight was <15 g. In two genotypes, the seed weight was <1.0 g, whereas in seven genotypes, it was >4.0 g.

A large number of crosses were made in all possible combinations involving Shahi, China and Bedana litchi cultivars. 900 seeds of Shahi, 350 of China and 360 of other litchi cultivars were sown and the seedlings were raised in the nursery for selection from provincial population. To establish the natural segregating population of litchi, fruits of the 26 supposed to be the natural hybrids were collected from Ranchi and the seeds were sown in the nursery. In an evaluation trail of eleven longan germplasms, the accession Lgc - 9 had highest plant height (3.45m) and girth (80 cm), while minimum plant height (1.50m) and girth (18cm) were recorded in Lgc - 2.

#### 2. Crop Production

The highest survival (93.20 %) of litchi air-layers in polyethylene bags was found after 11 months after planting with Rhizobacterium (1 % dip solution) than dipping in Cabendazim (0.2%) with vigorous and healthy litchi plants. Application of 75: 50:75 g NPK / plant / year showed better growth response and plant girth, spread in Shahi litchi during September, 2012. Use of 20kg FYM + 2 kg Vermicompost + 1 kg Neem cake + bio fertilizers showed better growth performance in Shahi litchi. Under HDP of litchi, 6 year old plant with medium density i.e. 6 x 4 m, 8 x 4 m and 4 x 4 m recorded significantly better growth performance. More than 5000 seedlings were raised as root stocks and grafting operations performed during July, August and September. Better success was recorded in the month of September. Litchi tree receiving pruning at 2.5 m height with four branches /trunk showed the maximum canopy development horizontally, increase in height and canopy spread compared to other treatments. The maximum length (6.56cm) of flush in litchi tree and number of times (4.12) of extension was recorded under natural flush appeared during July. Earliest natural flush tagged in July and August bore maximum percentage of pure panicle and maximum numbers of flowers. The fruit set was also recorded higher in the panicle emerged on shoots developed during July, August and September.

Early fruit maturity (5-6 days) was observed in ethrel applied trees. Application of GA<sub>3</sub> delays the fruit maturity by 4-5 days. Maximum fruit weight (20.62g) and fruit volume (20.13 cc) were recorded after spray of MH (25ppm). Spray of 2.0 % KNO<sub>3</sub> led to early emergence of panicles in 'China' litchi. Maximum flowering in China litchi was recorded in the tree treated with PBZ @ 4.0 g a.i per m<sup>2</sup> canopy spread followed by 2.0 % KNO<sub>3</sub>.

After assessment of diversity of native AM fungi in litchi rhizosphere, the results revealed that in almost all the sites *Glomus* species dominated the AMF population. Other genera found were *Acaulospora*, *Entrophospora* and *Scutellospora*.

#### 3. Crop Protection

Based on characteristics of the pathogen the causal organism of leaf blight in nursery plants was tentatively identified as *Alternaria alternata*. The severity in nursery plants was recorded between 7<sup>th</sup> July 2012 and 15<sup>th</sup> January 2013. During July 2012, the incidence, severity and percent infected leaflets were lower than in January 2013. The incidence of the "twig blight"

disease was 44.5% to 61.8% during August 2012 at NRCL farm. Pathogens consistently isolated from twig blight affected leaves were *Colletotrichum gleosporioidis* and *Gloeosporium* sp. 'Bark Splitting' on main trunk of 5-8 year old plants, between collar zones to a height of 2-3 feet, were observed in various litchi orchards.

Survey of litchi orchards during the year revealed that fruit and seed borer, leaf mite, leaf miner, shoot borer, leaf roller and bark eating caterpillar are the most serious pests. In most of the orchard, occurrence of red weevil (*Apoderus blandus*) causing severe leaf damage on young shoots was found. The outbreak of a semilooper pest was observed in September flush of litchi, both in farmers' fields and at NRCL Experimental Farm. Higher incidence and damage to foliage was observed more in 'Shahi, than 'China'. Based on morphological characteristics and developmental biology of pest (semilooper), it was identified as *Anisodes illepidaria* Guenée (family Geometridae, order Lepidoptera). The bagworm or encased caterpillar, infested few plants during December - February was identified as *Eumeta crameri* Westwood (Family: Psychidae, order: Lepidoptera).

#### 4. Post Harvest Technology and Value Addition

On studies for assessment of post-harvest losses in litchi at various stages of delivery chain in the sample of retailers of various vendors observed that sunburn was 1.5- 44.5 %, cracked fruits were 0.5-14.0 % and physically or mechanically damaged fruits during harvesting were 0.0-44.1%. In some cracked fruits, there was visible green mould colonization. The incidence of fruit borer (0-5%) and anthracnose (0.0-10.0%) was low during 2012 season. Fruits treated with bavistin (0.05%) + Citric acid (2%) + KMS (500 ppm) and chitosan (1%) and packed in recycled poly bag (doubled) gave minimum percentage of fruit loss (6.57%) on 4<sup>th</sup> days after harvest at ambient condition followed by LDPE packed fruits (7.77%) maintaining other quality parameters. Litchi fruits packed in polyethylene bags and kept in CFB boxes have 15.60 percent discarded fruits whereas in traditionally packed fruits it was 26.56 percent on 3<sup>rd</sup> day of harvest after reaching to Delhi.

Fermentation of litchi juice at 15 °C retained compounds related to fresh and fruity aromas, like methyl propanol, ethyl ester (42.5mg/l) and total acetate (2.40mg/l) in litchi wine due to low sugar fermentation rate (0.61g/l/h). While nut preparation, it was recorded that maximum damage percentage (76.04) nuts was found in boiling water pretreatment followed by dye treated fruits and minimum was in

KMS (0.1%) treated followed by citric acid (2 %) treated fruits.

Sulphited litchi fruits and nuts during storage were found to be spoiled due to colonization by *Alternaria* sp., while storage fruit rot was caused by *Alternaria* sp., *Colletotrichum gleosporioidis* and *Aspergillus niger*.

#### 5. Externally Funded Projects

Under UNEP-GEF Projects, survey was conducted to identify the variability and 28 clones of mango were characterized for fruit physico-chemical characteristics from the farmer's field. One late maturing clone and one with good shelf life were identified. Eight clones of pummelo were characterized, but none was found suitable for further multiplication. 450 air-layers were prepared of seven pummelo clones and 300 mango grafts were made from four selected clones. The profiles of two custodian farmers were selected in global workshop on custodian farmers of Asia and south East Asia for conservation and maintenance of mango biodiversity.

Under AMMAS Project, comparatively higher number of spore count was observed in samples from well managed plantation than in samples of poorly managed plantation. At all the sites, *Glomus* species dominated the AMF population. Population of *Trichoderma* and *Azotobactor* increased after litchi planting in the treated blocks. The mycorrhizae inoculated plants showed colonization of roots of litchi plants. The results revealed that P did not have any effect on root colonization; potassium had neither affected spore density nor the root colonization of AMF in litchi.

"Development of National Database on Mango" through survey and documentation of field gene bank, traditional knowledge, usages database, package and practices, post harvest technology of mango in 38 districts of Bihar was sanctioned by DBT, New Delhi.

Under TCP/IND/3202 project, litchi fruits were sent to PHT Laboratory, IARI, New Delhi to study the effect of MAP on shelf life of litchi fruits and it was found that O<sub>2</sub>: 13; CO<sub>2</sub>: 5 percent had given maximum peel moisture, texture and L value (for colour) on 4<sup>th</sup> days of harvest.

Under RFS, centre made 44,000 of litchi gooties, out of which 34000 well rooted planting material of litchi (Shahi and China) were made available for commercial sale. A sum of Rs. 5, 36, 870 has been generated during the year. The centre has refunded the money of about Rs. 2, 00,000 with intimation to the DSR, Mau.



## 6. 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 and Centres. This year an MOU was signed between NRCL and NABI, Mohali for collaborative research program on Litchi improvement and post harvest biotechnology. Another MOU was signed with SHIATS, Allahabad for collaborative research and enrichment of faculty with advanced research.

## 7. Transfer of Technology

NRC for Litchi has taken 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. During the year, the centre has organised Farmer's Innovation Day, All India Litchi Show, 2012 and Kisan Gothi, various field trainings and Agriculture Education Day.

Training programmes on pickle making and capacity building on methods of propagation were conducted at Jagdishpur and Mahmada community under TFT Project. Two very old orchards (>50 years) of mango at Jagdishpur locality were rejuvenated to make them profitable for the custodian farmers as well as for conservation of the mango diversity.

## 8. Other Activities

NRCL had organized meeting of 'Nagar Rajbhasha Karyayan Samiti', Muzaffarpur on 4<sup>th</sup> May, 2012. The 'Hindi Chetna Mas 2012' from 14<sup>th</sup> September - 13<sup>th</sup> October 2012 was observed. During this period, various competitions were organized and winners were awarded to encourage the use of Rajbhasha Hindi in day-to-day activities.

## 9. Infrastructural development

The centre is trying to develop our own laboratory facilities for the molecular characterization and other biotechnological studies. Development of laboratory facilities for plant pathological and microbiological research, soil sciences and state of art facilities for post harvest management is under progress. Facility for isolation and studies of pathogens was created. MAP unit has been installed under Post Harvest Management laboratory. Common facilities at the centre have also been developed.

In farm area, a separate block for farming system research comprising of low lying agronomical blocks, bunds for horticultural crops and pond for fish rearing is being developed at the centre. A post harvest workshop is also being developed for honey processing, sulphitation and processing of litchi fruits at large scale.



Meeting on Nagar Rajbhasha Karyayan Samiti at NRCL

# INTRODUCTION

## The Institute

The National Research Centre on Litchi (NRCL) was established on 6<sup>th</sup> June, 2001 at the fag end of IX<sup>th</sup> Plan by Ministry of Agriculture, Government of India under the aegis of Indian Council of Agricultural Research to act as a Nodal Centre to work exclusively on litchi Research and Development in India. The Centre started functioning from 2002 with a small budgetary allocation and the joining of two Scientists at the Centre in March, 2002. The lease deed for land was signed on 25<sup>th</sup> June, 2002 between the ICAR and Government of Bihar to transfer 100 acres of land to the Centre at Mushahari, Muzaffarpur. The Centre was strengthened during 2005 and onwards by redeploying scientific, technical and supporting staff along with administrative support and financial assistance for developing infrastructural facilities and to carry out the research work.

## Mandate

- Systematic collection, conservation characterization and documentation of litchi cultivars/species.
- Undertake basic, strategic and applied research to enhance productivity, processing and utility
- Evolution of high quality cultivars for tropics through breeding, genetic engineering and bio-informatics.
- Develop center of excellence for litchi and act as repository/data base/ware house on litchi.
- Act as center for HRD and capacity building in modern technology on all aspects of litchi
- Establish linkages with National and International organizations.

## Past Achievements

### Crop Improvement

- The centre started working on genetic resource management with collection of fifty-two (52) accessions of litchi from Bihar, Jharkhand, West Bengal and Uttarakhand.
- Characterization (including molecular) and documentation of litchi cultivars and related species from different agro-climatic zones are in progress.
- Longan (a related species of litchi) is performing well under Muzaffarpur conditions as 15 %

plants flowered in the 3<sup>rd</sup> year of its planting and its fruit matures in August. However the size of fruits and pulp content is not up to mark in the initial years.

- 24 superior clones of litchi have been identified and are under evaluation.
- In an externally funded project from BIOVERSITY INTERNATIONAL 10 germplasm of pummelo and 3 of mango have been identified and collected.
- Eight hundred seedlings of Shahi and China cultivars of litchi are under evaluation.
- Eight varieties of litchi have been introduced from Spain under FAO project.

### Crop Production

- Plantation of different litchi cultivars in 25.0 ha of land under different experiments along with 1.0 ha as mother block has been completed at research farm of the Centre.
- Package of practices for higher production of quality litchi fruits by foliar application of Planofix @2.5ml/10 litre of water or NAA 20 mg/litre of water, one week after fruit set significantly checked the fruit drop.
- Spray of 4.0% KNO<sub>3</sub> delayed colour break by 5 days in litchi cv. Shahi.
- Three sprays of Borax @4.0g/litre of water during fruit development stage at 15 day interval maintaining moisture level in the soil was standardized for checking the fruit cracking and quality improvement.
- Technique for tree architect/canopy management by pruning of non selective twigs every year after harvest and opening central portion to maximize solar energy utilization has been standardized & disseminated to the litchi growers.
- Application of GA<sub>3</sub> (75ppm and 50ppm) and MH (25ppm) during October showed early initiation of flowering panicle and conversion of some vegetative flushes into mixed flowering panicle in comparison to control.
- Inter space utilization protocol for young non-bearing litchi orchards in form of different models have been developed;

**Model 1:** Litchi based cropping system with banana showed better potentiality for quality production for three consecutive years.



**Model 2:** Okra- *Gladiolus* crop rotation was found to be the best in terms of net return and plant growth followed by Cowpea- Potato-Onion and Cowpea-French bean-Okra.

- Reiterative pruning methods and rebuilding canopy for rejuvenation of old senile orchards (>40 years) was standardized. Careful de-topping at 2-2.5 m height to be done in the month of August followed by thinning of unwanted shoots after six months and applying manures as per schedule resulted in enhanced production of quality fruits after 3 years.
- Riverbed soil + Vermi-compost (2:1) + fertilizers (DAP+MOP 5g each) showed healthy and vigorous saplings growth.
- Off season plant propagation through air layering has been standardized to reduce the post nursery maintenance cost.
- 35000 quality plating materials of litchi have been raised and made available to the interested growers and various State Governments on demand.

### Crop Protection

- Major pests of litchi prevalent in the area were identified, which include fruit borer, shoot borer, leaf miner, leaf roller, mite, bark eating caterpillar, leaf eating weevil, bug, and minor pests mealy bug, mealy scale, mango hopper, grass hopper and field crickets (young plants).
- *Trichogramma chilonis* @ 50,000/ha and application of Nimbecidine @ 0.5%, Cypermethrin @ 0.005% and Nimbecidine 0.5% and Cypermethrin with Nuvan were effective in minimizing the damage caused by fruit borer.
- Lower percentage (5.3%) of damaged fruits at harvest was recorded using pheromone trap + Tricho. card @50000/ ha and *Kamdhenu Keet Niyanttrak* sprays followed by pheromone trap +

Tricho. card + Nimbecidine (5.3%) when sprayed at specified time.

### Post Harvest Management and Value Addition

- Quantification of losses in litchi at various stages of post harvest has been done.
- The process of wine making from litchi fruits yielding 11.5% alcohol has been standardized in collaboration with CTCRI-RS, Bhubaneswar.
- Protocol for litchi wine and litchi nut has been developed and is further being refined.
- Physico-chemical studies of litchi fruits during fruit development stage revealed that last week of May is the best time for harvesting.
- Effect of chemicals and PGR on fruit drop and cracking revealed that  $KNO_3$  (2.0 and 4.0%) and  $CaNO_3$  (1.0%) delayed the colour break stage by 4 days and increased the fruit retention by 18.0 and 26.0 per cent, respectively.
- Covering the canopy with 30% green and 50% white shade net has extended the harvesting period by almost 16 days.

### Library

Centre has purchased 25 Hindi books, 275 English books during 2012-13. In library, we have also procured 21 Encyclopedia on various aspects, Britannica, State of Indian Farmers (27 volumes), Wealth of India (27 volumes), Survey of Rural India (27 volumes). Now, total number of books available in our Library has gone up to 1487 (295 Hindi and 1192 English). Library of this Centre has been subscribing to 15 Indian, 15 foreign Journals to facilitate the research activities. Centre has also subscribed 6 to Indian magazines (*Kheti*, *Phal-Phool*, *Indian Horticulture*, *Indian Farming*, *Agricultural Today*, *Krishika*) this year (2012-13).

## FINANCIAL SET-UP

Budget allocation and expenditure during 2012- 2013 (in Lakhs)

### Plan

Heads	Particulars	Allocation	Utilization
Recurring	<b>Establishment</b>	-	-
	TA	8.00	7.99
	HRD	1.00	0.60
	Contingencies	105.50	105.51
	<b>Total</b>	<b>114.50</b>	<b>114.10</b>
Non Recurring	Equipment	127.70	128.37
	Works	155.00	154.56
	Land Development	-	-
	Library	20.00	20.18
	Vehicles	-	-
	Furniture & Fixtures	-	-
	<b>Total</b>	<b>302.70</b>	<b>303.10</b>
	<b>Grand Total</b>	<b>417.20</b>	<b>417.20</b>

### NON-PLAN

Heads	Particulars	Allocation	Utilization
Recurring	Estts. Charge	150.36	150.35
	T.A.	1.04	1.04
	Contingencies	23.05	23.02
	Loan & Advances	01.00	0.84
	<b>Total</b>	<b>175.45</b>	<b>175.26</b>
Non Recurring	Equipments	2.50	2.38
	Furniture & Fixtures	-	-
	Library	0.50	0.51
	<b>Total</b>	<b>3.00</b>	<b>2.88</b>
	<b>Grand Total</b>	<b>178.45</b>	<b>178.14</b>

### Revenue Receipts (in Rs.)

Sl. No.	Head	Amount (Rs)
1.	Farm Produce	515115.00
2.	Sale of Publications	9428.00
3.	Sale of tender papers	10000.00
4.	Interest on STDR	13,42,065.00
5.	<b>Total</b>	<b>1876608.00</b>
6.	RFS	543550.00

### Staff Position (as on 31.03.2013)

Sl. No.	Category	Sanctioned	Filled
<b>Scientific</b>			
1.	R.M.P.	01	01
2.	Principal Scientist	01	Nil
3.	Senior Scientist	05	02
4.	Scientist	09	06
<b>Technical</b>			
1.	Technical Officer (T-6)	02	01
2.	Filed Technical (T-3)	05	01
3.	Field/Lab Technician (T-1)	07	01
<b>Administrative</b>			
1.	AO	01	01
2.	AAO	01	01
3.	AF&AO	01	01
4.	Assistant	03	02
5.	UDC	01	01
6.	Steno Gr. III	01	Nil
7.	LDC	04	02
<b>Supporting</b>			
	SSS	10	03



## RESEARCH ACHIEVEMENTS

### Theme Area 1 : Plant Genetic Resources Management And Crop Improvement In Litchi

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

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

Nine cultivars of litchi, collected last year under the FAO project “Improving productivity and quality of litchi in Bihar” from Spain, were transplanted in the screen-house to protect them from the extreme weather and also to maintain under quarantine. Five cultivars, viz. Tai So, Kwai Mi, Sue Tong and Kwai Mai Pink have finally survived and are growing well. The non-survival of some cultivars may be due to poor adaptation of these cultivars to the entirely new growing conditions. If there is good vegetative growth in these cultivars, they will be multiplied vegetatively.

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

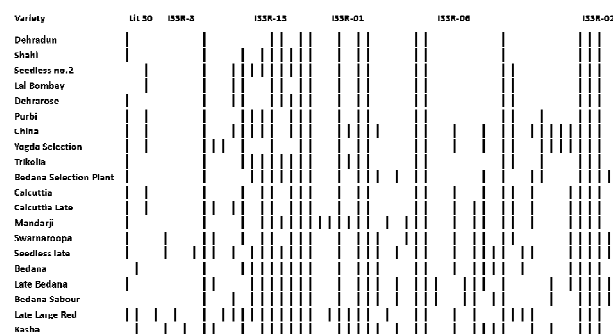
The morphological characterization of the litchi germplasm in the field genebank was started and the observations on plant height, stem girth, canopy spread, leaf type, new flush colour and initiation of flowering were recorded on 30 litchi cultivars and a related species longan. Flowering was observed only in seven litchi cultivars and the longan, but very less fruit set (Table 1). This may be due to the fact that these plants are still in juvenile phase.

**Table 1: Performance of Litchi germplasm in field genebank (2012-13)**

Cultivar	Percent fruit set
Mandraji	50.00
Dehra Rose	25.00
Lal Bombay	25.00
Longan	100.00
Ajhauli	25.00
Rose Scented	50.00
Dehradun	66.67

#### Molecular characterization of litchi cultivars based on microsatellite based barcoding

Microsatellite allele sizes were determined at six loci in 20 litchi genotypes, indigenous to the India. Pair wise comparison of the microsatellite data led to the identification of unambiguous nomenclature and established differences between two litchi cultivars, Dehradun and Dehrrrose; previously thought of as identical. The results also pointed to several unique alleles in cultivar Kasba, Madraji, Late Large Red, Yogda Selection and Seedless late. The DNA typing information was used to construct a barcode system, thereby increasing the precision. Here, alleles at *Lit30* and five polymorphic ISSR loci arranged as per their molecular weight (allele size) clearly establish the uniqueness of the twenty Litchi cultivars. ISSR 8<sub>2100</sub>, ISSR 8<sub>1600</sub> are representative elite alleles for discriminating Late Large Red. Similarly ISSR 8<sub>2027</sub>, ISSR 8<sub>1584</sub> are characteristic to Kasba, and ISSR 8<sub>831</sub> for Seedless Late Madraji and Late Large Red typically presented the ISSR 01<sub>600</sub> allele, displaying their distinctness over other cultivars. Madarji, a choice cultivar of the Bhagalpur region exhibited isolated incidence of 300 bp fragment (ISSR 13<sub>300</sub>), implying its potential for developing cultivar specific marker. Late Bedana and Bedana Sabour falling in Seedless group (Fig. 1) are characterized by a 1200 and 600bp fragments (ISSR 06<sub>1200</sub> and 600).



**Fig. 1: Barcodes of litchi genotypes**

#### Phylogenetic analysis:

Based on the presence or absence of the amplification of alleles, the pair-wise genetic similarity according to Jaccard's coefficient was analyzed which ranged from 0.63-0.90 for RAPD markers, 0.58-0.95 for ISSR and 0.63-0.90 for cumulative polymorphic microsatellites. The similarity matrix was used to

construct a dendrogram (Fig. 2) with UPGMA method displaying clustering pattern. Broadly grouped into two clades having jaccard's distance of 0.16. Which could be arranged into five clusters if clustering done at less than 0.13 jaccard's distance.

- Comprised of cultivars like Shahi, Dehharose, Dehradun etc in which Purbi and Tirkoilra were also placed.
- China, a commercial variety with very high yield potential, tolerant to extreme weathers; similar to Calcuttia, Bombaiya etc.
- Interestingly Late Large Red and Mandarji grouped together forming a distinct cluster corresponding to their morphological placements.
- While Bedana selections, Late bedana and Bedana sabour form a cluster.
- Swarnaroopa, seedless late and bedana grouped into another cluster.
- Kasba formed an out group in this, even though sharing 87% genomic information.

Principal component analysis based on Eigen values further corroborated the grouping obtained by Jaccard's similarity coefficients in UPGMA as four distinct clusters. Clearly the grouping and similarity values indicated low diversity as differentiation was depicted within a very narrow range (0.28 to 0.04), confirming narrow genetic base of the Indian litchi.

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

This experiment could not be initiated as we do not have the required laboratory facilities. The laboratory facilities are being developed and the experiment will only be initiated then.

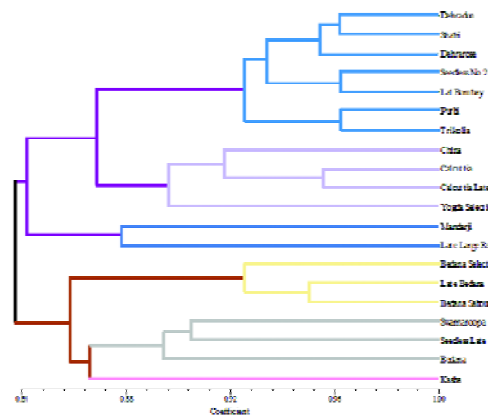


Fig. 2: Dendrogram showing genetic relationship among Litchi cultivars using SSR- ISSR combined analysis

### 1.1.4. Collection, characterization and evaluation of longan (*Dimocarpus longan*) germplasm

In an evaluation trail of eleven longan germplasm, (Table 2-5) the accession Lgc-9 recorded to have the highest plant height (3.45m) and girth (80 cm), while minimum plant height (1.50m) and girth (18cm) were recorded for Lgc-2. Among the parameters for the reproductive phase, the panicle emergence stated from first week of March and continued up to second week of March, while flowering started from last week of March and continued up to second week of April. The period of panicle emergence to Flowering was recorded as 21-23 days. Fruit set started from last week of April to first week of May. The period recorded for flowering to fruit set was 11-13 days. It was observed that fruit set to fruit development up to maturity period remained from second week of May to first week of September and the period taken for this was recorded as 096 to 105 days. The highest fruit yield (10.50kg/plant) was recorded for the accession Lgc-6. The fruit weight varied from 6.5g (Lgc-10) to 10.40g (Lgc-7), while TSS varied from 19.0°Brix (Lgc-1 and Lgc-11) to 21.5°Brix (Lgc-6).

Table 2: Growth parameters recorded for longan germplasm (2012)

Longan germplasm	Plant height (m)	Girth (cm)	Canopy spread E-W (m)	Canopy spread N-S (m)	Height of skirting (cm)
Lgc-1	2.90	41.0	2.75	3.05	0.75
Lgc-2	1.65	20.0	1.30	1.60	0.50
Lgc-3	2.30	23.0	2.50	2.25	0.75
Lgc-4	3.65	55.0	5.10	5.15	0.75
Lgc-5	4.65	57.0	5.25	5.65	0.75
Lgc-6	2.95	48.0	3.90	4.75	0.75
Lgc-7	3.40	41.0	5.05	4.25	0.75
Lgc-8	3.55	49.0	5.15	3.70	1.00
Lgc-9	4.55	61.0	5.35	5.20	1.00
Lgc-10	1.90	38.0	1.85	2.25	0.50
Lgc-11	2.90	63.0	3.70	3.60	0.75





**Table 3: Time and period of flowering, fruiting and harvest for longan germplasms (2012)**

Treatment details	Date of 1 <sup>st</sup> panicle emergence	Date & days to 1 <sup>st</sup> flowering		Date & days to 1 <sup>st</sup> fruit set		Date & days to fruit harvest	
		Date	Days	Date	Days	Date	Days
Lgc-1	06.03.2011	29.03.2011	23	11.04.2011	13	26.07.2011	105
Lgc-2	08.03.2011	30.03.2011	22	12.04.2011	13	27.07.2011	105
Lgc-3	10.03.2011	03.04.2011	22	16.04.2011	13	30.07.2011	105
Lgc-4	10.03.2011	02.04.2011	21	15.04.2011	13	29.07.2011	104
Lgc-5	10.03.2011	02.04.2011	21	14.04.2011	12	29.07.2011	105
Lgc-6	03.03.2011	24.03.2011	21	05.04.2011	12	09.07.2011	096
Lgc-7	10.03.2011	02.04.2011	22	14.04.2011	12	25.07.2011	101
Lgc-8	09.03.2011	01.04.2011	22	13.04.2011	12	26.07.2011	103
Lgc-9	09.03.2011	01.04.2011	22	14.04.2011	13	28.07.2011	104
Lgc-10	09.03.2011	01.04.2011	22	14.04.2011	13	27.07.2011	103
Lgc-11	08.03.2011	29.03.2011	21	11.04.2011	12	23.07.2011	103

**Table 4: Flowering pattern and fruit set (%) recorded for longan germplasms (2012)**

Treatment details	Nos. of flowers / panicle	Male/ Female Nos	Sex ratio	Fruit set (%)
Lgc-1	260	190/76	2.50:1	4.23 (11)
Lgc-2	200	136/68	2.00:1	3.00 (06)
Lgc-3	310	195/117	1.67:1	2.25 (07)
Lgc-4	460	346/113	3.06:1	2.82 (13)
Lgc-5	430	354/88	4.02:1	3.02 (13)
Lgc-6	960	669/289	2.31:1	5.73 (55)
Lgc-7	840	545/295	1.84:1	5.12 (43)
Lgc-8	430	327/104	3.14:1	3.25 (14)
Lgc-9	210	158/49	3.22:1	2.38 (05)
Lgc-10	280	236/44	5.36:1	2.50 (07)
Lgc-11	380	286/94	3.04:1	2.89 (11)

**Table 5: Physico-chemical characteristics recorded for longan germplasms (2012)**

Treatment detail	Fruit yield (kg/tree)	Fruit wt (g)	TSS ( <sup>0</sup> Brix)	Acidity (%)
Lgc-1	2.40	05.20	20.1	0.22
Lgc-2	1.00	06.10	20.0	0.26
Lgc-3	3.20	06.10	20.2	0.26
Lgc-4	3.60	06.30	20.2	0.22
Lgc-5	5.80	06.40	20.2	0.22
Lgc-6	6.50	06.80	21.4	0.26
Lgc-7	6.80	07.20	21.0	0.24
Lgc-8	4.40	06.00	20.0	0.26
Lgc-9	2.00	06.80	19.1	0.24
Lgc-10	2.00	06.50	19.2	0.24
Lgc-11	3.00	07.20	19.0	0.26

### 1.1.5. Collection, characterization and evaluation of rambutan germplasm

The grafted and seedling plants of one rambutan cultivar were collected from Central Horticultural Experiment Station, Chethalli, Karnataka. The plants were planted in the screen house. The fruits were also collected from this cultivar, but the seeds have not germinated. The grafted plants have not survived, but there is new vegetative flush in the seedlings as well as the rootstocks. The non-survival of the rambutan grafts may be due to the non adaptability of rambutan in this location and it will require some sort of acclimatization, which has to be provided by modifying the growing conditions, i.e. we have to grow them under artificial conditions, free from very severe environmental factors, particularly the low and high temperature.

## 1.2. Evolving improved cultivars in litchi

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

a). **Selection of litchi clones in Bihar:** A survey was

undertaken in the Samastipur and other districts of Bihar state during May and June, 2012 to identify the superior clones of litchi. Different orchards were surveyed and 52 plants were identified based on fruit maturity period, yield and fruit physico-chemical characteristics. The fruit colour varied from green to dark red depending on the genotypes. Maximum fruit of >25g was recorded in two clones, whereas in three clones, the fruit weight was <15g. Majority of the fruits were round or near round, whereas fruits in three clones were elongated having length: width ratio of >1.2. Majority of the fruits in the clones were possessing intermediate TSS (15-17°Brix). In two genotypes, the seed weight was <1.0g, whereas in seven genotypes, it was >4.0 g. Five genotypes were having >75% edible portion, whereas in one genotype, it ranged from 60-65% (Table 6). Thus, the clones exhibited a wide variation for fruit physico-chemical characteristics.

b). **Vegetative propagation of the selected litchi clones:** To multiply the selected clones for detailed evaluation, air-layering was done in eight clones

**Table 6: Fruit characters in litchi clones characterized during the survey**

Fruit character	Number of genotypes (%)	Fruit character	Number of genotypes (%)
Fruit wt. (g)		Seed wt. (g/fruit)	
a). <10.0	0(0.00)	a). <0.50	1 (1.92)
b). 10.01-15.00	3(5.77)	b). 0.51-1.00	1 (1.92)
c). 15.01-20.00	20 (38.46)	c). 1.01-1.50	0 (0.00)
d). 20.01-25.00	27 (51.92)	d). 1.51-2.00	0 (0.00)
e). >25.01	2 (3.85)	e). 2.01-2.50	4 (7.69)
		f). 2.51-3.00	5 (9.62)
		g). 3.01-3.50	21 (40.38)
		h). 3.51-4.00	13 (25.00)
		i) >4.00	7 (13.46)
L:B ratio		Percent edible portion	
a). <0.90	0 (0.00)	a). <50.00	0 (0.00)
b). 0.91-1.00	0 (0.00)	b). 50-01-55.00	0 (0.00)
c). 1.01-1.10	26 (50.00)	c). 55.01-60.00	0 (0.00)
d). 1.11-1.20	23 (44.23)	d). 60.01-65.00	1 (1.92)
e). > 1.21	3 (5.77)	e). 65.00-70.00	15 (28.85)
		f). 70.01-75.00	31 (59.62)
		g). >75.01	5 (9.62)
TSS °Brix			
a). <15.00	6 (11.54)		
b). 15.01-17.00	31 (59.62)		
c). 17.01-19.00	15 (28.85)		
d). 19.01-21.00	0 (0.00)		
e). >21.01	0 (0.00)		



(Table 7). Thirty-five air layers were prepared from each clone during October, 2012. The success of air-layering was observed at the farmer's fields and good rooting was recorded in four plants. During February, 2013, the successful air-layers were removed from the parent tree and planted in the nursery at National Research Centre on Litchi, Muzaffarpur under the screen house. Remaining gooties were left on the tree for further rooting. Further studies are in progress.

- c). **Planting of selected clones in the field:** To evaluate the performance of selected litchi clones, the vegetatively propagated plants of 20 clones were planted in the field at a spacing of 8.25m x 8.25m. Five plants each of 13 clones, four plants, each of four clones and three and two plants of one clone were planted during the monsoon

season (Table 8). All the clones survived and are growing satisfactorily in the field. Further studies are in progress.

### 1.2.2. Development of improved hybrids of litchi

From the hybridization programme (Table 9), only fifteen fruits were harvested. The seeds were mostly undeveloped/underdeveloped and only two seedlings were raised. The seedlings are being maintained in the nursery along with the hybrid seedlings obtained from the last year breeding programme. The seedling growth is satisfactory and the seedlings are exhibiting a wide variation in the plant morphological characteristics. The seedlings will be planted in the field for their detailed evaluation.

**Table 7: Air-Layering in the selected clones**

Farmer	Date of air-layering	No. of air layers done	Successful air-layer cut
Sh. Jawahar Singh	14/10/12	35	-
Sh. Vipin Kumar Pandey	14/10/12	40	--
Sh. Jagan Nath Pandey	14/10/12	35	11
Sh. Shatrughan Singh	14/10/12	40	7
Bhola Nath Jha			
Suman Kumar Chanchal	14/10/12	40	7
Suman Kumar Chanchal	14/10/12	40	-
Nageshar Paswan	14/10/12	30	5

**Table 8: Planting of selected litchi clones in the field**

Clone	No. of plants	Date of planting
Ram Chander Pandey-2	4	29/8/2012
Md. Sikander	4	29/8/2012
Jitender Shah	5	29/8/2012
Vipin-1	5	30/8/2012
Habib Ansari	4	30/8/2012
Billat Shah-3	5	30/8/2012
Billat Shah-1	5	30/8/2012
Sujoy-3	5	30/8/2012
Bhullan-2	5	30/8/2012
Byas Ojha	5	30/8/2012
Sujoy-1	5	31/8/2012
Bhola Nath Jha	5	31/8/2012
Billat Shah-2	5	31/8/2012
Jawahar Singh	5	31/8/2012
Ram Chander-1	5	31/8/2012
Jagan Nath Pandey	5	31/8/2012
46-2-4	4	31/8/2012
54-7-1	4	1/09/2012
Bhullan-1	3	1/09/2012
Sudhanshu	2	1/09/12

**Table 9: Hybridization programme taken during 2011-12**

Cross	Flowers pollinated	Total fruit set after one week	% fruit set after one week of crossing (24/03/2012)	% fruit set after two weeks of crossing (31/03/2012)	Fruits harvested (31/05/2012)
Cross-1 (Shahi x Bedana)	1802	34	1.88	0.00	00
Cross-2 (Bedana x Shahi)	1021	165	16.16	0.09	00
Cross-3 (China x Shahi)	3907	3045	77.94	22.03	1
Cross-4 (China x Bedana)	3231	2245	69.48	18.11	2
Cross-5 (Bedana x China)	1815	1144	63.03	47.46	8
Cross-6 (Shahi x China)	1184	594	50.17	23.90	4

To create larger population of segregating seedlings of litchi, the breeding programme was further strengthened during the year. A large number of crosses were made in all possible combinations involving Shahi, China and Bedana litchi cultivars (Table 10).

**Table 10. Crossing programme taken up during 2012-13**

Cross	Flower Pollinated	Fruit set/% Fruit set (as on 31/03/13)
Shahi X China	3500	12/0.34
Shahi X Bedana	1800	20/1.67
Bedana x China	2500	25/1.00
Bedana x Shahi	1200	34/2.83
China x Shahi	2200	221/10.05
China x Bedana	4000	410/10.25

Initial fruit set was satisfactory but after the second week of crossing, very low fruit set was recorded. Further studies are in progress.

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

Seven hundred and thirty six seedlings of litchi were maintained in the field by providing irrigation, fertilizers and insect-pest control measures. The seedlings exhibited a large variation for plant morphological characteristics, viz. plant height, stem

**Table 11. Performance of seedling population**

No. of flowering seedlings	Number of seedlings with good fruit set (>20 set fruits)
65	52

girth, leaf length and width, canopy spread and colour of the new vegetative flush. Flowering was observed in 65 seedlings, but with very poor or no fruit set in 13 seedlings (Table 11). Further studies are in progress.

More than one thousand seedlings were raised from Shahi, China and Bedana cultivars to increase the size of the population. Two blocks were developed and lay out and pits digging has been completed. The pits were dug at a spacing of 4m x 4m for the planting of these seedlings and the seedlings will be planted during the monsoon season.

### 1.2.4. 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 as well as composite samples. In total 900 seeds of Shahi, 350 of China and 360 of other litchi cultivars were sown and the seedlings were raised in the nursery. The seedlings are exhibiting a wide range of variation in plant morphological characteristics. The seedlings growing in the nursery from last year programme were maintained in the screen house and will be planted in the field during July, 2013.

### 1.2.5. Establishment and evaluation of segregating population of litchi

To establish the natural segregating population of litchi, fruits of the 26 natural probable hybrids were collected from Ranchi and the seeds were sown in the nursery. The seeds germinated only in 14 natural hybrids and the natural hybrids exhibited a large variation for the morphological characteristics in the seedlings. The seedlings are being raised in the nursery and will be planted in the field during July, 2013.



## Theme Area 2 : Development of Sustainable Production Technology

### 2.1. Plant propagation and nursery management growth

#### 2.1.1. Standardization of grafting technique

The initial attempt of grafting of litchi has shown good success. The revised experiment has been planned and executed. During the year under report, more than 5000 seedlings were raised which will be used as root stocks. The grafting operations attempted during the months of July, August and September and studies on cambial union and survivability have been taken up. The attempt made during August and September showed better success and comparatively higher success in the month of September (Table-12 a, b, c).

#### 2.1.2. Standardization of protocol for mound layering in litchi (*Litchi chinensis* Sonn.):

The experiment has been laid out in the field (2011). The girth of the established plants were recorded just before the cutting of a plant to stump and subsequently observations pertaining to date of sprouts emergence, growth of emerged shoots and elongation rate, etc are being recorded. The survival of new sprouts is negligible due to narrow cratch and physical damage. Hence, fresh attempt of topping off and sprout generation is being made.

**Table 12 (a) : Survivability of litchi grafted plants (Grafting operation during July, 2012)**

Treatment number and combination	Survivability of grafted plant after 30 Days (Nos.)	Survivability of grafted plant after 60 Days (Nos.)	Survivability of grafted plant after 90 Days (Nos.)	Survivability of grafted plant after 120 Days (Nos.)
T <sub>1</sub> - M <sub>1</sub> S <sub>1</sub>	7	3	2	1
T <sub>2</sub> - M <sub>1</sub> S <sub>2</sub>	9	7	4	2
T <sub>3</sub> - M <sub>1</sub> S <sub>3</sub>	16	8	7	1
T <sub>4</sub> - M <sub>2</sub> S <sub>1</sub>	9	2	0	0
T <sub>5</sub> - M <sub>2</sub> S <sub>2</sub>	16	6	2	0
T <sub>6</sub> -M <sub>2</sub> S <sub>3</sub>	16	11	3	2

**Table 12 (b) : The survivability of litchi grafted plants (Grafting operation during August, 2012)**

Treatment number and combination	Survivability of grafted plant after 30 Days (Nos.)	Survivability of grafted plant after 60 Days (Nos.)	Survivability of grafted plant after 90 Days (Nos.)	Survivability of grafted plant after 120 Days (Nos.)
T <sub>1</sub> - M <sub>1</sub> S <sub>1</sub>	7	3	2	1
T <sub>2</sub> - M <sub>1</sub> S <sub>2</sub>	12	7	4	2
T <sub>3</sub> - M <sub>1</sub> S <sub>3</sub>	12	8	7	2
T <sub>4</sub> - M <sub>2</sub> S <sub>1</sub>	9	2	0	0
T <sub>5</sub> - M <sub>2</sub> S <sub>2</sub>	13	6	2	0
T <sub>6</sub> -M <sub>2</sub> S <sub>3</sub>	18	11	3	2

**Table 12 (c) : Survivability of litchi grafted plants (Grafting operation during September, 2012)**

Treatment number and combination	Survivability of grafted plant after 30 Days (Nos.)	Survivability of grafted plant after 60 Days (Nos.)	Survivability of grafted plant after 90 Days (Nos.)	Survivability of grafted plant after 120 Days (Nos.)
T <sub>1</sub> - M <sub>1</sub> S <sub>1</sub>	11	3	2	2
T <sub>2</sub> - M <sub>1</sub> S <sub>2</sub>	14	7	3	3
T <sub>3</sub> - M <sub>1</sub> S <sub>3</sub>	18	8	3	3
T <sub>4</sub> - M <sub>2</sub> S <sub>1</sub>	13	3	3	1
T <sub>5</sub> - M <sub>2</sub> S <sub>2</sub>	18	6	2	2
T <sub>6</sub> -M <sub>2</sub> S <sub>3</sub>	18	8	3	2

Note: M1 - Wedge grafting, M2 - Side grafting; S1 - Scion with leaf S2 - Scion defoliated 7 days before grafting, S3 - Scion defoliated 15 days before grafting.

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

Sufficient number of Shahi air-layers were propagated from the Centre's Mother block for utilization in the experiments using the similar rooting mixture during the rainy season so that the rooted air-layers were ready for detachment during last week of September. Uniform potting mixtures were prepared by using river bed soil (RBS), vermi-compost, coco-pith and vermiculite. Highest survival of litchi air-layers in polyethylene bags 93.2% were found in treatment with Rhizobacterium 1 % dip solution even higher than Cabendazim 0.2% dip (84.5%) with vigorous and healthy litchi plants at 11 months after planting (Fig. 3). The average c.f.u. ( $7 \times 10^4$  cfu/ml) was found in Kamdhenu keet niyantrak (1.5% ) dip whereas in the the *Trichoderma viride* (1%) the *Trichoderma* was  $20.5 \times 10^4$ cfu/ml. *Trichoderma* colonies were very low or negligible in the other treatments. All the saplings under the experiment got similar production care for humidity maintenance, irrigation, weeding and management of insect pest attack. The experiment was carried out in the agro-shed net house in the nursery area of the Centre.

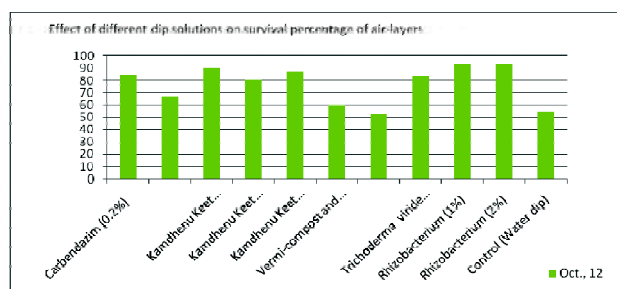


Fig. 3: Effect of dip solutions on establishment of gooties

## 2.2. Development of sustainable production techniques in litchi

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

Observations recorded on growth parameters showed non-significant differences. However

application of 75 : 50 : 75 g NPK / plant / year showed better growth response and plant girth, spread N-S and E - W were recorded 55.25 cm, 6.02 m and 5.88 m, respectively during September 2012. Soil and leaf samples were collected and analysis revealed that Nitrogen content ranged in various treatments from 85 kg /ha to 215 kg /ha. Where as phosphorus ranged from 0.72 ppm to 0.31 ppm. Cu and Zn varied from 1.2 to 2.5 ppm and 1.9 to 3.0 ppm in leaf and 4.2 to 6.2 ppm and 1.9 to 3.0 ppm in soil, respectively. Nitrogen availability /ha was found increasing with increasing dose of Nitrogen / Plant

### 2.2.2. Effect of graded level NPK on vegetative and reproductive character 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 were recorded 45.53 cm, 4.57 m and 4.78 m, respectively during September 2012. Soil and leaf samples were collected and analysis is under progress.

### 2.2.3. Standardization of organic inputs for litchi production

Application of 20kg FYM + 2 kg Vermicompost + 1 kg Neem cake + bio fertilizers showed better growth performance. Flowering noticed in the experimental plants and observations will be recorded on fruiting and yield.

### 2.2.4. Effect of nutrition and intercropping on canopy development, bearing behaviour, fruit yield and quality in reiteratively pruned old senile litchi trees

The reiterative pruning leading to top off the branches during September 2010 at a height of 2.0 to 2.5m from ground depending on the structure of the individual trees in the orchard is in progress since 2011. The revised treatments were imposed as per

Table : 13. Vegetative growth after reiterative pruning of old litchi trees during 2012

Treatment details	Increase in height (m)	Increase in canopy E-W (m)	Increase in canopy N-S (m)
Pruning at 2.0 m height	0.56 (2.62)	0.71 (2.32)	0.77 (1.65)
Pruning at 2.0 m height + 3 branches/trunk	0.62 (2.70)	0.93 (2.73)	0.94 (1.59)
Pruning at 2.0 m height + 4 branches/trunk	0.66 (2.82)	0.87 (3.42)	0.71 (2.24)
Pruning at 2.5 m height	0.53 (2.73)	0.83 (3.22)	0.87 (1.78)
Pruning at 2.0 m height + 3 branches/trunk	0.56 (2.78)	0.90 (2.98)	0.96 (1.57)
Pruning at 2.5 m height + 4 branches/trunk	0.68 (3.10)	1.02 (2.96)	0.98 (3.54)
Unpruned tree (Control)	0.54 (3.14)	0.43 (2.89)	0.70 (2.72)

Figures in paranthesis are the total growth of plant after rejuvenation



programme after proper thinning operation. The growth of branches contributing towards canopy development i.e. increase in height (m), canopy spread (m) E-W and N-S have been rescored. In the initial observation the treatment having pruning at 2.5 m height with four branches /trunk showed the maximum canopy development horizontally, and better growth (increase in height - 0.78 m) and canopy spread (1.0 m E-W; 0.86 m N-S) compared to other treatments (Table 13).

### 2.2.5. High density planting in litchi

Observations recorded on growth parameters in different densities during September 2012 revealed significant differences in plant girth and spread, whereas plant height showed non - significant differences. Maximum plant girth (TCA) 35.76 cm recorded in 6 x 4 m followed by 35.60 in 8 x 4 m planting density. Plant spread N-S and E-W (4.07 m and 4.30 m respectively) were also recorded maximum in 6 x 4 m density. In general up to 6<sup>th</sup> year of plant growth medium density i.e. 6 x 4 m, 8 x 4 m and 4 x 4 m of planting recorded significantly better growth performance (Table 14 and Table 15). Flowering started in all densities but up to 8-10 panicles in some plants only.

**Table 14 : Effect of High Density Planting on plant girth (cm) over the period of three years**

Treatments	September,10	September,11	September,12
T <sub>1</sub> (8 x 8 m)	16.79	21.42	26.80
T <sub>2</sub> (8 x 4 m)	20.63	24.14	35.60
T <sub>3</sub> (8 x 6 m)	19.97	24.16	33.45
T <sub>4</sub> (6 x 4 m)	20.92	26.05	35.76
T <sub>5</sub> (10 x 10 m)	17.97	23.14	32.28
T <sub>6</sub> (6 x 6 m)	17.21	22.27	30.72
T <sub>7</sub> (4 x 4 m)	19.29	25.54	33.32
T <sub>8</sub> (2 x 2 m)	16.35	22.63	24.92
C.D. @ 5%	2.34	2.81	4.08

**Table 15: Effect of High Density Planting on plant spread (m) over the period of three years**

Treatments	September, 10		September, 11		September, 12	
	N-S (m)	E-W (m)	N-S (m)	E-W (m)	N-S (m)	E-W (m)
T <sub>1</sub> (8 x 8 m)	1.91	2.00	3.06	3.02	3.48	3.50
T <sub>2</sub> (8 x 4 m)	2.33	2.31	3.36	3.37	4.15	4.08
T <sub>3</sub> (8 x 6 m)	2.42	2.36	3.37	3.34	3.83	3.85
T <sub>4</sub> (6 x 4 m)	2.46	2.39	3.57	3.65	4.07	4.30
T <sub>5</sub> (10 x 10 m)	2.04	2.06	3.14	3.15	3.84	3.85
T <sub>6</sub> (6 x 6 m)	1.89	1.95	2.97	2.97	3.72	3.67
T <sub>7</sub> (4 x 4 m)	2.11	2.01	3.31	3.25	3.94	3.97
T <sub>8</sub> (2 x 2 m)	1.66	1.60	2.77	2.76	2.75	2.85
C.D. @ 5%	0.34	0.41	0.36	0.38	0.64	0.58

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

Layout of experiment completed and pruning treatments were imposed as per following details: For Spacing of 2 x 2 m (Height: 1m, 1.5m and 2m) and Pruning intensity (25 and 50 % of annual shoot growth (back pruning one time during June). For Spacing of 4 x 4 m (Height: 2m, 2.5m and 3 m) and Pruning intensity (25 and 50 % of annual shoot growth (back pruning one time during June).

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

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

The observations recorded with respect to time of appearance of vegetative flush (natural and forced), followed by marking and then monitoring for further vegetative and reproductive growth. The maximum length (6.56cm) and number of times (4.12) of extension growth was recorded in treatment having natural flush appeared in the month of July. The sequence of floral formation exhibited obvious phase change leading to

**Table 16: The growth and flowering parameters recorded in vegetative flushes of various months**

Treatment details	Length of the flush (cm)	Times of extension growth	Number of branched shoots	Total length of shoot at the time of flowering (cm)	Total length the panicle the time of floweri (cm)
July 2012	6.56	4.12	6.66	88.56	16.62
	3.25	3.24	5.78	44.24	14.42
August 2012	6.26	3.72	6.80	72.26	16.82
	3.24	2.24	6.62	42.24	14.24
September 2012	5.64	2.26	7.20	48.22	14.64
	2.76	1.56	3.24	33.34	0.52
October 2011	5.52	2.24	5.52	36.22	14.44
	2.32	1.22	3.66	16.46	0.44
November 2012	4.56	1.12	4.34	42.22	14.26
	2.24	0.68	3.22	22.22	0.00
December 2012	4.32	0.72	1.26	16.42	12.46
	1.66	0.12	2.12	05.26	0.00

flowering and fruiting. The data showed that the earliest natural flush tagged in July and August bore maximum percentage of pure panicle and maximum numbers of flowers in different phases of appearance (1833, 1661). The fruit set percentage responsible for quantum of fruit yield was also recorded comparatively higher in the panicle emerged on shoots dependent on its appearance age (July, August and September). The length of pure panicles, number of flowers per panicle were also recorded higher (Table 16) in shoots emerged during the months of July (16.62cm), August (16.82cm) and September (14.64 cm). The fruit set were found to give inconsistent result when calculated on the basis of number of flowers per panicle and number of final fruit set per panicle.

### 2.3.2. Effect of PGR sprays on yield, maturity and quality of litchi fruits cv. Shahi

Twig length and number of compound leaves per twig had significant effect on appearance/initiation of flower panicles. The lower number of compound leaves (less than 12) with twig length (less than 25 cm) had higher percentage of flowering panicle. Flowering panicle emergence were found in the 4<sup>th</sup> year (continuously) where treatment of MH 15 and 20 ppm, and Ethrel 150 ppm were applied. Early fruit maturity by 5-6 days was observed in ethrel applied trees. Application of GA<sub>3</sub> delays the fruit maturity by 4-5 days. Bigger fruits size having 31mm diameter was found in GA<sub>3</sub> (50 ppm), Ethrel (150 ppm) and MH (20 ppm) treated plants during October, December and April. In fruit qualitative parameter studies revealed that different treatments varies significantly. Maximum fruit weight (20.62 g) and fruit volume (20.13 cc) were recorded in treatments (MH 25 ppm), pulp percentage (69.86 %) in MH (15 ppm) and maximum TSS (19.40 °B) was in GA<sub>3</sub> (50 ppm). In the storage studies of fruits from different treatments revealed significant effect and the fruits can be stored up to 12 days in clod storage condition without any pre-cooling and sulphur treatment.

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

Trees were identified/selected and continuous monitoring of new flushed was done after imposition of PBZ, KNO<sub>3</sub> treatment in Litchi cv. China. November flush was delayed by one week (23<sup>rd</sup> November) in the tree treated with PBZ @ 3.0 g and 2.0 g. Control tree had flush as usual (16<sup>th</sup> November). Spray of PBZ significantly reduces 'Chlorophyll a' contents and found maximum in control tree (2.09 mg per g FW) followed by tree received PBZ @ 4.0 g. Chlorophyll b was found maximum in the tree with 1.0 % KNO<sub>3</sub> followed by 1.0 g PBZ. Maximum flowering was recorded in the tree treated with PBZ @ 4.0 g a.i per m<sup>2</sup> canopy spread followed by 2.0 % KNO<sub>3</sub>. North side of the canopy had maximum flowering branches; fruit set but fruit retention was maximum in the tree treated with 2.0 % KNO<sub>3</sub> (Fig. 4a - 4c). South direction of the canopy had more no. of flowering branches than other side. The treatment has shown good response and will be taken up further with addition of few more compounds like *Morphactine* and *Prohexadion-Ca* in the next season.



Fig. (4 a - c) : Effect of Paclobutrazol and KNO<sub>3</sub> on flushing pattern in China Litchi, a.) Control tree, b.) 3.0 g PBZ, c.) 2.0 g PBZ, and d.) 4.0 g PBZ





## 2.4. Studies on mycorrhizal association and role of biofertilizers for improved litchi production

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

#### 1.1. Survey and sampling

A total of 105 samples were collected from Muzaffarpur, Vaishali, Samstipur and East Champaran 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. Seventy-nine samples collected from different places in Muzaffarpur and Vaishali districts were analysed for various parameters.

#### 1.2. Soil chemical characteristics

Soil chemical properties and nutrient content were assayed to study its 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. The micronutrients assayed were Zn, Cu, Fe, B, Mn and S. It was evident that the soil pH of litchi orchards in Muzaffarpur and Vishali district was in the range of 8.24 to 9.53. The electrical conductivity of soil was in the range of 0.07 to 0.39 dSm<sup>-1</sup>. In majority of the samples the organic carbon was low (<0.5% in 48 samples) but nitrogen, phosphorus and potash was in the range of medium to high level. Out of 79 samples, available phosphorus was in medium range (11-25 kg P<sub>2</sub>O<sub>5</sub>/ha) in 55 samples and high (>25 P<sub>2</sub>O<sub>5</sub>/ha) in 20 samples.

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

The spore density ranged from 2 to 44 per two gram rhizospheric soil. In terms of average number of spores count per gram soil, out of 79 samples, 45 samples had spores between 1.0-5.0, 24 had between 5.1-10.0, 5 samples had between 10.1-15.0, 9 samples had between 15.1-20.0 and only one sample had more than 20 (22 spores) (Fig. 5). Thus, the results indicated a high level of spore density of AMF in rhizospheric soils of litchi (Fig. 6). However, the spore density showed no correlation with total root colonization indicating that AMF sporulation, germination and root colonization was dependant on a wide range of host, fungal and environmental factors.

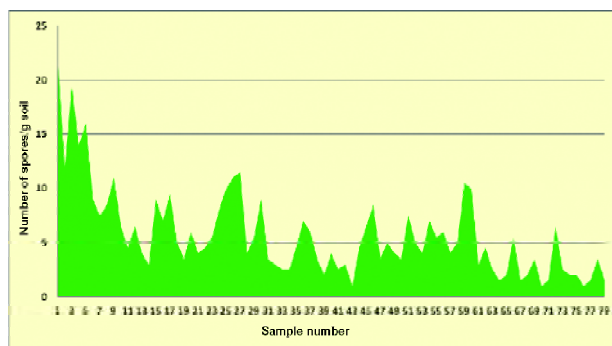


Fig. 5. Average spore count of AMF in rhizospheric soil samples

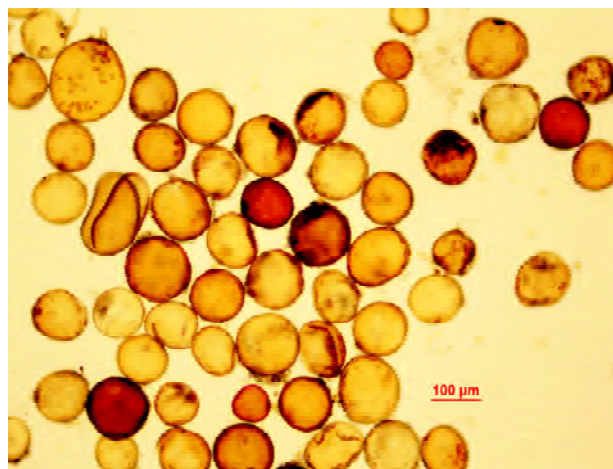


Fig. 6: A group of spores of AMF sieved from soil

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

### 2.1. Root colonization of AMF in litchi

For root colonization of litchi by AM fungi the method was standardized. The root segments were observed for presence of arbuscules and vesicles (Fig. 7). The percent root segments colonized by AM fungi were estimated. The results revealed that all the

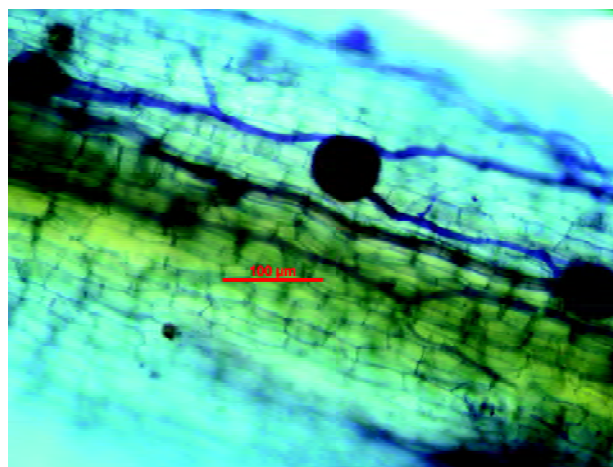


Fig. 7: Vesicles of AMF in a section of litchi root

**Table 17. Distribution of root samples of litchi under different percent colonization category**

Category (Percent colonization)	Arbuscular colonization		Vesicular colonization		Vesicular + Arbuscular colonization		Total root colonization	
	No. of samples	% samples	No. of samples	% samples	No. of samples	% samples	No. of samples	% samples
Zero	2	2.53	4	5.06	12	15.19	0	0.00
1 to 10	24	30.38	24	30.38	45	56.96	4	5.06
11 to 20	23	29.11	27	34.18	13	16.46	4	5.06
21 to 30	7	8.86	14	17.72	7	8.86	8	10.13
31 to 40	11	13.92	6	7.59	1	1.27	19	24.05
41 to 50	10	12.66	4	5.06	1	1.27	9	11.39
51 to 60	1	1.27	0	0.00	0	0.00	16	20.25
61 to 70	1	1.27	0	0.00	0	0.00	6	7.59
71 to 80	0	0.00	0	0.00	0	0.00	6	7.59
81 to 100	0	0.00	0	0.00	0	0.00	7	8.86

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 17). 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 5.06, 2.53, 15.19, and 0.0 percent root samples, respectively. Considerable variation in percent root colonization and number of AMF spores in rhizospheric soil was observed but no definite correlation could be established between them.

## 2.2. Factors affecting AMF spore density and root colonization of litchi

### 2.2.1. Effect of pH and EC on spore density and root colonization by AMF

The pH of the soil ranged between 8.24 to 9.53 and within this range spore densities and colonization of AM fungi had no correlation. Soil salinity in terms of electrical conductivity (EC) affected spore density and above EC 0.1 dSm<sup>-1</sup>, spore density was reduced.

### 2.2.2. Effect of available P on spore density and root colonization

In general, moderate level (18-32 kg P<sub>2</sub>O<sub>5</sub>/ha) of available phosphorus (P) had a positive response on spore density, but P did not have any effect on root colonization.

### 2.2.3. Effect of potassium content of soil on spore density and root colonization

The level of potassium (K<sub>2</sub>O) in soil of litchi plantation in Muzaffarpur district of Bihar varied from 90-293 kg/ha. Out of 49 samples, 2 samples was under low level (< 112 kg/ha), 28 was in medium (112-280 kg/ha) and 19 was in high (>280 kg/ha) level range. The results revealed that the level of potassium had neither affected spore density nor the root colonization of AMF in litchi.

### 2.2.4. Effect of age of litchi plantation on root colonization by AMF

The age of plants influenced root colonization by AM fungi but there was no effect on spore density of AMF in the soil.

### 2.2.5. Management status of litchi plantation vs. spore density and colonization

Comparatively higher number of spore count was observed in samples from well managed plantation (where application of fertilizers and manures, etc. were done) than in samples of poorly managed plantation (where no application of fertilizer and manures were done). Similar trend was observed with respect to root colonization of litchi by AMF. This indicates that a minimum level of nutritional status of soil is required for this symbiotic organism to function. This is just an indicative result and more number of samples needs to be studied for a valid conclusion.



### 3. Assessment of diversity of native AM fungi in litchi rhizosphere

In almost all the sites *Glomus* species dominated the AMF population. Other genera found were *Acaulospora*, *Entrophosphora* and *Scutellospora* (Fig. 8 and 9). The genus *Glomus* as the most common AMF genus distributed globally had been reported by several workers and it is also known to dominate in the tropical areas as well as temperate region of the World. *Glomus* has the ability to adjust its sporulation pattern in relation to environmental conditions, thus ensuring dominance in the soil rhizosphere. *Glomus* was more resilient while *Entrophosphora* was more sensitive to tillage. 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

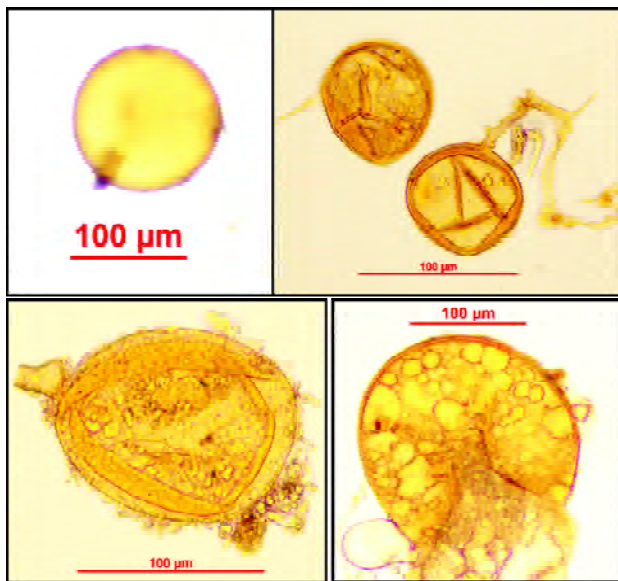


Fig. 8: Diversity of AM fungi in litchi

that is responsible for its adaptability and survival in different habitats.

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

Field experiment was laid out in October 2011 in a randomized block design with twenty treatments having components *viz.*, arbuscular mycorrhizal fungi (*Glomus mosseae*), *Azotobacter chroococcum*, *Bacillus megatarium* and *Trichoderma harzianum* to study the effect of combination of mycorrhiza, biofertilizers and biocontrol agent on growth and initial establishment of litchi. Three replications (one plant in each) were kept under each treatment. Vermicompost was applied in all the treatments @1 kg/plant. All the plants are surviving and growing well and the proposed observations are scheduled to be recorded from 2013.

The initial observations on three parameters *viz.*, no of leaves, no. of branches and girth were taken at two months interval (December 2012 and February 2013) indicated that all the biofertilizers had positive effect on growth and establishment of plants. The highest increase in all the parameters was observed with application of mycorrhiza.

### 5. Studies on initial microflora of mycorrhiza experimental plots

The microflora was enumerated by serial dilution technique. Population of *Trichoderma* and *Azotobacter* increased after planting. The mycorrhizae inoculated plants also showed colonization of roots of litchi plants. The microbial population will be monitored after inoculation with effect from July 2013.

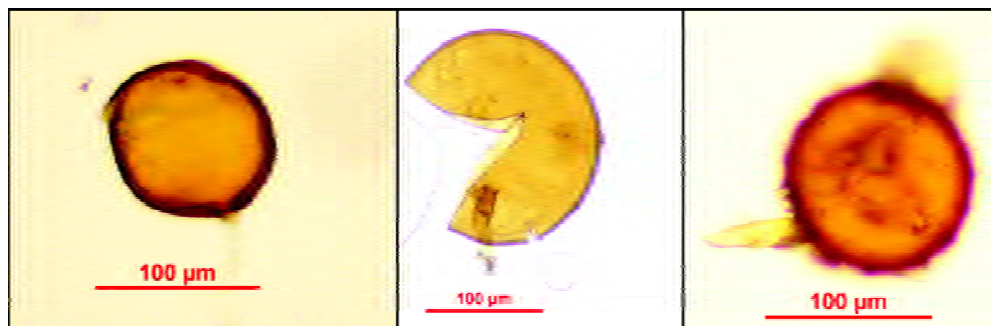


Fig. 9. A spore of *Glomus mosseae* (note funnel like subtending hyphae), *Acaulospora scrobiculata*, and *Entrophosphora infrequens* (Left to right)

## Theme Area 3 : Standardization of Plant Protection Technology

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

**Incidence and severity of pre-harvest diseases and their etiology :** In nursery plants, leaf blight was recorded as a prominent disease. The 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. 10). The pathogen was isolated and brought to axenic culture through single spore isolation. The morphological characteristics such as colony characters, dimension and shape of conidia and conidiophores were examined. In the front view, the colony appeared greenish black having concentric growth rings with white margin. In the reverse view, colony appeared blackish with concentric ring (Fig. 11). The fungus produced profusely branched, brownish, septate mycelia. Conidiophores arose singly or in small groups and were simple or branched. Conidia were oval to ellipsoidal, with 2-8 transverse and 1-3 longitudinal or oblique septa, tapering gradually to form a short swollen beak at the apex. Conidia had an overall length of 16.6-40.4  $\mu\text{m}$ , width at broadest part of 2.8-11.4  $\mu\text{m}$  and beak of 4.16-16.6  $\mu\text{m}$ . Based on these characteristics the pathogen was tentatively identified as *Alternaria alternata*. However, the confirmation of identification and the pathogenicity test under glasshouse conditions was to be being carried out.

The severity of 'leaf blight' in nursery plants was recorded on 7<sup>th</sup> July 2012 and 15<sup>th</sup> January 2013 February 2012 at NRCL farm and farmers' fields respectively. Disease incidence was calculated based on number of plants showing blight symptoms on leaves. Further, ten plants were selected in a nursery to record percentage infected leaflets, and 30 leaves in a nursery was scored individually for disease severity 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 during July 2012, in general the incidence, severity and percent infected leaflets were lower than in January 2013. The incidence, percent disease severity index (PDI) and % infected leaflets in nursery plants during July 2012 varied between 31.94-50.30, 15.55-52.96, and 7.1-100.0, respectively while it was 23.19-57.56, 62.59-83.33 and



Fig. 10: Field view of symptoms of leaf blight affected nursery plants

12.9-7.1, respectively during January 2013 (Table 18). Further, PDI and % infected leaflets were more in seedling plants than in gooties. Among the gooties of five different cultivars viz. Rose scented, Longia, Yogdapi, Purbi and Bedana the highest incidence (96.43%), severity (PDI 68.50%) and infected leaflets (46.67-93.75%) were in cv. Bedana.

The incidence of the "twig blight" disease was 44.5% to 61.8% during August 2012 at NRCL farm. The percent infected leaflets in a tree varied from 21.0 to 37.0 in two litchi blocks at NRCL farm. The percent leaf area damaged i.e. the PDI was in the range of 3.7 to 47.8. During October 2012 to March 2013, the incidence of the disease was less than 10% and severity was also low in various orchards. Pathogens consistently isolated from twig blight affected leaves were *Colletotrichum gloeosporioides* and *Gloeosporium* sp.



Fig. 11. Characteristics of the pathogen: Colony on PDA, A. Front view, B. Reverse view, C. Conidia

Table 18: Incidence and severity of leaf spots in nursery plants at NRCL farm during 2012

Name of the Block	Date of observation: 07.07.2012				Date of observation 15.01.2013			
	Disease incidence (%)	PDI in nursery plants	Plant number	Percent infected leaflets	Disease incidence (%)	PDI in nursery plants	Plant number	Percent infected leaflets
Nursery 1	35.00	52.96	1	60.7	44.12	63.33	1	31.4
			2	52.9			2	12.9
			3	66.7			3	27.2
			4	78.1			4	29.4
			5	39.5			5	76.2
			6	7.1			6	20.0
			7	19.1			7	15.0
			8	51.7			8	31.3
			9	31.3			9	35.5
			10	46.7			10	27.6
Nursery 2	31.94	31.48	1	61.9	23.19	62.59	1	90.0
			2	22.2			2	97.1
			3	37.5			3	84.5
			4	68.0			4	78.5
			5	48.4			5	85.7
			6	53.8			6	92.7
			7	75.0			7	92.1
			8	40.7			8	70.8
			9	30.0			9	90.5
			10	66.7			10	85.0
Nursery 3	49.00	40.37	1	25.9	29.27	67.03	1	70.0
			2	72.0			2	52.0
			3	56.7			3	83.3
			4	75.0			4	54.8
			5	48.3			5	61.9
			6	57.1			6	25.0
			7	75.0			7	81.8
			8	40.0			8	68.0
			9	64.0			9	90.0
			10	83.3			10	58.8
Nursery 4	36.66	34.07	1	13.3	32.67	78.88	1	85.2
			2	90.0			2	30.2
			3	60.0			3	78.6

			4	45.0			4	81.8
			5	26.7			5	52.6
			6	33.3			6	75.0
			7	100.0			7	34.6
			8	58.3			8	41.2
			9	25.0			9	77.8
			10	77.8			10	85.0
Nursery 5*	39.39	15.55	1	27.8	57.56	83.33	1	88.0
			2	65.2			2	80.0
			3	100.0			3	40.0
			4	81.0			4	60.0
			5	80.0			5	40.0
			6	48.3			6	78.6
			7	24.1			7	54.6
			8	84.6			8	88.9
			9	78.9			9	90.0
			10	35.0			10	66.7
Nursery 6*	50.30	34.44	1	100.0	27.10	72.22	1	50.0
			2	80.0			2	33.3
			3	68.4			3	69.0
			4	20.0			4	83.3
			5	31.6			5	68.8
			6	40.0			6	33.3
			7	100.0			7	30.0
			8	20.0			8	46.2
			9	64.7			9	42.5
			10	55.6			10	41.7

\*Seedling plants

The incidence of “anthracnose” caused by *Colletotrichum gloeosporioides* (Fig. 12) was observed on fruits at harvesting stage. The incidence of the disease was between zero to 10%. Besides this, sporadic occurrences of ‘bark splitting’ on main trunk of 5-8 year old plants, between collar zones to a height of 2-3 feet, were observed in various orchards.



Fig. 12: Anthracnose on litchi fruits

**Isolation and identification of the microflora associated with litchi tree diseases and their pathogenicity:** Characterizations of 26 fungal cultures that were isolated from samples of fruit drops and leaf spots were done. *Colletotrichum gloeosporioides* and *Oidium* sp. were found consistently associated with

fruit drops however its pathogenicity is yet to be confirmed.

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

This project is under suspended animation till any Entomologist joins the Centre. However, one of the activity i.e. “**Monitoring and surveillance of pest and diseases of litchi**” is being carried out under AICRP on subtropical fruits (Litchi Experiment 5.3.1).

The achievements under the approved activities have been presented :

The important pests recorded in the region were fruit and seed borer, leaf mite, leaf miner, shoot borer, leaf roller and bark eating caterpillar. Borer complex of litchi were most important as they extensively damaged the developing and matured fruits reducing the yields and marketability.

Surveys of litchi orchards revealed the occurrence of red weevil (*Apoderus blandus*) causing severe leaf damage on young shoots. It was bright brownish red in colour, about 5-7 mm in length and having elongated



snout. As a result of feeding, leaves dried up from the pricked parts giving scorched appearance to the twigs. Transverse puckering of affected leaves was also observed (Fig. 13). Young growing trees of less than five years old were highly damaged. Infestation of the weevil was observed throughout the year but was less during December and January due to extremely low temperature (<math>12^{\circ}\text{C}</math>) and during May-June due to high temperature (>math>34^{\circ}\text{C}</math>). Almost all the plants surveyed had incidence of red weevil. During 2012, the mean count per hundred leaflets varied from 5.0 to 43.6 (Fig. 14). The least count was during December and May while maximum was during March and September months of the year. Among young leaflets, up to 30% leaf area was damaged during the peak population of the insect.

Incidence/count of leaf roller was recorded at NRCL farm in five plantation blocks of litchi during November 2012. The observation was taken on ten plants in a block. In each plant, a portion of canopy was randomly selected having approximately 100 leaflets that were observed for number of rolled leaves/count. The results indicated that the mean number of count/100 leaflets varied between 7.90-11.62 and the number ranged between 5.3-21.0 (Table 19).

**Table 19: Incidence/ count of leaf rollers in the NRCL field during November 2012**

Block	Variety	No. of infested leaf or counts per 100 leaflets	
		Mean	Range
Block I	Shahi	11.62	7.3-19.3
Block II	Shahi	9.23	6.0-21.0
Block III	Shahi	8.10	6.7-13.3
Block IV	China	8.43	5.7-10.7
Block V	China	7.90	5.3-10.3



**Fig. 13: Symptoms of damage by red weevil (A, B) and the adult (C) (Enlarged)**

The outbreak of a semilooper pest was observed in September flush of litchi, both in farmers' fields in Muzaffarpur and East Champaran districts of Bihar,



**Fig. 14: Population of red weevil at NRCL Experimental Farm, Muzaffarpur during 2012. The least significant difference (P=0.05) for mean number of insects/100 leaflets was 1.27**

and at NRCL Experimental Farm. The larvae fed voraciously on lamina of young leaves leaving only the mid ribs and veins. It also sometimes fed on tender shoots. Within a week only bare rachis was left on the top canopy of plants.

The data on sixteen randomly selected farmers' fields during October 2012 indicated that incidence of semiloopers infested plants varied between 34.1 to 84.5%. The distribution of plants in four different levels of damage by semiloopers in these sixteen orchards is given in the Table 20. In different orchards, plants up to 30 percent damaged foliage were between 16.1-100% while in the 81-100% damaged foliage category there were up to 39.4% plants. Among the two widely cultivated litchi cultivars viz., *Shahi* and *China*, higher incidence and damage to foliage was observed in the cv. *Shahi*.

The period of occurrence of semiloopers in litchi was from September to November, the peak infestation being in October. In 2012, the mean temperature during

September, October and November were 25.3-32.2°C, 21.1-31.6°C and 11.3-23.5°C, respectively. Almost all the plants surveyed had infestation of semiloopers.

**Table 20. Incidence and damage to plants by litchi semiloopers during October 2012 in farmers' fields of Bihar**

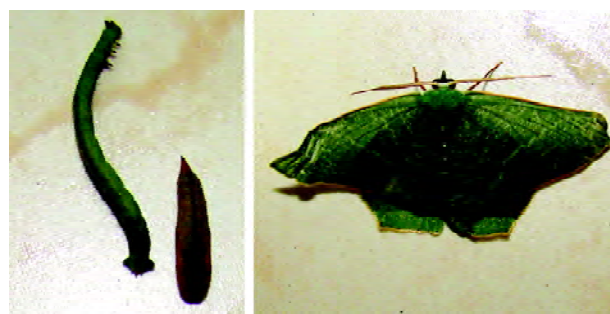
Orchard No.	Cultivar	% Incidence	Plants in different levels of foliage damage (%)			
			≤ 30%	31-60%	61-80%	81-100%
1	Mixed	56.9	26.8	18.3	31.7	23.2
2	Mixed	62.4	22.7	22.7	27.3	27.3
3	Shahi	72.0	17.5	21.4	22.3	38.8
4	Shahi	56.9	20.7	19.5	22.0	37.8
5	Shahi	59.7	23.3	25.6	23.3	27.9
6	Shahi	82.5	16.7	18.2	25.8	39.4
7	Shahi	84.5	23.3	26.7	28.3	21.7
8	Shahi	72.5	17.2	20.7	31.0	31.0
9	China	56.3	22.5	22.5	31.3	23.8
10	China	65.5	16.1	23.7	23.7	36.6
11	China	67.7	19.3	21.6	22.7	36.4
12	Shahi	81.3	25.0	28.8	26.9	19.2
13	Mixed	34.1	33.3	66.7	0.0	0.0
14	Mixed	43.1	45.5	36.4	9.1	0.0
15	Shahi	44.2	35.7	47.6	11.9	4.8
16	China	35.4	100.0	0.0	0.0	0.0

The data on larval count vis-à-vis percent damaged twigs during last week of October to first week of November 2012 in nineteen orchards is given in Table 21. It was evident from the data that the mean number of semiloopers larvae per 10 leaflets among the orchards significantly varied from 0.6 to 14.7. The highest count (19.8/10 leaflets) was in an orchard from Mahishi in East Champaran district of Bihar and in a litchi plantation block at NRCL Farm. The mean percent damaged twig among the orchards significantly varied from 3.8 to 79.0. The highest percent damaged twig was 88.1 in an orchard from Mahishi in East Champaran district of Bihar.

Based on morphological characteristics and developmental biology of pest, it was identified as *Anisodes illepidaria* Guenée (family Geometridae, order Lepidoptera).

A green caterpillar was also found feeding on litchi foliage. This is a slow feeder of younger leaves. The caterpillar looked like a green stick similar to the midrib of leaves that serve as a camouflage for the pest. The size of the caterpillar was 3-5 cm. While moving forward its body formed a loop. The newly emerged pupa was light brown in colour. The adult moth had green colour wings. Each wing had a faint darker band edged in white across the middle, and the hind wings had an angular margin. The moths had a wing span of about 3 cm (Fig. 15). Based on these characteristics it was identified as *Thalassodes pilaria* Guenée (family Geometridae, order Lepidoptera). The adult moths of this species are members of the group called 'Emeralds'. This species occurs across the south Pacific basin,

including Fiji, Society Islands, Tahiti, as well as Queensland in Australia. In all probability, so far this species had not been reported from India as pest of litchi.



**Fig. 15: The Green caterpillar, *Thalassodes pilaria* (larvae, pupae and adult)**



**Fig. 16: Bagworms feeding on a litchi leaf**





**Table 21: Count of semiloopers and percent damaged twigs in litchi at NRCL farm and farmers' field during October-November 2012**

Block/ orchard <sup>+</sup>	Location	Semiloopers count /10 leaflets		% Damaged twig	
		Mean*	Range	Mean**	Range
Block I	NRCL Farm	3.3 (1.82)	0.5 – 5.3	53.4 (46.91)	43.3 – 63.2
Block II	NRCL Farm	5.3 (2.30)	1.0 – 8.2	48.3 (44.04)	37.5 – 60.0
Block III	NRCL Farm	5.8 (2.41)	3.7 – 7.7	79.0 (62.75)	60.0 – 84.2
Block IV	NRCL Farm	7.0 (2.64)	2.3 – 11.3	56.2 (48.57)	47.1 – 66.7
Block V	NRCL Farm	7.3 (2.69)	4.3 – 10.2	46.1 (42.75)	40.0 – 58.3
Block VI	NRCL Farm	14.7 (3.82)	9.1 – 19.8	69.3 (56.38)	60.7 – 77.8
Block VII	NRCL Farm	6.6 (2.56)	4.1- 10.3	77.8 (61.93)	68.4 – 81.8
Block VIII	NRCL Farm	4.8 (2.20)	2.9 – 10.0	44.6 (41.87)	36.4 – 52.2
Block IX	NRCL Farm	5.0 (2.24)	3.2 – 8.3	56.8 (48.94)	53.9 – 66.7
Block X	NRCL Farm	6.3 (2.50)	3.1 – 9.0	62.5 (52.29)	57.9 – 72.7
Block XI	NRCL Farm	6.2 (2.49)	2.5 – 10.4	65.3 (53.92)	50.0 – 76.2
Orchard 1	Sabhapur	2.2 (1.49)	0.9 – 3.5	22.8 (28.50)	14.8 – 26.1
Orchard 2	Chhapra	1.6 (1.27)	0.6 – 1.3	22.8 (28.41)	13.0 – 23.8
Orchard 3	Tarora	4.6 (2.15)	3.5 – 5.8	13.0 (20.57)	7.0 – 22.2
Orchard 4	Raghunathpur	1.3 (1.14)	0.5 – 2.3	7.3 (15.61)	2.2 – 15.5
Orchard 5	Jhapahan	4.6 (2.14)	2.1 – 6.7	20.0 (26.54)	9.1 – 33.3
Orchard 6	Mahishi	0.6 (0.77)	0.2 – 0.9	8.1 (16.44)	4.6 – 13.0
Orchard 7	Mahishi	1.4 (1.18)	0.4 – 0.7	3.8 (11.23)	2.0 – 5.4
Orchard 8	Mahishi	13.3 (3.64)	10.2 – 19.8	75.1 (60.06)	56.7 – 88.1
LSD (P=0.05)		0.86	-	2.85	-

\* Orchard 1-5 is from Muzaffarpur and 6-8 is from East Champaran district of Bihar \* Data in parenthesis are square root transformed value \*\* Data in parenthesis are Arc Sine transformed value

The bagworm or encased caterpillar, the infestation of which was seen on few plants during December to February was identified as *Eumeta crameri* Westwood (Family: Psychidae, order: Lepidoptera) (Fig. 16).

Among the diseases at vegetative phase, leaf spot, twig blight and bark splitting were noticed in field. In nursery leaf blight was an important disease. The twig blight disease started appearing from August flush and continued up to February but the severity was low (PDI zero to 10%). Pathogens were isolated and its morphology and colony characteristics were studied.

## Theme Area 4 : Post-harvest Management and Value Addition

### 4.1. Standardization of maturity standards, harvesting and post harvest handling techniques for litchi fruits

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

Fruits treated with bavistin (0.05%) + 2% Citric acid + 500 ppm KMS and 1% chitosan and packed in recycled poly bag (doubled) gave minimum percentage of fruit loss (6.57%) on 4<sup>th</sup> days after harvest at ambient condition followed by LDPE packed fruits (7.77%) maintaining the other quality parameters (Fig. 17).

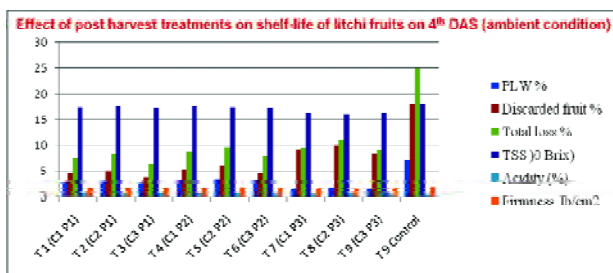


Fig. 17: Effect of post harvest treatment on shelf life of litchi fruits on 4th DAS at ambient temperature



Different poly bags and sulphitation was done for enhancement of shelf-life of litchi fruits (stored at at low temperature: 5 °C with 85 % RH) and data was recorded after 25 DAS. It was found that perforated Respiratory poly bag (RP) had minimum percentage of discarded fruits (5.88) and weight loss (1.04%) at 25 DAS, whereas the sulphited fruits with same poly bags and pre-treatments had 28.60 percent discarded fruits at 25 DAH (Fig. 18).

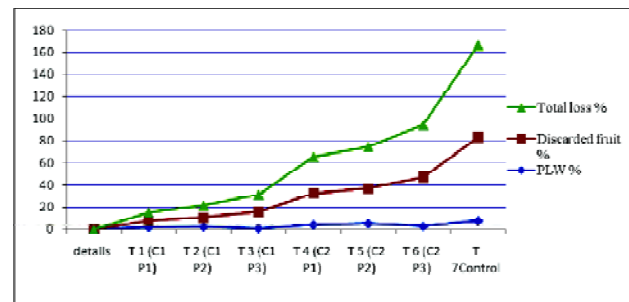


Fig. 18: Effect of packing of treated fruits of litchi at low temperature

#### 4.1.2. Standardization of maturity indices in litchi cultivars

Shahi and China litchi was assessed for directional variation of flowering, fruiting and fruit quality. Maximum shoot length was found in South direction of canopy in 'Shahi' litchi. The canopy of East direction had maximum number of leaves per branches, fruits per panicle, highest fruit weight, least fruit drop (8.60 %) with highest TSS. Hailstorm caused maximum damage to the fruits in west direction of the canopy. Maximum shoot length, no. of leaves per branches, fruit weight, pulp weight was recorded in East direction of canopy in 'China' Litchi. Number of fruit per panicle was recorded highest in west direction with least TSS. Fruit drops were least in South direction of canopy with highest TSS. Litchi cv. China and Shahi was evaluated for maturity indices and recorded 10 days lag in maturity of 'China' than 'Shahi' litchi. The fruits of 'Shahi' litchi were severely damaged (up to 90 percent) after hailstorm, China litchi showed only 30 percent damaged fruits. Most of the damaged fruits were recorded in west direction under the canopy of 'China' litchi and south direction of 'Shahi' litchi.

#### 4.1.3. Effect of different packaging and lining materials and other treatments on shelf life of litchi fruits

Three types of packaging materials viz. Wooden box, CFB box and Themocol box with different types of

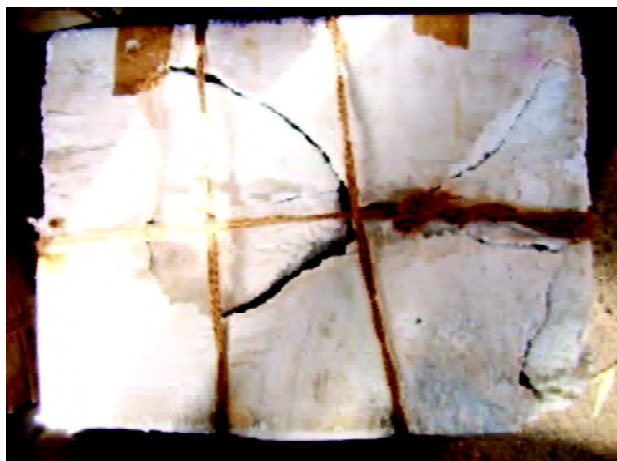


Fig. 19: Effect of different packaging and lining on shelf life of litchi fruits during distant transportation

lining material viz. litchi leaves, perforated poly bags (PP, LDP, RPB) were used to study their effect during transportation to Delhi. Unfortunately Themocol box packed treatments broken down during transportation, so compare were made between two types of packaging material. It was found that litchi fruits packed in polyethelene bags and kept in CFB boxes having only 15.60 percent discarded fruits whereas in traditionally packed fruits it was 26.56 percent 3rd day after harvest (DAH) at Delhi (Fig. 19).

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

It was observed that  $O_2 : CO_2 - 13 : 5$  percent gave satisfactory shelf life (12-15 days) at refrigerator where as at ambient condition the shelf life was 5-6 days only.

#### 4.1.5. Standardization of thermocol packaging for enhancement of shelf life of litchi fruits

Litchi fruits packed in Respiradatory Polythene / Low Density bag and kept in thermocol box containing 3 silica gel ice pads maintained the quality upto 5th days of storage (Fig. 20).



Fig. 20: Litchi fruits packed in thermocol boxes containing in Respiratory bags at 5th day of storage

#### 4.1.6. Post harvest browning of litchi fruit by water loss and its prevention by Pre-cooling and MA storage

Infrastructure are being developed to conduct this experiment with precise concentration of gaseous composition of N<sub>2</sub>, CO<sub>2</sub> and O<sub>2</sub> and low temperature storage after various pre-cooled litchi fruits.

### 4.2. Investigation and management of Post harvest losses in litchi

#### 4.2.1. Investigation of losses due to post harvest diseases and their management

**Studies on post-harvest losses in litchi at various stages of delivery chain :** A detail studies was conducted to assess the extent of losses at harvesting, wholesale market and retail levels during May-June 2012. Harvest level samples were collected from farmers' fields in Muzaffarpur district. Wholesale market samples were collected from Azadpur market, New Delhi after transportation by truck. The litchi consignment was sent from Muzaffarpur, Bihar and the cultivar was *Shahi*. The retail samples were collected from various venders at Inderpuri and Karolbagh market in Delhi and local venders of Muzaffarpur market in Bihar.

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. The results indicated that sunburn was 1.5- 44.5%, cracked fruits were 0.5-14.0% and physically or mechanically damaged fruits during harvesting were 0.0-44.1%. In some cracked fruits, there was visible green mould colonization. The incidence of fruit borer (0-5%) and anthracnose (0.0-10.0%) was low during 2012 season (Table 22).

The results indicated that the average loss (cracking + infected with visible mould growth) at transport level in Delhi (wholesale) market was 15.83%. At the level of retailers the losses varied from 3.64 to 8.91% at Muzaffarpur and 17.88 to 45.02% in Delhi retail market (Table 23, Fig. 21).



Fig. 21: Litchi on a cart of vender at Karolbagh Market, New Delhi

Table 22. Various types of losses at harvesting of litchi in farmers' field during May-June, 2012

Orchard number	Sunburn (%)	Cracked fruits (%)	Cracked with green mould (%)	Mechanical damage *	Anthracnose (%)	Fruit Borer (%)
1	7.2	4.1	0.0	44.1	0.0	0.0
2	5.5	4.5	0.0	5.0	0.0	0.0
3	8.0	7.0	1.0	5.0	3.0	5.0
4	27.5	14.0	1.0	6.0	10.0	0.0
5	5.5	3.0	0.0	0.0	0.0	0.0
6	22.0	12.5	0.0	10.5	0.0	0.0
7	44.5	7.0	0.0	0.0	0.0	0.0
8	1.5	0.5	0.0	7.5	0.0	0.0
9	7.5	1.0	0.0	7.5	0.0	0.0
10	4.0	1.0	0.0	10.0	0.0	0.0
11	18.5	12.5	0.0	10.0	0.0	0.0
12	20.0	8.0	0.0	6.0	0.0	0.0
13	20.0	6.0	0.0	5.0	0.0	0.0
14	24.0	0.5	0.0	5.0	5.0	2.0
15	18.0	2.0	0.0	17.5	0.0	2.5

\*Without pedicel/bruised



**Table 23: Various types of losses at retailers' level in different litchi markets during 2012 season**

Sample No.	Cracked fruits (%)	Infected visible mould growth (%)	Spoilage (%)	Browning (%)	Discarded (%)	Good (%)
Delhi						
Vender 1, Karolbagh Market	13.27	18.99	32.27	9.49	41.76	58.24
Vender 2, Inderpuri Market	8.78	9.10	17.88	0.00	17.88	82.12
Vender 3, Karolbagh market	15.46	29.56	45.02	27.94	72.97	27.03
Muzaffarpur						
Vender 1	8.91	0.00	8.91	0.00	8.91	82.18
Vender 2	3.64	0.00	3.64	77.27	80.91	19.09
Vender 3	8.11	0.00	8.11	18.92	27.03	57.66

**Isolation and identification of the pathogens and etiology of post-harvest fruit rots of litchi :** Samples from sulphated litchi fruits and litchi during storage were found to be spoiled due to colonization by *Alternaria* sp., while storage fruit rot was caused by *Alternaria* sp., *Colletotrichum gloeosporioidis* and *Aspergillus niger* (Fig. 23).

A low temperature tolerant strain of *Aspergillus flavus* spoiled the litchi juices stored in refrigerator. Its morphological characteristics and temperature tolerance was studied.



**Fig. 22: Post-harvest fruit rots caused by three pathogens, *Aspergillus niger*, *Alternaria* sp. and *Colletotrichum gloeosporioides* (Left to Right)**

### 4.3. Standardization of processing and value addition techniques in litchi

#### 4.3.1. Standardization of techniques in respect of temperature at various levels of litchi wine preparation and screening of yeast culture and their optimum dose

Fermentation at lower temperature (15 °C) gave higher concentration of compounds related to fresh and fruity aromas, like methyl propanol, ethyl ester (42.5mg/l) and total acetate (2.40mg/l) in litchi wine due to low sugar fermentation rate (0.61g/l/h).

#### 4.3.2. Standardization of techniques in respect of stage of harvest and duration of treatments for preparation of litchi nuts

The experiment was conducted for standardization of techniques for preparation of litchi nuts with 5 pre-treatments replicated four times. The result showed that the damaged nut percentage was in between 11.03 to 76.04%. The maximum damage percentage (76.04) was in case of boiling water pretreatment followed by dye treated fruits and minimum was found in case of KMS 0.1% followed by 2% citric acid treated fruits.

## Externally Funded Projects

### Externally Funded Project I: Conservation and Sustainable use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services

Under this project, the targeted crops are citrus and mango. The Project site is Pusa (Bihar) and the project communities are Mahamada, Jagdishpur, Murliyachak and Dhobgamma. Bhuskaul and Dighra were identified as control communities. MDST (Multidisciplinary Site Team), SMU (Site Management Unit) were constituted. The richness, divergence and evenness of diversity were studied for the project communities.

**Evaluation of seedling population of mango and citrus (pummelo):** Survey was conducted and 28 clones of mango were characterized for fruit physico-chemical characteristics from the farmer's field (Table 23). One late maturing clone and one clone with good shelf life were identified (Fig. 23-25).

Eight clones of pummelo were also characterized, but none was found suitable for further multiplication. Five clones confirmed the fruit characteristics as observed during the last year (Fig. 26) which shows the stability in genotype.



Fig. 23: Mango clone with good keeping quality



Fig. 24: Mango clone with quality fruits for table purpose



Fig. 25: Late maturing mango clone No. 77 (August-September maturity)



Fig. 26: Confirmation of Quality fruits production in the pummelo clone



Table 24: Characterization of mango seedlings

Fruit characters	Number of genotypes (%)	Fruit characters	Number of genotypes (%)
<b>1. Fruit colour</b>		<b>4. TSS (<sup>o</sup>Brix)</b>	
a). Green	6 (21.43)	a). <15.00	11 (39.29)
b). Yellow	10 (35.71)	b). 15.01-18.00	13 (46.43)
c). Dark yellow	5 (17.86)	c). 18.01-21.00	4 (14.29)
e). Orange	2 (7.14)	d). 21.01-24.00	0 (0.00)
f). Dark orange	4 (14.29)	f). >24.01	0 (0.00)
g). Red	1 (3.57)		
h). Dark Red	0 (0.00)		
<b>2. Fruit wt. (g/fruit)</b>		<b>5. Seed wt. (g/seed)</b>	
a). < 100g	1 (3.57)	a). <30.00g	5 (17.86)
b). 101-150g	3 (10.71)	b). 30.01-35.00g	7 (25.00)
c). 151-200g	6 (21.43)	c). 35.01-40.00g	5 (17.86)
d). 201-250g	6 (21.43)	d). 40.01-45.00	5 (17.86)
e). 251-300g	8 (28.57)	e). 45.01-50.00	2 (7.14)
f). 300-350g	3 (10.70)	f). >50.01g	4 (14.29)
h). >350g	1 (3.57)		
<b>3. Length : Breadth</b>		<b>6. Percent edible portion</b>	
a). <1.00	0 (0.00)	a). <50.00	4 (14.29)
b). 1.01-1.20	6 (21.43)	b). 50.01-55.00	0 (0.00)
c). 1.21-1.40	11 (39.29)	c). 55.01-60.00	5 (17.86)
d). 1.41-1.60	6 (21.43)	d). 60.01-65.00	7 (25.00)
e). 1.61-1.80	4 (14.29)	e). 65.01-70.00	8 (28.57)
f). >1.80	1 (3.57)	f). >70.01	4 (14.29)

#### Identification, multiplication and distribution of elite types of red and low/nil bitterness pummelo:

Seven clones of pummelo and four of mango were propagated vegetatively for their detailed evaluation and distribution among the farmers of the project communities. Around 450 air-layers were prepared in seven pummelo clones and about 300 mango grafts were prepared from the four selected clones of mango. Two hundred and fifty five seedlings of rough lemon were collected from NRC Citrus, Nagpur and 250 pummelo seedlings were raised for pummelo grafting. Further 2600 seeds of pummelo were sown for raising rootstock seedlings. Additionally, 300 seedlings of mango were also raised in the nursery for grafting of selected mango clones.

The successful grafts of the four mango selected clones are growing in the nursery satisfactorily and these include Chandeshwar Prasad Singh (3 plant), Upender Thakur (2 plants), Kailash Prasad Rai (4), Gaya Prasad Singh (8 plants). Further, grafting was also done in one mango clone from Gaya Prasad Singh (19/60).

Pummelo grafting (Fig. 27) was also done from the plants of Jagdish Das (1/20) and Ram Kumar Rai (2/40). The gooties of the clones from Tribhuwan Thakur (18) and Manoj Tahkur were also planted in the nursery.



Fig. 27. Grafting in pummel

#### Capacity Building on propagation methods in Mango and Pummelo :

A training programme was organised on 20<sup>th</sup> March, 2013 at two villages of Pusa Site [Under UNEP-GEF Project] namely Mahamada (at 8.30-11.30 AM) and Jagadishpur (2.30-5.30 PM), Pusa, Samastipur Bihar. The training was based on feedback received [from mango and pummelo growers] while preparation of profiles of custodian farmers and same presented in the workshop recently held at New Delhi.

While imparting training we had given reading material in *Hindi* to every participant on following topic:

- 1) Propagation in citrus fruits (by budding and air layering)

- 2) Mango propagation (by softwood as well as veneer grafting)
- 3) Rejuvenation techniques of old and senile Mango orchards.
- 4) Monthly operation to be performed in well established mango orchards.
- 5) INM techniques in Pummelo

The training was organised in the morning at Mahamada and in the afternoon at Jagdishpur and about 50 [adding number from both the places] farmers took part in training programme. Most of the farmers were given lecture [in brief] on Principle and Practices of propagation technique in mango and pummelo. The expert also demonstrated the technique of selection and excision of scion material from mother plant and immediately to be grafted on rootstock. Softwood grafting and Veneer grafting in Mango and forkert budding and air layering in Pummelo were main focus techniques learnt by the growers (Fig. 28 a, b). They were also supported by GAPs in mango and pummelo, as they are practicing in their orchard. Farmers were asked to propagate as maximum no. of plants in coming monsoon season of elite mango/pummelo varieties selected under this project.



**Fig. 28:** Farmers are being trained on a.) Propagation techniques in Mango and Pummelo, b) Mali is imparting training on selection of scion sticks vis-a-vis growers are getting hand-on experience

**Training of women groups on pickle making:** Two training programmes on pickle making were conducted at Jagdishpur on 7<sup>th</sup> July, 2012 and at Mahmada on 23<sup>rd</sup> July 2012 (Fig. 29). Twenty five women, each from these villages participated in the programme. Different types of pickle were prepared with the main base from seedling mango fruits.



**Fig. 29:** Pickle making training at Jagdishpur and Mahmada

**Generation of awareness about Good Practices for Diversity Conservation (GPD):** Eight Good Practices for Diversity conservation were identified and sent for piloting to the National Coordinator of the UNEP/GEF TFT Project. One GDP on “Home or Kitchen gardening is in the process of publishing”. The GDPs identified included: multi fruit planting in the field, multi variety planting of a fruit, planting of seedlings along with the grafted plants of mango, kitchen gardening, intercropping, non-interculture & no input use, *puja* celebrations, brown bagging and seed distribution among farmers and relatives, maintenance of sacred groves, etc.

**Rejuvenation of old mango orchards:** Two very old orchards (>50 years) of mango at Jagdishpur village, having a large diversity of mango were





rejuvenated to make them profitable to the custodian farmers as well as the conservation of the diversity, which is depleting at a greater pace (Fig. 30).



**Fig. 30: Rejuvenated mango orchard**

**Alternate uses and value addition for maintenance of diversity:** A consignment of pummelo fruits was sent to Hyderabad (distant market) with a view to improve its utilization and making its cultivation remunerative to the farmers. The response of the farmers was very good as they could make a lot of profit from the sale of pummelo fruits, which are presently used for the *Chhath Puja* celebrations only.

**Development of home gardens with new and old biodiversity:** The identified clones of mango and pummelo were multiplied and will be distributed among the farmers of the project communities. Three sites have been identified in Samastipur district for the planting of diversity orchards.

### **Externally Funded Project II: 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)**

This scheme was sponsored by ICAR to get the acquaintance with of the IPR regime. 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 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. There should

be proper implementation of IPR guidelines at the Institute level. Keeping these points in view, the NaCL has compiled and prepared the technology profile of the centre and submitted to BPD Units. We have also participated in various *Exhibitions/Conference/Melas* for showcasing and commercialization of technologies (Fig. 31).



**Fig. 31: Scientist explaining the post harvest technology to Business Incubators during the BPD meeting**

The centre has also conducted/or organized ovarious meeting with traders/processors/entrepreneurs for commercialization of technologies developed by NRCL. Timely submission of monthly RFD related to ITMU was done to BPD units.

### **Externally Funded Project III: Network project on "Application of Microorganisms in Agriculture and Allied sectors (AMAAS) subproject "Harnessing arbuscular mycorrhizae for biofertilization in horticultural crops"**

On the broader theme of mycorrhizal association and biofertilizers, the centre has an institute project "Investigation on mycorrhizal association and role of biofertilizers for sustainable production of litchi". Hence, both the works are complimenting to each other and has been presented under the institute project.

### **Externally Funded Project IV: “Development of National Database on Mango”. (Sponsored by Department of Biotechnology, GOI, New Delhi)**

Following work are being initiated under this project for for all 38 districts of Bihar:

- 1) Survey of mango orchard, data collection and documentation on traditional/regional/extant mango varieties.
- 2) Collection and digitization of passport data and morphological/molecular characterization of regional, extant and farmer’s varieties of mango.
- 3) Documentation of field gene bank, traditional knowledge, usages database, package and practices, post harvest technology of mango.

### **Externally Funded Project V: Mega Seed project on Seed production in Agricultural crops and Fisheries**

The centre is maintaining nine commercial cultivars of litchi viz (Shahi, Rose scented, Longia, China, Mandraji, Swarnrupa, Purbi, Bedana and Yogda selection) for round the year propagation of litchi planting materials. From the experimentation best time for making the air-layers in litchi plants in 2-3<sup>rd</sup> week of June followed by 2<sup>nd</sup> week of January as off season propagation. In the present year the centre made 44000 of litchi gooties and out of which 41050 layers were taken out and planted in the polyethylene bags. Finally 34000 well rooted planting material of litchi cv. Shahi and China were made available for commercial sale. A sum of Rs. 5,36,870.00 has been generated during the year apart from maintaining the expenditure of Rs. 4,97,975.00 During the period the centre has refunded the money of the share of Rs. 2,00,000 aslo with intimation to the DSR, Mau.



## Human Resource Development

### Participation of Scientists/Staffs in Conference/Courses/Workshops/Symposia/Seminars Training/Meetings during 2012-13

Sl. No.	Title	Venue and Date	Name of the participant
1.	Technical training on 'Litchi and Mango Orchard Management for Enhanced Quality Fruit Production'	Patna 27 <sup>th</sup> April, 2012	Dr. Rajesh Kumar
2.	Executive Council Meeting of HSI	NASC, Complex New Delhi 5 <sup>th</sup> May 2012	Dr. Vishal Nath
3.	Orientation training on Methods of updation, creation and uploading of database related information on PERMISNET, PIMS and HYPM'	IASRI, New Delhi 8 <sup>th</sup> May, 2012	Dr. Sanjay Kumar Singh
4.	National Seminar on 'Plant Genetic Resources for Eastern and North-eastern India'	ICAR Research Complex for NEH Region, Umiam, Meghalaya 11-12 <sup>th</sup> May, 2012	Dr. Awtar Singh
5.	National Seminar on Horticulture	College of Engineering Roorkee 12-13 May, 2012	Dr. Rajesh Kumar
6.	Brain storming session on "Water use potential of flood affected and drought prone areas of Eastern India'	ICAR-RCER, Patna 14 <sup>th</sup> May, 2012.	Dr. Vishal Nath
7.	"Global Conference on Horticulture for Food, Nutrition and Livelihood options"	OUA&T, Bhubaneswar 28 <sup>th</sup> -31 <sup>st</sup> May, 2012	Dr. Vishal Nath Dr. Rajesh Kumar Dr. Sanjay Kumar Singh
8.	Workshop on "Bagicha Bachao Abhiyan"	Muzaffarpur 4 <sup>th</sup> June, 2012	Dr. Vishal Nath Dr. S. D. Pandey
9.	7 <sup>th</sup> Research Council Meeting (Kharif): 2012	RAU, Pusa, Samstipur 14-15 <sup>th</sup> June, 2012	Dr. Vishal Nath
10.	Annual Technical Review and Planning Meeting, UNEP-GEF Project	NRC on Litchi, Muzaffarpur 22 <sup>nd</sup> June, 2012.	Dr. Vishal Nath Dr. Awtar Singh Dr. Sanjay Kumar Singh
11.	4 <sup>th</sup> NPSC Meeting, UNEP-GEF Project	NRC on Litchi, Muzaffarpur 23 <sup>rd</sup> June, 2012.	Dr. Vishal Nath Dr. Awtar Singh Dr. Sanjay Kumar Singh
12.	Seminar on 'Right to information Act-2005'	ISTM, New Delhi. 29 June, 2012	Dr. Vishal Nath
13.	Meeting for finalization of action plans for UNEP/GEF Project and GPDs	Biodiversity International, NASC Complex, New Delhi. 10 <sup>th</sup> July, 2012	Dr. Awtar Singh
14.	"Protocol for mycorrhizal studies and its identification"	College of Biological Science and Humanities, GBPUA&T, Pantnagar 23 <sup>rd</sup> -28 <sup>th</sup> July, 2012.	Dr. Vinod Kumar

15.	Training on CA and MA storage works on tropical and subtropical fruits	IIHR, Bangalore 17 <sup>th</sup> - 18 <sup>th</sup> August, 2012	Dr. Sushil Kumar Purbey Dr. Sanjay Kumar Singh
16.	Knowledge Meet - 2012	NASC, New Delhi 21-22 August, 2012	Dr. Vishal Nath
17.	National seminar on 'Possibilities of fruit processing and cultivation of fruit crops in Eastern Uttar Pradesh'	Directorate of Horticulture, Uttar Pradesh 4 <sup>th</sup> September, 2012	Dr. Vishal Nath Dr. S.D. Pandey
18.	"Agricultural Education Day"	Central School, Muzaffarpur 6 <sup>th</sup> September, 2012.	Dr. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. Amrendra Kr. Dr. Vinod Kumar Dr. S. K. Pandey
19.	MDP training programme	NAARM Hyderabad 11 <sup>th</sup> - 17 <sup>th</sup> September 2012	Dr. S.D.Pandey
20.	Meeting for 'Introduction of Bioersity International, TFT project NPMU staff and Site Coordinators, to Secretary (DARE) and DG (ICAR) and DDG (Hort.), ICAR.	Bioersity International, New Delhi 18 <sup>th</sup> September, 2012	Dr. Awtar Singh
21.	Training on "Preparation of Agromet Advisory Services and Use of Weather Data" under AICRP on Agro-meteorology	CRIDA, Hyderabad 24 <sup>th</sup> - 25 <sup>th</sup> September, 2012	Dr. Rajesh Kumar
21.	Velidictory function of Winter School on Underutilized Horticulture	CIAH, Bikaner 25 September, 2012	Dr. Vishal Nath
22.	"Agri-Tech Exhibition" (organized by ITMU, BPD unit, East Zone)	NIRJAFT, Kolkata 25 <sup>th</sup> - 26 <sup>th</sup> September, 2012	Dr. S.K. Purbey
23.	23 <sup>rd</sup> IMC meeting of Central Institute of Sub-tropical Horticulture (CISH), Lucknow, U.P.	CISH, Lucknow 28 <sup>th</sup> September, 2012	Dr. Rajesh Kumar
24.	National Training on Use of simulation modeling in climate change research : with special reference to natural resource management	Indian Institute of Soil Science, Bhopal 3 <sup>rd</sup> -12 <sup>th</sup> October, 2012	Dr. Rajesh Kumar
25.	Agro-Expo 2012	ICARRC ER, Patna 11 <sup>th</sup> -13 <sup>th</sup> October, 2012.	Dr. S.K. Purbey
26.	Interactive dialogue on "Dynamics of Nutrient Management in Horticulture Crops"	Fertilizer Association of India, New Delhi 26 <sup>th</sup> October, 2012.	Dr. Vishal Nath
27.	CAFT Training Programme on "Current Biochemical and Molecular Techniques for Nutritional Enhancement and Stress Tolerance in Crop Plants"	Division of Biochemistry, IARI, New Delhi. 01 <sup>st</sup> -21 <sup>st</sup> November, 2012	Dr. Sanjay Kumar Singh
28.	3 <sup>rd</sup> National Symposium on "Agriculture Production and Protection in Context of Climate Change"	BAU, Ranchi 3 <sup>rd</sup> - 5 <sup>th</sup> November, 2012	Dr. Vinod Kumar
29.	5 <sup>th</sup> Indian Horticulture Congress 2012: Horticulture for Food and Environment Security	PAU, Ludhiana 6 <sup>th</sup> - 9 <sup>th</sup> November, 2012	Dr. Vishal Nath Dr. Rajesh Kumar
30.	Meeting of RFD Nodal officers of RSC	Horticulture Division KAB-II, Pusa, New Delhi 23 <sup>rd</sup> November 2012	Dr. Vinod Kumar



31.	4 <sup>th</sup> International Symposium on 'Lychee, Longan and Other Sapindaceae Fruits'	White River, South Africa, 2 <sup>nd</sup> - 6 <sup>th</sup> December 2012.	Dr. Rajesh Kumar
32.	PME Workshop	NDRI Karnal 08 <sup>th</sup> December, 2012	Dr. S.D.Pandey
33.	"Production Protocol for Bioagents and Quality Assessment and Quality Management of Microbial Biopesticides"	National Institute of Plant Health Management, Hyderabad 10 <sup>th</sup> - 30 <sup>th</sup> December, 2012	Dr. Vinod Kumar
34.	National Consultation on Management of Horticulture Genetic Resources	NBPGR New Delhi 18-19 <sup>th</sup> December, 2012	Dr. Vishal Nath
35.	Annual Technical Review and Planning Meeting, UNEP-GEF Project	Sirsi, Karnataka 5 <sup>th</sup> January, 2013	Dr. Awtar singh
36.	5 <sup>th</sup> NPSC Meeting, UNEP-GEF Project	Sirsi, Karnataka 6 <sup>th</sup> - 7 <sup>th</sup> January, 2013	Dr. Vishal Nath Dr. Awtar singh
37.	"National Seminar on Tropical and Subtropical Fruits"	Navsari Agricultural University, Gujarat 9-11 <sup>th</sup> January, 2013	Dr. Rajesh Kumar Dr. Vinod Kumar
38.	Meeting of RFD Nodal officers and Directors of institutes	Horticulture Division KAB-II, Pusa, New Delhi 16 <sup>th</sup> January 2013	Dr. Vishal Nath Dr. Vinod Kumar
39.	Workshop of Custodian Farmers of Agricultural Biodiversity on Tropical and Sub-tropical fruits under UNEP-GEF Project	NASC, New Delhi 11 <sup>th</sup> - 12 <sup>th</sup> February, 2013	Dr. Sanjay Kumar Singh
40.	Industry/Farmer Interaction Meet	Amarpur, Navgachhiya, Bhagalpur 16 <sup>th</sup> March, 2013	Dr. Vishal Nath Dr. S. K. Purbey Dr. Amrendra Kumar
41.	Bihar Divas- 2013	Patna 24 <sup>th</sup> March, 2013	Dr. S.D.Pandey
42.	Agricultural Technologies and Media Meet	CISH, Lucknow 30 <sup>th</sup> March, 2013	Dr. Rajesh Kumar
43.	24 <sup>th</sup> IMC meeting of Central Institute of Sub-tropical Horticulture (CISH), Lucknow, U.P.	CISH, Lucknow 30 <sup>th</sup> - 31 <sup>st</sup> March, 2013	Dr. Rajesh Kumar

## Meetings/Workshops/Events organized by NRCL

During 2012-13, a good number of meetings, workshops and other events were organised by NRCL for creating awareness about litchi among farmers and dissemination of improved technology. The details

have been given in following table however some of the events have been enumerated with action photographs.

Sl. No.	Name of Event	Date	Venue	Convenor/ Co-Convenor
1.	'Farm Innovators' Day	9 <sup>th</sup> April 2012	Shahbazpur, Kanti, Muzaffarpur	Dr. S. D. Pandey
2.	"Nagar Rajbhasha Karyanwayan Samiti" Meeting	4 <sup>th</sup> May, 2012	NRCL, Muzaffarpur	Dr. S. K. Purbey
3.	Foundation Day cum "National Litchi Show cum Kishan Gosthi"	6 <sup>th</sup> June 2012	NRCL, Muzaffarpur	Dr. Amrendra Kumar
4.	Workshop on Good Agricultural Practices in Litchi	2 <sup>nd</sup> - 8 <sup>th</sup> July 2012	NRCL, Muzaffarpur	Dr. S. D. Pandey
5.	Litchi Awareness Programme	14 <sup>th</sup> June 2012	Ramkola, Kushinagar, UP	Dr. S. D. Pandey
6.	Litchi Udhyamita Vikas Hetu Pruning and Rejuvenation (2 Nos.)	2 <sup>nd</sup> - 8 <sup>th</sup> July, 2012 30 <sup>th</sup> Oct. - 4 <sup>th</sup> Nov., 2012	NRCL, Muzaffarpur	Dr. S. K. Purbey
7.	Training on 'Rejuvenation and Good Agricultural Practices'.	2 <sup>nd</sup> August, 2012	NRCL, Muzaffarpur	Dr. Rajesh Kumar
8.	"Agriculture Education Day"	6 <sup>th</sup> September 2012	Central School, Gannipur Muzaffarpur	Dr. Rajesh Kumar
9.	Training on "Rejuvenation of old orchards"	31 <sup>st</sup> October - 04 <sup>th</sup> November, 2012	NRCL, Muzaffarpur.	Dr. S. K. Purbey
10.	Field Training of 50 litchi growers	29 <sup>th</sup> January 2013	Rajkhand Gayghat, Muzaffarpur	Dr. S. D. Pandey
11.	Field Training programme	25 <sup>th</sup> February 2013	Motihari, Bihar	Dr. Rajesh Kumar
12.	Exposure visit and training to Litchi growers of East Champaran	28 <sup>th</sup> February, 2013	NRCL, Muzaffarpur	Dr. Rajesh Kumar
13.	Training programme on Rejuvenation and Good Agricultural Practices	4 <sup>th</sup> - 6 <sup>th</sup> March, 2013	NRCL, Muzaffarpur	Dr. S. D. Pandey
14.	Field day on Farmer's field	16 <sup>th</sup> March, 2013	NRCL, Muzaffarpur	Dr. S. D. Pandey
15.	"Farmers Field Day"	22 <sup>nd</sup> March, 2013	Nayanagar, Samastipur	Dr. Rajesh Kumar
16.	Field visit of group of farmers of Sidharth Nagar UP	24 <sup>th</sup> March 2013.	NRCL, Muzaffarpur	Dr. Amrendra Kumar

### Farmer's Innovator's Day

The Centre has organized Farmer's Innovation Day at Shahabajpur Village of Muzaffarpur district with theme 'Organic production of litchi' on 9<sup>th</sup> April 2012. More than 125 farmers and traders attended the *gosthi* and a group of scientists of NRCL along with Director were participated. Very fruitful discussion was made with farmers during question - answer session.

### Foundation Day

On the occasion of 'Foundation Day' of the Centre, an All India Litchi Show, 2012 and *Kisan Gosthi* was organised at the Centre on 6<sup>th</sup> June, 2012. More than 100 entries carrying atleast 50 number of fruits were displayed by the litchi growers of the region (Muzaffarpur, Samastipur, Vaishali, East Champaran and Sitamarhi). The best litchi fruit producer were awarded in different groups of litchi cultivars.. The centre has also displayed various products prepared at the centre. In this *gosthi*, about 185 progressive farmers were participated and involve in discussion. Most of the grower's problems were discussed at length.



Foundation day cum Litchi show on 06th June 2012

## Field Day

The Centre has organized 'Field Day' at Rajkhand, Gayghat, Muzaffarpur on 29<sup>th</sup> January 2013. More than 50 litchi growers participated in the field activity. A group of scientists of NRCL took part in the training and interaction programme with the litchi growers/entrepreneurs.

Another 'Field Day' was organised at the farmer's field of Bihpur, Naugachhia, Bhagalpur on 16<sup>th</sup> March, 2013. More than 125 farmers attended the *kisan gosthi*. A field demonstration was done on production of quality litchi fruits and maintenance of orchard through canopy management, water management, increasing FUE, management of fruit drop/cracking etc. The Director along with two scientists of NRCL were participated and taken feedback of the farmers.



Training on Rejuvenation of Litchi and Mango at NRCL

## Outreach Programmes by NRCL across the States

### Interface Meeting of ICAR Scientists, Horticulture Officers and Farmers at Rayagada, Odisha

A team consisting of Scientists of ICAR, namely Dr. G.S.Prakash, Ex HOD, Fruit crop, IIHR Bangalore, Dr. H.S.Singh, Head, CHES-IIHR, BBSR, Dr. R.A. Marathe, Principal Scientist, NRC for Pomegranate, Solapur (MS), Dr. S.D.Pandey, Principal Scientist, NRC for Litchi Mujaffarpur, Dr. Raju M. Kurien, Principal Scientist, IIHR, Dr. A.D.Huchche, Principal Scientist, NRC for Citrus Nagpur and DDH Rayagada District and 6 progressive farmers conducted a joint visit to Kashipur area on 02.04.13 and 03.04.13 in different pockets namely Mandavisi, Sunger, Sharambhai, Bandal, Sindurghati, Bhitarsunger, Prajashila, kumarshila and some fields along the roadside in order to oversee the existing mango plantation, canopy management practices, and assessment for further scope of fruit crop diversification in the area. In the process, drip irrigated pomegranate plantation and old orchard of orange were also visited.

An interface meeting was held under the chairmanship of Dr. G.S Prakash at Rayagada. Scientists, PD, and they pointed out that fruit crops like Mango, Cashew which are grown in Rayagada and Koraput District need scientific backup for sustenance in terms of various aspects. They also emphasized for fruit diversification with crops like Litchi, Pomegranate, pine apple, Orange and to some extent Grapes as the local climate is indicative of their suitability. The need of cropping system models, mango canopy management, mite management in litchi, and introduction of kinnow, oranges, pomegranate and grapes was emphasized.



Interface meeting at Rayagada, Odisha

### Status of Litchi in Western Uttar Pradesh

Uttar Pradesh is potential State for litchi production. Presently, the state occupies about 10%

area and production of the country. The major litchi growing areas in the state includes eastern districts like Kushi Nagar, Gorakhpur, Mahrajganj, Basti, Sidharth Nagar and western districts like Saharanpur, Meerut, Bulandshahar, Hapur etc. New areas in the foot hills of Himalayas like Pilibhit, Sitapur etc. are also seem to be promising as some entrepreneurs have already started plantations.

Keeping this in view a visit was made during October, 2012 to Hapur, Meerut and Saharnapur districts. Few sites were visited with state department officials and Sh. R. P. Singh, a progressive farmer and IMC Member.



(1)



(2)

Interaction with farmer's/Stakeholders in Shahjahanpur, Meerut (1) Discussion with young entrepreneurs regarding good Management practices in litchi (2) Explaining the benefits of Centre opening in grown-up litchi plants

The important observations made during visit are as follows:

- 1) In Shahjahanpur area of Meerut, the plantations of litchi are very good but the farmers do not have idea about canopy management, hence they need exposure on various aspects of Canopy management.
- 2) The farmers showed there inability to grow inter crops and manage pest problem in orchards.



They were advised to follow the orchard management schedule and growing shade loving crops in interspaces.

- 3) The height of plant at some places seems to be very high which often hinders the pest management and hormone application. They were advised to go for Centre opening and pruning to make the plants more productive. But the farmers need a training and practical demonstration camp at one or two places to make them aware of good management practices.
- 4) In Saharanpur, farmers are now planting litchi at 6x6m spacing with good initial frame. The orchards need constant monitoring for having a balance between vegetative growth and flowering. It was advised that under any conditions, the plant should not be allowed to grow more than 3 m in height and 2.0-2.5 m canopy radius which can be done through regular pruning after harvesting.

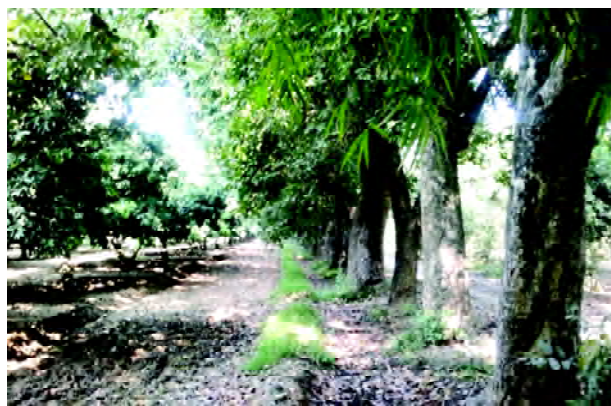
**The Action Plan:** NRC on Litchi will conduct an awareness meeting with KVK, Saharanpur, some nodal farmers in Saharanpur and Meerut for better technology adoptions and confidence building.

### Status of Litchi in Punjab

Punjab is a potential state as far as litchi is concern. The state enjoys the advantage of its proximity to Delhi and availability better infrastructure for agriculture. Presently, about 1600 ha area in the state is under litchi with main concentration in Pathankot, Gurdaspur, Hoshiyarpur and parts of other districts adjoining to river Rabi. The state has the highest productivity of 14.1 tonnes/ha in the country. The reasons for higher productivity in the state have been analyzed by visiting the litchi production area of Gurdaspur, Deena Nagar, Nangal, Kidikhurd, Vanilad, Sujampur, Manwal and Pathankot with



Interaction with Farmers/Scientists at ZRS Gurdaspur



Provision of wind break in systematic litchi orcharding

Dr. V.J. Singh and two other scientists of KVK, Gurdaspur in November, 2012. The reasons for higher productivity in the area have been attributed to favourable climate and soil and better orchard management. The following observations had been made during visit.

- Most of the plants in the area are in highly productive age (30-35 years) with good orchard management.
- The soil of the litchi growing belt is mainly deposit soils with 1-1.25m depth below which the pabells of stone mixed with humus rich soils are present which provides better root growth and aeration.
- The area is near to foot hills and also adjoining to J&K and H.P. and therefore, the climate during ripening is not becoming very harsh.
- Although the farmers are taking better care of plants but few orchard management practices like centre opening, pruning immediately after harvest, and spray of hormones are not being followed because of lack of knowledge.
- Although the SAU/ZRS has some good plantations at Gurdaspur but the proper technology demonstration will help farmers further increase of production.
- Few more potential areas such as Makeria, Batala, Budewala needs to be brought under systematic litchi orchards for which the state horticulture mission and PAU are making all efforts and supplying altogether 30-35 thousands plant every year.

**Proposed Action:** Since Punjab is an upcoming potential state as far as litchi is concern, training programme at farmers field in collaboration with PAU, Ludhiana, SKUAST, Jammu and HPKV can be taken up at appropriate place in the season.

## Status of Litchi in Kerala

Kerala has the advantage of excellent weather conditions due to western Ghat which helps grow a wide range of tree species. Litchi is one of them which was planted by some a matures nearly 50 years back. The Waynad and Iduki districts which has an elevation of 1000 msl, modest temperature of 11.0°C-37.0°C and high relative humidity (70-90%) has shown promise for good litchi plant growth and yield. Being proximity to Southern hemisphere the area has an added advantage of flowering during monsoon (September) and fruit ripening during winter (December) when the main litchi crop in country (May-June) is not available. The visit was made in January 2013, and the preliminary observations are as follows.

- The plant growth in the area is quite high which may be due to congenial conditions for plant growth round the year.
- The yield potential as told by the farmers is as high as 400-500 kg/plant which quite possible seeing the plant growth.
- The fruit quality is also at par which is depicted by 19° Brix TSS of pulp and small seed resulting in to high pulp recovery along with attractive peel colour.



**Litchi plants in full bearing at waynad, Kerala, and Director, NRCL interacting with Litchi growers**

- The soil of the area is acidic in nature and at many places in Kelpetta, Vithree, Mepadi was clayey in nature.
- Due to high humidity, the attack of Litchi mite and coccids seems to be limiting factor.

While discussion with farmers, they expressed their concerns on following aspects for which appropriate measures were suggested.

- Rain at flowering washes flowers.
- Heavy fruit drop at pin head stage.
- Fruit fly and borer at ripening stage.
- Sourness of pulp.
- Browning of peel in 3-4 days of harvest.

## Proposed Action

The litchi can be grown in the area with good pit preparation, filling and addition of lime for ensured plant establishment and growth. The shady places should be avoided for litchi plantations. The measures should be adopted to restrict the excessive vegetative growth, fruit and flower drop and enhancement of fruit quality. Interaction of farmers and officials of University/State Department with NRC on Litchi for technical knowledge should be conducted on routine basis.



## Transfer of Technology

Dissemination of Litchi technologies was done through training to farmers, delivering lectures, organising Kisan Goshthi and interaction with

farmers. The details have been provided in following table.

Sl. No.	Activities	Venue and Date	Participating Scientist	No. of Participants/ Farmers
1.	'Farm Innovators Day'	Shahbazpur, Kanti, Muzaffarpur 9 <sup>th</sup> April 2012	Dr. Vishal Nath Dr. S.D. Pandey Dr. Rajesh Kumar Dr. Amrendra Kumar Dr. Vinod Kumar Dr. Madhubala Thakre	80
2.	Delivered a lecture on 'Purane Bagon Ka Jirnodhar'.	S.K. Memorial Hall, Patna 18 <sup>th</sup> May, 2012.	Dr. Rajesh Kumar	2000
3.	Exhibition and display of mango varieties of Pusa Site (UNEP-GEF Project)	Bhubaneswar, Odisha 28 <sup>th</sup> -31 <sup>st</sup> May, 2012	Dr. Sanjay Kumar Singh	35
4.	"Entrepreneurship development Programme" (Ministry of Food Processing, GOI, New Delhi)	KVK, Sitamrhi 28 <sup>th</sup> May, 2012 15 <sup>th</sup> June, 2012	Dr. S.K. Purbey	60
5.	Foundation Day cum Litchi show 2012	NRC on Litchi Muzaffarpur 06th June 2012	Dr. Vishal Nath Dr. S. D. Pandey Dr. Awatar Singh Dr. Rajesh Kumar Dr. S. K. Purbey Dr. Amrendra Kumar Dr. Vinod Kumar Dr. Sanjay Kumar Singh Dr. Madhubala Thakra	200
6.	Delivered a lecture on 'Prospects of litchi in Eastern Uttar Pradesh' and tried to sensitize the farmers to switch over from cereal crops/sugarcane to litchi or mango'.	<i>Kisan Degree College</i> , Basti, Uttar Pradesh. 15 <sup>th</sup> June, 2012	Dr. Sanjay Kumar Singh	50
7.	"Khalihan me Vigyan" Sangosthi	Shivaharsh Kisan College, Basti, UP 15-16 <sup>th</sup> June 2012	Dr. Vishal Nath Dr. S.D. Pandey Dr. Sanjay Kumar Singh	500
8.	Displayed seedling [38] germplasm of mango of Pusa Site (UNEP-GEF Project)	Kisan Degree College, Basti, Uttar Pradesh 15-16 <sup>th</sup> June, 2012	Dr. Vishal Nath Dr. S.D.Pandey Dr. Sanjay Kumar Singh	50
9.	Training to litchi growers on "Adoption of rejuvenation techniques in old senile/unproductive litchi orchards for enhancement of quantity and quality production"	Motipur, Muzaffarpur 22 <sup>nd</sup> June, 2012	Dr. Rajesh Kumar	30
10.	Delivered a lecture on 'Objective and purpose of preparation of Pickles from seedling mango under UNEP-GEF Project.	Pusa Site, Samastipur 23 <sup>rd</sup> July, 2012	Dr. Sanjay Kumar Singh	20
11.	One day awareness and demonstration programme on "Aam awam litchi ka phal turai tatha chatai machine dwara chatrak prabandhan"	KVK, Hariharpur, Vaishali 4 <sup>th</sup> August, 2012	Dr. Rajesh Kumar	28

12.	Delivered a lecture on 'Chatrak Prabandhan and Jirnodhar in litchi ( <i>Litchi chinensis</i> Sonn.)	Roorkee, Uttarakhand 7 <sup>th</sup> – 10 <sup>th</sup> September, 2012	Dr. Rajesh Kumar	200
13.	Training programme on 'Progeny Orchard'	Patori, Samastipur 12 <sup>th</sup> September, 2012	Dr. Rajesh Kumar	-
14.	Delivered lecture on 'Potential of Underutilized Horticulture in Eastern Region'.	CIAH, Bikaner 24 <sup>th</sup> September, 2012	Dr. Vishal Nath	25
15.	Delivered lecture on 'Needs for rejuvenation of senile orchards in training on Rejuvenation of old orchards'.	NRC on Litchi, Muzaffarpur 31 <sup>st</sup> October, 2012	Dr. Vishal Nath	45
16.	Delivered lecture on 'Improved cultivars of Mango and Litchi'	Pusa Site, Samastipur 31 <sup>st</sup> October - 4 <sup>th</sup> November, 2012	Dr. Awtar Singh.	20
17.	Kisan Sangoshthi	Mutlupur, Muzaffarpur 24 <sup>th</sup> November, 2012	Dr. Vishal Nath	48
18.	" <i>Litchi – Unnat Krishi Kriyaein</i> "	Rajkhand, Aurai, Muzaffarpur 29 <sup>th</sup> January 2013	Dr. Vishal Nath Dr. S.D. Pandey Dr. Amrendra Kumar Dr. Vinod Kumar	45
19.	Delivered a lecture on 'Rejuvenation of old orchards and High Density Orchard Management'	KVK, Birauli, Samastipur 28 <sup>th</sup> January, 2013	Dr. Vishal Nath	15
20.	Brain Storming Session on Exploring Potential Technologies for marginalized districts of Bihar'	Patna 31 <sup>st</sup> January, 2013	Dr. Vishal Nath	20
21.	Delivered lecture on 'Agronomical practices in litchi for better production and reiterative pruning and rejuvenating the old senile orchards.	KVK, Birauli, Samastipur 1 <sup>st</sup> February, 2013.	Dr. Rajesh Kumar	15
22.	Delivered lecture on 'Potential of Litchi in plains of Central U. P.'	KVK Masaudha 14 <sup>th</sup> February, 2013	Dr. Vishal Nath	30
23.	One day Krishak Prashichan on 'Purane Bagon Ka Jirnodhar Evam Chatrak Prabandhan'	Horticulture Office, Khagaria, Bihar 20 <sup>th</sup> February, 2013	Dr. Rajesh Kumar	20
24.	Delivered a talk on " <i>Mausam Pariwartan Ka Litchi Par Prabhav</i> ".	Doordarshan Patna 20 <sup>th</sup> February, 2013.	Dr. Rajesh Kumar	Air Telecast
25.	Inaugural Lecture during Opening Ceremony of organic input and Information Centre	Muzaffarpur 20 <sup>th</sup> February, 2013.	Dr. Vishal Nath	60
26.	Long term training on PHM in Litchi	RAU, Pusa 27 <sup>th</sup> February, 2013	Dr. Vishal Nath	35
27.	Horticulture Show and Sangosthi	RAU Pusa, Samastipur 2 <sup>nd</sup> March 2013	Dr. S.D. Pandey	250
28.	Kisan Mela and Horticulture Show	RAU, Pusa, Samastipur 2 <sup>nd</sup> – 4 <sup>th</sup> March, 2013	Dr. Vishal Nath Dr. Rajesh Kumar Dr. S.K.Purbey	250



29.	Delivered a talk on ' <i>Litchi Ke Bagon Mein Esh Samay Kya Karen; Litchi Ke Manjar Evam Dano Ki Dekhbhal; Litchi Ke Gunwattapurn Utpadan Hetu Taiyari.</i>	Doordarshan, Muzaffarpur 6 <sup>th</sup> March, 2013.	Dr. Rajesh Kumar	AIR Telecost
30.	Kisan Mela – 2013	BAU, Sabour, Bhagalpur 9 <sup>th</sup> - 10 <sup>th</sup> March, 2013	Dr. Sanjay Kumar Singh	100
31.	Delivered lecture on 'Floor Management and High Density Planting in litchi'	TCA Dholi , Muzaffarpur 12 <sup>th</sup> March, 2013	Dr. S.D. Pandey	40
32.	"Kisan Mela-2013"	IARI Regional Station, Pusa, Bihar 16 <sup>th</sup> March 2013	Dr. Vinod Kumar	200
33.	Training on GAPs in litchi	Amarpur, Bhagalpur 16 <sup>th</sup> March, 2013	Dr. Vishal Nath Dr. S.K.Purbey Dr. Amrendra Kumar	185
34.	National Kisan Mela	Katihar 17-18 <sup>th</sup> March, 2013	Dr. S.K.Purbey	500
35.	Delivered a lecture on ' <i>Principle and Practices of propagation technique in mango and pummele</i> '	Pusa Site, Samastipur 20 <sup>th</sup> March, 2013	Dr. Sanjay Kumar Singh	15
36.	"Farmers Field Day" on "Broadening the genetic base of crops to empower farmers for climate change adaptation through crowdsourcing"	Nayanagar, Samastipur 22 <sup>nd</sup> March, 2013	Dr. Rajesh Kumar	110
37.	Delivered lecture on 'Nutrient and Water Management requirement and possibilities of inter and cover crops in litchi orchards in	Horticulture Sangosthi, Gandhi Maidan, Patna 24 <sup>th</sup> March, 2013	Dr.S.D.Pandey	1500



Transfer of technology on Litchi at exhibition, Kisan Melas

## Research Advisory Committee, Institute Management Committee and Institute Research Council

### Research Advisory Committee Constituion

During 2012-13, Council has constituted new Research Advisory Committee (RAC) for the Centre with following members:

1.	Dr. S. P. Ghosh, Former DDG (Hort) & FAO Expert, 68, Qutab View Apartments, Near Kutub Hotel, Katwaria Saria, New Delhi-110 016.	Chairman
2.	Dr. G. S. Prakash, Principal Scientist (Hort), Indian Institute of Horticultural Research, Hessarghatta Lake, Bangalore - 560 089.	Member
3.	Dr. D. K. Shahi, Chief Scientist cum Professor and Chairman Birsa Agricultural University, Kanke, Ranchi - 8340 06, Jharkhand.	Member
4.	Dr. R. K. Jain, Head (Plant Pathology), Indian Agricultural Research Institute, Pusa, New Delhi 110 012.	Member
5.	Dr. R. K. Pal, Director, NRC on Pomegranate, Solapur- Pune Highway, PO. Kegaon, Solapur, Maharastra – 413 255.	Member
6.	Sh. Alok Kedia, Radha Krishna Implex, Sikandarpur, Muzaffarpur – 842 002.	Member
7.	Sh. Bipin Kumar Pandey, Katarmala, Vaishali, Bihar.	Member
8.	Sh. Sudhir Pandey, Bakhari, Dhodi, Muzaffarpur	Member
9.	Sh. Rajpal Singh, Vill. Jaghata, Gujar, Sharanpur, (U.P.)	Member
10.	Dr. Vishal Nath, Director, NRC on Litchi, Mushahri Farm, Muzaffarpur- 842 002, Bihar.	Member
11.	Dr. Rajesh Kumar, Principal Scientist, NRC on Litchi, Muzaffarpur-842 002, Bihar	Member Secretary

### Institute Research Council Meeting

The 7<sup>th</sup> IRC meeting was held under the Chairmanship of Director, NRC for Litchi, Muzaffarpur from 24<sup>th</sup> - 28<sup>th</sup> August, 2012 at 10.00 am in the Conference Hall of NRC Litchi, Mushahari,

Muzaffarpur to discuss the research achievements and finalize the research projects with technical programmes of the center. The new research projects were discussed at length and were approved after through discussion. The following members attended the meeting and presented their achievements:

1.	Prof. (Dr.) Vishal Nath	Director, NRCL	Chairman
2.	Dr. S. D. Pandey	Pr.Scientist (Horticulture)	Member
3.	Dr. Awtar Singh	Pr. Scientist (Plant Breeding)	Member
4.	Dr. Rajesh Kumar	Pr.Scientist (Horticulture)	Member
5.	Dr. S.K. Purbey	Sr. Scientist (Horticulture)	Member
6.	Dr. Amrendra Kumar	Sr. Scientist (Horticulture)	Member
7.	Dr. Vinod Kumar	Scientist SS (Plant Pathology)	Member
8.	Dr. Madhubala Thakre	Scientist (Horticulture)	Member
9.	Dr. Sanjay Kumar Singh	Scientist (Horticulture)	Member Secretary



The 8<sup>th</sup> IRC meeting was also conducted from 23<sup>rd</sup>-24<sup>th</sup> November, 2012 at 12.00 Noon in the Conference Hall of NRC Litchi, Mushahari, Muzaffarpur to discuss the research achievements during 2012-13 and finalize the line of work for next year.

### Institute Management Committee

The 7<sup>th</sup> IMC meeting was held under the Chairmanship of Director NRC on Litchi, Muzaffarpur on 27<sup>th</sup> August, 2012 at 11.00 AM. The following members attended the meeting and discussed the matter relevant to IMC of the Centre.

1.	Prof. (Dr.) Vishal Nath, Director, NRC on Litchi, Mushahri Farm, Muzaffarpur - 842 002, Bihar.	Chairman
2.	Dr. I.P. Singh, Principal Scientist, NRC on Citrus, Nagpur, MS	Member
3.	Dr. Neelima Garg, Principal Scientist & Head, Division of PHM, CISH, Lucknow, UP	Member
4.	Dr. C. Aswath, Principal Scientist & Head, Division of Biotechnology, IIHR, Bangalore.	Member
5.	Dr. Raghvendra Pratap Singh, Joint Director (Horticulture) Basti, UP	Member
6.	Sh. P.K. Naik, AF&AO, CIFRI, Barrackpore, Kolkatta	Member
7.	Sh. Sudhir Kumar Pandey, Vill. Bakhari, TCA Dholi, Muzaffarpur, Bihar	Member
8.	Raj Pal Singh, Vill. Jaghata, Gujar, Saharanpur, U.P.	Member
9.	Sh. Ramji Giri, Assistant Administrative Officer, NRC on Litchi, Muzaffarpur - 842 002, Bihar	Member Secretary

## Distinguished Visitors during 2012-13

SI. N.	Name	Designation and Place	Date of Visit
1.	Sh. S.K. Negi	IAS, Divisional Commissioner, Tirhut Range, Muzaffarpur	10 <sup>th</sup> April, 2012
2.	Sh. V.P.N. Tiwari,	Chairman, RRB, Muzaffarpur	04 <sup>th</sup> May, 2012
3.	Sh. Peiter Kenmore	FAO Representative in India	15 <sup>th</sup> May, 2012
4.	Sh. Satya Priya	FAO, New Delhi	15 <sup>th</sup> May, 2012
5.	Dr. Mathura Rai	Former Director, IIVR, Varanasi	17 <sup>th</sup> May, 2012
6.	Dr. Prakash Patil	Project Coordinator (Tropical Fruits), IIHR, Bangalore	17 <sup>th</sup> May, 2012
7.	Dr. A.S. Sidhu	Director, IIHR, Bangalore	22 <sup>nd</sup> June, 2012
8.	Dr. B.M.C. Reddy	Ex.- Director, CISH, Lucknow	22 <sup>nd</sup> June, 2012
9.	Dr. P.C. Tripathi	Head CHES, Chettali, Karnataka	22 <sup>nd</sup> June, 2012
10.	Dr. S. Rajan	CISH, Lucknow	22 <sup>nd</sup> June, 2012
11.	Dr. H.P. Singh	DDG, (Horticulture), ICAR, New Delhi	23 <sup>rd</sup> June, 2012
12.	Prof. R.K. Pathak	Ex. Director, CISH, Lucknow	2 <sup>nd</sup> September, 2012
13.	Dr. S.N. Pandey	Ex. ADG (Horticulture), ICAR, New Delhi	2 <sup>nd</sup> September, 2012
14.	Dr. R.D. Rawal	Ex. Head IIHR, Bangalore	2 <sup>nd</sup> September, 2012
15.	Dr. P.N. Mathur	Bioversity International, India Region, New Delhi	2 <sup>nd</sup> September, 2012
16.	Dr. Babita Singh	Professor, Amity University, Noida, UP	2 <sup>nd</sup> September, 2012
17.	Sh. S.S. Mehta	President, All india Aonla Grower Association, Salem, Tamil Nadu	2 <sup>nd</sup> September, 2012
18.	Dr. H.P. Singh	Ex- DDG (Hort.) ICAR, New Delhi.	2 <sup>nd</sup> September, 2012
19.	Dr. G. Trivedi	Ex- VC, RAU, Pusa, Samastipur	2 <sup>nd</sup> September, 2012
20.	Dr. P.K. Ray	Professor, (Horticulture) RAU, Pusa, Samastipur	2 <sup>nd</sup> September, 2012
21.	Dr. S. Ayyappan	Secretary (DARE) & Director General (ICAR), New Delhi	23 <sup>rd</sup> September, 2012
22.	Dr. R.C. Srivastava	Principal Scientist, DWM, Bhubaneshwar	21 <sup>st</sup> November, 2012
23.	Sh. Tariq Anwar	Hon'ble Minister of State for Agriculture and Food Processing, Govt. of India.	01 <sup>st</sup> December, 2012
24.	Dr. K.K. Jindal	Former ADG (Horticulture) and Retd. Director Research UH &F, Solan (H.P.)	26 <sup>th</sup> February, 2013
25.	Prof. K.R. Koundal	Former Joint Director (R) IARI, New Delhi	26 <sup>th</sup> February, 2013
26.	Dr. A.K. Mishra	PC, AIRCP-STF, CISH, Lucknow	26 <sup>th</sup> February, 2013
27.	Dr. S.K. Sharma	Director, CIAH, Bikaner	11 <sup>th</sup> March, 2013
28.	Dr. S. L. Mehta	Ex Vice Chancellor, MPUAT, Udaipur	29 <sup>th</sup> March, 2013





FAO India Head, Dr. Peter Kennmore visited NRCL on 15.5.2012



Dr. H.P. Singh, DDG (Hort.) visited NRCL on 23.6.2012



Secretary DARE and DG, ICAR, Dr. S. Ayyappan, visited NRCL on 23.9.2012



Prof. R. K. Pathak, Chairman QRT along with team visited NRCL on 2.9.2012



Sh. Tariq Anwar, MOS Agriculture, Govt. of India, visited NRCL on 1.12.12



Dr. S. L. Mehta, Ex Vice Chancellor MPUAT, Udaipur visited the NRCL along with high level team

## Publications

### Research articles

- Kumar, Amrendra, Pandey, S.D. and Rajiv Ranjan Rai (2012). Inter cropping of vegetables with pre-bearing litchi plants for profitable and sustainable production system. *Vegetable Science* 39 (2): 128-131.
- Kumar, Dinesh, V. Pandey and Vishal Nath (2012). Growth, yield and quality of vegetable banana Monthan (Banthal-ABB) relation to NPK fertigation. *Indian. J. Hort.* 69(4): 467-471.
- Kumar V, Lukose C, Bagwan NB, Koradia VG and Padavi RD (2012). Occurrence of *Alternaria* leaf blight of groundnut in Gujarat and reaction of some genotypes against the disease. *Indian Phytopathology*. 65 (1): 25-30.
- Kumar V, Rathnakumar, AL and Bagwan, NB (2012). Effect of crop residues and root exudates on mycelial growth, sclerotial formation, and *Sclerotium rolfsii*-induced stem rot disease of groundnut. *Indian Phytopathology*, 65 (3): 238-243.
- Kumar V, Nath Vishal and Anal AKD (2013). New threats of insect pests and disease in litchi (*Litchi chinensis* Sonn.) in India. *Indian Journal of Horticulture*, (Communicated)
- Kumar V, Reddy PVR, Nath Vishal and Anal AKD (2013). Outbreak of semilooper, *Anisodes illepidaria* Guenee (Lepidoptera: Geometridae) - a new record of pest of litchi (*Litchi chinensis* Sonn.) in India. *Phytoparasitica*, (Communicated).
- Purbey, S. K. and Ray, R. C. (2012). Optimization of fermentation process for production of wine from litchi juice. *Journal of Food Science and Technology*. (Communicated)
- Purbey, S. K. (2012). Evaluation of shade net on maturity and quality of litchi fruit (*Litchi chinensis* Sonn. cv. Shahi). *Indian Journal of Horticulture*. (Communicated)
- Purbey, S. K., and Kumar Amrendra (2012). Effect of bagging on quality of litchi fruits. *Progressive Horticulture*. (Communicated).
- Selvarajan, Selvarajan, R., Balasubramanian, V., Jeyabaskaran, K.J., Pandey, S.D. and Mustafa. M.M. (2012). Mitigating the effect of banana bract mosaic disease through application of increased dose of fertilizers in banana cultivar Robusta (AAA). *Journal of Plant Disease Sciences*. 7 (2), 158-161.
- Singh, Awtar and Vishal Nath (2012). Variability in fruit physico-chemical characters of litchi (*Litchi chinensis* Sonn.): an index for selection of improved clones for processing and value addition. *Indian J. Genet.* 72(2): 143-147.
- Singh D, Radhakrishnan T, Kumar V, Bagwan NB, Basu MS, Dobaria JR, Mishra GP and Chanda SV (2013). Molecular characterization of *Aspergillus* section Flavi isolates collected from a major peanut cropping system of India using AFLP. *Physiological and Molecular Plant Pathology*, (Communicated).
- Singh D, Radhakrishnan T, Kumar V, Bagwan NB, Basu MS, Dobaria JR, Mishra GP and Chanda SV (2013). Morphological and toxigenic variability in the *Aspergillus flavus* isolates from peanut (*Arachis hypogaea* L) production system in Gujarat (India). *Journal of Phytopathology*, (Communicated).
- Singh, H.S. and Vishal Nath (2011). Hawk moth as a pest on Noni its nutritional indices and organic management. *International J. Noni Res.* 6(1-2):

### Papers presented in Conferences/Symposia/Seminars/Meetings etc.

- Kumar, Rajesh (2012). A success story- venturing successful litchi (*Litchi chinensis* Sonn.) production in non traditional area: Maharashtra. In: Global conference on Horticulture for food nutrition and livelihood options. OUAT, Bhubneshwar, Orissa. 28<sup>th</sup>-31<sup>st</sup> May, 2012. 329p.
- Kumar, Rajesh (2012). Litchi Enterprise in Bihar: Biophysical analysis for Interstate trade and export. In: *National Seminar on Agribusiness Potential of Bihar* (2<sup>nd</sup>- 3<sup>rd</sup> November, 2012). R.A.U., Pusa, Samastipur, Bihar. 73p.
- Kumar, Rajesh (2012). Effect of vegetative flushing and shoot maturity on flowering, bearing behaviour, fruit yield and quality in litchi (*Litchi chinensis* Sonn.). In: *5<sup>th</sup> Indian Horticulture Congress – 2012 on Horticulture for food and environment security*. (6<sup>th</sup> – 9<sup>th</sup> November, 2012). PAU, Ludhiana.
- Kumar, Rajesh (2013). Exploring Potential of litchi (*Litchi chinensis* Sonn.) production in Non Traditional area: Gujarat. In: *National Seminar on Tropical and Subtropical Fruits* (January 09-11, 2013). Gujarat Agricultural University, Navasari, Gujarat.
- Kumar, Rajesh (2012). Effects of climate change and climate variable conditions on litchi (*Litchi chinensis* Sonn.) productivity and quality. In: *4<sup>th</sup> International Symposium on Lychee, Longan and Other Sapindaceae Fruits* (2<sup>nd</sup> – 6<sup>th</sup> December, 2012). White River, South Africa.



- Kumar, Rajesh (2012). Planned honey bee pollination in litchi (*Litchi chinensis* Sonn.) – A new production strategy for enhancing fruit yield and quality. In: *4<sup>th</sup> International Symposium on Lychee, Longan and Other Sapindaceae Fruits* (2<sup>nd</sup> – 6<sup>th</sup> December, 2012). White River, South Africa.
- Kumar, V., Kumar, Amrendra, Vishal Nath and Kumar, Rajesh (2012). New threats of insect pests and disease in litchi (*Litchi chinensis* Sonn.) in India – A new production strategy for enhancing fruit yield and quality. In: *4<sup>th</sup> International Symposium on Lychee, Longan and Other Sapindaceae Fruits* (2<sup>nd</sup> – 6<sup>th</sup> December, 2012). White River, South Africa.
- Kumar V, Kumar Rajesh Anal AKD and Singh PR (2012). Arbuscular mycorrhizal diversity associated with roots and rhizospheric soil of litchi (*Litchi chinensis* Sonn.) In: Bihar. In: *3<sup>rd</sup> National symposium on “Agriculture Production and Protection in Context of Climate Change”* (3-5<sup>th</sup> November 2012), BAU, Ranchi. P-63
- Kumar V and Kumar Amrendra (2013). New threats of insect pests and diseases in litchi (*Litchi chinensis* Sonn.). In: *Proceedings of the “National Seminar on Tropical and Subtropical Fruits”* (January 9-11, 2013) Navsari Agricultural University, Gujarat, 112p
- Nath Vishal, Purbey, S.K. and Singh, Sanjay Kumar (2012). “Management for Improvement of Nutritive Value of Litchi and Its Processed Products” In: *“Global Conference on Horticulture for Food, Nutrition and Livelihood options”* (28-31 May 2012), Organised by Lt. Amit Singh Memorial Foundation, New Delhi. at Bhubaneswar, Odisha. 83-88pp
- Nath, Vishal, M Thakre, S.D. Pandey, A. Kumar and R. Kumar (2012). Canopy architecture for high density litchi (*Litchi Chinensis* Sonn.) orchards. In: *4<sup>th</sup> International Symposium on Lychee, Longan and Other Sapindaceae Fruits* (2<sup>nd</sup> – 6<sup>th</sup> December, 2012). White River, South Africa: 44p
- Purbey, S.K., Singh, Sanjay Kumar and Vishal Nath (2012). Post Harvest Management of Litchi Fruits. In: *Workshop on Post Harvest Care and Value Addition of Horticultural Crops*. Directorate of Horticulture, Odisha Horticulture Development Society, Bhubaneswar pp 42-52.
- Singh, Awtar, Vishal Nath, Bhuwon Sthapit and BMC Reddy. (2012). Maintaining pummelo and mango seedling trees in home gardens for conservation of diversity and nutritional security. UNEP/GEF Project, Bioversity International, New Delhi. (in Press).
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- Singh, Sanjay Kumar and Awtar Singh (2013). The Custodian of high yielding diversity of ‘Bathua’ mango in Pusa Block, Samastipur, India. In: *Custodian Farmers of Agricultural Biodiversity: Selected Profiles from South and South East Asia. Workshop on Custodian Farmers of Agricultural Biodiversity*, New Delhi, 11-12<sup>th</sup> February, 2013. 10/2013
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- Kumar, Amrendra, Pandey, S.D. and R.R. Rai (2012). *Litchi Aadharit Phasal Paddhati*. *Krishi Bharati* 2(8) 05-07.
- Kumar, Amrendra, Pandey, S.D. and R.R. Rai (2012). *Litchi Bag Men Antarwanti Phasalon Ki Kheti. Khalihan Men Vigyan Sangosthi* pp 39-41.
- Kumar, Amrendra, S.D. Pandey, S.K. Purbey and M. Thakre. (2012). *Litchi Ke Daihik Vikar. Khalihan Men Vigyan Sangosthi* pp 44-46.
- Rajesh Kumar (2012) Litchi Vipanan: Rasta Sahi To Manjil Asan (Hindi), *Krishika* 1(38):1,6
- Rajesh Kumar (2012) Litchi Ke Karyik Vikar:Karan awam Bachao (Hindi), *Krishika* 1(37):4,5
- Rajesh Kumar (2012) Litchi Samekit Kit Prabandhan (Hindi), *Krishika* 1(38):5,7
- Rajesh Kumar (2012) Sakarkand Lagayen Labh Kamayen (Hindi), *Krishika* 1(49):3
- Rajesh Kumar (2012) Off season air layering technique in litchi : a boon to farmers. *Indian Horticulture* 57(5):25-29.
- Rajesh Kumar (2012) Bee keeping an ideal option for prosperity. *Indian Farming* (June, 2012) 62(3):29-33.
- Rajesh Kumar (2012) Muanfe Ke Liye Ol Ki Kheti (Hindi). *Phal Phul* 34 (1): 7-10

- Rajesh Kumar (2013) Litchi ko Dahik Vikaro se Bachao (Hindi), *Udyan Rasmi* (July-December). 13(2):45-50.
- Rajesh Kumar (2013) Bahupyogi Litchi ki Safal Bagwani (Hindi), *Kisan Jyoiti* (July-December) 3(3): 76-82.
- Kumar V and Kumar Amrendra (2013). *Litchi ke pramukh keeton avam rogon ka akikrit prabandhan (in Hindi)*. ATMA Sandesh (in press)
- Kumar V and Kumar Amrendra (2013). *Litchi mein lagnewale pramukh keeton avam rogon ke lakshan aur unka prabandhan (in Hindi)*. *Udyan Samvad (Smarika)*, p. 17- 21.
- Pandey, S.D., Vishal Nath, Amrendra Kumar and M. Thakre 2012. *Litchi Bag Men Urwark Awm Jal Prabandh. Khalihan Men Vigyan Sangosthi* pp 42-43
- Nath, Vishal (2013). Post Harvest Handling of Litchi. *Udyogprerana*, (December 2012- February 2013): 25-30
- Purbey, S K and Nath, Vishal (2012). Litchi ke phalo ki turai uprant prabandhan. *Atma Sandesh, Bihar Krishi prabandhan evam prasar prashikshan, Patna*, 4:28-31
- नाथ, विशाल, संजय कुमार सिंह तथा सुशील कुमार पूर्व (2013). लीची के पोशक तत्व एवं औषधीय गुण। हरित कृषि, उत्तर प्रदेश
- सिंह, एस.एस., विशाल नाथ और एस. के. द्विवेदी (2012). लीची उत्पादन में एकीकृत फसल प्रबन्धन। फल-फूल 33 (3): 15.21
- सिंह, संजय कुमार और नाथ, विशाल (2012) लीची का वैज्ञानिक उत्पादन। उन्नत कृषि 49 (4):3-16

## Books

- Nath, Vishal, Pandey, Dinesh Kumar, Mishra, Ajay, Kumar, Amrendra and D.N.Singh (2012). *Udyan Vigyan Ke Maulik Siddhanta. (Bhag-I:Phal Vigyan)*. Satish Serial Publishing House, New Delhi: 1-456.
- Nath, Vishal, Pandey, Dinesh Kumar, Singh, D.N., Mishra, Ajay, and Md. Mustfa (2012). *Udyan Vigyan Ke Maulik Siddhanta. (Bhag-II: Sabji evam Phool Vigyan)*. Satish Serial Publishing House, New Delhi: 1-402.
- Singh, D.N. and Vishal Nath (2012). Winter Vegetables: Advances and developments. Satish Serial Publishing House, New Delhi: 1-869.
- Singh, Gorakh, Nath, Vishal, Pandey, S.D., Ray, P.K. and Singh, H.S. (2012). *The Litchi*: FAO, New Delhi: 1-219

## Technical Bulletins

- Kumar V, Kumar Amrendra and Nath Vishal (2012). *Litchi mein akikrit nashijeev prabandhan* (In Hindi). Technical Bulletin. National Research Centre for Litchi, Muzaffarpur, India, p-65
- Singh, Awtar and Vishal Nath (2012). Varietal Wealth of Fruit Crops in India: Litchi. (in Press).
- Singh, Awtar. (2012). GPDs Documentation for Piloting. GPDs submitted to National Project Coordinator of the UNEP/GEF TFT Project, Bangalore.

## Scientific / Teaching reviews:

- Kumar V and Thirumalaisamy, PP (2013). Major diseases of groundnut: current status and future research needs. *Indian Phytopathology* (In press).

## Extension Folders

- Kumar V, Kumar Amrendra and Nath Vishal (2012). *Litchi ko nasheekeeton aur rogon se bachayein* (in Hindi). Extension Folder-10. National Research Centre on Litchi, Muzaffarpur, India, 6pp.

## Chapters in Books/Compendiums/Manuals etc.

- Kumar, Rajesh (2012). SWOT analysis for litchi enterprise in Bihar perspective In: *National Seminar on Agribusiness Potential of Bihar*, organized by RAU, Pusa, Samastipur and Indian Society of Agricultural Marketing, Nagpur. RAU Pusa, Samastipur, Bihar, 2<sup>nd</sup>-3<sup>rd</sup> November, 2012. 53-58pp
- Kumar, Rajesh and Vishal Nath (2013). Climate resilient adaptation strategies for litchi production. In: *Climate Resilient Horticulture : Adaptation and Mitigation strategies* (Ed.; H.P. Singh, N. K. S. Rao and K. S. Shivashankar). Springer, New Delhi Chapter -8: 81-88.
- Kumar, Rajesh (2013). Litchi enterprise in Bihar: Biophysical analysis for interstate trade and export In: *National Seminar on Agribusiness potential of Bihar*. (Eds - Singh et al.). (2<sup>nd</sup> - 3<sup>rd</sup> November, 2012). RAU Pusa, Samastipur. 117-129 pp
- Nath, Vishal and Kumar Amrendra (2013). Canopy Architecture Management for Precision Farming in Fruits. In: *Precision Farming in Horticulture*. *New India Publishing Agency, New Delhi*: 87-94.
- Nath, Vishal and Singh Sanjay Kumar (2012). Present Scenario of underutilized fruit crops of Eastern India. In: *Winter School on Exploitation of Underutilized Horticultural Crops for Sustainable Production* (Editors: Singh et al.).



## Compilations and Editing

Titles	Venue	Scientists involved
Annual Report 2011-12.	National Research Centre on Litchi, Muzaffarpur 842 002, Bihar.	Dr. Vishal Nath Dr. Sanjay Kumar Singh Dr. Awtar Singh Dr. S.D. Pandey
NRCL: At a Glance	National Research Centre on Litchi, Muzaffarpur 842 002, Bihar.	Dr. Vinod Kumar Dr. Vishal Nath
वार्षिक रिपोर्ट 2011-12	राष्ट्रीय लीची अनुसंधान केंद्र, मुशहरी, मुजफ्फरपुर, बिहार	डॉ. संजय कुमार सिंह डॉ. अवतार सिंह, डॉ. एस.डी. पांडेय डॉ. सुशील कुमार पूर्बे
12 <sup>th</sup> Plan EFC Document	National Research Centre on Litchi, Muzaffarpur 842 002, Bihar.	Dr. Vishal Nath Dr. Sanjay Kumar Singh
Vision 2050	National Research Centre on Litchi, Muzffarpur, Bihar	Dr. Vishal Nath Dr. Sanjay Kumar Singh

Central Institute for Arid Horticulture, Beechwal, Bikaner 334 006, Rajasthan. 36-44pp.

Purbey, S.K. and Vishal Nath (2012). Agribusiness Opportunities in litchi. In: *National Seminar on Agribusiness potential of Bihar*. (Eds. Singh *et al.*). (2<sup>nd</sup> - 3<sup>rd</sup> November, 2012). RAU Pusa, Samastipur: 33-38 pp.

Purbey, SK, Kumar, Amrendra and Vishal Nath (2012). Farmers friendly technology of NRC on Litchi. In: 5<sup>th</sup> Indian Horticulture Congress, (6<sup>th</sup> - 9<sup>th</sup> November, 2012). PAU, Ludhiana, pp 139-141.

Singh, Sanjay Kumar, Singh, I.S. and Sharma, S.K. (2013). Processing and Nutritive Values of Aonla, Ber, Datepalm and Khejri Fruits. In: *Developing the Potential of Underutilized Horticultural Crops of Hill Regions*. (Editors: N Prakash, S.S. Roy, P.K. Sharma and Nagachan). *Today's and Tomorrow Printers and Publishers*, New Delhi 110 002. 561-566 pp

## Others

A M.Sc. thesis entitled "**Studies on arbuscular mycorrhizal fungi associated with roots and rhizospheric soil of litchi (*Litchi chinensis* Sonn.) in Bihar**" was submitted in September 2012 by a student (Ms. Pankhuri Rani Singh of Jiwaji University, Gwalior) on research works carried at this Centre under the guidance of Dr. Vinod Kumar (Co-guide).

## Awards and Recognitions

Dr. Vishal Nath and Dr. Rajesh Kumar were facilitated with "Fellowship Award" from Confederation of Horticulture Association of India (CHAI) on 31<sup>st</sup> May, 2012 at OUA&T, Bhubneshwar, Orissa in recognition of their contribution and commitment to the furtherance of horticulture research and development.

## Research Programmes and Projects

Programmes and Projects	Title	Principal Investigators (PI)
<b>Programme 1.</b> 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
Project 1.2	Evolving improved cultivars in litchi	Dr. Awtar Singh
<b>Programme 2.</b> Development of Sustainable production technology in litchi		
Project 2.1	Plant propagation and nursery management in litchi	Dr. Rajesh Kumar
Project 2.2	Development of sustainable production techniques in litchi	Dr. S. D. Pandey
Project 2.3	Investigation and establishing the physiological and biochemical relations for improved litchi production	Dr. Amrendra Kumar
Project 2.4	Studies on mycorrhizal association and role of biofertilizers for improved litchi production	Dr. Vinod Kumar
<b>Programme 3.</b> Standardization of plant protection technology		
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	-----
<b>Programme 4.</b> Post harvest management and value addition		
Project 4.1	Standardization of maturity standards, harvesting and post harvest handling techniques for litchi fruits	Dr. Sanjay Kr. Singh
Project 4.2	Investigation and management of Post harvest losses in litchi	Dr. S.K. Purbey
Project 4.3	Standardization of processing and value addition techniques in litchi	Dr. S.K. Purbey



## Externally Funded Projects

Funding Agency	Title of The Project	PIs/Co-Pi
UNEP/GEF, Bioversity 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, Director Dr. Awtar Singh, Pr. Scientist (Site Coordinator) Dr. Sanjay Kumar Singh, Project Associate
XI Plan Scheme (Intellectual Property Right (IPR) ICAR, New Delhi	"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).	Dr. Vishal Nath, Director Dr. Sushil Kumar Purbey, Nodal Officer
ICAR [Plan]-NBAIM, Mau (U.P)	Application of Microorganisms in Agriculture and Allied Sectors (AMAAS) - project - "Harnessing arbuscular mycorrhiza for biofertilization in horticultural crops"	Dr. Vishal Nath Dr. Vinod Kumar Dr. Rajesh Kumar
Department of Biotechnology, Govt. of India	Development of National Database on Mango	Dr. Vishal Nath Dr. Sanjay Kumar Singh
ICAR revolving fund scheme	Mega Seed project on Seed production in Agricultural crops and Fisheries	Dr. Vishal Nath Dr. Amrendra Kumar

## Personnel

### Scientific

01.	Prof. (Dr.) Vishal Nath, M.Sc. (Ag.), Ph.D	:	Director
02.	Dr. S. D. Pandey, M.Sc. (Ag.), Ph.D	:	Principal Scientist (Hort.)
03.	Dr. Awtar Singh, M.Sc. (Ag.), Ph.D	:	Pr. Scientist (Plant Breeding)
04.	Dr. Rajesh Kumar, M.Sc. (Ag.), Ph.D	:	Pr. Scientist (Hort.)
05.	Dr. S. K. Purbey, M.Sc. (Ag.), Ph.D	:	Sr. Scientist (Hort.)
06.	Dr. Amrendra Kumar, M.Sc. (Ag.), Ph.D	:	Sr. Scientist (Hort.)
07.	Dr. Vinod Kumar, M.Sc. (Ag.), Ph.D	:	Sr. Scientist (Plant Pathology)
08.	Dr. Sanjay Kumar Singh, M.Sc. (Ag.), Ph.D	:	Scientist (Hort.)
09.	Dr. Madhubala Thakre, M.Sc. (Ag.), Ph.D	:	Scientist (Hort.)

### Technical

01.	Sh. Rajeev Ranjan Rai, M.Sc. (Ag.)	:	T-6
02.	Sh. Shyamji Mishra, M.Sc. (Hort.)	:	T-3 (Farm)
03.	Smt. Pallavi	:	T-2 (Lab. Technician)

### Administrative

01.	Sh. Abhishek Yadav	:	Administrative Officer
02.	Sh. Ramji Giri	:	Assistant Administrative Officer
03.	Sh. Subhankar Dey	:	Asst. Finance & Account Officer
04.	Sh. Dileep Kumar	:	Assistant
05.	Sh. Akshay Kr. Yadav	:	Assistant (on deputation)
06.	Sh. Avinash Kumar Kashyap	:	Sr. Clerk
07.	Sh. Sawan Kumar	:	Jr. Clerk
08.	Sh. Pawan Kumar	:	Jr. Clerk
09.	Sh. Ajay Kumar Rajak	:	S.S.S.
10.	Sh. Surendra Rai	:	S.S.S.
11.	Sh. Dharmendra Kumar	:	S.S.S.





## Recruitments / Promotions / Transfers/Retirements

### New Entrants

- Sh. Asim Kumar, Assistant joined this centre on 18<sup>th</sup> May, 2012 (FN) through fresh recruitment by ASRB, New Delhi.
- Sh. Abhishek Yadav, Administrative Officer joined this centre on 11<sup>th</sup> June, 2012 through fresh recruitment by ASRB, New Delhi.
- Sh. Akshaya Kr. Yadav, Assistant joined this centre on 12<sup>th</sup> June, 2012 on deputation basis from CIFRI, Barrackpore, Kolkatta.
- Sh. Pawan Kumar, Jr. Clerk joined this centre on 10<sup>th</sup> October, 2012 (FN) after getting transfer from NRCY, Dirang, Arunachal Pradesh.

### DPC/Promotion

- Dr. Vinod Kumar, Scientist SS (Plant Pathology) promoted to Senior Scientist (Plant Pathology) w.e.f. 16<sup>th</sup> April, 2012.
- Dr. Sanjay Kumar Singh, Scientist (Horticulture) promoted to Scientist SS (Horticulture) (RGP-7000) with effect from 7<sup>th</sup> January, 2012.
- Sh. Subhankar Dey, Assistant Finance and Account officer was cleared probation period and his service was confirmed with effect from 5<sup>th</sup> August, 2011.

- Sh. Dileep Kumar, Assistant was cleared probation period and his service was confirmed with effect from 14<sup>th</sup> June, 2012.
- Sh. Ramji Giri, Assistant promoted to the post of Assistant Administrative Officer with effect from 13<sup>th</sup> March, 2013.
- Sh. Shaymji Mishra T-3 was cleared probation period and his service was confirmed w.e.f. 30<sup>th</sup> June, 2011
- Smt. Pallvi, T-2 promoted from T-1 to T-2 w.e.f. 13<sup>th</sup> November, 2011
- Sh. Dharmendra Kumar, SSS was cleared probation period and his service was confirmed with effect from 18<sup>th</sup> December, 2011.

### Transfer

- Dr. (Mrs.) Madhubala Thakre, Scientist relieved from this centre to join IARI, New Delhi on 18<sup>th</sup> December, 2012

### Resignation

- Sh. Asim Kumar, Assistant resigned from ICAR service on his personal interest on 16<sup>th</sup> February, 2013 (AN).

## Monthly Weather Data 2012

Months	Temperature (°C)		Relative humidity		Rainfall (No. of rainy days)
	Maximum	Minimum	Maximum	Minimum	
January	21.48	09.77	89.59	52.22	02
February	26.00	11.66	84.48	41.00	01
March	31.2	14.96	77.24	31.02	02
April	37.00	23.09	70.59	27.31	01
May	40.14	25.40	49.22	18.66	03
June	39.03	27.92	62.34	22.96	07
July	34.46	26.46	87.26	44.38	19
August	32.48	26.22	89.00	63.25	17
September	32.20	25.40	89.72	70.64	10
October	31.82	21.21	84.47	55.00	03
November	28.58	15.00	86.05	49.11	00
December	23.46	11.38	89.61	44.34	00





## National Research Centre on Litchi

(Indian Council of Agricultural Research)

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