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ICAR-Indian Institute of Natural Resins and Gums
भाकृअनुप - भारतीय प्राकृतिक राल एवं गोंद संस्थान
Namkum, Ranchi - 834 010 (Jharkhand)
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भा.प्रा.रा.गो.सं. IINRG

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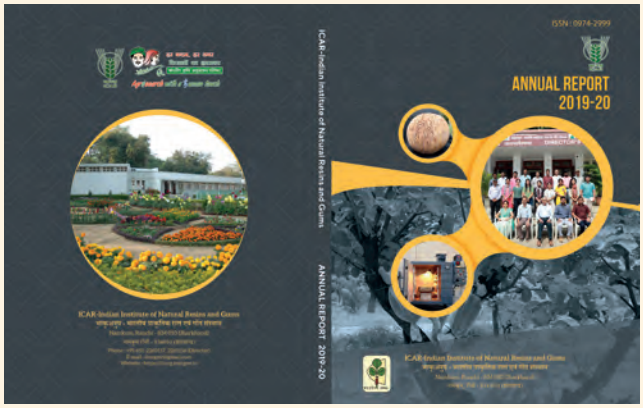

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Clockwise from top small circle :

1. Lac insects grown on pumpkin
2. Participants of NP-CLIGR training programme
3. Interior view of IR dryer

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ICAR-IINRG Director's office

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Preface

India is among the leading producers of Natural Resins & Gums (NRGs) in the world especially lac, *guar* and *karaya* gums. Barring small fluctuations due to demand, price and policy interventions like minimum support price, the annual national production of natural resins and gums has more or less stabilized. Total production of NRGs has been recorded to be 5,28,164 tons in 2019-20 of which 2,29,787 tons were exported fetching foreign exchange of Rs. 2944 Crore. NRGs have wide variety of applications traditionally & industrially as well and are source of livelihood for millions of people throughout the world especially in developing countries like India. The distinct advantages of natural gums over their synthetic counterparts are their biodegradability/ bio-compatibility, lower cost, low toxicity, eco-friendliness and relatively widespread availability. The industrial uses/applications of gums have been widely reported, notably in food, pharmaceutical, adhesive, cosmetic, textile, paint and print industries, wherein these are used as food additives, dietary fibers, binders, thickeners, stabilizers, emulsifiers, suspending, gelling agents and surface coating agents etc.

The present COVID-19 crisis and subsequent lockdown in the country, left farm and forest produce un-harvested in the fields, collapsed supply chains and disturbed the transport network which adversely affected the livelihoods of the tribal farmers. With the help of Small Scale Lac Processing Unit, developed by ICAR-IINRG, Ranchi, lac growers/farmers could convert their sticklac into seedlac (value added product) without facing much storage-problem, provided relief to some extent to them during these crucial days.

Under such prevailing circumstances, *Van Dhan Vikas Kendras* (VDVKs) and Farmers Producers Organizations (FPOs) can act as link between producers and consumers and also bringing VDVKs & lac based FPOs in consortium mode will be much more helpful in keeping the supply chain normal. Many more such initiatives are required to be taken to overcome from the present crisis. Taking advantage of the wide reach of social media, ICAR-IIINRG, Ranchi too disseminated advisories by creating WhatsApp Group '*Laksha* Updates' to post advisories and get feedback from progressive and innovative farmers of lac sector as well as NGOs. Due to strong linkage mechanism and accessibility of stakeholders with huge number of experts, stakeholders feel motivated and encouraged.

During the year, Institute continued to excel in allied activities also. Institute was one of the organizers of State Level Agro-Tech Fair, organized workshop on Enabling Village Level Organizations through Technological Interventions in Production and Value Addition of NRGs besides organizing/participating in a number of other events. Last but not the least, Institute Hindi Magazine *Laksha*-2018 bagged Second *Ganesh Shankar Vidyarthi* Award for disseminating knowledge and achievements of the Institute to the lac growers and other stakeholders.

December, 2020
Namkum, Ranchi

(KK Sharma)
Director

Introduction

Mandate

- Research on lac production technologies and processing and value addition of natural resins (including lac), gums and gum-resins.
- Information dissemination, training and technology transfer to farmers, processors and entrepreneurs and tribal people on lac, gums and gum-resins for sustainable livelihood.

Historical Perspectives

India is one of the largest producers of natural resins, gums and gum-resins (NRGs) along with China, Indonesia, Russia and Brazil. Our country is the world leader in production of *guar*, *karaya* and *psyllium* gums as well as lac. Total production of NRGs has decreased slightly from 6,25,769.67 tons in 2016-17 to 6,03,369.0 tons in 2018-19. A decline of about 8.67% in the production of NRGs was observed over the previous year. ITC calculations based on UN COMTRADE statistics, the world trade aggregation of all commodities during 2018 revealed that out of 130 exporting countries in the world, India ranks 19th position in export with a share of 1.74% in the total world export value. Similarly, out of 130 importing countries of the world, India ranks 9th position in import with a share of 2.71% in the total world import value.

ICAR-Indian Institute of Natural Resins and Gums (ICAR-IINRG) fills in the gap of a National R & D Institution to the NRG sector, which is quite important from social, export and ecological angles. The Institute provides holistic support in research to the NRG sector under one roof, from production of lac, processing, value addition, application development and related areas like quality control, capacity building, to strengthen the sector in the country. The origin of the Institute dates back to 1920s during the British era, when the need for establishment of an R&D organization for lac, a natural resin of insect origin, was felt.

Realizing the strategic importance of this commodity, the then Imperial Government of India constituted the Lindsay-Harlow Committee in 1920 to look into all aspects of the country's lac trade and its development. On the suggestions of this committee, lac merchants organized themselves into the Indian Lac Association for Research, under the aegis of which, the foundation stone of the Indian Lac Research Institute (ILRI) was laid on September 20, 1924 at Ranchi. Subsequently, on the recommendations of the Royal Commission on Agriculture, the Indian Lac Cess Committee (ILCC) was constituted, which took over the reins of the ILRI in 1931. As a result of reorganization of agricultural research and education in the country after independence, the ICAR took over the administrative control of the ILRI in April 1966. This Institute is thus, one of the oldest institutions within the ICAR system, having completed 97 years of existence. It has contributed immensely towards all-round development of lac maintaining India's leadership in production, installed processing capacity and export of the commodity.

Recognizing the importance of other natural resins and gums, which are cultivated and collected in the Indian sub-continent, and are of tremendous industrial importance in divergent industries and export markets, the ICAR revised the mandate of ILRI and renamed it as IINRG. All natural gums and resins were brought under its scope, under the revised research mandate of the Institute *w.e.f.* September 20, 2007. Subsequently, the ICAR also sanctioned a new Network Project on Conservation of Lac Insect Genetic Resources launched in August, 2014 with eight centres besides the existing Network Project on Harvesting, Processing and Value Addition of NRGs with increased strength. Since November 29, 2009 the Institute is recognized as National Lac Insect Germplasm Centre (NATLIGEC). On May 30, 2015, the Institute was certified as ISO 9001:2008 organization.

Location and Agro-Climate

The Institute is located 9 km south-east of Ranchi city, on the Ranchi-Jamshedpur highway (NH33) at an altitude of 650 m above mean sea level, 23^{0}23" N latitude and 85^{0}23" E longitude. The soil of the experimental farm is of lateritic type. The area experienced mild salubrious climate, with rather good rainfall of about 1064 mm, of which about 75 per cent (795 mm) was during the monsoon season.

Organizational Structure

ICAR-IINRG has responded to the globalization of industries and agricultural enterprises of the country as well as functional reorganization of ICAR. The Institute also has undergone structural changes and the priorities have been redefined. In 1995-1996, the erstwhile Divisions and Sections were abolished and the scientific manpower divided into three divisions, *viz*. Lac Production, Processing and Product Development and Transfer of Technology. The NATLIGEC maintains Lac-Insect and Lac-Host Plant Field Gene Banks. The Institute is headed by Director.

Staff

The Institute has a sanctioned strength of 1 RMP, 47 scientific, 72 technical, 33 administrative and 84 supporting grade staff with a total of 237 sanctioned posts, out of which 28 scientific including RMP, 47 technical, 19 administrative and 43 supporting posts with a total of 137 staff are in position as on December 31, 2019.

Infrastructure

Manned by a team of dedicated scientists from various disciplines including Agricultural Entomology, Plant Sciences, Agricultural Chemicals, Engineering, Biotechnology etc., the Institute has about 137 staff in scientific, technical, administrative and supporting categories. The Institute has a number of prestigious labs, like Biotechnology, Bio-control Laboratory, Instrumentation Laboratory, Quality Evaluation Laboratory etc. The Institute shoulders the responsibility of collection and maintenance of germplasm of lac insect lines as well as lac host trees (NATLIGEC). Similarly, the Lac Host Plant Field Gene Bank of the Institute has 89 collections of 55 species comprising trees, medium and bushy types of lac host plants collected from different agro climatic regions of the country.

There are several well organized and equipped service sections to support research activities of the Institute. The administrative wing comprises Director's Office, Administrative Section, Audit and Accounts Section, Purchase and Central Stores. The sections providing technical support are Library; Prioritization, Monitoring and Evaluation Cell; Institute Research Farm and Maintenance & Workshop Unit. The Auxiliary units are Hindi Cell, Security, Medical and Estate Maintenance services.

The Institute Research Farm (IRF) spread over 36 ha, has all conventional land cultivated lac host plants. Presently, it has approx. 1550 host trees of *Schleichera oleosa* (*Kusum*), 2480 trees of *Butea monosperma* (*palas*), 1351 trees of *Ziziphus mauritiana* (*ber*) and 8700 minor host plants. The IRF also maintains a nursery of host plants for meeting the demand from other institutions as well as farmers. More than 1290 cultures of 56 lac insect lines are being conserved on *F. macrophylla* in National Lac Insect Germplasm Centre (NATLIGEC).

The ICAR-IINRG Library has a holding of more than 35,000 volumes of scientific journals, 2000 rare books, including back volumes of research periodicals in the field of resins and gums including lac and surface coatings. Since the holdings of back volumes of certain journals date back to circa 1868, the library is also a partner of the Consortium for e-Resources in Agriculture (CeRA), of ICAR. Besides catering to the learning needs of scientists and the staff of the Institute, the library also attracts researchers from neighboring educational and research institutions, including Birla Institute of Technology, Ranchi University, Birsa Agricultural University and ICAR-Research Complex for Eastern Region, Regional Centre, Ranchi and others.

The Quality Evaluation Laboratory of the Institute, caters to the quality control needs of the lac processing/lac product industries as well as exporters of lac/lac products. The lab has facilities for carrying out testing of lac/lac products as per BIS requirements.

The PME Cell provides access to internet and e-mail facilities for communication and information retrieval to the scientists. The Institute website at https://iinrg.icar.gov.in is a valuable source of information in the Institute.

Executive Summary

Characterization and Conservation of Lac Insects and Host Plants

- Germplasm of pigeonpea (*Birsa Arhar* 1, *Bahar*, Assam local 1, RCMP2, RCMP5, KA 9-2) gave consistent performance for broodlac and scrapedlac with grain yield giving broodlac and scrapedlac yield ratio of 3.5 and 36%, respectively. Production of lac on pigeonpea with slight decrease in grain yield provides additional income.
- To popularize odisha *kusmi* yellow lac insect in farmers' field, it was inoculated on *semialata* which yielded broodlac ratio 17.66 during winter season (*aghani*) crop at Hensla village, Jhalda, (West Bengal). Similarly, *Kusmi* broodlac inoculated on *Calliandra calothyrsus* gave broodlac ratio of 5:95 at farmers' fields in Benyazara and Lodma villages of Ranchi district.
- Recorded natural population of lac insect on host plant, *Calliandra surinamensis* at Konkan coastal area Ganapatipule, Ratnagiri district (Maharashtra). *Palas* morphological variant *swadi* (INGR19031 with IC number 629501) was registered by Plant Germplasm Registration Committee of ICAR.
- Industrial parameters of *kusmi* yellow and *kusmi* crimson seedlac *viz*. flow, life, colour index, acid value, moisture content and wax content were analysed. Colour index showed significant difference between *kusmi* yellow and *kusmi* crimson seedlac. *Kusmi* yellow had lower colour index.
- Significant (47 %) decrease in lac insect mortality has been recorded on *palas* in lowland condition as compared to upland and 15.2 % increase in shoot length was registered in lowland condition.
- qPCR experiments revealed differential expression of the genes such as *fpps*, *dpds* and *add* which matches with the level of resin secretion in different developmental stages. It gives an indication that genes such as *fpps*, *add* and *dpds* are probably involved in resin biosynthesis.
- Few putative pigment biosynthesis genes were identified from the differentially expressing genes from RNA-seq of crimson and cream lac insects. Among them, partial genes coding for acyl carrier protein 1 and acyl carrier protein 2 were cloned. RNAi knock down mutants of the lac insects for deaminase (*da*), tyrosine monooxygenase (*tymo*) and acyl carrier protein (*acp*) were developed. qPCR studies revealed the downregulated expression of the *da* and *acp* in the respective knock down mutants. HPLC analysis of the lac dye components of the *da* and *tymo* knockdown mutants showed lesser level of lac dye components in them up to 3 days after injection. Full length *tymo* cDNA was cloned in bacterial expression vector.
- Storage of *Schleichera oleosa* (*Kusum*) seeds in air tight plastic jar and HDPE bag could maintain its vigour and viability. Further, September and October are pre-eminent months of nursery raising of *kusum* plant. Seeds of *kusum* treated with chitosan and imidacloprid before storage showed an increase in potential seed longevity, vigour and viability.
- Higher exudation of latex after pruning can be taken up as a good parameter to judge a healthy shoot from an unhealthy one. Branches oozing negligible latex after pruning could not regenerate new shoots in 83 per cent cases. Therefore, it may be considered as a good criterion to judge whether the tree requires rest or not.

Pest Behaviour and Management

- Emergence profile of lac associated fauna was compared between different caging methods *viz*. *in-situ* caging and laboratory caging during summer season (*baisakhi*) and rainy season (*katki*) crops. Higher numbers of *T. tachardiae and E. amabillis* were recorded in *in-situ* caging compared to laboratory caging on both *ber* and *palas.* Whereas, numbers of *A. purpureus* was recorded more in laboratory caging as compared to *in-situ* caging on both *ber* and *palas* during *Katki* crop.
- Relative abundance and emergence profile of parasitoids and predators associated with lac insect were recorded during *baisakhi* and *katki* crops. It revealed that two parasitoids (*A. purpureus* and *T. tachardiae*) and one predator *E. amabilis* were abundant during the crop seasons.

- Correlation and regression analysis of peak population of *A. purpureus* recorded from *ber* and *palas* with standard meteorological week (current, 1 week lag, 2 week lag and upto 5 week lag) was carried out during *baisakhi* crops of last six years. Result shows that significant correlation was observed between peak populations of *A. purpureus* with evening relative humidity on *palas.* Regression model/equation is derived and using these models, we can validate observed value with predicted value of *A. purpureus* of *palas* and *ber* during *baisakhi* crops.

Good Cultivation Practices

- Intercropping of *okra* with *semialata* performed better than other treatment combination in terms of yield, total biomass production and total carbon stock of crop in both summer and rainy seasons. Among the treatment combinations, maximum soil carbon stock was observed in s*emialata*+*okra* for summer season and *semialata*+radish for rainy season. The results showed that all the growth parameters of *okra* were not significantly different between sole *okra* and intercropped *okra*. Fresh fusiform tap root length was observed significantly higher in the intercropped radish than sole radish.
- Evaluation of the effect of drip irrigation and furrow irrigation with plastic mulch (green and silver/black) on growth and seed yield of *F. semialata* at 25%, 50% and 75% level of irrigation showed that silver/black plastic mulch performed better than green plastic mulch in terms of growth of the shoot height and the shoot girth.
- Demonstration of nutrient management on lac cultivation by chemical fertilizers showed 31 to 227% increase in lac yield in three villages of Ranchi and Purulia districts.
- Selected *semialata* (FS-S) can be utilized for raising summer season lac crop under limited irrigation conditions. 15% higher scrapedlac yield was obtained on FS-S in comparison to local line. It's response to fertilizer application, especially extra potash had significantly positive effect on lac yield in summer season.

Tapping, Processing and Characterization of NRGs

- Hydrogels were synthesized from *guar* gum by varying cross-linker concentration using ceric ammonium nitrate as a free radical initiator. Characterization of hydrogel was done using scanning electron microscopy, FTIR, thermogravimetic and elemental analysis.
- *In vitro* evaluation of *Acacia nilotica* and *jhingan* gum induced silver nanoparticles (AgNPs) and controls (distilled water and *Acacia nilotica* gum solution) was assayed for their protectants and therapeutants efficacy against powdery mildew of pea caused by *Erysiphe pisi* using detached leaf techniques. Antifungal efficacy of pre- and post inoculation treatments of *Acacia nilotica* and *jhingan* gum induced AgNPs against powdery mildew of pea showed that both are equally effective as protectants as well as therapeutants against pea powdery mildew caused by *E. pisi.*
- Field evaluation of *Acacia nilotica* and *jhingan* gum induced AgNPs, controls (distilled water, *Acacia nilotica* gum solution and silver nitrate solution) along with commercial sulfur fungicide formulation (Sulfex® 80WP @ 2g/lit) was carried out as therapeutants after onset of powdery mildew of pea caused by *E. pisi* under field conditions. Higher plant protection/disease inhibition was recorded in *Acacia nilotica* gum induced AgNPs.

Application and Product Development

- Coating formulations developed for paper packaging materials were found to be hard, smooth and glossy. The formulations showed flexibility and resistance to scratch and impact. Improvement in mechanical properties such as tensile strength, elastic modulus, elongation %, tearing resistance and toughness was observed after coating the packaging papers with the formulations. Barrier properties such as air permeability, water absorption and water vapour transmission rate (WVTR) reduced to a great extent after coating the papers. SEM analysis of coated packaging papers indicated that papers got smoothened and pores were blocked after coating the papers with the formulations.
- Evaluation of isolated dietary fibre from *guar* and *arabic* gum revealed that it has potential to serve as prebiotic material. The biochemical analyses of the diatary fibre samples inferred that the given samples did not contain *E. coli* and *Salmonella* and were free from bacterial contamination. The enzyme kinetics of the endo-β-mannanase and protease showed that protease action are faster than the endo-β-mannanase hydrolysis for isolation of dietary fibre.

- *Guar* and gum *ghatti* based silver nanocomposite hydrogels were synthesized and evaluated for wound healing efficacy in fish in murine model. The gum *ghatti* based silver nanocomposite hydrogel was found more effective in wound healing as compared to *guar* gum nanocomposite hydrogel. Thus, the silver nanocomposite hydrogel could be utilized as potential wound care formulation to improve aquaculture production as well as in animal model. Another evaluation study revealed that the *guar* and gum *ghatti* based ZnO-nanocomposite hydrogel may also be utilized as pollutant degradation agent for removal of coloured impurities present in waste water.
- Different formulations developed from the synthesized hydrolyzed lac, as resin/gum based sticky insect trap, showed good adhesive power averaging 0.3 Kg/cm^2 besides acid value, tensile strength, etc. Preliminary field trials of sticky insect trap with light coloured hydrolyzed lac as a glue gave encouraging results. About 300 small flying insect were found stuck on the trap in 7 days.

Capacity Building and Training

- 13 Farmers' training programmes on Scientific lac cultivation, processing and utilization were organized for 460 farmers from four States *viz*. Jharkhand, Chhattisgarh and Maharashtra. One HRD programme was organized for 23 students from *Guru Ghashi Das* University, Bilaspur, C.G. A total of 10 Training Programmes on Lac Cultivation & Primary Processing of Lac under World Food Programme were organized for 492 farmers from Jharkhand and Odisha. Two Educational programme on Production, processing and uses of natural resin and gums were conducted for 72 UG/PG students of six institutions namely, Institute of Agriculture, *Banaras Hindu* University (BHU), Varanasi (Uttar Pradesh); Quantum University, Roorkee (Uttarakhand); Himgiri Zee University, Dehradun (Uttarakhand); Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad (Uttar Pradesh); Doon Business School, Dehradun (Uttarakhand) and Jharkhand Rai University, Ranchi (Jharkhand) and 12 newly joined technical personnel from ICAR-IINRG Ranchi.
- 13 On-farm training programmes were organized for 994 stakeholders of Jharkhand. Three On-farm motivational training programmes were organized for 151 stakeholders of Jharkhand. 66 On-campus one day orientation programme on Natural resins and gums were organized and 2996 stakeholders visited the Institute.
- Institute participated in six exhibitions *i.e.* State Level Agricultural Fair-Agrotech 2019; *Kisan Mela*, BAU, Ranchi; Annual *Kisan Mela*-2019, RK Mission Ashram, Ranchi; *Krishi Kumbh*-2019, Gandhi Maidan, Motihari, Bihar; *Krishi Takniki Avam Yantra Pradershani*, Ramkrishna Seva Ashram, Rahe, Ranchi and Annual *kisan Mela*-cum-Exhibition-2019, CRURRS, Hazaribag, Jharkhand. Total 74200 farmers visited the stall. Four *Kisan Gosthi*/Workshop/Educational Programmes on Lac cultivation were organized for 2430 farmers of Jharkhand.
- Five lac based product demonstration training programmes were organized for 14 stakeholders from Jharkhand, New Delhi and Andhra Pradesh.
- Three Front Line Demonstrations (FLDs) were organized by the Institute. Nine Lac Crop Surveillances conducted in different districts of Jharkhand.
- 1,834 SC farmers benefited under various capacity building, awareness and distribution of livestock/farm implements *etc.* under SC-Sub Plan.

Field Demonstrations, Technical Advisory and Extension Activities

- ICT enabled One to One Programme (OTOP), Market Oriented Technical Advisory Services (MOTAS), Diagnostic Crop Monitoring and industrial visits benefited 48 stakeholders including 4 entrepreneurs, 18 processors/manufactures, 6 farmers, 4 government organizations/policy makers, 10 researchers/research scholars, 3 traders, 3 NGOs and FPOs from India, Australia and China. *Laksha Updates* initiatives boosted the linkages with stakeholders.
- A sum of Rs. 55.67542 lakh was generated through training charges, consultancy project and literature during the period.

Technology Adoption, Impact Assessment and Market Research Activities

- 8.67 % decrease in the production of NRGs was found during 2018-19 in comparison to 2017-18. This decline in

production was observed in *dhawda* gum (10.00%), *guar* gum (9.20%) and pine resin (4.84%). Consequently, total production of NRGs has decreased from 6,60,612 tons in 2017-18 to 6,03,369 tons in 2018-19. However, lac and gum *karaya* production increased by 13.39 and 6.67%, respectively. Lac production in Jharkhand was observed 17.10% higher than the previous year.

- Export quantity (3.75 lakh tons) as well as value (Rs. 4457 crore) of NRGs from India increased and import scenario looked relatively stable over the period. The world trade aggregation of lac, natural gums, resins, gum-resins, balsams and other natural oleo-resins (HS code:1301) revealed that out of 95 exporting countries in the world, India ranks 4th in export with a share of 6.57% in the total world export value. Similarly, out of 125 importing countries of the world, India ranks 1st in import with a share of 20.51% in the total world import value.

Network Project on Harvesting, Processing and Value Addition of NRGs

- *In vitro* cytotoxic activity of the synthesized *piyar* gum induced AgNPs against Vero Cell Line (African green monkey kidney normal cell line), using MTT assay, showed that the synthesized AgNPs are non-cytotoxic with increased cells viability percentage. % survival of Vero cells against the synthesized AgNPs was found to be on quite higher side (128.074) as compared to $AgNO_3$ (14.579) at 100 µM concentrations.
- Gum inducer technique for *Commiphora wightii* was standardized. Gum inducer technique showed enhanced oleo-resin yield of *guggul* compared to the conventional method with no mortality of tree after the treatment.
- Comparison of quality parameters of *guar* meal with other meal *i.e.* soya meal and groundnut meal was carried out. *Guar* meal contained higher amount of amino acids as compared to the soybean meal and groundnut meal.
- Rosin based nano-composite has been synthesized for adsorptional photo-catalytic degradation of resistant organic pollutants such as dyes, antibiotics etc. from aqua systems. It has shown promising results and application for patent is submitted.
- Fortification of *babool* gum powder in the preparation of rice and maize based extruded products was carried out. Incorporation of gum in extruded products resulted in improved physical and functional properties of extruded product.
- Physico-chemical properties of *guggul* stored in different packing/containers *viz.* earthen pot, plastic jar, polythene bag and jute bag was studied. Change in physico-chemical properties of *guggul* was found least in case of storage in earthen pot.
- Foliar application of cycocel (a plant growth regulator) with 1000 ppm concentrations in tamarind germplasm showed maximum flowering in tamarind.
- Resin tapping technique in *Pinus kesiya* for sustainability and conservation of natural resources was standardized. Mean resin yield varied from 41.36 to 115.8 gm/tree and maximum production was achieved in January followed by October.

Network Project on Conservation of Lac Insect Genetic Resources

- Surveys for the presence of natural population of lac insects have been conducted in 462 (65.8%) districts of the country belonging to various agro-climatic zones. Lac insect populations were observed in 310 (64.3% of surveyed) districts. New potential areas for lac cultivation have been identified in the states like Rajasthan, Karnataka, and Andhra Pradesh etc. where lac is not commercially cultivated.
- Present method of preparation of Aleuritic acid, one of the high value commercially important constituents of lac resin takes around 10-15 days' time and the yield is up to 11-13% of the resin weight. A new method of synthesis has been developed which takes around 4-5 days' time, resulting in 15-16 % yield.
- For biological control of *Eublemma amabilis*, a major predator of lac crop, a new strain of entomo-pathogenic fungi, *Beauveria bassiana* was identified and isolated from the yellow tail tussock moth *Somena scintillans*. The newly identified strain when tested against *E. amabilis* was able to cause 100% mortality of the predators.
- *Isaria fumosorosea,* an entomo-pathogenic fungus (EPN) has been isolated from *E. amabilis*. This EPN is potential bio-

control agent and has host range of important insect pests of other crops like diamond back moth (*Plutella xyllostella*), spotted spider mite (*Tetranychus urticae*) and apple rust mite (*Aculuss chlectendali*).

- *F. semialata* an important bushy host plant for *kusmi* strain of lac insects is prone to water logging conditions. Hence, *F. semialata* was cleft grafted on *F. macrophylla* which is resistant to water logging, but not a good host for *kusmi* lac insects. The grafted plants have been found to give *kusmi* lac yield at par with the non-grafted *F. semialata* plants.
- Digital documentation of 50 major lac host plants of India *viz*. *kusum*, *palas*, *semialata*, rain tree, pigeonpea, *galwang*, Red *calliandra*, *Jalari*, *etc.* has been completed for preparing a field guide. The field guide would help farmers, scientists, researchers, traders, students and other stake holders in correct identification of the lac host plants.
- Barcoding of new lac insect collections from Tamilnadu, Punjab and Haryana showed that these insects were *rangeeni* strain of *Kerria lacca*. Two ant species associated with lac insects were also barcoded and found to be *Tapinoma melanocephalum* and *Formicidae* sp. V3-V4 metagenome sequencing of 16S rRNA genes of female lac insects and crawlers showed differential presence of microbes in both the stages.

KVK, Khunti

- 10 FLDs having area of 4.0 ha were conducted during *kharif* 2019 on paddy variety *sahbhagi dhan* covering 27 farmers of village Banai Toli (7), Churgi (10) of Torpa block and Kota (10) of Arki block in Khunti district. To enhance the productivity in *rabi* and summer seasons good quality seeds of chickpea (390 kg), mustard (8 kg) and green gram (180 kg), respectively, under FLD programme, were distributed among farmers of Khunti district.
- Scientific lac cultivation programme in four blocks (Khunti, Murhu, Rania, Arki) of Khunti district was initiated. More than 100 lac host plants were inoculated with 400 kg broodlac. Necessary inputs were also provided to ensure good return from the crop.
- Conducted 20 off-campus trainings for farmers on cultivation of paddy, pigeonpea, groundnut, soybean, green gram and black gram during *kharif* season, in which 2059 farmers participated. During *rabi* season, 18 off-campus trainings for farmers were conducted on cultivation of chickpea, lentil and rapeseed mustard.
- Two on-campus trainings for 66 farmers on Scientific lac cultivation techniques were conducted during the year.

कार्यकारी सारांश

लाख कीटों एवं परिपालक पौधों का अभिलक्षण वर्णन व संरक्षण

- अरहर (बिरसा अरहर 1, बहार, असम लोकल 1, आर सी एम पी 2, आर सी एम पी 5, के ए 9–2) के जननद्रव का बीहनलाख एवं छिली लाख के लिए प्रदर्शन अच्छा रहा तथा अनाज उत्पादन के साथ बीहनलाख एवं छिली लाख का उपज अनुपात क्रमशः 3.5 एवं 36% रहा। अरहर के ऊपर अनाज की उपज में थोड़ी कमी के साथ लाख का उत्पादन अतिरिक्त आय प्रदान करता है।
- ओडीशा कुसमी पीला लाख कीट को किसानों के खेत में लोकप्रिय करने के लिए इसे झालदा (पश्चिम बंगाल) के हेंसला ग्राम में शरत ऋतु (अगहनी) की फसल के दौरान सेमियालता पर संचारित किया गया, जिससे 17.66 अनुपात में बीहनलाख प्राप्त हुआ। उसी तरह राँची जिले के बेनियाजारा एवं लोधमा ग्राम में किसान के खेत में *कैलिएन्ड्रा कैलोथीरसस* पर कुसमी बीहनलाख के संचारण से 5.95 अनुपात के साथ बीहनलाख प्राप्त हुआ।
- कोंकण समुद्री तट के रत्नागिरि जिले के गणपति पूले क्षेत्र में *कैलिएन्ड्रा सुरीनामेन्सीस* नामक लाख परिपालक पौधे पर लाख कीट की प्राकृतिक आबादी देखी गई। भाकृअनुप की पौध जननद्रव पंजीयन समिति द्वारा पलास के आकारिकी प्रभेद स्वादी (आई एन जी आर 19031 – आई सी संख्या 629501) का पंजीकरण किया गया।
- कुसमी पीला एवं कुसमी किरमिजी चौरी के औद्योगिक मानदंड जैसे बहाव, आयु, रंग सूचकांक, अम्ल मान, नमी अंश एवं मोम अंश का विश्लेषण किया गया। कुसमी पीला एवं कुसमी किरमिजी चौरी के रंग सूचकांक में उल्लेखनीय अन्तर देखा गया। कुसमी पीला का रंग सूचकांक निम्न था।
- उपराउं भूमि की तुलना में तराउं भूमि स्थितियों में पलास पर लाख की मरणशीलता में उल्लेखनीय कमी (47%) रिकॉर्ड की गई एवं तराउं भूमि स्थितियों में प्ररोह लम्बाई में 15.2% वृद्धि देखी गई।
- क्यू पी सी आर प्रयोगों से पता चला कि विकास के विभिन्न चरणों में जीनों की अभिव्यक्ति अलग–अलग जैसे एफ पी पी एस, डी पी डी एस एवं ए डी डी होती है, जो राल के स्राव से मेल खाती है। इससे यह संकेत मिलता है कि एफ पी पी एस, ए डी डी एवं डी पी डी एस जैसे जीन राल जैवसंश्लेषण में शामिल हैं।
- क्रिमसन एवं क्रीम लाख कीटों के आर एन ए–श्रृंखला से अलग तरह से अभिव्यक्त जीनों से कुछ अनुमानित वर्णक जैव संश्लेषण जीनों की पहचान की गई। उनमें से एसाइल कैरियर प्रोटीन 1 एवं एसाइल कैरियर प्रोटीन 2 के लिए आंशिक जीन संहिता का कृंतक बनाया गया। *डीयेमिनेज* (डी ए), टाइरोसिन आक्सीजिनेज (टाइमों) एवं एसाइल कैरियर प्रोटीन (ए सी पी) के लिए लाख कीटों के आर एन आई नौकडाउन उत्परिवर्ती विकसित किया गया। क्यू पी सी आर अध्ययन से संबंधित नॉकडाउन परिवर्ती में डी ए और ए सी पी अभिव्यक्ति के निम्नता का पता चलता है। डी ए और टाइमो नॉकडाउन परिवर्ती के लाख रंजक अवयवों के एच पी एल सी विश्लेषण से इंजेक्शन के बाद तीन दिन तक निम्न स्तरीय लाख रंजक अवयवों का पता चलता है। जीवाणु अभिव्यक्ति वेक्टर में संपूर्ण टाइमों सी डी एन ए का कृंतक बनाया गया।
- एयर टाइट प्लास्टिक जार एवं एच डी पी ई थैले में भंडारण किए गए *श्लीचेरा ओलिओसा* (कुसुम) के बीजों की चमक एवं जीवन क्षमता बनी रही। इसके अतिरिक्त कुसुम के पौधों की नर्सरी के लिए सितम्बर एवं अक्तूबर उपयुक्त महीने हैं। भंडारण के पूर्व चीटोसन एवं इमिडैक्लोप्रिड से उपचारित कुसुम के बीजों की चमक, जीवन क्षमता एवं आयु में वृद्धि देखी गई।
- अस्वस्थ्य प्ररोह से स्वस्थ्य प्ररोह की पहचान के लिए छंटाई के पश्चात् शोणित के निःस्राव को अच्छा मानदंड माना जा सकता है। 83% मामलों में नाममात्र के शोणित रिसने वाली शाखाओं में छंटाई के बाद पुनर्उत्पत्ति नहीं हुई। वृक्ष को आराम की आवश्यकता है या नहीं, इसकी जाँच के लिए यह एक अच्छी कसौटी है।

नाशकजीव व्यवहार एवं प्रबंधन

- ग्रीष्म ऋतु (बैशाखी) एवं वर्षा ऋतु (कतकी) फसल के दौरान लाख से जुड़े जीवों का निर्गमन विवरण के विभिन्न केजिंग विधियों जैसे प्रतिस्थाने केजिंग एवं प्रयोगशाला केजिंग की तुलना की गई। बेर एवं पलास दोनों पर प्रयोगशाला केजिंग की तुलना में प्रतिस्थाने केजिंग में ज्यादा संख्या में *टी टेकार्डी* एवं *इ एमाविलीस* रिकार्ड किए गए। जबकि कतकी फसल में बेर एवं पलास दोनों पर प्रतिस्थाने केजिंग की तुलना में प्रयोगशाला केजिंग में *ए परप्यूरियस* की संख्या ज्यादा रिकॉर्ड किया गया।

- बैशाखी एवं कतकी फसल के दौरान लाख कीट से जुड़े परजीवियों एवं परभक्षियों की सापेक्ष प्रचूरता एवं निर्गमन विवरण रिकॉर्ड किया गया। इससे पता चला कि दो परजीवी *(ए परप्यूनियस* एवं *टी टेकार्डी)* तथा एक परभक्षी *ई एमाविलीस* फसल के दौरान प्रचुरता से थे।
- विगत छः वर्षों में बैशाखी फसल के दौरान बेर एवं पलास पर मानक मौसम सप्ताह (वर्त्तमान, एक सप्ताह बाद, दो सप्ताह बाद से 5 सप्ताह बाद तक) में *ए परप्यूरियस* की अधिकतम आबादी का सहसंबंध एवं प्रतिगमन विश्लेषण किया गया। परिणाम से पता चलता है कि पलास पर संध्या में सापेक्ष आर्द्रता के साथ *ए परप्यूरियस* की अधिकतम आबादी का सहसंबंध है। प्रतिगमन मॉडल/समीकरण निकाले गए एवं इस मॉडल का उपयोग कर हम बैशाखी फसल के दौरान पलास एवं बेर पर *ए परप्यूरियस* के अनुमानित मान एवं दृश्य मान को सुनिश्चित कर सकते हैं।

खेती के सहज तरीकें

- ग्रीष्म एवं वर्षा दोनों ऋतुओं की फसलों में उपज, कुल जैवमास उत्पादन एवं कुल कार्बन की दृष्टि से अन्य संयोजन की तुलना में सेमियालता के साथ ओकरा अन्तरफसल बेहतर रहा। उपचारित संयोजनों के बीच ग्रीष्म ऋतु के लिए सेमियालता + ओकरा तथा वर्षा ऋतु के लिए सेमियालता + मूली में अधिकतम मृदा कार्बन स्टॉक देखा गया। परिणाम से पता चला कि अकेले ओकरा तथा अन्तरफसल ओकरा के बीच सभी वृद्धि मानदंडों के बीच उल्लेखनीय अन्तर नहीं है। अकेले मूली की तुलना में अन्तरफसल मूली में ताजा फ्यूजीफॉर्म मूसला जड़ की लम्बाई ज्यादा देखी गई।
- एफ सेमियालता की वृद्धि एवं बीज उत्पादन पर 25%, 50% एवं 75% के स्तर पर प्लास्टिक पलवार (हरा एवं सिल्वर/काला) के साथ बूंद–बूंद सिंचाई एवं नाली सिंचाई के प्रभाव का मूल्यांकन करने पर पता चला कि प्ररोह लम्बाई एवं प्ररोह घेरा की वृद्धि की दृष्टि से सिल्वर/काला प्लास्टिक पलवार बेहतर है।
- राँची एवं पुरूलिया जिले के तीन ग्रामों में लाख की खेती पर रासायनिक उर्वरक द्वारा पोषक प्रबंधन के प्रदर्शन से लाख की उपज में 31 से 227% वृद्धि का पता चला।
- चुने गए सेमियालता (एफ एस–एस) को सीमित सिंचाई स्थितियों के अन्तर्गत ग्रीष्म ऋतु की लाख फसल की खेती के लिए उपयोग किया जा सकता है। स्थानीय किस्म की तुलना में एफ एस–एस पर छिली लाख की उपज 15% उच्चतर पाई गई। इस पर उर्वरक के प्रयोग, विशेष रूप से अतिरिक्त पोटाश की प्रतिक्रिया ग्रीष्म ऋतु में लाख उपज पर सकारात्मक रही।

प्रा. रा. गों. का निष्कर्षण, प्रसंस्करण एवं अभिलक्षण वर्णन

- सेरिक अमोनियम नाइट्रेट का मुक्त रेडिकल प्रारम्भक के रूप में उपयोग कर विभिन्न क्रॉस लिंकर सान्द्रण द्वारा ग्वार गोंद से हाइड्रोजेल का संश्लेषण किया गया। स्कैनिंग इलेक्ट्रोन माइक्रोस्कोपी, एफ टी आई आर, थर्मोग्रैविमेट्रिक एवं तात्विक विश्लेषण द्वारा हाइड्रोजेल का अभिलक्षण वर्णन किया गया।
- अलग हुई पत्ती तकनीक का उपयोग कर *अकेसिया निलोटिका* एवं झींगन गोंद प्रेरित सिल्वर सूक्ष्म कणों (ए जी एन पी एस) एवं नियंत्रण (आसवित जल एवं *अकेसिया निलोटिका* गोंद घोल) में इरीसिफी पिसी के कारण होने वाले मटर के पावडरी मिल्ड्यू के विरूद्ध उनके संरक्षक तथा औषधीय क्षमता का पता लगाने के लिए *इन विट्रो* मूल्यांकन किया गया। मटर पर पावडरी मिल्ड्यू के विरूद्ध *एकेसिया निलोटिका* प्रेरित ए जी एन पी एस के संचारण के पूर्व एवं संचारण के बाद प्रतिकवकीय क्षमता की जाँच से पता चलता है कि ई पीसी के कारण होने वाले मटर के पावडरी मिल्ड्यू के विरूद्ध दोनों संरक्षक के साथ–साथ औषधीय उपयोग के लिए प्रभावी हैं।
- प्रक्षेत्र स्थितियों के अन्तर्गत ई पी सी के कारण मटर पर होने वाले पावडरी मिल्ड्यू के आरम्भ में *एकेसिया निलोटिका* एवं झींगन गोंद प्रेरित ए जी एन पी एस, नियंत्रण (आसवित जल, *एकेसिया निलोटिका* गोंद घोल एवं सिल्वर नाइट्रेट घोल) का वाणिज्यिक गंधक कवकनाशी सूत्रण (सल्फेक्स 80 डब्ल्यु पी @ 2 ग्रा./ली.) के साथ उपचारक के रूप में प्रक्षेत्र मूल्यांकन किया गया। *एकेसिया निलोटिका* गोंद प्रेरित ए जी एन पी एस द्वारा उच्चतर पौध संरक्षण/रोग प्रतिरोध रिकॉर्ड किया गया।

अनुप्रयोग एवं उत्पाद विकास

- पेपर पैकेजिंग सामग्री के लिए विकसित लेपन सूत्रण कड़ा, चिकना एवं चमकदार पाया गया। सूत्रण में लचीलापन तथा खरोंच व प्रभाव प्रतिरोध क्षमता है। पैकेजिंग पेपर पर सूत्रण के लेपन के पश्चात् तनन सामर्थ्य, लचीलापन मापांक,

दीर्घीकरण प्रतिशत, फटने से प्रतिरोध एवं कड़ापन जैसे यांत्रिक गुणों में सुधार की जाँच की गई। पेपर पर लेपन के पश्चात् बाधक गुणों जैसे वायु पारगम्यता, जल अवशोषण एवं जलवाष्प संचरण दर (डब्ल्यू वी टी आर) काफी हद तक कम हो गया। सुत्रण से पेपर पर लेपन के पश्चात् उसके एस ई एम विश्लेषण से संकेत मिला कि कागज चिकना हो गया तथा उसके छिद्र बन्द हो गए।

- ग्वार एवं अरबी गोंद से पृथक किए गए खाद्य रेशा के मूल्यांकन से पता चलता है कि इनमें प्रिबायोटिक सामग्री के रूप में उपयोग की क्षमता है। खाद्य रेशा नमूने के जैवरासायनिक विश्लेषण से पता चलता है कि इनमें ई. कोलाई एवं सल्मोनेला नहीं है तथा ये जीवाणु संक्रमण से मुक्त हैं। इन्डो–बी–मनानेस एवं प्रोटिज के पाचक रस काइनेटिक्स से पता चलता है कि खाद्य रेशा के पृथक्करण के लिए इन्डो–बी–मनानेस की तुलना में प्रोटिज तीव्र गति से कार्य करता है।
- ग्वार एवं घट्टी गोंद आधारित सिल्वर नैनोकम्पोजिट हाइड्रोजेल का संश्लेषण किया गया तथा मरीन मॉडेल की मछली में घाव भरने की क्षमता का मूल्यांकन किया गया। ग्वार गोंद आधारित नैनोकम्पोजिट हाइड्रोजेल की तुलना में घट्टी गोंद आधारित सिल्वर नैनो कम्पोजिट हाइड्रोजेल घाव भरने में ज्यादा प्रभावी पाया गया। इस तरह जल सवर्द्ध उत्पादन के साथ–साथ पशु मॉडल के उन्नयन के लिए सिल्वर नैनो कम्पोजिट हाइड्रोजेल घाव ठीक करने के लिए आशाजनक सूत्रण है। एक अन्य मूल्यांकन अध्ययन से पता चला कि ग्वार एवं घट्टी गोंद आधारित जेड एन ओ नैनोकम्पोजिट हाइड्रोजेल अपशिष्ट जल में उपस्थित रंगीन अशुद्धियों को हटाने के लिए प्रदूषक अवक्रमण अभिकारक के रूप में भी उपयोग किया जा सकता है।
- संश्लेषित जल अपघटित लाख से राल/गोंद आधारित चिपकने वाला कीट फंदा जैसा विभिन्न सुत्रण विकसित किया गया, जिसमें अम्ल मान, तनन सामर्थ्य इत्यादि के अतिरिक्त 0.3 कि.ग्रा./से.मी.^{2} औसत के साथ अच्छी आसंजन क्षमता पायी गई। ग्लू के रूप में हल्के रंग के जल अपघटित लाख के साथ चिपकाने वाले कीट फंदा के प्रारंभिक प्रक्षेत्र परीक्षण से प्रोत्साहित करने वाले परिणाम आए हैं। सात दिनों में फंदे में लगभग 300 छोटे उड़ने वाले कीट चिपके हुए पाए गए।

क्षमता निर्माण एवं प्रशिक्षण

- झारखंड, छतीसगढ़ एवं महाराष्ट्र तीन राज्यों से आए 460 किसानों के लिए लाख की वैज्ञानिक खेती, प्रसंस्करण एवं उपयोग पर 13 कृषक प्रशिक्षण कार्यक्रम आयोजित किए गए। गुरू घासी दास विश्वविद्यालय, बिलासपुर, छतीसगढ़ के 23 छात्रों के लिए एक मानव संसाधन विकास कार्यक्रम आयोजित किया गया। झारखंड एवं ओडीशा के 492 किसानों के लिए विश्व खाद्य कार्यक्रम के अन्तर्गत लाख की खेती एवं प्रारंभिक प्रसंस्करण विषय पर 10 प्रशिक्षण कार्यक्रम आयोजित किए गए। संस्थान में हाल में योगदान देने वाले 12 तकनीकी कार्मिकों के अतिरिक्त छः संस्थानों कृषि संस्थान, बनारस हिन्दू विश्वविद्यालय (बी एच यू), बनारस (उ.प्र.); क्वांटम विश्वविद्यालय, रूड़की (उत्तराखंड); हिमगिरी जी विश्वविद्यालय, देहरादून (उत्तराखंड); सैम हिगीनबॉटम कृषि, प्रौद्योगिकी एवं विज्ञान विश्वविद्यालय, इलाहाबाद (उत्तर प्रदेश); दून बिजनेश स्कूल, देहरादून (उत्तराखंड) एवं झारखंड राय विश्वविद्यालय, राँची (झारखंड) के 72 स्नातक/स्नातकोत्तर के छात्रों के लिए प्राकृतिक राल एवं गोंद के उत्पादन, प्रसंस्करण एवं उपयोग पर दो शैक्षणिक कार्यक्रम आयोजित किए गए।
- झारखंड के 994 पणधारियों के लिए 13 प्रक्षेत्र प्रशिक्षण कार्यक्रम आयोजित किए गए। झारखंड के 151 पणधारियों के लिए तीन प्रक्षेत्र प्रोत्साहन प्रशिक्षण कार्यक्रम आयोजित किए गए। प्राकृतिक राल एवं गोंद पर परिसर में 66 अभिविन्यास कार्यक्रम आयोजित किए गए तथा 2996 पणधारियों ने संस्थान भ्रमण किया।
- संस्थान ने राज्य स्तरीय कृषि मेला–एग्रोटेक 2019, किसान मेला, वि.कृ.विवि, राँची; वार्षिक किसान मेला–2019, रामकृष्ण मिशन, राँची; कृषि कुम्भ 2019, गांधी मैदान, मोतीहारी, बिहार; कृषि तकनीकी एवं यंत्र प्रदर्शनी, रामकृष्ण सेवा आश्रम, राहे, राँची एवं वार्षिक किसान मेला सह प्रदर्शनी–2019, सी आर यू आर आर एस, हजारीबाग, झारखंड सहित छः प्रदर्शनियों में संस्थान ने भाग लिया। कुल 74200 किसानों ने संस्थान के स्टाल का भ्रमण किया। झारखंड के 2430 किसानों के लिए लाख की खेती संबंधी चार किसान गोष्ठी/कार्यशाला/शैक्षणिक कार्यक्रम आयोजित किए गए।
- झारखंड, नई दिल्ली एवं आन्ध्र प्रदेश के 14 पणधारियों के लिए पाँच लाख आधारित उत्पाद प्रदर्शन प्रशिक्षण कार्यक्रम आयोजित किया गया।
- संस्थान द्वारा तीन अग्रिम पंक्ति प्रदर्शन (एफ एल डी एस) का आयोजन किया गया। झारखंड के विभिन्न जिलों में लाख फसल के नौ पर्यवेक्षण कार्यक्रम आयोजित किए गए।
- अनुसूचित जाति उपयोजना के अन्तर्गत क्षमता निर्माण, जागरूकता एवं मवेशी/कृषि उपकरण इत्यादि के वितरण के तहत् 1834 अनुसूचित जाति के किसान लाभान्वित हुए।

प्रक्षेत्र प्रदर्शन, तकनीकी परामर्श एवं प्रसार गतिविधियां

- आई सी टी युक्त एक से एक कार्यक्रम (ओ टी ओ पी), बाजार से जुड़ा तकनीकी परामर्श सेवाएं (एम ओ टी ए एस), फसल सुरक्षा पर्यवेक्षण एवं औद्योगिकी दौरे से 4 उद्यमियों, 18 प्रसंस्करणकर्त्ताओं/निर्माताओं, 6 किसानों, 4 सरकारी संगठनों/नीति निर्माताओं, 10 अन्वेषकों/अनुसंधानकर्त्ताओं, 3 व्यापारियों, 3 एन जी ओ तथा भारत, ऑस्ट्रेलिया तथा चीन के 3 एफ पी ओ समेत 48 पणधारियों को लाभ पहुँचाया गया। लक्ष्य नवीकरण पहल से पणधारियों के साथ संपर्क मजबूत हुआ।
- इस अवधि में प्रशिक्षण शुल्क, परामर्श कार्य एवं प्रसार साहित्य से रू. 55,67,542 लाख का सृजन किया गया।

प्रौद्योगिकी अंगीकरण, प्रभाव मूल्यांकन एवं बाजार अनुसंधान गतिविधियां

- वर्ष 2017–18 की तुलना में 2018–19 की अवधि में प्रा.रा.गों. के उत्पादन में 8.67% की कमी आई। धावड़ा गोंद (10%), ग्वार गोंद (9.2%) एवं पाईन राल (4.84%) के उत्पादन में गिरावट देखी गई। परिणामस्वरूप प्रा.रा.गों. का कुल उत्पादन 2017–18 के 6,60,612 टन की तुलना में 2018–19 में 6,03,369 टन हुआ। हालांकि लाख एवं कराया गोंद के उत्पादन में क्रमशः 13.39% एवं 6.67% वृद्धि हुई। झारखंड में पिछले वर्ष की तुलना में लाख उत्पादन में 17.10% की वृद्धि हुई।
- भारत से प्रा.रा.गों. की निर्यात की मात्रा (3.75 लाख टन) के साथ–साथ मूल्य (रू. 4457 करोड़) में वृद्धि हुई तथा इस अवधि में आयात लगभग स्थिर रहा है। लाख, प्राकृतिक गोंद, राल, गोंद–राल, वाल्सम एवं अन्य ओलियो–रेजीन (एच एस कोड : 1301) के विश्व व्यापार समुच्चय से पता चला कि विश्व के कुल निर्यात मूल्य के 6.57% हिस्सेदारी के साथ 95 निर्यातक देशों में भारत का चौथा स्थान है। उसी तरह विश्व के कुल आयात मूल्य के 20.51% हिस्सेदारी के साथ 125 आयात करने वाले देशों में भारत का स्थान पहला है।

प्रा. रा. गों. के निष्कर्षण, प्रसंस्करण एवं मूल्यवर्द्धन पर नेटवर्क परियोजना

- एम टी टी जाँच का उपयोग कर वीरो सेल लाइन (अफ्रीकी हरा बंदर किडनी सामान्य सेल लाईन) के प्रति संश्लेषित पियार गोंद प्रेरित ए जी एन पी एस की *इन विट्रो* साइटोटॉक्सिक गतिविधियों से पता चलता है कि कोशिका के जीवन क्षमता प्रतिशत में वृद्धि के साथ संश्लेषित ए जी एन पी एस साइटोटॉक्सिक नहीं है। ए जी एन ओ 3 (14.579) के 10µ एम सांद्रण की तुलना में संश्लेषित ए जी एन पी एस के प्रति वीरो सेल की उत्तरजीविता % काफी उच्चतर (128.074) पाई गई।
- *कॉमिफोरा विघटि* की गोंद प्रेरक तकनीक को मानकीकृत किया गया। गोंद प्रेरक तकनीक से उपचार के बाद वृक्ष की मरणशीलता के बिना परम्परागत विधि की तुलना में गुग्गुल से ओलियो–राल के उत्पादन में वृद्धि हुई।
- ग्वार मील (खाद्य) की अन्य मील जैसे सोया मील एवं मूंगफली मील से गुणवत्ता मांनदंडों की तुलना की गई। सोया मील एवं मूंगफली मील की तुलना में ग्वार मील में उच्चतर अमीनो अम्ल अंश पाया गया।
- रंजक, प्रतिजैविक इत्यादि जैसे कार्बनिक प्रदूषक प्रतिरोधी के अधिशोषण फोटो उत्प्रेरक अवक्रमण के लिए गंधराल आधारित सूक्ष्म–संयोजी का जलीय पद्धति से संश्लेषण किया गया। इसके आशाजनक परिणाम आए हैं तथा पेटेन्ट के लिए आवेदन किया गया है।
- चावल एवं मकई आधारित निकले हुए उत्पादों की तैयारी के लिए बबूल गोंद पावडर का सुरक्षा घेरा बनाया गया। निकले हुए उत्पाद में गोंद के समावेश के परिणामस्वरूप उनकी भौतिक एवं कार्यात्मक गुणों में सुधार होता है।
- विभिन्न प्रकार की पैकिंग/बर्त्तन जैसे मिट्टी के बर्त्तन, प्लास्टिक जार, पॉलीथीन बैग एवं जूट के बोरे में रखे गए गुग्गुल की भौतिक–रासायनिक गुणवत्ता का अध्ययन किया गया। मिट्टी के बर्त्तन में गुग्गुल के भंडारण से उसके भौतिक–रासायनिक गुणों में बहुत कम अन्तर पाया गया।
- इमली के जननद्रव में 1000 पी पी एम सांद्रण के साथ *साइकोसेल* (एक पौध वृद्धि नियामक) के पत्ती संबंधी प्रयोग से इमली में अधिकतम फूल आए।
- प्राकृतिक संसाधनों की संपोषणीयता एवं संरक्षण के लिए *पाइनस केसिया* में राल दोहन तकनीक को मानकीकृत किया गया। राल का औसत उत्पादन 41.36 से 115.8 ग्रा./वृक्ष था तथा जनवरी एवं उसके बाद अक्तूबर में अधिकतम उत्पादन हुआ।

लाख कीट आनुवंशिक संसाधन के संरक्षण पर नेटवर्क परियोजना

- देश के विभिन्न कृषि जलवायु क्षेत्र के 462 (65.8%) जिलों में लाख कीट की प्राकृतिक आबादी की उपस्थिति संबंधी सर्वे किया गया। 310 (सर्वे का 64.3:) जिले में लाख कीट की आबादी देखी गई। लाख की खेती के लिए नए आशाजनक राज्य जैसे राजस्थान, कर्नाटक एवं आन्ध्रप्रदेश इत्यादि की पहचान की गई है, जहाँ लाख की वाणिज्यिक खेती नहीं होती है।
- लाख राल का एक सबसे उच्च मूल्य का वाणिज्यिक रूप से महत्वपूर्ण संघटक एल्यूरिटिक अम्ल की तैयारी की वर्त्तमान विधि में लगभग 10–15 दिन समय लगता है तथा राल के भार का 11–13% उत्पादन होता है। संश्लेषण की एक नई विधि विकसित की गई है, जिसमें 4–5 दिन समय लगता है तथा उत्पादन 15–16% तक होता है।
- लाख की फसल का मुख्य परभक्षी *यूब्लीमा एमाविलीस* के जैविक नियंत्रण के लिए कीट रोगजनक कवक की नई प्रजाति *ब्यूवेरिया बैसियाना* की पहचान की गई तथा उसे पीली पूंछ वाली टसक कृषि *सोमिना सिन्टीलैन्स* से पृथक किया गया। *ई. एमाविलिस* के विरूद्ध जब नई उपजाति का परीक्षण किया गया तो परभक्षी की 100% मरणशीलता देखी गई।
- एक कीट रोगजनक कवक (ई पी एन) *इसारिया फ्यूमोसोरोसी* को *ई. एमाविलीस* से पृथक किया गया। यह इ पी एन आशाजनक जैव–नियंत्रक अभिकारक हैं एवं इसके परिपालक रेंज में अन्य फसलों के महत्वपूर्ण कीटनाशक जीव जैसे *डायमंड बैकमॉथ* (*प्लूटेला जिलोस्टेला*), *स्पॉटेड स्पाइडर माइट* (*टेट्रानिकस अर्टिसी*) एवं *एपल रस्ट माइट* (*एक्यूलस क्लेक्टेनडली*) हैं।
- लाख कीट की कुसमी प्रजाति का एक महत्वपूर्ण झाड़ीदार परिपालक पौधा फ्लेमिंजिया सेमियालता जल जमाव वाले क्षेत्र के लिए उपयुक्त नहीं है। अतः एफ सेमियालता की गूंठी (कलम) *एफ मैक्रोफाइला* पर लगाई गई, जो कुसमी लाख कीट का अच्छा परिपालक नहीं है परन्तु जल जमाव प्रतिरोधी है। कलम लगाए गए पौधे पर कुसमी लाख की उपज बिना कलम वाले *एफ सेमियालता* के बराबर थी।
- प्रक्षेत्र निर्देशिका बनाने के लिए 50 महत्वपूर्ण लाख परिपालक पौधे जैसे कुसुम, पलास, सेमियालता, रेन ट्री, अरहर, गलवांग, रेड कॉलिएन्ड्रा, जलारी इत्यादि का डिजीटल दस्तावेज की तैयारी पूरी की गई। प्रक्षेत्र निर्देशिका से कृषकों, वैज्ञानिकों, व्यापारियों, छात्रों एवं अन्य पणधारियों को लाख परिपालक की सही पहचान में सहायता मिलेगी।
- तमिलनाडु, पंजाब एवं हरियाणा से संग्रह किए गए नए लाख कीट की बारकोडिंग से पता चला कि ये *केरिया लैका* के रंगीनी उपजाति के लाख कीट हैं। लाख कीट से जुड़े चींटियों की दो प्रजाति का भी बारकोड बनाया गया तथा पता चला कि *टैपिनोमा मेलानोसेफेलम* एवं *फॉर्मिसाइड* प्रजाति वी–3 वी–4 *मेटाजीनोम* मादा लाख कीट के जीन 16 एस आर आर एन ए की श्रृंखला में हैं तथा दोनों चरणों में रेंगने वाले कीट में अलग किस्म में सूक्ष्म जीव की उपस्थिति है।

कृषि विज्ञान केन्द्र, खूंटी

- खूंटी जिले के अरकी प्रखंड के कोटा (10) एवं तोरपा प्रखंड के चुर्गी (10), बनाय टोली (7) ग्राम के 27 किसानों के बीच खरीफ 2019 की अवधि में 4.0 हे. क्षेत्र में सहभागी धान किस्म के चावल का 10 प्रक्षेत्र स्तरीय प्रदर्शन किया गया। रबी एवं ग्रीष्म ऋतु की फसलों की उत्पादकता बढ़ाने के लिए खूंटी जिले के किसानों के बीच प्रक्षेत्र स्तरीय प्रदर्शन के अंतर्गत चना (390 कि.ग्रा.), सरसों (8 कि.ग्रा.) एवं मूंग (180 कि.ग्रा.) के गुणवत्तापूर्ण बीज बांटे गए।
- खूंटी जिले के चार प्रखंडो (खूंटी, मुरहू, रनिया, अर्की) में लाख की वैज्ञानिक खेती कार्यक्रम आरंभ किया गया। 100 से ज्यादा लाख परिपालक पौधों पर 400 कि.ग्रा. बीहनलाख का संचारण किया गया। फसल से अच्छी आय मिले, इसके लिए आवश्यक जानकारी भी दी गई।
- किसानों के लिए खरीफ फसल के दौरान धान, अरहर, मूंगफली, सोयाबीन, मूंग एवं उरद की खेती के लिए परिसर से बाहर 20 प्रशिक्षण कार्यक्रम आयोजित किए गए, जिसमें 2059 किसानों ने भाग लिया। रबी फसल के दौरान किसानों के लिए चना, मसूर एवं रेपसीड सरसों की खेती के लिए परिसर से बाहर 18 प्रशिक्षण कार्यक्रम आयोजित किए गए।
- इस वर्ष की अवधि में 66 किसानों के लिए लाख की वैज्ञानिक खेती की तकनीक पर परिसर से बाहर दो प्रशिक्षण कार्यक्रम आयोजित किए गए।

Research Accomplishments

Lac Production

1. Productivity and Quality Improvement

1.1 Collection, conservation, characterization and documentation of lac insect and host plant bio-diversity

Behavioural pattern of trivoltine lac insect *Kerria sharda* between potted plants and field condition
First crop (November-December, 2018 to May-June, 2019)

Initial settlement density (43.79 and 16.04 per sq cm) of *K. sharda* was higher with low mortality (12.99 and 20.1 per cent) on *ber* field condition than *F. macrophylla* potted plants. Optimum sex ratio was recorded on both *ber* and *F. macrophylla.* Survival at maturity was also similar in field condition as well as potted plants. Average fecundity was more on *F. macrophylla* (83.0 Nos.) than *ber* (15.18 Nos.), fecundity was very less and crawlers died on *ber* due to heat mortality. Whereas cell and resin weight were more on *ber* (6.30 and 4.07 mg) than *F. macrophylla* (5.19 and 3.70mg).

Total life cycle of trivoltine lac insect was 170 days on *F. macrophylla* potted plants whereas it was 180 days on *ber* field condition.

Second crop (May, 2019 to August, 2019)

Initial settlement density (7.02 per sq cm) and mortality (20.42 per cent) of *K. sharda* were recorded on *F. macrophylla* potted plants whereas no settlement was observed on *kusum* field condition due to unhealthy broodlac of previous crop. Sex ratio (37 per cent), survival at maturity (8.2 Nos.), average fecundity (79.5 Nos.), cell and resin weight (5.48 and 4.15 mg) were recorded on *F. macrophylla* potted plants.

Total life cycle of trivoltine lac insect was 92 days.

Third crop (August, 2019 to January-February, 2020)

Initial settlement density (36.73 and 28.6 per sq cm) of *K. sharda* was higher with low mortality (30.34 and 46.77 per cent) potted plants than field condition on *F. macrophylla.* Sex ratio was recorded less on potted plants (22 per cent) than field condition (39 per cent). Survival at maturity was 3.3/cm^2 on potted plants but it did not survive upto crop maturity in field condition.

Total life cycle of trivoltine lac insect was 177 days on *F. macrophylla* potted plants.

Study of industrial parameters between seedlac of *kusmi* yellow and *kusmi* crimson

Industrial parameters *viz*., flow, life, colour index, acid value, moisture content and wax content were analysed of seedlac of *kusmi* yellow and *kusmi* crimson. Moisture per cent (1.34 and 1.58 per cent), colour index (8 and 18), flow (82 and 100 mm), polymerization/life time (50 and 70 minutes), wax per cent (3.005 and 4.15 per cent) and acid value (69.63 and 70.57) were recorded in *kusmi* yellow and *kusmi* crimson, respectively. Major difference was recorded in colour index of *kusmi* yellow and *kusmi* crimson among all industrial parameters analyzed.

Survey, collection and conservation of lac insect / host plant bio-diversity

- Discovered the natural population of lac insect on host plant *Calliandra surinamensis* (Fig. 1.1) at Konkan coastal area Ganapatipule, Ratnagiri district (Maharashtra).

Fig. 1.1: Natural population of lac insect on host plant *Calliandra surinamensis*

- *Palas* morphological variant *swadi* was registered by Plant Germplasm Registration Committee of ICAR having number INGR19031 with IC number 629501.

Conservation of lac insects/host plants biodiversity

- 89 collections of 55 species are being conserved in the lac host field gene bank.
- 1290 cultures of 56 lac insect lines are being conserved

on *F. macrophylla* in National Lac Insect Germplasm Centre (NATLIGEC).

- *Swadi palas* plantations consisting of 75 plants are being conserved in a separate plot.

Taxonomic studies of lac insects (Hemiptera: Coccoidea: Tachardiidae) and associated insect fauna

Twelve lac insect populations with accession numbers IINRG-LIK 0011, IINRG-LIK 0019, IINRG-LIK 0002, IINRG-LIK 0021, IINRG-LIK 0004, IINRG-LIK 0015, IINRG-LIK 0012, IINRG-LIK 0001, IINRG-LIK 0005, IINRG-LIK 0023, IINRG-LIK 0016 and IINRG-LIK0065 from lac insect gene bank, ICAR-IINRGcampus were collected and preliminary processing of the specimens were carried out for the taxonomic studies. The lepidopteran predators of lac insect which are collected in the study were sent for the identification at Division of Entomology, ICAR-IARI, New Delhi.

Field level demonstration of *Calliandra calothyrsus* at farmer's field

kusmi broodlac inoculated on *C. calothyrsus* yielded broodlac ratio of 5.5 during *aghani*, 2019-20 at Benyazara, Angara block, Ranchi (Fig. 1.2). Similarly, *Kusmi* broodlac inoculated on *C. calothyrsus* provided broodlac ratio of 7.2 during *aghani*, 2019-20 at farmer's field, Lodma, Ranchi (Fig. 1.3).

Fig. 1.2: *Kusmi* lac insect on *Calliandra* at Benyazara, Ranchi

Fig. 1.3: *Kusmi* lac insect harvested from *Calliandra* at Lodma, Ranchi

Biochemical study between common *palas* (*B. monosperma*) and its morphological variant *swadi palas*

In leaves of *palas* total sugar content (14.32mg/g fr. wt.), reducing sugar (2.99mg/g fr. wt.), protein content (29.31mg/g fr. wt.) and phenol content (13.43mg/g fr. wt.) was significantly higher than the *swadi palas* sugar content (10.63mg/g fr. wt.), reducing sugar (1.18mg/g fr. wt.), protein content (25.74mg/g fr. wt.) and phenol content (5.29mg/g fr. wt.). Similarly, total sugar content (155.61µg/ml) in leaf phloem sap of *swadi palas* was significantly higher as compared to *palas* (67.97µg/ml). Whereas reducing sugar (6.75µg/ml) and phenol content (12.83µg/ml) were significantly lower (12.67µg/ml and 36.25µg/ml, respectively) than *palas* (Fig. 1.4 & 1.5).

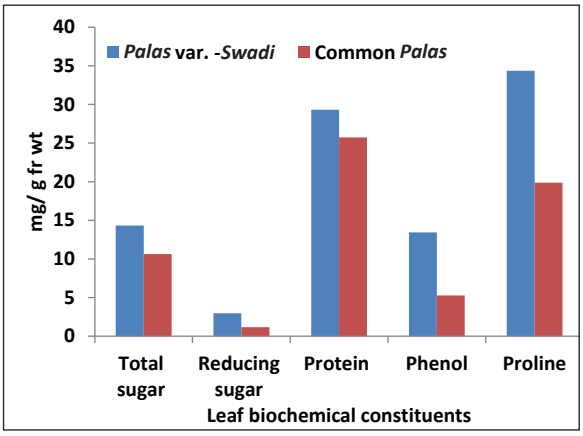


Fig. 1.4: Comparison of leaf biochemical constituents between common *palas* (*B. monosperma*) and *swadi palas*

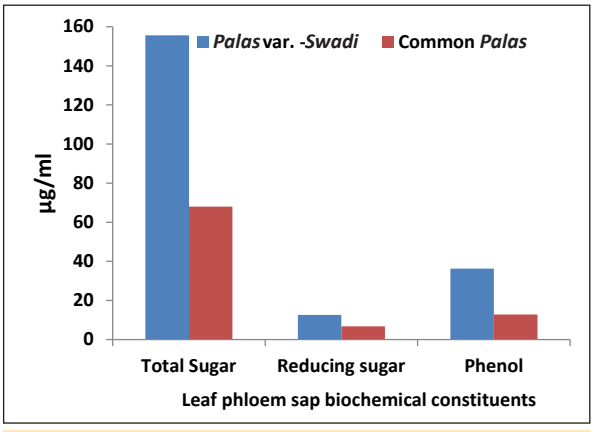


Fig. 1.5: Comparison of leaf phloem sap biochemical constituents between common *palas* (*B. monosperma*) and *swadi palas*

Effect of lac insect feeding on biochemical parameters in leaf and bark of *F. semialata*

The present study was carried out at Institute Research Farm in summer season (*jethwi*) crop of *kusmi* strain in drought tolerant line of *F. semialata* (Fig. 1.6) for oxidative stress. The major biochemical constituents studied are:

Superoxide Radicals

Decrease (52.06 %) in superoxide radicals content in the leaves of lac insect infested plant (929.33 ΔA540/min/g fr.wt) was observed as compared to control (1938.67 ΔA540/min/g fr.wt). Whereas, the bark of lac insect infested plant recorded 46.3 % higher superoxide radicals content (1592.67 ΔA540/min/g fr.wt) as compared to control (1088.67 ΔA540/min/g fr.wt).

Hydrogen Peroxide

65.93 % increase in H_2O_2 content in the leaves of lac insect infested plant (1822.50mmol/g fr. wt.) was observed as compared to control (1098.33mmol/g fr. wt.).

Ascorbic Acid

3.1 % increase in ascorbic acid content (8.66mg/g fr. wt.) in the leaves of lac insect infested plant as compared to control (8.40 mg/g fr. wt.) and 66.97 % increase bark of lac insect infested plant (7.98 mg/g fr. wt.) was recorded as compared to control (4.77mg/g fr. wt.).

Carotenoid

Increase (47.35 %) in carotenoid content (31.35 mg/g fr. wt.) in the leaves of lac insect infested plant (31.35 mg/g fr. wt.) was observed as compared to control (21.27 mg/g fr. wt.). The bark of lac insect infested plant also recorded 52.85 % higher level of ascorbic acid content (46.72 mg/g fr. wt.) as compared to control (30.56 mg/g fr. wt.).

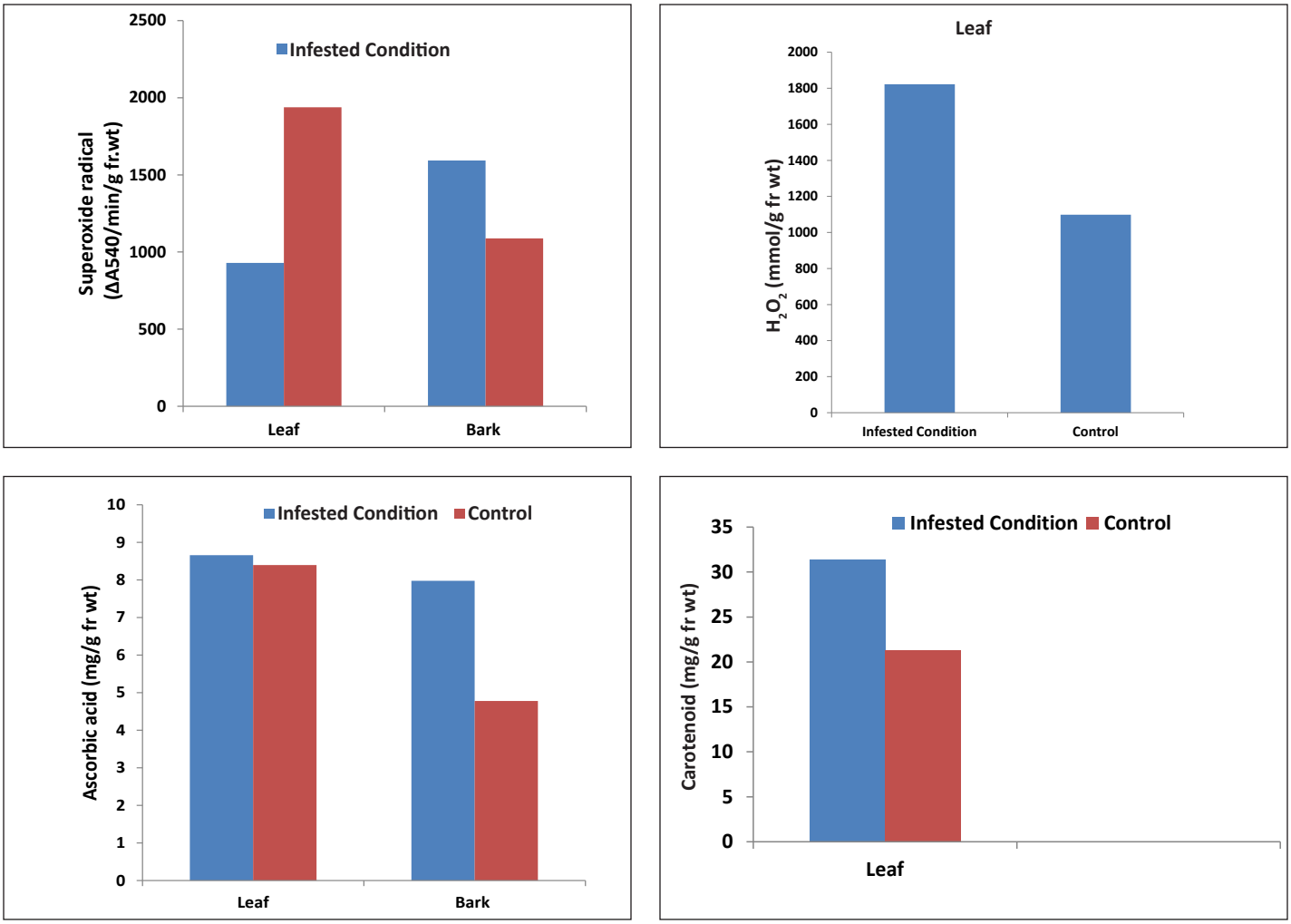


Fig. 1.6: Effect of lac insect feeding on biochemical parameters of *F. semialata* during *jethwi* (summer season) crop 2019

A study was conducted to identify the effect of insect density load upon inoculation on host plant physiology. One year old plants were inoculated with insects at four different levels of increasing density and growth as well as indirect photosynthesis parameter readings were recorded over three time periods. Good quality *Kusmi* broodlac was inoculated on host plant which was removed after two weeks to ensure complete settlement of lac on host plant. Inoculated host plants were then categorized into four groups based on lengthwise area of insect settled on stem surface measured with respect to stem height. Plants were thus categorized such that their stem height has 25%, 50%, 75% and complete stem (100%) is inhabited by insect. Control (C) plants did not have inoculation. Data was collected with 4 replicates each and plants were grown in Green house under natural conditions.

Chlorophyll a (Chl a), Chl b, total chlorophyll was measured by non-maceration method using DMSO and carotenoids were measured using Hendry and Pierce method, 1993. All of the pigments showed decline upon inoculation and the amount decreased close to linear form as density of insect increased (Fig. 1.7 to 1.10).

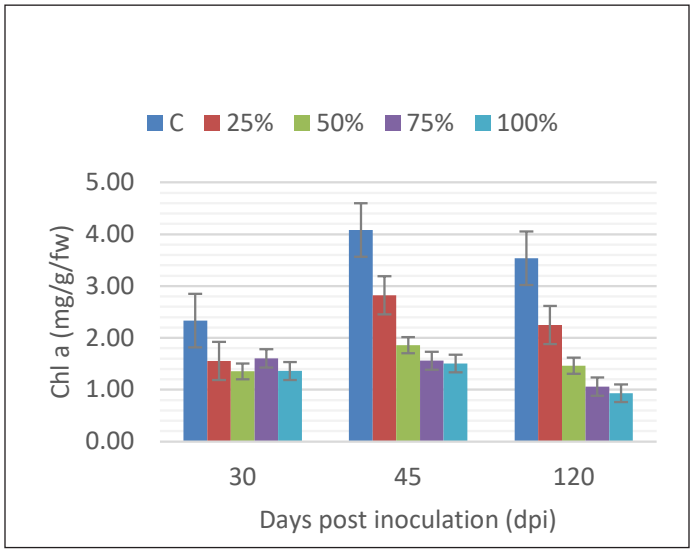


Fig. 1.7: Mean of Chlorophyll a content in *F. macrophylla* after 30, 45 and 120 days of inoculation

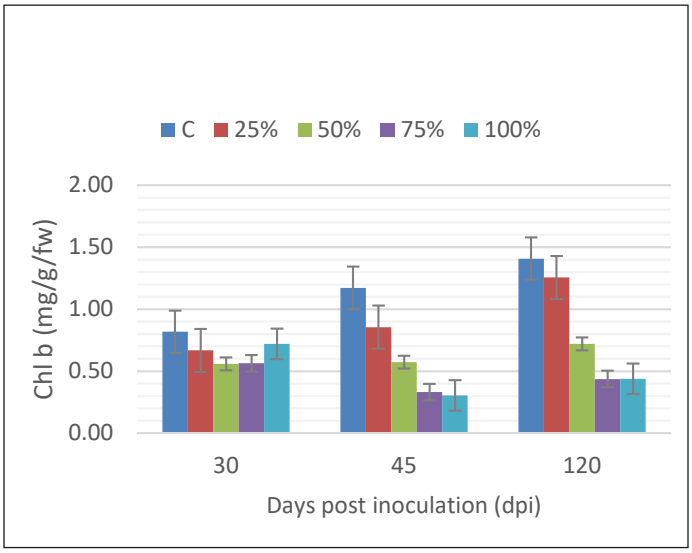


Fig. 1.8: Mean of Chlorophyll b content in *F. macrophylla* after 30, 45 and 120 days of inoculation

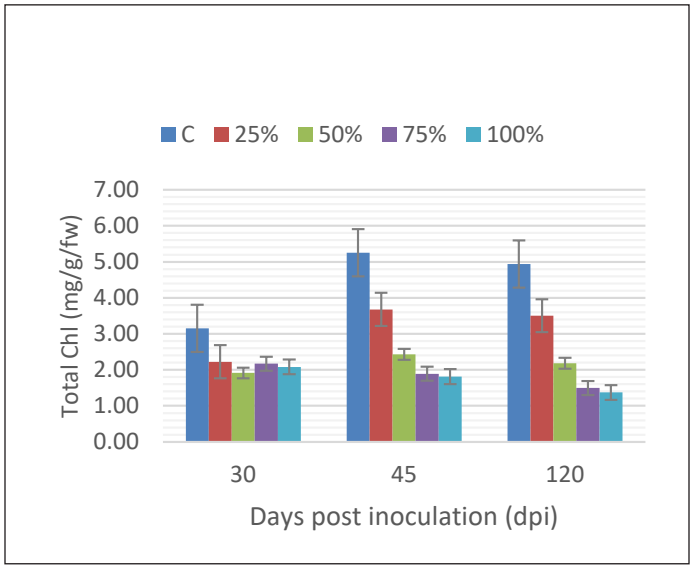


Fig. 1.9: Mean of Total Chlorophyll content in *F. macrophylla* after 30, 45 and 120 days of inoculation

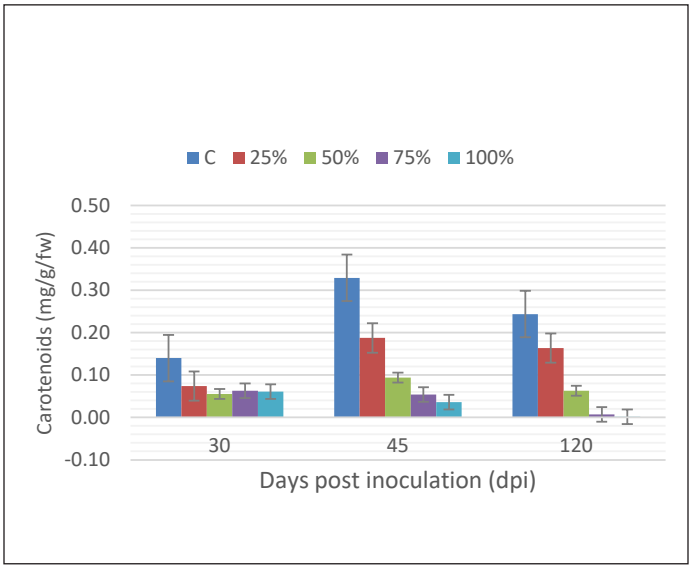


Fig. 1.10: Mean of Carotenoid content in *F. macrophylla* after 30, 45 and 120 days of inoculation

Host plant physiology was also monitored for fresh and dry biomass of plant as well as leaves and total one-side leaf area of entire plant over three time periods *viz.* 30, 45 and 120 days post inoculation (Fig. 1.11 to 1.14).

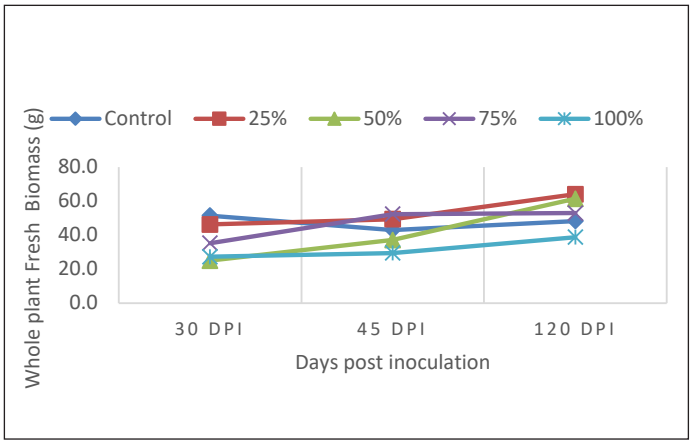


Fig. 1.11: Mean of whole plant fresh Biomass at three time intervals

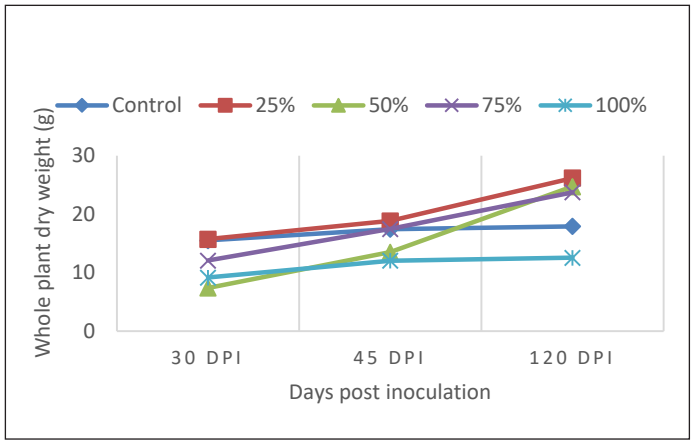


Fig. 1.12: Mean of whole plant dry Biomass at three time intervals

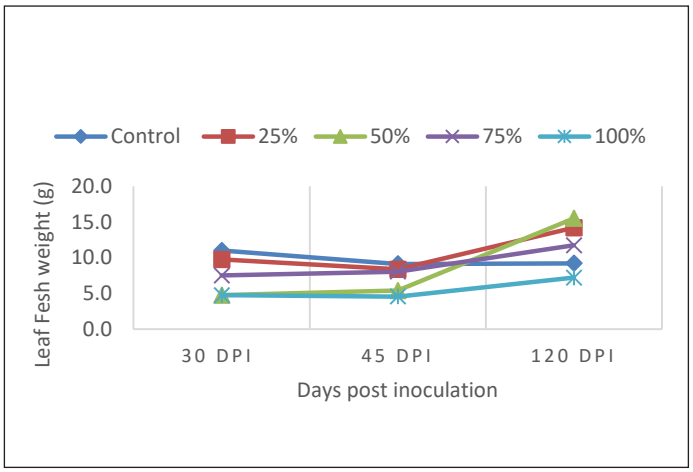


Fig. 1.13: Mean of Leaf fresh Biomass at three time intervals

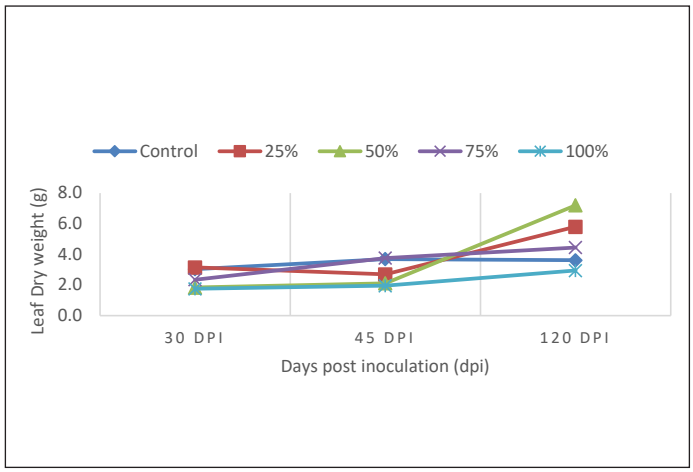


Fig. 1.14: Mean of Leaf Dry Biomass at three time intervals

Leaf area was also recorded for each sample and relative growth rate was calculated. Leaf area is an indirect measure of photosynthetic area and its measurement upon inoculation would indicate effect of insect density on photosynthesis of plant. Realative Growth Rate (RGR) is the well-known parameter for dry matter accumulation over growth of plant and is known to be influenced by several factors in different environment such as under biotic stress (Fig. 1.15 to 1.16).

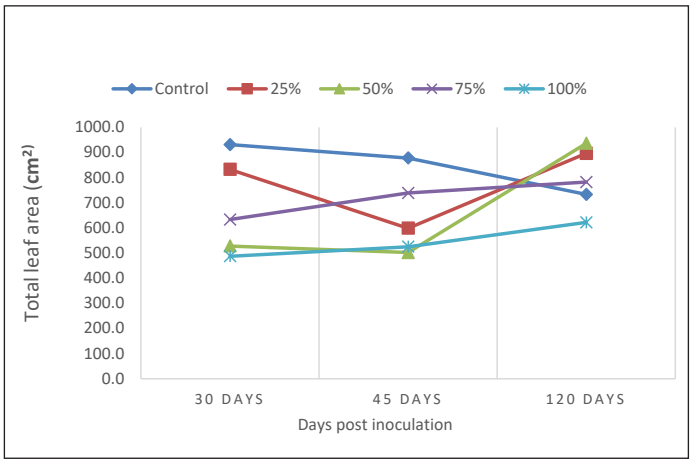


Fig. 1.15: Leaf area of total leaves at three time intervals

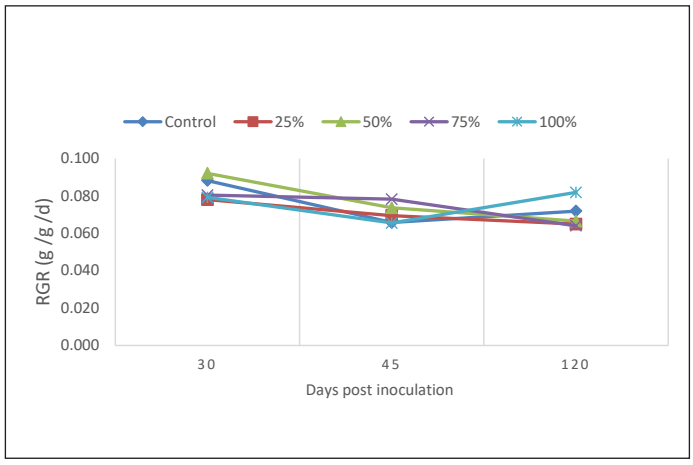


Fig. 1.16: Realative Growth Rate (RGR) at three time intervals

Barcoding of major lac host plants

Barcoding PCRs for genes such as maturase K (matK), ribulose 1,5 bisphophate carboxylase (rbcL), DNA dependent RNA polymerase subunit beta (rpoB), DNA dependent RNA polymerase subunit beta` (rpoC1), inter genic spacers such as psbK–psbI (photosystem II protein-photosystem II reaction center protein I), psbA-trnH (photosystem II protein D1-tRNA histidine), atpF-atpH (ATP synthase subunit b- ATP synthase subunit c) were carried out for the major host plants *ber* and *kusum*. In case of *ber*, two different species and in *kusum*, two different accessions were taken for barcoding. All the PCR products were sequenced and the barcode sequences were submitted to Gene Bank. The accession numbers obtained for the respective samples are given in the Table 1.1.

Table 1.1: Accession numbers for barcode sequences of *ber* and *kusum*

Name of the barcode region	*Ziziphus xylopyrus* (LIH 0052 ZXY)	*Ziziphus mauritiana* (LIH 0025 ZMA)	*Schleichera oleosa* (LIH 0005 SOL)	*Schleichera oleosa* (LIH 0006 SOL)
matK2	-	MN853143	-	MN853144
matK3	MK992786	MK992787	MK932882	MK932883
rbcL	MN787056	MN787057	MN787058	MN787059
rpoB	MN885895	MN885896	MN885897	MN885898
rpoC1	MN867456	MN867457	MN867458	MN867459
psbA-trnHf	MN787062	MN787061	MN787060	MN807296
atpF-atpH	MN807298	MN807297	MN817132	MN817131
psbKf-psbIr	MN881096	MN881097	MN881098	-

Comparative analysis of life table and population parameters of lac insect strains

Evaluation of life table and population parameters of *rangeeni* strain of lac insect, *Kerria lacca* on three bushy host plants *viz., F. semialata*, *F. macrophylla* and Red gram was carried out. The host plants were maintained in the earthen pots in uniform environmental conditions and individual lac insect cell was inoculated and covered with mesh in the month of the November. The initial settlement and mortality data recorded 30 days after inoculation did not have significant difference among the treatments except 6.89 % initial mortality in *C. cajan* which was significantly different to *F. semialata* (18.83%) and *F. macrophylla* (23.63%) (Table 1.2).

Table 1.2: Initial population density and mortality of *rangeeni* strain of lac insect, *Kerria lacca* on three bushy host plants

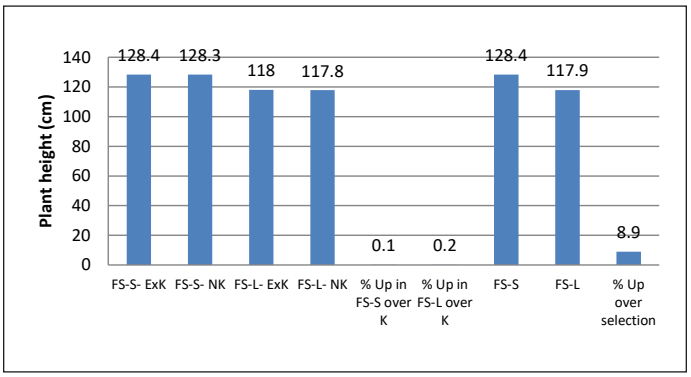
Treatments	Total population (cm^2)	Live population (cm^2)	Dead population (cm^2)
F. semialata	51.83	41.93	9.89 (18.83 %)
F. macrophylla	38.33	29.77	8.57 (23.63 %)
C. cajan	38.42	35.35	3.07 (6.89 %)
$CD_{0.05}$	NS	NS	4.73*
SE(m)	4.83	4.63	1.62

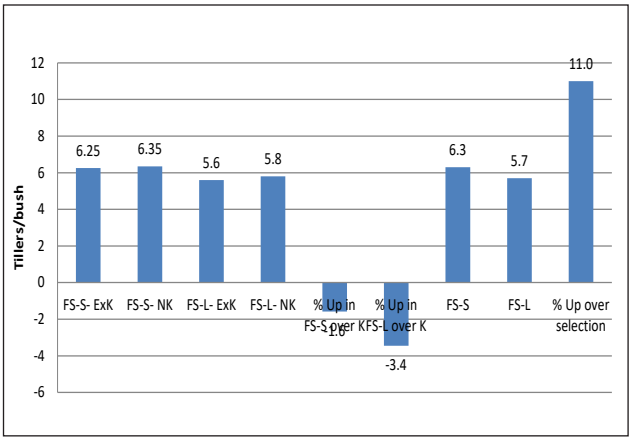
*Significant at 5% level

1.2 Development and evaluation of lac production practices for *swadi palas, arhar* and *semialala*

Management for optimizing summer *kusmi* lac on selected *semialata*

Selected *F. semialata* (FS-S) is better than control (FS-L) in respect to morpho-physiological- biochemical parameters. It gives better summer *kusmi* lac under limited irrigation conditions. Plant height recorded in FS-S was 128 cm and 118 cm in FS-L. Relatively, more number of leaves per plant (75) in selected as compared to control (65) and 11 % more number of tillers per plant were observed as compared to local. Application of Muriate of Potash (MoP) had no significant effect on these morphological traits (Fig. 1.17).





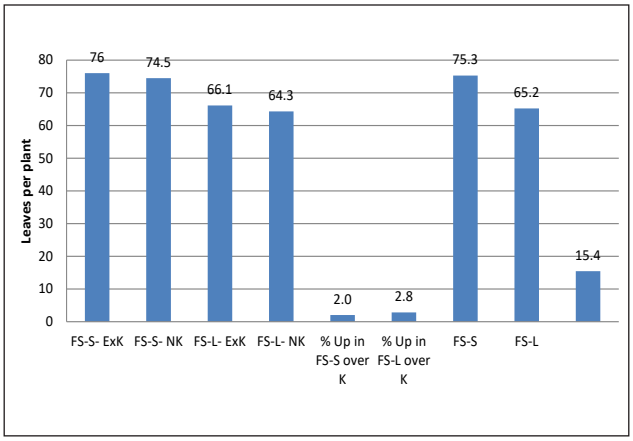


Fig 1.17: Plant height, number of leaves and tillers per plant in lines of *F. semialata* during summer *kusmi* crop

Length of lac encrustation was significantly higher in selection (123 mm) as compared to local (89 mm). Weight of Broodlac yield was 47 gram and 39 gram per bush in FS-S and FS-L. There was positive response of extra MoP on lac encrustation, broodlac and scrapedlac yield in both selection as well as local *F. semialata*. As far as scrapedlac yield is concerned it was 16.1 and 14.3 gram in FS-S and FS-L, respectively but these differences was non-significant over selection (Fig. 1.18). Lac insect settlement on selected *semilata* with enhanced K and normal K are depicted in Fig. 1.19 a&b, respectively.

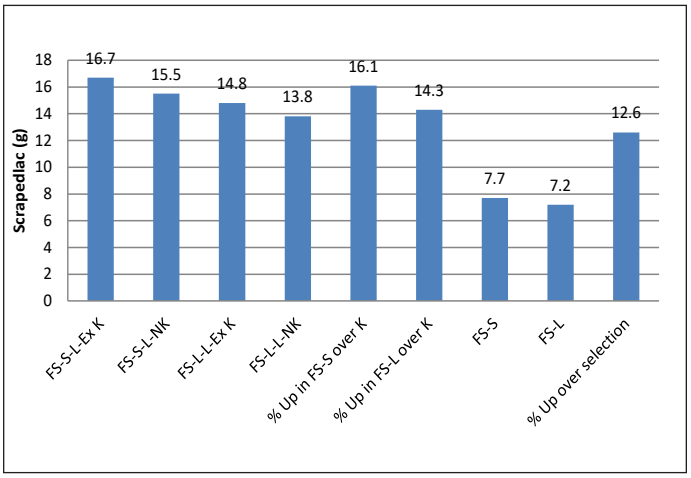
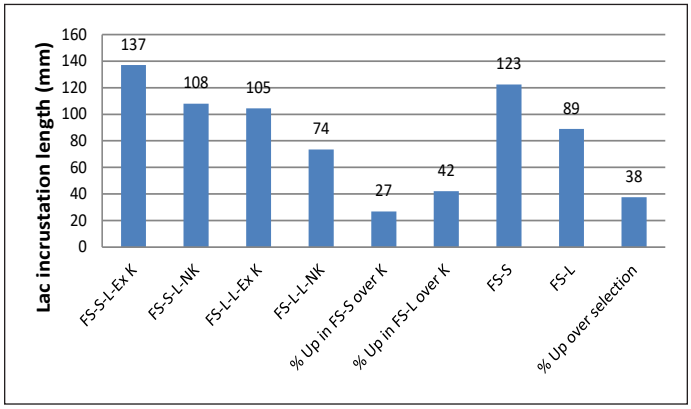


Fig. 1.18: Lac encrustation, broodlac and scrapedlac in lines of *F. semialata* during summer *kusmi* lac

This selection (FS-S) showed positive response for lac yield in field trial as well as at farmers' field and yielded 15% and 16% higher scrapedlac, respectively as compared to local. It is also fertilizer responsive, especially application of extra MoP had significantly positive effect on lac yield in



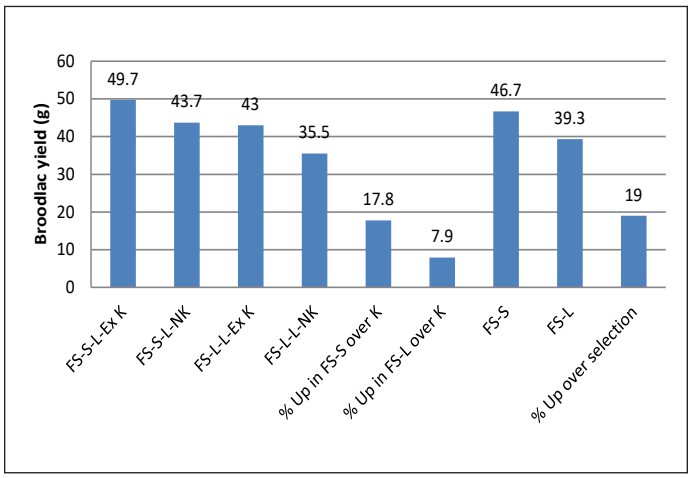


Fig. 1.19a: Lac insect under enhanced K application

Fig. 1.19b: Lac insect settlement with normal fertlilzer

summer season (Fig. 1.9 a & b). Hence, recommendations made are: Seedlings should be planted in paired row at R-R= 75 cm and P-P= 100 cm, space between paired row should be 2 to 2.5 m, compost should be applied @ 2.5-5.0 kg per hill at sowing time, fertilizer N:P: K should be applied @25:50: 50 kg/ha, crop should be irrigated at critical stages of lac crop, *i.e*. lac settlement, sex differentiation, lac developmental stage and at maturity and three spray of pesticides *i.e*. Ethofenprox @ 2 ml/ lit of water and Carbendazim @ 1g/ lit of water at 30, 60 and 90 days after inoculation should be done.

Grouping of pigeonpea germplasm on the basis of ESS markers

Pigeonpea is a nutritious tropical legume with several desirable characteristics of our interest e.g. susceptibility to lac insect. Adequate molecular markers are lacking and no linkage map has been developed so far. Microsatellites remain the markers of choice due to their high polymorphism and their transferability from closely related genera. Population structure of 27 pigeonpea genotypes based on 63 EST-SSR markers has been drawn. The graph of estimated membership fraction for K= 4. The maximum of adhoc measure ΔK determined by structure harvester was found to be K= 4, which indicated that the entire population can be grouped into 4 sub-populations (Fig. 1.20).

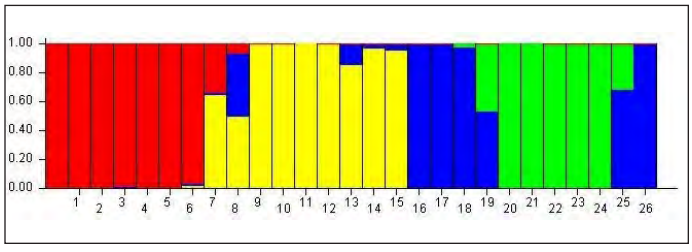


Fig. 1.20: Grouping of pigeonpea germplasm

Management practices for maximizing *rangeeni* crop on pigeonpea germplasm

Selected germplasm of pigeonpea (Birsa Arhar 1, Bahar, RCMP2, RCMP 5, Assam local 1 and IPA 8-2) were evaluated for response of fertilizer and irrigation for optimizing/ maximizing *rangeeni* lac productivity. Two level of irrigation: I_1 at critical stages *i.e.* crawler settlement, sex differentiation and maturity, I_2 at 15 days interval and two level of chemical fertilizer: F_1 as recommended for grain *i.e.* N: P: K= 25: 50: 25 kg/ha, F_2 as recommended in F_1 + 50% more potash was given. Plant height ranged from 179cm to 189cm. Although irrigation and fertilizer had positive effect on plant height, number of primary branches per plant and basal stem diameter, the difference was observed non-significant (Table 1.3).

Table 1.3: Plant height, primary branches and basal diameter of pigeonpea germplasm

Treatment	Plant height (cm)	Effect of irrigation		Effect of fertilizer	
I_1F_1	188.3			F_1	188
I_1F_2	184.9	I_1	187	F_2	182
I_2F_1	188.5	I_2	184		
I_2F_2	179.3				
CD I	ns	CD F	ns		
Treat	Primary branch (no)	Effect of irrigation		Effect of fertilizer	
I_1F_1	7.9			F_1	8.1
I_1F_2	9.0	I_1	8.4	F_2	8.7
I_2F_1	8.4	I_2	8.4		
I_2F_2	8.5				
CD I	ns	CD F	ns		
Treat	BSD	Effect of irrigation		Effect of fertilizer	
I_1F_1	16.0			F_1	16.5
I_1F_2	15.4	I_1	15.7	F_2	15.8
I_2F_1	16.9	I_2	16.6		
I_2F_2	16.3				
CD I	ns	CD F	ns		

Hail storm caused severe injury to stem and pod resulting in loss of grain yield due to shattering of seeds. Plants tried to recover from injury, but heavy mortality of lac insect was observed (Fig. 1.21 a & b).

Fig. 1.21: Field view (a) before calamity (b) after calamity

Based on previous observations that germplasm, irrigation and fertilizer were significant, and irrigation has significant role on broodlac production (raised broodlac yield by 31%) and additional dose of potash (increase in lac yield by 15%) the package has been developed (Table 1.4).

Table 1.4: Broodlac output ratio in selected germplasm of pigeonpea as affected by irrigation and fertilizer during 2018-19

Factor 1/2	Irrigation 1		Irrigation 2		Mean	Percent increase
Germplasm	Fertilizer 1	Fertilizer 2	Fertilizer 1	Fertilizer 2		
Birsa Arhar 1	2.58	2.94	3.35	3.86	**3.18**	
Bahar	2.81	3.2	3.65	4.2	**3.47**	
IPA 8-2	3.3	3.76	4.29	4.93	**4.07**	
RCMP2	3.03	3.45	3.94	4.53	**3.74**	
RCMP5	2.78	3.17	3.61	4.16	**3.43**	
Assam local1	2.49	2.84	3.24	3.72	**3.07**	
Mean	**2.83**	**3.23**	**3.68**	**4.23**	**3.49**	
Irrigation alone	3.03		3.96			**30.6**
Fertilizer alone	3.26		3.73			**14.6**

Factors	SE(m)	C.D.
Factor A (Irrigation)	0.022	0.062
Factor B (Fertilizer)	0.022	0.062
Factor C (Germplasm)	0.038	0.108
Int A X B	0.031	0.088
Int A X C	0.053	N/A
Int B X C	0.053	N/A
Int A X B X C	0.076	N/A

Package developed on pigeonpea with added compost/ FYM during field preparation is as follows:

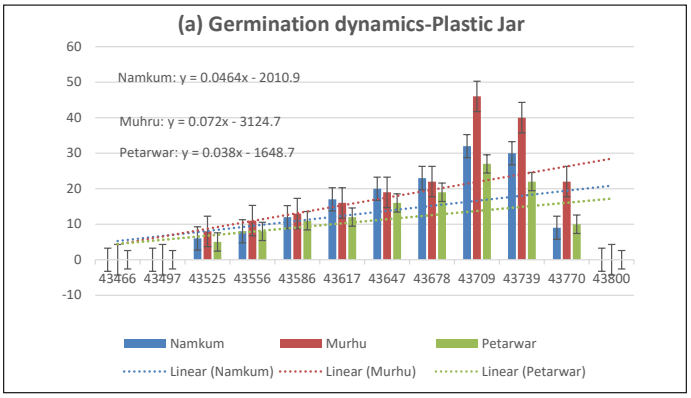
Seeds of selected germplasm should be sown on raised bed after onset of monsoon, Chemical fertilizer N: P: K should be applied @ 25: 50: 50 kg/ha, Good quality *rangeeni* broodlac should be inoculated @ 25 gram per plant, Irrigation should be provided at critical stages of lac crop, *i.e.* lac settlement, sex differentiation, lac insect developmental stage and at maturity, Three spray of recommended insecticides along with fungicide should be done as per schedule, hand picking of pod should be done at 75% pod maturity (in the month of April-May), Harvesting of broodlac should be done after maturity *i.e.* in the month of June.

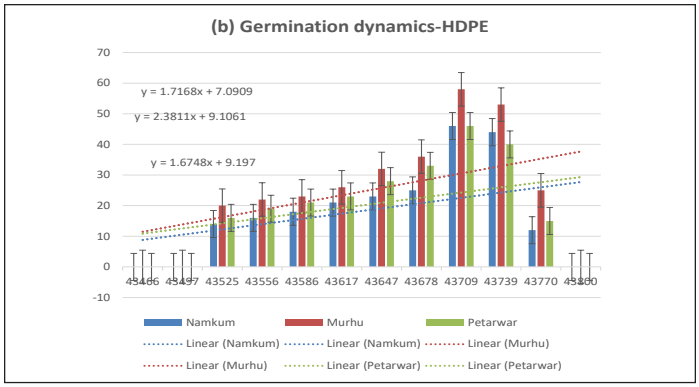
1.3 Morpho-physiological characterization *vis-à-vis* strategies to augment quality and storability of seeds of *Schleichera oleosa*

Seed storage behaviour and germination dynamics

The seeds of *Schleichera oleosa* from three locations *viz*. Namkum (Ranchi), Murhu (Khunti) and Petarwar (Bokaro) were stored in three different types of containers namely, airtight plastic jar, HDPE bag and cotton bag to assess their influence on germination.

Irrespective of the storage conditions and locations of the seed collections, the change in quality of *kusum* seeds was affected noticeably in the second year of experimentation. Significant variations in germination were recorded from the stored seeds under different conditions (Fig. 1.22a to c). Seeds from





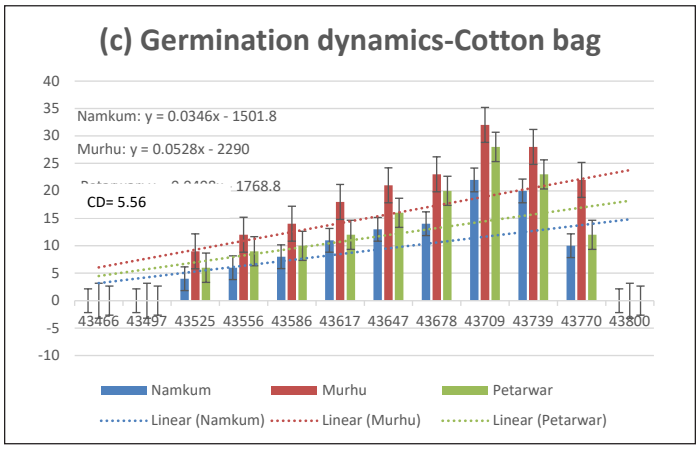


Fig. 1.22: Germination dynamics of *kusum* seed under different storage condition

Murhu stored in HDPE bags and sown in September showed higher germination (58 %) followed by October (53 %). The same trend was observed with the seeds of Namkum (46 & 44 %) and Petarwar (46 & 44 %), respectively. The values for the seed stored in plastic jars were 46 & 40 % (Murhu) followed by 23 & 32 % (Namkum) and 27 & 22 % (Petarwar) during September and October, respectively. Cotton bag stored seed showed comparatively poor germination *viz*. 32 % (Murhu), 22 % (Namkum) and 28 % (Petarwar) in September and 28 % (Murhu), 23 % (Petarwar) and 20 % (Namkum) in October, respectively. Seed germination in June & July was relatively better than the seed sown in March-May. However, germination of *kusum* seed affected adversely during December, January and February which might be due low temperature irrespective to location of seed collection and storage conditions.

Storage behaviour of pre-treated seeds and germination dynamics

Seeds from all the three locations were pre-treated with chitosan, lac polymer (shellac) and imidacloprid 17.8 SL @ 4% before storage in the three different types of containers to ascertain their effect on germination. In general, an enhancement in germination rate in all studied seasons *i.e.* August, September, October and November was observed. Higher enhancement in germination per cent was observed in the seed collected from Murhu and sown in September followed by October irrespective of the storage conditions. Higher germination was observed in the seed treated with chitosan (50.0 %) followed by imidacloprid (48.0 %) and Lac coating (47.0 %) with respect to control (46.0 %) in the seed stored in plastic jar (Table 1.5), whereas HDPE stored seed (Table 1.6) also showed higher germination enhancement - chitosan treated seed (64.0 %) followed by imidacloprid (62.0 %) and lac coating (60.0 %) with respect to control (58.0 %). Under cotton bag storage (Table 1.7), chitosan treated seed showed higher germination enhancement of 38.0 % followed by imidacloprid (35.0 %) and lac coating (33.0 %) with respect to control (32.0 %). Storage duration, location of seed collection and seed pre-treatment significantly influence the germination. It is evident that interaction of location of seed collection at individual storage duration (AXB) has a significant effect on seed germination.

Table 1.5: Effect of seed pre-treatment on germination of *kusum* seed stored under plastic jar

Location (A)	Namkum				Murhu				Petarwar				Mean over location			
Month (B)/ Treatment(C)	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19
Control	23.0	32.0	30.0	9.0	22.0	46.0	40.0	22.0	24.0	27.0	22.0	10.0	21.3	35.0	30.7	13.7
Chitosan	28.0	36.0	34.0	14.0	26.0	50.0	48.0	27.0	23.0	33.0	25.0	19.0	25.7	39.7	35.7	18.3
Imidacloprid	24.0	35.0	32.0	12.0	25.0	48.0	44.0	25.0	21.0	31.0	23.0	13.0	23.3	38.0	33.0	16.7
Lac coating	25.0	33.0	31.0	11.0	24.0	47.0	42.0	24.0	21.0	29.0	21.0	11.0	23.3	36.3	31.3	15.3
Mean	25	34	31.8	11.5	24.3	47.8	43.5	24.5	22.3	30	22.8	13.3	24.1	38.0	33.3	16.8
	SEM	CD					SEM	CD								
Locations (A)	0.36	1.02		Treatment (C)			0.41	1.17								
Months (B)	0.41	1.17		Interaction A X C			0.71	N/A								
Interaction A X B	0.71	2.03		Interaction B X C			0.82	N/A								

Table 1.6: Effect of seed pre-treatment on germination of *kusum* seed stored under HDPE

Location (A)	Namkum				Murhu				Petarwar				Mean over location			
Month (B)/ Treatment(C)	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19
Control	25.0	46.0	44.0	12.0	36.0	58.0	53.5	25.0	33.0	46.0	40.0	15.0	31.3	50.0	45.7	17.3
Chitosan	30.0	54.0	52.0	15.0	44.0	64.0	60.0	28.0	38.0	54.0	46.0	19.0	37.3	57.3	52.7	20.7
Imidacloprid	28.0	50.0	50.0	14.0	40.0	62.0	56.0	26.0	35.0	52.0	44.0	18.0	34.3	54.7	50.0	19.3
Lac coating	26.0	48.0	48.0	13.0	38.0	60.0	55.0	24.0	34.0	49.0	42.0	16.0	32.7	52.3	48.3	17.7
Mean	27.2	49.5	48.5	13.5	39.5	61.0	56.1	25.7	35.0	50.2	43.0	17.0	33.9	53.6	49.2	18.8
	SEM	CD					SEM	CD								
Locations (A)	0.26	0.75		Treatment (C)			0.31	0.87								
Months (B)	0.31	0.87		Interaction A X C			0.53	N/A								
Interaction A X B	0.53	1.50		Interaction B X C			0.61	N/A								

Table 1.7: Effect of seed pre-treatment on germination of *kusum* seed stored under cotton bag

Location (A)	Namkum				Murhu				Petarwar				Mean over location			
Month (B)/ Treatment(C)	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19	Aug 19	Sept 19	Oct 19	Nov 19
Control	14.0	22.0	20.0	10.0	23.0	32.0	28.0	22.0	20.0	28.0	23.0	12.0	19.0	27.3	23.7	14.7
Chitosan	18.0	28.0	26.0	14.0	27.0	38.0	34.0	27.0	26.0	34.0	27.0	16.0	23.7	33.3	29.0	19.0
Imidacloprid	17.0	25.0	24.0	12.0	26.0	35.0	32.0	24.0	24.0	32.0	26.0	14.0	22.3	30.7	27.3	16.7
Lac coating	15.0	24.0	20.5	11.0	24.0	33.0	30.0	20.0	22.0	33.0	24.0	13.0	20.3	30.0	25.0	14.7
Mean	16.0	24.7	22.6	11.7	25.0	34.5	31.0	23.2	23.0	31.7	25.0	13.7	21.3	30.3	26.3	16.3
	SEM	CD					SEM	CD								
Locations (A)	0.24	0.70		Treatment (C)			0.28	0.83								
Months (B)	0.28	0.80		Interaction A X C			0.49	N/A								
Interaction A X B	0.49	1.39		Interaction B X C			0.56	N/A								

Phenological study of *Kusum*

Phenological observations were made on 10 *kusum* trees located in ICAR-IINRG campus. Two branches of each tree were tagged for observation. Observations were made on leaf initiation, leaf fall, flowering and fruiting of *kusum* trees at the one month intervals from January to December 2019. The tree of *kusum* was considered in a particular phenophase when more than 80% of the individuals of *kusum* plant present in the branch were passing through that phase. Leaf initiation started in February-March, continued up to July-August with a peak in May just before the onset of monsoon (Table 1.8). The observations indicated that most of the branch completed leaf development by July and August. There was a complete absence of leaf flushing in most of the *kusum* plant from September to January. In *Kusum*, leaf shedding begins in the month of December with peak in February –March and flowering in the month of March and April. Tree exhibited flower initiation in response to increasing length of photoperiods. The peak period of maturation of fruits was June-July in most of the plants.

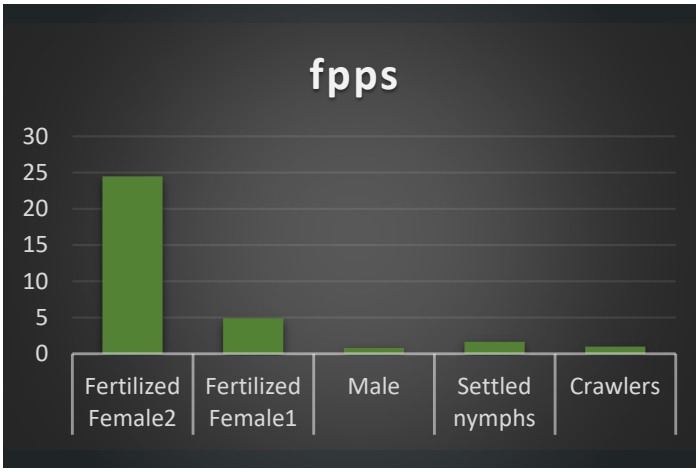
Table 1.8: Phenological stages of *Kusum* observed during 2019

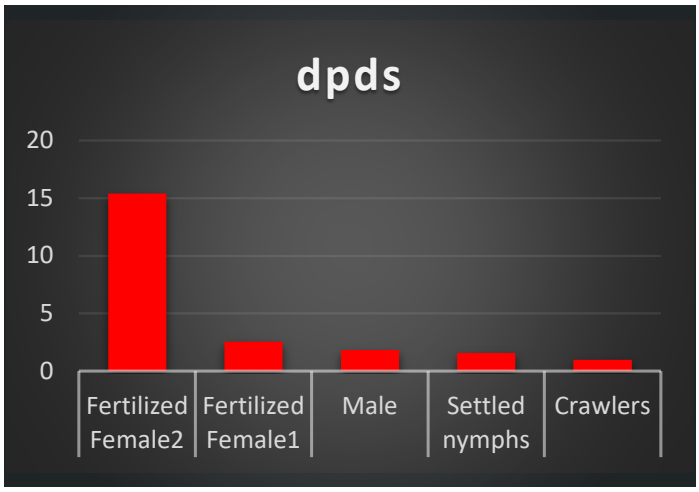
Growth stage		Period											
Leaf	I		■	■	■	■	■	■	■				
	F							■	■				
	D	■	■	■									■
Flower	I			■	■								
	F				■	■							
	D				■	■							
Fruit	I				■	■							
	F						■	■					
	D							■	■				
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

I: Initiation; F: Full flush; D: Drop

1.4 Identification and cloning of putative key genes involved in terpene biosynthesis of the Indian lac insect, *Kerria lacca* (Kerr)

Quantitative PCRs (qPCR) were carried out for putative key genes of resin biosynthesis namely, farnesyl pyrophosphate synthase (*fpps),* decaprenyl diphosphate synthase (*dpds*), and acyl coA delta desaturase (*add*) with cDNAs prepared from different developmental stages of lac insects. The developmental stages taken up for this qPCR experiment were crawlers, settled nymphs, male insects, fertilized females stage 1 and fertilized females stage 2. All the selected genes (*fpps*, *dpds*, and *add*) were found to be upregulated in nymphs after settlement, fertilized females stage 1 and fertilized females stage 2 compared to crawlers. Expression level of *fpps*in male insects was less than that of crawlers. Although, expression level of *dpds* and *add* in male insects were more than crawlers, their level is less than fertilized females (Fig. 1.23). These results show that the genes such as *fpps*, *add* and *dpds* would probably be involved in resin biosynthesis.





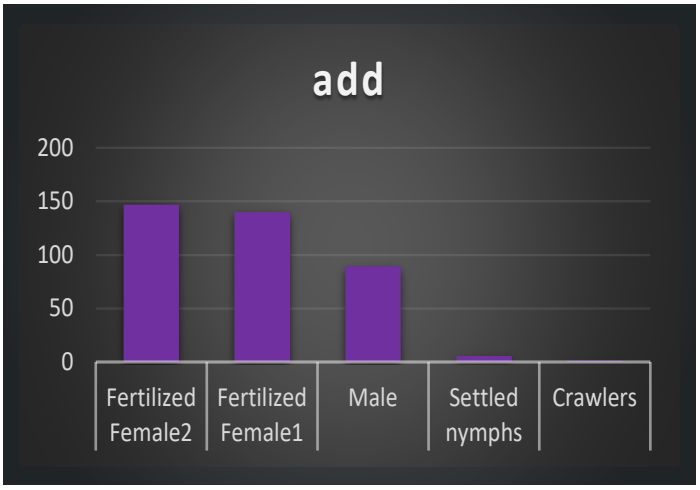


Fig. 1.23: Expression profile of putative key genes of resin biosynthesis in various developmental stages (X axis- different stages, Y axis – fold expression of the corresponding genes)

1.5 Understanding lac insect-host plant interaction - A molecular approach

Reactive oxygen species (ROS) and its detoxification is an entire cellular system in itself which is employed by plants to signal and/or cope up with any sort of disturbance encountered. The system comprises of metabolic intermediates, molecular players and several enzymes which are in most cases, isozymes behaving differently under temporal, spatial and development conditions. *F. semialata* and *F. macrophylla* are two host plants for lac insect. While *F. macrophylla* is capable of tolerating both strains although differing in efficacy but *F. semialata* sustains *Kusmi* strain and performance of *rangeeni* strain is very poor crop. Therefore the underlying difference needs to be understood in this differential behavior of hosts to different strains. Leaf is the primary organ of photosynthesis and majority of plant response is assayed in this organ. However lac insect is a stem-dweller thus, local effect of its attachment on host needs to be deciphered apart from the systemic and Systemic Acquired Resistance (SAR) effect in long runs. Keeping in view of above points a study was conducted to identify the effect of two different strains of lac insect var., *Kusmi* and *Rangeeni* on host plant ROS production as well as its detoxification under a temporal range of 12 and 24 hour post inoculation (hpi). For the study, three months old potted plants were inoculated with optimum insect load and samples of leaf and succulent stem were collected in replicates. Superoxide dismutase enzyme (SOD) was assayed and H_2O_2 content was measured to get an understanding of ROS quantity at a given time. Detoxification enzymes viz., Peroxidase (POD) and Catalase (CAT) were assayed at given time points. Four parameters of comparison are mentioned here wherein

two host plants are compared for two strains for each biochemical component.

Upon *Kusmi* inoculation, SOD activity was shown to increase in leaf but decreased over time in stem of *F. macrophylla* but that in stem of *F. semialata* showed increased activity with time while its leaf showed a drop in activity at early 12 hpi. While on *rangeeni* inoculation on *F. semialata* , leaf as well as stem showed increased SOD activity than control at 12 hpi followed by decrease. Decreased SOD activity upon *Kusmi* as well as *rangeeni* inoculation on *F. macrophylla* is recorded (Fig. 1.24 to 1.27)

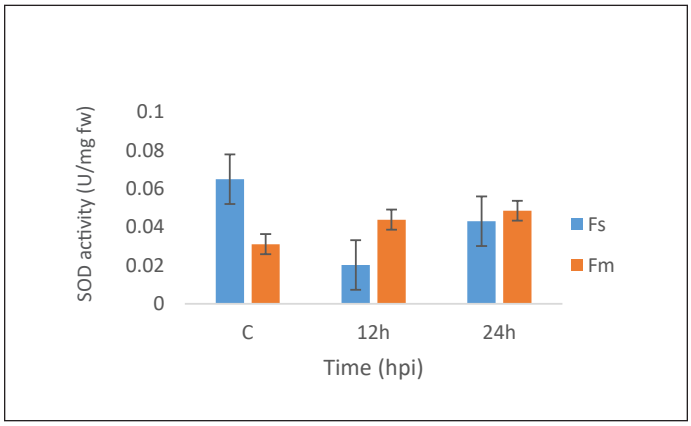


Fig. 1.24: Leaf SOD activity in control (C) and *kusmi* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

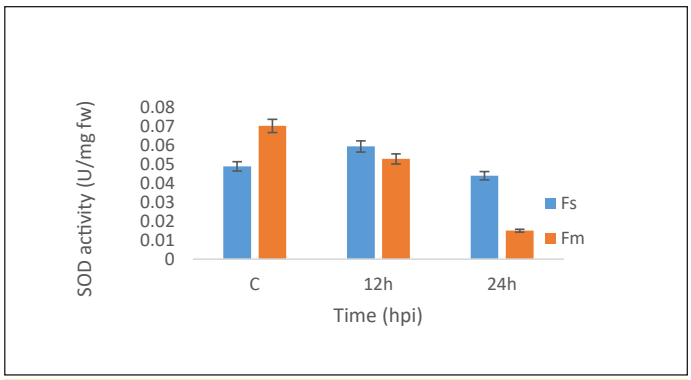


Fig. 1.25: Stem SOD activity in control (C) and *kusmi* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

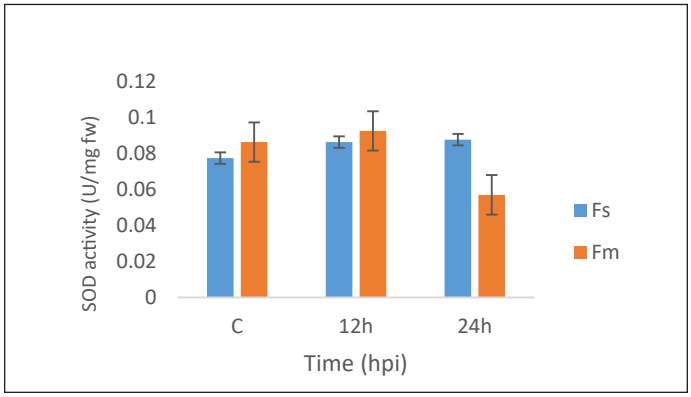


Fig. 1.26: Leaf SOD activity in control (C) and *rangeeni* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

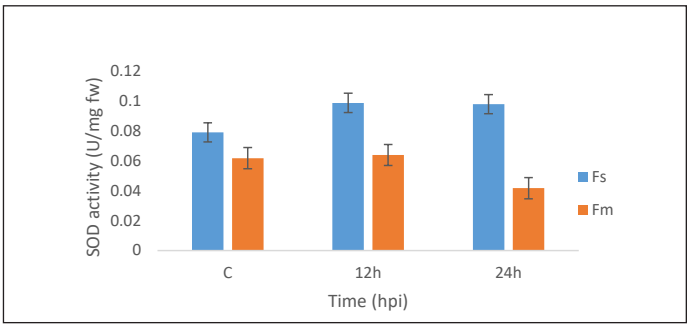


Fig. 1.27: Stem SOD activity in control (C) and *rangeeni* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

F. macrophylla showed decrease in leaf H_2O_2 content when inoculated with any of the strain while *F. semialata* showed similar trend with *rangeeni* but an oscillating activity with *kusmi* (Fig. 1.28 to 1.31). Stem samples from both host plants showed a decrease and then increase in amount at 12 and 24 hpi from control only and *F. semialata* showed consistently decrease in H_2O_2 upon *kusmi* inoculation.

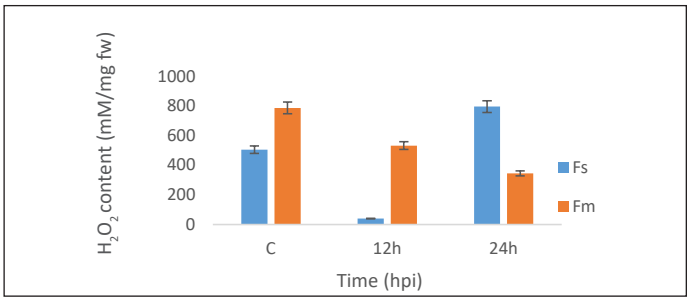


Fig. 1.28: Leaf H_2O_2 content in control and *Kusmi* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

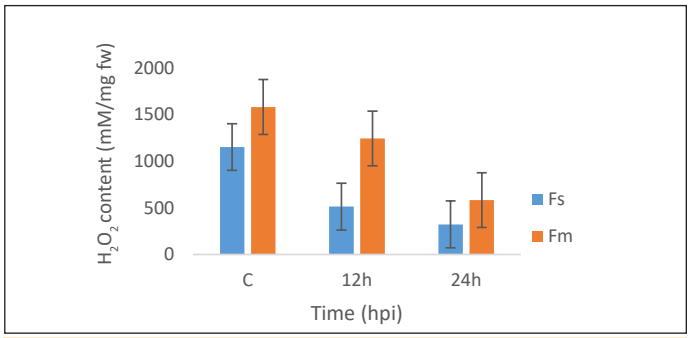


Fig. 1.29: Leaf H_2O_2 content in control and *rangeeni* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

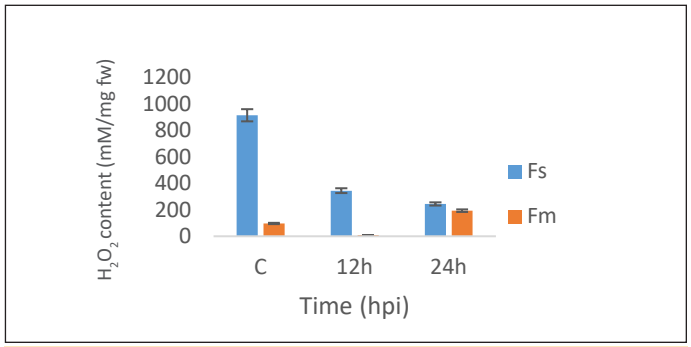


Fig. 1.30: Stem H_2O_2 content in control and *Kusmi* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

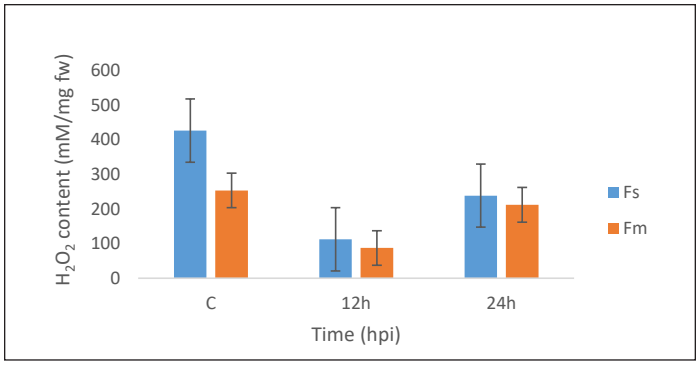


Fig. 1.31: Stem H_2O_2 content in control and *rangeeni* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

Stem sample of *F. macrophylla* showed a decrease and then increase of detoxification enzyme POD at 12 and 24 hpi for both strains. While leaf POD activity *F. semialata* showed similar trend with both *Kusmi* as well as *rangeeni*, its stem had similar trend with *Kusmi* but with continuous decrease in POD when *rangeeni* was inoculated (Fig. 1.32 to 1.35). Catalase assay results could not be analysed due to technical error.

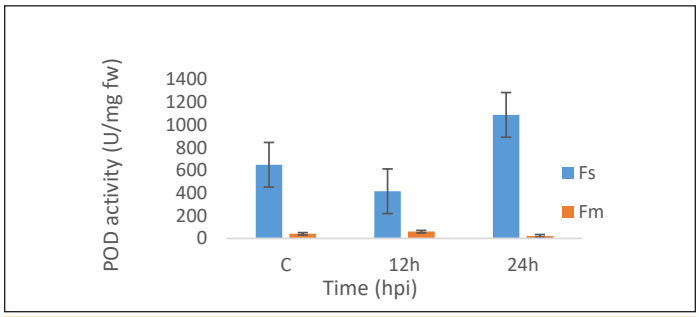


Fig. 1.32: Leaf POD content in control and *kusmi* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

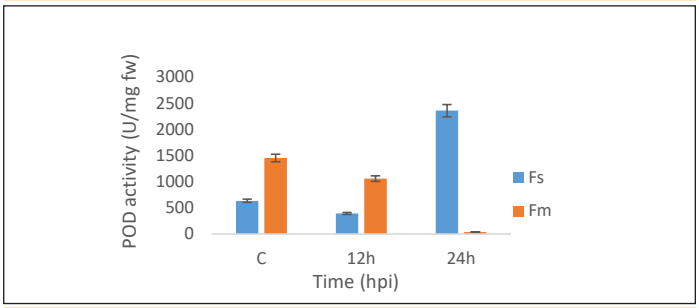


Fig. 1.33: Stem POD content in control and *rangeeni* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

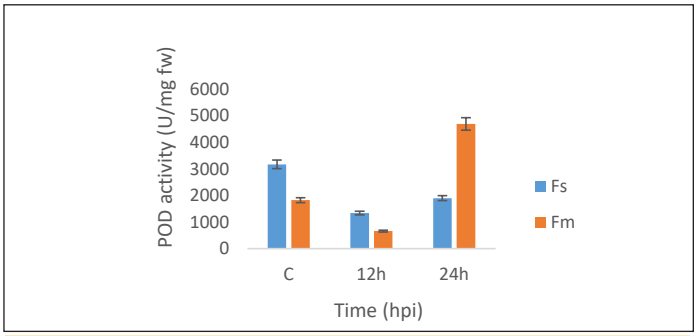


Fig. 1.34: Stem POD content in control and *kusmi* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

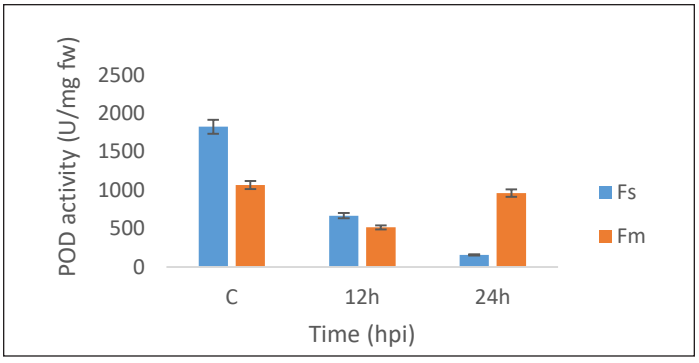


Fig. 1.35: Stem POD content in control and *rangeeni* inoculated plants in *F. semialata* (Fs) and *F. macrophylla* (Fm)

1.6 Agronomic interventions influencing lac production in *palas* (*B. monosperma*) in summer season

Regeneration of good quality shoots is a key to successful lac cultivation. Based on field observation, different factors like topography (Upland/Lowland), soil Fertility levels (Control/ liming 2 kg/ Lime (2 kg)+ FYM (25kg)+ 300g urea+ 300g DAP+ 800g MOP/ lime (4kg)+ FYM (50kg) + 600g urea+ 600g DAP+ 1600g MOP) and Rest period (7 months/19 months) are being tested for their possible role in quality shoot production and lac production out of it. These factors have been shown symbolically as U/L, $F_0/F_1/F_2/F_3$ and R_1/R_2, respectively (Table 1.9). In this season, trees under R_1 have been inoculated; R2 sector will be inoculated next year. Significant decrease in lac insect mortality has been recorded (Table 1.9) in lowland condition as compared to upland (7.1 and 13.4 per cent respectively). While approaching December, tip portion of shoots starts dying. Therefore, little decrease in shoot length has been noticed in upland condition. But in lowland condition, 15.2 percent increase in shoot length was registered. The difference was significant. Other attributes, like dry matter percent and shoot diameter did not vary significantly. Levels of factors like soil fertility levels and rest period could not influence any of the attributes significantly. Highest level of soil fertility tended to resist dropping of succulence level of shoots (as dry matter percent recorded was lesser). At the same time, much reduction in shoot length (due to dying of shoot tips) was observed in December. It could be attributed to favourable growth condition of lac insect in this treatment. R_1 (7 months rest) has been inoculated. Therefore, shoot length increase was much lesser. Observation also indicated that under upland condition, lac settlement is significantly better than that in lowland condition. Similarly, enhanced soil fertility increases the percent settled shoots (Fig. 1.36).

Table 1.9: Tree growth and lac insect mortality affected by different factors

	Dry Matter % July	Dry Matter % Dec	Dec Mortality %	Shoot diameter (July)	Shoot diam-eter (Dec)	% increase	Av. Shoot length (July)	Av. Shoot length (Dec)	% in-crease
U	30.1	35.9	13.4	7.8	8.6	15.9	33.5	28.7	-6.4
L	29.7	34.4	7.1	7.9	9.2	18.9	29.8	33.4	15.2
$CD_{(0.05)}$	1.1 NS	1.6 NS	3.0*	0.9 NS	0.8 NS	12.4 NS	5.1 NS	5.2 NS	14.8*
F0	30.0	35.6	9.3	7.7	8.4	12.8	29.1	32.1	21.8
F1	29.3	35.5	11.0	7.9	9.0	16.6	32.8	33.0	5.3
F2	30.1	35.1	9.3	7.6	9.3	23.2	32.6	31.4	1.0
F3	30.3	34.4	11.4	8.1	8.9	17.0	31.9	27.6	-10.6
$CD_{(0.05)}$	1.6 NS	2.3 NS	4.2 NS	1.2 NS	1.2 NS	17.6 NS	7.2 NS	7.3 NS	20.9NS
R1	29.7	34.7		8.0	9.0	17.1	33.2	30.5	-0.6
R2	30.1	35.6		7.7	8.8	17.7	30.1	31.6	9.4
$CD_{(0.05)}$	1.1 NS	1.6 NS		0.9 NS	0.8 NS	12.4 NS	5.1 NS	5.2 NS	14.8NS

*Significant at 5% level

**NS: Non-Significant

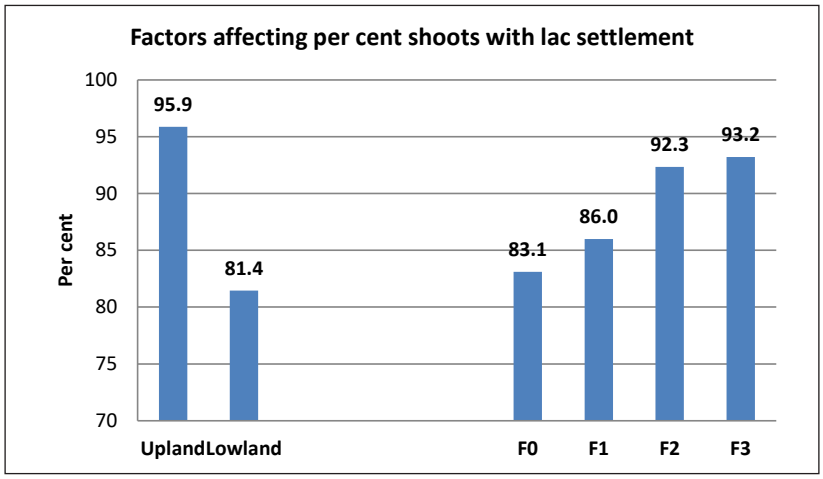


Fig. 1.36: Topography and fertility levels affecting lac settlement

Criteria of judging healthy shoot in *palas*

Palas, being a slow growing host tree, suffers a lot of stress due to lac cultivation and regular pruning. Due to stress put on the tree, shoot growth is not satisfactory. Since good lac production is expected from a healthy shoot only, criteria of a healthy shoot should be well known. While doing pruning operation, some prune points were found to exude latex (Fig. 1.37 & 1.38), few failed to do so. Therefore, points with latex and without latex were marked and counted from certain number of trees.

Fig. 1.37: Exudation of latex from *F. semialata*

It was found that points with latex could regenerate new shoots very easily. Also dead per cent of healthy and unhealthy branches (prune points) was significantly different Fig. 1.39. Therefore, exudation of latex can be taken up as a good parameter to judge a healthy shoot from an unhealthy one. It gives some idea whether the emerged shoots require rest in next season, or is fit for lac cultivation.

Fig. 1.38: Exudation of latex from *palas*

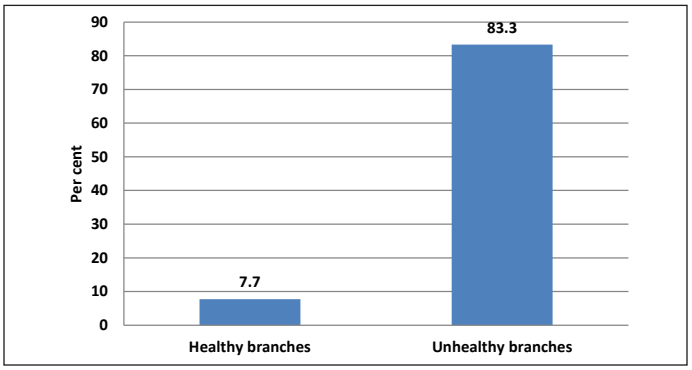


Fig. 1.39: Dead per cent in healthy and unhealthy prune points

2. Crop Production System Management

2.1 Lac integrated cropping system through participatory approach

Lac host *semialata* (*F. semialata*) based cropping system

Relative performance, biomass production and carbon stock under lac host *semialata* based cropping system both in summer and rainy season were studied at Institute Research Farm. In summer season of 2019, cropping models *viz.* sole *semialata*, *okra*, bitter gourd, and bottle gourd; intercrops *semialata*+*okra*, *semialata*+bitter gourd and *semialata*+bottle gourd were evaluated. And cropping models *viz*. sole *semialata*, *okra*, tomato and radish; intercrops *semialata*+*okra*, *semialata*+tomato and *semialata*+radish were evaluated in rainy season of the same year. Since, lac was harvested in winter season there was no production from *semialata* for both summer and rainy season. In rainy season tomato crop failed due to bacterial wilt even after control measures, so no yield was obtained from tomato treatments.

Relative performance under lac host *semialata* based cropping system in summer and rainy season

For ease in comparison, *okra* equivalent yield (kg/ha) as influenced by different cropping system has been worked out. The significantly maximum *okra* equivalent yield (p<0.01) was found in sole *okra* (10571.86 kg/ha) whereas, the minimum was obtained in intercrop *semialata*+bitter gourd (1154.58 kg/ha) in summer season. *Okra* equivalent yield was significantly maximum (p<0.01) in sole *okra* (6391.08 kg/ha) whereas, minimum was obtained in intercrop *semialata*+radish (1805.34 kg/ha) in rainy season (Table 2.1).

Table 2.1: Effect of different cropping system on *okra* equivalent yield (kg/ha) in summer season

Treatments	Crop yield (kg/ha)	*Okra* equivalent yield (kg/ha)
Okra	10571.86	10571.86
Bitter gourd	8443.21	8443.21
Bottle gourd	4890.997	2445.50
Semialata+*Okra*	7784.329	7784.33
Semialata+Bitter gourd	1154.577	1154.58
Semialata+ Bottle gourd	2792.162	1396.08
p-value		<0.01

Effect of intercropping with *semialata* on the growth of *okra*

The effect of intercropping with *semialata* on the growth of *okra* was studied during rainy season of 2019. The results showed that all the growth parameters were not significantly different among the treatments (p>0.05). The plant height of sole *okra* (17.02cm) was higher than intercrop *okra* (16.81cm) in 30 DAS (Days after Sowing). However, the plant height of intercrop *okra* (49.09cm) was higher than sole *okra* (42.63cm) in 60 DAS. Absolute growth rate of intercrop *okra* (1.07cm/day) was found to be higher than sole *okra* (0.85cm/day). The result exhibited that average number of leaf of sole *okra* was higher than intercrop in both 30 and 60 DAS with values of 5.00, 8.67 respectively for sole *okra* and 4.78, 8.00 respectively for intercrop *okra*. Intercrop *okra* showed higher leaf no. growth rate (0.50/day) than sole *okra* (0.12/day). Average number of flowers was same in both sole and intercrop *okra* with value of 2.44. The sole okra showed higher average number of fruit sets (4.56) than intercrop *okra* (4).

Effect of intercropping with *semialata* on the growth of radish

The effect of intercropping with *semialata* on the growth of radish was studied during rainy season of 2019. It was observed that the plant height at 30 DAS and fresh total root length of radish was observed higher in the sole radish than the intercropped but their differences were non-significant (p>0.05). However, significantly higher average number of leaves per plant at 30 DAS was observed in sole radish (p<0.05). Fresh fusiform tap root length was observed significantly higher in the intercropped radish (p<0.05). The plant height was higher in sole radish (19.34 cm) than intercropped radish (19.31cm). The average number of leaves per plant was significantly higher in sole radish (6.11/plant) than intercropped radish (5/plant). The fresh fusiform tap root length was significantly higher in intercropped radish (7.69 cm) than sole radish (6.34 cm). The higher fresh total root length was recorded in sole radish (11.96 cm) than intercropped radish (11.92 cm).

Biomass production and carbon stock under lac host *semialata* based cropping system in summer and rainy season

Different cropping system significantly influenced total biomass (above and below ground) and total carbon stock of the crops (p<0.01) in both summer and rainy season (Fig. 2.1 & 2.2). For summer season, sole *okra* recorded maximum total biomass (4.83 t/ha) while, the minimum was recorded in intercrop *semialata*+bitter gourd (0.35 t/ha). Total carbon stock was observed maximum in sole *okra* (2.42 t/ha) whereas, the minimum was recorded in intercrop *semialata*+bitter gourd (0.17 t/ha). For rainy season, the maximum total biomass was obtained in sole *okra* (0.96 t/ha) whereas, the minimum was recorded in intercrop *semialata*+radish (0.22 t/ha). Total carbon stock was maximum in sole *okra* (0.48 t/ha) while, the minimum was recorded in intercrop *semialata*+radish (0.11 t/ha).

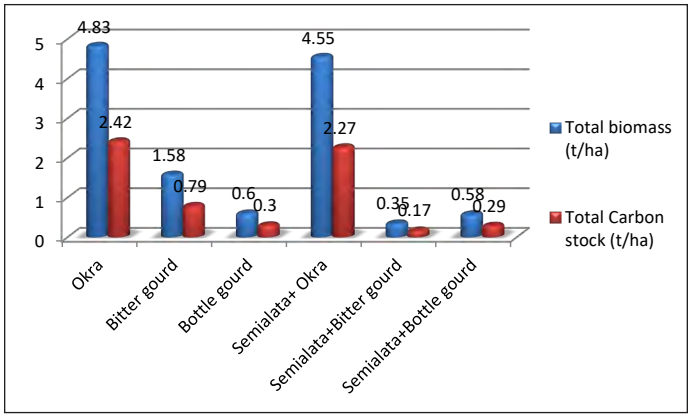


Fig. 2.1: Biomass production and carbon stock of crop under different cropping system in summer season

The different cropping system was not significantly influenced the soil carbon stock. The maximum soil carbon stock (t/ha) was recorded in sole bitter gourd (12.94 t/ha) whereas, the minimum was obtained in sole *semialata* (9.61 t/ha) in summer season (Fig. 2.3). In rainy season, the maximum soil carbon stock (t/ha) was recorded in sole radish (9.79 t/ha) whereas, intercrop *semialata*+*okra* (5.5 t/ha) was recorded minimum (Fig. 2.4).

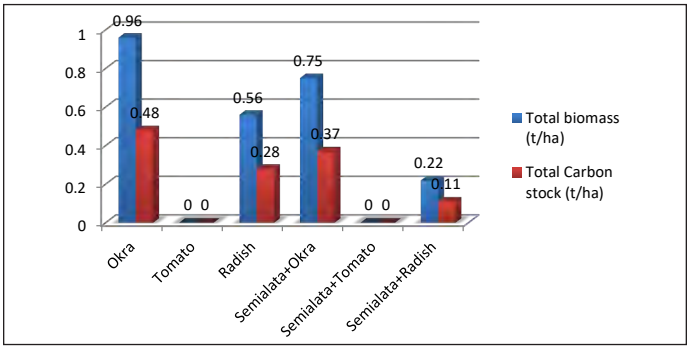


Fig. 2.2: Biomass production and carbon stock of crop under different cropping system in rainy season

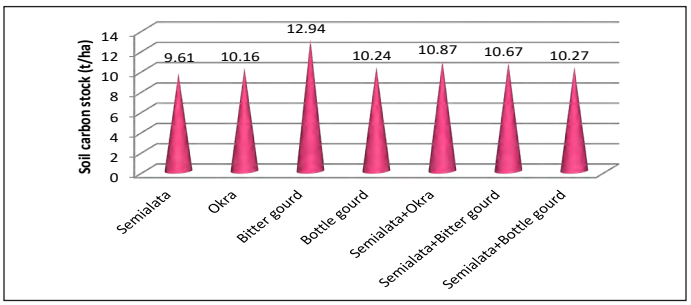


Fig. 2.3: Soil carbon stock (t/ha) under different cropping system in summer season

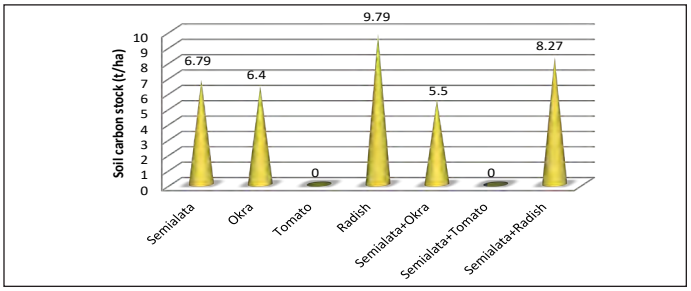


Fig. 2.4: Soil carbon stock (t/ha) under different cropping system in rainy season

2.2 Evaluation of the effect of drip irrigation and plastic mulch on growth and seed yield of *F. semialata*

An experiment on effect of drip irrigation and plastic mulch on growth and seed yield of *F. semialata* was carried out in 2019-20. In all there were three levels(25%, 50% and 75%) of irrigation and thirteen treatments *viz.* T1=Drip irrigation at 75%, T2= Drip irrigation with silver/black plastic mulch at 75%, T3= Drip irrigation with green plastic mulch at 75%, T4= Drip irrigation at 50%, T5= Drip irrigation with silver/ black plastic mulch at 50%, T6= Drip irrigation with green

plastic mulch at 50%, T7= Drip irrigation at 25%, T8= Drip irrigation with silver/black plastic mulch at 25%, T9= Drip irrigation with green plastic mulch at 25%, T10= Furrow irrigation at 50%, T11= Furrow irrigation with silver/black plastic mulch at 50% and T12= Furrow irrigation with green plastic mulch at 50% and Tc=control.

Drip irrigation with green plastic mulch at 75% level of irrigation is performing better in terms of growth of number of shoots (1.67) as compared to drip irrigation with silver/black plastic mulch at all levels of irrigation (Fig.2.5). Drip irrigation with silver/black plastic mulch at 75% level of irrigation is performing better in terms of growth of shoot height (15.83 cm) as compared to drip irrigation with green plastic mulch at all levels of irrigation. Also the growth of shoot height increases with increase in level of irrigation for drip irrigation with silver/black plastic mulch. Maximum growth in shoot height (20.08 cm) has been recorded in treatment of furrow irrigation with silver/black plastic mulch (Fig.2.6). Maximum growth in shoot girth (0.84 mm) was recorded in treatment of drip irrigation with silver/black plastic mulch at 25% level of irrigation (Fig. 2.7). Seed yield as recorded in April 2019 is presented in Fig. 2.8. T 6, T7 and T11 produced the maximum and least production was registered in T 10 and T 12.

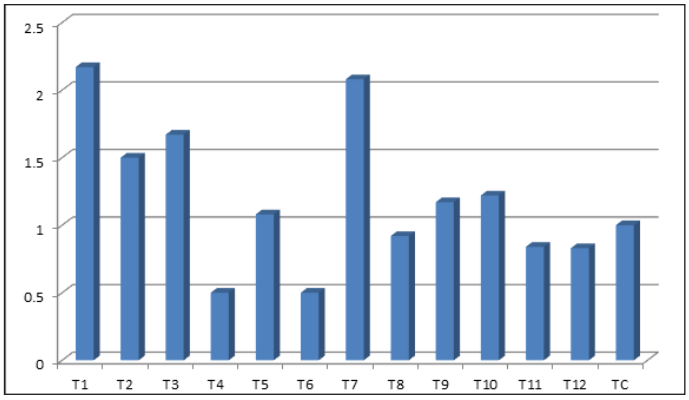


Fig. 2.5: Treatments vs number of shoots

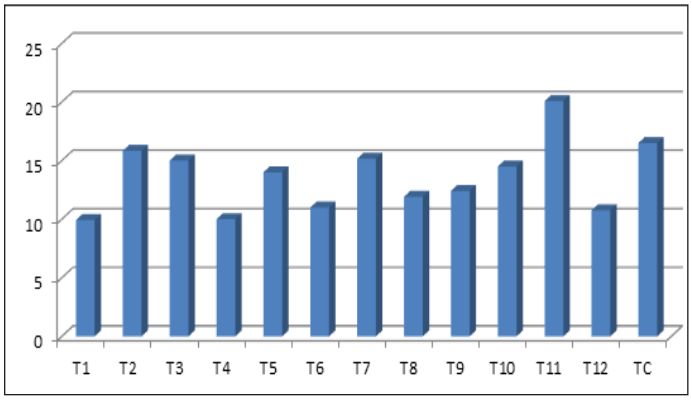


Fig. 2.6: Treatments *vs* shoot height(cm)

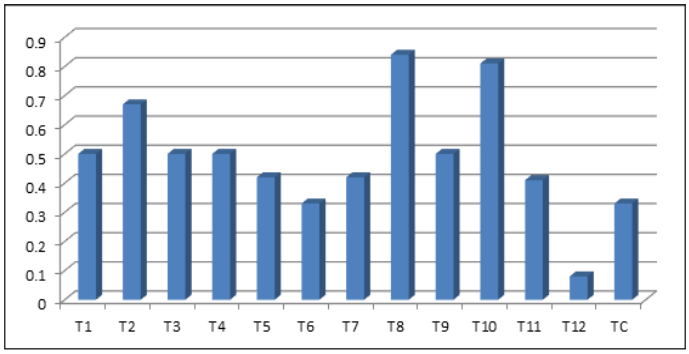


Fig. 2.7: Treatments *vs* shoot girth (mm)

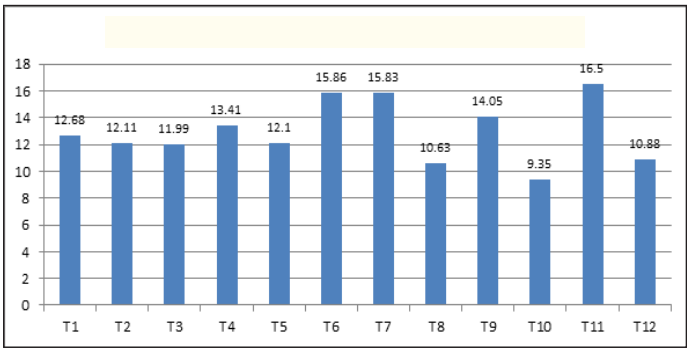


Fig. 2.8: Seed yield per plant affected by different treatments

2.3 Effect of abiotic factors on lac associated fauna in *rangeeni* crops (Phase-II)

Relative abundance and emergence profile of parasitoids and predators associated with lac insect were recorded at Institute Research Farm during summer season (*baisakhi*) and rainy season (*katki*) crops of *rangeeni* strain sprayed with fungicide (Chlorothalonil) only. The information generated reveals that, two parasitoids (*Aprostocetus purpureus*, *Tachardiaephagus tachardiae*) and one predator *Eublemma amabilis* were abundant in *baisakhi* and *katki*, 2019. Among lac associated fauna, *A.purpureus* was recorded in more numbers on *ber* and *palas* during *baisakhi* and *katki*, 2019 (Table 2.2).

Table 2.2: Relative abundance of lac associated fauna during *baisakhi* and *katki* 2019

Lac associated fauna	*Baisakhi* 2019 (Numbers per meter lac encrustation)		*Katki* 2019 (Numbers per meter lac encrustation)	
	Ber	*Palas*	*Ber*	*Palas*
Tachardiaephagus tachardiae	0	16	4	14
Aprostocetus purpureus	59	97	192	161
Eublemma amabilis	0	13	12	14
Total	59	126	207	189

Emergence profile of lac associated fauna during *rangeeni* lac crops

Study on weekly emergence profile of lac associated fauna (per meter lac encrustation) showed maximum population of *A. purpureus* (23 on *ber* and 30 on *palas*) in those samples which were collected in 14th Standard Meteorological Week (SMW) during sexual maturity period when caged during *baisakhi* 2019 (Fig. 2.9 & 2.10). In *Katki*, 2019, the maximum emergence of *A. purpureus* was recorded during crop maturity period (43 and 45 SMW) when raised on *ber* (34) and *palas* (38), respectively (Fig. 2.11 & 2.12).

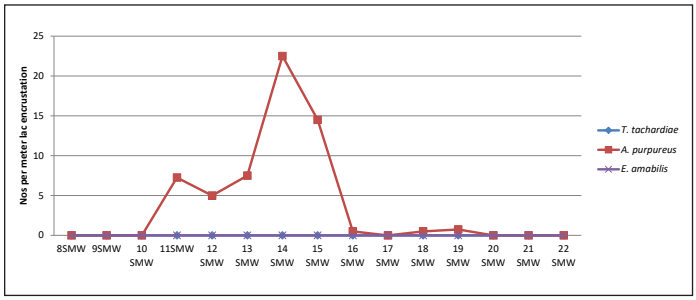


Fig. 2.9 : Emergence profile of lac associated fauna on *ber* during *baisakhi* 2019

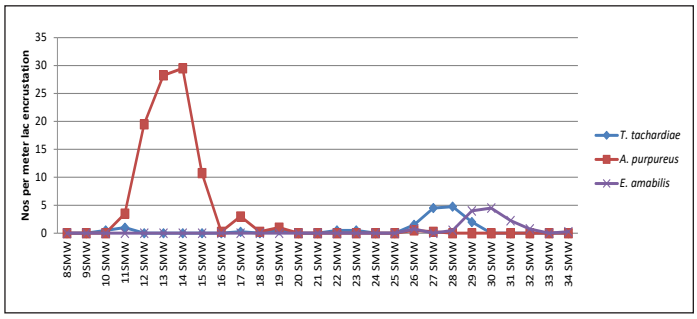


Fig. 2.10: Emergence profile of lac associated fauna on *palas* during *baisakhi* 2019

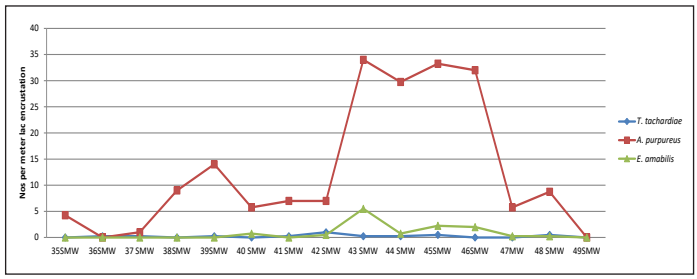


Fig. 2.11: Emergence profile of lac associated fauna on *ber* during *katki* 2019

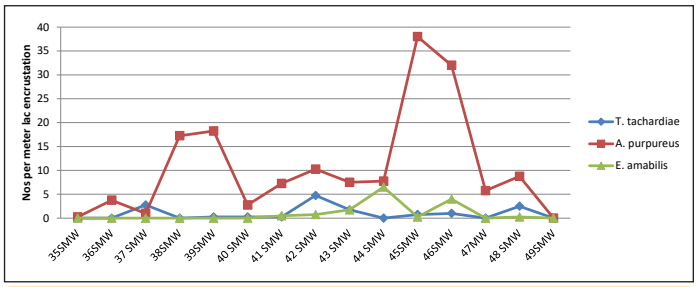


Fig. 2.12: Emergence profile of lac associated fauna on *palas* during *katki* 2019

In-situ and lab caging study on emergence of lac associated fauna

Emergence profile of lac associated fauna was compared between different caging methods *viz*. *in-situ* caging and lab caging during *baisakhi* 2019 and *katki*, 2019. Higher numbers of parasitoids were recorded in lab caging method (20, 43) compared to *in-situ* caging (8, 28) on *ber* and *palas,* respectively during *baisakhi*, 2019 (Fig. 2.13). In *katki*, higher numbers of *T. tachardiae and E. amabilis* were recorded in *in-situ* caging (28 and 31), (31 and 17) compared to lab caging (2 and 7) (7 and 16) on *ber* and *palas,* respectively. Whereas, number of *A. purpureus* was recorded more in lab caging (83 and 36) compared to *in-situ* caging (33 and 18) on *ber* and *palas*, respectively (Fig. 2.14). Un-emerged *E. amabilis* (immature stages *viz*., larva and pupa) were also recorded while pricking/scrapping of lac encrustation sample on both the host and methods of caging during *katki*, 2019.

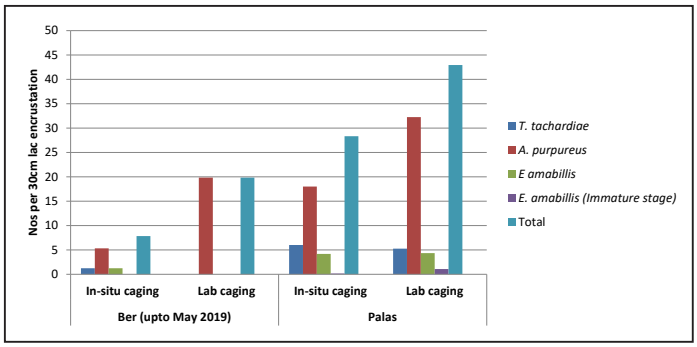


Fig. 2.13: Emergence profile of lac associated fauna using different methods on *ber* and *palas* during *baisakhi* 2019

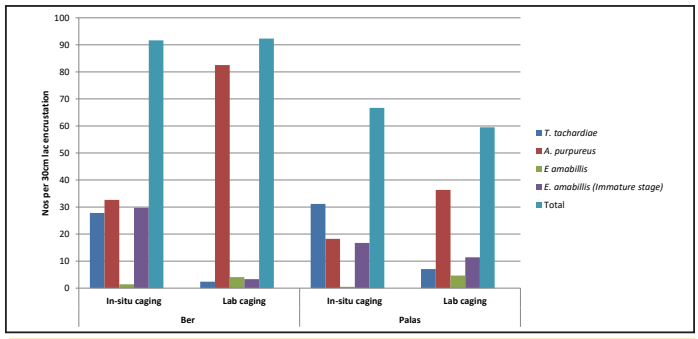


Fig. 2.14: Emergence profile of lac associated fauna using different methods on *ber* and *palas* during *katki* 2019

Correlation between weather parameters and lac insect associated fauna

Correlation and regression were done with peak population of *A. purpureus* recorded from *ber* and *palas* based on standard meteorological week (current, 1 week lag, 2 week lag upto 5 week lag) during *baisakhi* 2011-12 to 2017-18. This results show, there is no significant correlation between peak populations of *A. purpureus* with weather parameters on *ber* while significant correlation

was observed between peak populations of *A. purpureus* with relative humidity evening on *palas.*

Regression equation was made using highest correlation value among current, 1 week lag, 2 week lag and upto 5week lag of weather parameters with peak population of *A. purpureus* during *baisakhi* 2011-12 to 2017-18 on *ber* and *palas.* Derived regression equation is given below,

Derived regression equation for peak population of *A. purpureus* on *ber*

$Y= 22.63 – 0.30\times T_{max}$ (Current) + $0.04\times T_{min}$ (1week lag) + 0.14 Rainfall (Current) – $0.09\times RH_{Mor}$ (4 week lag) – $0.04\times Rh_{Eve}$ (Current)

R^2 value = 0.97

Derived regression equation for peak population of *A. purpureus* on *palas*

$Y= 12.01 – 0.23\times T_{max}$ (4 week lag) + $0.22\times T_{min}$ (Current) + 5.0 Rainfall (2 week lag) + $0.01\times RH_{Mor}$ (4 week lag) – $0.09\times Rh_{Eve}$ (3 week lag)

R^2 value = 0.95

Using these models, we can validate observed value (next year peak population of *A. purpureus*) with predicted value (peak population of *A. purpureus* derived from regression model) for predicting peak population of *A. purpureus* of *palas* and *ber* during *baisakhi* crops.

2.4 Exploratory Study

1. Study on lac inoculation using rubber band

Lac inoculation requires cutting and sizing of brood sticks, its bundling and tying the same with branches, after climbing on trees. The process is labour intensive and expensive.

The major advantage of inoculation with rubber band is that it does not require bundling; there by it cuts expenditure significantly. But, inoculation with *sutli* has limitation in this regard, since bundle weight is kept fixed, irrespective of size of branches. Thus, in cases of bigger branches, it becomes under inoculated and in case of smaller branches, it becomes over inoculated (Fig. 2.15). The process is very easy, the rubber band is fastened to the branch with the help of a noose and then requisite number of broodlac sticks cut in optimum size are placed on the branch, tied rigidly encircling once or twice all through the branch and finally the band is fastened to the brood sticks (Fig. 2.16).

The entire procedure takes less than half time than the *sutli* method for a single site. Number of shoots with lac insect settlement was higher (385) in rubber band method as compared to bundled method (334). Cost of inoculation is also reduced significantly (Rs.63.9 to 43 for 600g bundle which is sufficient to inoculate one *palas* tree).

Fig. 2.15: Inoculation of broodlac using plastic *sutli* (conventional method)

Fig. 2.16: Inoculation of broodlac using rubber band (new method with sticks)

2. Incidence of root grubs on *palas* trees

Severe root grub incidence was recorded on *palas* trees in the year 2019 and observations were recorded to analyse the species diversity and quantum of damage done to the trees by the adult beetle feeding. The collected beetles were sent to ICAR-NBAIR, Bengaluru for identification and 4 different genera of the beetles were recorded to damage *palas* foliage *viz*. *Holotrichia, Apogonia, Aodretus* and *Sophrops* belonging to 2 subfamilies of Scarabaeidae. The observations were made to quantify the damage done by the beetles in two parameters *i.e.* Per cent leaves damaged per shoot and Per cent damage per leaf in 3 different levels of the trees. The results showed significant difference among the treatments and the highest damage was recorded in the lower strata of the trees compare to middle and upper (Table 2.3). While in comparison with the height of the trees in means of the damage occurred, the trees with height ≤ 2mts are affected more significantly in comparison with trees with ≥ 4mts in both cases like percent leaves damaged per shoot and percent damage per leaf (Fig. 2.17).

Table 2.3: Beetle damage incidence in *palas* trees of ≥ 4 mts height

Treatments	Per cent leaves damaged per shoot	Per cent damage per leaf
Lower shoot	80.48 (67.62)	31.11 (33.06)
Middle shoot	67.18 (57.73)	25.51 (28.94)
Upper shoot	57.08 (49.56)	18.04 (23.81)
$CD_{0.01}$	7.75*	5.54*
(m)	2.72	1.94

Figure in SE parenthesis are Arcsine transformed values; *=Significant at 5% level

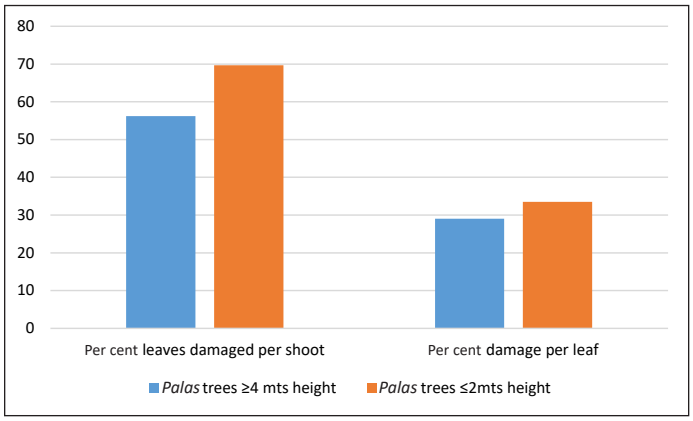


Fig. 2.17: Comparison of beetle damage on *palas* trees with two different tree heights

3. Tritrophic interaction in lac Ecosystem: A semio-chemical approach

Five combination mixtures of major semio-chemicals identified using GC-MS *viz*. hexadecane, nonadecane, decane and eicosane were prepared *i.e.* C_1 (4:1:1:1), C_2 (4:2:1:1), C_3 (2:2:2:2), C_4 (4:2:0:0) and C_5 (2:2:0:0) along with lac insect whole body. 100 ml of whole body extract in hexane (WBH) was prepared and concentrated to 10 ml and 5ml of different combination mixtures were also prepared. Prepared extract was sent to Division of Entomology, Indian Agricultural Research Institute (IARI), New Delhi for preparation of septa. Prepared septas were received from IARI and tested in the field condition with four replicates. The septas were hanged into the funnel trap on 02.11.2019 and kept for attracting the lac associated fauna.

One lac predator *Eublemma amabilis* was found in C_2 combination after 15 days of installation of the funnel trap. Beside, these different lepidopteron adult moths were also recorded in the funnel trap with WBH (5 Nos.) and different combination mixtures (C_1- 3 Nos., C_2-2 Nos., C_3-3 Nos., C_4-3 Nos.). No insect was trapped in C_5 combination (Table 2.4).

Table 2.4: Different semiochemicals used for funnel trap study

Sl. No.	Semio-chemical combinations	Lepidoptera insect
1.	C_1 (4:1:1:1)	3
2.	C_2 (4:2:1:1)	2 + 1 *E. amablis*
3.	C_3 (2:2:2:2)	3
4.	C_4 (4:2:0:0)	3
5.	C_5 (2:2:0:0)	0
6.	WBH	5

2.5 Externally Funded Project

Identification, cloning and characterization of genes involved in pigment biosynthesis of the Indian lac insect, *Kerria lacca* (Kerr) under DBT Bio-CARe project

Identification and cloning of putative pigment biosynthesis genes

In order to identify the genes involved in pigment biosynthesis of lac insects, whole transcriptome sequencing of crimson (wild type), yellow (mutant) and cream (mutant) colour lac insects was carried out. RNA was isolated following Trizol method and Paired end library for sequencing was constructed and the library was sequenced using the Illumina HiSeq 2500 platform. A total of 37,014,410, and 27,286,302 and 26,533,642 QC passed high quality reads were obtained for cream, crimson and yellow insects, respectively. Differential gene expression analysis was performed using DESeq2 program and the transcripts with p-value < 0.05 were considered.

Based on the available literature, few putative genes which would be supposedly involved in pigment biosynthesis of lac insects were identified among the differentially expressing genes especially among the genes showing upregulation in crimson insects in comparison with cream insects. They include acyl carrier protein, carboxylic ester hydrolase, acetyl-coA-acetyl transferase, alcohol dehydrogenase, glycine N methyl transferase, aldehyde dehydrogenase and flavin containing monooxygenase, cytochrome P450, long chain fatty acid CoA ligase, lysine specific demethylase, few hydrolases and peptidases.

Few cDNAs were cloned using the primers designed from the transcriptome data. They are acyl carrier protein 1 (853 bp), acyl carrier protein 2 (423 bp), demethylase 3a (591 bp) and N-acetyl transferase 4 (553 bp).

RNAi experiment in lac insects

For administering double stranded RNA (ds-RNA) to the lac insects, insects were grown on mature ripened pumpkins (Fig. 2.18). Double stranded RNA of three genes viz., tyrosine 3-monooxygenase1, deaminase and acyl carrier protein were injected into pumpkins harbouring fertilized female lac insects. RNA was isolated from the lac insects collected from 1 to 4 days after injection (DAI). cDNA was synthesized and qPCR was conducted to study the expression level of the concerned genes. The qPCR experiment showed that the expression of deaminase was down regulated to 0.4 fold, 0.4 fold and 0.3 fold in samples collected 1 DAI (day after injection), 2 DAI and 3 DAI, respectively. In case of acyl carrier protein, expression was down regulated to 0.19 fold, 0.33 fold, 0.28 fold and 0.54 fold (Fig. 2.19) in ds-RNA administered lac insect samples collected 1 DAI, 2 DAI, 3 DAI and 4 DAI, respectively.

Fig. 2.18: Lac insects grown on pumpkin

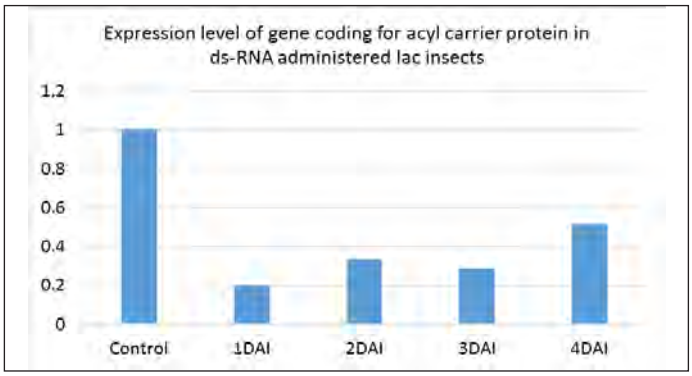


Fig. 2.19: Expression level of *acp* gene in ds-RNA administered lac insects (DAI-Days after injection)

HPLC analysis of lac samples

The resin of the ds-RNA treated lac insect samples and control lac insect samples were dissolved in ethanol and were analyzed for the quantitative presence of lac dye components through HPLC. Care was taken to represent equal amount of resin per ml of the solvent to facilitate quantitative comparison. HPLC analyses of colour pigments from knockdown mutants of lac insects for tyrosine 3-monooxygenase1 and deaminase genes were carried out. Reverse phase HPLC (Waters 510) detector: waters 486 tenable absorbance detector was used. Absorbance was taken at 254 nm using the solvent system as Phosphate buffer (pH=7.0, 0.1M) and Methanol in the ratio 16:5 with a flow rate of 0.40 ml/min. Injection Volume was kept at 20 µl and the column used was C-18 column. The results clearly indicated that the relative abundance of the pigment showed a decreasing trend as the days after RNAi injection has increased (Fig. 2.20a & b). This is however, a preliminary information supporting the involvement of tyrosine 3-monooxygenase1 and deaminase genes in the pigment biosynthesis of lac insects, which needs to be further confirmed by identifying the lac dye components formed using HR-LCMS.

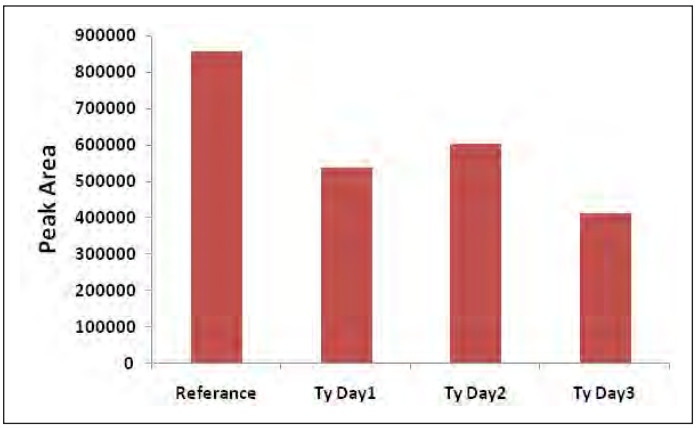


Fig. 2.20a: Peak area of pigment isolated from tyrosine3 monooxygenase1 knockdown mutant of lac insects during day 1, 2 & 3 in comparison with wild type (Reference)

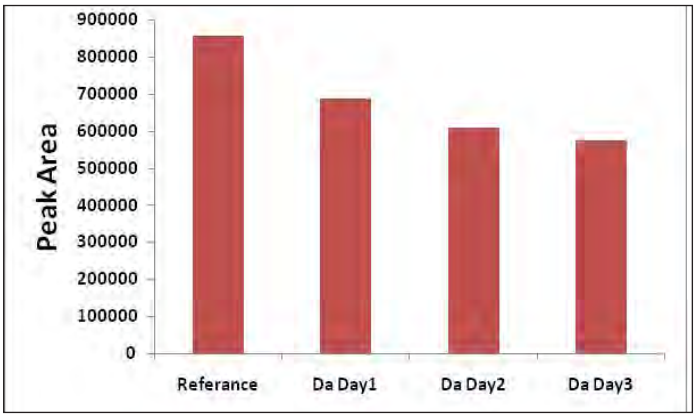


Fig. 2.20b: Peak area of pigment isolated from deaminase knockdown mutant of lac insects during day 1, 2 & 3 in comparison with wild type (Reference)

Cloning of tyrosine monooxygenase gene in bacterial expression vector

Full length tyrosine 3-monooxygenase1 cDNA (1695 bp) having *Hin*dIII and *Xho*I flanking sites was cloned into pET 28 (a) vector and transferred into *E. coli* BL21 cells for its expression. The presence of the gene fragment was confirmed by restriction digestion of the recombinant plasmids with *Hin*dIII and *Xho*I enzymes (Fig. 2.21) and the presence of sequence in frame with the ORF of the vector was also confirmed by sequencing the recombinant plasmids. Expression of the protein in BL21 cells is in progress.

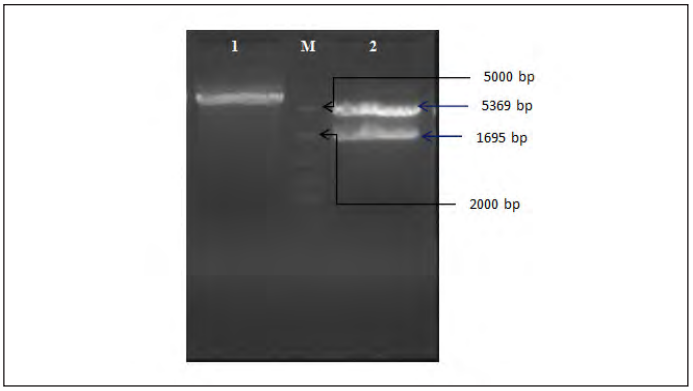


Fig. 2.21: Restriction digestion of the recombinant pET28 (a):*tymo*. Lane 1: Undigested plasmid, Lane M: Molecular weight marker, Lane 2: Plasmid digested with *Hin*dIII and *Xho*I

2.6 Transfer of Technology Activity

Demonstration of 'improved winter season *kusmi* lac production through application of chemical fertilizer' was taken up in five villages involving eight farmers in Jharkhand and West Bengal on *ber* and *semialata* plants. Villages chosen were Mangubandh, Nialdih, Naryan-soso and Porhotoli Jharkhand and Hesla in West Bengal. In Naryan-soso, fertilizer application increased lac yield 31 per cent; in Hesla, fertilization increased lac yield 227 per cent yield ratio 17.3 and 7.6 with and without fertilizer application). Mangubandh also witnessed a positive response. In Nialdih and Porhotoli, lac production was not at all satisfactory due to poor management practices adopted by the farmers.

Processing and Product Development

3. Processing Storage and Quality Management

3.1 Establishment of pilot plant of dewaxed decolourized lac (DDL)

DDL preparation and use of alternate solvent in the process

Trials were carried out for preparation and validation of dewaxed decolourised lac (DDL). A total of 11 fresh trials were carried out in lac-solvent ratio 1:6 in 2-Propanol for DDL preparation. The initial colour value of seedlac used for these trials was 13 and 12. For colour removal of lac in solution, 20% fresh charcoal was used during refluxing of lac solution in solvent. Time duration for charcoal treatment in refluxing was 1 to 2.5 hrs. Wax removal and hot filtration of charcoal were carried out in thick jeans cloth in place of filter paper (Table 3.1).

Table 3.1: Process validation and optimization for up-scaling the process

Sl. No.	Colour of seedlac	Charcoal (%)	Refluxing time, hrs.	Lac-solvent ratio (w/v)	Yield of DDL (%)	Colour of DDL	Wax (%)	Impurity (%)	Acid value	Flow (mm)	Life (min.)
1.	13	20	2.0	1:6	69	3.0	1.59	0.272	69.62	90	30
2.	13	20	2.0	1:6	75	CND	1.62	4.478	67.60	Nil	10
3.	13	20	2.0	1:6	79	3.0	1.44	0.294	73.49	85	25
4.	13	20	2.5	1:6	76	1.0	0.90	0.380	73.62	55	33
5.	13	20	2.5	1:6	73	1.2	0.84	0.406	73.71	42	27
6.	13	20	2.5	1:6	74	1.0	0.83	0.202	72.70	85	43
7.	13	20	2.5	1:6	73	4.0	0.81	0.910	74.42	75	45
8.	13	20	2.5	1:6	66	5.0	0.91	0.424	69.30	28	33
9.	12	20	1.5	1:6	78	4.8	0.72	0.196	52.71	90	33
10.	12	20	1.0	1:6	74	4.6	0.82	0.166	54.88	90	32
11.	12	20	1.5	1:6	75	4.8	0.62	61.90	24.75	Nil	Nil

CND - Could not be determined

In these trials, yield of DDL was 66 to 79% by weight of seedlac with average yield of 73.82%. Reduction in colour value of lac (seedlac colour value 13) in DDL varied from 1 to 5. Time duration of treatment with charcoal was 1 to 2.5 hrs. Flow and life of DDL samples varied from 28 to 90 mm and 10 to 45 minutes, respectively. Wax, impurity content and acid value of DDL samples were also better and within acceptable limit in most of the trials. In these trials, yield above 70% for most of trials validated 2-propanol as an alternate solvent for DDL preparation other than spirit. High impurities in samples at Sl. No. 2 & 11 are due to manual error in heat treatment while removing moisture before sheeting and may be due to heat polymerization. Higher colour value of DDL may be due to passing of charcoal while hot filtration. Use of coarse grain charcoal or granular charcoal needs to be tried for getting clear decolourised solution for filtration through Jeans/thick cloth.

Light colour DDL sample

Dark colour DDL sample

Development of pilot plant of DDL

The procurement of equipments/machineries of desired specification for pilot plant of DDL (Capcity-5kg/batch) is under process.

3.2 Biodegradation studies of lac resin

Lac samples (sticklac, seedlac and shellac) were buried in the soil of farm pit and pot for biodegradation study (Fig. 3.1). The samples were drawn from the soils on quarterly intervals. After interval of 36 months, samples were drawn and processed for study of weight loss and other properties. Weight loss of the samples was calculated and found significant loss in weight of the samples. In sticklac samples, it was 32-44% loss. Higher loss (44%) was observed in samples buried in farm pit soil. Seedlac and shellac samples showed 23-29% and 6-8% loss in weight, respectively. Contrary to sticklac, higher loss (29% and 8%) was recorded in samples buried in pot soils (Fig. 3.2 & 3.3).

Fig. 3.1: Lac samples buried in pot and farm pit soils

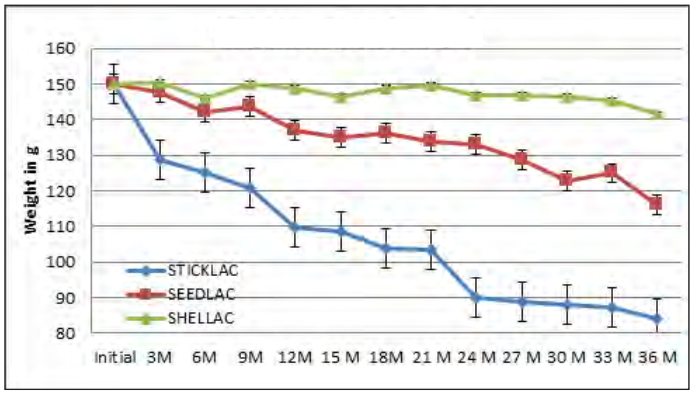


Fig. 3.2: Weight loss of farm pit samples over a period of three years

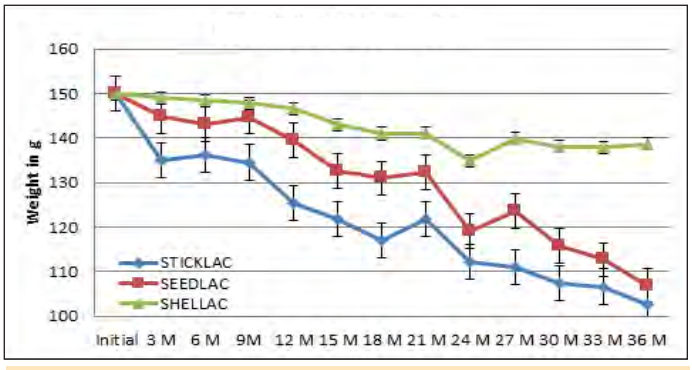


Fig. 3.3: Weight loss of pot samples over a period of three years

Study on physico-chemical properties

Study on physico-chemical properties such as flow, life under heat, colour index and cold alcohol insoluble % was carried out. Significant change was observed in control samples of sticklac and seedlac. Flow of sticklac and seedlac control samples also became zero, with no fluidity (Fig. 3.4 & 3.5). Shellac control sample showed higher flow as compared to that of buried samples (Fig. 3.6).

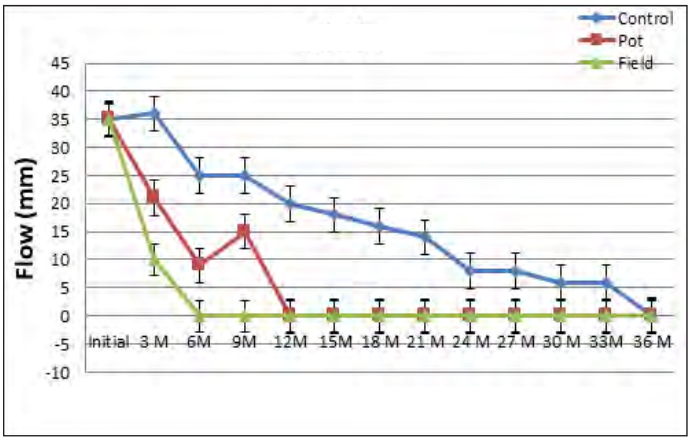


Fig. 3.4: Flow of sticklac samples over a period of three years

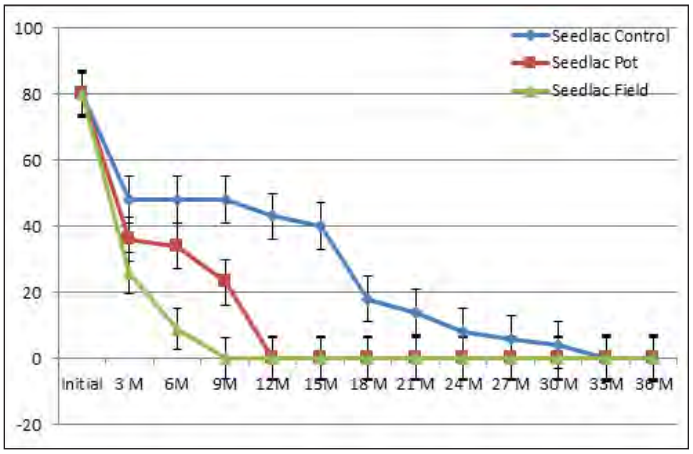


Fig. 3.5: Flow of seedlac samples over a period of three years

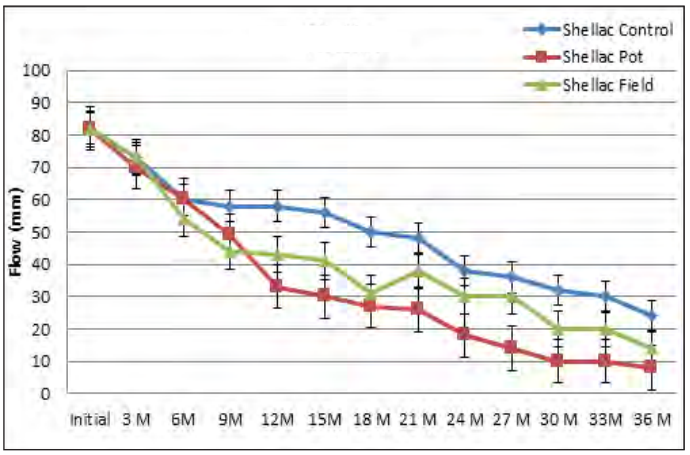


Fig. 3.6: Flow of shellac samples over a period of three years

Life decreased in all the samples over a period of time and no life was observed in case of sticklac samples after 3 years, buried in farm pit soil (Fig. 3.7) while not much difference was recorded in seedlac and shellac control and buried samples (Fig. 3.8 & 3.9).

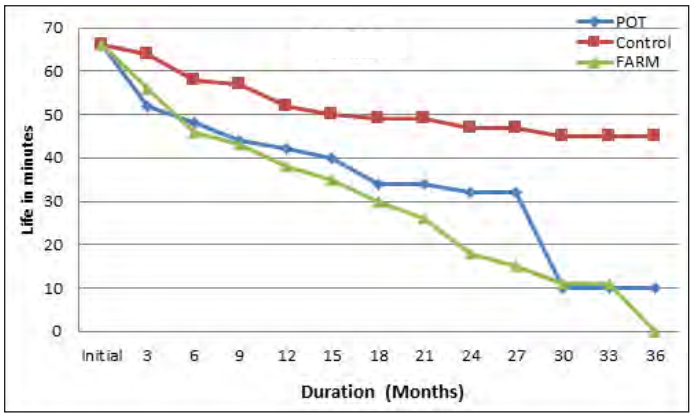


Fig. 3.7: Life under heat of sticklac samples over a period of three years

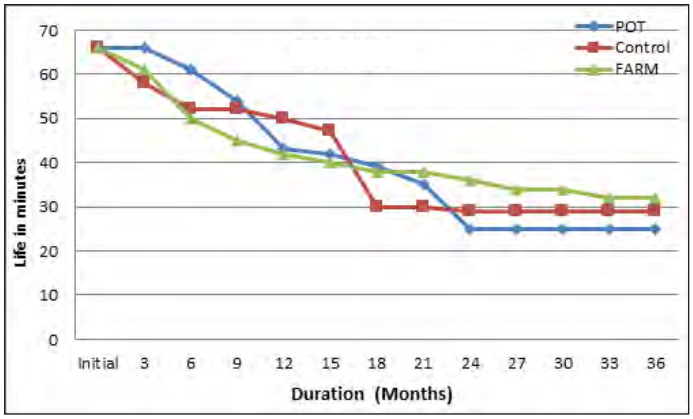


Fig. 3.8: Life under heat of seedlac samples over a period of three years

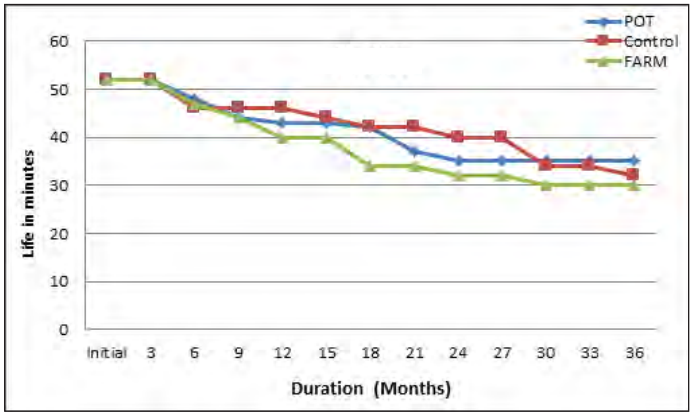


Fig. 3.9: Life under heat of shellac samples over a period of three years

Colour index of all the lac samples (control as well as buried) increased over a period of time. Similarly, cold alcohol insoluble percentage (impurity) increased in all the samples (Table 3.2).

Table 3.2: Colour index and cold alcohol insoluble % of sticklac, seedlac and shellac including control samples

Samples/ Parameters		36 Months	
		Colour index	CAI %
Sticklac	Initial data	40	11.8
	Pot	15 OS	16.62
	Control	45	18.09
	Farm	12	18.54
Seedlac	Initial data	9	6.57
	Pot	9	16.64
	Control	14	21.02
	Farm	12	15.446
Shellac	Initial data	7	5.07
	Pot	12	9.524
	Control	10	7.17
	Farm	11	7.67

FTIR and DSC analyses

In Differential Scanning Calorimetry (DSC) analysis, peaks of resin of lac disappeared or became broad in sticklac and seedlac samples while control samples showed somewhat distinct peaks (Fig. 3.10 & 3.11). In case of shellac, peak of resin was less significant, while control samples showed sharp peak of high intensity (Fig. 3.12). FTIR spectra showed that peak intensity of carbonyl group and C-H moiety of buried samples reduced as compared to control samples.

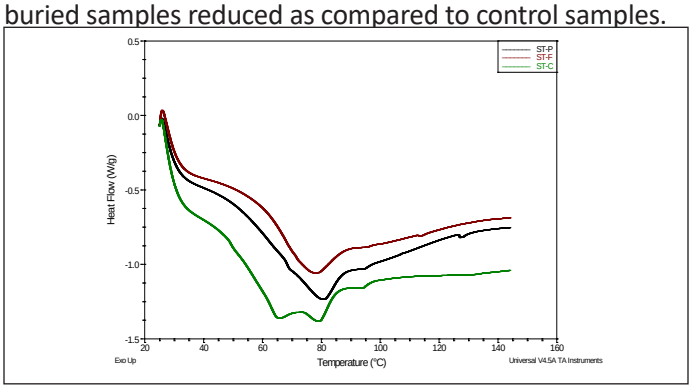


Fig.3.10: DSC thermograms of sticklac samples over a period of three years

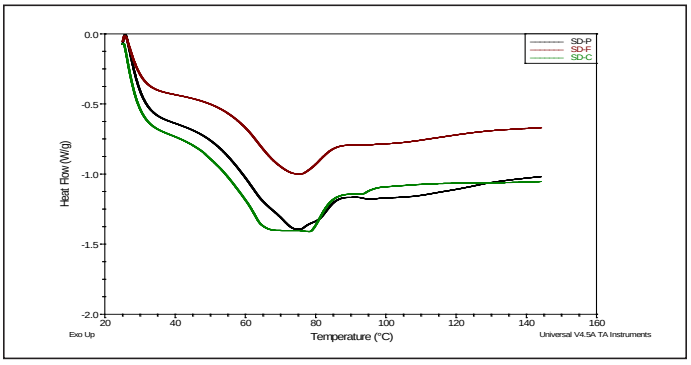


Fig. 3.11: DSC thermograms of seedlac samples over a period of three years

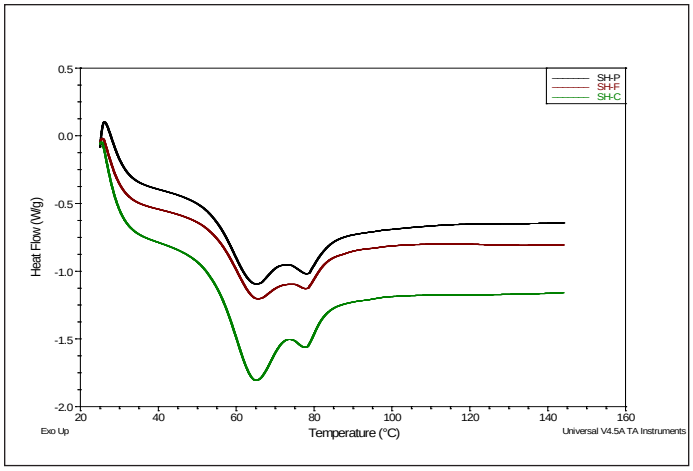


Fig. 3.12: DSC thermograms of shellac samples over a period of three years

3.3 Development of pilot plant of *guar* gum derivative

Carboxy methyl *guar* gum derivative preparation

Trials of carboxy methyl *guar* gum derivative preparation from *guar* gum powder using reagents with variations in mixing time, reaction time and drying time were carried out to observe the difference in quality parameters (viscosity, pH and degree of substitution) of carboxy methyl *guar* gum derivative. Effect of processing parameters (mixing time, reaction time and drying time) on quality parameter of prepared carboxy methyl *guar* gum derivative are detailed below:

Effect of processing parameters on viscosity of carboxy methyl *guar* gum derivative

Experimental trials of carboxy methyl *guar* gum derivative preparation from *guar* gum powder using reagents with variations in mixing time (30, 60 and 90 min), reaction time (3 and 4 h) and drying time (3, 4 and 5 h) were carried out and observed that with reaction time 3 h, mean viscosity of the prepared carboxy methyl *guar* gum derivative was higher at all levels of mixing time (30, 60 and 90 min) and drying time (3, 4 and 5 h) compared to 4 h reaction time with same treatment of mixing time and drying time. Mean viscosity value of carboxy methyl *guar* gum derivative prepared with 30 min mixing time, 3 h reaction time and 3 h drying time was higher compared to 30 min mixing time, 5 h reaction time and 5 h drying time followed by 30 min mixing time, 3 h reaction time and 4 h drying time (Fig. 3.13).

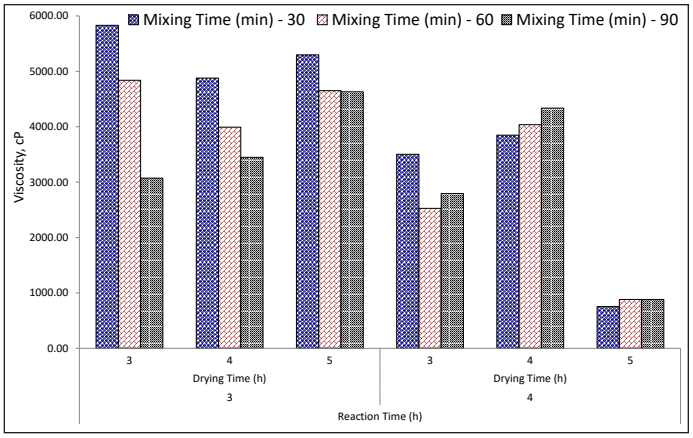


Fig. 3.13: Effect of processing parameters on viscosity of carboxy methyl *guar* gum derivative

Effect of processing parameters on pH of carboxy methyl *guar* gum derivative

Trials of carboxy methyl *guar* gum derivative preparation from *guar* gum powder using reagents with variations in mixing time, reaction time and drying time were carried out and observed that with mixing time 90 min, reaction time 4 h and drying time 5 h, mean pH of the prepared carboxy methyl *guar* gum derivative was higher compared to mixing time 30 and 90 min, 4 h reaction time and drying time 3 and 4 h. Mean pH value of carboxy methyl *guar* gum derivative prepared with 30 and 60 min mixing time, 3 and 4 h reaction time and 3, 4 and 5 h drying time was observed to be almost similar (Fig. 3.14).

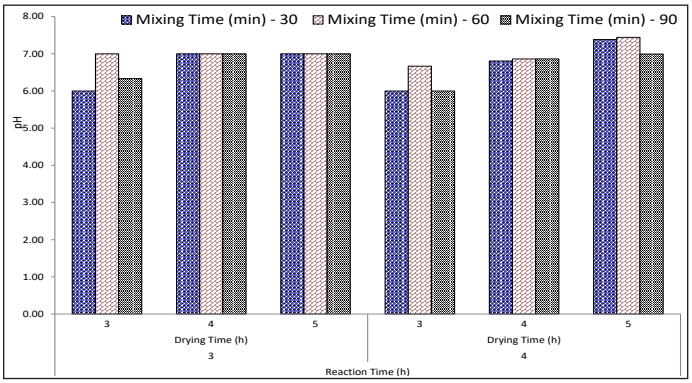


Fig. 3.14: Effect of processing parameters on pH of carboxy methyl *guar* gum derivative

Effect of processing parameters on degree of substitution of carboxy methyl *guar* gum derivative

Experimental trials of carboxy methyl *guar* gum derivative preparation from *guar* gum powder using reagents with variation in processing parameters *i.e.* mixing time, reaction time and drying time were carried out and observed that with reaction time 4 h, mean degree of substitution of the prepared carboxy methyl *guar* gum derivative was higher at all levels of mixing time (30, 60

and 90 min) and drying time (3, 4 and 5 h) compared to 3 h reaction time with same treatment of mixing time and drying time. Mean value of degree of substitution of carboxy methyl *guar* gum derivative prepared with 90 min mixing time, 4 h reaction time and 3 h drying time was higher compared to 4 h reaction time and 4 h drying time followed by 4 h reaction time and 5 h drying time at all levels of mixing time (Fig. 3.15).

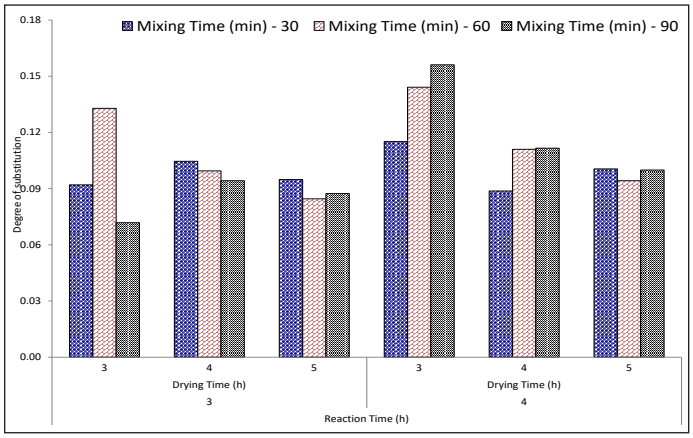


Fig. 3.15: Effect of processing parameters on degree of substitution of carboxy methyl *guar* gum derivative

Development of detailed design drawing of *guar* gum derivative pilot plant

Detailed manufacturing design drawing of carboxy methyl *guar* gum derivative pilot plant developed utilizing Pro Engineer (Creo Element) CAD Software in collaboration with ICAR – Central Institute of Agricultural Engineering, Bhopal (Fig. 3.16) consisted of different units *i.e.* mixing cum reaction unit, filtration unit, drying cum agitator unit and distillation unit.

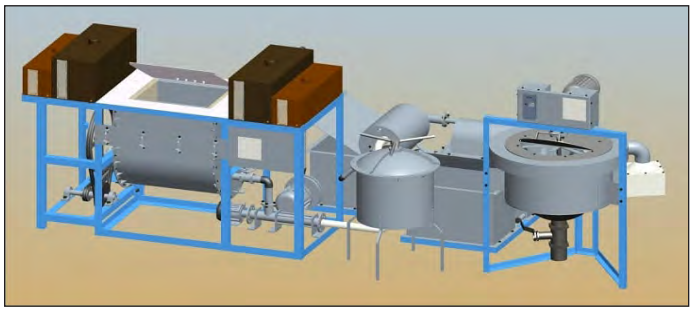


Fig. 3.16: Design drawing of carboxy methyl *guar* gum derivative pilot plant

3.4 Spray drying of gum *ghatti* (*Anogeissus latifolia*)

Drying characteristics of gum *ghatti* was evaluated and drying curves (moisture content vs time, drying rate vs time) were plotted to know the drying characteristics of gum *ghatti*. The drying rate increased with increase in air temperature, which is the main factor influencing the drying kinetics. Moisture content gradually decreased with increase in drying time, drying temp 50 °C had a marked difference in removal of moisture as compared to 40 °C & 60 °C temp. Rate of moisture removal was high at initial stage of drying which created a steeper slope may be due to evaporation of free available surface moisture. Latter moisture removal rate was decreased with decrease in surface moisture, indicating the beginning of sub-surface moisture evaporation (Fig. 3.17).

A three stage process - physical abrasion, grinding and

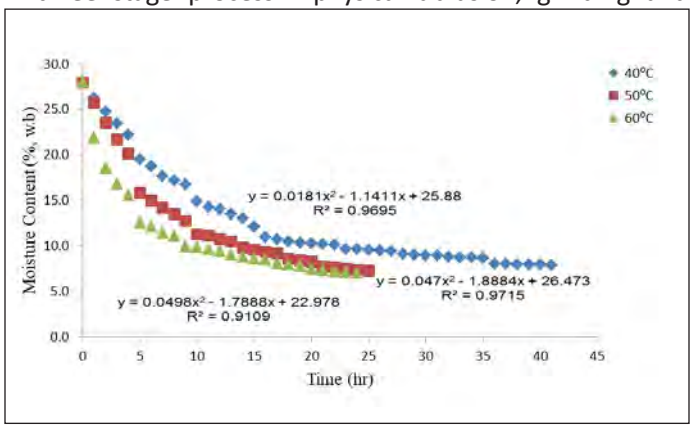


Fig. 3.17: Moisture content vs drying time

dissolution followed by filtration of gum *ghatti* was developed to remove initial bark/foreign matter for achieving the desired level of bark and organic matter (Fig. 3.18).

Gum *ghatti* (raw) Gum *ghatti* (abraded)

Gum *ghatti* (abraded + maceration+ filtration)

Fig. 3.18: Different forms of gum *ghatti*

Process for achieving desired level of bark and organic matter

Method 1

Stage	% Bark & organic matter (Initial)	% Bark & organic matter (Final)	Remark
Dissolution + Maceration	1.35 ± 0.22	--	--
Filtration	1.35 ± 0.22	0.598±0.016	55.7% bark & organic matter removal

Method 2

Stage	%Bark & organic matter (Initial)	% Bark & organic matter (Final)	Remark
Physical abrasion	1.35 ± 0.22	0.402 ± 0.126	70.2% bark & organic matter removal & weight loss 9.16%
Dissolution + Maceration	--	--	--
Filtration	0.402 ± 0.126	0.045 ± 0.006	96.6% bark & organic matter removal

Dissolution time decreased as the temperature increased from ambient to higher range (80°C) at different level of concentration (3, 5 and 7 %). It was found that on an average there was 83 % reduction in time (from 28 min to 5 min) for dissolution of gum *ghatti* at different level of concentration (3, 5 and 7 %) at 60 °C as compared to ambient temperature (Fig. 3.19).

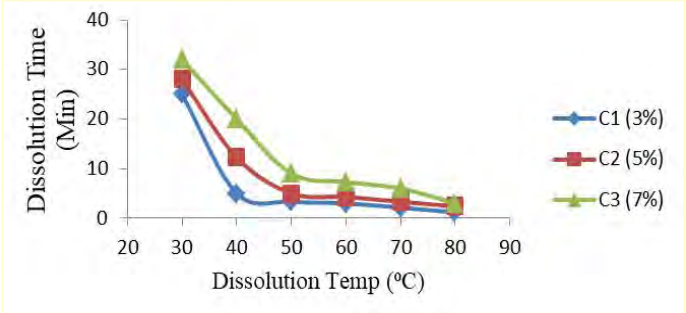


Fig. 3.19: Dissolution time (min.) vs Dissolution temp (°C)

3.5 Infrared drying of seedlac

Experimental set-up was developed by modifying tray dryer wherein infrared power, air temperature and air velocity could be varied within the experimental range. The dryer selected for modification was having a drying chamber of the size 71cm × 41cm× 58 cm, air inlet and outlet vent along with flap for opening or closing of inlet/outlet and a single door opening at the front. The dryer also consisted of electric heaters (4 Nos.) with temperature regulator, blower/ fan for circulation of air and a temperature sensor for measuring temperature of drying chamber. For performing IR and IR assisted convective drying, the dryer was equipped with IR lamp (1000W) at the top, with the provision to adjust the distance between lamp and product surface. The power of the IR lamp can be regulated with power controller. A vibrator with speed regulator was fitted for vibrating sample tray to facilitate proper mixing of the sample. A speed regulator was also provided for controlling the speed of the fan and thereby air velocity inside the chamber. Ammeter, voltmeter and energy meter were provided for calculating power consumption during drying experiment. Exterior and interior view of the dryer is depicted in Fig. 3.20a & b.

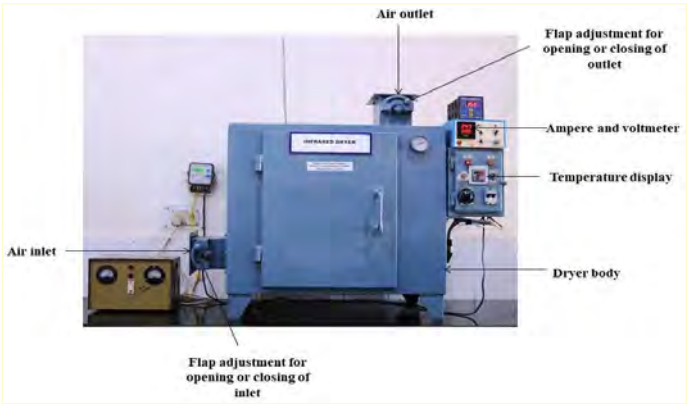


Fig. 3.20a: Exterior view of IR dryer

Fig. 3.20b: Interior view of IR dryer

4. Value Addition, Application Development and Product Diversification

4.1 Green synthesis of silver nanoparticles capped in *Acacia* and *Jhingan* gum

Evaluation of antifungal efficacy of *A. nilotica* and *Jhingan* gum induced silver nanoparticles against powdery mildew of pea

In vitro evaluation of *Acacia nilotica* (AN) and *jhingan* (JH) gum induced silver nanoparticles (AgNPs) and

controls (distilled water and AN gum solution) was assayed for their protectants and therapeutants efficacy against powdery mildew of pea caused by *Erysiphe pisi* using detached leaf techniques. Antifungal efficacy of pre- and post inoculation treatments of AN and JH gum induced AgNPs against powdery mildew of pea showed that both are equally effective as protectants as well as therapeutants against pea powdery mildew caused by *E. pisi.* In pre- inoculation treatment, both the gums induced AgNPs showed strong antifungal efficacy and plant leaves were protected by 88.89%. On the other hand enhanced concentration of $AgNO_3$ (1 mM) used for the synthesis of nano formulations for both the gums decreased the percentage of plant protection in similar fashion. While in post inoculation treatments, JH 3% - 0.5 mM AgNPs showed even stronger antifungal efficacy and plant leaves were protected by 98.75% as compared to AN 2% - 0.5 mM AgNPs (93.75%) (Table 4.1 & 4.2; Fig. 4.1 & 4.2).

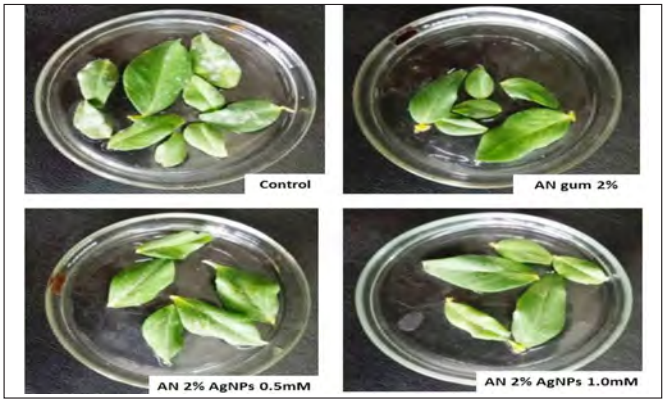
Table 4.1: Pre-emergence laboratory evaluation of *Acacia nilotica* and *Jhingan* gum induced AgNPs against powdery mildew of pea

Treatment	Disease Intensity (DI) Mean±S.E.	% Plant Protection
AN 2% - 0.5mM AgNPs	5.00±2.59	88.89
AN 2% - 1 mM AgNPs	10.00±4.88	77.78
JH 3% - 0.5 mM AgNPs	5.00±2.59	88.89
JH 3% - 1 mM AgNPs	15.00±5.70	66.67
AN gum 2%	20.00 ±4.47	55.56
Control	45.00±6.33	0.00
C.D.	13.97	
SE(m)	4.83	
C.V.	63.98	

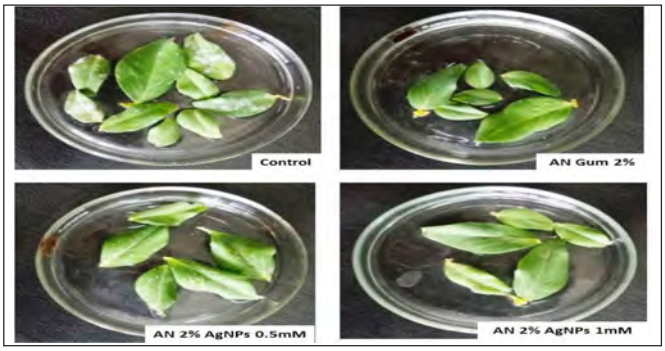
Table 4.2: Post emergence laboratory evaluation of *Acacia nilotica* and *Jhingan* gum induced AgNPs against powdery mildew of pea

Treatment	Disease Intensity (DI) Mean±S.E.	% Plant Protection
AN 2% - 0.5mM AgNPs	5.00±3.76	93.75
AN 2% - 1 mM AgNPs	10.00±4.42	87.5
JH 3% - 0.5 mM AgNPs	1.00±0.00	98.75
JH 3% - 1 mM AgNPs	10.00±4.14	87.5
AN gum 2%	35.00±10.95	56.25
Control	80.00±13.32	0.00
C.D.	21.759	
SE(m)	7.473	
C.V.	78.173	

DI = (Sum of ratings) x 100/Max. score x No. of leaves observed
The rating (0-4 scales) was done as followings:
0 = No powdery mildew symptoms; 1 = 1~10% leaf area infected; 2 = 11~25% leaf area infected; 3 = 26~50% leaf area infected; 4 = > 51% leaf area infected.
% Protection= (Control-Treatment) x 100/Control



a. Pre- emergence



b. Post emergence

Fig. 4.1: Laboratory evaluation (pre- and post emergence) of *Acacia nilotica* gum induced AgNPs against powdery mildew of pea

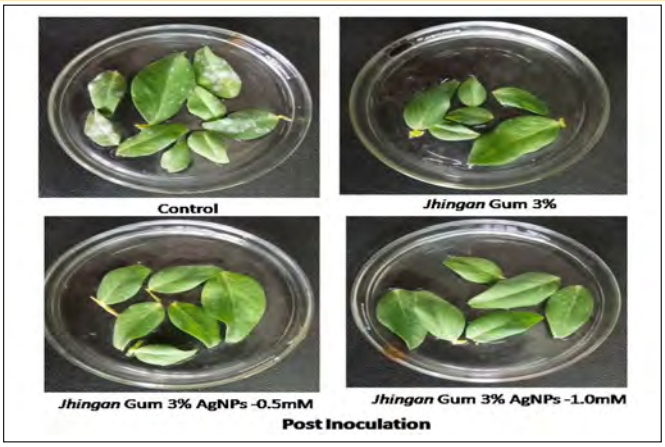


Fig. 4.2: Laboratory evaluation (pre- and post emergence) of *Jhingan* gum induced AgNPs against powdery mildew of pea

Field Evaluation of *A. nilotica* and *Jhingan* gum induced silver nanoparticles against powdery mildew of pea

Field evaluation of AN and JH gum induced AgNPs, controls (distilled water, AN gum solution and silver nitrate solution) along with commercial sulfur fungicide formulation (Sulfex® 80WP @ 2g/lit) was carried out as therapeutants after onset of powdery mildew of pea caused by *E. pisi* under field conditions. Foliar spray of the test concentrations of AN & JH gum induced AgNPs were sprayed on the leaves at the time of first appearance of powdery mildew in pea (Arkel). While control plants received only sterilized distilled water. Other controls *i.e.* 2% *A. nilotica* gum solution and commercial formulation (Sulfex® 80WP) were also applied in the similar way. All the set of experiments were laid down in triplicate. Disease scoring was recorded periodically after interval of 24 hrs. Different concentrations of AN & JH gum induced silver nano particles (AN 2% - 0.5 mM AgNPs; AN 2% - 1 mM AgNPs; JH 3% - 0.5 mM AgNPs & JH 3% -1 mM AgNPs) showed varying inhibitory potentials. Amongst the synthesized AN & JH gum induced silver nano formulations, the highest plant protection/disease inhibition was recorded in AN 2% - 0.5 mM AgNPs (28.43%). Enhanced concentration of $AgNO_3$ used for the synthesis of nano formulations for both the gums decreased the percentage of plant protection drastically. $AgNO_3$ solution (0.5 mM & 1 mM) (positive control) exhibited higher plant protection (24.77% & 26.59%) even with that of commercial formulation (11.19%) (Table 4.3).

Statistical analysis

The data reported are the means of triplicate observations. Data have been analyzed by non-parametric one-way analysis of variance (ANOVA) using OP Stat Package using Completely Randomized Design (CRD) with Critical Difference (CD) ($p < 0.05$). The field evaluation data have also been analyzed by non-parametric one-way analysis of variance (ANOVA) using OP Stat Package using Randomized Block Design (RBD).

Table 4.3: Field evaluation of *Acacia* & *Jhingan* gum induced AgNPs against powdery mildew of pea

Treatment	Disease Intensity (Mean ± S.E.)	% Plant Protection
AN 2% - 0.5 mM AgNPs	65.00±1.44	28.43
AN 2% - 1 mM AgNPs	95.83±2.21	- 5.5
Jhingan 3% - 0.5 mM AgNPs	75.00 ±8.04	17.43
Jhingan 3% - 1 mM AgNPs	79.17±4.41	12.84
0.5 mM $AgNO_3$	68.33±4.64	24.77
1 mM $AgNO_3$	66.67±5.47	26.59
Acacia gum 2%	85.83±4.17	5.5
Commercial	80.67±7.88	11.19
Control	90.83±4.64	0
C.D.	16.44	
SE(m)	5.53	
C.V.	12.07	

4.2 Development of coating formulation for paper packaging materials

Different coating formulations were prepared and refinement in formulations was done for paper packaging material. Films were developed on tin panels and glass plates and found to be flexible and impact-resistant. The formulations were applied on the packaging papers. Thickness of the films was measured to be 37±7.22µ. The formulations were found to be smooth, uniform and glossy (Fig. 4.3 & 4.4).

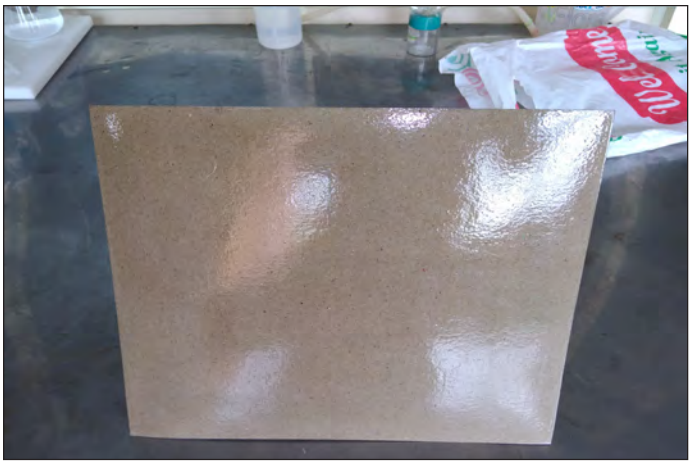


Fig. 4.3: The packaging paper coated with one of the formulations

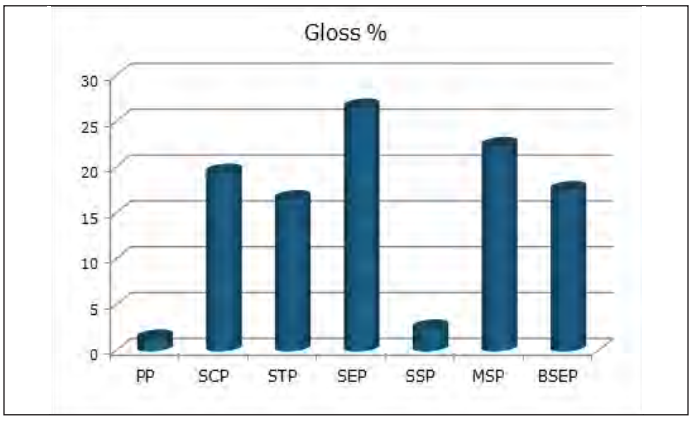


Fig. 4.4: Gloss % of the packaging papers coated with the formulation

Mechanical properties

The coated papers were studied for mechanical properties such as tensile strength (TS), elongation % and toughness with UTM. Elastic modulus (EM) was calculated and tearing resistance was also measured. Improvement in mechanical properties was observed after coating the papers. Tensile strength and elastic modulus were recorded to be 23-31 MPa and 2.83-3.33 GPa as compared to control (15.87 MPa and 2.55 GPa), respectively (Fig. 4.5 & 4.6). The highest TS (31MPa) was recorded for the paper coated with MSP formulation followed by paper coated with BSEP, SCP (Fig. 4.5), whereas the maximum EM was calculated to be 3.33 GPa for the paper coated with MSP formulation followed by the papers coated with the STP, SCP and BSEP formulations (Fig. 4.6). Elongation of the packaging paper increased after coating with the formulations. Maximum elongation (3.88 %) was recorded for the paper coated with SEP formulation followed by the papers coated with the SCP, BSEP and SSP (Fig. 4). The packaging papers were found to become tough after coating the papers with the formulations. The highest toughness was recorded for the paper coated with the SCP and SSP formulations followed by the paper coated with the BSEP formulation (Fig. 4.7). Tearing resistance of the coated packaging papers was measured as per the standard and observed increase in resistance after coating the packaging papers. The highest resistance was recorded for the paper coated with the STP formulation followed by the papers coated with the BSEP, SCP and SSP formulations (Fig. 4.8).

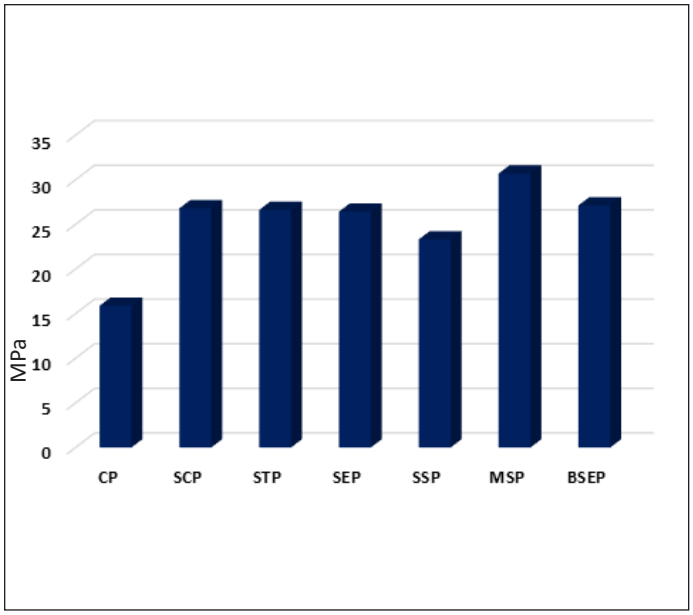


Fig. 4.5: Tensile strength of the paper coated with the formulations

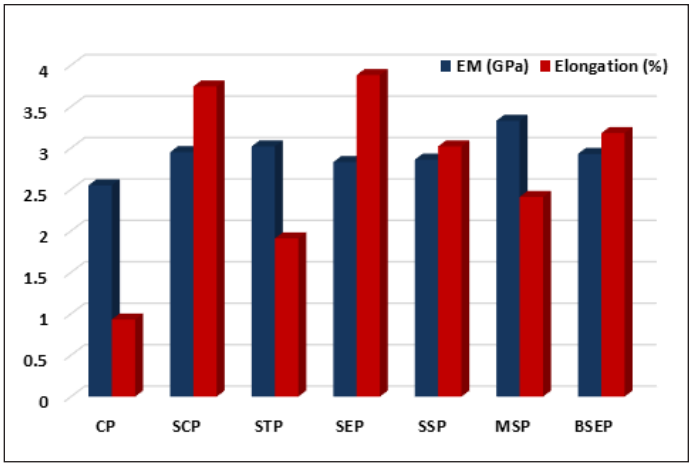


Fig. 4.6: Elastic modulus and elongation % of the paper coated with the formulations

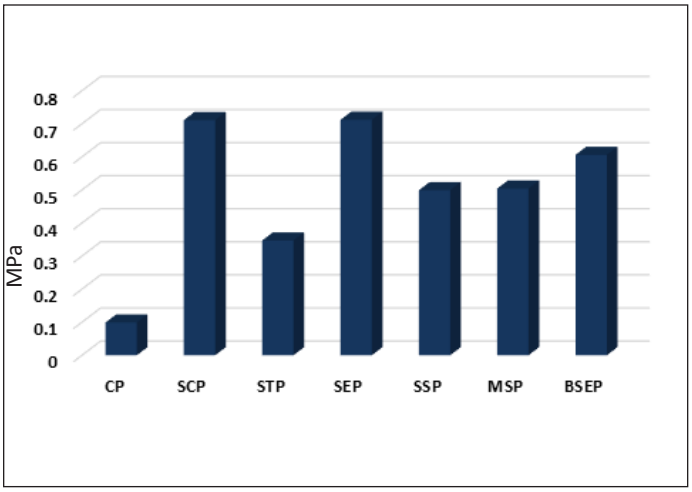


Fig. 4.7: Toughness of the packaging paper coated with the formulations

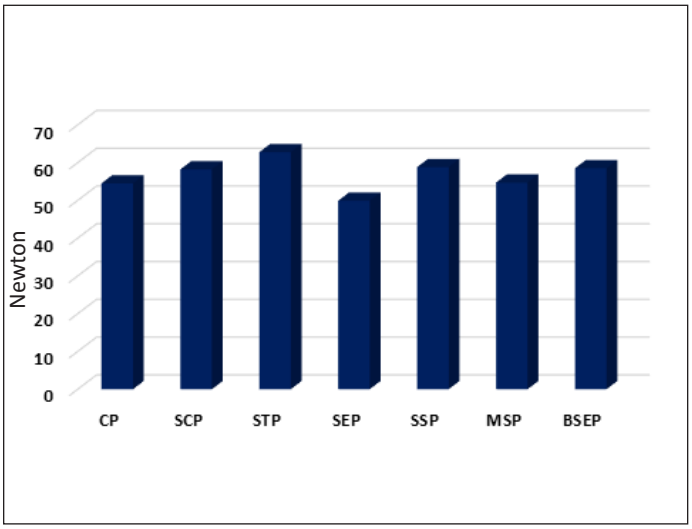


Fig. 4.8: Tearing resistance of the packaging paper coated with the formulations

Barrier properties

The coated packaging papers including control were evaluated for barrier properties such as air permeability (Porosity), water absorption test (Cobb's test) and water vapour transmission rate (Dish method) from Indian Institute of Packaging (IIP), Mumbai. It was observed that the porosity, water absorption and water vapour transmission rate reduced to a great extent after coating the papers with the formulations. Air permeability of the coated papers reduced to 8.33-12.22% in respect of control (Fig. 4.9). WVTR of the coated papers was observed to be 30-66 g/m^2/day as compared to control (776 g/m^2/day). WVTR reduced to 3.87-8.51% in respect of control (100%) (Fig. 4.9). Coated papers did not absorb water or very less quantity of water (0.38-0.48 g/m^2/min) was absorbed in comparison to control paper (44.97 g/m^2/min) (Fig. 4.10).

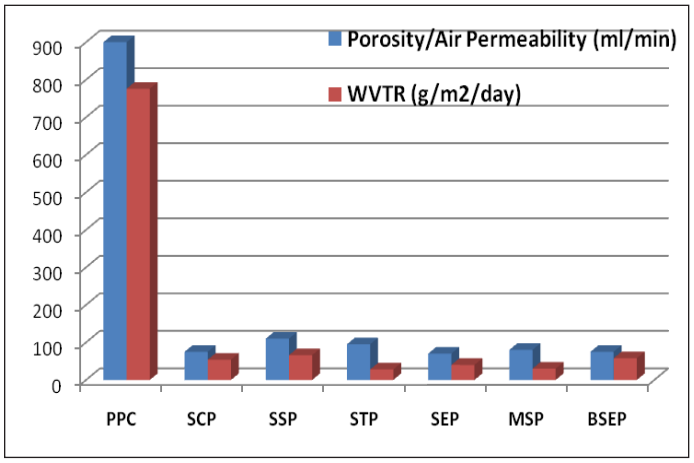


Fig. 4.9: Porosity and WVTR of packaging papers coated with the different formulations

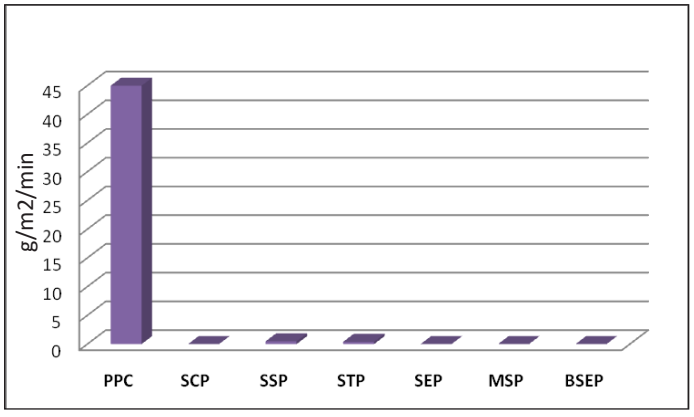
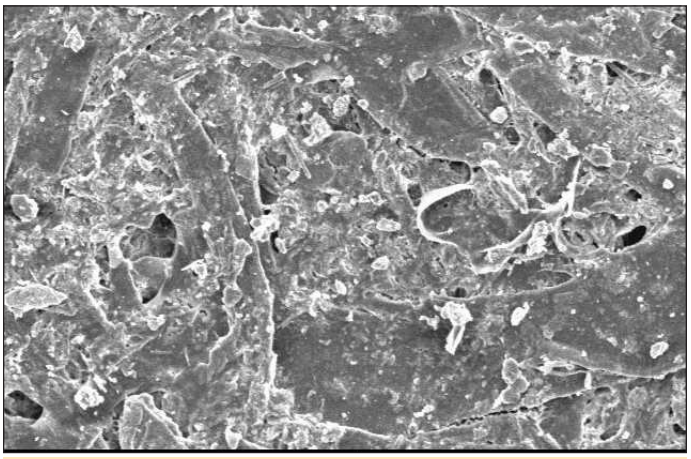


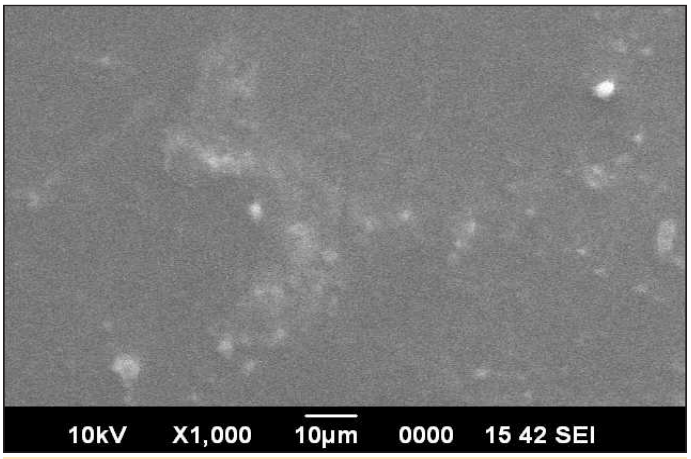
Fig. 4.10: Water absorption of packaging papers coated with the different formulations

Morphological study

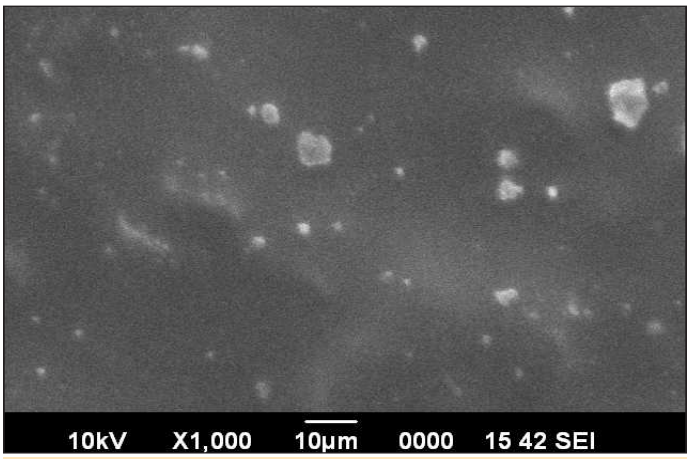
Surface morphology of the coated packaging papers was studied with Scanning Electron Microscopy (SEM) under different magnifications. It was found that pores of the paper filled and surface got smoothened after coating with the formulations. Some un-dissolved materials and particles were also observed in the micrographs (Fig. 4.11).



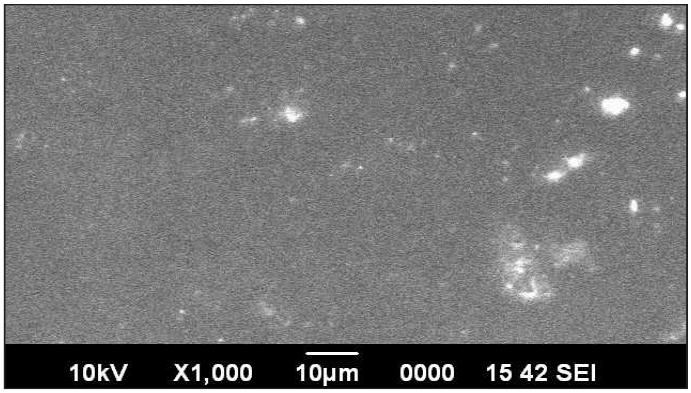
Control Paper



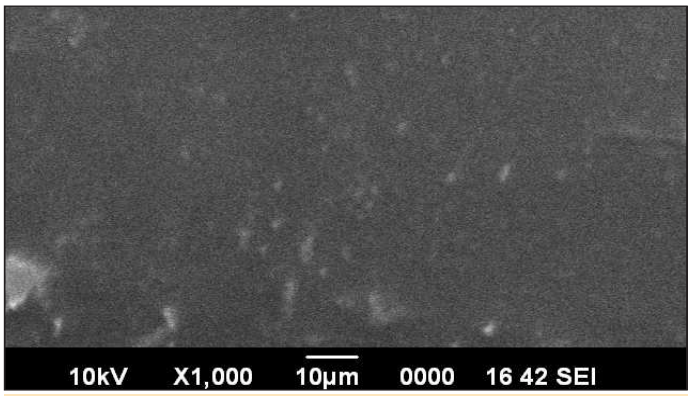
SCP



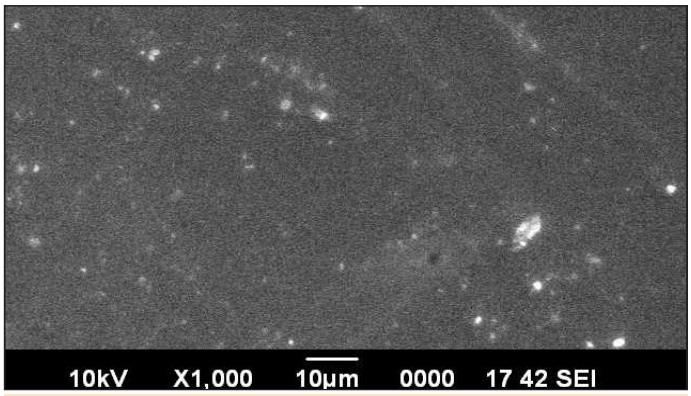
SSP



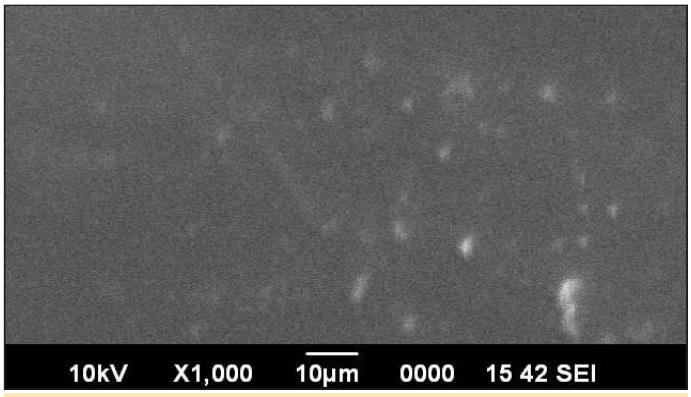
SEP



STP



MSP



BSEP

Fig. 4.11: SEM images of the control and the papers coated with the different formulations

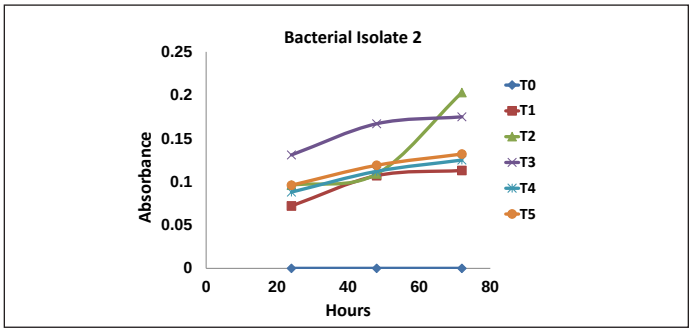
4.3 Modification of *guar* and *arabic* gum for potential use as dietary fibre

Prebiotic evaluation of dietary fibre isolated from *guar* and *arabic* gum

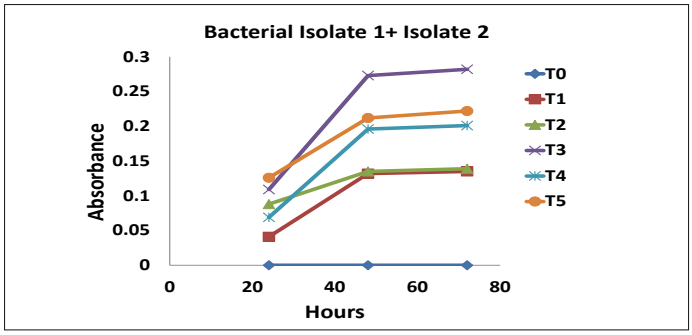
Prebiotic evaluation study of isolated dietary fibre from *guar* gum and gum *arabic* was undertaken with two isolates of *Bacillus* bacterial culture isolated from fish gut. Two isolates of *Bacillus* bacterial culture (*B. acetobacter)* isolated from fish gut were grown using dietary fibre as sole carbon source and in the negative control with no carbon source alongwith a positive control (glucose as carbon source) (Table 4.4). The experiments were designed by taking bacterial isolate1, bacterial isolate 2 and mixture of two bacterial isolate (Fig. 4.12a to c). Bacterial growth rate was determined by the absorbance of the sample at wavelength of 660 nm as the absorbance is proportionate to bacterial population in the culture. The evaluation was performed to assess the ability of bacteria to use dietary fiber as an energy source to enhance the bacterial population which in turn increases the absorbance of the culture medium, indicative of increased bacterial population. The study revealed that the highest absorbance was recorded in case of 2% *guar* and *arabic* gum dietary fibre and absorbance for all the treatments with dietary fibre showed higher value than the glucose. So, bacteria are able to use isolated dietary fibre as energy source. Thus, it can be concluded that isolated dietary fibre can be utilized as prebiotic sources.

Table 4.4: Treatments of the prebiotic evaluation of the dietary fibre

Test solution	Composition
T_0(Negative control)	Distilled water + Bacteria
T_1 (Positive Control)	Glucose (2%)+ Bacteria
T_2	*Guar* Dietary fibre (1%) + Bacteria
T_3	*Guar* Dietary fibre (2%) + Bacteria
T_4	*Arabic* Dietary fibre (1%) + Bacteria
T_5	*Arabic* Dietary fibre (2%) + Bacteria



(a)



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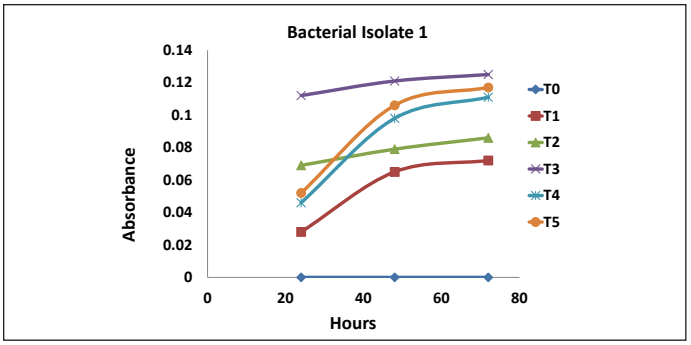


(c)

Fig. 4.12: Effect of doses of dietary fibre on bacterial growth from the two isolates (a), (b) and their mixture (c)

The dietary fibre samples from *guar* and *arabic* gum were tested for the presence of *E. coli* and *Salmonella*. Microbial screening of *E. coli* and *Salmonella* of the given sample was carried out by enrichment of bacterial colonies followed by isolation of presumptive colonies and finally biochemical analyses. The biochemical tests (Fig. 4.13) revealed that the tested colonies were negative for *E. coli* and *Salmonella*. Hence, it may be inferred that the samples did not contain *E. coli* and *Salmonella* and were free from bacterial contamination.

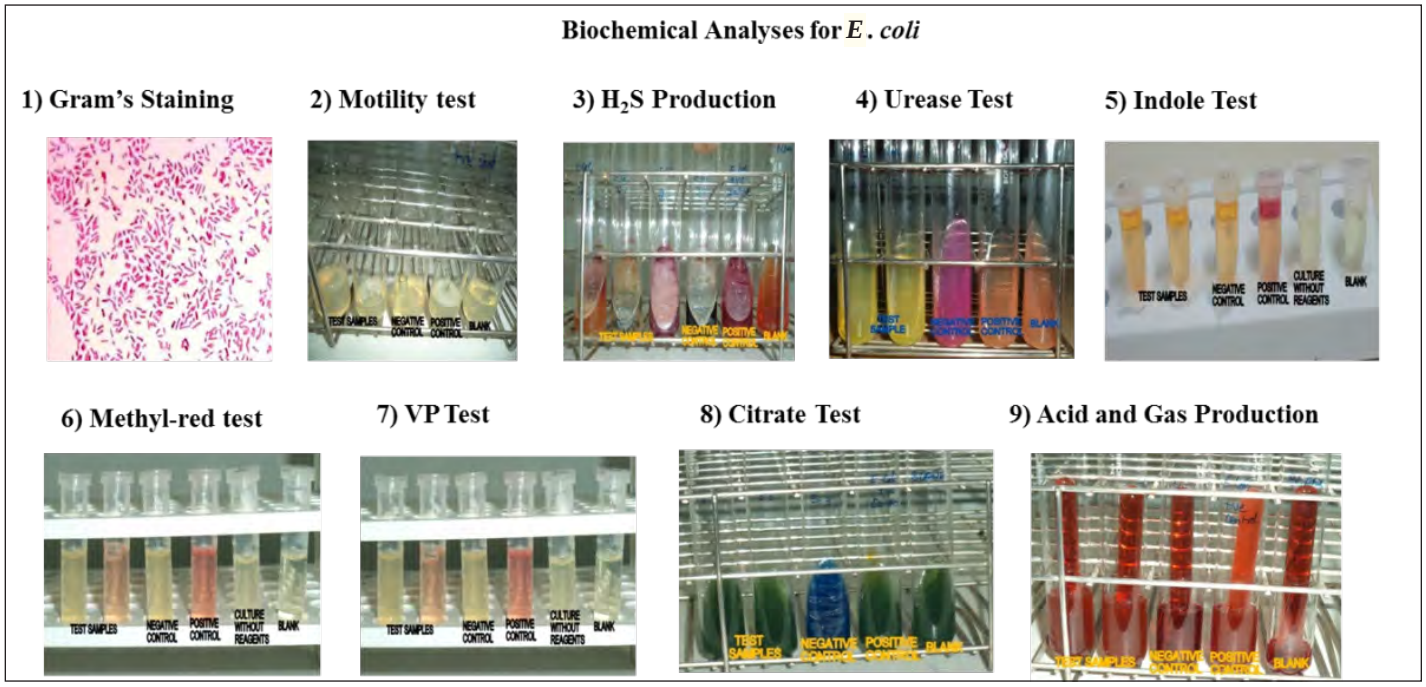


Fig. 4.13: Biochemical analyses of dietary fibre for *E. coli* study of enzyme kinetics

The enzyme kinetics of the endo-β-mannanase on hydrolysis of *guar* gum was determined using Lineweaver-Burk double reciprocal plot using different substrate concentrations and reaction velocity of each substrate concentration. The enzyme kinetics was represented by Km and Vmax value of enzyme endo-β-mannanase where Vmax indicated maximum rate achieved by enzyme at saturating substrate concentration and Km (Michelis constant), the substrate concentration at which the reaction rate is half of Vmax. In the Lineweaver-Burk plots, a straight line having slope equal to Km/Vmax and y-intercept equal to 1/Vmax was obtained. The Vmax and Km of the endo-β-mannanase for *guar* gum substrate was calculated and found to be 2.81 mg/ml and 11.627 µmol $ml^{-1}hr^{-1}$, respectively.

The enzyme kinetics of the protease on hydrolysis of gum *arabic* was also determined using Line weaver-Burk double reciprocal plot using the different substrate concentrations and reaction velocity of each substrate concentration. The Vmax and Km of the protease for gum *arabic* hydrolysis was calculated and found to be 20 mg/ml and 8.196 µmol $ml^{-1}min^{-1}$, respectively. The data indicated that the protease action is faster than the endo-β-mannanase hydrolysis.

4.4 Natural gum based adsorbents for removal of heavy metals from water

Adsorption studies of thiolated gum *karaya* (TK) and thiolated gum *arabic* (TA) for the removal of Chromium (Cr) and Cadmium (Cd) were carried out at different concentration of heavy metals (10, 20 and 30 ppm), different pH (2, 4 and 6) with varying agitation speed (0, 300 and 500 rpm) and fixed adsorbent dose (500 mg) per 500 ml of water. Fixed amount of sample, 3 ml was taken out from the upper layer of the beaker at regular time interval of 0, 1, 2, 4, and 8 hrs. Final analysis of samples was carried out using ICP-OES, Model: Perkin Elmer 2100DV (Fig. 4.14a to e).

Fig. 4.14a: Analysis of water sample by ICP-OES

Thiolated gum *karaya* showed the highest adsorption of 21.16 ppm (70.54%) of Cr and 9.93 ppm (33.1%) of Cd per 0.5 g of adsorbent at pH 6 within 8 hrs. Whereas, thiolated gum *arabic* showed the highest adsorption of 15.70 ppm (50.34%) of Cr and 12.32 ppm (41.07%) of Cd per 0.5 g of adsorbent within 8 hrs at 300 rpm agitation speed and pH 6.

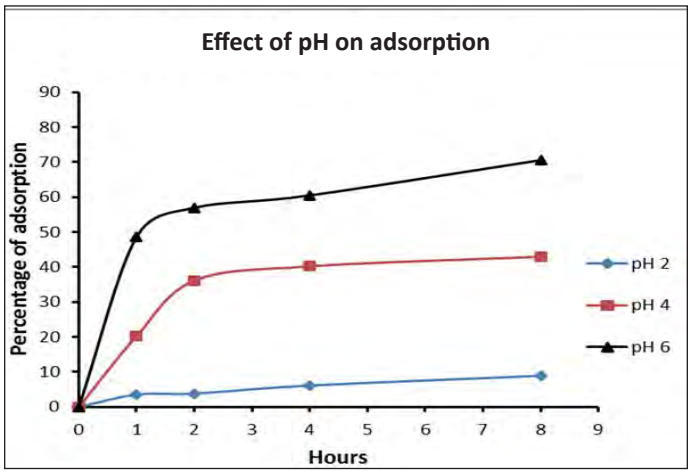


Fig. 4.14b: Cr adsorption by TK

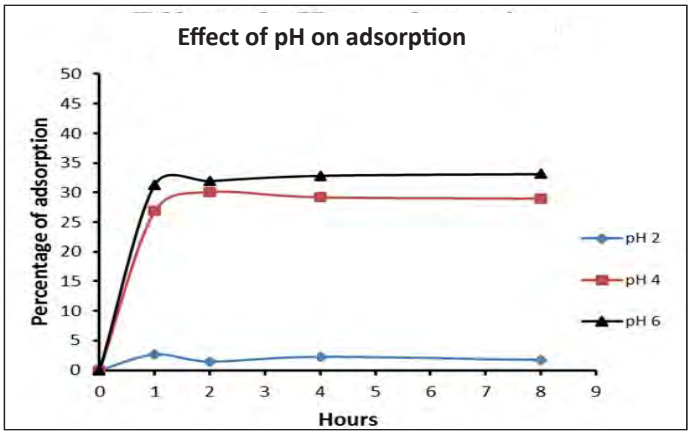


Fig. 4.14c: Cd adsorption by TK

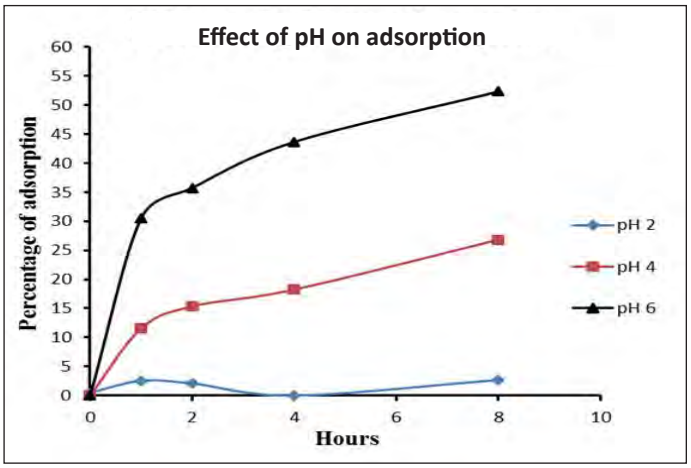


Fig. 4.14d: Cr adsorption by TA

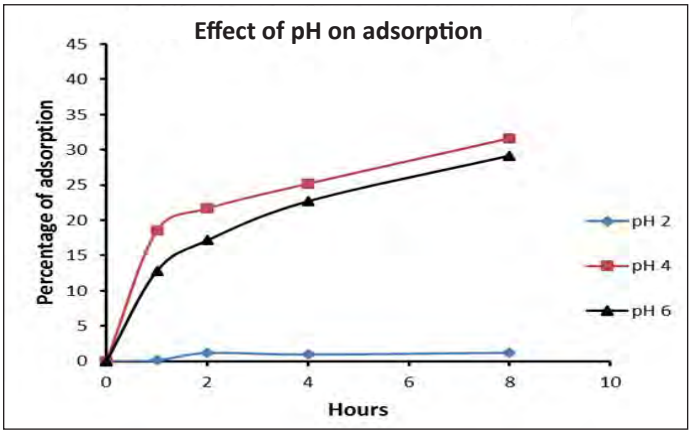


Fig. 4.14e: Cd adsorption by TA

To understand the controlling mechanism that takes place during the adsorption which involves mass transfer, diffusion, chemical reaction, adsorbent concentration, adsorption rate and equilibrium point, experimental data were subjected to various kinetic equations. For this study, a known concentration of heavy metal solution (500 ml) was taken in a glass beaker with pH set at 6.0. Fixed amount of adsorbent *i.e.* (0.5 g) was added and adsorption was allowed to take place at room

temperature using magnetic stirrer at 200 rpm. The data generated from these experiments was fitted to various kinetic equations including pseudo-first-order kinetic equation, pseudo-second-order kinetic equation, intra-particle diffusion model (Weber–Morris model) and Elovich model to know the mechanism of the adsorption. It was observed that the adsorption of Cr and Cd by thiolated derivatives of gum *karaya* and *arabic* followed pseudo second order kinetics model, where chemical interaction between active sites is dominant factor controlling rate of adsorption.

4.5 Synthesis of natural gum based nanocomposite hydrogel for wound healing

Wound healing evaluation of synthesized silver nanocomposite hydrogel on fish model

To observe the effect of synthesized silver nanocomposite hydrogel on wound healing efficiency, an experiment was conducted on a fish species, *Labeo rohita*. Sixty fingerlings of *L. rohita* average weight (8.04 ± 0.32 g) were randomly distributed into three treatment groups as control and treated with silver nanocomposite hydrogel of *guar* gum and gum *ghatti* with 3 replicates of each. Prior to commencement of trial, unseasonal wound was created by sterilized blade posterior to the base of pectoral fin at dorsal side. Nanocomposite hydrogels were directly applied to the wounds and images were recorded periodically with the bifocal stereo microscope. The wound healing effect of silver nanocomposite hydrogel was determined by visual observation of wound size on 1, 7 and 14 days post wound (dpw). A wound with clear margins was first observed at 7 dpw, the treatment with silver nanocomposite hydrogel displayed faster wound closure at 7 and 14 dpw compared to the control. Wound size gradually decreased in both the groups during 14 days healing period, however significant decrease was observed in both silver nano composite hydrogel treated group, compared to control (Fig. 4.15). Overall preliminary results indicated that gum *ghatti* silver nanocomposite hydrogel was more effective than *guar* nanocomposite hydrogel for gradual improvement of wound owing to its higher antimicrobial efficacy. Hence, natural gum based silver nanocomposite hydrogel could be utilized for wound care in fish in order to improve aquaculture production.

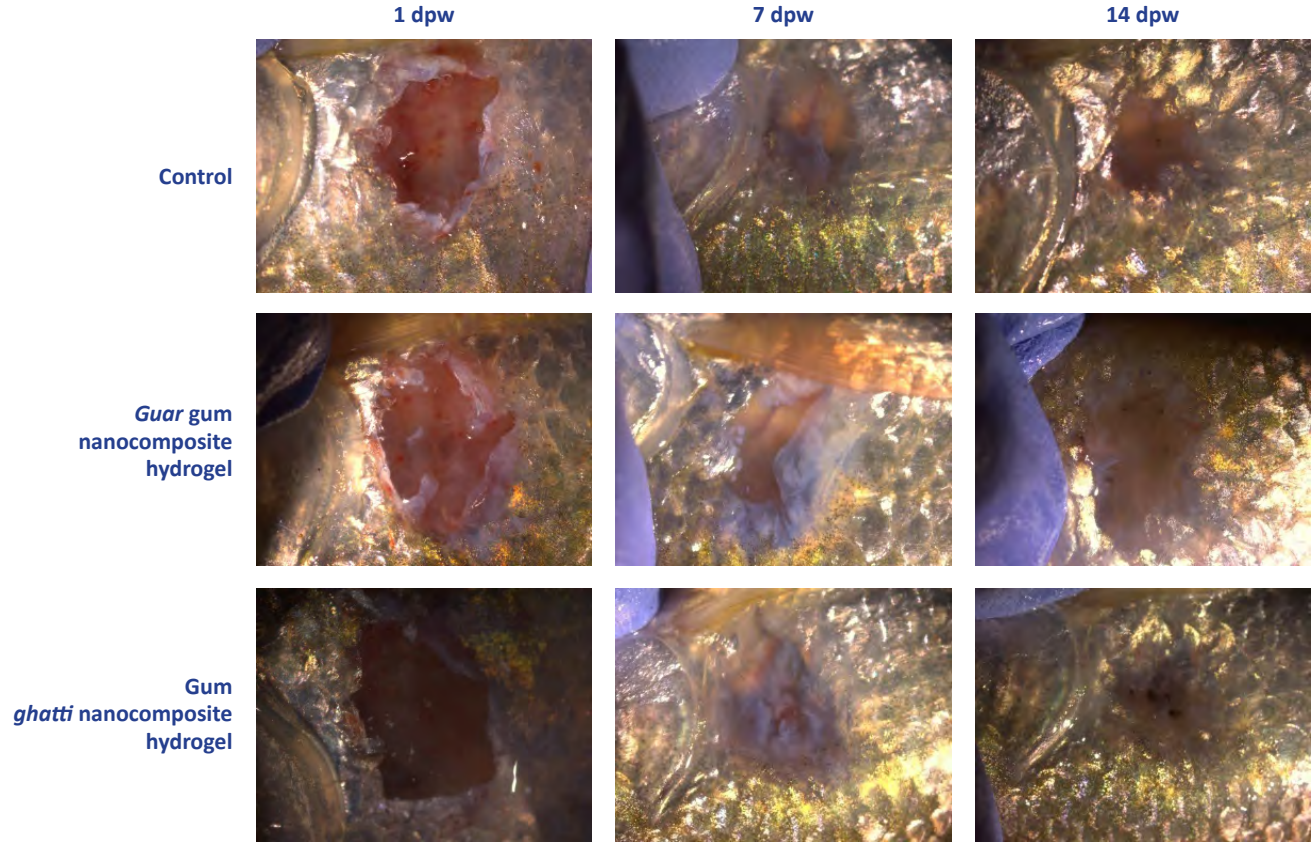


Fig. 4.15: Impact on wound healing in *Labeo rohita* fingerlings by using silver nanocomposite hydrogel

Wound healing evaluation of synthesized silver nanocomposite hydrogel in animal model

The study was carried out with 20 male BALB/c mice of 8 weeks old weighting 20–25 grams. All animals had free access to standard feed and drinking water and were maintained on a 12 hr light and dark cycle. The animals were randomly divided into five groups (Group A, B, C, D & E) with 4 mice in each group.

The entire procedure was performed aseptically in the standard animal operating room of Tripura University Animal House. Briefly, at first the operative region of the mouse was prepared by removing fur with a wahl clipper from the base of the neck to down the back at the level of shoulder. After shaving, the skin was sterilized by wiping with 70% alcohol to minimize the risk of infection. The mice were anesthetized injected intra-peritoneally before creating wound as per the guideline of Animal Ethics Committee. Following anaesthesia, a 4 mm skin biopsy puncher was used to excise the circular piece of skin tissue from either side of mouse midline at the level of shoulder. Thus a circular skin wound was formed on mouse shoulders blades. Soon after the wound has been created, sufficient amount of powdered hydrogel was applied to cover the area of wound created and the entire operating area was dressed with sterile gauze. The first four groups of mice received gum *ghatti* blank hydrogel (A group), *guar* gum blank hydrogel (B group), gum *ghatti* nanocomposite hydrogel (C group) and *guar* gum nanocomposite hydrogel (D group), respectively whereas the group E was used as control. No dressing was applied to the control group.

The size of the wound in both treated and control mice were determined for a period of 20 days with data recorded at 5 days interval. The day on which wounds were created was designated as Day 0. The wound diameter, therefore, measured in all treated and control group on Day 5, Day 10, Day 15 and Day 20. From the change in wound diameter, the healing efficiency of hydrogels was assessed (Fig. 4.16).

On Day 20, the maximum wound healing was observed in group C (1.03 ± 0.10 mm). The second most wound healing process was observed in group A (1.41 ± 0.06 mm). The mean wound diameter in group D was measured to 2.1 ± 0.18 mm, which is much lower as compared to the mean wound diameter of control group (3.42 ± 0.17 mm). But the mice in group B received hydrogel B (3.41 ± 0.02) showed no wound healing process at all as compared to the control.

It may be concluded that gum *ghatti* based nanocomposite hydrogel has maximum wound healing effect among all. Gum *ghatti* blank hydrogel and *guar* gum nanocomposite hydrogel also have some wound healing property but *guar* gum blank hydrogel does not have any significant wound healing capability in murine model. This study indicated that the gum *ghatti* based nanocomposite hydrogel has the maximum potential to be used as wound care formulation.

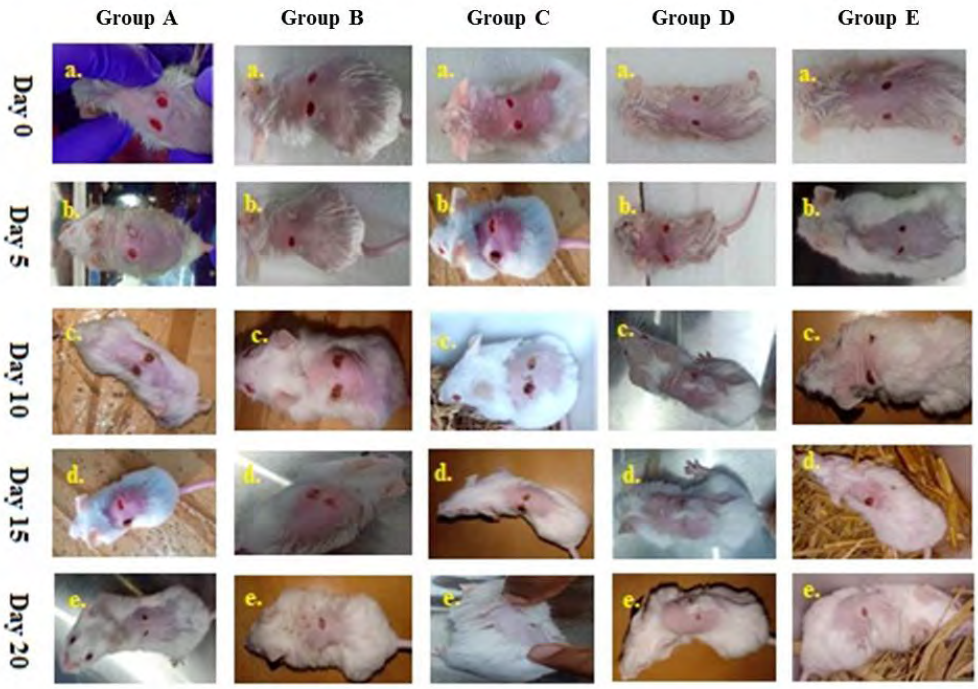


Fig. 4.16: Wound healing evaluation of silver nanocomposite hydrogel in mice model

Evaluation of the nanocomposite hydrogels for dye removal efficiency in water

Industrial dyes in waste water of textile, paper and other industries pose serious problem. In an attempt to remove these dyes from water, *guar* and *ghatti* gum based synthesized hydrogels and their ZnO-nanocomposites were tested for their efficiency in removing various industrial dyes from water. Along with the *guar* and *ghatti* gum based blank hydrogels without nanoparticle and their ZnO-nanocomposites were used for the study (Fig. 4.17). Dye removal efficiency of the test materials was studied by measuring the concentration of dye in the solution recording the absorbance at their respective λ_{max} of the standard dye solution with double beam UV–Vis Spectrophotometer. Out of the several dyes tried for experiment three dyes, namely, methylene blue, methyl violet and new fuchsine were found to be removed effectively by the synthesized hydrogels. Typical trend in the absorbance of methylene blue, methyl violet and new fuchsine dye solution with time was observed (Fig. 4.18a to c). All the figures indicated drop in dye concentration with time, owing to dye removal by *guar* gum and gum *ghatti* based blank hydrogel and ZnO-nanocomposite hydrogels.

In case of methylene blue, dye performance of *guar* and gum *ghatti* based ZnO-nanocomposite hydrogels was found better than their respective blank hydrogels. *Guar* gum-ZnO-nano composite hydrogel reduced the concentration to 44% whereas *ghatti* gum ZnO-nanocomposite hydrogel was found most effective in reducing the concentration to 21% of the initial. In case of methyl violet, all four hydrogels showed some dye removal initially, but after about 45 minute exposure, absorption maxima shifted to 508 nm. The formation of new peak gradually and shifting of absorption maxima may be attributed to formation of s emoval study showed that ZnO nanocomposite hydrogels of *guar* and *ghatti* gum were effective in reducing concentration to 83 and 61%, respectively. Blank hydrogels showed shift in absorption maxima indicating formation of some colour complex with new fuchsine dye. Overall the performance of gum *ghatti* based ZnO nanocomposite hydrogel was found better as compared to other hydrogels for removal of methylene blue, methyl violet and new fuchsine dye from waste water.

Gum *ghatti* based ZnO nanocomposite hydrogel was found better as compared to blank hydrogel in removal of methylene blue, methyl violet and new fuchsine dye from waste water. Thus, the nanocomposite hydrogels are relatively stable and chemically neutral as compared to their blank hydrogels. These nanocomposite hydrogels may be utilized as pollutant degradation agent for coloured impurities present in waste water.

Methylene blue | Methyl violet | New fuchsine

Fig. 4.17: Removal of industrial dye through natural gum based nanocomposite hydrogels

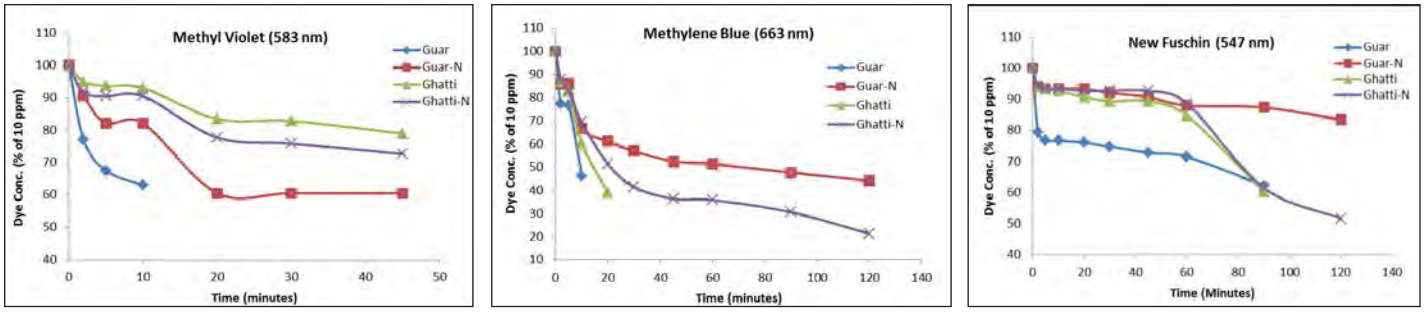


Fig. 4.18: Performance test of ZnO-nanocomposite hydrogels for dye removal (a) Methyl violet (b) Methylene blue (c) New fuchsine

4.6 Synthesis of *guar* gum hydrogel nanoparticle hybrid scaffold

Swelling behaviour of the gum based hydrogels was studied by tea bag method. A weighed amount of the dried sample was added to a small bag made of nylon (50 mm x 90 mm; 200 mesh). Then the bag was completely immersed in the swelling medium (200 ml) at room temperature for 24 hr to reach the swelling equilibrium. It was removed from the swelling medium and hung up for some time to remove the excess fluid and weighed (Fig. 4.19a to d). The equilibrium swelling (ES) was defined as follows:

$$ES\ (\%) = \frac{(W_s - W_d) \times 100}{W_d}$$

Where, W_s and W_d are the weights of the swollen sample and the weight of dried gel, respectively.

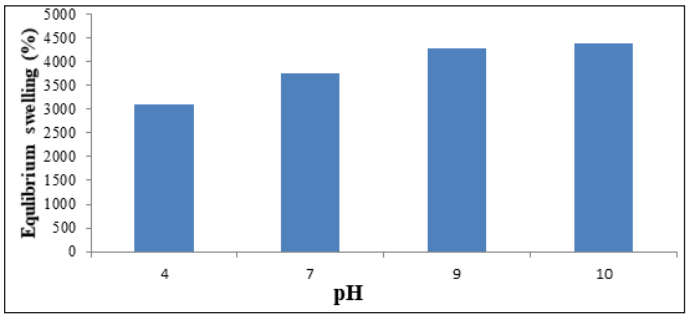


Fig. 4.19a: Equilibrium swelling of hydrogel at different pH

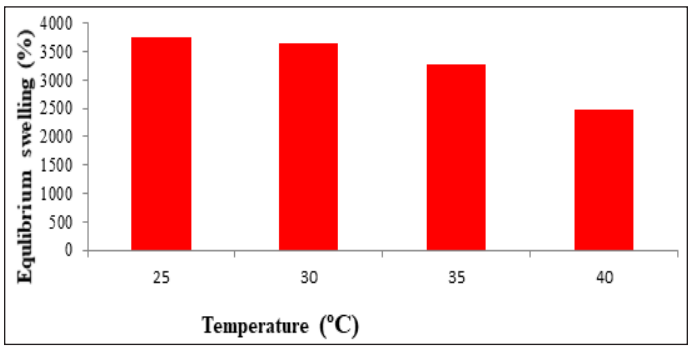


Fig. 4.19b: Equilibrium swelling of hydrogel at different temperature

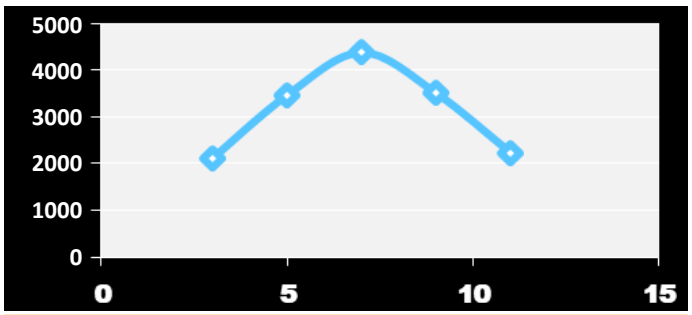


Fig. 4.19c: Effect of mass ratio of monomer and *guar* gum on swelling index of hydrogel

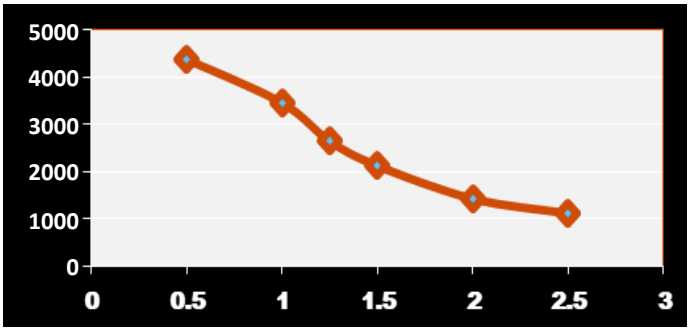


Fig. 4.19d: Effect of cross-linker on swelling index of hydrogel

Uniform, well-dispersed, silver nanoparticles (AgNPs) were prepared by a simple chemical reduction method. The particles were synthesized via the reduction of $AgNO_3$ by trisodium citrate and ascorbic acid as a surfactant. The Hydrogel was swollen and stirred by a magnetic bar in AgNP solution for 4 h. The material was washed with water and then air dried for 24 h and vacuum dried.

4.7 Development and evaluation of resin/ gum based sticky insect trap

Hydrolysis of shellac was carried out by different methods to obtain best quality non-drying adhesive with decent yield. To achieve quality as well as quantity of the adhesive, different parameters like quantity of alkali for hydrolysis, amount of acid for neutralization, heating time, number of washings, etc. were varied. With all parameters optimized and using 25% alkali solution, the yield of required quality hydrolyzed lac was recorded as 60- 70%. Starting material, shellac was analyzed from Quality Evaluation Laboratory for flow, polymerization time, ash percent and acid value. Hydrolyzed lac synthesized from the same shellac was also tested and remarkable increase in the acid value was observed for hydrolyzed lac (132.5) as compared to shellac (72.5). Bleaching of the hydrolyzed lac further increased the acid value to 176.5.

Acrylic sheet tools for testing tensile strength of the adhesive formulation using Universal Testing Machine (UTM) were fabricated. Developed lac based non-drying adhesive formulations were analyzed for their tensile strength by universal testing machine with cross-head speed: 2 mm/min; full scale load range: 10 kN; temp: 30°C. It was observed that the average strength of the formulation was about 0.3 Kg/cm^2. The formulations were compared with commercially used formulation (Crop guard) and it was observed that the developed formulation showed higher tensile strength than the commercial one (0.25 Kg/cm^2). Out of all the formulations, hydrolyzed lac prepared from dewaxed decolorized lac (DDL) showed maximum strength of 0.34 Kg/cm^2 (Fig. 4.20).

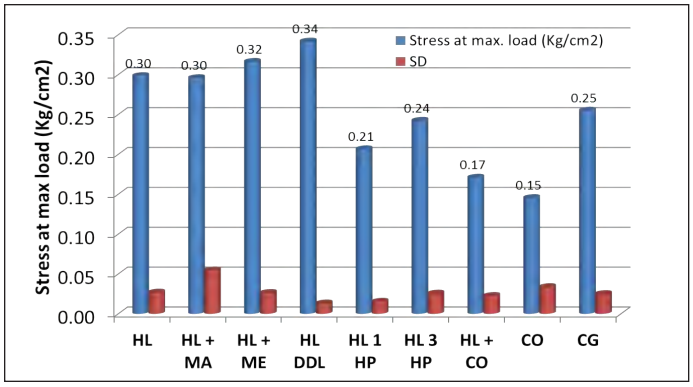


Fig. 4.20: Adhesive strength of different adhesive samples

To obtain hydrolyzed lac with light colour shade, the process was modified further and various combinations starting from chocolate brown to golden yellow colour were obtained (Fig. 4.21). Preliminary field trials of sticky insect trap with light coloured hydrolyzed lac as a glue gave encouraging results at ICAR-IINRG Farm. About 300 small flying insects were stuck on the trap in 7 days.

Fig. 4.21: Variety in color shades of the hydrolyzed lac

In an effort to use plant based essential oils as insect attractants, several sets of experiments were carried out to extract essential oil from lemon (*Citrus limon*) leaves, cinnamon (*Cinnamomum verum*) leaves and citriodora leaves (*Eucalyptus citriodora*) using Clevenger apparatus. The oil-water colloidal suspension was further partitioned with solvent to separate pure essential oil which was concentrated and stored for further use.

Y tube Olfactometer was fabricated using borosilicate glass with 15 cm long with each arm and 2 cm outer diameter for screening of insect attractants chemicals. Essential oils *viz*. Lemon oil, Big Lemon oil, Cinnamon oil, Eucalyptus oil and other attractant α-Pinene were tried for their attractant efficiency against bhindi leaf hopper. Among these essential oils, Eucalyptus oil (*Eucalyptus citriodora*) has shown significant efficiency (61.29 per cent) towards bhindi (Lady Finger) leaf hopper (Fig. 4.22).

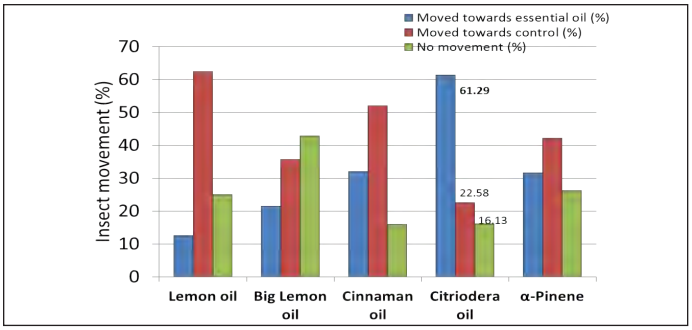


Fig. 4.22: Insect attractant efficiency of different chemicals

4.8 Development of natural gum based dietary fibre as encapsulant for delivery of functional feed

Encapsulation of ascorbic acid using *guar* gum dietary fibre

Encapsulation is a promising approach to ensure the stability of ascorbic acid and it is also a useful tool to improve delivery of bioactive molecules into foods. Partially hydrolyzed *guar* gum (PHGG) produced from *guar* gum by enzymatic process has already been proved to have potential for use as dietary fibre. Since, PHGG has lower hydrophobicity and having emulsifying property, a crucial parameter for microencapsulation. Encapsulation of ascorbic acid was carried out with dietary fibre of *guar* gum using ionic gelation method with sodium alginate as gelling agent in calcium chloride solution as hardening agent. After encapsulation, the encapsulated ascorbic acid globules (Fig. 4.23) are lyophilized to store for longer duration. The load of the ascorbic acid in the encapsulated granules is estimated as 50mg/g of the matrix. The encapsulation efficiency is calculated as 20.8-47.2%. Encapsulation of ascorbic acid with *guar* gum dietary fibre was also tried using spray drying technique. The process optimization (inlet temperature, concentration of the suspension, ascorbic acid load) of encapsulation of ascorbic acid was is in progress. The particle size of the encapsulated material was determined and found to be d_{50} 7.928 µm (Fig. 4.24).

Fig. 4.23: Encapsulated ascorbic acid globules

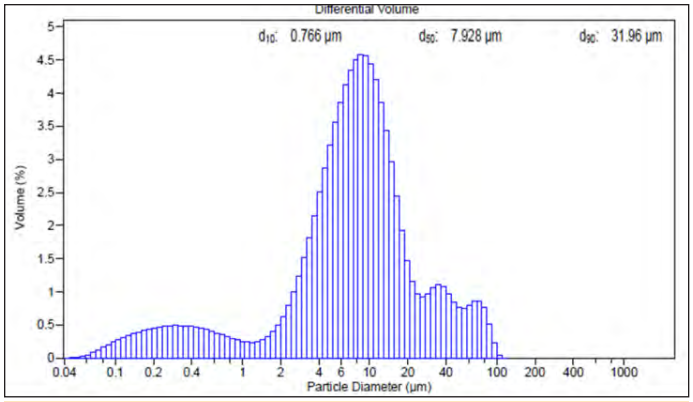
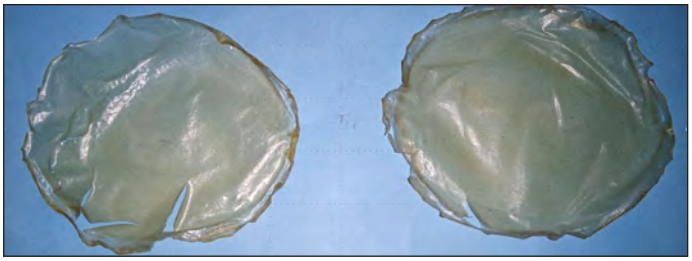


Fig. 4.24: Particle size analysis of the spray dried material

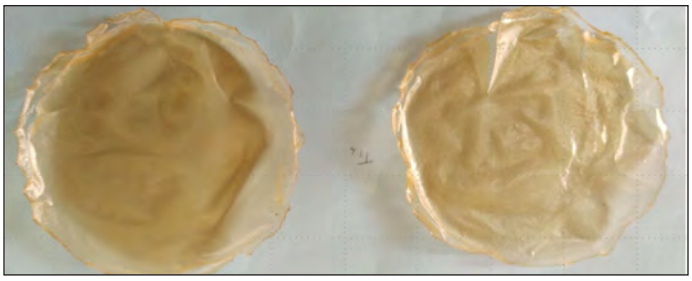
4.9 Exploratory Study

Preparation and characterization of modified *guar* gum nanocomposite films reinforced with *Acacia nilotica* / *Jhingan* AgNPs

A number of nanocomposite films reinforced with *Acacia nilotica* AgNPs were developed for diversified applications through solution casting method by varying reaction conditions and the syntheses were monitored by recording UV-Vis spectra at 200-700 nm. It was found that the nanocomposite films developed by reacting 0.5% modified *guar* gum along with 0.3% plasticizer and *Acacia nilotica* AgNPs showed maximum % transmittance. Films were dried in an oven at 40 °C for 24 hr., peeled off and kept at 25 °C and 58 % relative humidity (RH) for further analysis. Control films were similarly prepared, but without the addition of nanoparticles (Fig. 4.25 & 4.26).



a) 0.25 % Modified *guar* gum + 0.15 % plasticizer



b) 0.5 % Modified *guar* gum + 3 % plasticizer

Fig. 4.25: Modified *guar* gum nanocomposite films

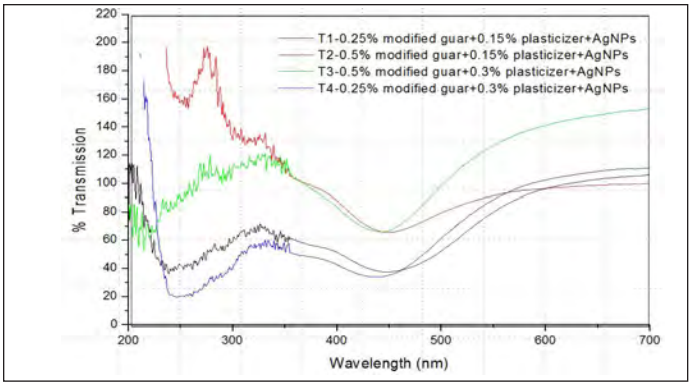


Fig. 4.26: Characterization by UV-Vis spectral analysis

Transfer of Technology

5. Capacity Building of Farmers and Entrepreneurship Development

5.1 Capacity building, skill development, extension education and information services on natural resins and gums

The Institute has conducted different types of training programmes pertaining to scientific lac cultivation, processing and utilization under Capacity Building and Entrepreneurship Development programme. It is continuously assessing the needs of stakeholders and modifying the programmes accordingly. Besides many in-campus programmes, field out-reach activities in terms of training, technical guidance, lac crop monitoring, *etc.* were also undertaken. A total of 29579 stakeholders were benefited under various capacity building and skill development programmes (Table 5.1).

Table 5.1: Details of capacity building and entrepreneurship development programme

Sl. No.	Name of programme	No. of batch/ camps	Male	Female	Total beneficiaries
1.	Farmer's training programme on scientific lac cultivation, processing and utilization (One week)	13	320	140	460
2.	HRD programme on lac cultivation and processing (One week)	01	19	04	23
3.	Training programme on lac cultivation andprimary processing of lac (One week)	10	398	94	492
4.	Educational programme - Summer/winter workshop on natural resins and gums (10 days)	02	33	39	72
5.	Schedule Caste Sub-Plan (SC-SP) (Training on different aspects)	04	-	-	494
6.	On-farm training programme on scientific lac cultivation	13	851	143	994
7.	On-farm motivational/supplementary training programme on lac cultivation	03	84	67	151
8.	On-campus one-day orientation programme on lac cultivation	66	1623	1373	2996
9.	*Kisan gosthi*/Workshop/Educational programme on lac cultivation	04	-	-	2430
10.	Participation in Exhibitions/*Kisan melas*	06	-	-	21455
11.	Lac based product demonstration training	05	07	07	14
	Total	**125**	**3335**	**1867**	**29579**

Farmer's training programme on scientific lac cultivation, processing and utilization

The programme on scientific lac cultivation, processing and utilization is for one week and it covers lac cultivation, processing at farm level and its uses. A total of 460 farmers from different districts of three states viz., Jharkhand, Chhattisgarh and Maharashtra participated in the programme. The participants were sponsored by various organizations and details are given in *Annexure - 1*.

HRD programme on lac cultivation and processing

HRD programme on lac cultivation and processing is for one week and it covers lac cultivation, processing and uses. A total of 23 students from Guru Ghasidas University, Bilaspur, (Chhattisgarh) participated in the programme (*Annexure - 2*).

Training programme on lac cultivation and primary processing of lac

A total of 10 training programmes on lac cultivation and primary processing of lac under World Food Programme were organized for 492 farmers from four states (*Annexure - 3*).

Educational programme on production, processing and uses of natural resins and gums

Two educational programmes on production, processing and uses of natural resins and gums were conducted for 72 UG/PG students of seven institutions namely, Institute of Agriculture, Banaras Hindu University (BHU), Varanasi (Uttar Pradesh); Quantum University, Roorkee (Uttarakhand); Himgiri Zee University, Dehradun (Uttarakhand); Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (Uttar Pradesh); Doon Business School, Dehradun (Uttarakhand) and Jharkhand Rai University, Ranchi (Jharkhand) (*Annexure - 4*).

On-farm training programme on scientific lac cultivation

Institute organized 13 on-farm training programmes on lac cultivation in collaboration with various GOs and NGOs of different states. A total of 994 farmers participated from different districts of Jharkhand. The participants were

nominated by Forest Divisions of Jharkhand. The details are given in *Annexure - 5*.

On-farm, motivational/supplementary training programme on lac cultivation

A total of 151 participants were trained in on-farm motivational/supplementary training programme on lac cultivation in collaboration with various NGOs and GOs of Jharkhand. The details are given in *Annexure - 6*.

In-campus one-day orientation programme on natural resins and gums

66 In-campus, one day orientation programme on natural resins and gums were organized in collaboration with GOs and NGOs of different states. 2996 Farmers, school children, college students and executives visited the Institute for this purpose. These participants were nominated by various agencies as mentioned in *Annexure - 7*.

Product demonstration training

Short term lac based product demonstration trainings were organized for participants from different states on shellac gasket cement compound (from hydrolyzed lac), testing and analysis of lac, lac dye (technical grade), lac processing, dewaxed bleached lac, dewaxed decolourized lac, lac based varnishes (Lac Wood Shine and Lac Glaze), aleuritic acid, skill development on lac based micro and small enterprises *etc.* The details are given in *Annexure - 8*.

***Kisan gosthi*/Workshop/Educational programme**

The Institute organized *kisan gosthis*/workshops/ educational programmes on lac cultivation in collaboration with various institutions**.** A total of 04 such events were conducted and 2430 stakeholders benefited (*Annexure - 9*).

Diagnostic and crop monitoring visits

A total of 9 crop monitoring visits were conducted across the districts of Jharkhand (*Annexure -10*).

Liaison with lac processing industry

Liaisoning with 12 lac processing industries situated in states like Jharkhand, Chhattisgarh, West Bengal, Madhya Pradesh and Maharashtra has been strengthened through visits and interactions (*Annexure - 11*).

Market Oriented Technical Advisory Services (MOTAS)

Based on the information generated under market support, a data base has been maintained in the TOT Division (Fig. 5.1).

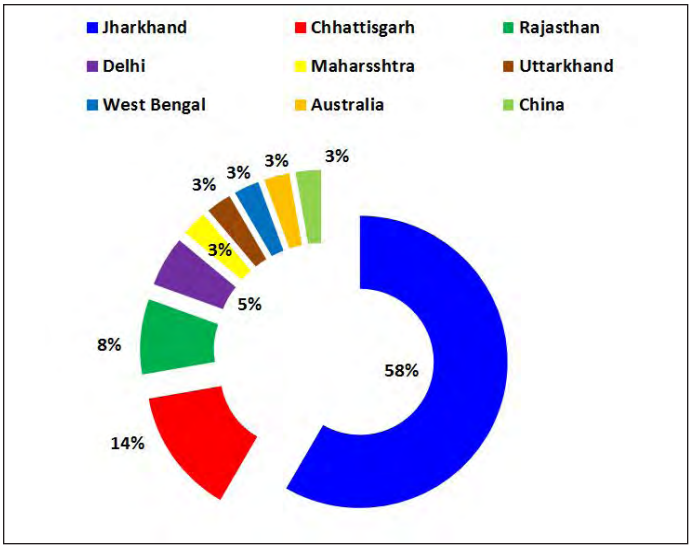


Fig.5.1: State-wise beneficiaries under MOTAS

During 2019, information related to the production, price/ minimum support price (MSP), marketing, processing, export and policy issues have been disseminated through the direct interactive meetings, discussions, writings, telephones and e-mails to a total of 36 stakeholders including 4 entrepreneurs, 6 processors/manufactures, 6 farmers, 4 government organizations/ policy makers, 10 researchers/research scholars, 3 traders, 3 NGOs and FPOs from India, Australia and China (*Annexure - 12*). Beneficiaries belonged to 16 districts spread over the 7 states (Fig. 5.1). Data on NRG production, processing, EXIM were also sent to ICAR-IASRI for Agriculture Research Data Book.

ICT based intervention: *Laksha updates*

Keeping in view the importance of ICT enabled intervention, a social media group was created with the objective to provide a virtual platform to experienced faculty, key resource person, market agencies, industrialists, young entrepreneurs and progressive/innovative farmers of lac sector for the interaction with lac growers. Due to this intervention, the number of beneficiaries covered during 2019 under MOTAS declined drastically. More than 500 responses were recorded and stakeholders got benefited. Due to strong linkage mechanism and accessibility of stakeholders with huge number of experts, stakeholders feel motivated and encouraged (Fig. 5.2).

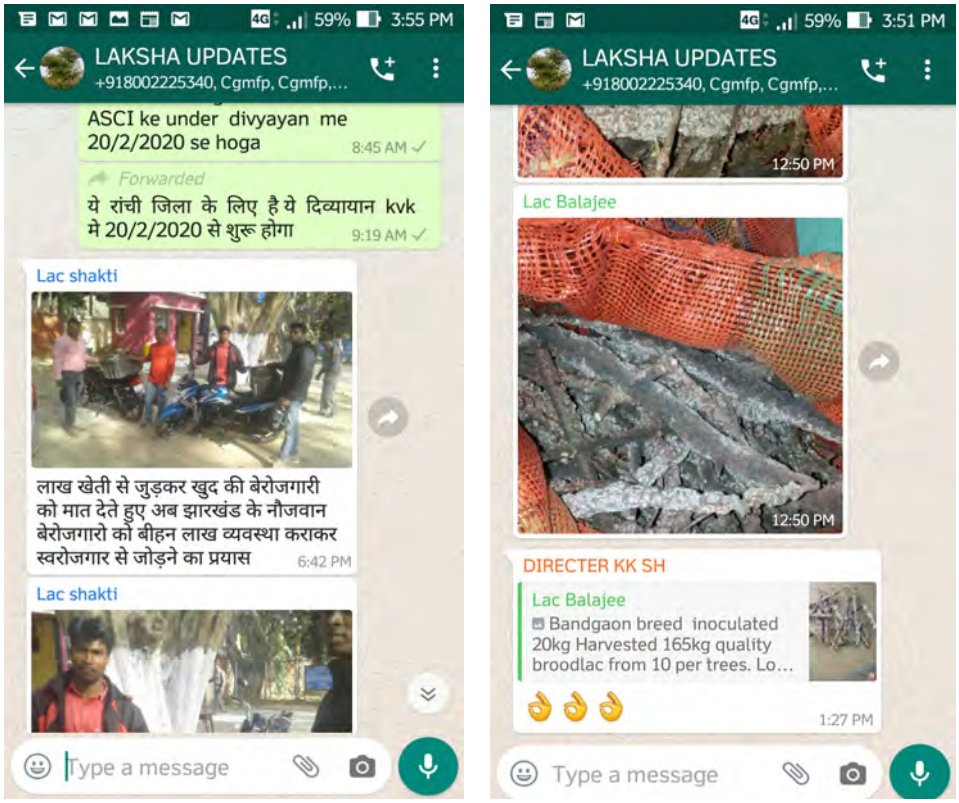


Fig.5.2: Screen shots of the activities at ICT enabled module *Laksha* updates

Participation in exhibitions/*kisan melas*

The experts from ICAR-IINRG, Ranchi, participated in various exhibitions/*kisan melas* organized by different other agencies and provided technical expertise on NRGs to the stakeholders. Altogether, Institute participated in 06 exhibitions/*kisan melas* and about 21455 beneficiaries got benefitted and made aware about the technologies of ICAR-IINRG. Need based advisory services were also provided to the various stakeholders (*Annexure - 13*).

Front line demonstrations (FLDs)

Three front line demonstrations were conducted in Hazaribagh district of the Jharkhand (*Annexure - 14*).

Schedule Caste Sub-Plan (SC-SP)

A total of 1834 SC farmers got benefited under various capacity building, awareness and distribution of livestock, farm implements *etc.* under SCSub-Plan (*Annexure - 15*).

6. Technology Evaluation, Refinement, Dissemination and Demonstration

6.1 Market information support (MIS) and impact assessment of technological interventions for NRGs

Interacted with 872 stakeholders including, 459 farmers, 118 traders, 133 processors/whole salers/exporters, 162 resource persons from various institutions through visits and telephonic conversations in 54 districts of 20 states of India. Secondary data on NRGs about production was collected from various central and state government organizations.

A decrease in the production of NRGs was found during 2018-19 in comparison to 2017-18. This decline in production was observed in *dhawda* gum (10.0%), *guar* gum (9.20%) and pine resin (4.84%). Consequently, total production of NRGs has decreased slightly from 6,25,769.67 tons in 2016-17 to 6,03,369.0 tons in 2018-19 (Table 6.1). A decline of about 8.67 % in the production of NRGs was observed over the previous year. Total production of lac in Jharkhand was observed around

17.10% higher than the previous year. Production of other resins and gums decreased slightly in 2018-19. Overall, NRGs production level during 2018-19 is estimated comparatively lower than the previous year. However, lac and gum *karaya* production increased by 13.39 and 6.67%, respectively.

The production of *guar* seed is directly related to monsoon. In *guar* seed producing areas, fluctuations inrainfall results in high instability in production. The physical market of the *guar* gum involves speculators and stockiest. The commodity is subjected to a long storage period based on demand and market prices. While the demand is almost constant over the years, supply varied from 2.5 to 6.3 lakh tons over the years. In 2018-19, India exported 5,13,211 tons of *guar* derivatives, which included 3,62,902 tons of *guar* gum that is used in oil fracking and processed food, and 1,50,309 tons of *guar* meal, which is used as animal feed. *Guar* gum exports would continue to decrease due to weak demand from the US and a decrease in active oil rigs numbers in the country. The replacement of *guar* gum with cheaper alternatives such as polyacrylamide, carboxymethyl cellulose, xanthan gum, and partially hydrolyzed polyacrylamide is also likely to keep demand for *guar* gum subdued this financial year. Low export demand has had a cascading effect on local *guar* gum prices. The price of *guar* gum has dropped by about 22% during the year to a 31 month low of 6,825 rupees per 100 kg. The sown area under *guar* crop declined by 11.2%. Lower exports of derivatives, large carryover stocks and expectations of relatively higher output have led to a sharp drop in *guar* seed prices as well. Supply side of the NRGs depends on Afghanistan, China, Indonesia and USA. Price competitiveness and proximity of suppliers are the key strengths in the international trade of NRGs.

ITC calculations based on UN COMTRADE statistics, the world trade aggregation of all commodities during 2018 revealed that out of 130 exporting countries in the world, India ranks 19th position in export with a share of 1.74% in the total world export value. Similarly, out of 130 importing countries of the world, India ranks 9th position in import with a share of 2.71% in the total world import value. In these figures, re-export and re-import is excluded (Table 6.1).

Table 6.1: Total NRG production during 2012-13 to 2018-19 (in tons)

Name of product	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Guar gum*	8,19,057	11,30,247	10,94,989	9,38,404	6,01,740	6,38,877	5,80,104
Lac	19,577	21,008	16,978	18,746	16,352	14,230	16,135
Pine resin	8,361	6,875	6,699	5,726	5,773	5,254	5,000
Karaya gum	212	129	83	100	145	150	160
Dhawda gum	380	448	295	194	240	200	180
Other gums	552	567	333	389	380	400	390
Other resins and gums	1,083	975	1,190	980	1,140	1,500	1,400
Grand Total	8,49,222	11,60,250	11,20,567	9,64,540	6,25,770	6,60,612	6,03,369

**Advance estimates of production figure (includes only gums and pine resins)*

World EXIM data classification is based on Harmonized System Codes (HS Codes) and it ranges from two digits to eight digits. Based on availability and accessibility of the data, the broad commodity groups including two digit HS Code (13) and four digit HS Code (1301) level classification was analyzed. During 2018, the world trade aggregation of lac, gums, resins and other vegetable saps and extracts (HS Code:13) revealed that out of 111 exporting countries in the world, India ranks 2nd position in export with a share of 13.31% in the total world export value of HS Code:13. Similarly, out of 130 importing countries of the world, India ranks 6th position in import of HS Code:13 with a share of 3.19% in the total world import value. In this figure, re-export and re-import is excluded.

The world trade aggregation of lac, natural gums, resins, gum-resins, balsams and other natural oleoresins (HS code:1301) revealed that out of 95 exporting countries in the world, India ranks 4th position in export with a share of 6.57% in the total world export value of HS Code:1301. Similarly, out of 125 importing countries of the world, India ranks 1st position in import of HS Code: 1301 with a share of 20.51% in the total world import value. Table 6.2 depicts the international trade including export from the country as well as domestic demand of the country.

A total of 12,315.04 tons of lac, natural gums, resins, gum-resins, balsams and other natural oleoresins were exported from India worth of about 70 million US Dollars and 58836.42 tons of the same commodity group were imported in India worth of about 170 million US Dollars.

Table 6.2: Total NRGs export and import during 2012-13 to 2018-19

Year	Export		Import	
	Quantity (in tons)	Value (in Rs. lakhs)	Quantity (in tons)	Value (in Rs. lakhs)
2012-13	3,40,384.75	21,76,118.62	89,746.33	78,534.90
2013-14	4,83,060.85	12,17,055.20	89,535.92	96,501.64
2014-15	5,43,620.51	9,63,270.94	86,189.81	1,07,413.18
2015-16	2,72,462.21	3,43,995.98	96,387.62	1,29,169.37
2016-17	3,29,045.55	2,89,060.92	1,09,764.64	1,37,165.89
2017-18	3,79,979.77	4,06,496.80	1,07,399.56	1,48,878.70
2018-19	3,75,412.29	4,45,725.07	1,00,010.17	1,53,290.13

Export quantity of NRGs from India decreased slightly while the value of exported products increased significantly and import scenario looks relatively stable over the period. Export of NRGs in terms of the quantity declined (1.2%) slightly but the earning of foreign exchange has increased (9.65%) significantly in 2018-19 in comparison to the 2017-18. On the other hand, the import of NRGs in terms of the quantity declined (6.88%) slightly but the value of imported NRGs has increased (4.37%) in 2018-19 in comparison to the 2017-18. During the year 2019, the MSP announced by the Government for gum *karaya* remained Rs. 10,800 per quintal. During the 2018-19, price of rosin and turpentine oil ranged from Rs.35-76/kg and Rs.147 to 150/litre, respectively (HPSFC Ltd.).

On the basis of survey in the markets and processing centers of different lac producing states, the estimated national production of sticklac during 2018-19 was approximately 16,135 tons (Fig. 6.1). Jharkhand state ranks 1st followed by Chhattisgarh, Madhya Pradesh, West Bengal and Maharashtra. These five states contribute more than 95% to the lac production in India (Fig. 6.2).

The data on prices of *rangeeni* and *kusmi* sticklac and seedlac have been collected from the lac markets on quarterly basis. During previous year, the market price for lac has improved and it was higher than the MSP declared by GOI.

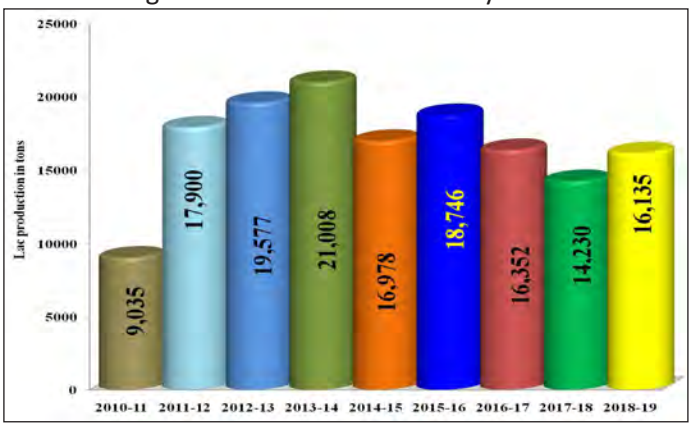


Fig. 6.1: Lac production in India during recent years

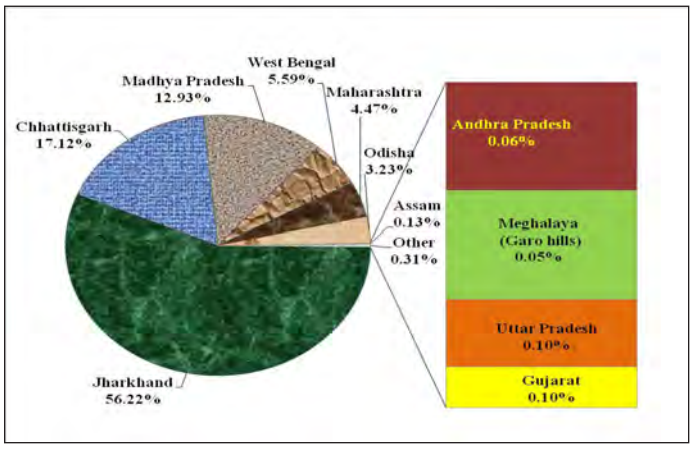


Fig. 6.2: State-wise lac production (in %)

Price at various levels of the market for the *guar* seed (local), *guar* seed (delivery), *guar* split and *guar* gum (powder) was recorded and ranged from Rs. 20/kg for *guar Churi*, Rs.30/kg for *guar Korma*, Rs.40/kg for *guar* seed, Rs.80/kg for *guar* split and Rs. 100-140/kg for *guar* gum powder. Establishment cost was estimated around Rs.40 lakh with per day capacity of more than 100 tons of *guar* seed processing for *guar* gum splits. Presently, local as well as overseas demand of the *guar* split has declined and factories for *guar* split are running under capacity in Jaipur local areas. Employment opportunities in some factories declined from 25-100 employees per unit to 5-20 employees at current. Local artisans were interacted about the issues related to the supply of button lac as well as rosin. They supply these materials to retail shops, state government handicraft showrooms/outlets and sometimes for putting stall to showcase the art at exhibitions *etc.* Local method is still prevailing, they also market these items through '*feriwali* (sales-women)' who collect the bangles from the dealers with 5-15% margin and wander door to door for selling these items. Natural gumprocessors from Ajmer and Jaipur were also interacted. Major suppliers were from African countries and major hubs for consumption in India are Jaipur, Surat, Udaipur,

Jodhpur, Bikaner, Bhopal, Ahmedabad, Mumbai (Vasim) and Delhi (Kharibowli area).Different grades of natural gums including *Tallu, button, 2.5 number, 2.0 number, Bajra* and powder were observed at the gum factories and samples were also collected for the Museum. Discussion on various issues including processing, production and marketing of natural tree gums was carried out. Lac dye based firms were also interacted to knowthe progress about the quality supply. Sample of a new product, lip guard cream, in which lac dye is being applied for colouring effect was observed. Discussion was also made with the dealers/suppliers of seedlac for paint and varnish, stone cutting and polishing enterprises, traditional lac bangle clusters, handicraft designers, NRGs based exporters, processors/manufactures/wholesalers, traders, experts, farmers, forest dwellers and other concerned officials.

The information on the price revealed that price range of *kusmi* and *rangeeni* sticklac, at various levels of markets, has improved slightly since September 2016 and continued till December 2017. Subsequently in 2018, due to the intervention by the Government of India (GOI), the price support mechanism helped to stabilize and improve the unit price of lac (Table 6.3 & Fig. 6.3). The scheme is designed as a social safety net for improvement of livelihood of MFP gatherers by providing them fair price for the MFPs they collect. The MSP scheme seeks to establish a framework to ensure fair returns for the produce collected by tribal, assurance of buying at a particular price, primary processing, storage, transportation *etc.* while ensuring sustainability of the resource base. Lac processing in India during last seven years is shown in Fig. 6.4.

Table 6.3: Procurement of lac at minimum support price (MSP)

Year	Crop type	Quantity/ Value units	Chhattisgarh	Jharkhand	Gujarat	Total
2014-15	Lac *Rangeeni*	Quantity MT	0	0	0	0
		Value (Rs. in Lakhs)	0	0	0	0
	Lac *Kusmi*	Quantity MT	0	0	19.51	19.51
		Value (Rs. in Lakhs)	0	0	6.24	6.24
2015-16	Lac *Rangeeni*	Quantity MT	140	0	0	140
		Value (Rs. in Lakhs)	348	0	0	348
	Lac *Kusmi*	Quantity MT	333.7	0	0	333.7
		Value (Rs. in Lakhs)	1150	0	0	1150
2016-17	Lac *Rangeeni*	Quantity MT	101.17	0	0	101.17
		Value (Rs. in Lakhs)	250.92	0	0	250.92
	Lac *Kusmi*	Quantity MT	350.63	3.91	2.66	357.2
		Value (Rs. in Lakhs)	1208.14	5.87	0.46	1214.47
2017-18	Lac *Rangeeni*	Quantity MT	16.09	0	0.65	16.74
		Value (Rs. in Lakhs)	17.71	0	1.02	18.73
	Lac *Kusmi*	Quantity MT	2.03	0	0	2.03
		Value (Rs. in Lakhs)	3.05	0	0	3.05
2018-19	Lac *Rangeeni*	Quantity MT	NA	2.52	0	2.52
		Value (Rs. in Lakhs)	NA	32.3	0	32.3
	Lac *Kusmi*	Quantity MT	NA	54.27	1.052	55.322
		Value (Rs. in Lakhs)	NA	102.21	1.7571	103.967
Total		**Quantity MT**	**943.62**	**60.7**	**23.872**	**1028.19**
Value (Rs. in Lakhs)		**2977.82**	**140.38**	**9.4771**	**3127.68**	
Average/Year		**Quantity MT**	**188.72**	**12.14**	**4.77**	**205.64**
Value (Rs. in Lakhs)		**595.56**	**28.08**	**1.90**	**625.54**	

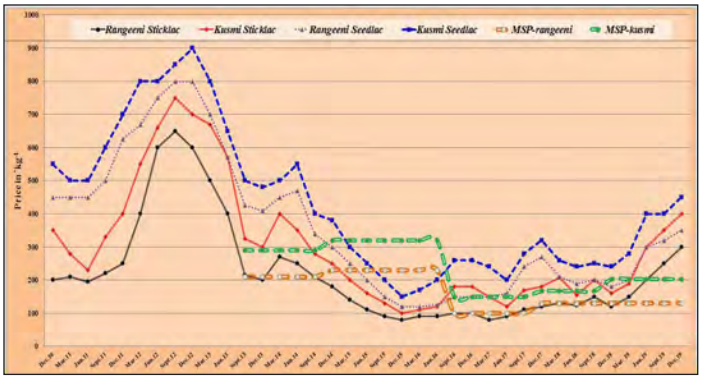


Fig. 6.3: Movement in prices of scrapedlac and seedlac during last 10 years

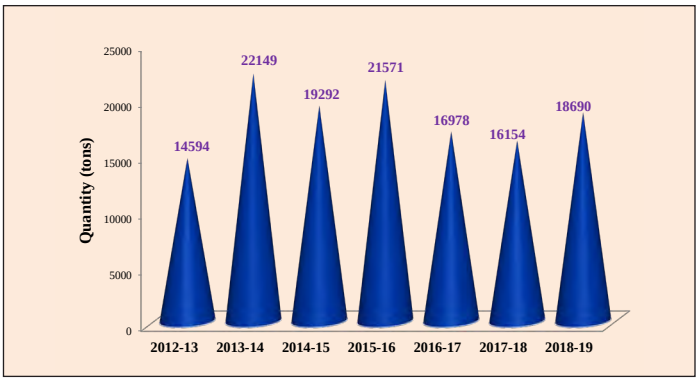


Fig. 6.4: Lac processing in India during last seven years

In December 2017, the average export price of ambrettolide was observed at low level of Rs.5600/kg. The demand for ambrettolide has increased and an increase in the price was also observed at Rs.6900/kg in December 2018 and subsequently reached at Rs.7800/kg in December 2019. Export price of aleuritic acid ranged from Rs.9000/kg in December 2012 to Rs.2738/kg by December, 2015. In the subsequent quarters of 2016, price continuously declined and reached at very low level of Rs.1600/kg. However, it has improved over the period of two years and reached at Rs.3800/kg by December, 2019. USA, Norway, Russia, China and Germany remained major export destinations for *guar* gum during 2018-19 (Fig. 6.5 to 6.7).

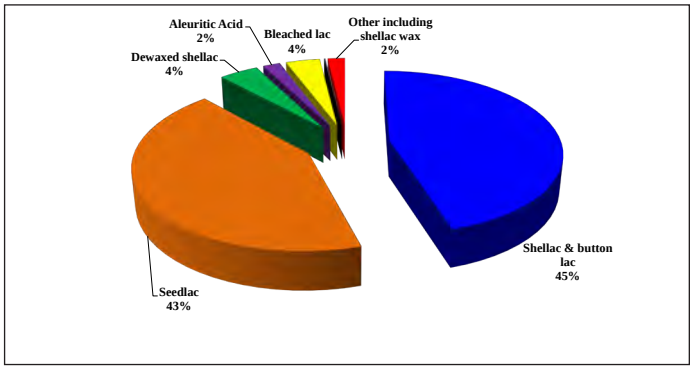


Fig. 6.5: Value added products of lac prepared during 2018-19

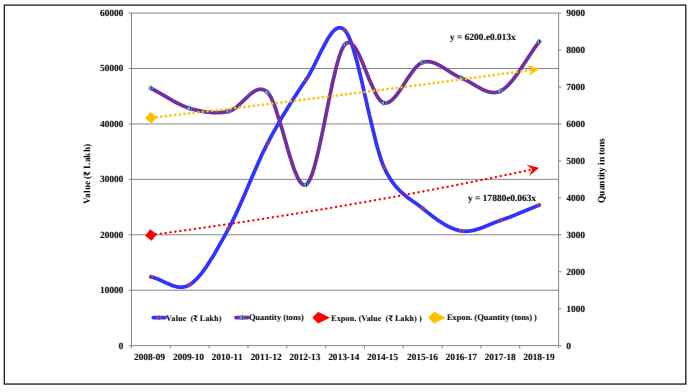


Fig. 6.6: Trends in overseas demand of lac and its value added products

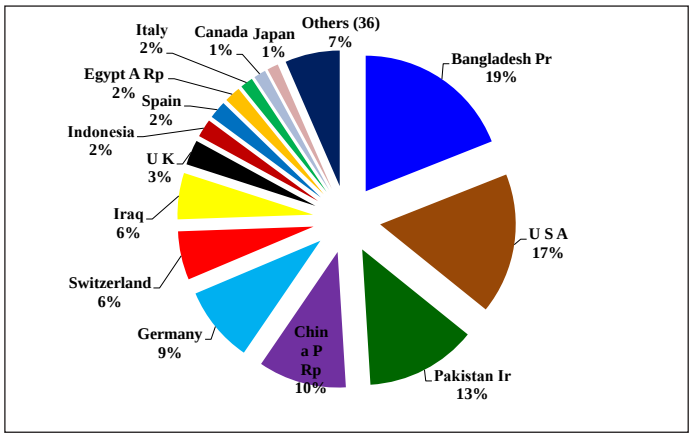


Fig. 6.7: Distribution of the overseas demand of lac and its value added products

Impact assessment: Socio economic characteristics and utilization pattern

The identified households under the 'world food programme' by the Forest Department attended training programmes on 'scientific lac cultivation' at the Institute. A total of 179 farmers from 60 villages of the 21 blocks of 5 districts of the state of Jharkhand were selected for this study. Average land holding was observed 3.37 acres with an average annual income of Rs 37,289 from various sources including lac (Rs. 4,015/annum). More than 42% households owned less than 2 acre land only and the highest trainees found in the age group between 21-30 years. Utilization of host trees for lac cultivation in the study area was observed 18.24, 6.82 and 3.09% for *Butea monosperma (Palas), Ziziphus mauritiana (Ber)* and *Schleichera oleosa (Kusum)*, respectively. This indicated a greater scope for increasing lac production by utilizing more lac hosts trees and creating gainful employment opportunities for the migrating rural population at local level.

SC - SP plan

More than 1000 households were surveyed for identification of interested households for need based interventions. A total of 10 one-week trainings programmes

were conducted for 248 SC category households. Nine trainings on 'Recent advances in management practices of horticultural crops' were conducted at ICAR-RCER, Plandu, Ranchi and one training programme on 'Scientific lac cultivation' was conducted at ICAR-IINRG, Ranchi. Viable Livestock Units and Combo Tool Kits have planned for distribution during the financial year of 2019-20. Under Animal Unit Distribution programme, a total of 371 SC category households got benefited under the SC-SP plan (Table 6.4). More than 500 SC category households also got benefited under various workshops extension activities and awareness programmes conducted in collaboration with the KVKs.

Table 6.4: Details of livestock distributed among SC category households under SC-SP plan

District	Poultry	Piggery	Goat	Duck-ery	Total
Garhwa	50	14	0	30	94 (25.35)
Chatra	20	20	20	0	60 (16.17)
Palamu	30	0	30	0	60 (16.17)
Ranchi	0	17	23	0	40 (10.78)
Hazaribag	0	0	38	0	38 (10.24)
Giridih	0	0	38	0	38 (10.24)
Khunti	0	0	21	0	21 (5.66)
Bokaro	0	0	20	0	20 (5.39)
Total SC households	**100**	**51**	**190**	**30**	**371 (100.00)**

Figure in parentheses are the percentages of the total SC households covered under the scheme

6.2 Success Story

Entrepreneurship development through lac cultivation and value addition

Jharkhand is the largest lac producing State in India and Khunti is among the top lac producing district of the state. *Siladon Lah Utpadak Sahyog Samiti* Limited (SLUSSL), Khunti was constituted in 2011 with 21 founder members and with an objective to generate the opportunities of self-employment. According to Sri Mahaveer Oraon, Secretary, SLUSSL, Khunti, till April 2019, 703 members including 300 women entrepreneurs have been registered in the samiti. During the initial three years, members were trained for scientific lac cultivation at ICAR-IINRG Ranchi. Subsequently, JASCOLAMPF took initiatives to establish a Small Scale Lac Processing Unit (SSLPU) and to train the interested women entrepreneurs for the 60 days. Consequently, SLUSSL procured about 21 tons of scrapedlac under the scheme 'Mechanism for marketing of minor forest produce through MSP and development of value chain for MFP'. The procured scrapedlac was processed by SLUSSL and handed over to the JASCOLAMPF after charging the processing fee. Moreover, a total of 20 master trainers were trained under the skill development programme on lac bangle making. They participated in an exhibition at Indian Institute of Technology (IIT), Delhi and conferred second prize. Master trainers from this society have conducted various training programmes on lac bangle making sponsored by the MLKUB, JHARCRAFT, TRIFED, JASCOLAMPF, UDYOGINI, TRDS, *etc.* This group is also playing key role in providing raw materials as well as finished products to the various Government and private agencies.

At national level, SLUSSL participated in the Republic Day Parade and the tableau (*jhanki)* was conferred 3rd prize for the live demo on lac bangle making on 26th January, 2019. Similarly, SLUSSL also participated in an event organized by the Ministry of Textiles, Government of India. The best artisan in lac based bangle making and the best stall prize were conferred to the member of SLUSSL by Smt. Smriti Irani, Hon'ble Minster of Textiles, GoI.

Recently, new units for lac processing, plastic molding machine for packaging and printer for stickers have been established with the help of Udyog Department, Government of Jharkhand. During the previous years, button lac was also prepared for self-consumption as a raw material for bangle making. TRIFED ordered for the supply of lac bangles of Rs. 21 lakh to SLUSSL during 2019. There was another order for one ton button lac from Indo Lacca Pvt. Ltd. under the scheme 'Mechanism for marketing of minor forest produce through MSP and development of value chain for MFP'.

Impact: This initiative created more than 5000 human days of employment annually for the tribal women members of the society. Moreover, many members of households got exposure at local, regional and national level platforms and were felicitated for the excellence in the field of handicraft making. These activities promoted the domestic consumption of the lac. Consequently, in long run the activities of SLUSSL are helpful in creating local demand and higher price of scrapedlac for the lac growers.

Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums

A. Lead Centre: ICAR-IINRG, Ranchi

Development and antibacterial activity of *Buchanania lanzan* (*Piyar*) gum induced silver nanoparticles (AgNPs)

In vitro cytotoxic activity of the synthesized *piyar* gum induced silver nanoparticles (AgNPs) was measured against Vero Cell Line (African green monkey kidney normal cell line) using MTT assay following standard protocol. The MTT assay was found to stimulate the proliferation of cell lines and with an increase in concentration insignificant effect was observed (Fig. 7.1). So, the synthesized *piyar* gum induced AgNPs are non-cytotoxic showing an increase in % viability.

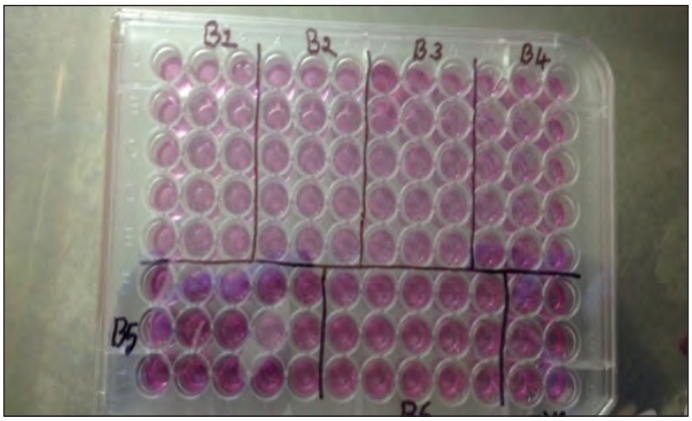


Fig. 7.1: *In vitro* cytotoxic activity of *piyar* gum induced AgNPs using MTT assay

Antifungal efficacy of *piyar* gum induced silver nanoparticles against powdery mildew of pea by detached leaf techniques: *In vitro* evaluation of *piyar* gum induced AgNPs and controls (distilled water and *piyar* gum solution) was assayed for their protectants and therapeutants efficacy against powdery mildew of pea caused by *Erysiphe pisi (E. pisi)* using detached leaf techniques following standard protocols. Disease onset and disease scoring was recorded periodically after 48 hrs, 72 hrs and 96 hrs. The whole experiment was conducted in triplicate. Disease intensity and percentage protection were calculated by the following formula:

DI = (Sum of ratings) x 100/Max. score x No. of leaves observed

The rating (0-4 scales) was done as followings:

0 = No powdery mildew symptoms; 1 = 1-10% leaf area infected; 2 = 11-25% leaf area infected; 3 = 50% leaf area infected; 4 = > 51% leaf area infected.

% Protection= (Control-Treatment) x 100/Control

The results showed that *piyar* gum induced AgNPs have protectants and therapeutants mode of action against powdery mildew.

Field evaluation of *piyar* gum induced silver nanoparticles against powdery mildew of pea: *Piyar* gum induced AgNPs along with commercial sulfur fungicide formulation (Sulfex® 80WP @ 2g/lit) were evaluated against powdery mildew of pea under field condition. Foliar spray of the test concentrations of *piyar* gum induced AgNPs were sprayed on the leaves at the time when first appearance of powdery mildew in pea (Arkel) while control plants received only sterilized distilled water and *piyar* gum solution. Commercial sulfur formulation (Sulfex® 80WP) was also applied on pea plants infected with powdery mildew of pea in the first fortnight of February, 2019. All the set of experiments were laid down in triplicate. Disease scoring was recorded periodically after 24 hrs interval. Foliar spray of *piyar* gum induced AgNPs after onset of pea powdery mildew in field showed 28.44% disease inhibition potential as compared to commercial formulation (Table 7.1, Fig. 7.2).

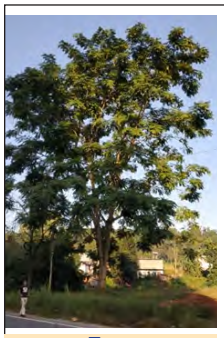
Table 7.1: Field evaluation of *piyar* gum induced AgNPs against powdery mildew of pea

Treatment	Disease Index (Mean ± S.E.)	% Protection
Piyar 1% - 0.5 mM AgNPs	65.00±1.44	28.44
Piyar 1% - 1 mM AgNPs	95.83±2.21	-5.50
Piyar Gum 1%	85.83±4.17	5.50
Commercial	80.67±7.88	11.19
Control	90.83±4.64	0
$C.D._{(0.05)}$	16.64	
SE(m)	5.02	
C.V.	10.40	

Fig. 7.2: Field evaluation of *piyar* gum induced AgNPs against powdery mildew of pea

Exploration and preparation of field guide for minor gum and resin producing plants in India

After a successful compilation of photographs and literature on major resin and gum plants, and release of book regarding the same, the project was continued for exploration and identification of minor resin and gum plants. Under this project, different field visits were conducted for collecting photographs and information regarding minor resin and gum producing trees. Visits were made to sub-tropical hill forest region covering Assam, Meghalaya and Arunachal Pradesh at north east India; arid region covering Jodhpur, Udaipur, Jaisalmer and surrounding areas of Rajasthan; and local forest areas in Jharkhand state.


Tree


Leaves and inflorescence


Flowers


Fruit

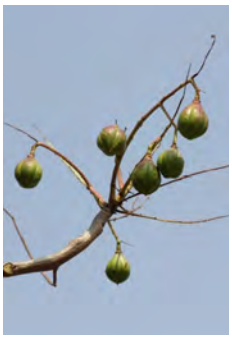

Gum

Photo: Different plant parts of the *Soymida febrifuga tree*


Tree


Leaves


Fowers


Fruit


Gum Exudates

Photo: Different plant parts of the *Parkia roxburghii*

An oleo-resin producing tree, hollong (*Dipterocarpus macrocarpus*) was found in the Likabali forest range, Assam and photographs of tree, leaves, fruit, bark, etc. were taken. Resin producing tree, Hilum (*Canarium spp*.) and gum producing tree Liba (*Garcinia spp*.) were found in the farm of ICAR RC NEH, Basar, Arunachal Pradesh. Photographs of the different plant parts were taken. Photographs of the gum exudates, leaves, tree, flowers, bark of the *Parkia roxburghii* (tree bean) was taken at Umiam, Meghalaya during visit to attend the Annual Workshop of the Network Project.

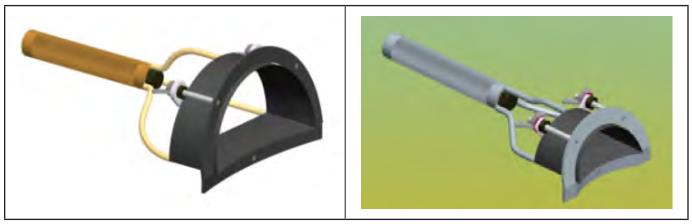
During the visit to Rajasthan, photographs of various plant parts of gum and resin producing plants including *Prosopis cineraria, Anogeissus rotundifolia, Commiphora wightii, Acacia albida, Balanites aegyptiaca, Ailanthus excelsa, Hardwickia binata and Colophospermum mopane* were taken from Jodhpur district of Rajasthan. Cordiamyxa, locally known as lasoda, was identified as a gum producing tree. Fruits of the tree contain gummy mucilage. *Acacia nilotica* sub sp. *Cupressi formis* was found and identified in Sirohi and Pali districts of Rajasthan. The visit was also made to the Botanical Survey of India, Arid Zone Regional Centre, Jodhpur. The literature on NRG plants of the arid zone was surveyed. Efforts to get more photographs of season-specific plant parts and literature on other minor gum resin plants are being made in order to cover and document various gum and resin producing trees.

Effect of tapping techniques on gum yield from *Moringa oleifera* trees

Development of conceptual/line diagram of gum tapping tool: Conceptual/line diagram of the gum tapping tool/die developed considering semi-circular method of *karaya* gum tapping developed by Koval Foundation, Visakhapatnam in collaboration with Girijan Co-operative Corporation, Visakhapatnam so that the shape and size of blaze/incision

made on the tree trunk for gum tapping may be uniform for each blaze/incision per tree.

Development of design drawing of gum tapping tool for fabrication: On the basis of prepared conceptual/ line diagram of gum tapping die, detailed manufacturing design drawing along with different components and assembly developed (Model – 1 and Model - 2) using Pro-Engineer CAD software in collaboration with ICAR – Central Institute of Agricultural Engineering, Bhopal for fabrication (Fig. 7.3). Both the developed models are the same in design except the size of the blade (length and height) so that blaze size may be developed based on tree diameter. The developed design of gum tapping die mainly consists of working blade, stopper mechanism and handle.

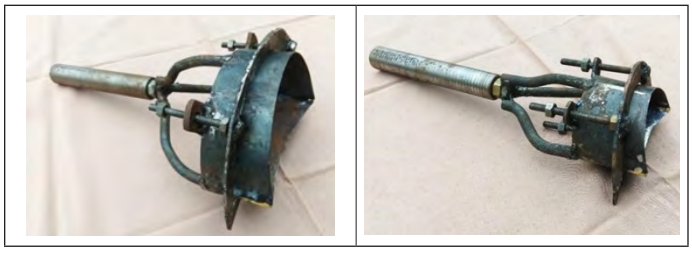


Model - 1 **Model - 2**

Fig. 7.3: Gum tapping tool developed in Pro Engineer CAD software

Improvement in developed design drawing of gum tapping tool: The developed detailed manufacturing design drawing of gum tapping die modified as per requirement considering ease in fabrication and its handling. During the improvement stopper mechanism with an adjusting system was included in the design of gum tapping die to maintain the uniform depth of blaze/ incision during tapping work.

Fabrication of gum tapping tool: On the basis of detailed manufacturing design drawing developed in Pro Engineer CAD Software, gum tapping die (Model – 1 and Model - 2) were fabricated/developed in collaboration with M/s National Enterprises, Hatia, Ranchi as shown in Figure 7.4. Site for the present investigation finalized and selection of suitable *Moringa* trees for gum tapping experiments are under progress.



Model - 1 **Model – 2**

Fig. 7.4: Fabricated models of gum tapping die

Comparative evaluation of properties of *bahera* (*Terminalia bellerica*) gum exudates collected from different agro-climatic zones

Three agro-climatic zones selected for carrying out the study are Eastern Plateau and Hills Region (Jharkhand), Trans-Gangetic Plains Region (Rajasthan) and Eastern Himalayan Region (Assam). *Bahera* gum samples collected from the zones falling under Jharkhand, Rajasthan, and Guwahati were first purified, and then a comparison was done between the physico-chemical and rheological properties of purified and impure samples. Physico-chemical properties of purified and impure samples collected from Jharkhand, Rajasthan, and Assam regions were studied. It was observed that the ash content (%), nitrogen (%), bulk density (g/cc) and tap density (g/cc) were higher in the impure sample compared to pure one from all the three zones.

SEM: Scanning electron micrographs of raw and purified *bahera* gums was measured at x1000 magnification and 50 µm scale. The raw or impure *bahera* gum had a plane, non-porous and smooth surface. Its shape indicated that it was amorphous. The pure gum sample had rough, porous and fibrillar structure. The same nature was observed in gums of both the zones (Jharkhand and Rajasthan).

FT-IR: The spectrum was recorded by studying the % transmittance with respect to wave number (cm^{-1}). Both the gums showed peaks between 750 and 1300 cm^{-1}. The same nature was observed in gums of both the zones (Jharkhand and Rajasthan).

XRD: No sharp peak was observed in both raw and purified gums. Although crystallinity increased with purification.

Rheology: All the three gums showed a decrease in viscosity with an increase in temperature as shown in Figure 7.5 a, b and c. Impure samples had a comparatively greater viscosity than the pure ones. The behavior can be seen from the following curves.

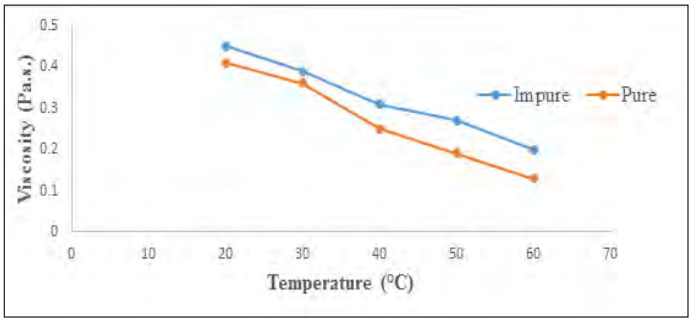


Fig. 7.5a: Viscosity (Pa.s) *vs* Temperature (°C) curve for *bahera* gum from Jharkhand

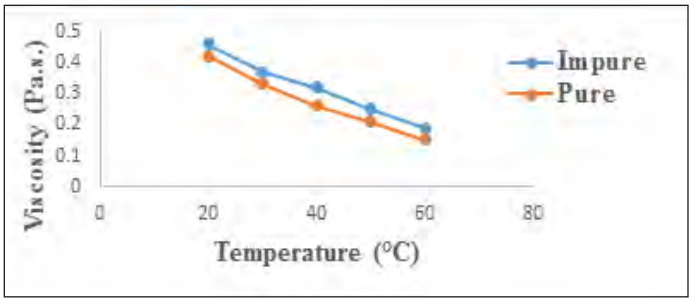


Fig. 7.5b: Viscosity (Pa.s) *vs* Temperature (°C) curve for *bahera* gum from Rajasthan

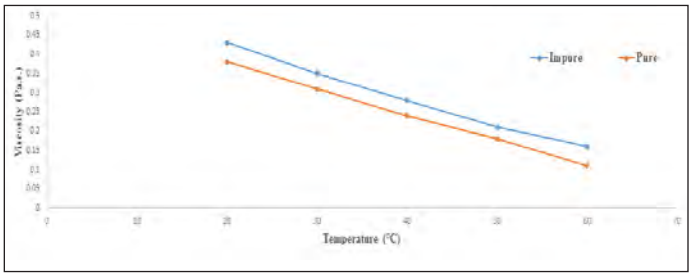


Fig. 7.5c: Viscosity (Pa.s) *vs* Temperature (°C) curve for *bahera* gum from Jharkhand

B. Network Co-operating Centers

7.1 Project on gum *arabic* at ICAR-CAZRI, Jodhpur

Standardization of gum inducer technique for *Commiphora wightii*

The existing population of *Commiphora wightii* (*C. wightii*) at CAZRI Kailana afforestation area were selected for the experiment. Plants with even age were selected and divided into three groups, and each group was treated with different chemicals and their concentration. The control group was also monitored where the simple blaze was given to the main stem/branches of the plant. With the help of the surgical blade, three half-moon pit blazes (average 2.35 mm) were made in branches including stem (Fig. 7.6). CAZRI, Kailana afforestation area has rocky land-form (desertic soil) with medium hillock. *C. wightii* natural population was found very dense comprised of rich biodiversity. The experiment site constitutes a wide area. Experiment period this year was December 2018 to January 2019.

Photo: Wide angle view of the experimental site of *C. wightii* at Kailana Afforestation area

Even aged 5 plants with similar structural traits were treated with different chemicals CGI and KGI. A control group was also kept. The average plant height in each group was 163.0 cm. The average canopy was 155.2 cm with 23.1cm average girth. The maximum average oleo-resin yield of *guggul* was 24.19 g/plant when plants are treated with CGI. In the case of KGI *i.e.* 19.9 g/plant was recorded (Fig. 7.6). Results clearly indicated that CGI and KGI gave appreciable yields for *guggul* in a short period without any mortality to plants.

In case of farmers' trials conducted at the above-mentioned site, the experimental plant was randomly

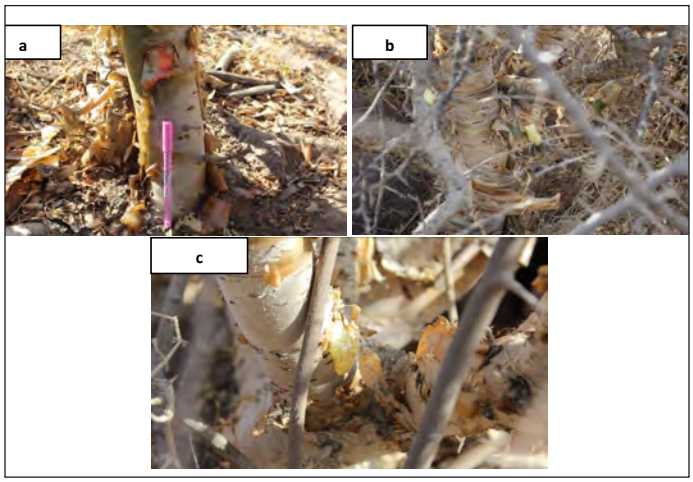


Fig. 7.6: *Guggul* exuded from *C. wightii* at Kailana afforestation area (a) CGI, (b) KGI and (c) control

selected at their field boundaries. Twenty plants were treated with CGI inducer. Moreover, farmer's practices *i.e.* conventional methods of *guggul* treatment were also done at the same time as treatments. The average plant height in the treatment group was 259.0 cm with an average canopy of 242.0 cm and 33.0 cm average girth. In conventional method group plants had average height 268.0 cm with average canopy 250.0 cm and 35.3 cm average girth.

The maximum average oleo-resin yield of *guggul* was obtained 122.5 g/plant when plants are treated with CGI (Fig. 7.7). In the case of the conventional method *i.e.* 105.0 g/plant was recorded. Results indicated that the oleo-resin yield of *guggul* was enhanced compared to the conventional method. It is 18.37% higher than the

conventional method with no mortality as per feedback from farmers after the treatment.

Fig. 7.7: *Guggul* exudation after treatment of (a) CGI inducer and (b) conventional method applied in farmers at village Javrol, MP

In all experiments, yield was diverse with the girth of the treated plants and climatic conditions. *Guggul* yield gradually increased with girth. However, some other factor *i.e.* temperature, humidity and health of plants also affected the *guggul* production.

Study on refining gum *arabic*

An experiment was carried out to refine gum *arabic* by using a simple technique. The following treatments were applied.

i. Twenty-five gram of gum *arabic* was dissolved into 25 ml, 50 ml and 75 ml in warm (heated only till gum dissolves) distilled water and mixed thoroughly, filtered using musline cloth and kept in shade for drying.

ii. In the same manner, 25 g gum *arabic* was dissolved into 25 ml, 50 ml and 75 ml room temperature distilled water, mixed thoroughly and was filtered using muslin cloth and kept in shade for drying.

Various observations on dry weight, loss of gum, dissolving time and drying duration were recorded. The pure gum samples were tested for their nutritional information. The experiment was designed for the house hold purification of gum *arabic*. The gum *arabic* solution was prepared in different concentrations, filtered and dried in shade. The highest recovery of gum *arabic* was seen in 1:3 ratios of gum *arabic* and solvent. It had the less dissolving time and a comparable drying period. Warm distilled and room temperature distilled water treatments yielded 92.4; 89.64 % pure gum, respectively in 1: 3 ratio (Fig. 7.8, Table 7.2). The loss of gum *arabic* was higher in the 1:1 ratio of gum and solvent in both treatments. The loss was due to the high concentration of gum in the solvent and was not filterable up to an extent. The dissolving period was very less in warm water with a 1:3 ratio in comparison to room temperature water treatment, the drying period was found almost the same in both treatments to be longer due to high moisture content compared to 1:1 ratio. The rate of solidification was inversely proportional to the concentration. As per the results, a 1:3 ratio of warm distilled water method can be feasible to remove impurities with a short time duration of the dilution period.

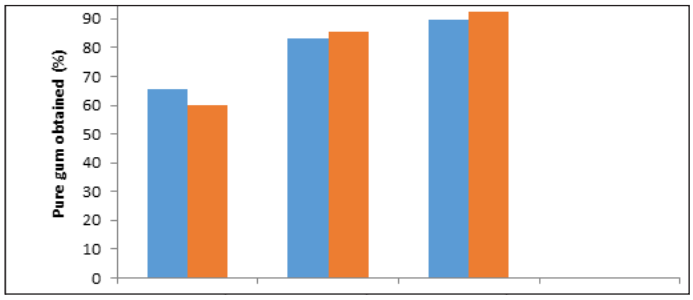


Figure 7.8: Pure gum obtained in room temperature and warm distilled water

Table 7.2: Gum *arabic* refining methods with warm (B) and room temperature (N) distilled water in various concentrations

	Treatment	Pure gum obtained (%)	Loss (g)	Dissolving time (min.)	Drying duration (days)
Room temperature water (N)	25 g+25 ml (1:1)	60.08	9.98	135	13
	25 g+50 ml (1:2)	85.5	3.62	105	15
	25 g+75 ml (1:3)	92.4	1.89	75	15
Warm water (B)	25 g+25 ml (1:1)	65.6	8.6	25	13
	25 g+50 ml (1:2)	83.08	4.23	12	15
	25 g+75 ml (1:3)	89.64	2.59	9	15

The gum block prepared as shown in Fig. 7.9, using 25 ml, 50 ml and 75 ml distilled water at room temperature had an ash content of 3.40 %, 3.50 %, and 3.70 %. The protein

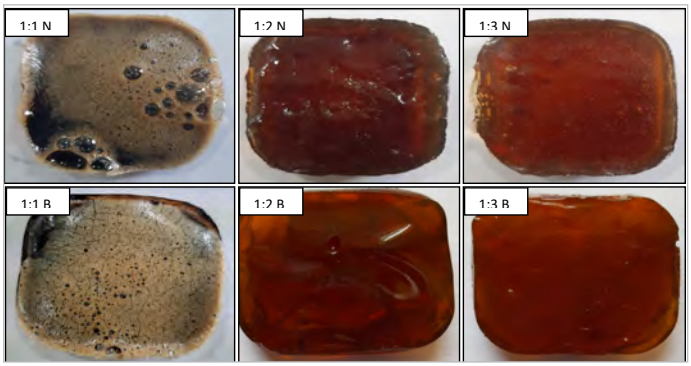


Fig 7.9: Refined gum blocks after drying in the room (B) and warm temperature (N) distilled water with the various concentration ratio

content was 0.91%, 1.0% and 0.81 % for 25 ml, 50 ml and 75 ml, respectively. The gum block prepared using 25 ml, 50 ml and 75 ml distilled water at warm temperature had an ash content of 3.60 %, 3.30 %,and 3.50 %. The protein content was 0.91%, 1.1% and 0.1 % for 25 ml, 50 ml and 75 ml, respectively.

The methodology adopted for the refining of gum *arabic* in this experiment was very simple and effective. The rural population can easily adopt the refining method in their own houses for value addition and also for domestic purposes. The experiments suggest that the ratio of 1:3 gum and distilled water can yield 92.4% pure gum and effective removal of the impurities. The higher concentrations of gum will not be easy to practice and will have a loss of more gum compared to lower concentration.

7.2 Project center at ICAR-CAFRI, Jhansi

Growth and productivity of agroforestry models

Agroforestry models on-farm: In agri-horti-silviculture model, as shown in Fig. 7.10, maximum GBH (cm), plant height (cm) and canopy diameter (m^2) were recorded in *A. senegal* (kumat), followed by *Aegle marmelos* (bael), *Citrus limon* (lemon) and *Carissa carandas (*karonda). Since, casualty replacement was done during 2017-18; hence, maximum survival (%) was recorded in *C. carandas*, followed by *A. senegal*, *C. limon* and *A. marvelos.* During *rabi* season of 2017-18, mustard (variety RH 749) was cultivated and during *kharif* season of year 2018, moong (variety Sweta) was cultivated as intercrop. This year *i.e.* 2018-19 (*rabi* season), wheat (variety HD 2967) has been sown. During 2018-19, natural oozing of gum (average 34.14 g/tree) from *A. senegal* was recorded.

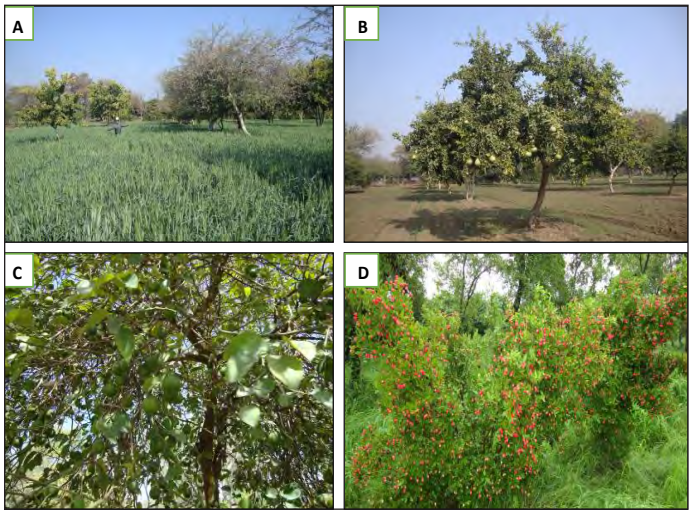


Fig 7.10: *Acacia senegal* based agri-horti-silvi model at the research farm of CAFRI (A. Intercrop- wheat, B. *Aegle marmelos*, C. *Citrus limon* and D. *Carissa carandas*)

In agri-silviculture model, wherein *A. senegal* and *A. nilotica* were planted in three different spacings; maximum survival was recorded by *A. senegal* planted in 10 m × 10 m spacing and least in *A. nilotica* planted in 10 m × 10 m spacing. After six years of plantation, higher GBH (cm) and plant height (cm) were recorded in *A. nilotica* than *A. senegal* in all spacings. During *kharif* season of 2018, moong (variety Sweta) was sown in agri-horti-silviculture model (field number 25) and the recommended package of practices was followed. Planted tree species did not affect plant population, plant height and seed yield. Maximum above ground biomass was recorded under *C. limon* which was statistically at par with *A. marvelos.* Plant population, seed yield and above ground biomass were found to be increasing with increase in the distance from tree trunk *i.e.* their maximum values were recorded at 4.5 m distance and minimum at 1.0 m distance. The interaction effect of tree species and distances were not significant for all the recorded parameters, except plant population which was maximum at 4.5 m under *A. senegal*.

Agroforestry models on farmers' fields: After nine years of planting, *A. senegal* recorded relatively more survival (57%) than *A. nilotica* (50%) at Garhkundar watershed area. At the farm of Shri Thakur Das, among planted species, maximum growth and survival was exhibited by *A. nilotica*, followed by *Psidium guajava* (guava) and *C. carandas*. At the farm of Shri Ghanshyam, *A. senegal* planted during 2012 showed poor performance in terms of growth; however, survival percentage was comparatively higher than the values recorded from other two fields. In general, at Garhkundar watershed area, *A. senegal* recorded relatively more survival (59.5%) than *A. nilotica* (50%). At village Ambabai, 37% survival of *A. senegal* with average height of 270.1 cm and average collar diameter of 7.6 cm was observed. Natural exudation of gum from *A. senegal* was observed during 2018 at farm of Shri Himmat.

Demonstration and development of gum yielding tree-based agroforestry models

At Institute research farm: During rainy season of 2018, four bio-fence models were developed at the Institute research farm, wherein *A. senegal* along with *C. carandas* were planted in single and double rows. Bio-fence model-1 aimed to optimize distance apart trees consists of single row plantation of *A. senegal*+*C. carandas* alternated in three distances *i.e.* 1.0, 1.5 and 2.0 m apart on field boundaries. After six months of planting, survival of *A. senegal* and *C. carandas* was 67.4 and 87.0%, respectively.

Bio-fence model-2 aimed to assess effectiveness of double row planting consists of *A. senegal* as outer row and *C.*

carandas as inner row on field bunds. Distance between two rows was 1.0 m and within the row, plant to plant distance was 2.0 m. The planting of both species in two rows was done in staggered manner. After six months of planting, 32.1 and 64.2% survival of *A. senegal* and *C. carandas*, respectively were observed.

The bio-fence model-4 consists of two rows of *A. senegal* (inner and outer) kept at 1.5 m apart wherein plant to plant distance was also 1.5 m. This model was planted along two sides of a well-established *Punica granatum* (pomegranate) orchard. Planting was done in staggered manner in two rows. After six months of planting, 65.2 and 68.6% survival were recorded from inner and outer rows, respectively.

At farmers' fields: During rainy season of 2018, a total of 3925 seedlings, consisting of 3005 *A. senegal*, 570 *C. carandas*, 245 *C. limon*, 80 *Dendrocalamus strictuts* (bamboo) and 25 *P. guajava* were distributed and planted at different locations. 1000 seedlings of *A. senegal* were provided to army station at Talbehat (Uttar Pradesh). After six months of planting, the survival percentage of *A. senegal* varied from 49.7-80.0%, *C. carandas* from 60.0-75.0%, *C. limon* from 40.0-78.0%, *D. strictus* from 40.0-46.0% and *P. guajava* recorded 80.0% at different locations.

Survival of *A. senegal* and fruit plant species (*C. limon*, *P. guajava* and *P. granatum*), distributed and planted in the field of 14 farmers of village Parasai during rainy season of 2017 was also recorded. After 1.5 years of planting, the survival of *A. senegal* ranged from 80-90%, 55.0-80.0% in *C. limon*, 60.0-80.0% in *P. guajava* and 59.1% in *P. granatum*.

Studies on root distribution pattern and above & below ground-biomass in *Acacia senegal*

For determining root biomass of *A. senegal*, roots of selected tree was excavated manually. Prior to excavation, rooting zone was moistened with water, and sufficient care was taken to reduce the damage to the fine roots. Whole root system was dug-out, and entire root system was divided into 30 cm long sections. From each section, primary, secondary and tertiary (fine roots having <2 mm size) roots were separated (Fig. 7.11). Observations on diameter (mm), length (cm) and weight (kg) were taken.

In shoot portion, 24 primaries, 85 secondary and 193 tertiary branches were recorded. The total fresh biomass of above-ground portion was 24.02 kg. The study recorded 9.20 kg fresh weight of main stem, 6.62 kg primary

Photos: Studies on root distribution pattern and biomass/carbon stock in three-years-old *A. senegal*

Fig 7.11: Sectioning of the root system of *Acacia senegal* into the (A)main root, (B)primary roots, (C)secondary roots and (D)fine/feeder roots

branches, 3.87 kg secondary branches, 2.25 kg tertiary branches and 2.08 kg foliage. Total depth of root system was recorded up to 270 cm with 3.34 kg total fresh weight. Below-ground root bound soil volume was 17.3 m^3. In entire root system, 25 primary, 64 secondary and 748 feeder roots were recorded. The study recorded 1.58 kg main root, 1.14 kg primary roots, 0.46 kg secondary roots and 0.16 kg feeder roots. Root to shoot ratio, on the basis of total above and below-ground fresh biomass, was recorded 0.139.

Root cation exchange capacity assessment: Cation exchange capacity (CEC) in roots of wheat plant grown in agri-horti-silviculture model was assessed. Fresh root samples of wheat were collected from three different distances *viz*. 1.0, 2.0 and 4.0 m from *A. senegal* stem base, after one month of sowing and at maturity. The fresh root samples from *A. senegal* were also taken. For estimating fresh root CEC, the roots were separated from plants,

cut into 1 cm long bits and washed with distilled water. Surface of root samples were saturated by immersing in 0.01 N HCl for 5 minutes. Extra chloride ions adhered to root surface were removed by intermittent shaking in distilled water. Thereafter, roots were stirred in 1.0 N KCl solution and drop in pH was noted, and then titrated with 0.01 N KOH solution to bring back the pH up to 7.0.

Fresh root CEC of wheat was comparatively higher after one month of sowing than the value recorded at the time of maturity. Initially, the root CEC of wheat increased up to 2.0 m distance from the tree and then declined. However, at maturity the root CEC remained almost similar up to 4.0 m distance. The fresh root CEC of *A. senegal* remained higher than the wheat, except at 2.0 m distance from the tree. After estimating dry root CEC of wheat and *A. senegal*, a more reliable parameter, the competitive uptake of cations by crop and tree components will be evaluated.

7.3 Project on *Guar* gum at VNMKV, Parbhani

Preparation of *guar* meal by wet and dry methods and effectiveness of methods of preparation on the chemical composition of *guar* meal

Guar meal was prepared by wet and dry methods and prepared *guar* meal was analyzed for the chemical composition. The proximate composition of the *guar* meal prepared using wet and dry methods is presented in Table 7.3.

Table 7.3: Proximate composition of the *guar* meal

SL. No.	Method	Chemical composition (%)					
		Moisture	Protein	Fat	Carbohydrate	Ash	Fiber
1	Wet	10.23	49.50	5.60	20.87	6.80	7.00
2	Dry	10.19	50.10	5.69	20.18	6.83	7.01

*Each value represents the average of three determinations

The moisture content of *guar* meal in case of wet method was found to be 10.23 %, whereas protein, fat, ash and fiber content of *guar* meal was observed to be *i.e.* 49.50 %, 5.60 %, 6.80% and 7.00% respectively. While in case of dry method moisture content of *guar* meal was found to be 10.19 %, whereas protein, fat, ash and fiber content of *guar* meal was observed to be higher *i.e.* 50.10 %, 5.69 %, 6.83 % and 7.01 % respectively. It was noticed that not very much variation observed with respect to chemical composition as compared to wet method.

Technology development for preparation of nutra laddu

By incorporation of linseed, amaranth, *guggul* gum, jaggery, honey and cardamom essential oil good quality nutra laddu can be prepared having shelf life up to 28 days (Fig. 7.12). Linseed grain has fat content of 39.2%, protein 20.5%, carbohydrate 28.1%, ash 2.0 %, fiber 5.6% and energy 547.2 kcal, respectively. Amaranth grain has fat content of 6.5%, protein 14.3%, carbohydrate 67.0%, ash 2.8 %, fiber 2.3% and energy 383.7 kcal, respectively. Jaggery has carbohydrate 95% and energy 382.5 kcal. The color *guggul* fortified nutra laddu showed better score than the control sample. With respect to taste and flavor, increase in score was observed. It might be due to addition of cardamom essential oil.

Fig. 7.12: Linseed, amaranth and *guggul* gum incorporated nutra laddu

In case of texture, increase in score was noticed as the incorporation of gum improved the texture of nutra laddu, this may due to the binding effect of *guggul* gum. *Guggul* fortified laddu was found to be overall acceptable as compared to the control sample.The nutra laddu contains fat, protein, ash and fiber 42.3%, 28.1%, 4.2% and 6.8% respectively. Fat, protein and fiber was found to be at higher level. Energy of nutra laddu was observed to be 571.4 kcal. Nutra laddu was found to be having good nutritional value. It may be due to the incorporation of linseed and amaranth. Microbiological examination of the nutra laddu revealed that total plate count was found to be in the range of 51-5694 cfu/ml which was below the acceptable limit. Further total plate count was found to be 5694 cfu/ml on 28th day of storage. In case of yeast and mold, count was obtained between 0-10 cfu/ml, but it was 10 cfu/ml on 28th day of storage.

Comparative study of *guar* germ meal with other meal

Moisture, protein, fat, crude fiber, ash and minerals of *guar* meal, soybean meal and groundnut meal were determined using the method given by AOAC (2019). It was observed that moisture and ash content of soybean meal was higher than the *guar* meal and groundnut meal and also indicated that the fat, fiber and carbohydrate content of groundnut meal is higher as compared to the

guar meal and soybean meal. Further, it can be observed that the protein content of *guar* meal is higher than the soybean meal and groundnut meal.

The mineral composition of *guar* meal, soybean meal and groundnut meal is the calcium, magnesium, potassium, phosphorous, iron, zinc and manganese contents of *guar* meal, soybean meal and groundnut meal were found to be 1.16 mg/100g, 2.7 mg/100g, 0.97 mg/100g, 3.2 mg/100g, 110 ppm, 39 ppm, 18 ppm; 0.28 mg/100g, 0.27 mg/100g, 1.9 mg/100g, 0.57 mg/100g, 118 ppm, 48 ppm, 28 ppm and 0.09 mg/100g, 0.3 mg/100g, 1.11 mg/100g, 0.49 mg/100g, 355 ppm, 12 ppm, 30 ppm, respectively.

Guar meal contained higher amount of amino acids like, tryptophan (0.64 %), isoleucine (2.03 %), lysine (2.95 %), serine (3.71 %), proline (2.76 %), alanine (2.51 %), leucine (3.49 %), phenyl alanine (3.22 %), glycine (4.51 %), aspartic acid (6.45 %) and glutamic acid (12.77 %) as compared to the soybean meal and groundnut meal. Hence, *guar* germ meal could be good alternative as cattle feed compared with soybean meal and groundnut meal. Whereas saponin content in *guar* seed hull and germ was found to be 5.42 % and 5.9 %. *Guar* seed hull and germ exhibited antioxidant activity *i.e.* 24.6 % GAE and 58.2 % GAE, respectively.

Further saponin content of *guar* hull and germ showed maximum zone of inhibition to *E. coli* followed by *Streptococcus aureus, Pseudomonas aeruginosa* and *Aspergillus niger* as an antimicrobial activity. *Guar* meal was found to be better with respect to chemical composition, minerals and amino acid profile as compared to soybean meal and groundnut meal.

Isolation and characterization of the bioactive component from *guar* germ and hull: In the present study, saponin extracts of *guar* seed hull and the antibiotic *viz.* amikacin is tested for antibacterial activity against four strains of bacteria. Saponin content of *guar* hull showed maximum zone of inhibition to the *E. coli* (31 mm) followed by *Streptococcus aureus* (29mm), *Pseudomonas aeruginosa* (22mm) and *Aspergilius niger* (20mm). The present work revealed that the saponin extracts of *guar* seed hull possess potential antibacterial activity against aforesaid microorganisms. Antioxidant test of given *guar* seed hull sample was measured using DPPH assay method. It was evident from the result that the *guar* seed hull exhibited a higher phenolic content and its antioxidant activity was 24.6 % GAE.

7.4 Project on Rosin at Dr. YSPUH & F, Solan

Standardization of borehole height for oleoresin tapping in *Pinus roxburghii* Sargent

Natural stand experiment at Nauni (main campus) UHF, Solan: In this experiment, diameter at breast height (DBH) was measured and all the trees were classified into four diameter classes *viz.* 30-40 cm, 40-50 cm, 50-60 cm and >60 cm. Six boreholes at different months *viz.* March, April, May, June, August and September were drilled in each tree and yield was recorded at the end of October for all the six boreholes. There were 3 treatments (heights) and each treatment had three replications. Each replication comprised of four trees. The highest oleoresin yield of 4,537.33g/season was recorded in H3 and the lowest yield of 2,901.67g/season was observed in H1. The data revealed significant variation in oleoresin yield and diameter of the tree. The highest oleoresin yield of 961.39 g/hole/tree was recorded in the diameter class >60 cm whereas, lowest oleoresin yield of 475.74 g/hole/tree was observed in the diameter class 30-40 cm.

The analysis of variance revealed significant differences for treatments, the mean maximum oleoresin yield of 872.53 g/hole was noticed in H3 (150 cm) and mean minimum yield of 532.04 g/hole in H1 (50 cm). However, the interaction between the height and diameter classes also showed significant effect on oleoresin yield. The maximum oleoresin yield of 1050.44 g/hole was recorded in H3D4, whereas the minimum (281.67 g/hole) in H1D2.The significant differences for the month of borehole drilled highest oleoresin yield of 1046.47 g/hole/tree was obtained from the borehole drilled in the month of April (M2). The lowest oleoresin yield of 401.81 g/hole was recorded from the borehole drilled in the month of September (M6). The scrutiny of data revealed significant differences for borehole height, where maximum oleoresin yield of 872.53 g/hole was recorded in H3 (150 cm) and minimum yield of 532.04 g/hole in H1 (50 cm).

The interaction between borehole height and month of borehole drilled was found non-significant at 5 per cent level of significance. The oleoresin yield ranged from 288.92 g/hole/tree to 1397.50 g/hole/tree. During the standardization of borehole heights for oleoresin tapping in *Pinus roxburghii* Sargent at Bhota (Hamirpur), the effect of different heights on oleoresin yield in borehole method was found non-significant. The highest oleoresin yield of 2,622.08 g/season was recorded in H3 and lowest yield of 1,998.42 g/season was observed in H1.

The significant effect of month of boreholes drilled and non-significant effect of borehole height on oleoresin yield. In different borehole height, the maximum oleoresin yield of 883.47 g/hole was noticed in H1 (50 cm) and minimum yield of 731.08 g/hole in H3 (150 cm). The interaction between borehole height and month of borehole drilled was found to be non-significant at 5 per cent level of significance.

The different months of borehole drilled the oleoresin yield of 1098.39 g/hole/tree was found to be highest from the borehole drilled in the month of June (M2) and the

lowest oleoresin yield of 530.75 g/hole was observed from the borehole drilled in the month of September (M3). The highest oleoresin yield of 968.37 g/hole/tree was obtained from the diameter class 50-60 cm whereas lowest oleoresin yield of 634.74 g/hole/tree was recorded from diameter class D2.

Effect of diameter classes on oleoresin yield in rill method: Rill method, the effect of different diameter classes on oleoresin yield was found significant at 5 per cent level of significance. The highest oleoresin yield (10.44 kg/season) was noticed in diameter class of >55 cm (D6) and lowest (5.96 kg/season) was observed in diameter class 35-40 cm (D2).

Identification and evaluation of high resin yielders of *Pinus roxburghii* Sargent from different sites in Himachal Pradesh

Experiment was laid out on resin tapping potential of *chir pine* progenies of superior trees raised at main campus and data was collected on oleoresin yield. The trees of progenies having more than 30 cm d.b.h were segregated for oleoresin tapping experiment. In total, 22 out of 60 progenies had minimum one tree above 30 cm d.b.h in at least two replications.

Photos: Progeny experiment at Nauni (main campus), UHF, Solan

The oleoresin yield from different selected progenies revealed significant differences. The maximum oleoresin yield (625.00 g/season) was noticed in 23 Kaldoo P-3 and minimum in 38 Rukhi P-8 (130.00 g/season). The oleoresin was extracted using borehole method of tapping and based on oleoresin yield, the high resin yielders were marked. The oleoresins collected from these sites were analyzed in the laboratory for rosin and turpentine yield.

The significant differences for rosin and turpentine content of high resin yielders of *Pinus roxburghii* Sargent from different sites at 5 per cent level of significance. The highest (80.11 %) rosin content was observed for Piplughat (Solan) whereas lowest (78.46 %) for Arki. The maximum (21.54 %) turpentine content was found for Arki, whereas minimum (19.89 %) for Piplughat (Solan). The maximum oleoresin yield (625.00 g/season) was recorded in 23 Kaldoo P-3. The high oleoresin yielders were marked at different sites *viz*. Nauni campus, Bhota (Hamirpur) and Piplughat. The maximum percentage of turpentine (21.54%) was recorded at Arki whereas the highest (80.11%) rosin per cent was found at Piplughat (Solan).

Value addition of oleoresin

The study is to partially replace the synthetic PF resin with natural pine rosin used in bonding of engineered wood composite materials (particle board and panel boards) without sacrificing their quality and performance. In water absorption (WA), no particular trend was observed due to addition of rosin in phenol formaldehyde (PF) resin and there is no significant difference in the thickness swelling of laminated veneer lumber (LVL) prepared by using different PF rosin blends. Rosin based nano-composite has been synthesized for adsorptional photo-catalytic degradation of resistant organic pollutants such as dyes, antibiotics, etc. from aqua systems. It has shown promising results and application for patent is submitted. The various physical properties of *Melia dubia* LVL using PF - Pine rosin blends were studied which resulted in increase in density.

Correlation between oleoresin yield and environmental factors

Simple correlation coefficients between environmental factors *viz*. maximum temperature (Max T (°C)), minimum temperature (MinT (°C)), average relative humidity (Av. RH (%)), total rainfall (Total RF (mm) and total evaporation (Total EVP (mm)) and oleoresin yield are presented in Table 7.4. Out of 15 correlation combinations, four was positive and significant at 1% level of significance and one correlation coefficient was negatively significant at 1% level of significance. One correlation coefficient was negatively significant at 5% level of significance. The correlation coefficients between rests of the combinations were found to be non-significant. The oleoresin yield exhibited a positive significant correlation coefficient with maximum temperature (0.472) and total evaporation (0.424). The negative significant correlation coefficient was also observed between oleoresin yield and average relative humidity (0.539).

Table 7.4: Simple correlation coefficient between oleoresin yield and environmental factors (2010-2018)

	Oleoresin Yield	Max T (°C)	Min T (°C)	Av. RH (%)	Total RF (mm)	Total EVP (mm)
Oleoresin Yield	1					
Max T (°C)	0.472**	1				
Min T (°C)	0.023	0.194	1			
Av. RH (%)	-0.539**	-0.229	-0.070	1		
Total RF (mm)	-0.144	-0.007	0.000	0.650**	1	
Total EVP (mm)	0.424**	0.397**	-0.136	-0.384*	-0.127	1

**Correlation is significant at the 0.01 level
*Correlation is significant at the 0.05 level

Demonstration of borehole technology of oleoresin tapping

- Demonstration of borehole method of oleoresin tapping to Kashmir Forest Corporation trainees of J & K on January, 2019 (Fig. 7.13a).
- Demonstration of borehole method of oleoresin tapping in *chir pine* to the PI and his team from Network Project on 'Harvesting, Processing and Value Addition of Natural Resins and Gums', CAZRI Centre, Jodhpur on March 23, 2019 (Fig. 7.13b).

Fig. 7.13: Demonstration of borehole method of oleoresin tapping to (a) Kashmir Forest Corporation trainees of J & K and (b) NP-HPVA on NRG team from CAZRI, Jodhpur

7.5 Project on *karaya* gum at IGKVV, Raipur

Studies on fortification of *karaya* and *babool* gums in the preparation of extruded products

Babool gum in the range of 5-15% with rice, ragi and gram whereas up to 10% of *babool* gum could be incorporated with maize, ragi and gram. Chocking problem was experienced beyond 15% gum in case of maize based blend. The expansion ratio of the extruded product did not vary appreciably with addition of gum. The bulk density of the product initially reduced appreciably up to 5% which with the increase in gum per cent gradually increased. Water Absorption Index (WAI) decreased with addition of gum up to 10% and further increase of gum increases WAI. The hardness of the extruded product was found to be decreased with the increase in gum content in case of rice based but in case of maize based it was not appreciable. However, this needs to be redone. The crispiness of the product was found to be improved with the addition of gum. The increase in gum concentration increased the crispiness.

Studies on sorption and desorption characteristics of gums (*babool* and *karaya*)

The isotherms of *babool* gum shows characteristics of type II BET isotherm and are sigmoid in shape, which may be because of presence of galactomannan gum which is known for its water binding property. The Halsey equation was useful for modeling moisture sorption of *babool* gum in a water activity range of 0.11 - 0.99 at 50°C. The equilibrium moisture content (%, db) decreased with increasing temperature at corresponding values of a_w. The equilibrium moisture content (%, db) increased with water activity which maintained in surrounding.

Improved tapping technique for *dhawara / ghatti* (*Anogeissus latifolia*)

Appropriate height for tapping purpose is 1 DBH. At 50 cm the exudation amount was significantly lesser than 1 DBH. Various gum enhancers were used for tapping purpose along with different mechanical methods and compared with traditional methods and observed that the use of gum enhancer increases the gum exudation significantly. Effects of Jasmonic acid, L-Methionine, Maleic Hydrazide, and NAA have no significant effect on the gum exudation. Graded concentration of ethephon was used on the similar girth class of *dhawara* trees and observed that 4.8% ethephon was found to be the best than lower and higher concentration. H_2SO_4 @10% (4 ml) was found to be effective and significantly enhanced the exudation of gum in *dhawara*. However, its combined effect with ethephon did hot increase the yield appreciably.

Development of tapping techniques for sustainable extraction of biopolymer in *rohina* (*Soymida febrifuga* Roxb.), *chironji* (*Buchanania lanzan* Spreng) and *saja* (*Terminalia tomentosa* Roxb.)

The process of gummosis and exudation started with in week in traditional, mechanical as well as chemical

methods of tapping in all experimental trees. The rate of exudation was greater in chemical treatment (Fig. 7.14) as compared to mechanical and traditional methods of tapping (Fig. 7.15 and 7.16) in all the experimental trees except in *saja* (*Terminalia tomentosa* Roxb.). The temperature and relative humidity play significant role on quantity of gum exudation in experimental trees. In mechanical methods T_3 (semi arc method) was found to be best as compared to other mechanical methods in gum yield. The maximum yield observed in *rohina* (27.69 g) followed by *saja* (22.84 g) and *chironji* (11.28 g). The flow rate of biopolymers was significantly higher with in month (Dec.–Jan.) in all experimental trees except in *saja* (Dec.-Feb.). The rate of gum exudation in mechanical methods (semi arc method) was significantly higher within month (Dec.–Jan.) in all experimental trees except in *saja* (Dec.-Feb.). The semi arc method was found to be suitable in gum tapping in winter season also. However, the mechanism of gummosis has significantly affected by high temperature and low relative humidity.

***Terminalia tomentosa* Roxb.**

***Soymida febrifuga* Roxb.**

***Buchanania lanzan* Spreng**

Fig. 7.14: Gum taping experiments by mechanical (semi arc) tapping method

T_4 – Ethephon @3.9 + H_2SO_4@1%	T_2 - Ethephon @ 3.9%	T_3 – H_2SO_4 @ 1%

Fig. 7.15: Chemical method of tapping for gum exudation in *rohina* (*Soymida febrifuga* Roxb.)

T_4 – Ethephon @3.9 + H_2SO_4@1%	T_2 – Ethephon @ 3.9%	T_3 – H_2SO_4 @ 1%

Fig. 7.16: Chemical method of tapping for gum exudation in chironji (*Buchanania lanzan* Spreng)

The use of ethephon is significantly effective to induce gum production in *chironji* during April up to June and as compared to mechanical and traditional method of tapping. Mechanical and traditional method of tapping was not effective for the production of gum. The higher concentration of gum @5.5% ethephon is significantly superior for the production of gum in the month of June as compared to other gum enhancer, mechanical and traditional method**.** Thus, the appropriate time of tapping in *chironji* is June.

Training and Demonstration Activities

- 42 persons participated in one day training at *Krishi Vigyan Kendra*, Mungeli on Feb. 27, 2019.
- 40 persons participated in one day training at *Krishi Vigyan Kendra*, Dhamtari on Feb. 28, 2019.
- 43 persons participated in one day training at *Krishi Vigyan Kendra*, Kabirdham on March 01, 2019.
- 55 persons participated in one day training at *Krishi Vigyan Kendra*, Kanker on March 12, 2019.
- 41 persons participated in one day training at *Krishi Vigyan Kendra*, Gariyaband on March 14, 2019.

7.6 Project on *guggul* gum at JNKVV, Jabalpur

Physio-chemical analysis of *guggul* gum in storage

Twelve months after the storage the *guggul* gum in different containers (Fig. 7.17) were subjected to physio-chemical and qualitative analysis. The same analysis was repeated after twenty four months also from Sophisticated Analytical Instrument Facility (STIC), Kochi, Kerala.Twenty four months after the storage, it was found that the samples stored in the jute bags had highest N (2.34%) and H (9.04%) while lowest value was 0.001%. The decline was 1.25, 1.56 and 0.75 per cent respectively. Sulphur content was highest (0.13%) in the *guggul* samples in earthen pots and lowest (0.001%) in jute bags. The decline was 6.38 and 0.079 per cent respectively.

a. Packing/containers used to store fresh *guggul* gum

b. Earthen pots of different thicknesses used to store fresh *guggul* gum

Fig. 7.17: Storage study for *guggul* gum

Guggul samples stored in earthen pots the spectra of T_1a were compared with T_1b. The BB of 3500-3200 cm^{-1} observed in the spectra of T_1a only, which indicates the presence of higher moisture content and presence of alcoholic compounds but the absence of these BB in T_1b demonstrates the loss of moisture content and alcoholic compounds after 24 months of storage. The data obtained after FT-IR analysis also revealed the superiority of earthen pots as a storage container among all the storage containers used in the present study. Irrespective of the storage containers, the duration of storage results in qualitative loss of active groups in *guggul* (Fig. 7.18).

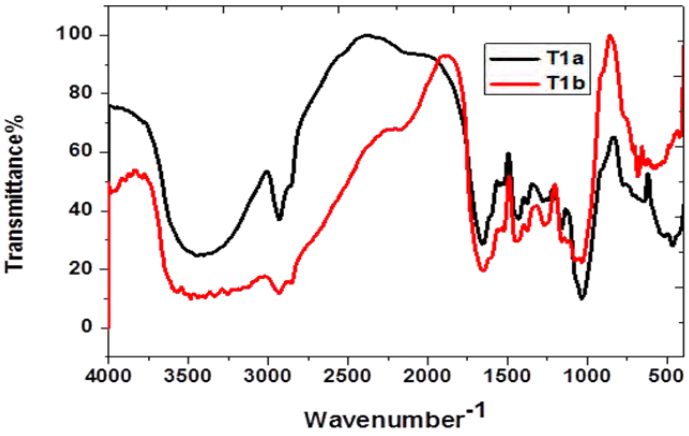


Fig. 7.18: FT-IR specra of *guggul* samples

Morphology shows specimen T_1b was viscid compared to other samples. This may be due to the presence of moisture in T_1b. FT-IR spectra also very well agreed to this. SE image of the sample T_2b appears to be cracked which indicates low moisture content in it. While the SE image of sample T_3b appears in a blended form. SE image of the sample T_4b was more like flakes or wafers. At higher magnifications specimen T_4b sample appeared free of any blends but as layers or flakes. If we compare all the images of the 24 months old stored samples of *guggul* with images of *guggul* samples stored for 12 months the data revealed a reduction of moisture content from all the samples stored up to 24 months (Fig. 7.19).

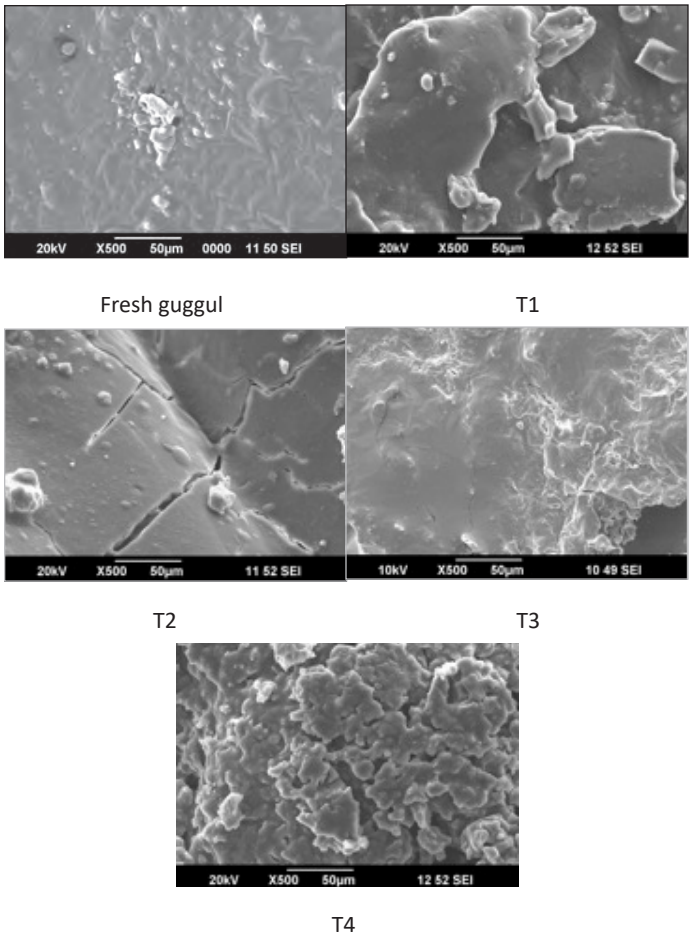


Fig. 7.19: SE images of *guggul* samples

Moisture content depends on the storage container and duration of storage. Among the storage containers earthen pots appears to be the best even for 24 months of storage of *guggul* samples. The temperature of initial and maximum decomposition of a material is important information obtained by TGA (Fig. 7.20).

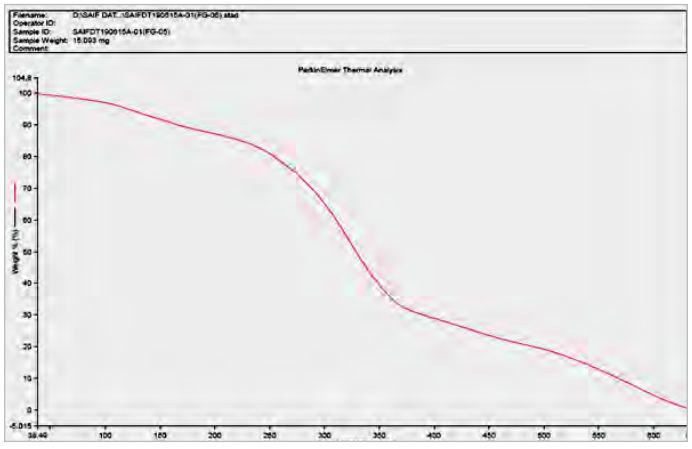


Fig. 7.20: TGA graph of *guggul* sample

The *guggul* sample stored for 24 months in earthen pots (T_1b) had an initial decomposition at about 100 °C against, the initial decomposition temperature of 140 °C of the 12 months old sample (T_1a) stored in earthen pot. This may be due to presence of high moisture content in T_1a sample as compared to T_1b. The maximum rate of decomposition of T_1a sample was near 300°C while in T_1b it was near 280°C. The initial decomposition of the 24 months old *guggul* samples stored in Plastic jars (T_2b) was at about 100°C whereas for 12 months old sample (T_1a) it was at near 120°C. The maximum rate of decomposition ofT_2a was at near 280°C while for T_2b it was near 210°C. The initial decomposition of the 24 months old stored *guggul* sample in polythene bag (T_3b) was at 100°C while that of 12 months old *guggul* sample (T_3a) was at near 140 °C, this indicates less moisture content in the second year sample. Maximum decomposition at low temperature indicates loss of other organic compounds in the sample. Similar trend was found during comparative analysis of TGA graphs for the *guggul* sample stored in jute bag (T_4).

Diffractogram of the *guggul* gum sample stored for 24 months in earthen pots (T_1b) exhibited lesser degree of crystallinity in comparison to that in 12 months. Similarly the samples stored in plastic jars (T_2), polythene bags (T_3), jute bags (T_4) and high density polyethelene bag (T_5) did not exhibit such a crystalline nature though they also exhibited less intense peaks at 25 °C. Thus all the physico-chemical analysis (CHNS, FTIR, SEM, TGA and X-Ray diffraction) strongly suggests for storage of *guggul* in earthen container. However, the length of storage reduces qualitative parameters of *guggul*.

Processing and value addition of *guggul*

Jaggery *Guggul* Laddu: Jaggery based *guggul* laddu was prepared with powdered *guggul*, cleaned, roasted and crushed linseed, ghee, jaggery, cashew, almonds and raisins.

Honey *Guggul* Laddu: The Tasters suggested if we could reduce the sweetness and also the quantity of ghee, as people with high cholesterol and diabetics may avoid it.

Tasters still complained for bitterness of *guggul* and the odd flavor of roasted linseed. They also suggested removing cashew, almonds and raisins as they were still making the laddu heavier to digest.

***Guggul* Fortified Laddu:** Cashew, almonds and raisins were replaced with rajgira (Amaranthus seeds). After sieving, washing, shade drying and roasting, the linseed was now grinded instead of crushing. Similarly, rajgira was also roasted and grinded. The grinded components were thoroughly mixed with spatula by sprinkling *guggul* powder at regular intervals.

Tasters reported reduction in bitterness of *guggul* and odour of linseed. Probably, mineral rich rajgira may have masked the undesirable taste.

a) **Standardization of the size of the laddu:** The 20 g *guggul* fortified laddu contains *guggul* l- 5.0 mg, linseed-13.5 g, rajgira- 1.7 g and honey- 4.5 g. After standardization of the composition of the *guggul* laddu, it was the time to decide the size of the laddu. We prepared *guggul* fortified laddus of three size: 30 g, 25g and 20g. Most of the tasters went for three bites to consume the 30 g *guggul* fortified laddu, while two bites were required for the 25 g laddu. All the tasters gulped the 20 g laddu without biting but chewed before consuming.

b) **Composition of 20 g *guggul* fortified laddu:** Two applications for the patents have been filed on 'Composition of *guggul* fortified laddu' and 'Preparation of *guggul* fortified laddu and method thereof'. Application No.201821031051A and 201821040442A have been generated respectively. Consequently, Department of Food and Drug, GoMP has issued the License/Registration No. 21418170000805 for its commercial production. Jawaharlal Nehru *Krishi Vishwa Vidyalaya*, Jabalpur has named the *guggul* fortified laddu as 'Jawahar *guggul* laddu' and the selling price is officially fixed at Rs. 250/- for a pack of 30 laddus.

7.7 Project on tamarind seed gum at TNAU Coimbatore

Flower production by inducing the florigen

Exogenous foliar application of chemicals plays a major role in the flower opening, fruit drop, growth and development of fruits, enhancing yield and keeping quality of fruits. These regulating chemicals, KNO_3 and KH_2PO_4 and some of the growth retardants, ethrel and cycocel at optimum concentrations, are playing vital role in increasing bearing and modifying physiological process of plants (Fig. 7.21). Ethrel (2- Chloroethylphosphonic acid) release ethylene gas, when it comes in to contact with the plant tissues in turn triggering the mechanism of flowering and also may be due to breaking of dormancy of shoots.

Fig. 7.21: Pruning of canopy for early flower inducing and the resultant flower induction after application of florigen

Cycocel brings about a reduction in gibberellins production in young leaves which in turn results in a reduced output of auxin from the apical meristem and consequently cycocel treated plants are more compact with shorter internodes, stronger stems and greater leaves. KNO_3 is one of the chemical inducing substances that have shown some potential for inducing flowering in mango by increasing the activity of nitrate reductase and stimulating the production of ethylene. In 5 tamarind germplasm planted, Hasanur 06 sprayed with foliar application of cycocel with 1000 ppm concentrations has showed maximum flowering in tamarind.

Value addition of tamarind seed gum for edible purpose

Preparation of fruit jelly using tamarind seed gum: Jelly is the semisolid fruit product made from fruit juice. It should be clear and free from any residual parts of fruit and firm to hold its shape.The percentage of fruit sugar in the juice is read with a refractometer. Multiplying the refractometer reading by the weight of the fruit juice gives the weight of the fruit sugar (soluble solids) in the juice. The weight of the sugar to be added as a jelly ingredient is attained by multiplying the weight of sugar required per unit weight of fruit solids by the weight of the fruit sugar in the juice. The viscosity of 108.60 cps was occurred in the fruit jelly prepared by using tamarind seed gum with the RPM of 50, this was equal with the jelly prepared with the commercial pectin.

Viscosity analysis: Tamarind kernel powder (TKP) taken in various concentrations with 100 ml of water and boiled for 20 min and the solution prepared used for viscosity analysis.

Entomological studies on tamarind pod and seed storage: Coconut oil 2%, pungam oil 3%, neem oil 3% and sweet flag oil 0.5 % are recommended for the management in tamarind weevil, which resulted in 100 per cent mortality.

Preliminary studies on assessing gum production in tree species with regional importance

Identifying and standardize the level of gum booster in neem (*Azadirachta indica*): In neem, the amount of gum production was maximum (111.59 g) in February followed by April (104.39 g), 31 March (101.81g), January (99.99 g) and May (93.92 g) respectively. The pH value range from 4.36 to 4.69 among the various observations. Maximum pH was recorded in drilling method and control (4.69) followed by 4.53 in T_3 and least pH was observed in T_5 (4.36). There was not much significant variation on pH.

The average protein content of neem gum during the different month from January to May was almost same and there was no significant difference among treatments. Among the treatments, T3 (29.45 %) had highest protein content followed by T_2 (29.32 %) and T_1 (29.16 %). Least protein percentage was reported in T_5 (28.08 %). The highest viscosity was observed (21.08 cps) at 20 rpm/min, whereas, lowest was recorded (10.39 cps) at 100 rpm/min. As the rpm increases the viscosity decreased, which indicates that the rpm influences the viscous property of gum. The average solubility percentage of neem gum in hot water (84%) was highest, followed by cold water (69.2%), acetone (33.62%). The gum was least soluble in ethanol (3.2%).

7.8 Project on Natural Dammar at KAU, Thrissur

Study on effect of girth classes and tapping method on gum-oleoresin yield from *Ailanthus triphysa*

Present study revealed that the gum-oleoresin yield from *Ailanthus* trees during the whole study period (May 2018 to April 2019) was ranged from 13.00 gm to 99.38 gm in an average. Among the girth classes it was varied from 13 gm to 75.09 g for 70-110 cm girth class, 19.46g to 99.38g for 111-150 cm girth class. Data presented above showed the similar trend as it was noticed at monthly intervals. Girth classes were found to be not significantly different.

Similarly, the gum-oleoresin yield due to concentration of ethephon ranged from 5.80 g to 32.97g in T1 (control method), 15.88 g to 92.67 g in T2 (2.34% ethephon), 14.15 g to 99.32g in T3 (3.12% ethephon) and 28.11 g to 123.99 g in T4 (3.9% ethephon). It is statistically found significant difference in gum-oleoresin yield due to different concentration of ethephon treatment (Table 7.5). The study reveals that the T4 (3.9%) is significantly different from other concentration of ethephon treatment in gum-oleoresin production. The September month was found to be best as it produces highest amount of gum-oleoresin *i.e.* 348.94 g. The interaction between girth classes and ethephon treatment found to be non-significant for all the monthly intervals as well as for whole study period that means there is no relationship between girth class and different concentration of ethephon treatment.

Table.7.5: Effect of ethephon on gum-oleoresin yield (g) (May 2018-April 2019)

Ethephon treatment	Months												
May		Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	
T1 (cm)	11.01	14.83	10.33	15.12	32.97	31.26	30.11	22.35	21.59	16.95	13.84	5.80	226.16[a]
T2 (2.34%)	16.83	22.33	21.76	50.25	92.67	73.21	55.78	34.74	65.96	32.10	31.33	15.88	512.74[a]
T3 (3.12%)	14.15	25.00	23.50	45.67	99.32	70.89	48.45	23.24	36.14	26.63	26.89	17.51	457.38[a]
T4 (3.9%)	37.87	43.50	27.50	52.72	123.99	105.36	84.94	50.33	126.39	72.21	65.07	28.11	817.99b
P-value(Treatment)	.001**												
P-value (Interaction)	0.917 ns												

** significant different at 5% and 1% level, ns -non-significant difference at 5 %

Physical characteristics of black dammar and white dammar from different areas in Kerala

Black dammar and white dammar were collected from different regions of Kerala and their physico-chemical properties were studied. The physical properties include pH, refractive index, specific gravity, mean viscosity, viscosity range, colour value and conductivity, as shown in Table 7.6.

Both dammars showed slightly alkaline pH except white dammar sample which was collected from Malakkapara, Vazhachal forest division. It showed slightly acidic pH (6.13). Refractive index and specific gravity of both black dammar and white dammar showed almost same value in different regions. Mean viscosity (900 cP) and viscosity range (10-600 cP) were found to be high in white dammar collected from Malakkapara.Black dammar and white dammar showed same colour values (5.5) in all regions. Conductivity was reported to be high in white dammar in comparison with black dammar.

Table 7.6: Physico-chemical analysis of black dammar and white dammar

Sl. No.	Samples	pH	Refractive index (nD)	Specific Gravity (g/ml)	Mean Viscosity (cP)	Viscosity Range (cP)	Colour Value	Conductivity (mS)
1.	Black dammar-Malakkapara (B.M.)	7.57	1.3006	0.999	687	7-400	5.5	0.001
2.	Black dammar-Neliampathy (B.N.)	7.38	1.3307	1.004	560	10-250	5.5	0.00

Sl. No.	Samples	pH	Refractive index (nD)	Specific Gravity (g/ml)	Mean Viscosity (cP)	Viscosity Range (cP)	Colour Value	Conductivity (mS)
3.	White dammar- Malakkkapar a (W.M.)	6.13	1.3308	0.997	900	10-600	5.5	0.008
4.	White dammar- Peechi (W.P.)	7.27	1.3307	1.000	323	5-200	5.5	0.005

Black dammar and white dammar were tested for the presence of various metals, moisture content and other physical features, in KAU and other regional laboratories.

Mineral analysis of the dammars revealed that NPK content of *canarium* was not much deviated from *vateria* and traces of heavy metals were recorded below detection level.

The quantification of various metals was carried out using Perkin Elmer - Avio 200 instrument. In black dammar, all elements were present except Calcium. Calcium content was very less or it was found to be below detection level. The content of Iron and Zinc was relatively higher in black dammar compared to white dammar. The Chromium and Nickel were present in equal amount in both dammars (Table 7.7 and 7.8).

Table 7.7: Minerals and heavy metal analysis of black dammar and white dammar

Minerals/Metals	Dammars	
	Black dammar	White dammar
Nitrogen (%)	0.015	0.0128
Phosphorus (%)	0.0080	0.0067
Potassium (%)	0.0060	0.0052
Lead (ppm)	BDL	BDL
Copper (ppm)	BDL	BDL
Mercury (ppm)	BDL	BDL

BDL-Below Detection Level

Table 7.8: Quantification of Ca, Cr, Fe, Mg, Fe, Mn, Ni, Zn

Sl. No.	Elements	White dammar (ppm)	Black dammar (ppm)
1.	Ca	162.5	BDL
2.	Cr	150.0	150.0
3.	Fe	262.5	1062.5
4.	Mg	350.0	412.5
5.	Mn	175.0	212.5
6.	Ni	137.5	137.5
7.	Zn	2787.5	3375.0

BDL-Below Detection Level

Both black dammar and white dammar were analyzed for the presence of carbon, hydrogen, nitrogen and sulfur (Table 7.9). Euro vector CHNS analyzer was used for analyzing these parameters. Nitrogen was below detection level in both dammars. Carbon percentage was relatively higher in white dammar compared with black dammar.

Table 7.9: Quantification of C, H, N and S

Sl. No.	Sample Name	Sample Weight (mg)	N (%)	C (%)	H (%)	S (%)
1.	White dammar	3.5	BDL	63.466	3.724	3.320
2.	Black dammar	3.9	BDL	57.0	2.827	4.428

BDL-Below Detection Level

Extension activities: The centre conducted several extension programmes on value addition of black dammar including black dammar incense sticks making. The black dammar incense sticks were sold through various outlets of KAU.

Lecture to post graduate students: A group of post graduate students from St. Mary's College, Thrissur visited Resin Laboratory to learn about extraction and processing of dammars of Kerala as a part of their Non-Timber Forest Products (NTFP) course. A lecture on 'Major resin yielding trees of Kerala, their sustainable extraction and its value addition' was delivered to them on 5thOctober, 2019.

Visit of Cornell University team: A team from Cornell University, New York visited the agarbatti making unit established under ICAR Network Project on 8th January, 2019. The PI explained the importance, economic utility and value addition of black dammar to the team. The Cornell University team appreciated the efforts of scientists working in the project.

Photos: Visit of Cornell University team at agarbatti making unit

Training for tribal in incense sticks making: A training programme was organized for the tribal on incense stick making on 20th February, 2019 at College of Forestry, Thrissur. Tribal from different Forest Divisions of Kerala participated in the training. Black dammar incense sticks making kits were distributed to tribal during the training programme.

Photos: Training to tribal in incense sticks making at College of Forestry, Vellanikkara

Release of black dammar incense sticks: The official release of black dammar incense sticks was conducted on 25thFebruary, 2019 by Hon'ble Agricultural Minister of State

Photos: **Release ceremony of black dammar incense sticks**

Sri VS Sunil Kumar at Kerala Agricultural University. The Minister released the product by handing over the packets of incense sticks to tribal in presence of various officials.

Production and marketing of black dammar incense sticks: After hands-on-training, tribal from Chimmony Wildlife Sanctuary had taken an initiative to produce hand-made black dammar incense sticks and they have now successfully started selling incense sticks through Vanasree Ecoshops.

7.9 Project on *Pinus kesiya* resin at ICAR-Research Complex for NEH Region, Umiam

Standardization of resin tapping technique in *Pinus kesiya* for sustainability and conservation of natural resources

The tree from three different provenances of the species was tapped to assess its resin production potential. Tapping was periodically done from April, 2018 to January, 2019 by the borehole method. Mean resin yield varied from 41.36 to 115.8 gm/tree, maximum production being achieved in January followed by October (Table 7.10). Oleoresin was distilled through a steam distillation process to separate turpentine and rosin from the oleo-rosin.The tree from three different provenances of the species was tapped to assess its resin production potential. Tapping was done monthly from April, 2018 to January, 2019 using a standardized borehole method.

Mean resin yield varied from 41.6 to 115.8 gm per tree, maximum production being achieved in January followed by October (Table 7.10). Resin yield was found to be maximum for Shangpung provenance as compared to other provenances for all the diameter classes. Oleoresin was distilled through a steam distillation process to separate turpentine and rosin from oleo-rosin. Turpentine was separated from all three provenances.

Table 7.10: Effect of tapping season and provenances on

resin yield of *Pinus kesiya*

Collection	Resin yield (g tree^{-1})								
	Umshing, East Khasi Hills			Umsawkhwan, Ri-Bhoi			Shangpung, West Jaintia Hills		
	Diameter class (cm)								
Month	30-35	35-40	40-50	30-35	35-40	40-50	30-35	35-40	40-50
April	77.34	70.55	92.93	68.91	90.35	68.92	47.91	114.18	52.39
May	83.99	38.72	65.37	59.03	53.49	62.99	88.60	98.07	9.17
June	67.25	43.29	83.98	62.03	54.20	61.49	-	-	-
July	46.32	49.36	44.00	31.48	115.15	43.68	95.32	217.00	118.84
August	62.22	36.15	41.79	29.20	113.23	23.47	96.69	117.64	94.78
September	54.40	59.18	44.98	29.09	102.93	52.70	114.31	71.11	72.71
October	40.12	77.73	41.91	42.02	59.16	43.98	120.01	143.52	188.75
November	45.60	63.66	40.37	53.26	84.99	96.70	97.46	158.85	206.31
December	41.81	64.84	26.55	53.07	59.52	109.52	125.40	163.25	91.64
January	93.77	94.55	95.88	98.02	118.99	123.38	87.59	139.12	190.89

Training programmes on improved method of resin extraction: Most of the forest in the north east region is owned by the local community. Few private owners are engaged in commercial resin tapping in the north east region. For example, In Nafra Valley, West Kameng, Arunachal Pradesh about 85000 tins (12,75,000 kg) of resin (each tina consist of 15 kg oleoresin) is collected every year using cup and lip method of resin tapping from *chir pine* (*Pinus roxburghii*). Every year resin is tapped from April to October. Commercial extraction of resin from *chir pine* is done on a lease basis. Resin is commercially extracted from community forest and collected resin is transported to factory Nafra Chemical Pvt. Ltd. situated at Bhalukpong, West Kameng, Arunachal Pradesh.

Every day about 2250 kg resin (150 tin) is processed and about 1650 kg of rosin and 250-270 kg turpentine oil is produced from processed resin. The small scale factory is run by one manager, two mistri (supervisor) and six labourers. Resin is processed and rosin and turpentine are collected. However, most of the trees in the community forest are severely damaged due to indiscriminate resin extraction from trees of all sizes. Since they extract resin on contract basis (Rupees per kg of the collection) and tree health is not a priority for the workers and trees of all sizes are tapped using cup and lip and now rill method of resin extraction.

The one-day training programme was organized on 18th March, 2019 with the help of local NGO, at Nafra village of West Kameng district of Arunachal Pradesh. A total of 40 resin extractors attended the training programme and they were given hands-on-training on the borehole method of resin tapping.

Another training programme was organized at Shangpung Mission Village of Jaintia Hill district of Meghalaya. A total of 40 persons participated in the training programme who were given hands-on training on the bore hole method. In Jaintia Hills, villagers peel and slice bark of the trees to collect resin and resinous firewood to initiate a fire in the fire places during winters. Most often the trees die because of severe injury to the trees. The villagers were demonstrated about the alternate method of resin extraction for their domestic use while avoiding fatal injury to the standing trees.

Photos: **Training and demonstration at Shangpung village of Meghalaya**

Photos: Hand-on-training on resin tapping at Nafra village of Arunachal Pradesh

Publications (Network Co-operating Centers)

Research Paper

- Balasubramanian A, Hari Prasath CN and RadhakrishnanS (2019). Agro-climatic influence on seed characterisation and kernel powder yield in tamarind (*Tamarindus Indica* L.). *Ind. J. Plant Soil* 6(2): 83–86.
- Hari Prasath CN, Balasubramanian A, RadhakrishnanS and SivaprakashM (2019). Comparative growth performance of gum yielding tree species cultivated under drip irrigation in farmlands. *Ind. J. Plant Soil* 6(2): 87–90.

Popular Article

- Prasad R, Singh R, Alam B, Handa AK, Shukla A, Singh P and KumarA (2019). Integration of gums and resins yielding trees in agroforestry systems for livelihood support in Bundelkhand, Central India. Agri-Life. January-June, 35-40.

Patent Filed

- Tripathi N, Thakur VV, Pooniya SK, Moni T, Tantwai K, Rajput LPS, Khare D (2019). A DNA based method for verification of *Boswellia serrata* gum as adulterant in gum oleo-resin of *Commiphora wightii* by extraction of DNA of high quality from them and development of a primer set for its amplification. No. 201921005333 A.

Research papers presented in conferences/symposia

- Suganthy M, BalasubramanianA, SabuAK, Hari Prasath CN and Kumar PP. Effect of insect feeding on physico-chemical properties of tamarind seed gum. National seminar proceedings of Nutraceuticals & Functional Foods 2019, IIFPT, Thanjavuron, January 30, 2019.
- Jadhav BA, Syed HM and Khapre AP. Technology development for preparation of nutra laddu by incorporation of Linseed, Amaranth and *Guar* gum. International Conference on Emerging Trends in Microbiological Sciences & IPR (ETMS-IPR–2019), Dr. BAMU at Milliya Arts, Science & Management Science College, Beed Maharashtra, February 07, 2019.
- Shiran K, Tewari JC, Sharma AK and Paree kK. Effect of management practices and dose of gum inducer on gum production of *Acacia senegal* in rocky land form. 13th International Conference on Development of Drylands-Converting dryland areas from Grey to Green, IDDC and AZRAI, Jodhpur, February 11–14, 2019.
- Swami S and Shiran K. Natural gums as microencapsulants for food flavours. 13th International Conference on Development of Drylands-Converting dryland areas from Grey to Green, IDDC and AZRAI, Jodhpur, February 11–14, 2019.
- Radhakrishnan S, Balasubramanian A, Sivaprakash M and Hari Prasath CN. Gum induction study in lesser known gum yielding tree species. Proceedings of National Conference on Climate Smart Agriculture for Livelihood Security: Challenges and Opportunities, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappallion, September 13-14, 2019.
- Balasubramanian A and Hari Prasath CN. Techniques for exploiting tamarind seed as a source of gum for greener future. XXV IUFRO World Congress, Curitiba, Paraná, Brazil, September 29 to October 05, 2019.
- Vidyasagaran K, Gopakumar S, Nishad ES and Sajith MS. Natural resins and gums of Kerala with special reference to resin extraction. Indian Botanical congress-XLII, All India Botanical Conference & National Symposium on Innovations & Inventions in Plant Science Research, University of Calicut, November 06 – 08, 2019.

Network Project on Conservation of Lac Insect Genetic Resources

A. Lead Center: ICAR-IINRG Ranchi

Evaluation of lac insects on different lac host plant for host suitability

Three lac hosts *viz*. *F. semialata* grafted on *F. macrophylla*, *F. semialata* and *F. macrophylla* were evaluated for host suitability during summer season (*jethwi*) *kusmi* and rainy season (*katki*) *rangeeni* lac crop 2019. Average initial density of settlement was more in *F. semialata* (51 per sq cm) followed by Grafted plant (42 per sq cm) and *F. macrophylla* (40 per sq cm) during *Jethwi* crop but, the average initial mortality was comparatively less in *F. macrophylla* (8 per cent) followed by *F. semialata* (10 per cent) and grafted plant (11 per cent). Male sex ratio was more than optimum (60 to 64 per cent) on all the hosts. The lac insect did not survive upto crop maturity in all the three hosts.

In *Katki*, 2019, the average density of settlement ranged from 22 to 32 per sq cm. Initial mortality on *F. macrophylla* was 21.84 per cent and at par with each other of Grafted plant and *F. semialata.* Male sex ratio was less than optimum on *F. semialata* (26 per cent) and grafted plant (23 per cent) and *F. macrophylla* (19 per cent). The survival at crop maturity was comparatively more in both grafted (14 per sq cm) and *F. semialata* (13 per sq cm) in comparison to *F. macrophylla* (6 per sq cm). Average fecundity was more (359 nos) in Grafted plant followed by *F. macrophylla* and *F. semialata*. No difference was found in cell weight and resin weight all three host plants (Fig. 8.1 and 8.2). Host suitability and Relative Index were in ascending order of *F. semialata* <Grafted<*F. macrophylla* (Table 8.1)

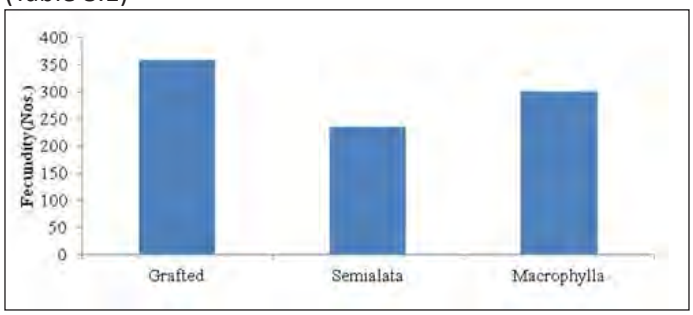


Fig. 8.1: Fecundity during rainy season (*katki*) crop 2019

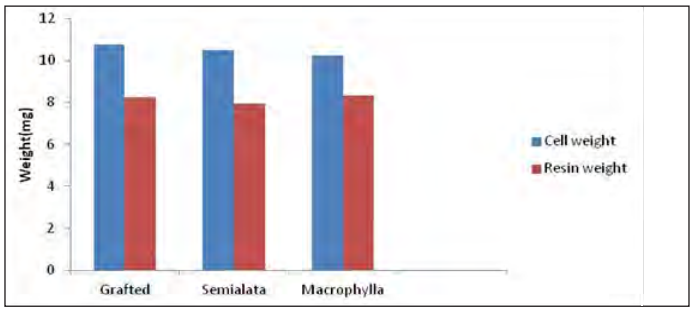


Fig. 8.2: Cell and resin weight during rainy season (*katki*) crop 2019

Table 8.1: Host suitability index during rainy season (*katki*) *rangeeni* lac crop 2019

Host	% Host preference	% Length of settlement at crop maturity	% survival of lac insect at crop maturity	Weight of resin produced by individual female (mg)	Host suitability index	Relative index
Grafted	93.33	72.15	48.29	8.22	26746.16	2.10
F. semialata	93.33	85.13	43.83	7.92	27591.38	2.16
F. macrophylla	80.00	58.42	32.77	8.32	12746.12	1.00

Propagation of *F. semialata on F. macrophylla*: Vegetative propagation using cleft grafting using *semialata* on *macrophylla* was continued. Out of one hundred cleft grafted forty-three per cent were successful (Fig. 8.3).

New host range for scale insect *Trijuba oculata* (Brain): *F. semialata* was recorded as new host at Thrissur for scale insect, *Trijuba oculata* (Brain) Coccidae, Hemiptera (Fig. 8.4).

Barcoding of lac insects and predators: Barcoding of newly collected lac insect lines was carried out for their identification up to species level. Genomic DNA of the

Fig. 8.3: Cleft grafted *F. semialata* on *F. macrophylla*

Fig. 8.4: *Trijuba oculata* on *F. semialata*

lac insects was PCR amplified with universal barcoding primers targeting cytochrome oxidase subunit 1 gene (*cox1*). PCR products were sequenced and the sequences were searched against the NCBI database to find their closest match. Based on the search results, two new lac insect lines collected from Madurai (Tamil Nadu) on rain tree and from Malerkotla (Punjab) on *ber* were found to be *rangeeni* strain of *Kerria lacca* (Table 8.2). *Cox1* sequences were amplified and sequenced from the two important lac insect associated ant species, for the first time.

Table 8.2: Barcoding of the newly collected lac insects

Code	Location	Host tree	Product length (bp)	Matching with species and its accession number	E value	% identities
Raj.Mdu	Madurai	Rain tree	647	*Kerria lacca* / HQ323770.1	0.0	99.38
PBPB6	Malerkotla	*Ber* sp	616	*Kerria lacca* / HQ323758.1	0.0	99.67

Optimal normalizer gene for lac insect gene expression studies: Primers for qPCR were synthesized for different house keeping genes viz., glucose 6 phosphate dehydrogenase (G6PDH), 60S ribosome subunit, 28S rRNA, elongation factor alpha, tubulin and actin. qPCR was conducted with cDNA prepared from different life stages of lac insects *viz.*, crawlers, settled nymphs, fertilized female insects and mature adult female insects and also with serially diluted cDNA concentrations from 500 ng/µl to 0.05 ng/µl. Normfinder software was used to find the optimal normalizer gene from the Ct (threshold cycle) values obtained. Gene coding for 28S rRNA and 60S ribosomal subunit were found to the optimal normalizer genes at different cDNA concentrations for all developmental stages of lac insects.

Microbiome study of lac insect crawlers and adult female lac insects: V3-V4 metagenome sequencing of crawlers and adult female lac insects were carried out using Illumina Hiseq 2500 platform. Approximately 87% reads obtained had phred score of Q30. A total of 15350 Operational Taxonomic Units (OTUs) were picked for both the samples. All sequences from both the samples were clustered into OTUs at 97% sequence similarity using QIIME. A total of 1646 OTUs were identified that represented the bacterial species present in these samples. Taxonomical annotations of the sequences were done based on SILVA database.

In females, Gammaproteobacteria and Alphaproteobacteria were the most abundant classes of bacteria present whereas in crawlers, Bacteroidia and Alphaproteobacteria were the most abundant classes. Enterobacteriales followed by unknown and Rickettsioses were the most abundant order OTUs in females compared to Rickettsiales and Enterobacteriales after others and unknown orders in crawlers. Proteobacteria followed by unknowns and Bacteroidetes were the most abundant phylum in females; Proteobacteria followed by Bacteroidetes were the most abundant phylum in crawlers. As far as families are concerned, Enterobacteriaceae and Anaplasmataceae were the most abundant in females and crawlers apart from unknown families. After unknown genus, *Wolbachia* and *Pantoea* were the most abundant genus in females compared to others and unknown, followed by *Wolbachia* and *Mucilaginibacter* in crawlers. At species level, after unknowns, uncultured and others, Wolbachia-endosymbiont of *Diaphorina citri* (Asian citrus psyllid) were the most abundant in both females and crawlers. *Asaia*-sp.-AG-3.5-Aa species was uniquely present in females but not in crawlers. Alpha diversity within the samples were analyzed by using Shannon and Chao1 metrics. The chao1 metric estimates the species richness while Shannon metric is the measure to estimate observed OTU abundances, and accounts for both richness and evenness. The rarefaction curve for each of the metric reached plateau revealing the depth of sequencing and sequencing coverage were good (Fig. 8.5).

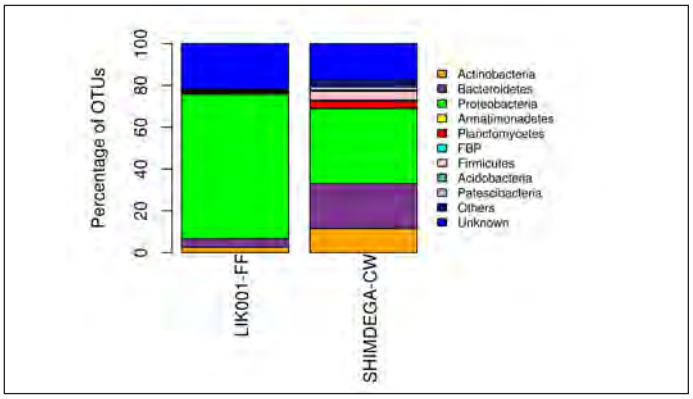


Fig. 8.5: Relative abundance of OTUs at phylum level present in females and crawlers

Lac biodegradibility study

Soil metagenome analysis: Seedlac samples were buried in the soil of Institute Research Farm and in the pot containing pot mixture on 17.9.2016. The soil samples were drawn on 17.6.2019 and sent for sequencing of V3-V4 region of 16S rRNA gene to Agrigenome Labs Private Ltd, Cochin. DNA was isolated from the samples and V3-V4 region of 16S rRNA gene was amplified using the primers

V3 Forward primer CCTACGGGNBGCASCAG and V4 Reverse primer GACTACNVGGGTATCT AATCC. The amplified product was checked on 2% agarose gel and gel purification was done to remove non-specific amplifications. Five ng of amplified product from each sample was used for library preparation using NEBNext Ultra DNA library preparation kit. The library quantification and quality estimation were done in Agilent 2200 TapeStation. The prepared library was sequenced in Illumina HiSeq 2500 platform.

Pot burial experiment results: The phred score of more than 30 and 20-30 were obtained for ~87% and 4% of the sequences, respectively. After removing duplicates and chimeras, from these sequences, a total of 582034 preprocessed consensus were obtained for control pot and seedlac buried pot samples. A total of 10118 OTUs were obtained for the pot experiment samples. The representative sequences from each clustered OTUs were picked and aligned against SILVA core set of sequences using PyNAST program. Further, taxonomy classification was performed using RDP classifier by mapping each representative sequence against SILVA OTUs database. The results showed that majority of the class, order, phylum, genus and species OTUs were unknown ones. Besides them, the most abundant class OTUs belonged to Alphaproteobacteria and Planctomycetacia classes in both control and seedlac pot samples. The most abundant order OTUs was Rhizobiales and uncultured bacterium in control whereas Rhizobiales and Gemmatales were the most abundant order OTUs in control and seedlac pot samples. The most abundant phylum OTUS were Proteobacteria and Acidobacteria in control and seedlac pot samples. The most abundant genus OTUs included Candidatus-Solibacter and Candidatus-Udaeobacter. In seedlac pot samples, the genus Candidatus-Udaeobacter and Gemmatimonas were slightly more than control sample. The most abundant species OTUs were uncultured-Acidobacteria-bacterium and uncultured-archaeon in both the samples (Fig. 8.6).

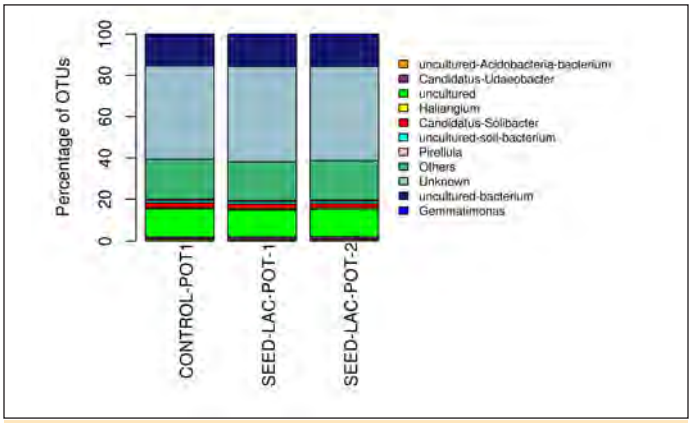


Fig. 8.6: Percentage of OTUs at genus level in control and seedlac buried pot samples

Soil burial experiment results: The phred score of more than 30 and 20-30 were obtained for ~86% and 5% of the sequences, respectively. The results showed that majority of the class, order, phylum, genus and species OTUs were unknown ones. Besides them, the most abundant class OTUs belonged to Planctomycetacia and Alphaproteobacteria classes in both control and seedlac pot samples. The most abundant order OTUs was Gemmatales and Rhizobiales in control and seedlac buried soil samples. The count of Betaproteobacteriales was slightly higher in seedlac buried soil samples compared to control. The most abundant phylum OTUS were Proteobacteria and Acidobacteria in control and seedlac buried soil samples. The count of Proteobacteria and Acidobacteria were slightly more in treated soil compared to control. The most abundant genus OTUs included Candidatus-Solibacter and Candidatus-Udaeobacter. The most abundant species OTUs were uncultured-Acidobacteria-bacterium and uncultured-archaeon in both the samples.

In both sets of experiments, the microbial diversity within the samples were analyzed by calculating Shannon, Chao1 and observed species metrics. The observed species metric is the count of unique OTUs identified in the sample. The rarefaction curve for each of the metric reached near plateau showing that the sequencing depth and coverage were adequate for all the samples. Apparently the soil metagenome of the control soil and soil exposed to seedlac did not reveal enough variation to be compared.

Field guide for identification of major lac host plants

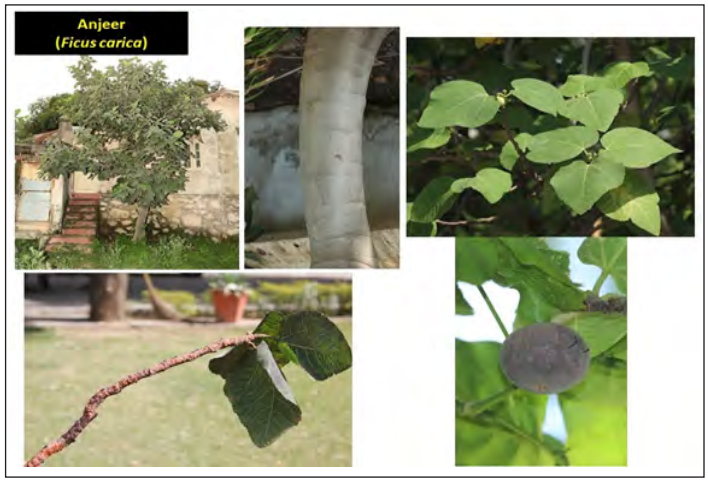
With the objective of creating a photographic guide for identification of major lac host plants, the photographs of different parts of lac host plants such as leaves, flowers, fruits, seeds, bark, lac, exudating gum if any, and their botanical details were compiled for 49 lac host plants. The list of lac host plants belonging to 18 families as given below:

1. Anacardiaceae: *Mangifera indica* (Mango)
2. Annonaceae: *Annona squamosa* (Custard apple)
3. Bombacaceae : *Adansonia digitata* (*Baobab*)
4. Burseraceae: *Garuga pinnata* (Kondeyore)
5. Caesalpinioideae: *Peltophorum ferrugineum* (Copper pod)
6. Dipterocarpaceae: *Shorea talura* (*Talura*)
7. Euphorbiaceae: *Croton oblongifolius* (*Putri*)
8. Fabaceae: *Butea monosperma* (*Palas*), *Cajanus cajan* (*Arhar*), *Dalbergia oojeinensis* (*Sandan*), *B. superb*

(*Latar palas*), *Desmodium pulchellum* (*Jatsalpan*), *Butea monosperma* Var *swadi* (*Swadi Palas*), *Pithecellobium dulce* (*Jungle jilebi*), *Amhertia nobilis* (*Shimshipavrisham/ Urvashi*)

9. Leeaceae: *Leea crispa* (*Leea*)
10. Leguminosae: *F. semialata* (*Semialata*), *F. macrophylla (Bhalia), F. bracteata (Madipata), F. chappar (Galphuli)*
11. Malvaceae: *Malvaviscus penduliflorus* (Turk's cap mallow), *Eriolaena spectabilis, Thespesia populnea* L *(Paras peepal)*
12. Mimosaceae: *Albizia saman* (Rain tree), *Albizia lucida (Galwang), Acacia catechu (Khair), Acacia farnesiana (Mimosa bush), Acacia nilotica (Babool), Acacia auriculiformis (Akashmani), Acacia tortulis (Kikar).*
13. Mimosoideae: *Calliandra calothyrsus* (Red calliandra), *Calliandra surinamensis* (Surinam)
14. Moraceae: *Ficus religiosa* (Pipal), *Ficus bengalensis (Banayan tree), Ficus benjamina* (Black fig), *Ficus glomerata (Gular), Ficus rumphii, Ficus carica (Anjeer), Ficus mollis, Ficus tsiela, Ficus tsjakela, Ficus microcarpa*
15. Papilionaceae: *Milletia extensa (Ganj, Gonj)*
16. Rhamnaceae: *Ziziphus mauritiana (Ber), Z. xylopyra (Ghont)*
17. Sapindaceae: *Schleichera oleosa (Kusum), Litchi chinensis* (Litchi)
18. Tiliaceae: *Grewia hirsuta* (Gursikhi)

Templates for some of the host plants are given below



Elemental analysis in lac insect-host plant ecosystem

Elemental analysis of leaf, stem, root, soil, lac insect, lac resin, was carried out for the presence of N,P, K, Ca, Mg, S, Fe, Mo, Mn, Cu, Zn, B, Cl, Pb. Out of these calcium, potassium, iron, magnesium, manganese and zinc were found in high to medium as compared to other elements in lac resin.

Per cent distribution of various elements in different treatments T1 (Lac insect + Fertilizer), T2 (Lac insect + No

Fertilizer), T3 (No Lac insect + Fertilizer) and T4 (control- No Lac insect + No Fertilizer) before inoculation and at maturity are shown in Tables 8.3 to 8.8.

Table 8.3: Per cent calcium partitioning in lac insect-host plant ecosystem

Treatments	Root		Stem		Leaf		Lac
	Before inoculation	Maturity	Before inoculation	Maturity	Before inoculation	Maturity	Maturity
T1	19.43	8.92	53.73	40.58	26.83	49.89	1.17
T2	21.06	8.71	55.63	21.99	23.29	69.05	0.43
T3	11.84	3.92	49.14	16.91	39.01	79.16	0
T4	11.02	3.98	46.88	8.27	42.09	87.73	0

Table 8.4: Per cent potassium partitioning in lac insect-host plant ecosystem

Treatments	Root		Stem		Leaf		Lac
	Before inoculation	Maturity	Before inoculation	Maturity	Before inoculation	Maturity	Maturity
T1	25.14	6.88	47.39	26.14	27.45	64.93	2.04
T2	11.32	6.44	67.63	29.93	21.04	61.77	1.84
T3	11.85	4.94	61.55	28.20	26.59	66.85	0
T4	13.84	16.79	69.48	30.90	16.67	52.29	0

Table 8.5: Per cent iron partitioning in lac insect-host plant ecosystem

Treatments	Root		Stem		Leaf		Lac
	Before inoculation	Maturity	Before inoculation	Maturity	Before inoculation	Maturity	Maturity
T1	70.33	60.99	14.73	25.52	14.92	1.46	12.02
T2	81.67	73.19	5.99	12.30	12.32	2.84	11.66
T3	18.81	35.84	13.87	56.48	67.31	7.67	0
T4	41.37	65.29	9.96	21.07	48.65	13.63	0

Table 8.6: Per cent magnesium partitioning in lac insect-host plant ecosystem

Treatments	Root		Stem		Leaf		Lac
	Before inoculation	Maturity	Before inoculation	Maturity	Before inoculation	Maturity	Maturity
T1	48.07	18.60	30.26	56.32	21.66	12.45	12.60
T2	23.27	21.14	63.32	52.79	13.40	20.14	5.91
T3	17.23	16.83	58.57	51.55	24.18	31.61	0
T4	16.22	34.05	60.32	30.35	23.45	35.58	0

Table 8.7: Per cent manganese partitioning in lac insect-host plant ecosystem

Treatments	Root		Stem		Leaf		Lac
	Before inoculation	Maturity	Before inoculation	Maturity	Before inoculation	Maturity	Maturity
T1	43.77	98.58	21.07	0.67	35.15	0.06	0.69
T2	46.71	98.05	21.51	0.93	31.78	0.13	0.89
T3	8.73	94.66	64.18	5.23	27.09	0.10	0
T4	29.23	99.29	16.87	0.62	53.90	0.10	0

Table 8.8: Per cent zinc partitioning in lac insect-host plant ecosystem

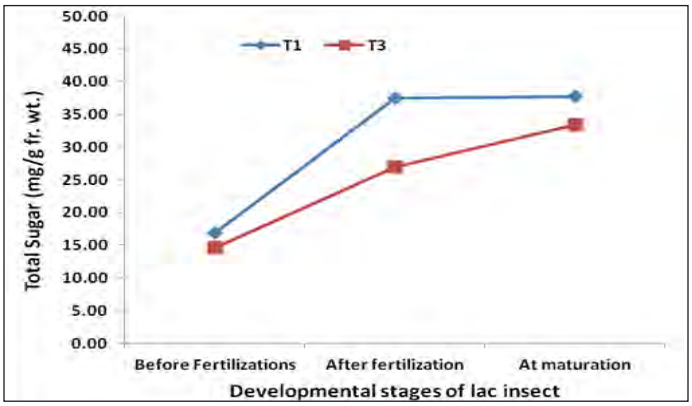
Treatments	Root		Stem		Leaf		Lac
	Before inoculation	Maturity	Before inoculation	Maturity	Before inoculation	Maturity	Maturity
T1	30.63	14.13	49.76	56.21	19.61	0.07	29.59
T2	40.28	39.06	48.21	39.55	11.50	0.17	21.21
T3	19.88	22.48	45.95	77.07	34.17	0.45	0
T4	19.84	43.90	59.22	55.47	20.94	0.63	0

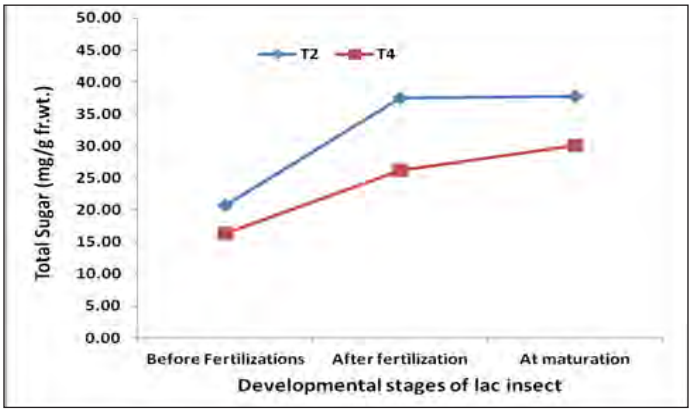
Estimation of biochemical parameters in *F. semialata* during different developmental stages of lac insect

The sampling was carried out at before lac insect fertilization stage, after lac insect fertilization stage and at maturity. The biochemical parameters such as total sugar, phenol, protein and proline were carried out during these lac insect developmental stages. The total sugar, phenol and proline content of the host plant were affected in all the developmental stages of lac insect as compared to control. The results are as follows:

Total sugar

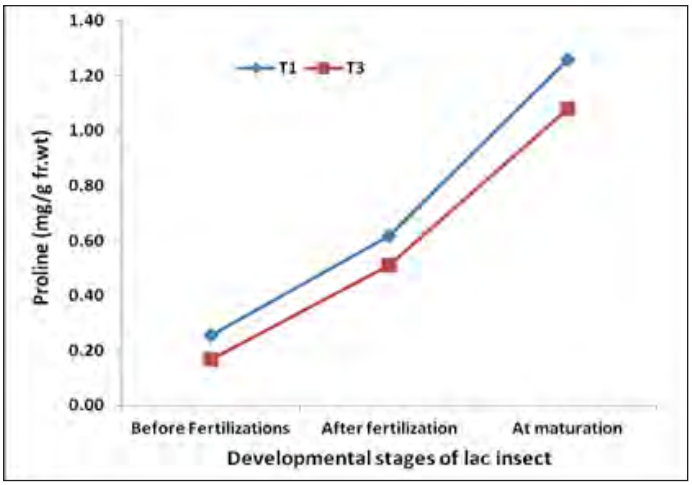
Treatment T1 showed increase in total sugar in all the developmental stages of lac insect as compared to treatment T3. Treatment T2 also showed the same trend over treatment T4.

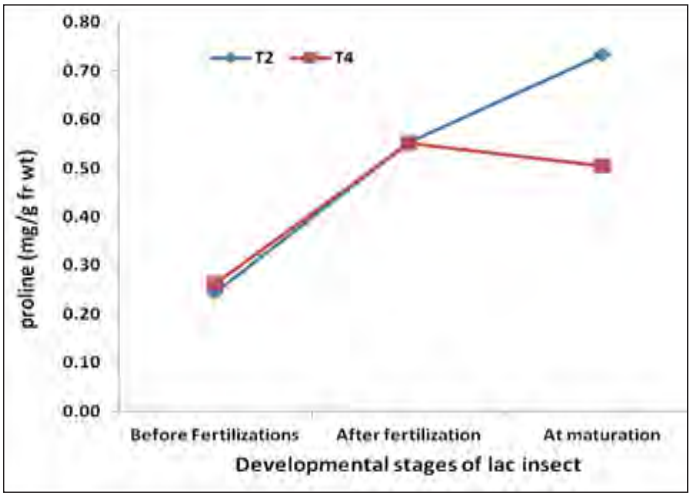




Proline

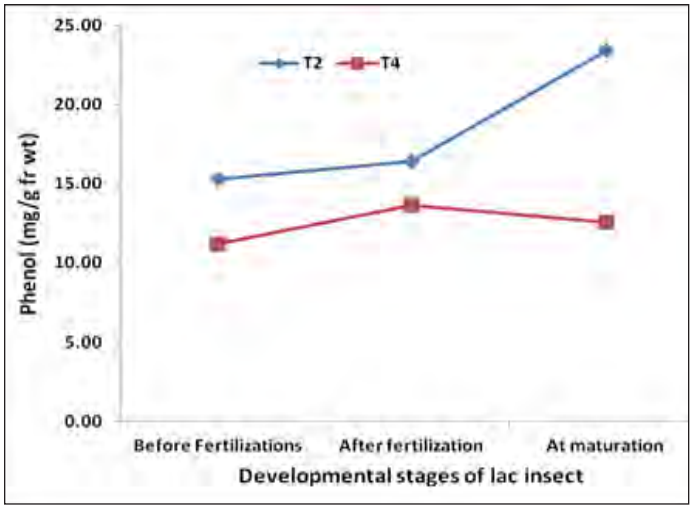
Treatment T1 showed increase in proline in all the developmental stages of lac insect as compared to treatment T3. Treatment T2 also showed the same trend over treatment T4.

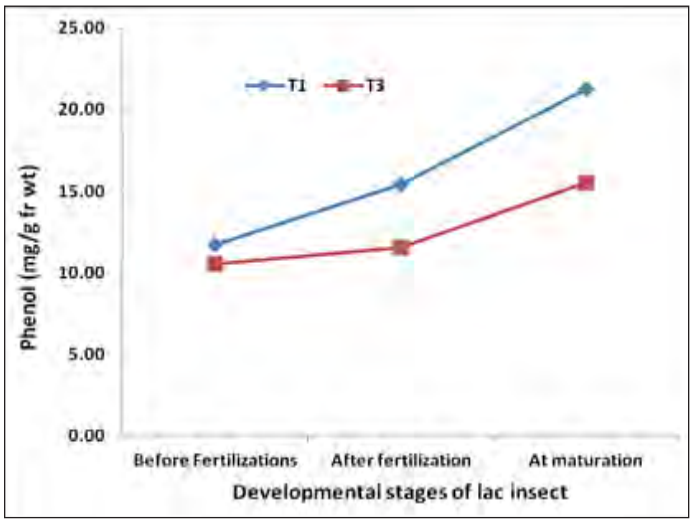




Phenol

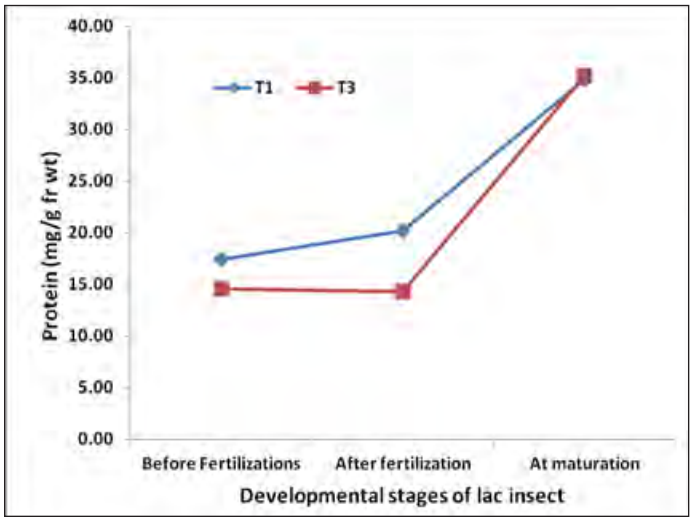
Treatment T1 showed increase in phenol in all the developmental stages of lac insect as compared to treatment T3. Treatment T2 also showed the same trend over treatment T4.

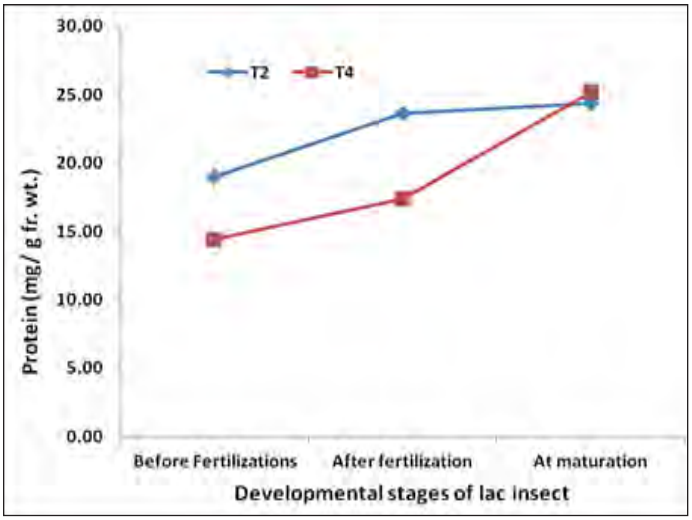




Protein

Treatment T1 showed increase in protein in all the developmental stages of lac insect as compared to treatment T3. Treatment T2 also showed the same trend over treatment T4.





T1 (lac insect with fertilizer), T2 (lac insect with no fertilizer), T3 (no lac insect with fertilizer), T4 (control-no lac insect with no fertilizer)

Diversity analysis of aleuritic acid content in major lac insect species/ strains and its use for better isolation strategies

Variation in aleuritic acid content in different host plant and strain *viz*., *kusmi* and *rangeeni* as well as lac insect colour mutants *viz*. yellow and crimson were evaluated at different time interval (Table 8.9). Aleuritic acid content was found the maximum in *Kerria chinensis* (19.81 per cent) with 98.78 per cent purity followed by *Kerria lacca* of *aghani* (17.07 per cent) with 93.71 per cent purity after harvesting while it was the least (9.23 per cent) in *Kerria sharda* (Trivoltine *Kusmi*) with 93.90 per cent purity.

Similarly, aleuritic acid content after six month of harvesting was maximum in *K. lacca* (16.84 per cent) in yellow mutant of *Kusmi* strain with 98.63 per cent purity followed by *kusmi* crimson with 16.34 per cent and 96.5 per cent purity while the least in *K. sharda* (7.72 per cent) with 90.61 per cent purity.

In *Kusmi* yellow, aleuritic acid content was more (17.18 per cent) with 92.81 per cent purity as compared to *kusmi* crimson (15.1 per cent) with 87.02 per cent purity after twelve month of harvesting. The result shows, variation in aleuritic acid content in different lac insect species, strain, colour, season and the host plant (Table 8.9).

Table: 8.9: Estimation of Aleuritic acid content in lac resins of different host plant and insect species at different time interval

Host	Strain	Season	Species	Colour	Aleuratic acid (Per cent)	Melting point (°C)	Purity from acid value
A. After harvesting							
Palas (SCL)	*Rangeeni*	Summer (*Baisakhi*)	*K. lacca*	Crimson+ Yellow	10.82	94.5	92.08
Palas (SEL)	*Rangeeni*	Summer (*Baisakhi*)	*K. lacca*	Crimson+ Yellow	16.60	94.5	92.05
F. semialata (SCL)	*Kusmi*	*Aghani*	*K. lacca*	Crimson	15.57	94.5	95.45
Ber	Trivoltine *Kusmi*	-	*K. sharda*	Crimson	9.23	92.5	93.90
Ber	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Crimson	15.18	92.6	95.86
Ber	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Yellow	17.07	92.5	93.71
F. macrophylla	Thailand	Rainy	*K. chinensis*	Crimson	19.81	92.5	98.78
B. 6 month after harvesting							
Ber	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Crimson	16.34	91.1	96.5
Ber	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Yellow	16.84	92.2	98.63
F. semialata	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Crimson	15.00	94.5	89.93
Trivoltine	*Ber/Kusum*		*K. sharda*	Crimson	7.72	91.5	90.615
C. 12 month after harvesting							
Ber (SCL)	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Yellow	10.32	93.5	92.78
Ber (SEL)	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Yellow	13.06	94.5	92.78
Kusum (SCL)	*Kusmi*	Summer (*Jethwi*)	*K. lacca*	Yellow	12.76	95.5	91.25
Kusum (SEL)	*Kusmi*	Summer (*Jethwi*)	*K. lacca*	Yellow	17.18	94.5	92.81
Kusum (SEL)	*Kusmi*	Summer (*Jethwi*)	*K. lacca*	Crimson	15.1	94.5	87.025
D. 18 month after harvesting							
Ber (SEL)	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Crimson	9.72	93.5	87.8

SCL – Scarpped lac; SEL – Seed lac

Relative density and molecular mass of pure aleuritic acid was 1.077 and 301.87, respectively, while relative density and molecular mass of *K. lacca* (*Kusmi*), *K. lacca* (*rangeeni*) and *K. chinensis* were (1.08 and 293.67), (1.120 and 314.32) and (1.046 and 289.65), respectively (Table 8.10).

Table 8.10: Relative density and molecular mass of aleuritic acid

Strain	Species	Relative density at 27 ±2°C	Molecular mass
Kusmi (SEL)	*K. lacca*	1.089	293.67
Thailand (SEL)	*K. chinensis*	1.046	289.65
Rangeeni (SEL)	*K. lacca*	1.120	314.32
Pure aleuritic acid		1.077	301.87

SEL – Seed lac

Training conducted

One week training programme on 'Collection and conservation of lac insect and host plants' for 16 participants comprising of Senior Research Fellow and Lac culture attendants from Lead Centre, Co-operating and Voluntary Centres under NP-CLIGR was organized during August 19-24, 2019. Thirteen lectures on different topics and ten 'Hands-on-training' sessions were arranged during the training programme. One visit to lac growing villages at Anagara Block, Ranchi was also organized for field experiment (Fig. 8.7 & 8.8).

Fig. 8.7: Participants of the training programme

Fig. 8.8: Hands-on-training session for the participants

B. Network Co-operating Centers

a. State Agricultural Universities

1. Assam Agricultural University (AAU), Jorhat

Survey in Assam

Seven districts of Assam comprising 13 blocks were surveyed out of which, naturally occurring lac insects were found in 2 districts and cultivated lac insect found in one district (Dhemaji). Till date 31 districts out of 33 districts of Assam has been surveyed. In Sissiborgaon block of Dhemaji district many farmers as well as shelf help groups (SHGs) were found engaged in lac cultivation. They cultivate lac on naturally grown *ber* plantations present in and around the riverine areas of Brahmaputra river.

Occurrence of lac insects was found at premature stage on two new local hosts, *E-ha* and *Kukurhuta* (vernacular names) during the survey conducted in Tinsukia district covering two blocks *viz.,* Sadiya and Kakopathar (Fig. 8.9). Broodlac was collected from West Karbi Anglong (Fig. 8.10). Although there was plenty of *peepal* tree in Khelua block of Sivasagar district, No lac insect was observed. Jamulpur and Baska blocks of Baksa and Gubardhana and Barpeta block of Barpeta districts along with three blocks of Nalbari district (Ghograpar, Mukalmua and Barama) were surveyed during September, 2019. Interaction with village people, occurrence of lac insect was there in the area approximately 10-15 years ago. Presence of a huge numbers of palas tree was noticed in that area without any lac.

Fig. 8.9: Survey at Sadiya block of Tinsukia district

Fig. 8.10: Collection of broodlac from West Karbi Anglong

Survey in West Bengal

Five districts (Alipurduar, Cooch bihar, Darjeeling, Kalingpong and Jalpaiguri) comprising 17 blocks were surveyed during March, 2019. Naturally occurring lac insects were not found in any one of these districts, but

host plants like *Siris* and *Peepal* were in abundance in Kalingpong district.

Germplasm conservation of lac insect and its host plants: 19 lac insect stocks have been collected since inception and at present one race of Assam and four races of West Bengal conserved live in Regional Lac Insect field Gene Bank, Jorhat. Similarly 18 lac host plants species are maintained in Regional Lac Insect field Gene Bank.

Morphological and biochemical analysis of different plants: Eight host plants *i.e. F. semialata, F. strobilifera, Indigofera teysmannii, F. religiosa, Z. mauritiana, L. chinensis, Hibiscus rosa-sinensis* and *C. cajan* were studied to observe the association between settlement of crawlers and lac production with morphological and biochemical analysis of host plants. Both Morphological characters *i.e* Girth and trichome density showed significant negative correlation with crawler settlement density and production of lac; whereas Phenol content of the bark registered a significant positive correlation with the production of lac (Table 8.11 & 8.12).

Table 8.11: Correlation of morphological characters of host plants with settlement density and production of lac

Morphological character	Statistical parameters	Density of settlement	Production of lac
Girth	R	-0.935**(S)	-0.892**(S)
	Y	y = -29.95x + 90.45	y = -0.095x + 0.298
Trichome	R	0.471 (NS)	0.414 (NS)
	Y	-	-

Table 8.12: Correlation of biochemical parameters of host plants on production of lac

Biochemical characteristic	Statistical parameters	Production of lac
Phenol	R	0.966**
	Y	y = 0.781x + 0.050
Flavanoid	R	-0.289 (NS)
	Y	-
Alkaloid	R	0.661 (NS)
	Y	-

R= Pearson Correlation; Y="Expected Y" of regression equation Y=a+bx

*= Significance at p=0.05; **= Significance at p=0.01; S=significant; NS=non-significant

Management of *Callosobruchus chinensis* Linn- a stored grain pest of *F.* spp.

a) Biology and morphometrics of *Callosobruchus chinensis* Linn. : Developmental parameters such as incubation period, larval period, instars duration, pupal period, total developmental period, adult male and female longevity were recorded on both *F. macrophylla* and *F. semialata* stored seeds during summer (June-July) and winter (November-December) months. The study revealed that all the parameters of *C. chinensis* were higher on seeds of *F. semialata* as compared to *F. Macrophylla* in both the seasons (Table 8.13). During winter season (Nov-Dec, 2019), the larval and pupal periods were found to be 26.00 days and 11.20 days, respectively on stored seeds *F. macrophylla* as compared to 26.80 and 11.40 days of larval and pupal periods on seeds of *F. semialata,* respectively. Likewise, during summer season (July-Aug, 2018), relatively shorter duration 18.4 and 19.8 (larval periods) and 7.40 and 7.60 (pupal periods) were recorded for both *F. macrophylla* and *F. semialata*, respectively. The total developmental period of male as well as female was observed to be higher in winter season as compared to summer and also the highest in *F. semialata* than *F. macrophylla*.

The different morphological parameters studied for both male and female adult of *C. chinensis* were body length, body width, antennal length, elytral length and elytral width. Table 8.14 shows the data on relevant aspects.

b) Body length and width of *C. chinensis:* Females of *C. chinensis* were larger in size than males. The maximum body length of male was recorded on *F. semialata* (3.48±0.01 mm) and minimum on *F. macrophylla* (3.27±0.01 mm). The body length of females on *F. macrophylla* (3.68±0.02 mm) was statistically at par with *F. semialata* (3.79±0.01 mm). In respect of body width of male *C. chinensis*, the lowest body width (1.58±0.01 mm) of male was found when reared on *F. macrophylla*. The maximum body width of female was observed on *F. semialata* (1.86±0.01 mm) and minimum on *F. macrophylla* (1.77±0.01 mm).

c) Antennal length of *C. chinensis:* Antennal size of male adult is larger than female adult. Moreover, male antennae were of pectinate while in female it was serrated. The antennal length in case of male *C. chinensis* was recorded on *F. semialata* (3.10±0.03 mm) and *F. macrophylla* on (3.02±0.01mm). In case of female, antennal length was recorded (2.22±0.01 mm) on *F. semialata* and (2.17±0.05 mm) on *F. macrophylla.*

d) Elytral length and width: Elytral length of male *C. chinensis* revealed that insects feeding on *F. semialata* seeds exhibited maximum length (1.95±0.01mm), while minimum (1.92±0.02 mm) in case of feeding on *F. macrophylla* (Table 8.14). The maximum elytral length of female *C. chinensis* was recorded on *F. semialata* (2.65±0.02 mm), which was found to be minimum (2.45±0.01mm) on *F. macrophylla*. Similarly, elytral width of male *C. chinensis* was 1.02±0.01 mm on *F. semialata* and 0.93±0.01mm on *F. macrophylla*. In female, elytral width observed on *F. semialata* was maximum (1.27±0.01 mm) as compared to *F. macrophylla* (1.22±0.05 mm).

Table 8.13: Duration of developmental period of *C. chinensis* on seeds of *F. macrophylla* and *F. semialata*

Seasons	Host seeds	Incubation period (days)	1st instar (days)	2nd instar (days)	3rd instar (days)	4th instar (days)	Total Larval period (days)	Pupal period (days)	Total developmental period	Adult longevity Male (days)	Adult longevity Female (days)
Summer (June-July, 2019)	*F. macrophylla*	5.00	3.40	4.20	4.80	6.00	18.40	7.40	30.80	9.20	8.00
	F. semialata	5.20	3.60	4.60	5.40	6.20	19.80	7.60	32.60	10.00	9.00
Winter (Nov-Dec, 2019)	*F. macrophylla*	8.00	5.00	5.60	6.80	8.60	26.00	11.20	45.20	12.00	10.80
	F. semialata	8.20	5.40	5.40	7.20	8.80	26.80	11.40	46.40	13.20	11.20

Table 8.14: Morphometry (mean±SE) of *C. chinensis* feeding on stored seeds of *F.* spp.

Host seeds	Body length (mm)		Body width (mm)		Antennal length (mm)		Elytral length (mm)		Elytral width (mm)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
F. macrophylla	3.27±0.01	3.68±0.02	1.58±0.01	1.77±0.01	3.02±0.01	2.17±0.05	1.92±0.02	2.45±0.01	0.93±0.01	1.22±0.01
F. semialata	3.48±0.01	3.79±0.01	1.61±0.01	1.86±0.01	3.10±0.03	2.22±0.01	1.95±0.01	2.65±0.02	1.02±0.03	1.27±0.05

*Data presented are the mean of five replications

e) Efficacy of plant oils, plant powders and *Beauveria bassiana* formulation against *C. chinensis:* The efficacy of some edible and non-edible oils, indigenous plant leaf powders and bio-control agent (*Beauveria bassiana*) was evaluated against the most destructive seed pest (*C. chinensis*) of *F.* spp. the treatments undertaken were: (i) Citronella oil, (ii) Lemongrass oil, (iii) Patchouli oil, (iv) Neem oil and (v) Mustard oil with doses varying between 2.5 to 20 ml/kg seed. For powder formulation treatments were (i) *Leucas indica,* (ii) *Vitex negundo* and (iii) *Beauveria bassiana* with doses varying between 0.5 to 15 g/kg seed. Treatments *viz*., Malathion 5% dust (5 g/kg) and Black pepper powder (3g/kg) were taken as check. The per cent mortality of adult *C. chinensis* exposed to various dosages of plant oils, plant powders and *Beauveria bassiana* formulation along with malathion 5% dust @ 5g/kg and black pepper powder @ 3g/kg (as standard check) at different time intervals were recorded and presented in Table 8.15. Among plant oils, Citronella oil after 3 days of treatment caused 100.0 per cent mortality at all the dose followed by lemongrass oil, patchouli oil and neem oil. Amongst powder formulations, *B. bassiana* formulation showed 90 per cent mortality after 3 days of treatment at the dose of 15 g/kg followed by *Leucas indica* with 88.00 per cent mortality of the test insect (Table 8.16). Whereas Malathion and Black pepper dusts caused 100 per cent mortality.

Table 8.15: Comparative efficacy of different plant oils on adult mortality (%) (mean ± SE) at 3 days after treatment

Dosage of plant oil (ml or g/kg seed)	Citronella	Lemongrass	Patchouli	Neem	Mustard
2.5 ml	100±0	94±2.44	86±2.44	64±2.44	22±3.73
5.0 ml	100±0	98±1.99	90±3.15	90±3.15	30±3.73
10.0 ml	100±0	100±0	98±1.99	96±2.44	48±2.44
15.0ml	100±0	100±0	100±0	98±1.99	62±2.44
20.0 ml	100±0	100±0	100±0	100±0	80±3.73
Control	2 ±1.99	2 ±1.99	2 ±1.99	2±1.99	2±1.99

Table 8.16: Comparative efficacy of different plant powders on adult mortality (%) (mean±SE) at 3 days after treatment

Dosage of plant powder (g/kg seed)	*Vitex negundo* powder	*Leucas indica* powder	*Beauveria bassiana* formulation
0.5 g	32±3.73	36±2.44	52±1.99
1.0 g	36±3.99	44±3.15	60±3.15
5.0 g	50±3.15	66±2.44	78±3.73
10.0 g	64±3.99	72±1.99	86±2.44
15.0 g	84±2.44	88±1.99	90±3.15
Control	2±1.99	2±1.99	2±1.99

Study on pathogenicity of naturally occurring indigenous isolate of entomopathogenic fungi (EPF) against *Eublemma amabilis* and lac insect

Two entomopathogenic fungi, *viz.*, isolated and identified, *Iseria fumosorosea* and *Isaria javanica* were evaluated at three doses (10^3, 10^5 and 10^7dilution) repeated three times against *Eublemma amabilis* at Lac Laboratory, Department of Entomology, AAU, Jorhat. The conidial density of different strains of entomopathogenic fungi collected from larva of *Eublemma amabilis* was grown on PDA plates for seven days under BOD incubators maintained at 26°C temperature. In laboratory and field condition different strains/isolate was bioassayed against the larvae and the pupae of *E. amabilis;* 2 ml of different concentration were sprayed on the larvae and pupa containing twigs with lac crawlers. Mortality was recorded three days after treatment but after 10 days, 100 % mortality was recorded at 10^5 and 10^7 dilution in both EPF.

The bio-safety test was also recorded on lac insect following two methods *viz*., 1) Dipping method 2) Spraying method

In dipping method broodlac was dipped in EPF solution for 2-5 minutes and inoculated in the host plants and productivity linkages and life cycle of lac insects were recorded. In spraying method 1st spray was done at initial crawler settlement stage, 2nd at sexual differentiation stage, 3rd at male emergence and 4th female wax secreting stage. The experiment was repeated for two seasons and it was found that EFP is extremely safe for lac and the occurrence of predators *viz*. *E. amabilis*, *Pseudohypatopa pulverea* and *Crysopa* spp. are less than untreated host plants (Fig. 8.11 and 8.12).

Fig. 8.11: Bio-efficacy of EPF against *E. amabilis* larvae

Fig. 8.12: Comparision between deformed and healthy larva

Effect of weather parameters on settlement density of lac insect crawlers: Settlement density of lac insect in *F. semialata* plant revealed a highly significant negative correlation with morning relative humidity (r = -0.977**) indicating longer duration of the crop with high morning relative humidity. Moreover, lac insect also established a significant negative correlation (r=-0.663**) with rainfall and (r=-0.939*) wind speed.

Study on life cycle parameters of *K. chinensis* on *F. semialata*: Study of various life parameters of *K. chinensis* in *F. semialata* for last 3 years (2016-2019) revealed that the average pre-sexual maturity period recorded was 43 days and the duration of male emergence was observed to be 69 days. 179 days were taken by *K. chinensis* to complete its life cycle on *F. semialata*.

Study on Productivity Linkage Parameters of AAUK-06 (Langardang, West Karbi Anglong) on different host plants: The local race (AAUK-06) was studied on five plants *viz., F. semialata F. strobilifera, C. cajan, Indigofera teysmannii* and *Zizyphus mauritiana* during 2019. Different productivity-linked parameters studies showed a positive result in all the four hosts except *Indigofera teysmannii* but *F. semialata* was found to be the most superior, followed by *C. cajan*in, *F. strobilifera* and *Z. mauritiana* terms of broodlac, *phunki* lac and scrapped lac yield. In case of cell weight, maximum weight was observed on *F. semialata* (33.62 mg) followed by *C. cajan* (29.04 mg), *F. strobilifera* (23.44 mg) and *Z. mauritiana* (23.17 mg). Moreover, the cell size showed significance difference among the plants. The highest size of female cell was recorded on *F. semialata* (3.77 mm) and the lowest on *Z. mauritiana* (2.62 mm). The highest resin weight was recorded on *F. semialata* (18.32 mg) and the lowest on *F. strobilifera* (12.13 g). The

average numbers of crawlers emerged from *F. semialata* were (305 Nos./cell) which showed significance difference with *Z. mauritiana* (255 Nos./cell) and presented in Table 8.17.

Table 8.17: Productivity linkage parameters of AAUK-06 (Langardang) on *F. semialata, F. strobilifera, Indigofera teysmannii* and *C. cajan*

Parameters		*F. semialata*			*F. strabilifera*			*Indigofera teysmannii*			*C. cajan*			*Z. mauritiana*		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Initial density settlement (No/cm^2)		111.68	102.36	99.49	84.66	85.25	78.14	45.98	37.80	29.84	102.12	92.36	95.91	84.18	80.66	80.90
Density after 21 days (No/cm^2)		96.82	89.16	83.21	79.01	80.30	75.43	-	-	-	96.21	88.27	82.45	79.71	79.32	79.04
Initial mortality (No/cm^2) (21 days after inoculation)		14.86	13.20	16.28	5.65	4.95	2.71	-	-	-	5.91	4.09	13.46	4.47	1.34	1.86
Initial mortality percentage		13.31	12.89	16.36	6.67	5.81	3.47	-	-	-	5.79	4.43	14.03	5.31	1.66	2.29
Male		7	6	4	3	3	4	-	-	-	7	6	7	4	3	5
Female		11	12	9	8	9	11	-	-	-	14	15	16	9	8	9
Sex Ratio (%)		38.9	33.34	30.77	27.27	25	26.66	-	-	-	33.3	28.5	30.40	30.76	27.27	35.70
Survival at maturity (No/cm^2)		6.1	5.98	5.64	5.95	4.97	4.83	-	-	-	4.94	4.88	4.64	4.18	4.09	3.76
Size of lac insect cell (mm)		3.77			3.02			-			3.48			2.62		
Weight (mg)	Female cell	33.62			23.44			-			29.04			23.17		
	Resin output	18.32			12.13			-			15.42			14.68		
Crawler emergence from one matured female cell		304.58			270.85			-			298.42			255.26		
Inoculated Broodlac (Kg)		0.1			0.1						0.1			0.1		
Broodlac yield at harvest (Kg)		0.31			0.27			-			0.28			0.25		
Broodlac ratio Output/ Input		4.21:1			3.63:1			-			3.87:1			3.10:1		
Broodlac-scrapped lac ratio		6.65:1			7.89:1			-			6.86:1			8.91:1		
Weight of one meter (kg)	Broodlac	295.16			254.50			-			271.37			217.20		
	Phunki lac	99.13			87.03			--			92.20			87.11		
	Scrapped lac	47.24			34.40			-			40.84			27.90		
	Wood weight after harvest	57.03			53.08						55.33			55.55		

Influence of different plants on life cycle parameters (Mean in days± S.D) of *K. chinensis*: During the period October, 2018 to April, 2019, the longest pre-sexual maturity period was recorded on *F. semialata* (49.34±2.62 days) followed by *C. cajan* (47.40±2.32 days) which was at par with and *Z. mauritiana* (47.31±1.81 days). The shortest pre-sexual maturity period was recorded on *F. strobilifera* (46.02±1.58 days) (Fig 8.13 and 8.14).

The longest duration of male emergence was registered by *F. semialata* (14.92±0.66 days). Significant difference was found among the other plants.

The lac insect, *K. chinensis* took maximum number of days to complete its life cycle on *F. semialata* (171.92±2.08 days) followed by *Z. mauritiana* (161.44±3.79days), *F. strobilifera* (159.33±1.39 days) and *C. cajan* (157.85±2.97days).

Whereas during April, 2019 to October, 2019 the longest

pre-sexual maturity period was recorded on *F. semialata* (47.05±0.1.52 days) *Z. mauritiana* (45.45±1.23 days), *F. strobilifera* (45.26 ±1.36 days) and *C. cajan* (44.29±1.27 days).

The longest duration of male emergence was registered with *F. semialata* (12.29±0.48 days) followed by *Z. mauritiana* (10.22±1.20 days), *F. strobilifera* (10.03±0.81 days) and *C. cajan* (9.65±0.94 days).

The lac insect, *K. chinensis* took maximum number of days to complete its life cycle on *F. semialata* (164.52±2.49days) followed by *Z. mauritiana* (158.33±0.90 days) which was at par with *F. strobilifera* (157.15±3.29 days), The life cycle duration recorded for *C. cajan* (153.87±4.36days) which recorded the lowest value.

Fig. 8.13: Lac on *F. strobilifera*

Fig. 8.14: Lac on *F. semialata*

Dissemination of scientific lac cultivation technologies and *in-situ* conservation of the same: Two hands-on-training were conducted to generate awareness and to disseminate technology on lac cultivation. First training was conducted at Baksa on 30th August, 2019 with 10 farmers, the 2nd was conducted at Barpeta district on 31st August, 2019 with 40 farmers (Fig 8.15 and 8.16).

Fig. 8.15: Training at Baksa

Fig. 8.16: Exhibition held at AAU, Jorhat

2. Central Agricultural University (CAU), Imphal

Factors controlling ant nest housing over lac encrustation and factors responsible for ant attendance on certain plants

Study was conducted for the second year to identify the factors controlling ant nest housing over lac insect encrustation in different locations of Manipur in natural populations of lac insect from February to December,

2019. Observations were recorded in these host plants of different locations (*Malvaviscus penduliflorus, Ficus religiosa* and *Ficus benghalensis*). Many ant species were seen visiting over lac encrustations in all the three host plants, but every ant species visiting the lac encrustation do not build their nest. During the investigation it was observed that the ant, *Crematogester sp.* was the only ant species which build their protective shelter (ant nest) over the lac encrustation. No micro-climate has caused any affects in the ant nest covering over the lac encrustation.

Out of the five observed lac encrustations in *M. penduliflorus* plant four plants were visited by *Crematogester* ant species were fully covered with ant nest over lac encrustation (Fig. 8.17). In *F. religiosa,* out of five observed samples, lac insect were visited by the non-*Crematogester* ant species and no ant nest housing over lac encrustation was seen in *F. religiosa* (Fig. 8.18). In *F. benghalensis* also, out of five observed samples, lac insect were visited by the same non-*Crematogester* ant species and no ant nest housing over lac encrustation was seen.

During the observation, it was also observed that no multiple ant species visited lac encrustation at the same time. It may be concluded that the main parameters responsible for ant housing on lac encrustation might be the behaviour of the ant. The ant *Crematogester sp*. has a habit of building their nest near to the food sources or on the food sources. The attendance of the ant was also seen in the host plants without lac encrustation. Most of the ants of different species visit the lac insect encrustation to collect the honey dew secreted by the lac insect but only *Crematogester species* builds their nest over the lac insect encrustation. However, in a very rare case an incomplete housing with mud nearby the ground on inculated lac encrustation inside the protected culture was also been observed.

Fig. 8.17: *Crematogester sp.* (Saint Valentine ant) building their protective shelter/covering over lac encrustation

Fig. 8.18: Non Crematogester sp. without building their protective shelter over lac encrustation

Major host plots maintained at the research farm, Lamsang (Fig. 8.19 and Table 8. 18)

Malvaviscus penduliflorus

Cajanus cajan

Fig. 8.19 : Major host plots maintained at the research farm, Lamsang

Table 8.18: No. of host plants maintained at the Research Farm, Lamsang

Sl. No.	Host plant	Number of plants
1.	*F. semialata*	160
2.	*F. macrophylla*	286
3.	*Cajanus cajan*	51
4.	*Malvaviscus penduliflorus*	129
5.	*Mallotus phillipensis*	5
6.	*Ficus glomerata* Roxb	3
7.	*Hibiscus rosa chinensis*	81
8.	*Hibiscus sp.* (red flower drooping type)	15
9.	*Hibiscus sp.* (white flower)	4
	Total plants	**734**

Whereas only litchi hosts were maintained at the Horticultural Research farm, Andro, Imphal East site (Research field).

Survival of lac insect on different hosts of Malvaceae family: Survival of lac insect on four different hosts of

Malvaceae family *Hibiscus rosa chinensis, Hibiscus sp.* white flower*, Hibiscus sp.* red flower drooping type *and M. penduliflorus,* lac insect can not survive in the Malvaceous plants except *M. penduliflorus* which is also a good host for the lac insect in Manipur condition.

Suitability of inoculation on different hosts: One kilogram each of broodlac was collected from *F. benghalensis* and *Calliandra surinamensis* from Imphal East district, Manipur for inoculation. One and half kilogram of broodlac was collected from *F. benghalensis* and six hundred grams from *Zizyphus sp.* from Imphal West district, Manipur for inoculation. Out of four major host plots of *F. macrophylla, F. semialata*, *M. penduliflorus* and *C. cajan* maintained for inoculation in the Research Farm located at Lamsang, Imphal West, it was observed that *F. macrophylla* is the most suitable host plant followed by *M. penduliflorus.*

***Ex-situ* conservation of lac insect:** Five strains of lac insect from the states of Nagaland, Mizoram, Arunachal Pradesh, Sikkim and Manipur are presently maintained at the Research Farm, Lamsang, Imphal West, Manipur.

Establishment of intercropping field of hosts with vegetables: An intercropping field of hosts with vegetables was newly established adjacent to the main Research Farm located at Lamsang. Two host plants *F. macrophylla* and *C. cajan* have been maintained with a total of twelve vegetables *viz*. 1. Cabbage, 2. Mustard 3. Oil mustard, 4. Coriander , 5. Garlic large, 6. Garlic small, 7. Lettuce, 8. Broad bean 9. Chamtruk (local name), 10. Pea, 11. Onion, 12. Local onion

Lac culture cum apiculture: Three honey bee boxes of *Apis cerana* Himalaya has been maintained at the Research Farm, Lamsang. It has been observed that more viable seeds of *F. sp.* were obtained by beekeeping honey bees in the host plants of *Malvaviscus penduliflorus* plots.

Participation at the Fair: A lac related stall was displayed at the Vibrant North East, 2019 (19-21 June, 2019 at CAU, Imphal) and at CAU Regional Agri. Fair, 2019 (11th to 13th January, 2019)

Pests of lac host plants: Mortality in the host plants was observed due to termite and long horned beetle (*Aristobia approximator*) and other insect pests. Major pests observed are shown in Table 8.19.

Table 8.19: Major pests of lac host

Sl. No.	Host plants	Partially affected	Insect pest concern	Totally dries up
1.	*F. semialata*	32	*Aristobia approximator*	14
2.	*F. macrophylla*	55	*Aristobia approximator*	2
3.	*C. cajan*	17	*Aristobia approximator*	8
4.	*M. penduliflorus*	Nil	*Aristobia approximator*	Nil
5.	*F. glomerata*	Nil	*Aristobia approximator*	Nil
6.	*F. semialata*	3	Termite	12
7.	*F. macrophylla*	5	Termite	8
8.	*C. cajan*	2	Termite	2
9.	*M. penduliflorus*	8	Termite	6
10.	*F. glomerata*	nil	Termite	nil

Development of Regional Lac Insect Field Gene Bank

A conctrete pucca structure with insect net roofing costing 1.49 lakh was contructed at the premises of College of Agriculture, Central Agricultural University, Imphal that was inauguralted by the Hon'ble Vice-Chancellor, Prof. M. Premjit Singh on 25th January, 2020. List of host plants maintained at the newly constructed Regional Field Gene Bank is given in Table 8.20.

Table 8.20: Number of host plants maintained at the newly constructed Regional Field Gene Bank

Sl. No.	Host plants	Number of host plants
1.	*F. semialata*	14
2.	*F. macrophylla*	49
3.	*C. cajan*	8
4.	*M. penduliflorus*	11
5.	*C. calothyrsus*	6
	Total plants	**88**

Documentation of ITK methods on lac dying and preparation of sealing wax: ITK methods of lac dying and preparation of sealing wax at Meghalaya has been documented. After discussion through a translater of Khasi language from Meghalaya and demonstration, it was known that they have been rearing lac insect from the time of their forefathers with indigenous method of inoculation without any scientific knowledge. They used only *Ficus* tree for inoculation in the villages of Sonidan and Korhadem and no other host plants were observed in the high altitude foothill of Umsning village, Rhibhoi, Meghalaya. They inoculated once a year and have no knowledge of two crops in a year. They revealed that for dyeing the *phunki* lac from the *Ficus* trees is scrapped out

from the twigs and then grind in the wooden mortar and pestle. After grinding, it is mixed slowly with hot water (80°C) with churning and sieved through a muslin cloth for dyeing mainly silk threads. Lac dye water is also used for medicinal purposes against pain in joints and ligaments, muscles, headache etc. The lac collected in the muslin cloth is used as sealing wax which is mostly preferred by blacksmith for fixing iron materials with the wooden handles.

Survey conducted in Manipur: Survey for lac insect and its host plants was conducted during June, July and 1st week of August, 2019 in the remaining three hill districts of Manipur *viz*., Kamjong, Pherzawl and Jiribam. Lac insect was found in two hill districts of Kamjong and Jiribam. Among the host plants, *F. macrophylla* was found in rear pockets along with *M. penduliflorus* in two hill districts of Kamjong and Pherzawl, while *ber*, *C. cajan* and *M. penduliflorus* were found in the Jiribam district.

3. Maharana Pratap University of Agriculture & Technology (MPUAT), Udaipur

Survey of lac insects and its host plants in different parts of arid western plain region of the country

The intensive surveys to record the natural occurence of lac insects and its host plants were conducted in different parts of the arid western plains region of the country. The available natural hosts were recorded and were observed for the presence of the natural population of the lac insects. During survey the observations on different parameters of host plants were recorded as per the passport data sheet of host plants. The survey was conducted in 12 districts of Rajasthan, 07 districts of Gujarat and nearby area of Udaipur region, in which 89 different location were covered and it was observed that the *palas* (*B. monosperma* Lam.), *ber* (*Z. mauritiana* Lam. and *Z. jujube* Lam,), *pipal* (*F. religosia* Linn.), *paras pipal* (*F. benjamina* Linn.), *siris* (*A. lebbek* Denth.), custard apple (*A. squamosa* Linn.), *anjeer* (*F. carica*), *arhar* (*C. cajan* Linn.), *gular* (*F. racemosa* Linn.), *Babool* (*A. arabica* Willd.), *Vilayati Babool* (*Prosophis juliflora*), *Jungle Jalebi* (*Pithecellobium dulce*) and *Bargad* (*F. bengalensis* Linn.) were found as major lac insect host plants in the region. It was also observed that at almost all locations only *Rangeeni* strain was found growing well on these natural hosts. In the majority of regions, *pipal*, *ber*, *palas*, *kikar* and *babool* were found in higher number as compared to other hosts (Fig. 8.20 and Fig 8.21, Table 8.21).

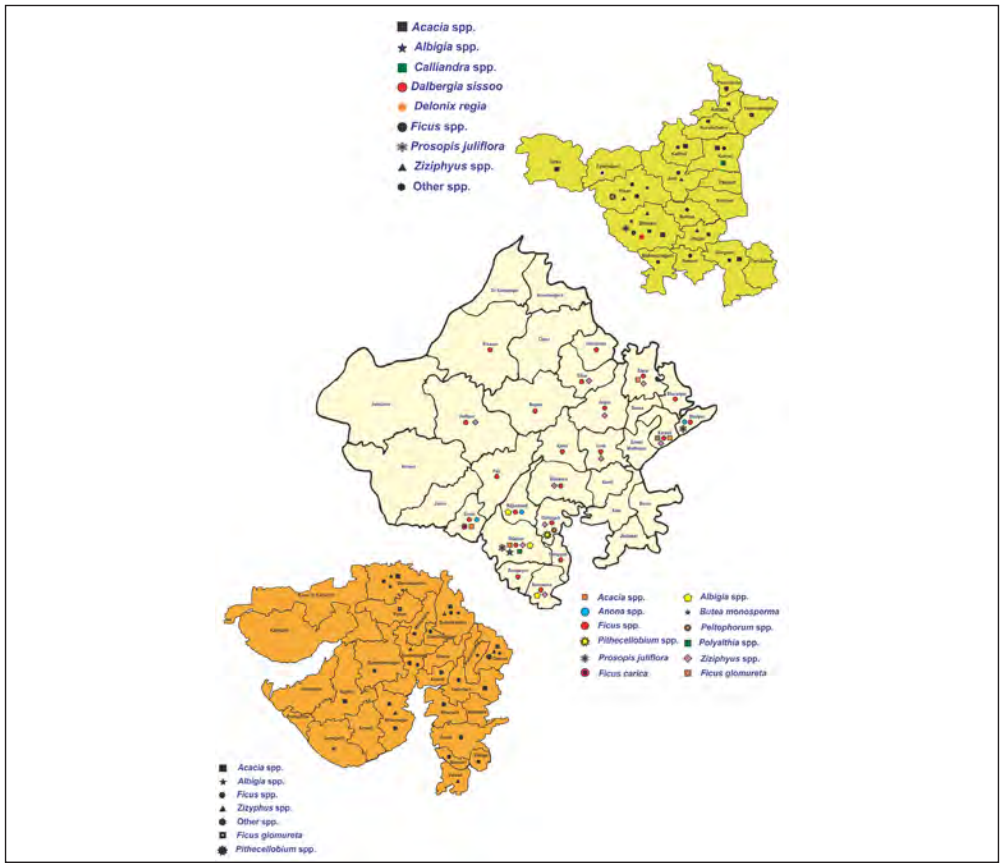


Fig. 8.20 : Host and lac insect resources availability in the three states of arid western plains

Albezzia lebbek Benth

Pithecellobium dulce Roxb.

Annona squamosa Linn.

Ficus carica Linn.

Prosophis juliflora (Sw.) DC.

Fig. 8.21: Host trees of lac insect recorded in arid western plains area during survey

Table 8.21: Important hosts trees identified in arid western plains of the country

Sl. No.	Name of host	Distribution
1.	*B. monosperma* Lam. (*Palas*)	Rajasthan, Gujarat
2.	*Z. mauritiana* Lam. and *Z. jujube* Lam. (*Ber*)	Rajasthan, Gujarat, Haryana
3.	*A. nilotica* (*Babool*)	Rajasthan, Gujarat
4.	*F. religiosa* Linn. (*Pipal*)	Rajasthan, Gujarat, Haryana
5.	*F. glomureta* (*Gular*)	Rajasthan
6.	*F. bengalensis* (*Baragad*)	Rajasthan, Gujarat, Haryana
7.	*A. Lebbek* Denth (Rain Tree, *Siris*)	Gujarat
8.	*A. squamosa* Linn. (*Custard Apple*)	Rajasthan, Gujarat
9.	*F. benjamina* Linn (Weeping Fig)	Gujarat
10.	*A. catechu* Willd. (*Khair)*	Rajasthan, Gujarat
11.	*C. cajan* Linn. (*Arhar*)	Rajasthan
12.	*A. arabica* Willd. (*Babool*)	Rajasthan, Gujarat
13.	*C. fistula* Linn. (*Amaltas*)	Rajasthan
14.	*P. dulce* (*Kikkar*)	Rajasthan
15.	*D. sissoo* (*Shisham*)	Rajasthan, Haryana
16.	*P. cineraria* (*Khejadi*)	Rajasthan, Haryana
17.	*A. auriculiformis* (*Akashmani*)	Rajasthan
18.	*C. haematocephala* Benth (*Calliandra*)	Rajasthan
19.	*Polyalthia.* spp. *pendula* (*Ashoka*)	Rajasthan
20.	*F. carica* (*Anjeer*)	Rajasthan
21.	*P. juliflora* (*Vilayati babool*)	Rajasthan

Collection and conservation of lac insect under *ex-situ* conditions: The lac insect genetic resources available in the region were collected and conserved under the *ex-situ* conditions on different hosts available at the gene bank cum lac garden situated at Department of Entomology, RCA, MPUAT, Udaipur. The samples of broodlac sticks were collected from the various areas and inoculated on the *arhar*, *palas*, *F.*, *Ficus* spp., *seetafal*, *paras peepal*, *siris* and *anjeer* available in the lac garden. 209 kg broodlac sticks were collected from different locations during March to December, 2019 (Fig. 8.22). Also the ber plantation at horticulture farm, ARS, Bhilwara of the MPUAT, Udaipur were pruned and utilized for conservation of lac insect genetic resources. A total 30 trees were used for the conservation of lac insect.

Conservation of lac insect under *in-situ* conditions: The broodlac sticks were collected from the various host plant from Udaipur region during *Baisakhi* and *Katki* season and were inoculated on the *palas*, *seetafal*, *ber*, *kikar*, *gular*, and *bargad* on farmers' field, DFRS Arjiya Bhilwara and forest areas Table 8.22 and 8.23. A total 131 hosts were utilized for the conservation of lac insect under *in-situ* conditions during 2019-20 (Fig. 8.23).

Fig. 8.22: Inoculation of broodlac on available hosts at Lac Insect Gene bank, RCA, Udaipur under *Ex-situ* conservation

Table 8.22: Status of the host plants and lac insect in survey conducted during 2019-20

Host	Total plant surveyed	Frequency of occurance without inoculation	Presence of lac	Brood status
Peepal	115	Frequent	23	Good
Desi Babool	200	Frequent	08	Good
Ber	60	Frequent	05	Good
Gular	40	Occasional	06	Good
Siris	24	Occasional	02	Good
Bargad	37	Occasional	05	Good
Anjeer	05	Rare	01	Poor
Sitafal	22	Rare	02	Poor

Fig. 8.23: Inoculation of broodlac on available host at farmers' field under in-situ conservation (2019)

Table 8.23: Details of host plant inoculated at farmers' field under *in-situ* conservation

Sl. No.	Location	Date of Inoculation	Name of Host	Number of plants inoculated
1.	KVK, Bhilwara	17-06-2019	*Ber*	27
2.	DFRS, Arjiya Bhilwara	14-11-2019	*Ber*	20
3.	Barwada	16-11-2019	*Ber*	15
			Seetafal	10
			Palas	10
			Kikar	02
			Gular	01
4.	Kunchauli (Kelwara)	16-11-2019	*Ber*	06
			Bargad	02
			Palas	05
			Seetafal	03
5.	Kakarva (Kelwara)	16-11-2019	*Seetafal*	10
6.	Resort Sada Neera (Kumbhalgarh)	16-11-2019	*Ber*	10
			Palas	10
Total				**131**

Collection of lac associated fauna in Southern Rajasthan: The samples collected were also preserved in absolute alcohol for further identification and caged in 60 mesh bags for studies on parasites and predators. Predators and hymenopterans parasites were found to infest the lac sticks. The emerged adults from the samples were collected and are preserved for identification and further studies (Fig. 8.24 to 8.26, Table 8.24).

Fig. 8.24: Survey for the associated fauna with lac insect in southern Rajasthan

Fig. 8.25: Collection of associated fauna with lac insect in southern Rajasthan

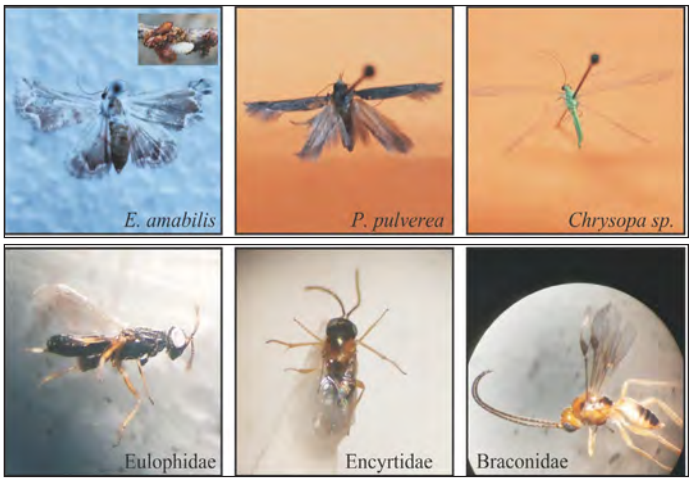


Fig. 8.26: Predators and parasitoids emerged from collected samples from different locations of southern Rajasthan

To evaluate the bio-efficacy of eco-friendly pesticides against major predators of lac insect *Kerria lacca* (Kerr): The results revealed that the application of spinosad 2.5 EC @ 2.0 ml/lit proved to be the most effective with maximum per cent reduction of the mean population of both the predators *i.e. E. amabilis* (84.85%) and *P. pulverea* (78.95) over control with the minimum mean population of 3.33 and 1.33 per meter lac stick. Emamectin benzoate 5 SG and @ 0.4 gm/lit, cartap hydrochloride 50 SP @ 2 gm/lit recorded the next effective treatments with 80.30, 73.68 and 74.24, 63.16 mean per cent reduction of *E. amabilis* and *P. pulverea* over control with 4.33, 1.67 and 5.67, 2.33 mean population per meter lac stick respectively. The treatment of spinosad 2.5 EC and emamectin benzoate 5 SG both were at par to each other. The treatment of neem oil 2% @ 20 ml/lit was recorded as the least effective against *E. amabilis* and *P. pulverea* with minimum 45.45 and 47.37 mean per cent reduction over the control with 12.00 and 3.33 mean population of predators respectively. Highest mean population *E. amabilis* and *P. pulverea* 22.00 and 6.33 were recorded in control (Table 8.25).

Table 8.24: Abundance of fauna associated with lac insect in southern Rajasthan during 2018-19

Entomophagy states	No. of Location	Trophic level states						Total
		Predators (Mean/m lac stick)			Primary parasittoids (Mean/m lac stick)		Hyperparasitoid (Mean/m lac stick)	
Location		*Eublemma amabilis*	*Peudohypatopa pulverea*	*Chrysopa sp*	Eulophidae	Encyrtidae	Braconidae	
Banswara	05	5.00 (4.31)	1.33 (1.15)	-	38.33 (33.05)	70.00 (60.35)	1.33 (1.15)	115.99
Bhilwara	03	4.33 (3.88)	1.66 (1.49)	-	43.00 (38.51)	61.66 (55.22)	1.00 (0.90)	111.65
Chittargarh	04	5.66 (7.68)	1.00 (1.36)	1.00 (1.36)	21.00 (28.51)	45.00 (61.09)	0.00 (0.00)	73.66
Dungarpur	06	6.60 (6.54)	1.00 (0.99)	-	36.66 (36.33)	56.66 (56.14)	0.00 (0.00)	100.92
Pratapgarh	08	11.66 (11.86)	3.66 (3.72)	-	24.33 (24.75)	57.00 (57.98)	1.66 (1.69)	98.31
Rajsamand	08	6.60 (8.36)	2.00 (2.53)	-	30.00 (38.01)	40.33 (51.10)	0.00 (0.00)	78.93
Udaipur	06	7.00 (7.55)	4.00 (4.32)	1.66 (1.79)	24.00 (25.90)	55.00 (59.36)	1.00 (1.08)	92.66
Total	40	46.85 (6.97)	14.65 (2.18)	2.66 (0.40)	217.32 (32.33)	385.65 (57.38)	4.99 (0.74)	672.12

Figures in the parentheses represent relative density of total population

Table 8.25: Efficacy of insecticides on the population of major predators lac insect during 2018-19

Treatments	Doses/Conc.	*E. amabilis*		*P. pulverea*		Survival of lac insect (%)
		Mean population at time of harvest	Reduction over control (%)	Mean population at time of harvest	Reduction over control (%)	
Neem Seed Kernel Extract (5%)	50 ml/lit	3.47* (11.67)	46.97	1.87 (3.00)	52.63	61.54 (51.67)**
Karanj oil (2%)	20 ml/lit	3.39 (11.00)	50.00	1.76 (2.67)	57.89	58.33 (49.80)
Neem oil (2%)	20 ml/lit	3.53 (12.00)	45.45	1.94 (3.33)	47.37	53.85 (47.21)
Spinosad 2.5 EC	2.0 ml/lit	1.95 (3.33)	84.85	1.34 (1.33)	78.95	78.57 (62.03)
Emamectin benzoate 5 SG	0.4gm/lit	2.20 (4.33)	80.30	1.46 (1.67)	73.68	75.00 (60.00)
Cartap hydrochloride 50 SP	2gm/lit	2.48 (5.67)	74.24	1.68 (2.33)	63.16	66.67 (54.74)
Control (Water only)	-	4.74 (22.00)	-	2.61 (6.33)	-	48.00 (43.85)
S. Em. ±		**0.83**	**-**	**0.33**		1.86
CD at 5%		**2.51**	**-**	**0.99**		5.61

*Square root √ (X + 0.5) transformations values and figures in parenthesis are retransformed values

** Figures in parenthesis are arc sine transformed % values

Mass awareness among farmers for adoption and conservation of lac insect genetic resources: Various activities were under taken for the creation of mass awareness about the lac insect and its host plants by conducting the campaign and farmers training. The farmers were imparted knowledge about the identification, biology and cultivation of lac insect on the available host plants. The training were imparted for the skill development on the cultivation of lac insect and various activities of lac cultivation were demonstrated for the better understanding and adaption among the farmers.

(i) **Trainings:** One training was conducted at Godan Kala (Madar), Udaipur, Rajasthan for farmers' awareness about lac insect and lac cultivation. 56 farmers participated in the training.

(ii) **Farmers visit:** 520 farmers who visited the lac museum and lac insect gene bank were imparted knowledge about lac insect and its conservation.

(iii) **Interaction and discusion with scientists of the various universities of the country:** The scientists from various universities of the country visited the lac lab and got aquinited with the lac insect, its biology and conservation.

(iv) **Exposure visits to students:** More than 280 students visited lac museum and acquired the knowledge about lac insect (Fig. 8.27 to 8.30).

Fig. 8.27: Mass awareness for lac cultivation during 2019

Fig. 8.28: Traditonal lac artisan working in shop, Jaipur market

Fig. 8.29: Visit of scientists from Western Sydney University, Australia to lac insect museum, RCA, Udaipur

Fig. 8.30: Glimpses of 6th Annual Workshop on 'Conservation of Lac Insect Genetic Resources' MPUAT, Udaipur, February 07-08, 2019

4. Punjab Agricultural University (PAU), Ludhiana

Survey for collection of information / lac insects / host plants from different parts of Punjab, Uttar Pradesh and Delhi

Regular surveys were conducted for collecting the information regarding lac insect and its host plants during

the year 2019 in 17 districts of Punjab, 7 districts of Uttar Pradesh and 3 districts of Delhi. The information of host plants and lac insect during each field survey was recorded on the passport data sheet.

Punjab

Thirty lac insect samples were collected from 7 host plants including *ber* (*Z. mauritiana*), *peepal* (*F. religiosa*), *chilkan* (*F. retusa*), *siris* (*Albizia* sp.), *bargad* (*F. bengalensis*), *kikkar* (*Acacia* sp.) and *jand* (*Prosopis* sp.) ranging from low to high lac population. The lac population on *Prosopis* sp. was recorded for the first time. The samples of lac insect collected from different sites of Punjab are given in Table 8.26 and Fig. 8.31.

Table 8.26: Status of lac insect in different locations of Punjab visited during 2019

Districts	Latitude (°N)	Longitude (°E)	Lac insect	
			Host	Population
Ludhiana	30º47.713'	75º52.219'	*Z. mauritiana*	Moderate
	30º39.270'	75º35.391'	*F. religiosa*	Moderate
Sangrur	30º36.791'	75º52.657'	*Z. mauritiana*	Moderate
	30º31.230'	75º52.777'	*Z. mauritiana*	Moderate
	30º31.238'	75º52.782'	*Albizia* sp.	High
	30º31.242'	75º52.777'	*F. religiosa*	High
	30º31.230'	75º52.782'	*F. bengalensis*	High
	30º31.231'	75º52.780'	*F. retusa*	High
	30º14.194'	75º50.322'	*Acacia* sp.	Moderate
	30º07.004'	75º49.090'	*Z. mauritiana*	Moderate
	30º04.558'	75º49.601'	*Z. mauritiana*	Moderate
Patiala	29 º49.437'	75º53.456'	*F. religiosa*	High
	29 º51.298'	75º57.745'	*Z. mauritiana*	Moderate
	30 º29.539'	76º24.326'	*Z. mauritiana*	High
Barnala	30º29.075'	75º34.049'	*Z. mauritiana*	High
	30º25.765'	75º34.001'	*Z. mauritiana*	High
Mansa	30º00.045'	75º23.449'	*Albizia* sp.	High
			Acacia sp.	Moderate
			Prosopis sp.	Moderate
	30º06.321'	75º31.875'	*Z. mauritiana*	High
	29º40.287'	75º15.644'	*Z. mauritiana*	Moderate
Faridkot	30º34.987'	74º49.832'	*Z. mauritiana*	Low
	30º34.793'	74º49.644'	*Z. mauritiana*	High
	30º32.106'	74º43.237'	*Acacia* sp.	Moderate
Muktsar	30º29.478'	74º32.374'	*Z. mauritiana*	High
Kapurthala	31º57.077'	75º36.436'	*Z. mauritiana*	High
Hoshiarpur	31º95.023'	75º61.180'	*Z. mauritiana*	High
Bathinda	30º18.171'	74º58.145'	*Z. mauritiana*	High
	30º22.171'	74°56.145'	*Z. mauritiana*	High
Amritsar	31º67.610'	74°75.421'	*Z. mauritiana*	High

Low: <100, Moderate: 100-1000 and High: >1000

Delhi

Twelve lac insect samples were collected from 2 host plants namely *ber* (*Z. mauritiana*) and *peepal* (*F. religiosa*), ranging from low to high lac population. Among these, *Z. mauritiana* was found to be major host plant having low to high population density at all the locations surveyed. The samples of lac insects collected from different sites of Delhi are given in Table 8.27 and Fig. 8.31.

Table 8.27: Status of lac insect in different locations of Delhi visited during 2019

Districts	Latitude (°N)	Longitude (°E)	Lac insect	
			Host	Population
Central Delhi	28º40.540'	77º13.860'	*Z. mauritiana*	Moderate
	28º40.512'	77º13.853'	*Z. mauritiana*	High
	28º37.770'	77º14.879'	*Z. mauritiana*	Low
	28º32.064'	77º23.910'	*Z. mauritiana*	Moderate
	28º32.708'	77º16.706'	*Z. mauritiana*	High
	28º32.757'	77º16.686'	*Z. mauritiana*	Low
	28º38.278'	77º10.500'	*Z. mauritiana*	High
			F. religiosa	
	28º39.700'	77º08.510'	*Z. mauritiana*	Low
	28º39.989'	77º08.311'	*Z. mauritiana*	Low
South Delhi	28º56.260'	77º29.141'	*Z. mauritiana*	Low
	28º58.989'	77º30.311'	*Z. mauritiana*	Low

Low: <100, Moderate: 100-1000 and High: >1000.

Uttar Pradesh

Ten lac insect samples were collected from 4 host plants namely *ber* (*Z. mauritiana*), *peepal* (*F. religiosa*), *pilkan* (*F. virens*) and *chilkan* (*F. retusa*) ranging from low to high lac population. Among these, *F. religiosa* was found to be major host plant having high population density at all the locations. The samples of lac insects collected from different sites of UP are given in Table 8.28, Fig. 8.31.

Table 8.28: Status of lac insect in different locations of Uttar Pradesh visited during 2019

Districts	Lac insect	
	Host	Population
Baghpat	*F. religiosa*	High
	F. religiosa	Low
	Z. mauritiana	Low
	F. virens	High
	F. retusa	Low
	F. religiosa	High
	F. religiosa	High
	F. virens	Moderate
Muzaffarnagar	*Z. mauritiana*	Moderate
	F. religiosa	High

Low: <100, Moderate: 100-1000 and High: >1000

Fig. 8.31: Lac insects collected from different parts of Punjab, Uttar Pradesh and Delhi

Studies on life cycle and productivity-linked parameters of lac insects (*rangeeni* strain; *katki* crop) on *F. semialata, F. macrophylla* and *Z. mauritiana*

The biological and productivity-linked parameters of *rangeeni* strain (*Katki* crop) of lac insect were studied on different host plants namely *F. semialata, F. macrophylla* and *Z. mauritiana* (Fig. 8.32 and 8.33) at Lac Insect and Host Park, Entomological Research Farm, Punjab Agricultural University (PAU), Ludhiana during July to October, 2019.

Inoculation of broodlac

The broodlac sticks (5 cm each) of *rangeeni* strain were tied to one year old *F. semialata* and *F. macrophylla* plants. Similarly, broodlac sticks (10 cm each) were tied to branches of three years old *Z. mauritiana* plants. The nymphs were allowed to emerge from mature females for about two weeks. After the emergence of newly hatched nymphs, the lac sticks (*phunki*) were removed from host plants. Observations *viz.* initial settlement density (number per square cm), initial mortality (%), duration of pre-sexual stages, male emergence initiation (days), sex ratio (% of male insects), density at crop maturity (number per square cm), weight (in mg) of the female cell and resin output, fecundity (number of young ones produced by the female insect), broodlac and scrapped lac yield (g) were recorded.

Fig. 8.32: Lac insect on F. semialata

Fig. 8.33: Lac insect on *Z. mauritiana*

The results of different biological and productivity linked parameters on *F. semialata, F. macrophylla* and *Z. mauritiana* are presented as under:

F. semialata: Initial density of lac insect settlement was observed to be 22.73±1.76 insects/ cm^2 and initial percentage mortality was 18.53±1.02. The mean duration of female and male cell differentiation *i.e.* duration of pre-sexual stages was 19.00±0.45 days (range 18-20 days)**.** The mean male emergence was observed to be initiated after 42.20±0.66 days (range 40-44 days) and sex-ratio (% male insects) was 19.31±3.79. The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 2.53±0.44/cm^2. Mean weight of female cell was 6.20±0.28 mg (range 5.93-6.80 mg) after crawler emergence. The average resin produced by an individual female cell recorded after removing the dead insect body from the cell 4.58±0.22 mg (range 4.61-5.23 mg). Average number of young ones produced by the single female insect ranged from 75.00 to 102 individuals (92.02±3.34). Scraped lac yield recorded after crop harvesting was 5.62±0.29 g/m shoot length.

F. macrophylla: Initial density of lac insect settlement was observed to be 23.63±1.13 insects/ cm^2 and initial percentage mortality was 18.71±0.83. The mean duration of female and male cell differentiation *i.e.* duration of pre-sexual stages was 19.20±0.48 days (range 18 – 20 days**).** The mean male emergence was observed to be initiated after 42.20±1.11 days (range 40-45 days) and sex-ratio (% male insects) was 13.04±4.86. The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 3.47±0.31/cm^2. Mean weight of female cell was 6.47±0.26 mg (range 6.16-6.74 mg) after crawler emergence. The average resin produced by an individual female cell recorded after removing the dead insect body from the cell 5.13±0.19 mg (range 4.70-6.02 mg). Average number of young ones produced by the single female insect was 90.06±3.73. Scrapped lac

yield /m shoot length recorded after crop harvesting was 8.26±0.59 g.

Z. mauritiana: Initial density of lac insect settlement was observed to be 33.36±2.76 insects/ cm^2 and initial percentage mortality was 27.98±1.04. The mean duration of female and male cell differentiation *i.e.* duration of pre-sexual stages was 19.20±0.58 (range 18 – 21days). The mean male emergence was observed to be initiated after 41.80±0.97 (range 40-45 days) and sex-ratio (% male insects) was 9.70±1.75. The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 3.47±0.31/cm^2. Mean weight of female cell was 8.03±0.32 mg (range 7.20-8.09 mg) after crawler emergence. The average resin produced by an individual female cell recorded after removing the dead insect body from the cell 6.72±0.33 mg (range 5.04 – 6.22 mg). Average number of young ones produced by the single female insect was 107.14±2.03 individuals. Scrapped lac yield recorded after crop harvesting was 23.35±3.29 /m shoot length.

Effect of lac cultivation (*rangeeni* strain; *katki* crop) on seed yield and quality parameter of pigeonpea, *C. cajan*

Studies on pigeonpea – lac insect interaction: Life cycle and productivity-linked parameters of *rangeeni* strain (*Katki* crop) and its effect on seed yield and quality parameters were carried out at the Entomological Research Farm, PAU, Ludhiana during 2019. Seeds of PAU recommended varieties (AL 882, AL 201 and PAU 881) were procured from Pulses section, Department of Plant Breeding and Genetics, PAU Ludhiana (Fig. 8.34). These were sown under field conditions on April 12, 2019 in spacing of 60 cm (row to row) and 60 cm (plant to plant). All recommended agronomic practices according to the PAU Package of Practices for *Kharif* crops were followed to raise the crop except plant protection measures. The brood lac sticks (5 cm each) of *Rangeeni* strain (*Katki* crop) having mature female (brood) cells were inoculated on July 19, 2019. The nymphs were allowed to emerge from mature females for about two weeks. After the emergence of newly hatched nymphs the stick lac (*phunki*) were removed from host plants. Once the crawlers emerged from brood cells, the observations were recorded on different parameters, *viz*. duration of pre-sexual stage, male emergence, initial density settlement, initial mortality, sex-ratio, survival at maturity, female weight, resin output, female fecundity, broodlac, and scrapped yield output. Data were also recorded for grain seed parameters like 100 seed weight, grain yield per plant, Height of plant, average seed count and crude protein (per cent) in seeds in inoculated plants. Similar data were also recorded from control (un-inoculated) plants for comparison. The results are presented as under.

Initial density of lac insect settlement was observed to be higher in variety AL 882 (34.80±2.24 insects/ cm^2) followed by AL 201 (30.70±2.64 insects/ cm^2) and PAU 881 (26.47±1.46 insects/ cm^2). Initial percentage mortality was lowest in variety AL 201 (20.72 ± 1.42) followed by PAU 881 (24.21±1.17) and AL 882 (26.39±0.38). The mean male emergence was observed to be initiated after 42.6±0.81 (range 40-45 days), 43.2 ±0.92 (range 41-45 days) and 44.8±1.32 (range 40-48 days) and sex-ratio (% male insects) was 12.31± 0.75, 11.99 ± 0.74 and 8.82±1.92 in varieties AL 882, AL 201 and PAU 881 respectively. The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 3.47±0.31, 3.53±0.22 and 3.30±0.23 per cm^2 respectively in varieties AL 882, AL 201 and PAU 881, respectively. The mean duration of female and male cell differentiation *i.e.* duration of pre-sexual stages was 19.00±0.55 (range 17-20 days), 19.40±0.68 (range 18-21days) and 19.8±0.80 (range 17-22 days). Mean weight of female cell was more in variety AL 201 (7.94± 0.41 mg) followed by PAU 881 (7.48 ±0.57 mg) and AL 882 (7.41±0.32 mg). The average resin produced by an individual female cell recorded after removing the dead insect body from the cell was 5.81±0.39, 5.73±0.41 and 5.28±0.22 mg in AL 201, PAU 881 and AL 882, respectively. Average number of young ones produced by the single female insect was 95.26±3.95, 99.03±3.87 and 90.44±3.86 in AL 882, AL 201, and PAU 881 respectively. Scrapped lac yield recorded after crop harvesting was maximum in variety AL 201 (17.00 g/m shoot length) followed by PAU 881 (16.46 g/m shoot length) and AL 882(14.18 g/m shoot length). Hundred seed weight was 10.57, 7.54 and 7.06 g in lac inoculated plants as compared to 14.24, 8.38 and 8.80 g

Fig. 8.34: Lac insect on *C. cajan*

in control (un-inoculated) plants resulting in a reduction by 25.77, 10.01 and 19.74 per cent in AL 882, AL 201 and PAU 882, respectively. Average seed yield per plot in lac inoculated plants was maximum in variety AL 882 (32.82 g) followed by AL 201 (29.51 g) and PAU 881 (27.76 g). The reduction in seed yield was 31.14, 18.06 and 23. 85 per cent in variety AL882, AL 201 and PAU 881, respectively. Average plant height was found to be maximum in variety AL 201 followed by PAU 881 and AL 882 *i.e.*, 109.20±2.35m, 108.60±3.01m and 81.80±3.51m respectively. However, number of pods/plant was recorded maximum in short duration variety, AL 882 (251.40±2.41) followed by AL 201 (134.40±10.04) and minimum in PAU 881 (109.80±2.52) respectively (Tables 8.29 to 8.32).

Table 8.29: Initial and final density of settlement, per cent mortality, sex ratio and survival at maturity of lac insect (*rangeeni*; *katki* crop) on *C. cajan*

Varieties	Initial density of settlement (no./cm²)	% Mortality	Sex ratio (% male insects)	Density at crop maturity (no./cm²)
AL 882	34.80±2.24 (27.50-41.00)	26.39±0.38 (25.35-27.27)	12.31±0.75 (11.32-15.29)	3.47±0.31 (2.67-4.33)
AL 201	30.70±2.64 (27.50-34.17)	20.72±1.42 (17.86-24.48)	11.99±0.74 (10.00-13.89)	3.53±0.22 (2.67-4.00)
PAU 881	26.47±1.46 (21.33-29.83)	24.21±1.17 (20.31-26.95)	8.82±1.92 (3.80-13.98)	3.30±0.23 (2.67-4.00)

Mean of 5 replications; Figures in parentheses are range values

Table 8.30: Duration of pre-sexual stages and male emergence of lac insect (*rangeeni*; *katki* crop) on *C. cajan*

Varieties	Duration of pre-sexual stages (days)	Initiation of male emergence (days)	Longevity of female cell (days)
AL 882	19.00±0.55 (17-20)	42.60±0.81 (40-45)	107.67±4.26 (104-109)
AL 201	19.40±0.68 (18-21)	43.20±0.92 (41-45)	110.00±1.23 (107-110)
PAU 881	19.80±0.80 (17-20)	44.8±1.32 (40-48)	106.00±1.25 (103-106)

Mean of 5 replications; Figures in parentheses are range values

Table 8.31: Female cell weight, resin output, fecundity, broodlac and scrapped lac yield of lac insect (*rangeeni*; *katki* crop) on *C. cajan*

Parameters	AL 882	AL 201	PAU 881
Female cell weight (mg)	7.41±0.32 (7.09-8.55)	7.94±0.41 (7.56-8.48)	7.48±0.57 (7.03-8.28)
Resin output (mg)	5.28±0.22 (4.99-5.84)	5.81±0.39 (5.23-6.11)	5.73±0.41 (5.39-6.13)
Fecundity/ female (no.)	95.26±3.95 (90-101)	99.03±3.87 (96-102)	90.44±3.86 (78-95)
Broodlac yield /m shoot length (g)	81.05±13.67 (33.17-116.1)	80.10±9.46 (79.4-102.1)	83.60±6.73 (64.21-105.7)
Scrapped lac yield/m shoot length (g)	14.18±1.46 (10.72-18.91)	17.00±2.31 (11.96-24.23)	16.46±3.40 (9.92-27.57)

Mean of 5 replications; Figures in parentheses are range values

Table 8.32: Effect of lac cultivation (*rangeeni*; *katki* crop) on seed yield and seed weight of *C. cajan*

Varieties	100 seed wt (g)		% Decrease	Total yield/ plant (g)		% Decrease
	Inoculated	Control		Inoculated	Control	
AL 882	10.57	14.24	-25.77	32.82	47.66	-31.14
AL 201	7.54	8.38	-10.01	29.51	36.02	-18.06
PAU 881	7.06	8.80	-19.74	27.76	36.46	-23.85

Studies on insect fauna associated with lac hosts, *F.* spp. under Punjab conditions: To record the fauna associated with lac hosts, *F. semialata* and *F. macrophylla*, observations were taken every alternate day during January to December, 2019. A total of 30 insects belonging to orders, Hemiptera (10), Lepidoptera (8), Diptera (6), Coleoptera (5) and Mantodea (1) and 6 spiders (Acari) were found to be associated with *F. semialata* and *F. macrophylla* under Punjab conditions.

Arthropod fauna recorded from *F. semialata* and *F. macrophylla*

- Acari : 6 spp of Spiders (Araneidae)
- Coleoptera : *Myllocerus* sp. (Curculionidae), *Cheilomenes sexmaculatus, Coccinella septempunctata* (Coccinellidae), *Raphidopalpa foveicollis* (Chrysomelidae) and *Paederus dermatitis* (Staphylinidae)
- Diptera : *Melanogromyza obtuse* (Agromyzidae), *Eristalis* spp. (Hover fly) (Syrphidae), Robber fly (Asilidae), Crane fly (Tipulidae), *Sturmiopsis* sp. (Tachinidae) and *Musca domestica* (Muscidae)
- Hemiptera : *Nezara viridula* (Pentatomidae), *Aphis craccivora* (Aphididae), *Oxyrachis* sp. (Tree hopper) (Membracidae), Reduvid bug (Reduviidae), *Dysdercus koengii* (Pyrrhocoridae), Jassid (Cicadellidae), Bug (Coreidae), *Dolycoris indicus* (Pentatomidae), *Riptotortus pedestris* (Alydidae) and Mealybug (Pseudococcidae)

- Lepidoptera *: Euproctis* spp. (Erebidae), Rice Leaf folder (Pyralidae/Crambidae), *Hyposidra* sp. (Geometridae), Beet Webworm Moth (Crambidae), *Euchrysops cnejus* (Lycaenidae), *Spodoptera* spp. (Noctuidae), *Dasychira mendosa* (Erebidae) and Green leaf Butterfly (Pieridae)
- Mantodea : Mantis (Mantidae)

Diversity of natural enemies (predators and parasitoids) associated with lac insect under Punjab conditions: Studies on the insect fauna associated with lac insect were carried out during January to December, 2019. The lac encrusted sticks were observed visually for presence of predator population. Lac insect samples were collected randomly with 5 replications after *phunki* removal at every 15 days interval till harvest. The samples were kept in bioagent collection cages (20x20x30 cm) filled with glass tubes. These cages were monitored at regular intervals to record the emergence of parasitoids and predators. The collected samples of parasitoids and predators were sent to ICAR-IINRG Ranchi for their identification up to species level. Under Punjab conditions, lac insect associated fauna comprised ten species (Table 8.33, Fig. 8.35).

Table 8.33: Natural enemies associated with lac insect under Punjab conditions

Sl. No.	Name	Predator/ Parasitoid	Family	Order	Percent abundance
1.	*Eublemma amabilis* Moore	Predator	Noctuidae	Lepidoptera	28.47
2.	Beetle (unidentified)			Coleoptera	24.30
3.	*Aprostocteus purpureus* (Cam.)	Parasitoid	Eulophidae	Hymenoptera	17.36
4.	*Bracon greeni* (Ashm.)	Hyper parasitoid	Braconidae	Hymenoptera	13.19
5.	*Coccinella septempunctata* (Lin.)	Predator	Coccinellidae	Coleoptera	6.94
6.	*Cheilomenus sexmaculatus* (Fab.)	Predator	Coccinellidae	Coleoptera	4.17
7.	*Chrysoperla zastrowi sillemi* (Esben-Peterson)	Predator	Chrysopidae	Neuroptera	3.47
8.	*Tachardiaephagus tachardiae somervilli* (Mahd)	Parasitoid	Encyrtidae	Hymenoptera	0.69
9.	*T. tachardiae* (How)	Parasitoid	Encyrtidae	Hymenoptera	0.69
10.	*Parechthrodryinus clavicornis* (Cam.)	Parasitoid	Encyrtidae	Hymenoptera	0.69

Chrysoperla zastrowi sillemi *Coccinella septempunctata* *Cheilomenus sexmaculatus* *Bracon greeni*

Fig. 8.35: Natural enemies associated with lac insect under Punjab conditions

5. Prof. Jayshankar Telangana State Agricultural University (PJTSAU), Hyderabad

a) Survey for collection of information / lac insects / host plants (i*n – situ* conservations)

Regular surveys were conducted for collecting the information on lac insects and hosts plants in Telangana. The details pertaining to places visited and the detailed information of host plants and lac insects during each field survey was recorded on the passport data sheet and has been compiled. The places and host plants where the lac insect population was found live and established were marked for *in-situ* conservation. The samples of lac insect (broodlac sticks) were collected from these host plants and brought to the laboratory for ex-*situ* conservation.

b) Identification & tagging of lac host trees: Various host plants such as *ber* (*Z. mauritiana*), *Shisam* (*Dalbergia sissoo*), *palas* (*Butea monosperma*), peepal (*F. religiosa*, *Ficus benzamina)* and *tumma* (*Acacia nilotica*) have been identified and tagged in Lac Insect and Lac Host Park, AINP on VPM, PJTSAU, Hyderabad. These trees are being

regularly maintained for their demonstration as lac insect host plants.

c) *Ex-situ* conservation: The broodlac sticks collected from different places were inoculated on *F.* spp, *C. cajan*, *A. nilotica* and *F. religiosa* plants at Lac Insect and Lac Host Park, AINP on VPM, PJTSAU, Hyderabad for *ex-situ* conservation. These were assigned different codes and are being monitored regularly for the emergence of nymphs and their establishment on new plants.

***In-situ* conservation:** In addition to the old places visited previous year, during July – December 2019, some new places were also visited where live population of lac insect was recorded. All these places along with host plants were marked for *in-situ* conservation and these areas will be visited in the next season to check the status of lac insect. The detailed area-wise scenario of lac insects and their host plants is enumerated as:

Telangana: All the thirty-one districts of Telangana were surveyed during the year for the identification of host plants, collection of lac insect and recording of its availability on possible host plants.

Adilabad: Huge infestation was observed on trees of *Peltophorum pterocorpum* and *A. saman* at Adilabad rural (78.534137°E, 19.658252°N) and Nirmal Town (78.343074°E, 19.092705°N), predominantly occurs in the urban area.

Mahabubnagar: Moderate to huge infestation was observed on wild species of *F. bengalensis, F. religiosa* and *F. hipsida.* In the village of Misigandi (78.30928 E,16.57243 N) nearby temple huge infestation of lac was observed on *F. religiosa* when compared to other spp.

Hyderabad: This urban area is having huge plantation of *P. pterocorpum* and *A. saman* by roadside. Most of these plants were infested with Lac insect. The areas where the infestation was huge are, Ravindrabharathi, Nampally (78.28144 E, 17.241065 N), Gandhi nagar (78.29283 E, 17.25750 N), Masab Tank (78.265985 E, 17.235656 N), Ashok Nagar (78°49'08.97"E, 17°40'64.78"N), Chandravihar Complex, Nampally (78.282422 E, 17.231052 N).

The moderate lac insect population was observed in the areas of Osmania University nearby hostel E location (78.31561 E,17.24780 N), on *F. bengalensis,* Lac insect was also observed on bare tree (*Ziziphus spp*.), also observed at Law Hostel Osmania university- Law Hostel (78.31534 E, 17.24843 N), Lac infestation was observed on rain tree (*A. saman*), Osmania University Law Hostel (78.31550 E, 17.24852 N), Osmania University ECE department (78.31083 E, 17.24460 N), Osmania University UGC – HRDC (78.31508E, 17.24829 N), Gandhi nagar high infestation was found (78.29283 E, 17.25750 N), OU Hostel E (78.31561 E, 17.24780 N), Masab Tank (78.265985 E, 17.235656 N), Chandra vihar, Nampally, (78.282422 E, 17.231052 N), Musheerabad, Arabindo Ashram (78°30'4.89"E17°25'13.58"N), Musheerabad, Mosque (78°30'0.52"E, 17°25'15.17"N), Prasad's IMAX (78°27'56.61"E, 17°24'49.61"N), NTR Gardens(78°28'4.83"E, 17°24'50.74"N), Lac host plants such as *F. bengalensis, Zizipus spp, A. saman*, *P. pterocarpum* and *F. religiosa* were observed during the survey.

Rangareddy: Low to huge population of Lac insect was reported in many parts of this district. High infestation was found on *A. saman* at Gudi Malkapur major Lac insect infestation was observed during the field (78°26'19.14"E, 17°23'0.77"N), (78°26'19.71"E, 17°22'55.33"), and Vanasthalipuram (78.35109 E, 17.201147 N), 2-4 location was recorded on *P. pterocarpum* most of the population's crawlers were reported from this area and almost all the host plants having huge lac infestation in this area.

Conducted survey other areas of Ranagreddy district, namely Shankarpally, Gundlapally, and Gandipet areas and LAC insect incidence was not recorded during the field visit.

Nizamabad: Survey was conducted in Nizamabad urban (78.093197° E, 18.673408° N) having Lac infestation moderate on *A. saman* also conducted a transit walk survey in surrounding area reserve forest , but Lac insect incidence was not found. Kamareddy region Basawapur village (78.415971° E, 18.152927° N) recorded huge population of Lac insect on *A. saman* (Fig. 8.36).

Karimnagar: Huge population of Lac insect is recorded on *F. religiosa* and *A. saman* at the roadside plantation in the Shabashpalle village (78°55'24.98"E, 18°26'3.12"N) and at temple of Bheemeshwaralayam in Vemulawada town (78°52'1.11"E, 18°28'8.82"N).

Fig. 8.36: Lac insect on *Albizia saman* at Nizamabad urban

6. Sher-e- Kashmir University of Agricultural Sciences and Technology (SKUAST), Jammu

In-situ conservation of lac-insects / host plants on wider scale

Multiplication of collected local lac insect population

Plants of *F. semialata* were raised in nursery for rearing Lac insects for the purpose of conservation and multiplication of the insect. A few seedlings of *F. semialata* were planted in pots and were raised in optimum protected natural condition. During mid-October, on the appearance of emergence marks in the tagged branches of infested trees in field, the branches were partially clipped and were made into cuttings of brood lac of small size (5 cms/ brood stick). Broodlac sticks were wrapped in muslin cloth bags and were inoculated on the succulent branches of substitute experimental host i.e. *F. semialata* both in nursery and in pots as well. '*Phunki*' were removed after complete emergence and settling of Lac insect crawlers on the branches. Periodic management of nursery and potted plants of *F. semialata* bearing Lac insect crawlers were performed. Observation on the maturation and growth of Lac insects were being recorded timely.

i. **Conservation through selfing in Jammu region:** Partial brood was allowed for natural inoculation on the same host plants for sustaining and conserving native strain. To be more precise, we also inoculated twelve secure plants in the vicinity (Fig. 8.37).

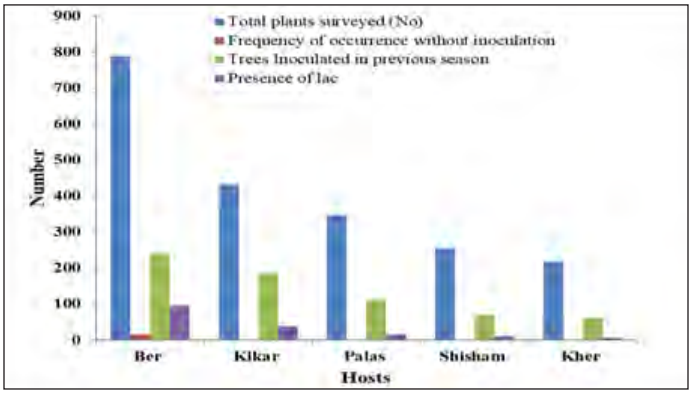


Fig. 8.37: Conservation through selfing in Jammu region

i. **Artificial inoculation and conservation in mid hills to escape summer mortality:** In artificial inoculation, brood twigs were cut in size 20 - 30 cm in length. Then, the cut pieces of brood twig were tied to fresh tree twigs in such a way that each stick touches the tender branches of trees (*Ber*, *Khair* and *Pipal*) at several places. This was done on or pre pruned *Ber* at Dhar Road from Majalta to Billawar and Basholi. A major initiative was done at Cherni Phari and around areas.

ii. **Artificial inoculation conservation:** Inoculated on Succulent branches of *Ficus* sp., *Ber* and *Kikar* at University Rainfed Research Station, Raya and around the Jammu region and Himachal Pradesh where brood twigs were tied with the selected and tagged plants.

iii. **On *arhar* at SKUAST-J:** Artificial inoculation of the brood was done at SKUAST-J campus on *arhar* plants that were raised in the gene bank of the university. A good settlement was recorded on the *arhar* plants so far.

iv. **Artificial Inoculation Conservation on *F. semialata* and *F. macrophylla* at SKUAST-J:** *F. semialata* and *F. macrophylla* were raised in nursery for rearing Lac insects for the purpose of conservation and were then transplanted to the gene bank where, they were inoculated with the brood. A few seedlings of *F. semialata* and *F. macrophylla* were planted in pots and were raised in optimum protected natural condition. Artificial inoculation was done was on the plants also (Fig. 8.38 and 8.39).

Fig. 8.38: A glimpse of lac insect on different host plants *viz. Arhar, Tali, Calliandra* and *Kikar*

Fig. 8.39: Artificial conservation on *kikar* (low summer mortality)

Brood multiplication and interventions for On-Farm trials and demonstrations

Brood Production: Last year collections were subjected to brood production and re-inoculated for further use.

Collection name	Quantity produced	Reintroduced for conservation in same location (No. of plants)	Demonstrations (No. of plants)
Gol Market	132 Kg	52	23
Bantalab	67 Kg	29	10
Purkhoo	55 Kg	23	10
Udheywala	29 Kg	18	8
Kathua	61 Kg	27	10
Canal Raod	34 Kg	19	7
Nagrota	37 Kg	19	7
Kangra (H.P.)	16 Kg	10	3
Cherni Pahari	172 Kg	67	28
Chi Chi Mata	108 Kg	53	21
Ghagwal	57 Kg	24	10
Railway Station area	45 Kg	20	9
Barmana	13 Kg	7	2
TOTAL	**826 KG**	**368**	**122**

a) Plants of *F. semialata* and *F. macrophylla* were raised in nursery

Nurseries of *F. semialata* and *F. macrophylla* were separately raised for rearing of Lac insect for the purpose of conservation and multiplication of the insect. The plants (1986 hos.) were also distributed among the famers.

b) Establishment of brood farm at Vijaypur and Chatha

Brood Farm at Chatha: For the establishment of brood farm at Chatha, the site selected for nursery was cleaned in advance and the existing growth was uprooted. The whole area was then divided into sub-plots so that plantation is effectively made. Seeds of *F.* procured from IINRG were then sowed in the plots. The nursery of *F.* raised in the nursery beds were then transplanted into field, where trials were laid down for the inoculation of brood lac (Fig. 8.40).

Brood farm at Vijaypur: Plants raised in the nursery at Chatha were also transplanted to brood farm at Vijaypur in Samba District for the preparation of brood lac from where farmers can easily get the brood for the inoculation on *Ber* plants in their fields. Partial plants were inoculated by putting of collected sticks of broodlac (lac sticks containing gravid females) in the host twigs for allowing young lac larvae (crawlers) to come out of their mother cells and settle on the host plant.

Fig. 8.40: Broodlac farm at Chatha with *arhar* and *Flemingia* plants

c) Gene bank

a) Brood maintenance for gene bank

Eleven collections that survived successfully from previous year collections were reinoculated on *Flamingia* and being maintained in the gene bank.

b) New collections made and their conservation

The lac insects samples collected from the different lac hosts from different localities were inoculated on different lac host plants at SKUAST- Jammu during the month of June and October 2019. After inoculation the emergence and settlement data were recorded for each sample of lac insect on host plants. To prevent the infestation of lac insects with different natural enemies and fungi different pesticides were sprayed on host plants at different stages of lac insect Table 8.34.

Table 8.34: List of lac insects samples collected from the different lac hosts from different localities

Collection name	Whether surviving or not	Settlement rate	Mean weight of fresh 100 cells (g)
Gol Market	Surviving	172.8 Crawlers/cm^2	1.98
Bantalab	Surviving	168.3 Crawlers/cm^2	1.71
Purkhoo	Surviving	107.5 Crawlers/cm^2	1.59
Udheywala	Surviving	92.8 Crawlers/cm^2	0.74
Kathua	Surviving	123.7 Crawlers/cm^2	0.99
Canal Raod	Surviving	32.9 Crawlers/cm^2	0.56
Nagrota	Surviving	58.5 Crawlers/cm^2	0.72
Kangra (H.P.)	Surviving	42.0 Crawlers/cm^2	0.61
Cherni Pahari	Surviving	150.6 Crawlers/cm^2	1.63
Chi Chi Mata	Surviving	141.2 Crawlers/cm^2	1.58
Ghagwal	Surviving	102.0 Crawlers/cm^2	0.93
Railway Station	Surviving	115.9 Crawlers/cm^2	0.94
Barmana	Surviving	28.5 Crawlers/cm^2	0.46

d) Artificial inoculation for multiplication on *ber* and *Kikar* in Jammu region

Artificial inoculation was done for the multiplication of lac insect. Brood twigs were cut in size 20 - 30 cm in length. Then, the cut pieces of brood twig were tied to fresh tree twigs in such a way that each stick touches the tender branches of trees at several places. This was done on or pre pruned *Ber* (256 No.) and succulent branches of *kikar* (172 No.), *khair*, *palas* and *peepal* around the Jammu region and Himachal Pradesh where brood twigs were tied with the selected and tagged plants of *ber, kikar, khair*, *palas* and *peepal*.

e) Effect of temperature on survival of lac insect

The relationship between the temperature and mortality is depicted in Fig. 8.41 that showed increased mortality with the increase in temperature. The mortality started increasing from 16th standard week, when the temperature tends to reach around 30°C. Among *ber, kikar, F.* and *arhar*, maximum mortality of 69.95 per cent was recorded in *F.* followed by *arhar*, *ber* and *kikar* with per cent mortality of 65.90, 60.18 and 46.15 respectively, when the maximum temperature of 43.1 °C was recorded.

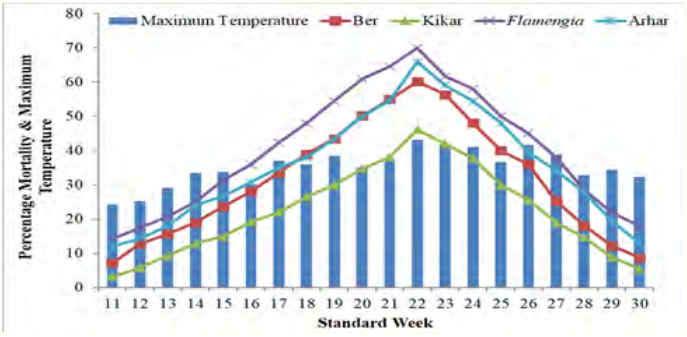


Fig. 8.41: Relation between temperature and mortality of lac insect as observed under field conditions on *ber, kikar, Flemingia* and *arhar*

g) Parasitism

1. Mean number of parasitoids infested lac cell at 90 days after Broodlac inoculation (BLI)

Two applications of Indoxacarb (0.5ml/l) significantly reduced the infestation of parasitoid infected lac cell on *rangeeni* lac on *ber* over the control at 90 days after BLI. At 90 days after BLI the mean incidence of parasitoids was lowered from 2.42/2.5sq cm to 0.53/2.5sq cm. However, the parasitoid numbers varied from 17 to 43.

2. Mean number of predator and parasitoids infected lac cell at harvest per 30cm

Sticklac

Pesticide applications significantly reduced the mean number predators/parasitoids infested lac cells at harvest. It was 42.31 in case of control and was reduced to 20.08 in treated plants at harvest (Fig. 8.42).

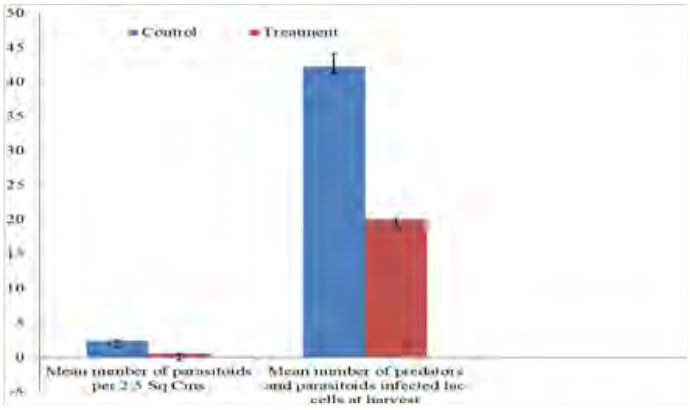


Fig. 8.42: Mean number of parasitoids and predators over control at harvest

C. To impart training to selective master trainers for lac cultivation inside the community

a) Trials at Research Farm, SKUAST-Jammu as well as at selected progressive growers

Four trials were conducted at Research Farm, SKUAST-Jammu and seventeen trails at selected progressive grower's fields for the demonstration of lac cultivation technologies. Saplings of *F. semialata* and *F. macrophylla* and brood lac were distributed to the potential grower for conservation and multiplication. One hundred and sixty nine farmers were provided with broodlac. Fifty seven visits for continuous deliberations with the people of the areas were conducted regarding the presence of lac insect in the area and also information was given to them regarding lac cultivation and its value and uses. Informative

pamphlets (913 Nos.) were also distributed among the participants. Eight interactive sessions were conducted for the farmers.

b) Training programmes

One day training programmes (7 Nos.) were conducted at Raya Station of SKUAST-Jammu, Cherni Phari, Vijaypur, Main campus Chatha, SKUAST-Jammu (4) in collaboration with IINRG, Ranchi. The farmers were briefed about the importance of lac insect and lac cultivation to the progressive growers of the region. Progressive growers were also informed about the monetary benefits of lac and how can they create their own livelihood while attaining lac cultivation on large scale. Near about 80 progressive growers actively participated in each training programme. These farmers were given complete demonstration from nursery preparation upto harvesting and inoculation of brood lacon different host plants of the region (Fig. 8.43). Pamphlets were distributed among the farmers containing information about scientific cultivation of lac in vernacular languages.

Fig. 8.43: Brood bundling, performance of crop, spraying on crop and harvesting

c) Involvement of students

Not only progressive growers, but the RAWE students (80 No.) of SKUAST-Jammu were also enlightened about the importance of lac insect and lac cultivation in the region. They were also briefed about the scientific culturing and handling of the lac insect. Besides this students from the visiting schools were briefed about the lac insect and their economic importance. Trainings were imparted to near about sixty seven (67) students of Diploma in Agriculture Training and Diploma in Horticulture Training which included candidates from Department of Agriculture and Horticulture J&K Government. They were briefed about the all the technical skills used in the scientific cultivation of lac from nursery preparation to nursery raising and from brood inoculation to brood harvesting. Seventy nine students of Government Degree College RS Pura, Jammu were also briefed about the lac insect, importance of lac and scientific cultivation of lac from inoculationto harvest. The astonishing thing was that, being science background students they were well familiar with lac, but some students told that they heard about lac from their grand parents as lac was exported to Sailkot from RS Pura route.

b. State Forest Institutes

7. Kerala Forest Research Institute (KFRI), Thrissur

Survey

Thrissur district in Kerala and sixteen districts from Tamil Nadu were surveyed in the year 2019. Twenty locations were recorded with the presence of lac, both from Kerala and Tamil Nadu, out of which seventeen locations were spotted with dead and three locations with live Lac. Climate change factors like unprecedented rainfall, humidity, temperature etc. can dwindle the distribution of lac. This can be clearly seen from the data collected from locations like Thenkasi, Madurai and Dindigul in Tamil Nadu. A total of twenty nine live lac sites were spotted from these locations during the survey in the year 2016-17 where the revisits to the same locations were recorded with sixteen dead and thirteen live lac sites which shows 55.5% loss in the distribution of lac.

In Kerala, ten farmers from two districts; Thrissur and Palakkad showed interest in lac cultivation and twenty numbers of host plant seedlings (ten each), *F. semialata* and *F. macrophylla* were given to the farmers. As an extension activity, news was published in national dailies and about twenty six phone calls were received from farmers of different locations in Kerala to know about the lac cultivation and its economic significance. Queries on lac insect, cultivation and future prospects are still being answered using our Helpline number. Maps denoting dead, live and distribution of lac was prepared for the year 2015-19. Separate maps showing dead, live and distribution of lac were also prepared (Fig. 8.44 to 8.51).

A gene bank of host plants for the cultivation of lac is being maintained in KFRI since 2014. The major host plants maintained in gene banks are *F. semialata* and *F. macrophylla*. Apart from these, *B. monosperma* host

plant has been raised since 2018. Seeds collected from first generation of host plants were sown and about four hundred seedlings are now available in the KFRI gene bank. Live lac collected from Vellore, Mettur, Salem and Karaikal in Tamil Nadu were used for the inoculation in *F.* host plants and these are well maintained in the gene bank of KFRI campus. Studies on the lifecycle of lac insect was observed and recorded from the KFRI gene bank. Biological attributes of lac were studied and compared with four different locations from South India (Table 8.35 to 8.38).

White fly attack on *F.* leaves were tried to be controlled using four chemicals- Neem oil, Actara and Imidan. It was found that Actara gave better control of the pest population.

Gene Bank

Lac collected from any of the location was inoculated in unaffected host plants like *A. saman*, *F. benghalensis* and *F. religiosa* in the collection site itself and the rest was inoculated in the KFRI Gene bank.

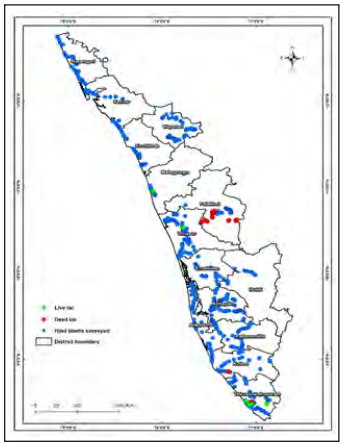


Fig. 8.44: Lac surveyed map of Kerala during 2014-2019

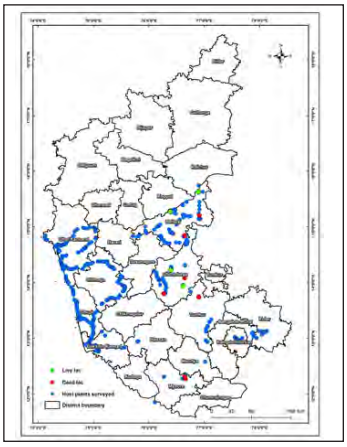


Fig. 8.45: Lac survey map of Karnataka during 2014-2019

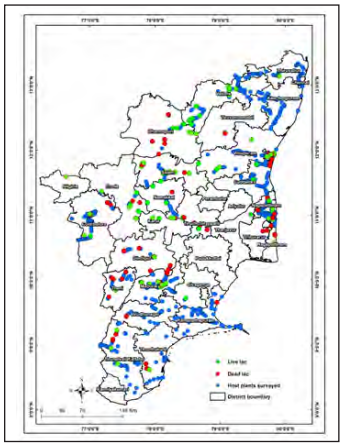


Fig. 8.46: Lac insect survey map of Tamilnadu during 2014-2019

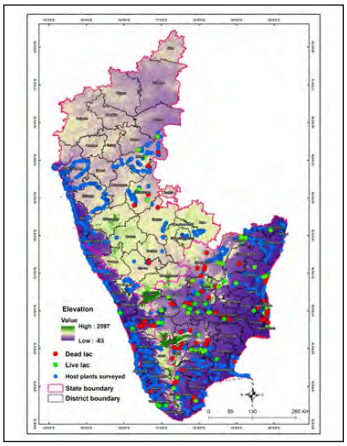


Fig. 8.47: Survey map of south India (Part) at elevation basis

Fig. 8.48: Live lac from Erode, Tamil Nadu

Fig. 8.49: Live lac on *A. saman* tree from Madurai

Fig. 8.50: Lac insect on *F. religiosa* from Dindugal

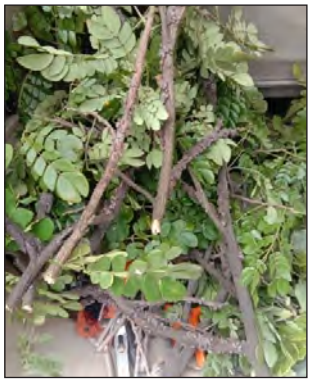


Fig. 8.51: Lac insect collected from Thenkasi district Tamilnadu

Table 8.35: Density of settlement (No/ cm²), intial mortality of lac insect on *F. semialata* collected from different locations

Location	Initial density of settlement						Total		TOTAL	Average		AVERAGE	Dead
	Lower		Middle		Upper								
	Living	Dead	Living	Dead	Living	Dead	Living	Dead	L+D	Living	Dead	L+D	
Vellore	36.4	6.8	44	10.4	54	8.4	134.4	25.6	160	44.8	8.53	53.33	16.00
Karaikkal	41.6	5.2	55	4.6	34	6.6	130.6	16.4	147	43.53	5.47	49.00	11.16
Chinna mettur	48.4	7	50.4	5.6	47.2	10	146	22.6	168.6	48.67	7.53	56.20	13.40
Thoppur	48.2	5.4	47.2	5.8	52.8	7.4	148.2	18.6	166.8	49.40	6.20	55.60	11.15

Table 8.36: The per centage male sex ratio of collected lac insect on *F. semialata* at KFRI (1 cm²)

Location	Sex ratio						Total		Total	Average		Average M+F	%of male
	1(L)		2(M)		3(U)								
	Male	Female	Male	Female	male	Female	Male	Female	M+F	Male	Female		
Vellore	15.2	14.2	11.8	9.4	14.2	6.8	41.2	30.4	71.6	13.73	10.13	23.87	58
Karaikkal	13.4	11.8	11	10.8	11	10.6	35.4	33.2	68.6	11.8	11.07	22.87	52
Chinna mettur	9.2	10.6	9.4	9.8	7.4	11.4	26	31.8	57.8	8.67	10.60	19.27	45
Thoppur	9.4	10.4	9.6	13	9	10.6	28	34	62	9.33	11.33	20.67	45

Table 8.37: Average number of lac insect cell at maturity (1 cm²)

Location	Survival at maturity			Total	Average
	Lower	Middle	Upper		
	Living	Living	Living	Living	Living
Vellore	8.4	6.2	5.4	100	6.66
Karaikkal	8.6	7.4	5.2	21.2	7.06
Chinna mettur	8.8	6.8	7.6	23.2	7.73
Thoppur	5.8	6.2	7	19	6.33

Table 8.38: Density of settlement and intial mortality percentage of death of lac insect on major lac host plants, *A. saman, F. benghalensis* and *F. religiosa* in south India

Cultivation of lac insect					Initial Density of Settlement						Total		Total	Average		Average	% of Dead
					Lower		Middle		Upper								
S.no	Host plant name	Place	Date of inoculation	Punki removal	Living	Dead	Living	Dead	Living	Dead	Living	Dead	L+D	Living	Dead	L+D	
1	*A. saman*	Thenkasi	29.11.2019	19.12.2019	25	7.5	36	6.5	49	6.5	110	20.5	130.5	36.67	6.83	43.5	15.76
2	*F. benghalensis*	Thenkasi	29.11.2019	19.12.2019	31	3	63	13	72	16	166	32	198	55.33	10.67	66.00	16.16
3	*F. religiosa*	Thenkasi	29.11.2019	19.12.2019	43	11	41	16	45	7	129	34	163	43.00	11.33	54.33	20.86
4	*A. saman*	Coimbatore	30.112019	19.12.2019	51.5	6.5	42	11	46.5	6.5	140	24	164	46.66	8	54.665	14.9
5	*F. benghalensis*	Coimbatore	30.112019	19.12.2019	38	12	37	15	42	11	117	38	155	39.00	12.67	51.67	24.52
6	*F. religiosa*	Coimbatore	30.112019	19.12.2019	32	10	51	17	43	12	126	39	165	42.00	13.00	55.00	23.64
				Total	**220.5**	**50.0**	**270.0**	**78.5**	**297.5**	**59.0**	**788.0**	**187.5**	**975.50**	**262.7**	**62.5**	**325.2**	**115.8**
				Average	**36.8**	**8.3**	**45.0**	**13.0**	**49.6**	**9.83**	**131.3**	**31.3**	**162.6**	**43.8**	**10.4**	**54.2**	**19.3**

Stem macromicro nutrients and heavy metals analysis: On testing the contents of nitrogen and phosphorus, the results showed that both have the opposite reactions in three species of plants. The nitrogen content of plants without lac insect is more than the plant with lac insect, but the Phosphorus content was found decreased.

In the case of *F. semialata* and *B. monosperma*, the potassium, magnesium and sodium contents of plants without lac insect were less than plants with lac insect. But in *F. macrophylla,* potassium, magnesium and sodium content of plants without lac insect was more than plants with lac insect. When calcium, manganese and zinc content of *F. semialata* with lac was compared to *F. semialata* without lac, it was found that the content of calcium, manganese and zinc increased due to the presence of lac insect. Same was the case for *F. macrophylla*, but in the case of *B. monosperma*, the calcium, manganese and zinc content of plants without lac insect was less than plants with lac insect. In the case of copper and iron, the three plant species without lac insects had more content than plants with lac insects. The cadmium content of *F. semialata* with or without lac remained the same. But in *F. macrophylla* and *B. monosperma*, the plant with lac contained more cadmium than the plant without lac. The chromium content of *F. semialata* without lac was more than that of *F. semialata* with lac. But in *F. macrophylla* and *B. monosperma*, the plant with lac contains more than of plant without lac. The lead and nickel content of *B. monosperma* were the same in both the plants with lac and without lac. In *F. macrophylla*, the lead and nickel contents of the plant with lac contain more than that of the plant without lac. But in *F. semialata,* lead content was more in the plant without lac and nickel content was more in the plant with lac.

Soil analysis

Macro nutrients such as nitrogen, phosphorus, sodium, etc. were found decreased in the soil after we cultivated the lac insect host plants. Micro nutrients such as copper, iron and manganese content in soil of *F. macrophylla* are more than *F. semialata,* but zinc content is more in the soil of *F. semialata* as compared with *F. macrophylla*. All the heavy metals were high in soil of *F. macrophylla* is as compared with that of *F. semialata* (Table 8.39 and Table 8.40).

Table 8.39: Analysis of macro nutrients, micro nutrients and heavy metals in different soil samples

Sample Name	*F. semialata*	*F. macrophylla*	Sand	Soil mixure 1:1:3
pH	6.20	6.27	5.93	6.38
OC (%)	9.72	6.13	2.76	10.15
N (kg/ha)	399.08	304.26	403.04	403.04
P (kg/ha)	602.31	786.48	38.46	851.08
K (kg/ha)	16744.00	20440.00	25480	1960
Na (kg/ha)	1250.67	1120.00	1232	1680
Ca (ppm)	755.58	2529.50	511.25	337.25
Mg (ppm)	10884.17	339324.58	173.33	184.9
Cu (ppm)	1.02	2.07	0.25	0.07
Fe (ppm)	63.43	142.43	14.87	45.31
Mn (ppm)	43.64	55.03	28.57	59
Zn (ppm)	20.72	18.67	6.95	12.65
Cd (ppm)	0.17	0.21	0.13	0.18
Cr (ppm)	1.68	1.73	0.63	0.26
Pb (ppm)	1.67	2.13	1.2	1.4
Ni (ppm)	0.11	0.45	0.06	0.06

Table 8.40: Analysis of macro nutrients, micro nutrients and heavy metals in different lac insect host plant stem

Sample Name	*F. semialata*		*F. macrophylla*		*B. monosperma*		*A. nobilis*
	With lac	Without lac	With lac	Without lac	With lac	Without lac	With lac
N (%)	2.01	0.64	1.8	0.85	1.06	0.58	0.58
P (%)	1.51	2.24	0.39	0.65	0.34	1.74	1.47
K (%)	0.668	0.826	4.3	0.87	0.584	1.048	0.698
Na (%)	1.9	2.6	5.6	2.7	1.9	3.4	2.3
Ca (ppm)	2410	2250	9290	2750	4760	9740	9200
Mg (ppm)	847	990	4785	785	3216	5240	246
Cu (ppm)	10.6	10.2	12	7.6	7	3.6	9.8
Fe (ppm)	297.6	150	5610	771.8	406.8	120.8	141.6
Mn (ppm)	23.4	20.8	87800	27.6	27.6	32	18.4
Zn (ppm)	38.44	36.58	220.16	33.64	31.56	33.8	27.54
Cd (ppm)	21.6	21.6	22.4	21	21.6	21.4	21.6
Cr (ppm)	8.2	17.4	21.6	11.2	5.6	4.6	19.2
Pb (ppm)	532	540	556	526	538	538	534
Ni (ppm)	8	7.8	8.8	7.8	8	8	8

Analysis of soil texture, macro, micro nutrients and heavy metals

Soil texture

One way ANOVA was conducted to test if there is any significant difference between soil texture of cultivated lac insect host plants (*F. semialata. macrophylla*), sand and soil mixture(1:1:3 proportion).

There is no significant difference between clay content of cultivated lac insect host plants, sand and soil mixture

(F (3,8) =1.00, p=0441). This means that cultivated lac host plant does not change the clay content. But there is a significant difference in silt content (F (3,8) =9.333, p=0.005). The silt content is more in *F. macrophylla* (5.33) and less in soil mixture (2). Similarly, there is a significant difference in content of sand (F (3,8) =6.25, p=0.017) and pH (F (3,8) =10.506, p=0.004). Sand content in soil of *F. semialata* is more than *F. macrophylla*.

Macro nutrients of soil

One way ANOVA was conducted to test if there is any significant difference between soil macro nutrients of cultivated lac insect host plants (*F. semialata* and *F. macrophylla*), sand and soil mixture(1:1:3 proportion). There is a significant difference between nitrogen (F (3,8) =14.862, p=0.001), phosphorus (F (3,8) =104.548, p=0.000), calcium (F (3,8) =4.779, p=0.034), potassium (F (3,8) =33.059, p=0.000), magnesium (F (3,8) =6.389, p=0.016) and sodium (F (3,8) =99.571, p=0.000) content of cultivated lac insect host plants, sand and soil mixture. All the macro nutrients except nitrogen and sodium content in soil of *F. macrophylla* is more than that in *F. semialata*. The contents of nitrogen, phosphorus, sodium, etc. are decreased from the soil after we cultivated the lac insect host plants because of its consumption.

Micro nutrients of soil

One way ANOVA was conducted to test if there is any significant difference between soil micro nutrients of cultivated lac insect host plants (*F. semialata, F. macrophylla*), sand and soil mixture(1:1:3 proportion). There is a significant difference between copper (F (3,8) =8.809, P=0.006), iron (F (3,8) =6.247, P=0.017), manganese (F (3,8) =33.785, P=0.000) and zinc (F (3,8) =41.925, P=0.000) content of cultivated lac insect host plants, sand and soil mixture. Copper, iron and manganese content in soil of *F. macrophylla (2.07,142.43* and *55.03)* are more than *F. semialata (1.02,63.43* and *43.64)*. But Zinc content is more in the soil of *F. semialata* (20.72) as compared with *F. macrophylla* (18.67).

Heavy metals of soil

One way ANOVA was conducted to test if there is any significant difference between soil heavy metal content of cultivated lac insect host plants (*F. semialata, F. macrophylla*), sand and soil mixture(1:1:3 proportion). There is significant difference between cadmium (F (3,8) =18.714, p =0.001), chromium (F (3,8) =22.102, p =0.000), lead (F (3,8) =7.928, p =0.009) and nickel (F (3,8) =40.792, p =0.000) content of cultivated lac insect host plants, sand and soil mixture. All the heavy metals content in soil of *F. macrophylla* is more when compared with *F. semialata.*

8. State Forest Research Institute (SFRI), Jabalpur

1. Survey of area for the lac insect and host plants

Survey of the lac insect/host plant potential areas in Madhya Pradesh, Maharashtra, Goa & Daman were conducted. Data was collected on lac insect population size, stage, crawler period, special characteristics, source/ habitat, frequency, predators, parasitoids, disease symptoms, host trees.

Madhya Pradesh

Intensive survey was conducted block wise in Madhya Pradesh for lac insect and their host plants. Survey of lac insect and host plants was done in 58 blocks of 16 districts but lac occurrence were found in 30 blocks of 14 districts in Madhya Pradesh lac insect species were occurring naturally in farm lands, revenue lands, and forest lands. The information on lac insect/host plants during each field survey was recorded in passport data sheets and compiled (Fig. 8.52 and 8.53).

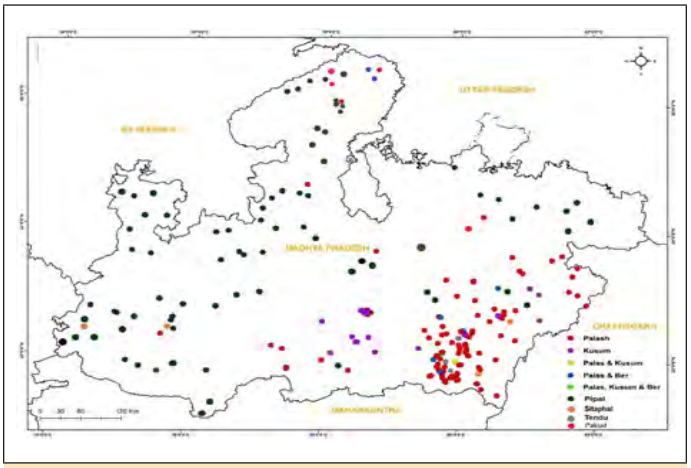


Fig. 8.52: Map showing the occurrence of the lac insect in different parts of Madhya Pradesh surveyed

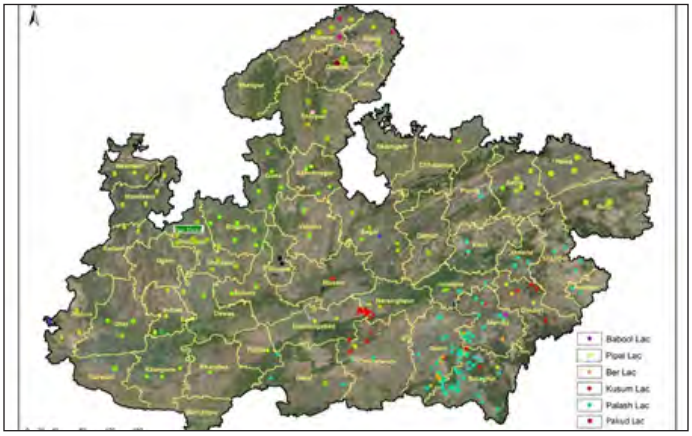


Fig. 8.53: GIS Map showing the occurrence of the lac insect in different host plants of eastern Madhya Pradesh surveyed

Maharashtra

Intensive survey was conducted in different blocks under Maharashtra state for lac insect and their host plants potential areas. Survey of lac insect and host plants was done in 18 blocks of 04 district but ony 2 blocks of 2 districts reported lac occurrence. The information on lac insect/host plants during each field survey was recorded in passport data sheets and compiled (Fig. 8.54).

Fig. 8.54: GIS Map showing the occurrence of the lac insect in different host plants of Maharashtra surveyed

2. Collection and conservation of lac insect under *ex-situ* condition

Collection of broodlac: After the survey, broodlac samples were collected from the different blocks of various districts in the season and inoculated on *F. macrophylla* and *F. semialata* plants in the Regional Lac Insect Field Gene Bank for *ex-situ* conservation of lac at SFRI campus (Fig. 8.55). Collected lac samples were also preserved in absolute alcohol for identification of lac insect species.

A. Madhya Pradesh

80 samples of lac insect from 40 blocks of 16 districts of Madhya Pradesh are conserved in Lac Insect Gene Bank as *ex-situ* conservation. Broodlac samples were collected from Sagar, Shivpuri, Vidisha, Guna, Agar Malwa, Shajapur, Mandsaur, Sehore, Indore, Seoni, Balaghat, Chhindwara, Hoshangabad, Narsinghpur districts of Madhya Pradesh.

B. Maharashtra

40 samples of lac insect from 17 blocks of 08 districts of Maharashtra are conserved in lac insect field gene bank. Broodlac samples were collected from Gondia, Dhule, Aurangabad, Ahmednagar, Sangli, Solapur, Parbhani, Latur districts of Maharashtra.

3. On-farm trials on lac cultivation technologies

3.1 Pruning demonstration of lac cultivation techniques was carried out in villages:

i. Village Kohani, Niwas block in Mandla district. Pruning technique was demonstrated on *Palas* trees with 16 farmers of village Kohani and Bhadari.

ii. Village Sukhri in Mandla. Pruning technique was demonstrated on *ber* and *palas* trees with 15 farmers.

iii. Village Chargaon, Bijadandi block in Mandla. Pruning technique was demonstrated on *ber* and *palas* trees with 17 farmers of village Chargaon (Fig. 8.56)

iv. Village Rehlonkala, Lakhnadon block in Seoni district. Pruning technique was demonstrated on *palas* trees with 15 *Van Samiti* members of village Rehlonkala

Fig. 8.55: Lac Insect Field Gene Bank of *F. macrophylla*

Fig. 8.56: Pruning demonstration in Chargaon, Mandla

3.2. Broodlac sample's inoculation in selected training sites: Carried out on-farm trials on lac cultivation technologies in different agro-climatic region of Madhya Pradesh as under:

A. Rehlonkala village, Lakhnadon block, Seoni- 17 kg broodlac samples were inoculated on 60 *Palas* trees in forest area with the help of *Van Samiti* members and 06 kg broodlac samples were inoculated in 12 *palas* tree in 05 farmer field

B. Kohani village, Niwas block, Mandla- 22 kg brood lac samples were inoculated on 55 *Palas* trees of 08 farmers.

C. Chargaon village, Bijadandi block, Mandla- 17 kg broodlac samples were inoculated in 12 farmers field on 65 *Palas* trees.

D. Bhadari village, Mandla- 13 kg broodlac samples were inoculated on 55 *Palas* tree of 05 farmers

E. Sukhri village, Niwas block, Mandla -05 kg broodlac samples were inoculated on 10 *Ber* and *Palas* tree of in 05 farmers.

4. Training of adopted/selected farmers in collaboration with ICAR-IINRG for *in-situ* conservation

Twelve lac cultivation training workshops on *palas*, *kusum*, *ber* were organized in various villages, blocks of districts in the states of Madhya Pradesh and Maharashtra. Initially suitable areas and spots were identified for proper implementation so that farmers benefit through training and initiate scientific method of lac cultivation on available natural resources and enhance their livelihood. Training workshop was provided in vernacular language through power point presentation, colored poster, field demonstration, *etc*. and lac cultivation was iniated in famers' field under the supervision.

4.1 Lac cultivation training workshops by scientific method in different districts of Madhya Pradesh

Ten lac cultivation training workshop were oraganized in Seoni, Balaghat, Narsinghpur, Hoshangabad, Chhindwara, Katni, Umaria, Dindori, Anuppur district of Madhya Pradesh by scientific method (Fig. 8.57 and 8.58, Table 8.41)

Table 8.41: Lac cultivation training workshop by scientific method in different districts of Madhya Pradesh

Sl. No.	Block/District/ Villages	Location	No. of farmers trained	Host trees	Date
1.	Keolari block, Seoni- Bamhnikheda, Chirchiratola and Dobh	Dobh	35	*Palas*	01/08/2019
2.	Paraswara block, Balaghat	Sherpar	26	*Palas*	02/08/2019
3.	Lakhnadone block, Seoni - Rehlonkala and Mohgaon	Rehlonkala	27	*Palas*	03/08/2019
4.	Chichli block, Narsinghpur - Kekra	Kekra	32	*Kusum*	05/09/2019
5.	Bankhedi block, Hoshangabad - Dangarhai and Padao	Dangarhai	39	*Kusum*	06/09/2019
6.	Jumnaradeo block, Chhindwara - Jhhotkhurd, Ghatiya, Kursidhana and Jamundhonga	Jhhotkhurd	32	*Kusum*	07/09/2019
7.	Rethi block, Katni - Bandha, Emlaj and Gudabandh	Bandha	31	*Palas*	28/09/2019
8.	Nowrojabad block, Umaria - Bodli, Karri, Mohini and Singhpur	Bodli	53	*Kusum*	29/09/2019
9.	Shahpura block, Dindori - Chhirpani and Khamariya	Chhirpani	30	*Kusum*	30/09/2019
10.	Jaithari block, Anuppur - Mediyaras and Chilhari	Mediyaras	30	*Palas*	15/10/2019
Total farmers trained			**595**		

Fig.8.57 : Lac cultivation training workshop in Mediyara (Jaithari, Anuppur)

Fig.8.58 : Lac cultivation training workshop in Selotpar Gadegaon (Tirrora, Gondia)

4.2 Lac cultivation training workshop by scientific method in different districts of Maharashtra

Two lac cultivation training workshop were organized in Gondia and Bhandara district of Maharashtra (Table 8.42).

Table 8.42: Lac cultivation training workshop by scientific method in different districts of Maharashtra

Sl. No.	Block/District/ Villages	Location	No. of farmers trained	Host trees	Date
1.	Bhandara - Rajegaon, Dawa, Khursipar, Dhargaon, Malepar, Tekepar, Bhandara, Madagi, Sanbhadi, Guthara, Kahera, Neharwani and Lakhni	Gadegaon	47	*Palas*	28/12/2019
2.	Tirrora block, Bhandara - Selotpar, Murpar with forest gurad of Navejhari beat	Selotpar	55	*Palas*	30/12/2019
Total farmers trained			**102**		

5. Need based and location specific studies on lac-insect and/or host-plants

5.1 Diversity assesement of lac host trees in Gondia, Maharashtra

A reconnaissance survey of the whole study area was done to identify the gregarious patches of lac host plants for biodiversity assesement.

After identification of the study site, quadrats of size 10 m X 10 m were randomly laid out in the field for observation on growth and phyto- sociological parameters. Total number of 31 such quadrat were laid out in Gondia, Amgaon, Deori blocks of Gondia district of which 15 quadrats were laid out in forest lands, 16 quadrats were in farm lands.Coordinates of the quadrats were recorded with the help of G.P.S. Soil type of the quadrats were also collected. Lac host plants standing in the quadrats were identified in the field. All the plants of lac host species of height >1m and girth at breast height (GBH) > 10 cm standing in the quadrats were enumerated. Observation of GBH and height for individual trees were recorded, along with the names of the lac-host species. The data collected were analyzed for various phyto-sociological parameters such as density, frequency, height, girth using standard methods. Seven host plant species in Gondia district of Maharashtra were observed (Table 8.43).

Table 8.43: Lac host tree species found in the quadrats

Sl. No.	Botanical name	Vernacular name	Family	Gondia district
1.	*B. monosperma*	*Palas*	Fabaceae	✓
2.	*Z. mauritiana*	*Ber*	Rhamnaceae	✓
3.	*A. nilotica*	*Babool*	Mimosaceae	✓
4.	*Leucaena lecocephala*	*Subabul*	Fabaceae	✓
5.	*A.auriculiformis*	*Akashmani*	Mimosaceae	✓
6.	*Annona squamosa*	*Sitaphal*	Annonaceae	✓
7.	*Diospyros melanoxylon*	*Tendu*	Ebenaceae	✓

Palas (*B. monosperma*) is the most commonly occurring lac host tree species in Gondia and also in nearby Bhandara district of Maharashtra and it was found in all types of areas *viz.* forest lands, revenue waste lands and farm lands. *Palas*, *ber*, *babool*, *subabool*, *akashmani*, *sitaphal* were found occurring over forest lands and farm lands but not in revenue waste.

Abundance of different lac host species: Basic information on host plant species availability per unit area at different sites of Gondia district is given in Table 8.44.

Table 8.44: Distributions of lac host plant species in Gondia district per hectare

Block	Host plant	Botanical name	Farmer field density (tree ha^{-1})	Forest area density (tree ha^{-1})
Gondia block	*Palas*	*B. monosperma*	100	269
	Ber	*Z. mauritiana*	12.5	5.55
	Babool	*A. nilotica*	0	2.77
	Akashmani	*A. auriculiformis*	0	2.77
	Sitaphal	*A. squamosa*	0	2.77
	Tendu	*D. melenoxylon*	0	5.55
Deori Block	*Palas*	*B. monosperma*	156	193.75
	Ber	*Z. mauritiana*	4	0
	Sitaphal	*A. squamosa*	0	12.5
	Subabool	*Vachellia nilotica*	4	0

Block	Host plant	Botanical name	Farmer field density (tree ha^{-1})	Forest area density (tree ha^{-1})
Amgaon block	*Palas*	*B. monosperma*	94.44	304
	Ber	*Z. mauritiana*	2.77	0
	Sitaphal	*A. squamosa*	0	12
	Babool	*A. nilotica*	5.55	0

In the field study conducted to estimate the lac host plant biodiversity in Amgaon, Deori, Gondia blocks of Gondia district, it was observed that *Palas* is the most abundant species in these block. If the above host plants distribution data is analyzed in two types of sites farm land and forest land, it can be seen that the forest lands have maximum density of lac host plant ha^{-1} in three studied blocks with maximum occurance of *palas* species, followed by farm lands, In the forest land *palas* is most widely distributed followed by *ber*, *babool*, *akashmani, sitaphal*, *tendu* but in farmers field only *palas*, *ber*, *sitaphal* are abundantly spread.

The highest total number of lac host species 316.0 plants per ha were found in forest land areas of Amgaon that are significantly higher than Deori and Gondia blocks. But in Deori block, farmers field are having maximum host plant population 164.0 as compared to other blocks. However, the most striking feature is that lac host plant species in farm lands over whelmingly outnumber the plants in forest lands. Whereas, the density is higher in forest lands than that in farm lands.

Among the host plant species in Gondia, *palas* having maximum 186.28 plants ha^{-1} followed by *sitaphal*, *ber*, *tendu*, *subabool* and minimum number of plant ha^{-1} was found in *babool* and *akashmani* (Fig. 8.59).

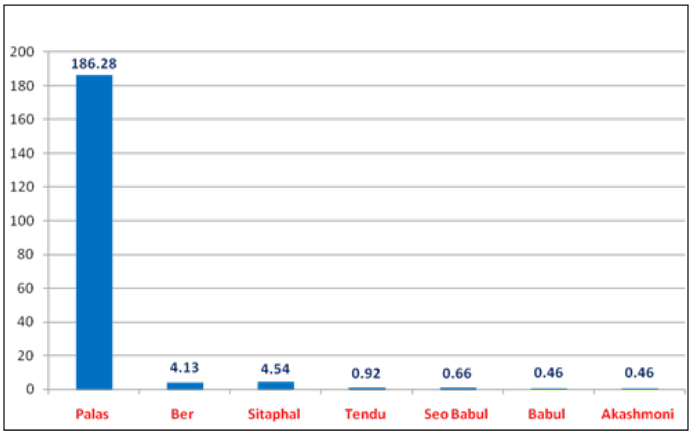


Fig. 8.59: Number of lac plants ha-1 in Gondia district of Maharatsra

Girth classes and height distribution of trees in Gondia, Deori and Amgaon blocks of district are shown in (Fig. 8.60 and 8.61, Table 8.45 to 8.47). Tree girth and height are better in farmers field than forest areas; its may be due to availability of water, nutrient, pruning and distance planting.

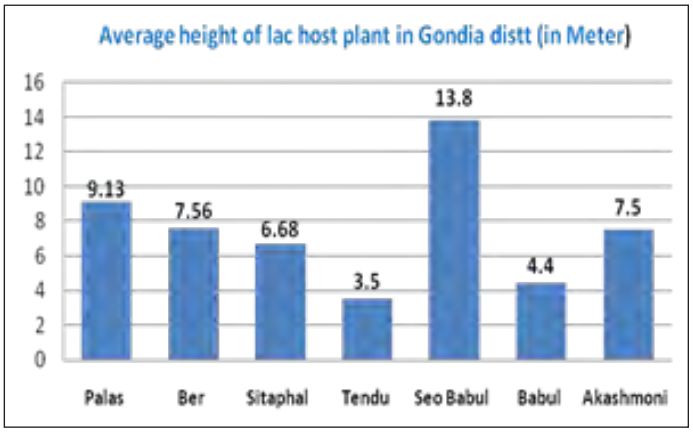


Fig 8.60: Average height of lac host plant uin Gondia dist.

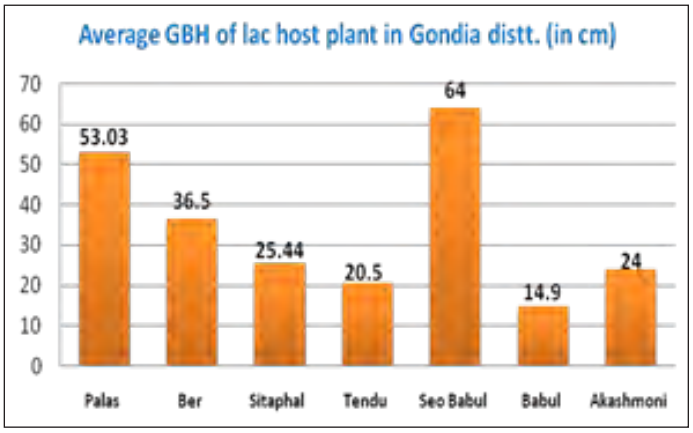


Fig. 8.61. Average GBH of lac host plant in Gondia Distt.

Table 8.45: Girth, and height of available lac host trees in Gondia block, Gondia district

Host plant	Farmer field		Forest areas	
	GBH	Height	GBH	Height
Palas	61.89	10.08	44.17	8.18
Ber	36.5	7.56	-	-
Babul	29	6.9	0.8	1.9
Akashmoni	-	-	-	-
Sitaphal	-	-	-	-
Tendu	-	-	20.5	3.25
Subabul	64	13.8		

Table 8.46: Girth,and height of available lac host trees in Deori block, Gondia

Sl. No.	Host plant	Botanical name	Farmer field		Forest area	
			GBH (cm)	Height (m.)	GBH (cm)	Height (m.)
1.	*Palas*	*B. monosperma*	50.75	8.54	48.70	8.42
2.	*Ber*	*Z. mauritiana*	35.5	9.4		
3.	*Sitaphal*	*A. squamosa*	-	-	32	10.35
4.	*Subabool*	*V. niltica*	64	13.8		
Total			**150.25**	**31.74**	**80.7**	**18.77**

Table 8.47: Girth, plant height of available lac host plants in Amgaon block, Gondia

Host Plant	Botanical name	Farmer field		Forest area	
		GBH	Height	GBH	Height
Palas	*B. monosperma*	67.45	11.61	44.62	7.49
Ber	*Z. iziphus mauritiana*	45	6.4	-	-
Babool	*A. nilotica*	29	6.9	-	-
Sitaphal	*A.squamosa*			27.33	5.5

5.2 Lac based Integrated cropping model

Four blocks *viz*. (Waraseoni, Katangi, Lalbarrha, Parswara) of Balaghat district and one block of Keolari of Seoni district was selected to develop lac based integrated cropping model with paddy crop. In the beginning, survey for identification of paddy farmers having natural population of palas/ber host plants and other agronomic components such as land holding, cropping system, soil texture, number of host plant availability, *etc.* was done. In the month of July, 2019 *rangeeni* broodlac was inoculated in the selected five sites of Balagaht and Seoni districts. Host plant pruning, broodlac inoculation, settlement, encrustation, predators and parasites management and harvesting practices were followed as per standard.

In Madhya Pradesh lac is commonly produced on natural stands of *palas* (*B. monosperma*), *ber* (*Z. mauritiana*) and *kusum* (*S. oleosa*) on the field bunds, waste land or forest areas. It was observed that farmers are having availability of natural *palas* host tree.

Fifty kg lac inoculated in five sites of Balaghat and Seoni yielded 272.7 kg from *katki* crop (Table 8.48). Lac production in integrated system can be better option of additional income generation for those paddy farmers having *ber*/*palas* plants on their field's bund (Fig. 8.62).

Table 8.48: Sticklac production under lac based integrated cropping model

Sl. No.	Block/ district	No. of farmers	*Palas* host plant availability (Nos.)	Brood lac inoculation quantity (kg)	Stick lac yield (kg)
1.	Keolari seoni	06	292	9.0	49.2
2.	Waraseoni balaghat	09	646	9.5	57.0
3.	Katangi balaghat	09	304	8.5	45.5
4.	Lalbarrha balaghat	13	184	12	67.5
5.	Paraswara balaghat	14	205	11	53.5
Total		**51**	**1631**	**50**	**272.7**

Fig. 8.62: Lac on *Palas* on field bunds

5.3 Lac cultivation based agro-horticultural model at SFRI campus

Adjacent to Lac Insect Field Gene Bank, SFRI, Jabalpur plantation of *F. semialata* was done in October 2018 with paired row system at 0.75 m distance from plant to plant and 1.0 m row to row in triangular pattern. Between paired rows of *F.* 2.0 m distance was maintained in which fruits and vegetable plants were taken. In this model, total 144 *Flemingia semialata* plants were planted in 20×17 m^2 plot and after one year of planting the *Flemingia* plants were taken for lac inoculation. *Kusmi* broodlac was inoculated in the month of January @20g /plant (total 2.88 kg broodlac). Vegetables like pigeon pea, sweet pea, cluster bean, fenugreek moringa, papaya, custard apple, lemon,

tomato, brinjal, chilli, bell paper, cabbage, cauliflower, carrot, radish, spinach were seeded/transplanted in the month of October and all cultural management practices followed (Fig. 8.63).

Fig. 8.63: Lac cultivation based agro-horticultural model at SFRI campus

c. Voluntary / Cooperating Centre

1. ICAR- KVK Sirsi, Uttara Kannada (UAS, Dharwad)

Survey results indicated the presence of sufficient number of lac insects (*rangeeni* strain) on *A. lebbeck* (L.) Benth, *F. benjamina* L. *F. benghalensis* L. *A. (Samanea) saman* (Jacq.) and *F. carica* Linn. in Yadgir and Raichur districts (Fig. 8.64). About 5.2 % lac infestation was noticed on Fig, *F. carica* plantation at Kataraki village, Manvi Tq, Raichur district. Farmers from Uttar Kannada and Mysore districts are involved in commercial *Kusmi* lac cultivation on *Kusum*, *ber* and *Flemingia* In Uttara kannada alone 80Kg of broodlac was inoculated on *kusum* tree during December 2019. An engineering graduate from Mysore started production of buttonlac first time in Karnataka in September, 2019. Till now he has produced 3 q of buttonlac and sold at Channapatna in Ramanagara district. The city is famous for its wooden toys and lacquerware. Channapatna is also called Town of toys**.**

Fig. 8.64: Lac on *A. lebbeck* and *F. benghalensis* in Yadgir and Raichur

2. Acharya N. G. Ranga Agricultural University (ANGRAU), Guntur

Survey was conducted in 7 districts *viz*., Guntur, Krishna, Srikakulam, Vizainagaram, Vishakapatnam, Chittoor and Kurnool. *A. saman, A. lebbeck, F. semialata, S. oleosa, Conocarpus erectus, Z. mauritiana, A. leucocephala* and *Ficus sps.* were some of the major host plants of lac insect recorded in the survey. Lac cultivation has been practiced on *F. semialata* in Srikakulam and Vishakapatnam districts. Lac insect occurrence has been reported on *A. saman* in Vizainagaram and Kurnool districts (Fig. 8.65). Along with this, lac encrustation was observed for the first time on *Conocarpus erectus* in *Chandragiri mandal* of Chittoor district, Andhra Pradesh (Fig. 8.66).

Fig. 8.65: Lac encrustation on *C. erectus* at Peruru Village, Chittoor (District)

Fig.8.66: Encrustation of lac on *A. saman* in Kalluru Village, Kurnool (District)

3. ICAR Research Complex for Eastern Region, (ICAR-RCER), Patna

Out of 123 blocks of 23 districts surveyed till date wherein lac insects were found only in 48 blocks of 14 districts (Table 8.49). In all place lac insects were found only on *Ficus* spp (Fig. 8.67).

Lac insect on *Ficus* at Patna | Lac insect on *Ficus* at Nawadah | Lac insect on *Ficus* at Sheikhpura

Fig 8.67: Lac insect on *Ficus* spp. on different districts of Bihar

Table 8.49: Survey conducted during 2019-20 by ICAR-RCER, Patna

District (No. of blocks)	No. of blocks surveyed	Name of block surveyed	Lac insect observed (No. of blocks)	Host plants observed	Period of survey
Bhagalpur (16)	4	Bhagalpur Sadar, Sabour, Sanhaula & Kahalgoan	Sanhaula & Kahalgoan	*Ficus* sp. & *Ber*	24-27 June, 2019
Nawadah (14)	3	Akbarpur, Govindpur & Nawadah	Akbarpur, Govindpur & Nawadah	*Ficus* sp. & *Ber*	16-18 July, 2019
Jehanabad (10)	2	Makhdumpur & Jehanabad	Makhdumpur & Jehanabad	*Ficus* sp. & *Ber*	13-14 August, 2019
Vaishali (17)	3	Hajipur, Patepur & Mahua	Patepur & Mahua	*Ficus* sp. & *Ber*	16-17 Sept., 2019
Patna (23)	4	Dhanarua, Patna, Punpun & Masaurhi	Patna, Punpun & Masaurhi	*Ficus* sp. & *Ber*	18-19 Sept., 2019
Munger (10)	6	Tetiabamber, Munger Sadar, Dharhara, Bariarpur, Jamalpur & Tarapur	Munger Sadar, Dharhara, Bariarpur, Jamalpur & Tarapur	*Ficus* sp. & *Ber*	18-22 Oct., 2019
Lakhisarai (6)	5	Piparia, Suryagarha, Lakhisarai, Barahia & Raigarh Chowk	Lakhisarai, Barahia & Raigarh Chowk	*Ficus* sp. & *Ber*	23-25 Oct., 2019
Saran (21)	9	Sonepur, Masarakh, Nagra, Dariyapur, Panapur, Taraiya, Amnaur, Parsa & Chapra	Panapur, Taraiya, Amnaur, Parsa & Chapra	*Ficus* sp. & *Ber*	04-07 Dec., 2019
Siwan (22)	8	Maharajganj, Jiradei, Raghunathpur, Siswan, Nautan, Siwan Sadar, Baraharia & Darauli	Nautan, Siwan, Baraharia & Darauli	*Ficus* sp. & *Ber*	08-10 Dec., 2019
Gopalganj (14)	5	Thawe, Phulwaria, Manjha, Gopalganj & Barauli	Gopalganj & Barauli	*Ficus* sp. & *Ber*	11-13 Dec., 2019
Arwal (5)	5	Arwal, Kaler, Karpi, Kurtha & Suryapur Vanshi	Kaler, Karpi, Kurtha & Suryapur Vanshi	*Ficus* sp., *Ber* & *Palas*	19-22 Dec., 2019
Bhojpur (14)	8	Jagdishpur, Tarari, Shahpur, Sahar, Agiawon, Bihia, Koilwar & Ara Sadar	Sahar, Agiawon, Bihia, Koilwar & Ara Sadar	*Ficus* sp. & *Ber*	03-06 Jan., 2020
Kaimur (11)	6	Rampur, Ramgarh, Chainpur, Adhaura, Bhagwanpur & Mohania	Adhaura, Bhagwanpur & Mohania	*Ficus* sp. & *Ber*	13-15 Jan., 2020
Begusarai (18)	8	Teghra, Birpur, Bachhwara, Dandari, Naokothi, Begusarai, Barauni, Matihani	Begusarai, Barauni, Matihani	*Ficus* sp. & *Ber*	24-29 Jan., 2020

Publications (Network Co-operating Centers)

Research Paper

- Saikia R, Das P, Hazarika LK, Islam AN, Kalita S and Saikia P (2019). Species composition, relative abundance and diversity of ants associated with lac insect in Assam. *Int. J. Current Microbiol. Applied Sci.*, 8**(4)**: 1852-1859.
- Das P, Saikia R, Hazarika LK, Islam AN and Saikia P (2019). Effect of weather parameters on life cycle duration of lac insect (*Kerria*.spp.) (Kerridae: Hemiptera). *J. Entomol. Zoology Studies*, 7**(3)** 502-504.
- Das P, Borah B, Saikia P, Sushmita TH and Chakraborty D (2019). Efficacy of *Beauveria bassiana* and *Isaria fumosorosea* against *Eublemma amabilis* (Noctuidae: Lepidoptera): A predator of lac insect, *Kerria lacca* (Kerr). *J. Entomol zoology studies*, 7(3) 1239-1241.
- Vikram, Lekha, Hemant Swami and Jain HK (2019). Survey for the occurrence of natural enemies of lac insect *Kerria lacca* (Kerr) in southern Rajasthan. *Ind. J. Applied Entomol.*, 33(1): 43-46.
- Sangha KS, Shera PS, Kaur R, Sharma S, Thakur A, Mangat HK and Thakur A (2019). Status of lac insect and its host plants in different agro-climatic zones of Punjab. *J. Entomol. Zoology Studies* 7**(2)**: 183-189.
- Sangha KS, Shera PS, Kaur R, Sharma S, Thakur A and Mangat HK (2019). Natural distribution of lac insect and its host flora in sub-humid Sutlej Ganga Alluvial Plains of India. *J. Insect Sci.* 32**(1-2)**: 85-93.
- Gupta RK, Kamlesh Bali and Suheel Ahmad Ganai (2019). Natural occurrence of lac insect, *Kerria lacca* and its conservation in Jammu and Kashmir. *J. Entomol. Zoology Studies,* 8(1): 689-695.

Book Chapter

- Hemant Swami, Lekha and Kuldeep Kumar (2019). Lac insect and its cultivation for doubling farmers income. *In*: Compendium of ICAR sponsored summer school on 'Skill Development through Technological Interventions for Doubling the Farmers Income', 197-207 pp.
- Hemant Swami, Lekha and Kuldeep Kumar (2019). Lac insect cultivation: opportunities and prospects in entrepreneurship development among rural youth. *In*: Compendium of ICAR sponsored summer school on Skill development for self employment in agriculture: A life changing opportunity for rural youth, 144-152 pp
- Hemant Swami, Lekha and Ashok Kumar.2020. Lac production technology for higher income. *In*: Compendium of ICAR sponsored winter school on Entrepreneurial skill development of rural youth through innovative approach, 125-131 pp.

Popular Article

- Singh KI, Niranjan C and Ngangom R (2019). Insect pest complex of two quick growing host plants of lac insect *F. macrophylla* and *F. semialata* in Manipur condition. CAU Farm Magazine, 9(3), 14-16 pp.
- Lac- a natural wonder (in Tamil) was published in Tamil newsletter Grow Great Newsletter, October – December: 10-14) (**தமிழரசி க மற்றும் மோகனசுந்தரம் ஆ, (2019). அரக்கு: இயற்கை அற்புதம். ஆறாம் திணை, அக்டோபர் - டிசம்பர்**: 10-14.)

Lac Training Manual

- कुसुम के वृक्षों में लाख की कृषि प्रक्रिया (2019) । प्रतिभा भटनागर, अनिरुद्ध सरकार एवं बलराम लोधी (प्रकाशक –लाख कॉपरेटिंग सेंटर,राज्य वन अनुसंधान संस्थान जबलपुर, मध्यप्रदेश), पृश्ठ सं. 1–30 ।

Monograph

- Das P, Borah B, Saikia P, Kalita S and Saikia R (2019). *Isaria fumosorosea* (EPF) from *Eublemma amabilis* in Assam. Directorate of Research, Assam Agricultural University, Jorhat-13 (AAU/DR/MG/331/2019-20**),** 1-15 pp.

Folders

- Gupta RK, Bali K and Ganai SA (2019). Lac insect cultivation in local vernacular language (Jammu Region), Directorate of Research, SKUAST-Jammu, 1-8 pp.
- Singh KI, Ngangom R and Niranjan C (2019). Lac insect and its importance in local vernacular language (Manipuri). Directorate of Research, CAU, Imphal, 1-11 pp.

Technical Bulletin

- Das P, Kalita S, Saikia P, Sarmah MS and Saikia J (2019). Makhioti gosot laa khetir orthoinaitik bishlekhon. Directorate of Research, Assam Agricultural University, Jorhat (AAU/DR/20/BU/329/2019-20**),** 1-3 pp.
- Gupta RK, Bali K Ganai SA and Kour R(2019). Lac cultivation in Jammu: A new venture for kandi farmers, SKUAST-Jammu.
- Gupta RK, Bali K Ganai SA and Kour R(2019). Lac cultivation in Jammu: A new venture for kandi farmers, SKUAST-Jammu.
- Gupta RK, Bali K Ganai SA and Kour R(2019). जम्मू में लाख खेती: कंडी किसानों के लिए एक नयाउद्यम । SKUAST-Jammu.

Booklet

- Das P, Kalita S, Saikia P, Sarmah M S and Saikia J (2019). Ahomot laa kheti**.** Directorate of Research, Assam Agricultural University, Jorhat-13 (AAU/DR/20/BL/330/2019-20**),** 1-10 pp.

Research papers presented in conferences/symposia

- Swami H. National Symposium on Sustainable Management of Pests and Diseases in Augementing Food and Nutrition Security, NAU, Navsari, Gujarat, January 22-24, 2019.
- Swami H. International Conference on Food, Agriculture and Innovations, Bangkok, Thailand, June 19-23, 2019.
- Gupta RK. Potential of lac production in Jammu. 5th J&K Agricultural Science Congress on Climate Change management for Sustainable Agriculture, Livestock Farming and Ecological Development, SKUAST-Jammu, August 8-10, 2019.
- Swami H. National Conference on Climate Smart Agriculture for Livelihood Security: Challenges and Opportunities, TNAU, Tamil Nadu, September 13-14, 2019.

Radio talk

- Dr. P Das delivered a radio talk on 'Lac cultivation technology', All India Radio, Dibrugarh, April 30, 2019.
- Dr. H Swami delivered a radio talk on 'Lac cultivation technology', All India Radio, Udaipur, June 15, 2019.
- Dr. K Bali delivered a radio talk on 'Rearing of beneficial insects for livelihood', All India Radio, Jammu, April, 2019.

- Dr. RK Gupta conducted a phone in programme on 'Natural enemies and their role in agriculture (With special emphasis on lac), All India Radio, Jammu, May, 2019
- Dr. RK Gupta delivered a radio talk on 'Non chemical methods of pest control (Disseminated to encourage lac inoculation for encouraging parasitods on trees) Jammu', All India Radio, Jammu, November, 2019

TV Talk

- Dr. H Swami delivered a TV talk on 'Lac insect and lac cultivation in the region, season 'in *News 18 Rajasthan* programme, December 22, 2019.

Approved on-going Research Projects

Sl. No.	Project No.	Title of the Project	Name of Investigators
Core Programme – I : Productivity and Quality Improvement			
1.	1.1.060	Collection, conservation, characterization and documentation of lac insect/host plant biodiversity (Phase - III)	Dr. VD Lohot Dr. J Ghosh Dr. Thamilarasi K Dr. A Mohanasundaram Ms Shruti Sinha
2.	1.1.066	Morpho-physiological characterization vis-à-vis strategies to augment quality and storability of seeds of *Schleichera oleosa* under ambient condition	Dr. NK Sinha Dr. VD Lohot Ms LC Langlentombi
3.	1.1.067	Understanding lac insect-host plant interaction --- A molecular approach	Ms Shruti Sinha Dr. Thamilarasi K
4.	1.1.069	Agronomic interventions influencing lac production in *palas* (*Butea monosperma*) in summer season	Dr. S Ghosal Sri NN Rajgopal
5.	1.1.070	Taxonomic studies of lac insects (Hemiptera: Coccoidea: Tachardiidae) and associated insect fauna	Sri NN Rajgopal
Core Programme – II : Crop Production System Management			
6.	1.1.065	Evaluation of the effect of drip irrigation and plastic mulch on growth and seed yield of *F. semialata*	Er. SK Srivastava
7.	1.1.068	Effect of abiotic factors on lac associated fauna in *rangeeni* crops (Phase-II)	Dr. A Mohanasundaram
8.	1.1.071	Lac Integrated Cropping System through Participatory Approach	Ms LC Langlentombi Dr. S Ghosal Dr. NK Sinha Er. SK Srivastava Sri NN Rajgopal
Core Programme – III : Processing, Storage and Quality Management			
9.	1.2.060	Establishment of pilot-plant of dewaxed decolourized lac (DDL) for training, demonstration and process refinement	Er. SK Pandey, Dr. SC Sharma Dr. N Prasad
10.	1.2.066	Biodegradation studies on lac resin using soil burial method	Dr. MF Ansari Dr. S Maurya, ICAR RCER, Plandu
11.	1.2.070	Development of pilot plant of *guar* gum derivative for training and demonstration	Dr. SC Sharma Dr. A Roy Chowdhury Er. SK Pandey Dr. N Prasad
12.	1.2.073	Study on spray drying of gum *ghatti* (*Anogeissus latifolia*)	Er. Ranjit Singh Er. Priyanka Sakare
13.	1.2.074	Study on infrared drying of seed lac	Er. Priyanka Sakare Er. Ranjit Singh

Sl. No.	Project No.	Title of the Project	Name of Investigators
Core Programme – IV : Value Addition, Application Development and Product Diversification			
14.	1.2.071	Synthesis of *guar* gum hydrogel-nanoparticle hybrid scaffold	Dr. SKS Yadav
15.	1.2.072	Development and evaluation of resin/gum based sticky insect trap	Dr. N Thombare Dr. S Srivastava
16.	1.2.075	Study on natural gum based dietary fibre as encapsulant for delivery of functional feed	Dr. A Roy Chowdhury Dr. N Thombare Er. Ranjit Singh Dr. Biplab Sarkar, ICAR-IIAB
Core Programme – V: Capacity Building of Farmers and Entrepreneurship Development			
17.	1.3.052	Capacity building, skill development, extension education and information service on natural resins and gums	Dr. Nirmal Kumar Dr. SKS Yadav Dr. RK Yogi
Core Programme – VI: Technology Evaluation, Refinement, Dissemination and Demonstration			
18.	1.3.053	Market information support and impact assessment of technological interventions for NRGs	Dr. RK Yogi Dr. Nirmal Kumar
Network Projects (ICAR, New Delhi sponsored)			
19.	3.2.026	Network Project on Harvesting, processing and value addition of natural resins and gums	Dr. N Prasad, Project Coordinator
20.	3.1.054	Network Project on Conservation of lac insect genetic resources	Dr. KK Sharma, Project Coordinator
ICAR-DBT			
21.	2.1.055	Identification, cloning and characterization of genes involved in pigment biosynthesis of the Indian lac insect, *Kerria lacca* (Kerr)	Dr. Thamilarasi K Dr. VD Lohot
ICAR-ICRAF			
22.	2.1.054	Enabling tribal communities to improve their livelihoods through agroforestry systems on a sustainable basis	Dr. J Ghosh Dr. A Mohanasundaram Dr. RK Yogi
Inter-Institutional Projects			
I. ICAR-IINRG, Ranchi & ICAR-IIAB, Ranchi			
23.	--	Development and evaluation of the efficacy of novel nanoparticles for enhancing yield in rice and Indian major carp	Dr. A Roy Chowdhury
II. ICAR-IINRG, Ranchi & ICAR-RCER Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi			
24.	--	Enhancing food, nutritional and livelihood security of marginal and small farmers in Jharkhand through need based agricultural technologies	Dr. Nirmal Kumar Dr. NK Sinha

Publication and Publicity

Publications

Research Papers

- Chowdhury AR and Gupta RL (2019). Synthesis and fungi-toxicity evaluation of Schiff bases of 4-amino-3-mercapto-5-phenyl-1,2,4-triazole. *Int. J. Chem. Stud.*7(6): 3-8.
- Ghosal S and Meena SC (2019). Factors affecting lac insect settlement. *Ind. For.* 145 (12): 1212-13.
- Kandasamy T, Roy T, Mohanasundaram A, Sharma KK and Ramani R (2019). 18S rDNA based detection of hymenopteran parasitoids in the Indian lac insect, *Kerria lacca* (Kerr). *Ind. J. Exp. Biol.* 57: 526-531.
- Kumari K, Thamilarasi K, Ghosh J, Lohot VD and Ghosal S (2019). Molecular diversity analysis of pigeonpea genotypes for scar marker development. *Int. J. Chem. Stud*. SP6: 534-540.
- Lohot VD, Ghosh J, Thamilarasi K, Mohanasundaram A, Sinha NK, Gunjan, Thakur VV, Neha K, Kumari S, Jha S, Xess M and Sharma KK (2019). Explicating the impact of phloem sap sucking lac insect (*Kerria lacca* Kerr) on phytochemistry of *Kusum* (*Schleichera oleosa* Oken.) host. Int. J. Chem. Stud. SP6: 142-147.
- Meena SC, Sharma KK, Rana BS, Swami H, Lekha and Thamilarasi K (2019). Study of productivity linked parameters of lac insect, *Kerria lacca* (Kerr) on *Flemingia macrophylla. J. Entomol. Zool. Stud.*7(3): 505-509
- Singh R and Ananda Kumar S (2019). Effect of ozone fumigation on controlling drugstore beetle and quality of coriander during storage. *Int. J. Chem. Stud.*7(6): 698-702.
- Sinha NK, Singh H and Sharma KK (2019). A new record of three seeded *Kusum* (*Schleichera oleosa* Lour.) Merr. fruits from Jharkhand, India. *Int. J. Chem. Stud.* SP6: 01-02.
- Yadav VK, Kumar N, Singh AK, Chakrabarti A, Bhadana VP and Sarkar PK(2019). Knowledge level of farmers and scientists about agricultural biotechnology in Jharkhand,India. *Int. J. Chem. Stud.* SP6: 703-706.

Papers presented/contributed in conferences/ symposia/seminars

- Thamilarasi K, Kumari K, Ghosh J, Lohot VD and Ghosal S (2019). Molecular markers for lac yielding pigeonpea genotypes. National Conference on Molecular Biotechnology, National Institute of Technology, Warangal, January 04-05, p. 16.
- Following papers were presented in 53rd ISAE Annual Convention and International Symposium on Engineering Technologies for Precision and Climate Smart Agriculture, BHU, Varanasi, January 28-30, 2019:
  - Sakare P. Utilization of banana pulp for production of greaseproof paper, p. 27.
  - Singh R. studies on powder flow properties of gum karaya (*sterculia urens*), p.99-100.
- Ansari MF (2019). Green composites using shellac as a natural matrix. 2nd International Conference on Chemistry, Industry and Environment (ICCIE-2019), Department of Applied Chemistry, Zakir Hussain College of Engineering & Technology, AMU Aligarh, February 18-19, p. 65.
- Thamilarasi K, Anees K, Gargi M, Kumari K and Ekbal S (2019). Bioprospecting for lac pigment biosynthesizing genes. DBT Bio-CARe Conclave on Women Scientists Achieving Great Heights, NIPGR, New Delhi, March 08-09, p. 178.
- Following papers were presented in National Conference on Doubling Farmers' Income for Sustainable & Harmonious Agriculture (DISHA-2019), BAU, Ranchi, August 10-11, 2019:
  - Chowdhury AR, Siddiqui MZ and Prasad N. Study of stability pattern of *piyar* gums collected from different agro-climatic zones, p. 81.
  - Chowdhury AR and Gupta RL. Synthesis and fungi-toxicity evaluation of Schiff bases of 4-amino-3-mercapto-5-phenyl-1,2,4-triazole, p. 86.
  - Srivastava S, Chowdhury AR, Sarkar B,Thombare N and Bhattacharjee S. Preparation of *palas* tannin based silver nanocomposites for antimicrobial application, p. 86.
  - Thombare N. Chemical profiling and chromatographic investigations of *Anogeissus latifolia* exudate gum, p. 87.
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  - Mohanasundaram A. Lac based indigenous technical knowledge in North East India, p. 132.

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- Sinha NK, Singh H and Sharma KK. A new record of three seeded *kusum* (*Schleichera oleosa* Lour.) Merr. fruits from Jharkhand, India, p. 206.
- Sinha NK, Ghosh J, Lohot VD, Singh Harihar and Sharma KK. Seasonal germination dynamics of *kusum* (*Schleichera oleosa*) seeds under different storage conditions, p. 240.

❖ Yogi RK, Kumar N and Sharma KK (2019). Relevance of natural resource statistics: A case of natural resins and gums from India. VIII International Conference on Agricultural Statistics, New Delhi, November 18-21, p. 47.

❖ Following papers were presented in International Seminar on Modern Agriculture Approaches in 21st Century, Department of Social Work, University of Lucknow, Lucknow (Uttar Pradesh), November 22 – 23, 2019:

- Pandey SK, Sharma SC and Prasad, N. Drying study of value added lac products for determining suitable drying method/system, p. 123-124
- Sharma SC, Pandey SK and Prasad N. Comparison of manufacturing seedlac: A natural resin of commercial importance, p. 126 -127.

❖ Siddiqui MZ, Chowdhury AR, Singh BR, Maurya S and Ali Md (2019). Development and antimicrobial evaluation of *Acacia nilotica* gum induced silver nanoparticles. CARBO-XXXIV-International Carbohydrate Conference on 'Emerging Frontiers in Carbohydrate Chemistry and Glycobiology' (EFCCG-2019), Department of Chemistry, University of Lucknow, Lucknow (Uttar Pradesh), December 05-07, p. 68.

❖ Sharma KK (2019). Science and technology based entrepreneurship development with special reference to natural resins and gums sector. 89th Annual Session of NASI and Symposium on Science and Technology based Entrepreneurship Development, ICAR-NAARM, Hyderabad, December 21-23, p. 39-44.

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- Lohot VD. Exploring the potential of rain tree (*Albizia saman*) for cultivation of lac insect (*Kerria* species), p. 22.
- Thamilarasi K,Ekbal S, Kumari K, Lohot VD, Ghosh J, Mohanasundaram A. Barcoding of major lac host plants, p. 94.
- Yogi RK, Mohanasundaram A, Ghosh J, Vidyakar V, Dhyani Shiv K, Rizvi J and Sharma KK. Enabling tribal communities for sustainable livelihoods through Lac based Agro Forestry Systems, p. 220.
- Mohanasundaram A, Monobrullah Md, Sharma KK, Naaz N, Yadav M and Zeeshan N. Relative abundance, emergence profile and parasitization of lac associated fauna during *rangeeni* lac crops, p. 221.
- Singh R and Anandakumar S. Effect of ozone fumigation on controlling drugstore beetle and quality of coriander during storage, p. 342.

Book/Chapters/Bulletins/Manuals/Extension folders/ Project reports

❖ निम्नलिखित अध्याय प्रसार पुस्तिका 01/2019 प्राकृतिक राल तथा गोंद उत्पादन एवं मूल्य वर्धन हेतु तकनीकी (संपादकः योगी राज कुमार, शर्मा सतीश चन्द्र, यादव संतोष कुमार सिंह, द्योष ज्योर्तिमय एवं कुमार निर्मल), भाकृअनुप–भारतीय प्राकृतिक राल एवं गोंद संस्थान, राँची, में प्रकाशित हुयें, पृष्ठः 1–45ः

- कुमार निर्मल, यादव संतोष कुमार सिंह एवं योगी राज कुमार। भाकृअनुप–भारतीय प्राकृतिक राल एवं गोदं संस्थान –– एक नज़र में, पृष्ठ सं. 1–9 ।
- द्योषाल सौमेन एवं द्योष ज्योर्तिमय । बेर वृक्ष पर वैज्ञानिक विधि से लाख की खेती, पृष्ठ सं. 10–12 ।
- शर्मा केवल कृष्ण । कुसुम वृक्ष पर लाख की वैज्ञानिक खेती, पृष्ठ सं. 13–15 ।
- मोनोबुल्लाह एवं मोहनसुन्दरम ए । पलास पर लाख की खेती, पृष्ठ सं. 16–18 ।
- शर्मा केवल कृष्ण । सेमियालता पर लाख की वैज्ञानिक खेती, पृष्ठ सं. 19–21 ।
- महताब ज़ाकरा सिद्दीकी। लाख से बनी लकड़ी पॉलिश, पृष्ठ सं. 22–23 ।
- अंसारी फहीम । लाख आधारित पेंट से घर की साज–सज्जा, पृष्ठ सं. 24 ।
- श्रीवास्तव संजय एवं यादव संतोष कुमार सिंह । किन्नू पर लेप, पृष्ठ सं. 25–26।
- यादव संतोष कुमार सिंह एवं शर्मा सतीश चन्द्र। लाख आधारित हस्त शिल्प, पृष्ठ सं. 27–28।
- पाण्डेय संजय कुमार, शर्मा सतीश चन्द्र एवं प्रसाद निरंजन। लाख आधारित मुख्य औद्योगिक उत्पाद, पृष्ठ सं. 29–33।

- संजय श्रीवास्तव। गुणवत्ता मूल्यांकन प्रयोगशाला, पृष्ठ सं. 34–35।
- शर्मा सतीश चन्द्र एवं यादव संतोष कुमार सिंह। कराया गोंद का उत्पादन, पृष्ठ सं. 36–38।
- कुमार निर्मल। लाख प्रसार गतिविधियां, पृष्ठ सं. 39–41।
- योगी राज कुमार, यादव संतोष कुमार सिंह, शर्मा सतीश चन्द्र एवं कुमार निर्मल। भारत में जनजातीय क्षेत्र के वनवासी समुदायों में महत्वपूर्ण प्रभाववाली सफलता की कहानियां, पृष्ठ सं. 42–45।

निम्नलिखित अध्याय प्रशिक्षण पुस्तिका 02/2019 ग्रामस्तरीय संगठनों के सशक्तिकरण हेतु प्राकृतिक राल व गोंद उत्पादन एवं मूल्यवर्धन तकनीकी (संपादकः योगी राज कुमार, शर्मा सतीश चन्द्र, यादव संतोष कुमार सिंह, कुमार निर्मल एवं शर्मा केवल कृष्ण), भाकृअनुप–भारतीय प्राकृतिक राल एवं गोंद संस्थान, राँची, में प्रकाशित हुयें,पृष्ठः 1–61:

- द्योष ज्योर्तिमय, योगी राज कुमार, शर्मा सतीश चन्द्र एवं कुमार निर्मल । ग्राम स्तरीय संगठनों के सशक्तिकरण में प्राकृतिक राल व गोंद आधारित कृषि उद्यमी–वैज्ञानिक मंच की भूमिकाः एक परिचय, पृष्ठ सं. 1–7 ।
- मोहनसुन्दरम ए एवं द्योष ज्योर्तिमय। लाख की खेती में उत्पादकता एवं आय में वृद्धि हेतु प्रबंधन तकनीकी, पृष्ठ सं. 8–12 ।
- घोषाल सौमेन । प्राकृतिक राल एवं गोंद क्षेत्र में उत्पादन प्रौद्योगिकी, पृष्ठ सं. 13–23।
- प्रसाद निरंजन । प्राकृतिक राल एवं गोंद के संग्रहण, प्रसंस्करण एवं मूल्य संवर्धन पर प्रौद्योगिकी, पृष्ठ सं. 24–26।
- कुमार निर्मल एवं योगी राज कुमार । ग्रामीण उद्यमिता विकास : अवसर और चुनौतियां, पृष्ठ सं. 27–30।
- यादव संतोष कुमार सिंह एवं शर्मा सतीश चन्द्र। प्राकृतिक राल एवं गोंद का रख–रखाव एवं भण्डारण, पृष्ठ सं. 31–34।
- शर्मा सतीश चन्द्र, पाण्डेय संजय कुमार एवं प्रसाद निरंजन। ग्रामीण उद्यमिता विकास के लिए लाख प्रसंस्करण एवं मूल्य संवर्धन तकनीक, पृष्ठ सं. 35–43 ।
- श्रीवास्तव संजय, अर्णब राय चौधुरी एवं नंद किशोर थोम्बरे। चौरी एवं चपड़ा लाख के गुणवत्ता मानक, पृष्ठ सं. 47–50 ।
- शर्मा केवल कृष्ण एवं योगी राज कुमार। ग्राम स्तरीय संगठनों के विकास हेतु संस्थागत तंत्र : एक अवलोकन, पृष्ठ सं. 51–56 ।
- योगी राज कुमार एवं शर्मा सतीश चन्द्र । आदिवासी क्षेत्रों में आमहित समूह के सशक्तिकरण की दिशा में नीतिगत बदलाव एवं संभावनाएं : एक परिचय, पृष्ठ सं. 57–61

निम्नलिखित अध्याय प्रशिक्षण पुस्तिका 03/2019 आजीविका सुरक्षा के लिए लाख एकीकृत कृषि वानिकी प्रणाली (संपादकः मोहनसुन्दरम ए, योगी राज कुमार, द्योष ज्योर्तिमय एवं शर्मा केवल कृष्ण), भाकृअनुप–भारतीय प्राकृतिक राल एवं गोंद संस्थान, राँची,में प्रकाशित हुयें,पृष्ठः 1–72:

- राजगोपाल एन एन, मोहनसुन्दरम ए एवं शर्मा केवल कृष्ण। लाख कीट जीवन एवं फसल चक्र, पृष्ठ सं. 1–4।
- मोहनसुन्दरम ए, लोहोट वी डी, सिन्हा आकाश एवं नासिरा। संस्थान अनुसंधान प्रक्षेत्र–परिदृश्य, पृष्ठ सं. 5–7।
- सिन्हा नवलेश कुमार एवं सिंह हरिहर। लाख पोषित पौधे का बागान और उसका प्रबंधन, पृष्ठ सं. 8–11।
- घोषाल सौमेन । लाख की खेती के लिये बेर एवं सेमियालता में पोषक तत्वों का प्रबंधन, पृष्ठ सं. 12–14।
- लोहोट वी डी, द्योष ज्योर्तिमय, मोहनसुन्दरम ए एवं ठाकुर वी वी । रंगीनी लाख खेती की वैज्ञानिक विधि, पृष्ठ सं. 15–19 ।
- द्योष ज्योर्तिमय, मोहनसुन्दरम ए, लोहोट वी डी, योगी राज कुमार एवं ठाकुर वी वी । कुसमी लाख की खेती, पृष्ठ सं. 20–25।
- मोहनसुन्दरम ए, शर्मा के के एवं राजगोपाल एन एन । लाख कीट एवं पोषक वृक्षों के परजीवी तथा उनका प्रबंधन, पृष्ठ सं. 26–31 ।
- चौधरी जे, कुमार पी, मोहनसुन्दरम ए एवं योगी आर के। बागवानी फसलों में कीट एवं रोग प्रबंधन, पृष्ठ सं. 42–50।
- लिशंगथेम चानु लैग्लेटोम्बी, राजगोपाल एन एन, त्रिपाठी संजय कुमार एवं विद्याकर विद्यापति । लाख समेकित कृषि–वानिकी प्रणाली, पृष्ठ सं. 51–54।
- शर्मा सतीश चन्द्र, पाण्डेय संजय कुमार एवं प्रसाद निरंजन । लाख की छिलाई, धुलाई एवं वर्गीकरण, पृष्ठ सं. 55–58।
- यादव संतोष कुमार सिंह एवं शर्मा सतीश चन्द्र। लाख का प्रसंस्करण एवं उपयोग, पृष्ठ सं. 59–64 ।
- योगी राज कुमार, मोहनसुन्दरम ए एवं द्योष ज्योर्तिमय। स्थायी आधार पर आदिवासी समुदायों को कृषि वानिकी प्रणालियों के माध्यम से उनकी आजीविका में सुधार करना, पृष्ठ सं. 65–69 ।
- कुमार निर्मल, योगी राज कुमार, मोहनसुन्दरम ए, द्योष ज्योर्तिमय, विद्याकर विद्यापति, सिंह हरिहर एवं जमा तारिक । प्रशिक्षण कार्यक्रम के अंतर्गत किसान प्रक्षेत्र स्कूल मे किसानों का विभिन्न गाँवों का भ्रमण, पृष्ठ सं. 70–71।

❖ Sharma KK (2018).Understanding the diversity of lac insects of *Kerria* spp. in India and the nature of insect-

host plant interaction. In: Peshin Rajinder and Dhawan Ashok K (Eds.), Natural Resource Management: Ecological Perspective, Sustainability in Plant and Crop Protection, Springer Nature Switzerland AG [https://doi.org/10.1007/978-3-319-99768-1_13 (ISSN 2567 9805, 2567 9821 (electronic)], 219 – 233 pp.

❖ Meena SC, Sharma KK and Ghosal S (2019). Lac insects and its interaction with environmental factors. In: Latest trends in Zoology and Entomology Sciences. Chandel BS (Eds.), Vol 5, Akinik Publication, New Delhi, 173-183 pp.

❖ Mohanasundaram A, Sharma KK and Naaz N (2019). Lac insect,natural enemies and their management. In: Kumar A, Kumar N and Chand H (Eds.), Commercial Entomology, New India Publishing Agency, New Delhi, India (ISBN- 978-93-87973-87-9), 111-128 pp.

❖ Jaiswal AK, Sharma KK, Thombare N and Yogi RK (2019). Lac culture in India. In: Industrial Entomology: Productive Insects, Applied Zoologists Research Association, Bhubaneswar, India (ISBN: 81-900947-4-8), 82-126 pp.

❖ Thamilarasi K and Sharma KK (2019). Interaction of lac insects with microbes. In: Kumar A, Kumar N and Chand H (Eds.), Commercial Entomology, New India Publishing Agency, New Delhi, India (ISBN- 978-93-87973-87-9), 129-140 pp.

❖ Srivastava SK, Srivastava S, Thombare N, Chowdhury AR and Prakash A (2019). Insect dyes: Past, present and future. In: Industrial Entomology: Productive Insects, Applied Zoologists Research Association, Bhubaneswar, India (ISBN: 81-900947-4-8), 193-215 pp.

❖ Sakare P (2019). Farm structures and farmstead planning In: Pandiselvam R, Kothakota A, Krishna kumar P (Eds.), Objective question bank in Agricultural Process Engineering (Food Engineering), Jain Brothers, New Delhi,143-177 pp.

❖ Sakare P (2019). Aquaculture processing technology & structure design In: Pandiselvam R, Kothakota A, Krishna kumar P (Eds.),Objective question bank in Agricultural Process Engineering (Food Engineering), Jain Brothers, New Delhi, 178-183 pp.

Popular Articles

❖ Following popular articles were published in Laksha, 2019 (ISSN No. 2454-7840), ICAR-IINRG, Ranchi, 122 p.:

- अर्णव राय चौधुरी एवं संजय श्रीवास्तव। लाख आधारित सुरक्षित प्राकृतिक रंजक, पृष्ठ सं. 1–2।
- नंदकिशोर ठोंबरे, वैभव डी लोहोट एवं लोकेश मीना। सफेद डामर : बहुपयोगी राल की एक विलुप्तप्राय प्रजाति, पृष्ठ सं. 3–4।
- सुनील कुमार श्रीवास्तव, सौमेन घोषाल एवं पवनजीत। बूंद–बूंद सिंचाई पद्धति के उपयोग से सेमियालता की अच्छी बढ़त, पृष्ठ सं. 5–6।
- सतीशचन्द्र शर्मा, संजय कुमार पाण्डेय एवं निरंजन प्रसाद। लाख उत्पादन का यंत्रीकरण, पृष्ठः सं. 7–13।
- सतीशचन्द्र शर्मा, संजय कुमार पाण्डेय एवं निरंजन प्रसाद। प्राकृतिक राल एवं गोंद उत्पादन का यंत्रीकरणः व्यवसायिक दृष्टि से महत्वपूर्ण, पृष्ठ सं. 16–22।
- राजकुमार योगी, संतोष कुमार सिंह यादव एवं संतोष कुमार मीना । झारखंड में लाख प्रसंस्करण संबंधी योजनाएं, पृष्ठ सं. 23–26।
- महताब ज़ाकरा सिद्दीक़ी, अर्णब राय चौधुरी एवं देवब्रत हरि। नैनोटेक्नोलॉजी : एक संक्षिप्त परिचय, पृष्ठ सं. 29–31।
- सतीशचन्द्र शर्मा, संजय कुमार पाण्डेय एवं निरंजन प्रसाद। कृषि यंत्रीकरण : आय एवं रोजगार का एक विकल्प, पृष्ठः सं. 32–42।
- वैभव डी लोहोट, ए मोहनसुन्दरम एवं तमिलरसी के। लाख कीट संरक्षण में फाइकस प्रजाति का योगदान, पृष्ठ सं. 47–48।
- राजन चौधरी, राजकुमार योगी एवं निर्मल कुमार। बदलती जलवायु का मुख्य खाद्यान्न फसलों पर प्रभाव, पृष्ठ सं. 52–54।
- प्रियंका साकरे, शेख मुख्तार मंसुरी एवं हिमा जॉन। फलों और सब्जियों के भंडारण के लिए वाष्पीकरणीय शीतलन प्रणाली, पृष्ठ सं. 55–57।
- राजन चौधरी, निर्मल कुमार एवं राजकुमार योगी। मौसम आधारित सब्जियों की खेतीः वार्षिक कैलेंडर, पृष्ठ सं.61–65।
- राजकुमार योगी, निर्मल कुमार एवं संतोष कुमार मीना। झारखंड में मधुमक्खी पालन की योजनाएं व संभावनाएं, पृष्ठ सं. 66–70।
- अजिता गुप्ता, अमित कुमार पाटिल एवं प्रियंका साकरे। एग्रोफोटोवोल्टिक्सः कृषि के साथ सौर खेती का मिश्रण, पृष्ठ सं. 74–75।
- रंजीत सिंह एवं हिमानी प्रिया। बिना जुताई (जीरो टिलेज) के खेती कैसे करें, पृष्ठ सं. 76–77।
- रंजीत सिंह, प्रियंका साकरे एवं मो अली। भारतीय सैफरन

एक बहुमूल्य मसाला : हल्दी का प्रसंस्करण, पष्ठ सं. 78–79 ।

- देवब्रत हरि एवं महताब ज़ाकरा सिद्दीकी। कुपोषण––एक गम्भीर समस्या, पृष्ठ सं. 88–89।
- महताब ज़ाकरा सिद्दीकी एवं अंजेश कुमार । वर्ष 18–19 की अनुसंधान की उपलब्धियां, पृष्ठ सं. 91–97।
- अंजेश कुमार एवं महताब ज़ाकरा सिद्दीकी। वर्ष 18–19 के महत्वपूर्ण आयोजन, पृष्ठ सं. 98–109।

❖ Following popular articles were published in Agriculture & Food: e-Newsletter, 2019 (ISSN: 2581-8317):

- Shinde R, Sarkar PK, Thombare N and Naik SK. Soil conservation: Today's need for sustainable development, 1 (5), 175-183 pp.
- Shinde R, Sarkar PK and Thombare N. Soil conditioners, 1 (10), 1-5 pp.
- Lohot VD, Ghosh J, Thamilarasi K, Mohanasundaram A, Rajagopal NN, Thakur VV and Sharma KK. Exploring the utilization potential of *Ficus* sp. for cultivation of lac insects (*Kerria* sp.) in India, 1 (12), J-M pp.

Institute Publications

- ICAR-IINRG Annual Report 2018-19, 1-196 pp.
- Laksha, Rajbhasha Patrika, 2019, 1-128 pp.
- Ms D Norris Memorial Lecture Booklet on Digital India: Cyber Crime Issues, Challenges and Way Forward, 2019, 1-14 pp.
- Large scale preparation of herbal *gulal* from *palas* flowers, Folder, 2019, 1-4 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, April-June 2017, 21(2), 1-8 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, July-September 2017, 21(3), 1-8 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, July-September 2018, 22(3), 1-12 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, October-December 2018, 22(4), 1-8 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, January-March 2019, 23(1), 1-8 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, April-June 2019, 23(2), 1-8pp.
- प्राकृतिक राल तथा गोंद उत्पादन एवं मूल्यवर्धन हेतु तकनीकी, प्रसार पुस्तिका 01/2019, पृष्ठः 1–45।
- ग्रामस्तरीय संगठनों के सशक्तिकरण हेतु प्राकृतिक राल व गोंद उत्पादन एवं मूल्यवर्धन तकनीकी, प्रशिक्षण पुस्तिका 02/2019,पृष्ठः 1–61 ।
- आजीविका सुरक्षा के लिए लाख एकीकृत कृषि वानिकी प्रणाली, प्रशिक्षण पुस्तिका 03/2019, पृष्ठः 1–72 ।

Publicity

Tours/Visits

❖ Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and monitored *kusmi* lac on *ber* and assessed the vegetable requirements of farmers at Silda, Khunti, Ranchi, under ICRAF Project, January 07, 2019.

❖ Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and monitored *kusmi* lac on *ber* and assessed the vegetable requirements of farmers at Mungadih village, Angarha block and Hesatu village, Ormanjhi block, Ranchi, under ICRAF Project, January 09, 2019.

❖ Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and monitored *kusmi* lac on *ber* and assessed the vegetable requirements of farmers at Dumra, Purihensa and Bada Chunchuniya village, Ichagarh block, Seraikela, Ranchi, under ICRAF Project , January 11, 2019.

❖ Sharma SC, Sr. Sc.; Pandey SK, Sc. and Yogi RK, Sc. visited Birsa Agricultural University, Ranchi regarding display of Institute exhibits under State Level Agricultural Fair, February 02 –0 4, 2019.

❖ Thamilarasi K, Sr. Sc. visited Sarjamdih village, Ranchi and delivered a lecture on lac crop cycle and lac associated fauna, February 14, 2019.

❖ Sharma SC, Sr. Sc.; Pandey SK, Sc. and Yogi RK, Sc. visited Ramkrishna Mission Asharam, Rahe, Ranchi regarding display of Primary Lac Processing Machinery in Agricultural Technology and Machinery Exhibition, February 15, 2019.

❖ Thombare N, Sc. visited Tajna Shellac Factory, Khunti, Ranchi, along with the Chairman & RAC Members, March 17, 2019.

❖ Lohot VD, Sr. Sc. visited Putadag and Koinardih, Angara block, Ranchi for collection of seeds of *swadi palas,* April 04 & 25, 2019.

❖ Lohot VD, Sr. Sc. and Kido AD visited Dumri, Giridih (Jharkhand) for collection of seeds of yellow flowered *palas*, May 15, 2019.

❖ Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and monitored farmers' fields, assessed the input requirements for upcoming season at Mungadih, Rupru

village, Angarah block and Hesatu village, Ormanjhi block, Ranchi, under ICRAF Project, May 31, 2019.

- Mohanasundaram A, Sc. visited and monitored summer season *kusmi* lac crops at Benyajara village, Angarha block, Ranchi, under MGMG programme, May 31, 2019.
- Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and monitored farmers' fields, assessed the input requirements for upcoming season at Silda, Roro and Kota village, Khunti, Ranchi, under ICRAF Project, June 03, 2019.
- Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and monitored farmers' fields, assessed the input requirements for upcoming season at Purihensa, Bada Chunchuniya village, Seraikela- Kharsawan, Ranchi, under ICRAF Project, June 06, 2019.
- Thombare N, Sc. visited forest area near Jonha village (Block-Angarah), Ranchi for collection of planting material (seedlings, stumps, seeds, etc.) of *salai* and *jhingan* gum for plantation at Resin and Gum Plants Germplasm, July 11, 2019.
- Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited and inoculated *kusmi* broodlac on *ber* and *semialata* in selected farmers' fields at Silda, Roro & Kota of Khunti district and Hesatu, Ranchi, under ICRAF Project, July 18, 2019.
- Lohot VD, Sr. Sc. and Thombare N, Sc. conducted survey at Udaipur, Sirohi, Pali, Jodhpur and Jaisalmer districts of Rajasthan for exploring the availability of lac insect/ host and gum/resin yielding plants, July 22-31, 2019.
- Langlentombi LC, Sc. and Rajgopal NN, Sc. visited Jaradih village (Block-Angarah), Ranchi for group discussion with farmers to select the intercrops for rainy season and to adopt farmers for LICS Project, July 23, 2019.
- Ansari MF, Pr. Sc.; Yadav SKS, Sc. and Mohanasundaram A, Sc. visited Benyazara village (Block-Angarah), Ranchi to monitor activities of *kusmi* lac production on *ber* under MGMG programme, August 03, 2019.
- Sharma SC, Sr. Sc. visited M/s National Enterprises, Hatia, Ranchi regarding development of gum tapping die as per detailed manufacturing design drawing developed in Pro Engineer (Creo Element) CAD Software, August 09, 2019 & September 12, 2019.
- Sharma SC, Sr. Sc. visited M/s Precision Engineering Works, Ancillary Industrial Area, Tupudana, Hatia, Ranchi to explore the possibility of licensing of Processing Unit and also its manufacturing at their site, August 23, 2019.
- Pandey SK, Sc. visited M/s Swastika Engineering and M/s National Enterprises, Hatia, Ranchi regarding development of tool for tapping/harvesting of gum/ resin and pilot plants of *guar* gum derivatives and DDL, September 07, 2019.
- Mohanasundaram A, Sc. and Yogi RK, Sc. visited and presented a project proposal jointly for establishing Biotech *Kisan* Hub for Aspirational districts of Jharkhand under Mission Programme on Biotech *Krishi* Innovation Science Application Network, New Delhi, September 22-24, 2019.
- Srivastava S, Pr. Sc.; Siddiqui MZ, Pr. Sc.; Ghosh J, Pr. Sc.; Thamilarasi K, Sr. Sc.; Chowdhury AR, Sc. and Srivastava SK, Sc. visited Gutidih and Jaradih village (Block-Angarah), Ranchi, under MGMG programme, and conducted awareness activities on 'Restriction of single use plastic'at Government Middle School, Tati Singari, Angarah, Ranchi, on the occasion of *Swachhta Pakhwada* (11th September to 2nd October, 2019), September 25, 2019.
- Ghosal S, Pr. Sc.; Pandey SK, Sc. and Langlentombi LC, Sc. visited Mangubandh village, Ranchi, under MGMG program, on the occasion of *Swachhta Pakhwada*, September 26, 2019.
- Lohot VD, Sr. Sc.; Sharma SC, Sr. Sc. and Rajgopal NN, Sc. visited Sarjamdih village (Angarah Block), Ranchi, under MGMG program, on the occasion of *Swachhta Pakhwada*, September 27, 2019.
- Ansari MF, Pr. Sc.; Yadav SKS, Sc.; Mohanasundaram A, Sc.; Sakare P, Sc. and Md Zaman T visited Benyazara village (Block-Angarah), Ranchi, under the MGMG programme, and conducted awareness activities on 'Restriction of single use plastic' among school children and farmers, October 01, 2019.
- Ghosh J, Pr. Sc. and Mohanasundaram A, Sc. visited selected farmers' fields at Benyazara, Mungadih, Hesatu villages and Silda, Roro and Kota villages, Ranchi to monitor *kusmi* lac cultivation on *F. semialata, ber, Calliandra* and *rangeeni* lac cultivation on *palas*. Vegetable crops were also monitored and suitable recommendations were provided to the farmers for the Lac Integrated Agro-forestry System, under ICRAF Project, October 17-18, 2019.
- Sakare P, Sc. and Singh R, Sc. visited M/s Nutron Workshop, Kanke, Ranchi to monitor the progress of experimental set up for infrared assisted hot air drying of seedlac, October 23, 2019.
- Mohanasundaram A, Sc. visited selected farmers' fields and collected yield data of *rangeeni* rainy season

(*Katki*) lac crop on *palas* at Silda, Khunti, Ranchi, under ICRAF Project, November 22, 2019.

- ❖ Mohanasundaram A, Sc. and Vidyakar V visited selected farmers' fields and monitored lac and vegetable crop's growth at Sidla, Roro, under ICRAF Project, December 17, 2019.
- ❖ Ansari MF, Pr. Sc.; Lohot VD, Sr. Sc. and Rajgopal NN, Sc. visited Government Middle School, Tati Singari (Angarah Block), Ranchi, under MGMG programme, on the occasion of *Swachhta Pakhwada,* December 18,2019.
- ❖ Ghosal S, Pr. Sc.; Pandey SK, Sc. and Langlentombi LC, Sc. visited Mangubandh village, Namkum,Ranchi, under MGMG programme, on the occasion of *Swachhta Pakhwada,* December 23, 2019.
- ❖ Mohanasundaram A, Sc. and Vidyakar V visited selected farmers' fields and monitored lac and vegetable crop's growth and also installed ICRAF Project board at Sidla, Roro and Kota,Ranchi, December 27, 2019.
- ❖ Mohanasundaram A, Sc. and Vidyakar V visited selected farmers' fields and monitored lac and vegetable crop's growth and installed ICRAF Project board at Munghadi and Hesatu,Ranchi, December 31, 2019.

Data Base

National level database of the NRGs production and EXIM data 2019 has been generated, maintained and updated at NRG Information Cell (NIC), TOT Division, ICAR-IINRG, Ranchi.

TV/Radio Talk

Expert	Topics	Date of Recording	Date of Broadcast/ Telecast
TV Talk (*Krishi Darshan-Doordarshan*, Ranchi)			
Dr. A Mohanasundaram, Sc.	Lac cultivation and its pest management	-	January 09, 2019
Dr. SC Sharma, Sr. Sc.	*Jharkhand mein utpadit gond avam jiewkoparjan kee sambhawnayein*	February13, 2019	March 03, 2019
Dr. RK Yogi, Sc.	Lac marketing and value addition	May 08, 2019	-
Dr. SC Sharma, Sr. Sc. Dr. RK Yogi, Sc.	*Siladon Lah Utpadak Sahyog Samiti* Limited (SLUSSL)	May 18, 2019	-
Dr. KK Sharma, Director	*kusmi fasal ki katai avam keet sancharan*	-	June 13, 2019
Dr. KK Sharma, Director	Walk the Talk – IINRG and its achievements (*Doordarshan*, Bihar)	-	June 27, 2019
Dr. A Mohanasundaram, Sc.	Precautions of lac cultivation during rainy season	July 02, 2019	-
Dr. KK Sharma, Director	*Semialata par lakh ki kheti se labh*	July 09, 2019	-
Dr. SC Sharma, Sr. Scientist	*Chhili lakh ka bhandaran avam bikri*	July 09, 2019	-
Dr. A Mohanasundaram, Sc.	Pest management on *kusmi* lac cultivation during rainy season	July 26, 2019	-
Dr. RK Yogi, Sc.	*Van evam Kisan ek doosre ke Sanrakshak*	August 22, 2019	August 24, 2019
Dr. KK Sharma, Director	*Lakh ki kheti mein rozgar ke awasar*	October 14, 2019	October 15, 2019
Dr. S Ghosal, Pr. Sc.	*Rangeeni lakh utpadan ka prabandhan*	November 19, 2019	November 23, 2019
Dr. J Ghosh, Pr. Sc. Dr. A Mohanasundaram, Sc. Dr. RK Yogi, Sc.	Activities conducted at Silda, Khunti, Ranchi under ICRAF Project	December 28, 2019	-
Dr. RK Yogi, Sc.	Marketing of *kusmi* lac	December 31, 2019	-
Dr. A Mohanasundaram, Sc.	*kusmi* lac cultivation and pest management during winter crop	December 31, 2019	-
Radio Talk (All India Radio, Ranchi)			
Dr. SC Sharma, Sr. Scientist	*Jharkhand ke pramukh gond utpadak vrikhh se buasayik utpadan*	June 14, 2019	June 22, 2019
Dr. S Ghosal, Pr. Sc.	*Lakh kheti me urvarokon ka prabhav*	July 12, 2019	July 13, 2019
Dr. S Ghosal, Pr. Sc.	*Palas vriksh par rangeeni lakh utpadan ka prabandhan*	November 18, 2019	November 19, 2019

Participation of Scientists in Conferences/Meetings/ Seminars/Symposia/Workshops/Trainings

By Director

Chaired/Convened

- Dr. KK Sharma, Director participated in progress review meeting, Engineering Division, KAB-II, New Delhi, January 03-05, 2019.
- Dr. KK Sharma, Director chaired the Institute Research Council meeting, January 18-19, 2019.
- Dr. KK Sharma, Director chaired Technical Session V on 'Role of beneficial and productive insects' in National Symposium on Sustainable Management of Pests and Diseases in Augmenting Food and Nutritional Security, Navsari Agricultural University, Navsari (Gujarat), January 22-24, 2019.
- Dr. KK Sharma, Director chaired the 84th Institute Joint Staff Council meeting, May 22, 2019.
- Dr. KK Sharma, Director chaired one day workshop on Competency Framework for Agricultural Research and Extension Scientists organized by ICAR-NAARM, Hyderabad in association with and at ICAR-IINRG Ranchi, March 06, 2019.
- Dr. KK Sharma, Director chaired the 54thInstitute Management Committee meeting, June 18, 2019.
- Dr. KK Sharma, Director chaired the Institute Research Council meeting, August 26 -27, 2019.
- Dr. KK Sharma, Director chaired the 85th Institute Joint Staff Council meeting, October 22, 2019.

Participated

- Dr. KK Sharma, Director participated in Director's Conference on January 31 and February 01, 2019 at New Delhi.
- Dr. KK Sharma, Director was invited to participate in State Level Bankers Committee - Sub-Committee on Agriculture organized by NABARD, Ranchi, April 02, 2019.
- Dr. KK Sharma, Director participated in State Level Workshop on MSP and MFP scheme and *Van Dhan Vikas Karyakaram* organized by TRIFED at ICAR- IINRG, Ranchi, April 12, 2019.
- Dr. KK Sharma, Director participated in Regional Advisory Group meeting organized by NABARD, Ranchi, May 29, 2019.
- Dr. KK Sharma, Director participated in Programme Advisory Committee of *Akashwani*, Ranchi, June 12, 2019.
- Dr. KK Sharma, Director participated as Member in Research Advisory Committee of Central Tasar Research and Training Institute, Ranchi, June 15, 2019.
- Dr. KK Sharma, Director participated in Programme Advisory Committee of *Doordarshan*, Ranchi, June 24, 2019.
- Dr. KK Sharma, Director participated in meeting with Development Commissioner for discussion on National Mission for Sustainable Agriculture, July 08, 2019.
- Dr. KK Sharma, Director was invited to participate in State Level Bankers Committee - Sub-Committee on Agriculture organized by NABARD, Ranchi, July 09, 2019.
- Dr. KK Sharma, Director participated as member in Forest Biotechnology Expert Committee meeting of DBT at NBRI, Lucknow, August 29-30, 2019.
- Dr. KK Sharma, Director was invited to participate in Research Advisory Group meeting of Institute of Forest Productivity, Ranchi, October 23, 2019.
- Dr. KK Sharma, Director & Project Coordinator, AINP on CLIGR participated in Review meeting of ICAR-IINRG and NP-CLIGR called by DDG (Engg.) at New Delhi, October 30, 2019.

By Others

- Dr. S Ghosal, Pr. Sc. & Head, LP Division participated in *kisan gosthi,* State level *kisan mela,* Birsa Agriculture University, Ranchi, February 03, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division participated in *kisan gosthi,* Central *kisan mela, Divyan Krishi Vigyan Kendra*, RK Mission, Ranchi, February 07, 2019.
- Dr. VD Lohot, Sr. Sc. and Dr. A Mohanasudaram, Sc. participated in 6th Co-ordination Committee Meeting of Network Project on Conservation of Lac Insect Genetic Resources, MPUAT, Udaipur (Rajasthan), February 07-08, 2019.
- Dr. N Kumar, Pr. Sc. & Head, ToT Division; Dr. N Prasad, Pr. Sc. & Head, PPD Division; Dr. S Ghosal, Pr. Sc. & Head, LP Division; Dr. MZ Siddiqui, Pr. Sc.; Dr. MF

Ansari, Pr. Sc.; Dr. VD Lohot, Sr. Sc.; Dr. SC Sharma, Sr. Sc.; Dr. Thamilarasi K, Sr. Sc.; Dr. SKS Yadav, Sc.; Dr. A Mohanasudaram, Sc.; Dr. RK Yogi, Sc.; Dr. AR Chowdhury, Sc.; Dr. NK Thombare, Sc.; Er. P Sakare, Sc. participated in one day workshop on Competency Framework for Agricultural Research and Extension Scientists jointly organized by ICAR – NAARM, Hyderabad and ICAR – IINRG, Ranchi, March 06, 2019.

- Dr. S Ghosal, Pr. Sc. & Head, LP Division **a**ttended Research Advisory Committee meeting of Forest Department of Jharkhand State Govt., as resource person, convened by PCCF, Jharkhand, March 26, 2019.
- Dr. RK Yogi, Sc. attended State Level *Kharif* workshop at Jharkhand Tribal Development Society (JTDS), Government of Jharkhand, Morabadi, Ranchi, April 01, 2019.
- Dr. N Kumar, Pr. Sc. & Head, ToT Division; Dr. N Prasad, Pr. Sc. & Head, PPD Division; Dr. S Ghosal, Pr. Sc. & Head, LP Division; Dr. MZ Siddiqui, Pr. Sc.; Dr. NK Sinha, Pr. Sc.; Dr. MF Ansari, Pr. Sc.; Er. SK Pandey, Sc. attended State Level Advocacy Program/Awareness Program on MSP for MFP/*Van Dhan Karyakaram* in the State of Jharkhand organized by Tribal Cooperative Marketing Development Federation of India Ltd. (TRIFED) in association with Jhascolamf, Jhamcofed, Jharkhand Forest Development Corporation, JSLPS, Chief Minister Small & Cottage Enterprises and ICAR-IINRG, ICAR-IINRG, Ranchi, April 02, 2019.
- Dr. SC Sharma, Sr. Sc. and Dr. RK Yogi, Sc. attended Micro Observer training organized at Jawahar Vidya Mandir, Shyamli, Ranchi and Aryabhatt Auditorium, Morabadi, Ranchi under Lok Sabha Election – 2019, April 12, 20 and 26, 2019, respectively.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division participated, as advisor, in State Plantation Advisory Committee meeting for introduction of lac hosts under MGNREGA, Project Bhawan, Dhurwa, Ranchi, May 10, 2019.
- Dr. RK Yogi, Sc. attended 38th Foundation Day celebration of National Bank for Agricultural and Rural Development (NABARD), Ranchi, July 15, 2019.
- Dr. RK Yogi, Sc. attended meeting on Unit cost for lac cultivation, value addition and composite plan, NABARD, Ranchi, July 17, 2019.
- Dr. SC Sharma, Sr. Sc. attended meeting on Jharkhand State Co-operative Lac Marketing & Procurement Federation Ltd. (JHASCOLAMPF), Ranchi regarding finalization of e-tender, July 17, 2019.
- Dr. MZ Siddiqui, Pr. Sc.; Dr. MF Ansari, Pr. Sc.; Dr. SC Sharma, Sr. Sc.; Dr. RK Yogi, Sc.; Dr. AR Chowdhury, Sc.; Dr. NK Thombare, Sc.; Er. R Singh, Sc.; attended lecture on Stress Management, delivered by Mrs. Smita Bhramachari, CTRTI, Ranchi, August 02, 2019.
- Dr. J Ghosh, Pr. Sc. participated in Review meeting of QRT, Directorate of Extension Education, Birsa Agricultural University, Ranchi, August 06-07 and October 03, 2019.
- Dr. N Kumar, Pr. Sc. & Head, ToT Division; Dr. N Prasad, Pr. Sc. & Head, PPD Division; Dr. S Ghosal, Pr. Sc. & Head, LP Division; Dr. S Srivastava, Pr. Sc.; Dr. MZ Siddiqui, Pr. Sc.; Dr. SC Sharma, Sr. Sc.; Dr. Thamilarasi K, Sr. Sc.; Dr. VD Lohot, Sr. Sc.; Dr. SKS Yadav, Sc.; Er. SK Pandey, Sc.; Dr. A Mohanasudaram, Sc.; Dr. RK Yogi, Sc.; Dr. AR Chowdhury, Sc.; Dr. NK Thombare, Sc.; Er. P Sakare, Sc. attended Hindi *Sanghoshthi* on 'जलवायु परिवर्तन एवं जैवविविधता' organized by ICAR-IINRG, Ranchi in collaboration with ICAR-IIAB, Ranchi, October 16, 2019.
- Dr. Thamilarasi K, Sr. Sc. and Dr. A Mohanasundaram, Sc. attended National Conference on 'A trends in higher education, taxonomy, agriculture, biotechnology and toxicology', Dr. B. Vasantharaj David Foundation, Chennai, November 17, 2019.
- Dr. MF Ansari, Pr. Sc.; Dr. SKS Yadav, Sc.; Sri Rajgopal NN, Sc. and Ms Langlentombi LC, Sc. participated in ICAR Zonal Sports Tournament, ICAR-NRRI, Cuttack, November 18-22, 2019. Dr. MF Ansari, Pr. Sc. was nominated as CDM of the Institute team.
- Dr. N Prasad, Pr. Sc. & PC; Dr. MZ Siddiqui, Pr. Sc.; Dr. SC Sharma, Sr. Sc.; Dr. NK Thombare, Sc. and Er. P Sakare, Sc. attended 11th Annual Workshop of Network Project on 'HPVA of NRGs', *Vasantrao Naik Marathwada Krishi Vidyapeeth*, Parbhani (Maharashtra), November 19-20, 2019.
- Dr. RK Yogi, Sc. attended a number of trainings, meetings with respect to Sector Magistrate/ Presiding Officer during Jharkhand State Legislative Assembly Elections 2019 and performed the duties during November 27, 2019 - December 12, 2019.

Human Resource Development

- Sri Rajgopal NN, Sc. completed three months' Professional Attachment Training (PAT) in Taxonomic studies of lac insects, ICAR-NBAIR, Bengaluru (Karnataka), February 20, 2019.

- Ms Langlentombi LC, Sc. completed three months' Professional Attachment Training, Forest Research Institute, Dehradun (Uttarakhand), March 02, 2019.
- Dr. RK Yogi, Sc. attended National Facilitators Development Programme (NFDPs) (Second Programme), CCS NIAM, Jaipur (Rajasthan), March 04-13, 2019.
- Dr. Thamilarasi K, Sr. Sc. participated in the DBT sponsored training programme NGSDAT-2019 - Bioinformatics for Metagenome Data Analysis, ICAR-IISR, Calicut, March 19-22, 2019.
- Dr. NK Sinha, Pr. Sc. and Dr. J Ghosh, Pr. Sc. attended MDP on Leadership development programme (a Pre-RMP programme), ICAR-NAARM, Hyderabad (Telangana), June 11-22, 2019.
- Er. Ranjit Singh, Sc. attended specialized training programme on Hospitality Management, ICAR-NAARM, Hyderabad (Telangana), June 26-July 02, 2019.

Honours, Awards and Recognitions

By Director

- Dr. KK Sharma, Director, Chairman, Brushware, Polishes, Lac and Lac products Sectional Committee CHD 23 of Bureau of Indian Standards, New Delhi.
- Dr. KK Sharma, Director, Member, Regional Advisory Committee on Off Farm Sector in Jharkhand, NABARD, Ranchi.
- Dr. KK Sharma, Director, Member, Research Advisory Group of Institute of Forest Productivity, Ranchi (ICFRE, Dehradun).
- Dr. KK Sharma, Director, Member, Research Advisory Committee of Central Tasar Research and Training Institute, Ranchi.
- Dr. KK Sharma, Director & Project Coordinator, AINP on CLIGR was invited as Guest of Honour in 6th Coordination Committee Meeting of NP-CLIGR, MPUAT, Udaipur, February 07-08, 2019.
- Dr. KK Sharma, Director was conferred Distinguished Scientist Award in National Conference on Doubling Farmer's Income for Sustainable and Harmonious Agriculture (DISHA-2019), BAU, Ranchi, August 10-11, 2019.
- Dr. KK Sharma, Director, ICAR-IINRG was invited to as Guest of Honour in the *Kisan mela* – cum – Exhibition organized by CRURRS, Hazaribagh, October 19, 2019.
- Dr. KK Sharma, Director, ICAR-IINRG was invited to as Guest of Honour in the Annual review meeting of Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums, held at *Vasantrao Naik Marathwada* Agricultural University, Parbhani, November 18-19, 2019.
- Dr. KK Sharma, Director was invited as Chief Guest to deliver a Keynote Address on Significance and scope of secondary agriculture with special reference to processing and value addition of natural resins & gums. National Seminar on Secondary Agriculture: Significance and scope in the era of globalization, Navsari Agricultural University, Navsari (Gujarat), November 27-29, 2019.

By Others

- Dr. VD Lohot, Sr. Sc. was External Member for selection of SRF under National Agriculture Innovation Fund Project (NAIF)/IPR, ICAR-RCER-RC, Plandu, Ranchi, January 22, 2019.
- Dr. NK Sinha, Pr. Sc. received Reviewer Excellence Award by Indian Journal of Agricultural Research (ARCC Journal), January 23, 2019.
- Dr. MZ Siddiqui, Pr. Sc. reviewed a research manuscript titled, 'Diethyl phenyl carbamothioyl phosphonate (ThmP) as a potential anti-inflammatory agent: Synthesis and pharmacological evaluation studies' for publication in Current Molecular Medicine, a NAAS Indexed International Journal, April 19, 2019._
- Dr. NK Sinha, Pr. Sc. received Reviewer Excellence Award by Agricultural Reviews (ARCC Journal), June 06, 2019.
- Dr. RK Yogi, Sc. was expert for viva voce of 8 students of Integrated Master Program in Rural Development at Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Morabadi, Ranchi, June 15, 2019.
- Best Oral Presentation Awards were conferred upon to the scientists during National Conference on Doubling Farmers' Income for Sustainable & Harmonious Agriculture (DISHA-2019), BAU, Ranchi, August 10-11, 2019:
  - Dr. VD Lohot, Sr. Sc. for paper titled, 'Impact of phloem sap sucking insect *Kerria lacca* Kerr on host plant *kusum*'.

- Dr. A Mohanasundaram, Sc. for paper titled, 'Lac based indigenous technical knowledge in north east India' and also acted as rapporteur in one of the technical sessions.
- Dr. AR Chowdhury, Sc. for paper titled, 'Study of stability pattern of *piyar* gums collected from different agro-climatic Zones'.
- Dr. Nandkishore Thombare, Sc. for paper titled, 'Chemical profiling and chromatographic investigations of *Anogeissus latifolia* exudate gum'.
- Rajgopal NN, Sc. for paper titled, 'Induced defense response in *okra* [*Abelmoschus esculentus* (L.) Moench] against red spider mite, *Tetranychus macfarlanei* Baker and Pritchard (Acari: Tetranychidae)'.

❖ Dr. NK Sinha, Pr. Sc. received Outstanding Achievement Award and also delivered a lead lecture on 'Seasonal germination dynamics of *kusum* (*Schleichera oleosa*) seeds under different storage conditions' during National Conference on Doubling Farmers' Income for Sustainable & Harmonious Agriculture (DISHA-2019), BAU, Ranchi, August 10-11, 2019.

❖ Following awards/prizes were bagged by the scientists in different competitions organized during Hindi Chetana Maas, ICAR-IINRG, Ranchi, between September 01-30, on 30.9.2019:

- Best Popular Article, 'चीड़ के वृक्ष से प्राकृतिक राल (लीसा) दोहन की उन्नत तकनीक' published in लाक्षा – 2018 authored by Dr. SC Sharma, Dr. N Prasad and Er. SK Pandey
- Best Popular Article, 'कीटवर्णक' published in लाक्षा – 2018 authored by Dr. Thamilarasi K, Madhuranjana Gargi and Sajia Eqbal
- First prize in Speech to Dr. MZ Siddiqui, Pr. Sc.
- Second Prize in Speech to Dr. AR Chowdhury, Sc.
- First Prize in Short Note Writing to Dr. NK Thombare, Sc.

❖ Dr. MZ Siddiqui, Pr. Sc. reviewed a research manuscript titled, 'Investigation of the adulteration of essential oils by GC-MS' for publication in Current Analytical Chemistry, September 06, 2019.

❖ Following awards were conferred upon to the scientists during National Conference on Trends in Higher Education, Taxonomy, Agriculture, Biotechnology and Toxicology, Dr. B. Vasantharaj David Foundation, Chennai, November 17, 2019:

- Young Woman Scientist Award to Dr. Thamilarasi K, Sr. Sc.
- Young Scientist Award to Dr. A Mohanasundaram, Sc.

❖ Dr. NK Sinha, Pr. Sc. received Reviewer Excellence Award by Legume Research (ARCC Journal), November 21, 2019.

❖ Following awards were conferred upon to the scientists and also delivered lead lectures during 3rd National Conference on Promoting & Reinvigorating Agri-Horti, Technological Innovations (PRAGATI -2019), Dhanbad (Jharkhand), December 24-25, 2019:

- Dr. VD Lohot, Sr. Sc. delivered a lead lecture on 'Exploring the potential of rain tree (*Albizia saman*) for cultivation of lac insect (*Kerria* species)' and co-chaired a technical session.
- Dr. Thamilarasi K, Sr. Sc. received Woman Scientist Award, delivered a lead lecture on 'Barcoding of major lac host plants and also chaired a technical session.
- Dr. A Mohanasundaram, Sc. received Outstanding Achievement Award, delivered a lead lecture on 'Relative abundance, emergence profile and parasitization of lac associated fauna during *rangeeni* lac crops' and also co-chaired a technical session.
- Dr. RK Yogi, Sc. received Young Scientist Award
- Dr. RK Yogi, Sc. received Best Oral Presentation Award for paper titled, 'Enabling tribal communities for sustainable livelihoods through lac based agro forestry systems'.
- Er. R Singh, Sc. received Best Oral Presentation Award for paper titled, 'Effect of ozone fumigation on controlling drugstore beetle and quality of coriander during storage' and also co-chaired a technical session.

❖ Dr. MZ Siddiqui , Pr. Sc. continued as Member, Technical Editorial / Advisory Board of '*Krishak Vandana*'----a highly reputed monthly Hindi Magazine on Agriculture & Farming, published from Jabalpur (M.P.), since March, 2012.

❖ Dr. MZ Siddiqui, Pr. Sc. continued as Member, Editorial Board, World Journal of Pharmaceutical Sciences, since January, 2013.

- Dr. MZ Siddiqui, Pr. Sc. continued as Member, Editorial Board and Reviewer Research Journal of Chemistry and Environment, an International Monthly Online NAAS Indexed Journal, since June, 2014.
- Dr. MZ Siddiqui, Pr. Sc. continued as Vice-President of Society for Advancement of Natural Resins & Gums (SANRAG), Ranchi, since October 19, 2016.
- Dr. N Prasad, Pr. Sc. & Head PPD Division received ISAE Fellow 2019 Award for contribution in the field of Agricultural Engineering by Indian Society of Agricultural Engineers, New Delhi.
- Dr. N Prasad, Pr. Sc. & Head PPD Division was Assistant Editor, Journal of Agricultural Engineering published by Indian Society of Agricultural Engineers, New Delhi, 2019.
- Dr. Nandkishore Thombare, Sc. received Elsevier Reviewer Recognition Certificate from a number of Journals *i.e.* Carbohydrate Polymers, Journal of Advanced Research and Polymer, 2019.
- Dr. Nandkishore Thombare, Sc. received award for his Outstanding Contribution in Reviewing from International Journal of Biological Macromolecules published by Elsevier, 2019.
- Dr. RK Yogi, Sc. reviewed around 15 research manuscripts for their publication in Jharkhand Journal of Development and Management Studies, International Journal of Forestry and Wood Science, Journal of Agricultural Economics and Rural Development, International Journal of Agricultural Marketing and Journal of Agricultural Science and Technology during 2019.
- Dr. RK Yogi, Sc. continued as Member, Editorial Board, International Journal of Agricultural Marketing, International Journal of Forestry and Wood Science, Journal of Agricultural Economics and Rural Development, International Journal of Agricultural Sciences and Journal of Agricultural Science and Technology A, since 2016.

Capacity Building/Lectures/Talk Delivered

By Director

- Dr. KK Sharma, Director was invited to deliver a Lead Lecture on Extent and cause of pre-summer mortality in *rangeeini* strain of Indian Lac Insect, *Kerria lacca* (Kerr). National Symposium on Sustainable Management of Pests and Diseases in Augmenting Food and Nutritional Security, Navsari Agricultural University, Navsari (Gujarat), January 22-24, 2019.

By Others

- Dr. VD Lohot, Sr. Sc. imparted 06 weeks training to 06 B.Sc. (Biotechnology) students from Ranchi Women's College, Ranchi on Influence of lac insect feeding on phloem sap composition of *F. semialata* (Roxb.), January 01 to February 20, 2019.
- Dr. A Mohanasundaram, Sc. delivered invited lecture on Cultivation of lac and industries based on lac, forward and backward linkages in marketing of Shellac for UG, PG students and Faculty, Department of Zoology, Ayya Nadar Janaki Ammal College, Sivakasi, Tamil Nadu, February 16, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a lecture on Importance of soil fertility, attended by 300 farmers, under *Pradhanmantri kisan samman nidhi* programme, ICAR-IINRG, Ranchi, February 24, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a lecture on Income generation through scientific lac cultivation, KVK, Kalyan, Purulia (W.B.) for Diploma in Agricultural Extension Services (DAESI) programme, April 06, 2019.
- Dr. VD Lohot, Sr. Sc. imparted 03 months training to 03 M.Sc. (Biotech) students from Botany Department, Ranchi University, Ranchi, April 10 to July 10, 2019.
- Dr. SC Sharma, Sr. Sc. delivered lecture on Lac production, processing, utilization and value chain of lac and lac based products in 03 batches under three days residential training on Lac cultivation and utilization for Jharkhand Block Coordinators sponsored by *Mukhyamantri Laghu evam Kutir Udyam Vikas Board*, Jharkhand organized at KVK, Bishunpur, Gumla during April 18 & 26, 2019 and May 09, 2019.
- Following lectures were delivered during 14th Summer Student Workshop on Natural Resins and Gums to B.Sc. (Ag.) students from Banaras Hindu University, Varanasi (U.P.), ICAR-IINRG, Ranchi, May 27, 2019 to June 05, 2019:
  - Dr. A Mohanasundaram, Sc. delivered two lectures on Lac insect life cycle, crop cycle and lac related terminology and Lac associated insect fauna and pest management in lac, May 27 and 29, 2019.
  - Dr. RK Yogi, Sc. delivered a lecture on National scenario of production of natural resins and gums, May 28, 2019.
  - Dr. J Ghosh, Pr. Sc. delivered a lecture on *Rangeeni* and *kusmi* lac cultivation on *ber* tree, May 28, 2019.

- Dr. SC Sharma, Sr. Sc. delivered a lecture on Processing of lac on small scale – village level entrepreneurship, May 28, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a lecture on Raising and management of lac host trees, May 29, 2019.
- Er. R Singh, Sc. delivered a lecture on Drying techniques of natural resins and gums, May 30, 2019.
- Dr. SC Sharma, Sr. Sc. delivered a lecture on Tapping techniques and tools for resins and gums, May 31, 2019.
- Dr. SKS Yadav, Sc. delivered a lecture on properties and industrial applications of natural resins and gums, May 31, 2019.
- Ms Shruti Sinha, Sc. delivered a lecture on Role of Biotechnology in lac production, May 31, 2019.
- Er. Priyanka Sakare, Sc. delivered a lecture on Natural resins and gums as edible coating material for food, May 31, 2019.
- Dr. N Kumar, Pr. Sc. & Head, TOT Division delivered a lecture on Extension techniques for effective transfer of technology, June 03, 2019.
- Dr. S Srivastava, Pr. Sc. delivered a lecture on quality control of natural resins and gums—Industrial perspective, June 03, 2019.
- Dr. MZ Siddiqui, Pr. Sc. delivered a lecture on Medicinal importance of oleo-resins, June 03, 2019.
- Ms Langlentombi LC, Sc. delivered a lecture on Lac Integrated Farming System, June 03, 2019.
- Er. SK Pandey, Sc. delivered lecture on Lac based technologies for entrepreneurship, June 04, 2019.
- Dr. AR Chowdhury, Sc. delivered a lecture on characterization techniques of natural resins and gums, June 04, 2019.

❖ Dr. Nandkishore Thombare, Sc. delivered a lecture on Gum and resin producing potential of tasar host plants, Central Tasar Research and Training Institute, Ranchi, June 04, 2019.

❖ Training on different aspects of natural resins & gums, lac processing, IRF and industry visits was organized for a B. Tech. (Chemical Engineering) student, BIT Sindri, Dhanbad (Jharkhand) by the scientists of Processing & Product Development Division, ICAR-IINRG, Ranchi, June 04 -July 05, 2019.

❖ Dr. SC Sharma, Sr. Sc. and Er. SK Pandey, Sc. imparted training on Lac processing and lac-based products to Sri Kanav Behl, M/s SPS Agro Care, Ranchi, June 10 - 15, 2019.

❖ Dr. S Ghosal, Pr. Sc. & Head, LP Division imparted On farm training to 20 farmers and Dr. A Mohanasundaram, Sc. delivered three lectures on topics, 'Lac insect life cycle and lac crop cycle', 'Lac insect and lac host plant pests identification and their management', '*Rangeeni* lac cultivation' and also provided hands-on-training on Scientific lac cultivation operations during on-farm training for orientation of rural youth on Scientific lac cultivation for ICAR ARYA project in collaboration with *Krishi Vigyan Kendra*, Kalyan, Purulia (W.B.), June 24-25, 2019.

❖ Training on different aspects of natural resins & gums, lac processing, IRF and industry visits was organized for a B. Tech. student, NIFFT, Ranchi by the scientists of Processing & Product Development Division, ICAR-IINRG, Ranchi, June 24 -July 27, 2019.

❖ Dr. VD Lohot, Sr. Sc. imparted training on Scientific lac cultivation on *kusum* and *palas* to the farmers from Kota village, Khunti (Jharkhand), June 26, 2019.

❖ Dr. A Mohanasundaram, Sc. and Ms Langlentombi LC, Sc. delivered lectures on Lac associated fauna and pest management in Lac and Integrated cultivation of vegetables and fruits with lac hosts during on-farm training cum-field-day programme on Lac Integrated Agroforestry System for Livelihood Security, Kota village, Khunti (Jharkhand), June 27, 2019.

❖ Following lectures were delivered during 15th Summer Student Workshop on Natural Resins and Gums to B.Sc. (Ag./Forestry) students, ICAR-IINRG, Ranchi, June 28, 2019 to July 07, 2019:

- Dr. A Mohanasundaram, Sc. delivered lecture on Lac insect life cycle, crop cycle and lac related terminology, June 28, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a lecture on Raising and management of lac host trees, June 29, 2019.
- Dr. SC Sharma, Sr. Sc. delivered a lecture on Processing of lac on small scale – village level entrepreneurship, June 29, 2019.
- Dr. RK Yogi, Sc. delivered a lecture on National

scenario of production of natural resins and gums, June 29, 2019.

- Dr. J Ghosh, Pr. Sc. delivered a lecture on *Rangeeni* and *kusmi* lac cultivation on *ber* tree, July 01, 2019.
- Dr. VD Lohot, Sr. Sc. delivered a lecture on Collection and conservation of lac insect and host biodiversity, July 01, 2019.
- Dr. MF Ansari, Pr. Sc. delivered a lecture on Diversified uses of lac, July 02, 2019.
- Dr. SC Sharma, Sr. Sc. delivered a lecture on Tapping techniques and tools for resins and gums, July 03, 2019.
- Dr. SKS Yadav, Sc. delivered a lecture on properties and industrial applications of natural resins and gums, July 03, 2019.
- Dr. AR Chowdhury, Sc. delivered a lecture on characterization techniques of natural resins and gums, July 03, 2019.
- Ms Shruti Sinha, Sc. delivered a lecture on Role of Biotechnology in lac production, July 05, 2019.
- Er. Priyanka Sakare, Sc. delivered a lecture on Natural resins and gums as edible coating material for food, July 05, 2019.
- Ms Langlentombi LC, Sc. delivered a lecture on Lac Integrated Farming, July 05, 2019.
- Dr. N Kumar, Pr. Sc. & Head, TOT Division delivered a lecture on Extension techniques for effective transfer of technology, July 06, 2019.
- Dr. S Srivastava, Pr. Sc. delivered a lecture on quality control of natural resins and gums—Industrial perspective, July 06, 2019.
- Dr. MZ Siddiqui, Pr. Sc. delivered a lecture on Medicinal importance of oleo-resins, July 06, 2019.
- Er. SK Pandey, Sc. delivered lecture on Lac based technologies for entrepreneurship, July 06, 2019.

❖ Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a guest lecture on *Gramin vikas me lakh utpadan prodyogiki,* NABARD, Ranchi, July 03, 2019.

❖ Dr. S Ghosal, Pr. Sc. & Head, LP Division and Dr. A Mohanasundaram, Sc. delivered lecture on Recent technologies on production of natural resins and gums: an overview and Demonstration of pruning, bundling, inoculation and Scrapping of lac, respectively, during workshop on Enabling Village Level Organizations through Technological Interventions in Production and Value Addition of Natural Resins and Gums, ICAR-IINRG, Ranchi, July 30, 2019.

❖ Dr. SC Sharma, Sr. Sc. imparted training on Lac processing (preparation of seedlac from sticklac) on Small Scale Lac Processing Unit to beneficiaries/ participants numbering ten sponsored by UDYOGINI, Nagra Toli, Ranchi, August 05 – 09, 2019.

❖ Following lectures were delivered during one week training on Collection and conservation of lac insects and host plants was organized for RAs, SRFs and LCAs of lead as well as co-operating centres of NP-CLIGR, ICAR-IINRG, Ranchi, August 19-24, 2019:

- Dr. A Mohanasundaram, Sc. delivered three lectures-cum-hands on training on Lac insect life cycle and productivity linked parameters of lac insect, Collection and conservation of lac insect and lac host plant biodiversity and Lac insect and lac host plant pests and their management, August 19 & 22, 2019.
- Sri Rajgopal NN, Sc. delivered lecture on Taxonomic aspects of lac insects, August 20, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a lecture on Nutritional management and agronomic practices for lac cultivation, August 21, 2019.
- Dr. Thamilarasi K, Sr. Sc. delivered a lecture on Role of biotechnological tools to study lac insect diversity, August 22, 2019.
- Ms Langlentombi LC, Sc. delivered a lecture on Lac integrated cropping system, August 22, 2019.

❖ Dr. SC Sharma, Sr. Sc. and Er. SK Pandey, Sc. imparted training on Lac processing, Dewaxed bleached lac, Dewaxed decolourized lac and Lac dye to M/s Aditya Traders, Rajahmundry (Andhra Pradesh), August 26 to September 12, 2019.

❖ Dr. SC Sharma, Sr. Sc. delivered a lecture on 'Farm implements suitable for small land holders' under training programme on 'Popularization of Women Friendly Farm Tools and Implements in Hill and Plateau Region', ICAR-RCER Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi, August 30 – 31, 2019.

- Dr. MF Ansari, Pr. Sc. transferred the process Know-how of Shellac gasket compound from hydrolyzed lac to M/s Aditya Traders, Rajahmundry (Andhra Pradesh), September 05-07, 2019.
- Dr. MZ Siddiqui, Pr. Sc. imparted training on Lac Wood Shine and Lac Glaze (Lac based varnishes) to M/s Aditya Traders, Rajahmundry (Andhra Pradesh), September 09 & 11, 2019.
- Dr. A Mohanasundaram, Sc. delivered lecture-cum-hands on training on Scientific *kusmi* and *rangeeni* lac cultivation during one day training programme on Scientific lac cultivation and processing, ICAR-IINRG, Ranchi, September 16, 2019.
- Dr. VD Lohot, Sr. Sc. imparted training on Scientific lac cultivation to farmers of Scheduled Caste community under Scheduled Caste Sub-plan, GOI, KVK, Peterwar, Bokaro (Jharkhand), September 30, 2019.
- Dr. VD Lohot, Sr. Sc. imparted training on Scientific lac cultivation to farmers of Scheduled Caste community under Scheduled Caste Sub-plan, GOI, KVK, Giridih (Jharkhand), October 01, 2019.
- Dr. SC Sharma, Sr. Sc. delivered a lecture on Improved equipments for lac processing and demonstrated Small Scale Lac Processing Unit to farmers/ beneficiaries in 02 batches under farmers training programme on Improved Method of Lac Production and Uses sponsored by SC sub plan, ICAR-IINRG, Ranchi, October 18, 2019 & December 21, 2019.
- Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered a lecture on *Pramukh evam sukshma poshak tatwa ka asantulit prayog* for *Urvarak anuproyog gagrukta karyakram*, KVK, Khunti (Jharkhand), October 22, 2019.
- Following lectures were delivered during training programme on Lac Integrated Agro Forestry System for Livelihood Security funded by World Agro Forestry Centre (ICRAF), New Delhi and organized at ICAR-IINRG, Ranchi, October 30-31, 2019:
  - Dr. S Ghosal, Pr. Sc. & Head, LP Division delivered lecture on Nutrients management for lac host plantation, October 30, 2019.
  - Dr. A Mohanasundaram, Sc. delivered lectures-cum-demonstration on Life cycle of lac insect and Lac insect and lac host plant pest and their management, October 30-31, 2019.
  - Ms Langlentombi LC, Sc. delivered lecture-cum demonstration on Lac Integrated Agroforestry System, October 30, 2019.
- Er. SK Pandey, Sc. imparted training on Lac dye (Tech. grade) to M/s Indo LACCA Shellac Industries Private Limited, New Delhi, November 06 to 15, 2019.
- Dr. VD Lohot, Sr. Sc. imparted training on Scientific lac cultivation to farmers of Scheduled Caste community under Scheduled Caste Sub-plan, GOI, KVK, Garhwa (Jharkhand), November 22, 2019.
- Dr. VD Lohot, Sr. Sc. imparted training on Scientific lac cultivation to farmers of Scheduled Caste community under Scheduled Caste Sub-plan, GOI, KVK, Palamu (Jharkhand), November 23, 2019.
- Er. SK Pandey, Sc. imparted training on Testing and analysis of lac to M/s Indo LACCA Shellac Industries Private Limited, New Delhi, November 25 to December 04, 2019.
- Following lectures were delivered during training program on लाख उत्पादन एवं उपयोग की उन्नत विधियाँ, ICAR-IINRG, Ranchi, December 17-21, 2019:
  - Sri Rajgopal NN, Sc. delivered lecture and demo on Lac insect life cycle and crop cycle, December 17, 2019.
  - Dr. A Mohanasundaram, Sc. delivered lecture on Lac associated insect fauna and pest management in lac, December 18, 2019.
  - Dr. VD Lohot, Sr. Sc. delivered lecture on सेमियालता पर लाख की खेती, December 20, 2019.
  - Ms Langlentombi LC, Sc. delivered lecture on Lac integrated cropping system. December 20, 2019.
- Dr. Thamilarasi K, Sr. Sc. guided one M.Sc. (Biotechnology) student, Vinoba Bhave University, Hazaribag for six months dissertation on the topic, 'Cloning of tyrosine monooxygenase, a putative key gene in pigment biosynthesis of the Indian lac insect, *Kerria lacca* (Kerr)', 2019.
- Dr. SC Sharma, Sr. Sc. imparted training on lac processing (preparation of seedlac from sticklac) to beneficiaries/participants sponsored by Chief Conservator of Forest-cum-Chief Coordinator, World Food Programme, Ranchi (Jharkhand) under Improved Scheme of Minor Forest Produce organized by TOT Division, in several batches throughout the year.

Events-2019

Institutional Attachment Training for IAS Officer Trainees of 2018 batch

An institutional attachment training programme was conducted for IAS Officer Trainees of 2018 batch on January 17, 2019 under Winter Study Tour at ICAR-Indian Institute of Natural Resins and Gums (IINRG), Ranchi. The purpose of this attachment training was to expose the newly recruited officers to the functioning of good public sector/private sector/institutions and their role in national economy/society. Dr. KK Sharma, Director welcomed and briefed about the world's largest research system of ICAR and its network of more than 108 research Institutes and centers across the country. These research Institutes deal with various research aspects on different agricultural crops/commodities. He informed that India is largest producer in lac, gum *karaya* and *guar* gum. He interacted with the IAS Officer Trainees for their feedback about the NRG sector and emphasized that production, processing, value addition and product development of NRG sector need to be addressed for sustainable development. He briefed that natural resins and gums are directly concerned with the tribal community spread over 70 out of 155 disadvantage districts of the country. Non-timber forest produce especially natural resins and gums are low volume high value crops and most produce are exported in raw form and imported back to the country after processing and value addition. He stressed upon the need of processing and development of lac, other resin and gum based high value products in the country for their remunerative price as well as increasing domestic consumption. On this occasion, Dr. S Ghosal, Pr. Sc. & Head, Lac Production Division briefed about the various research activities related to scientific cultivation of lac. Dr. S Srivastava, Pr. Sc. briefed about the activities in the field of value addition and product development. Dr. Nirmal Kumar, Pr. Sc. & Head, ToT Division briefed about the various extension activities. During the visit, IAS Officer Trainees got live demonstration of lac cultivation at Institute Research Farm & exposure at Institute Museum on NRGs. A total of 18 IAS Officer Trainees from various States attended the programme. The experts, scientists and staff of the Institute were also present during the function.

Trainees with experts and Director

State Level Agro-Tech Fair

Birsa Agricultural University (BAU), Ranchi and ICAR-IINRG, Ranchi collectively organized three days State Level Agro-Tech Fair in association with ICAR-Indian Institute of Agricultural Biotechnology (IIAB), Ranchi; Regional Stations of ICAR-Research Complex for Eastern Region, Research Centre, Ranchi; National Bureau of Plant Genetic Resources, Regional Centre, Ranchi and Central Rain-fed Upland Rice Research Station, Hazaribagh during February 02-04, 2019 at BAU, Ranchi.

The *mela* was inaugurated by Sri Randhir Kumar Singh, Hon'ble Agriculture Minister, Govt. of Jharkhand. Dr. Jitu Charan Ram, MLA was the Guest of Honour. Hon'ble Agriculture Minister said that Jharkhand has registered 19 per cent growth in agriculture sector during last four years which is the highest in the country. He also appreciated the research and training activities of National Agricultural Research System (NARS). He said that due to combined dedicated efforts of farm scientists, farmers and policy & infrastructure support of the State Govt., Jharkhand has been selected for *Krishi Karman Award* of 2018 by the Union Ministry of Agriculture & Farmers' Welfare for record increase in production of rice in the State. Welcoming the guests, BAU Vice-Chancellor, Dr. Parvinder Kaushal informed that all the 24 *Krishi Vigyan Kendras* (KVKs) of the State have been asked to adopt at least one village of their area for development as model village by implementing the recommendations enumerated in the strategic document prepared by the Jharkhand State Coordination Committee for Doubling Farmers' Income by 2022. He said diversification towards high value crop was a must for increasing farmers' income at a faster pace.

An impressive exhibition was organized wherein technology products and services were displayed in 11 thematic stalls - Integrated farming system, Crop production & diversification, Post harvest technology & value addition, Natural resource management, Organic farming, ICT, marketing & agribusiness management, Secondary agriculture (agro-based small industries), KVKs of Jharkhand, Livestock management and farm machinery & energy management. Apart from these, 100 commercial stalls were also put up where in Govt. departments, banks, dealers of seeds, planting material, fertilizers, farm implements, NGOs and other organizations displayed their products and services. On the second day of mega event, Guest of Honour Sri Ram Tahal Choudhary, MP, Ranchi urged the farmers to minimize the use of chemical fertilizers and pesticides and promote organic farming. More than 25,000 farmers including lac growers, women farmers, entrepreneurs, rural youth and officials from the line departments participated in the *mela*.

On concluding day, Her Excellency Governor of Jharkhand Smt. Droupadi Murmu was the Chief Guest. She emphasized upon dissemination of the technological interventions through extension functionaries for the quick benefit at grassroots level. She also told that scientists should adopt villages to demonstrate the technology in the farmers' fields. Welcoming the Chief Guest Dr. KK Sharma, Director, ICAR-IINRG threw light on the role of ICAR research Institutes for increasing productivity and dwelt on the potentials of Eastern States especially Jharkhand in bringing second green revolution to the region. He emphasized upon the integrated farming system particularly agro-forestry and lac cultivation in the rain-fed agro-ecosystem of the State. A *Mahila Kisan*

Felicitation of the progressive farmers by VC, BAU, Dr. P Kaushal

Ghosti was also organized wherein experts of the various organizations *i.e*. ICAR-IINRG, BAU, RCER RC, ICAR-IIAB and CRURRS, Hazaribagh interacted with them and provided on the spot solutions to problems faced by farmers. Progressive farmers and winners of the exhibition, the real torch bearer of the technology, were also felicitated.

HE Governor of Jharkhand, Smt. Droupadi Murmu addressing the farmers

Sixth Co-ordination Committee Meeting of Network Project on Conservation of Lac Insect Genetic Resources (NP-CLIGR)

The sixth co-ordination committee meeting of Network Project on Conservation of Lac Insects Genetic Resources (NP-CLIGR) was held at MPUAT, Udaipur on February 07-08, 2019. While welcoming the participants during the inaugural session, Dr. Hemant Swami, PI, MPUAT centre highlighted the role of activities and publications of Udaipur centre and importance of Lead centre and the key role played by PC, NP-CLIGR in execution of the project. Dr. KK Sharma, PC, NP-CLIGR and Director, ICAR-IINRG, Ranchi addressed the gathering emphasizing depletion of lac insect bio-diversity, *ex-situ* and *in-situ* conservation of lac insect, the importance of lac in various fields especially in providing livelihood support to tribals and rainfed farming community. He informed that the Rajasthan is one of the most bigger consumption of lac in the country. Lac integrated cropping system may increase the yield of farmers by 20-30 per cent per unit of land. In this occasion, two publications *viz*., *Ber* par Lakh Kheti, Status of lac insect and host in arid western plain by MPUAT, Udaipur, bulletin Economic analysis of lac insect on *semialata* (Assamese) by AAU, Jorhat and Lac training manual (पलाश के वृक्षों में लाख की कृषि प्रक्रिया) by SFRI, Jabalpur. Dr. SK Sharma, Zonal Director of Research, welcomed all and informed that lac bangles are very famous in Rajasthan and there is lots of scope for lac cultivation. Dr. Arnob Joshi, Dean, RCA, Udaipur, welcomed all and narrated importance of lac in Rajasthan. Dr. Abhay Kumar Mehta, Director of Research, MPUAT explained that, Lac has religious value in Rajasthan culture. In Rajasthan separate community *Lakkra* is there for bangle making, lac is good for farmers'

economy and need to educate proper cultivation of lac to farmers as well as extension agencies. Lac cultivation can be motivated on non-economical lac host plants like *palas*, *Ficus sp*. Dr. KK Singh, Assistant Director General (FE), ICAR, New Delhi, briefed about AICRP and AINWP projects in ICAR and he mentioned fresh EFC of this project to be prepared with new target, status, output and outcome. The inaugural function ended with vote of thanks by Dr. MK Mahla, HoD, Entomology, MPUAT, Udaipur.

The technical session began with the presentations of Principal Investigators of eight Co-operating centres on February 07, 2019. Field visits and business session were held on February 08, 2019. Major recommendations of the meeting are as:

- Status of lac insect and lac host plant should be prepared and submitted by all co-operating centres
- Proper utilization of budget and ranking may be given depends upon performance of the centres
- Sale counter of lac related products may be established in all the centres for its promotion
- Standardization of methodology of survey of lac insect and lac host plant and try latest technology for survey work
- Report may be prepared about impact of this project for last 4 to 5 years
- Documentation should be made on current status *i.e.* what state could not address? What are the trends of results? How to move forward?

Sixth Co-ordination Committee Meeting of NP-CLIGR, MPUAT, Udaipur, February 07-08, 2019

Agricultural Technology-cum-Machinery *Mela*

ICAR-IINRG, Ranchi organized Agricultural Technology-cum-Machinery *Mela* 2019 in association with *Ramakrishna Sewa Asharam* on February 15, 2019 at Beniyajara Rahe (Ranchi). The *mela* was inaugurated by the Chief Guest Smt. Subhadra Devi, *Mukhiya* Sonahatu *Panchayat*. Dr. Nirmal Kumar, Pr. Sc. & Head ToT Division, ICAR-IINRG, Ranchi was the Guest of Honour. Smt. Subhadra said that though the large number of lac host trees are available in this area, but the local farmers practice lac cultivation by traditional methods. Sometimes, they are not able to harvest good crop due to high mortality. She emphasized upon adoption of scientific lac cultivation technologies and exhorted the farmer to get trained at ICAR-IINRG, Ranchi.

Dr. Nirmal Kumar emphasized upon dissemination of the technological intervention through extension functionaries for the benefit of the local farmers. He assured that interested farmers will be encouraged through capacity building programmes by demonstrating the technology in the farmers' fields. Scientists from KVKs and Central Tasar Research and Training Institute (CTRTI), Ranchi also participated in the *mela*. Dr. SP Singh, Senior Scientist-cum-Head, KVK, Khunti said diversification towards high-value crop is a must for increasing farmers' income at a faster pace. He also urged the farmers to minimize the use of chemical fertilizers and pesticides and promote organic farming.

Dr. AK Singh, Senior Scientist-cum-Head, KVK Ranchi outlined the recent farmer welfare schemes of central and State Govt. While welcoming the guests, Sri Sunil Maharaj,

Inauguration by the Chief Guest and visit of stall pavilion by dignitaries

Ramakrishna Sewa Asharam, Rahe, Ranchi informed that all the local villages of Sonahatu *Panchayat* participates in this event every year in connection of the local *Tusu mela*. Innovative and progressive farmers put their stall to exhibit the farm produces. An exhibition was organized wherein machinery, technology products and services were displayed. More than 500 farmers including lac growers, women farmers, entrepreneurs, rural youth and officials from the line departments visited the exhibition. A *kisan gosthi* was also organized wherein experts of the various organizations *i.e*. ICAR-IINRG, CTRTI and KVKs interacted with stakeholders. Winners of the exhibition were felicitated by the dignitaries.

Workshop on Competency Framework for Agricultural Research and Extension Scientists

ICAR-IINRG, Ranchi and ICAR-NAARM, Hyderabad jointly organized a one day regional workshop on Competency Framework for Agricultural Research and Extension Scientists at ICAR-IINRG, Ranchi involving 40 scientists from four ICAR Institutes including regional stations located at Ranchi namely ICAR-IINRG, ICAR-IIAB, ICAR-RCER, ICAR-NBPGR, on March 06, 2019. The purpose of workshop was to identify attributes of different competencies required at Scientist, Senior Scientist and Principal Scientist levels through discussions and deliberations.

The workshop was inaugurated by Dr. KK Sharma, Director, ICAR-IINRG, Ranchi. During his address Dr. Sharma envisaged that the ICAR shall strive to evolve as a think tank for NARS in the field of agriculture, in addition to its role in building the capacity and enhancement of competency of individual research and extension scientists and institutions under the NARS. Dr. Nirmal Kumar Pr. Sc. & Head, ToT Division, ICAR-IINRG, Ranchi emphasized the need for such workshop for effective implementation and transfer of technologies to the farmers/stakeholders. Dr. KH Rao and Dr. Alok Kumar, Faculties from ICAR-NAARM, Hyderabad presented an Overview of Competency Framework. Workshop was conducted by forming different groups of research and extension scientists at the levels of Scientist, Senior Scientist and Principal scientist. The competency analysis and mapping of participating scientific cadre was conducted and competency framework was developed. The major competencies were discipline orientation, research attributes (cognitive), research methodologies, project management & governance skills, research communication skills and research application and extension attributes under the category of functional competencies. The behavioural competencies included managing relationships, leadership and networking.

Participants attending workshop

14th Summer Students Workshop on Natural Resins and Gums

14th Summer Students Workshop on Natural Resins and Gums was organized by ICAR-IINRG, Ranchi during May 27-June 05, 2019. The Workshop was attended by 19 undergraduate B.Sc. (Ag.) students from Banaras Hindu University, Varanasi and ten newly joined Technical Assistants of the Institute. The theme of the workshop was 'Educational training on lac production; tapping, processing and applications of natural resins and gums'. Participants were educated about processing of natural resins like lac, rosin, oleo-resins and their industrial applications and also on exudates as well as seed gums. Harvesting/tapping, collection, processing, quality control and their value addition and industrial uses were also covered. An industrial visit to expose the trainees about various processes in refinement of lac, its value addition and extraction of lac dye was conducted to a lac processing industry in district Khunti, Ranchi. Exposure-cum-educational visits to ICAR-Research Complex for Eastern Region, Ranchi Centre and *Divyayan Krishi Vigyan Kendra*, Ranchi were also organized to acquaint them with agriculture, horticulture, biodiversity conservation and ecological security.

Yoga Fortnight and International Yoga Day Celebration

Yoga fortnight was organized at ICAR- IINRG, Ranchi in joint collaboration with ICAR-IIAB, Ranchi which culminated on International Yoga Day. A fifteen day programme started on June 03, 2019 with gracious presence of Dr. KK Sharma, Director, ICAR-IINRG and other dignitaries. During the programme Sri Pramod Kumar Pandey and Smt. Renu Kumari Pandey guided the staff and explained about different Asana, Pranayama and Mudras, and their benefits to maintain prosperous health and happiness in our daily life.

During the concluding ceremony of 15 day yoga session Dr. KK Sharma highlighted the importance of the yoga

in our life to enlighten our inner energy to increase self-esteem quoting lines from Bhagavad Gita Saying, '*Yoga is the Journey of the self, through the self, to the self*'. Dr. TR Sharma, Director, ICAR-IIAB drew attention towards benefits of yoga for both mental and physical health, relaxation and to reduce stress and uplift the energy in our daily life. Both the yoga gurus Sri and Smt. Pandey were felicitated during the programme. The session was coordinated by the nodal officers Dr. Nandkishore Thombare, Sc.; Dr. Rajagopal NN, Sc., ICAR-IINRG and Dr. SK Gupta, Sc., ICAR-IIAB, Ranchi. Ranchi was fortunate to welcome Hon'ble Prime Minister, Sri Narendra Modi on the occasion of 5th International Yoga Day on June 21, 2019. The mega event led by Prime Minister was organized at the Prabhat Tara ground at Ranchi where over 30,000 yoga enthusiasts took part amid tight security and practiced yoga for about 45 minutes. Several top Govt. functionaries including Governor of Jharkhand, Smt. Droupadi Murmu; Chief Minister of Jharkhand, Sri Raghubar Das and others also attended the yoga event. During the programme, Prime Minister Narendra Modi said, he wants to take yoga from cities to villages of the country, make it accessible to all. He also declared this year's International Yoga Day theme as 'Yoga for Heart Care'. On this occasion, ICAR-IINRG, Ranchi headed the team and with sister organizations *i.e.* ICAR-IIAB and ICAR-RCER RC, Ranchi 104 participants participated in the mega event.

Participants performing yoga

Field Day-cum-Training Programme

ICAR-IINRG conducted Field Day-cum-Training programme on June 27, 2019 with the help of International Agro-forestry Research Centre at Kota village of Arki block of the Khunti district. This programme was organized under the project Enabling tribal communities to improve their livelihoods through agro-forestry systems on a sustainable basis. On this occasion, Dr. KK Sharma, Director inspected the activities under this project and monitored the peoples' participation. He informed about the various protection measures for natural resin production systems. Dr. Sharma distributed required equipments among farmers related to the integrated lac farming system. *Semialata* plantation provides women friendly option for lac cultivation and directly empowers the women from the identified areas. Sri Mahaveer Singh Munda, *Mukhiya* of the village *panchayat* also showed interest to adopt the technological interventions as well as ensured for the peoples participation in this eco-friendly activity for their livelihood support. He also informed that lac cultivation activities have been reduced since 8-10 years due to high mortality and unavailability of quality broodlac. Dr. J Ghosh, Pr. Sc. & Coordinator of the event presented the progress and also informed about the activities of KVK, Khunti for the interested farmers in the village. Experts also shared the information on scientific lac cultivation for high productivity, integrated lac farming systems for sustainability, integrated pest management to protect the crop, Govt. initiatives and price support mechanism for the forest dwellers. Around 150 farmers participated in the field day programme. Dr. A Mohanasundaram, Sc. proposed vote of thanks.

15th Summer Students Workshop on Natural Resins and Gums

ICAR-IINRG, Ranchi organized 15th Summer Students Workshop on Natural Resins and Gums during June 28 to July 07, 2019. The workshop was inaugurated by the Director, Dr. KK Sharma on June 28, 2019. This ten-day workshop was attended by 41 undergraduate students of Agriculture B.Sc. (Ag.) and B.Sc. (Forestry) from five different universities, namely, Quantum University, Roorkee (Uttarakhand); Himgiri Zee University, Dehradun (Uttarakhand); Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad (Uttar Pradesh); Doon Business School, Dehradun (Uttarakhand) and Jharkhand Rai University, Ranchi (Jharkhand). The theme of the workshop was Educational training on lac production, tapping, processing and applications of natural resins and gums. Students were trained about processing of natural resins like lac, rosin, oleo-resins and their industrial applications. Students were imparted training on exudate as well as seed gums and value addition, industrial uses and marketing of natural resins and gum. An industrial visit to expose the trainees about various processes in refinement of lac, its value addition and extraction of lac dye was also conducted at lac processing industry in Khunti district. The concluding function was held on July 07, 2019. Dr. KK Sharma, Director interacted with the participants to get their feedback. He informed that natural resins and gums are very important to the livelihood of about 10 million people of the country especially for income generation of poor and landless farmers. He informed students that future is very bright

Dr. KK Sharma, Director addressing the trainees

in agriculture education and urged students to work for betterment of the farmers and development of the nation through the agriculture education. Dr. KK Sharma, Director distributed certificates to the students and wished them success in all their endeavours. The experts, scientists and staff of the Institute also attended the valedictory function. Workshop was coordinated by Dr. SKS Yadav, Sc.

Workshop on Enabling Village Level Organizations through Technological Interventions in Production and Value Addition of Natural Resins and Gums

ICAR-IINRG, Ranchi organized a three days workshop on Enabling Village Level Organizations through Technological Interventions in Production and Value Addition of Natural Resins and Gums during July 30-August 01, 2019 sponsored by Chaudhary Charan Singh National Institute of Agricultural Marketing (CCS NIAM), Jaipur, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India. The Chief Guest of the inaugural session, Dr. HS Gupta, PCCF (Research & Training), Department of Forest, Environment & Climate Change, Govt. of Jharkhand in his inspiring address emphasized those overall aspects of NRG sector including production, processing, value addition and product development need to be addressed simultaneously for sustainable development. Integrated approach of farming is the key for ecological balance and lac cultivation is the best option for alternative agriculture like apiculture and sericulture. He briefed about the importance of lac cultivation in the context of Jharkhand state where forest dwellers depends on natural resources for their livelihood. In these remote areas, this activity creates employment opportunities and also helpful in minimizing the migration problem. He also put the issue of climate change in the picture and suggested for natural farming. He complimented the efforts of ICAR-IINRG for organizing such events, especially capacity building programmes to address the issues of tribal communities which is need of the hour. Dr. KK Sharma, Director in his address briefed about the achievements of the Institute and further scope of NRG sector for livelihood security and earning foreign exchange. Dr. Sharma informed that lac cultivation activity has synergistic effect on environment and helpful for conservation of natural resources. This activity also supports the livelihood of the stakeholders of handicraft industry in various cities like Jaipur, Hyderabad, Muzaffarpur, Delhi, *etc*. Edible gums have good potential in the Indian context as there is regular import of plant exudates from African countries. Areas in arid zones like Rajasthan, Gujarat & Haryana has tremendous scope for gum collection through scientific tapping.

The Chief Guest of the valedictory session, Sri AK Padhi, Chief General Manager (CGM), National Bank for Agriculture and Rural Development (NABARD), Jharkhand in his address emphasized on diversified agriculture including agriculture, animal husbandry and allied activities for doubling the farm income. The concept of Primary Agricultural Cooperative Society (PACS) were successful in developed areas like Punjab, Haryana, western Uttar Pradesh and southern States, but it is not so successful in eastern part of the country. Therefore, to overcome critical gaps, recently introduced FPOs Model may play an important role. Presently, about 4000 FPOs have been registered and more new 6000 are targeted in near future. Jharkhand is the largest producer of lac (>50%), but process less than 30 % of lac. He suggested strengthening the FPOs on lac processing and value addition for more benefits to the tribal community. Dr. KK Sharma, Director, ICAR-IINRG in his address during valedictory session said that NABARD has vital role in development of Village Level Organizations. Linking of Farmers Producers Organizations (FPOs) with e-NAM can prevent farming community from middlemen and provide better price for their farm produce. He appreciated the interactive and filed visit activities during the workshop. This kind of workshop is a good platform for discussing the issues related to the new policy environment involving producers, scientific as well as market experts to promote the technological interventions.

Dr. SR Singh, Deputy Director, CCSNIAM, Jaipur briefed about the need for market promotion of NRG based products through variation in application and design of the products. Regular supply of raw material is the key factor for related industry. Keeping in view of global competition, he also informed that recently designed minimum support price mechanism for minor forest products including lac and *karaya* gum may play important role in safeguarding the households in tribal areas against the price fluctuation.

He appreciated the efforts of the Institute in the field of NRG sector. Dr. Nirmal Kumar, Pr. Sc. & Head, ToT Division appreciated the efforts of the Village Level Organizations (VLOs) including Farmers Producer Organizations (FPOs), Farmer Producer Company (FPC), Self Help Groups (SHGs), Primary Cooperative Societies (PCSs) and NGOs. FPOs play a big role in reducing the production cost as well as enhance the bargaining power of producer.

On this occasion an extension bulletin and a training manual titled, 'Technological interventions for production and value addition of natural resins & gums' and 'Enabling Village Level Organizations through Technological Interventions in Production and Value Addition of Natural Resins & Gums' were released by the dignitaries. The workshop was attended by Chief Executives Officer / Chairpersons/Secretary from the FPOs/VLOs, officials from various organizations including State Agricultural University, Federations and NGOs from Jharkhand, Chhattisgarh and Odisha. Certificates were distributed to the 27 participants for attending the workshop successfully.

Certificates distribution by the dignitaries

Common Interest Group (CIG) Meeting

Keeping in the view about the policy initiatives taken by the Govt. for doubling farm income through strengthening the Village Level Organizations (VLOs), a Common Interest Group (CIG) meeting was conducted specially for the lac based VLOs on July 31, 2019. 2154 Farmers Producer Organizations (FPOs) have been registered in the country with the membership of 8,18,110 farm households over the 476 districts of 29 States. Similarly, a total of 65 FPOs have been registered with the membership of 28179 households over the 1011 villages of 21 districts in Jharkhand State. Dr. RK Yogi, Convener & Sc. briefed the scope of lac cultivation activity for employment and income generation for the forest dwellers. In this context, organized groups may play key role in setting up of the collection centers/bulking centers, strengthen the connectivity with market, facilitate sorting, grading & packaging for organized processing and marketing. Subsequently, it will shrink the marketing chain and consequently it would enhance the producer's share in consumer's rupee.

A total of 29 representatives from 15 VLOs including FPOs, Farmer Producer Company (FPC), Self Help Group (SHGs), Primary Cooperative Societies (PCSs), NGOs, *etc*. have been interacted with the resource persons from NABARD and ICAR-IINRG, Ranchi during this session. All the participants visited the *Siladon Prathmik Lah Utpadak Sahyog Samiti*, Khunti and ICAR-RCER, Research Centre, Ranchi to acquaint the village level entrepreneurship development as well as technological interventions for farm sector. About 23000 lac growing households over the 500 villages of 30 districts of six states are being mobilized by these VLOs. Few organizations have been enabled the group with the formation of FPOs/FPC and rest are in the process of registration with NABARD, State departments and ICAR organizations.

Farmers with subject experts

Farm Entrepreneur-cum- Scientist interface

Farm entrepreneur-cum-scientist interface was conducted on August 01, 2019 at ICAR–IINRG, Ranchi. Success of capacity building programmes for skill development depends on the interest of trainee. Success stories of innovative/progressive farmers may be important tool to motivate the rural youths. During this special session success stories in lac cultivation and value addition was explained by the innovators/ progressive farmers in the presence of expert. Dr. J Ghosh, Pr. Sc., ICAR-IINRG

briefed the importance of technological interventions to commercialize and productivity enhancement of lac sector. Even though all the existing constraints few farmers are enable to use the available natural resources efficiently and making the recognition at national level platforms for felicitation of Progressive/Innovative farmer awards by the GOs, NGOs, societies, *etc*.

The issues shared by the progressive and innovative farmers were based on their 15-20 years of experience in lac cultivation. Sri Ramesh Chandra Kumar, Secretary, *Banta Lah Utpadak Sahyog Samiti*, Silli, Ranchi informed that there is no skilled labour available to perform the various activities in lac cultivation. Each activity needs special skill particularly pest management activities. For successful lac cultivation, trained labour is required for pruning, broodlac inoculation, spraying and harvesting. Untrained labour without supervision of the expert may not be able to perform the task efficiently. Consequently, in many cases after three spray, lac growers are unable to save the crop from enemies including predators and parasites/parasitoids. During the session, the point related to the anthropological issues as well as the dependent mentality of tribal communities were also major constraints in development of these areas. They should ask for water and power supply rather than readymade food or MGNREGA wages. Consequently, labour is not employed for productive activities and resulting the failure of policy and technological interventions.

Farm entrepreneurs-cum-scientist interaction session

Parthenium Awareness Week

ICAR-IIINRG, Ranchi organized Parthenium Awareness Week during August 16-22, 2019. The programme was co-ordinated by Dr. NK Sinha, Pr. Sc. All officials including scientists, technical, administrative, RAs & SRFs participated in the event. Scientists also visited adjoining schools of Ranchi and acquainted the students through presentations about this hazardous weed, including its management strategies and utilization aspects.

Educational tour-cum-training programme under Scheduled Caste Sub Plan

ICAR-IIINRG, Ranchi organized one day Educational tour-cum-training and assistance programme under Scheduled Caste Sub-Plan on September 6, 2019. 66 scheduled caste farmers from Kute, obariya, Karamtoli, Chandaghasi villages of Ranchi district participated in this programme. Addressing the programme Dr. KK Sharma, Director said that with this assistance we expect increase in your income and development in life. Elaborating the purpose of this plan Dr. Nirmal Kumar, Pr. Sc. & Head, ToT Division said that all the participants should take advantage of this assistance. Director and scientists of the Institute interacted with the participants on the issues affecting the farmers with the possible solutions.

Open Day for School Students on the eve of 96th Foundation Day Celebration

ICAR-IIINRG, Ranchi celebrated its 96th Foundation Day on September 20, 2019. To celebrate this occasion, Open Day for school students was organized on September 19, 2019. On this occasion students were apprised of the research and development activities of ICAR-IIINRG and were shown the Institute museum, Institute Research Farm and related plantations. Students were also shown the video film on production, processing and value addition and applications of lac and other natural resins and gums. *Swachhata Hi Sewa* (SHS), Cleanliness is Service, awareness programme for school students was also organized at the Institute premises. Students were educated about the importance of cleanliness and shown the motivational video film on *swachhata*. Students were motivated to create an environment of cleanliness and were urged to accelerate *swachhata* activities during the 11th September – 2nd October. Students were also given a special pen as memento to remember the occasion.

On the Open Day celebration and *Swachhata Hi Sewa* Awareness Programme, 826 students of 12 Ranchi

Students visiting the museum

based different schools such as Bishop Westcott Girls' School, Doranda; Sachhidanand *Gyan Bharti* School, Doranda; *Kasturba Gandhi Balika Vidyalaya*, Namkum; Sacred Pioneer Public School, Sidrol; Mazzarello School, Namkum; Project High School, Namkum; St. Anthony School, Doranda; *Vivekanand Vidya Mandir*, Sector-II, HEC Colony; Paramveer Albert Ekka School, Namkum; St. Thomas School, Dhurwa; St. Anne's Intermediate College, Purulia Road and Amity University visited the Institute and attended the programme.

96th Foundation Day

ICAR-IINRG celebrated its 96th Foundation Day on September 20, 2019. A memorial lecture was delivered by Sri Navin Kumar Singh, IPS, Inspector General of Police (HR), Ranchi (Jharkhand) in honour of the Founder Director of the erstwhile Indian Lac Research Institute, Ms Dorothy Norris on the occasion. Sri Sudhir Tripathi, Chairman, Jharkhand Public Service Commission was the Chief Guest. A large number of scientists from Central Tasar Research and Training Institute, Ranchi; ICAR-IIAB, Ranchi; Regional Center of ICAR-Research Complex for Eastern Region and Regional Station of ICAR-NBPGR, Ranchi and representative from Sahabhagi Samaj Sevi Sanstha, NGO, Chhattisgarh participated in the programme. Retired staff of the ICAR-IINRG also attended the event. On this occasion, distinguished workers of the Institute Dr. Arnab Roy Chaudhury, Sc.; Sri P Patmajhi, Sr. Technical Officer; Smt. Janki Devi and Shri Chaitu Kachhap, Skilled Supporting Staff were awarded with certificates and trophies for their commendable contributions in their sphere of work. Dr. S Ghosal, Pr. Sc. was the Convener and Dr. Thamilarasi K, Sc. and Sri N N Rajgopal, Sc. were the Co-conveners. A cultural function was organized in the evening for the guests, employees of the Institute and their family members.

Dr. KK Sharma, Director addressing the gathering

Training on Lac Integrated Agroforestry System for Livelihood Security

ICAR-IINRG, Ranchi organized four-day training programme, funded by World Agroforestry Centre (ICRAF), New Delhi, on Lac Integrated Agroforestry System for Livelihood Security during October 29-November 01, 2019. The event was inaugurated by flagging off the teams of the experts by Dr. KK Sharma, Director to the Farmer Field Schools at nine villages of three districts namely Ranchi, Khunti and Saraikela Kharsawan of Jharkhand. The Chief Guest, Dr. Nitin Kulkarni, Director, Institute of Forest Productivity, Ranchi in his address emphasized upon the agroforestry models in enhancing the area under forest as well as doubling the income of the farmers. He suggested using various multipurpose tree species suitable for this region for land use diversification. Dr. KK Sharma, Director in his address during valedictory session said that integration of agriculture and forestry is the key for livelihood security for the tribal communities as well as forest dwellers. It ensures regular income and minimizes the risk in the remote areas of the country. He appreciated the interactive and field visit activities during the training programme and said that such events are good platform for understanding the grass root level issues related to the farming community to promote the technological interventions. Progress of the adoption of technological interventions under this project was presented by Dr. A Mohanasundaram, Sc. & Co-PI. On this occasion a training manual titled, 'Lac Integrated Agroforestry System for Livelihood Security' was released. Lac cultivation kit, vegetable seeds, planting material and certificates were distributed amongst the 23 beneficiaries. Convener and co-conveners of the programme were Dr. J Ghosh, Pr. Sc. & PI and Dr. A Mohanasundaram, Sc. & Co-PI and Dr. RK Yogi, Sc. & Co-PI, respectively.

Participation in ICAR Zonal Sports Tournament (ICAR TEZ-2019)

39 members ICAR-IINRG, Ranchi team participated in ICAR Zonal Sports Tournament for Eastern Zone (TEZ-2019) held at ICAR-NRRI, Cuttack during November 18-22, 2019. Sri Rajgopal NN, Sc. won silver medal in long jump (M) and Ms LC Langlentombi, Sc. won silver medal in chess game.

11th Annual Workshop of Network Project on HPVA of NRGS

The 11th Annual Workshop of Network Project on 'Harvesting, Processing and Value Addition of Natural Resins and Gums'(NP-HPVA of NRGS) was held on November 19-20, 2019 at *Vasantrao Naik Marathwada Krishi Vidyapeeth*, Parbhani (Maharashtra) to review the annual progress of the Network Project centres and to

discuss the technical programmes for the year 2019–20.

The meeting started with the welcome address by Dr. DP Waskar, Director of Research, VNMKV, Parbhani followed by felicitations of the dignitaries present on dais. Dr. N Prasad, Coordinator, Network Project on HPVA of NRGs & Guest of Honour on the occasion also welcome the dignitaries present on dais and all the delegates from different collaborating centres.

Dr. N Prasad presented an overview of the Network Project and briefed the objectives of the Project and also number of methodologies/techniques, process/products and technologies/patents developed or transferred by the PIs of Network Project to the interested farmers/ stakeholders.

Dr. KK Sharma, Director, ICAR-IINRG, Ranchi and Chief Guest on the occasion delivered presidential address. In his address, he highlighted the achievements of the Network Project centres and emphasized that the value addition of gums and resins be carried out on larger scale so that the products based on gum and resin are developed. He further stressed that the NRGs being low volume, high value and very important not only from the farmers' point of view but also from foreign exchange angle. A meager value addition in NRGs may increase foreign exchange a lot. He further added that it is the need of the hour to diversify and intensify the research activities under networking for the benefits of the farmers. During inaugural session four publications and *guggul* gum-based *laddus* developed by PIs of different centers under Network Project on HPVA of NRG were released by the dignitaries present on dais.

Dr. AS Dhawan, Hon'ble Vice-Chancellor, VNMKV, Parbhani during his address said that though the group is small but

represents the entire India. Delegates have come from the four directions of the country. He further emphasized that with scientific tools in our hands, we can ensureproduction, processing and value addition of NRGs. He also talked about the *guar* gum being largest export commodity and has enormous potentials in food industry and other sectors too. He also emphasized that the possibilities be explored for the utilization of natural forestry resources for specific industrial purposes. He further said that all the components of agro-forestry should be integrated with the farming system for livelihood improvement of the rural and poor people.

About 50 delegates from different collaborating centres and the host Institute participated in the deliberations. Lastly, vote of thanks was proposed by Dr. RB Kshirsagar, PI, Network Project on HPVA of NRGs & Organizing Secretary, VNMKV, Parbhani.

Meetings of Important Committees

Institute Research Council (IRC)

The Institute Research Council (IRC) meetings were held on January 18-19, 2019 and August 26-27, 2019 under the Chairmanship of Dr. KK Sharma, Director, ICAR-IINRG, Ranchi. During the meetings, the research progress of on-going projects (16), RPP-III (05) and new project proposals (04), under six core programmes, were discussed thoroughly and approved/adopted by the House. The following points emerged out:

- Head of Division should devote not less than 50% of time in Divisional management and Project coordination and 25% for planning/monitoring activities as PC, Network Project. Remaining time may be devoted to research project of their discipline.
- No scientist should be associated in more than 3 projects as PI or Co-PI as its mandatory to allocate atleast 25% of time in each project with relaxation to those who are handing externally funded projects.
- Remaining 25% of the time should be utilized for other assigned activities/assistance in research projects without being associated/Extension/MGMG/Swachh Bharat/Member of important committees.
- Contribution of each scientist associated with the project must be clearly defined in RPP-I.
- The duly completed RPP-I, RPP-II, RPP-III & RPP-IV must be submitted to PME Cell by 31.10.2019.
- Late submission of RPPs and other time bound reports like Annual Report, Quarterly Monitoring Targets, Monthly Report etc. must be reported in APAR of the scientist by Head of the Division concerned.

In the end, Member-Secretary extended sincere thanks to the Chairman for his valuable scientific inputs to improve upon the present research activities of the individual scientist, thereby, Institute as a whole.

Research Advisory Committee (RAC)

The XXVI Research Advisory Committee (RAC) meeting of ICAR-IINRG, Ranchi was held on March 15-16, 2019 in the *Kusmi* Conference Hall of the Institute. The meeting was chaired by Dr. Pitam Chandra, Former ADG (PE), ICAR, New Delhi & Director, ICAR-CIAE, Bhopal and the following members were present:

- Prof. RN Jagtap, Head, Institute of Chemical Technology, Mumbai
- Dr. Suresh Walia, Emeritus Sc., ICAR-IARI, New Delhi
- Dr. Subhash Chander, Professor and Pr. Sc., ICAR-IARI, New Delhi
- Dr. Sanjaya K. Dash, Dean, OUA and T, Bhubaneswar
- Dr. Kanchan K. Singh, ADG (FE), ICAR, New Delhi
- Dr. KK Sharma, Director, ICAR-IINRG, Ranchi
- Dr. NK Sinha, Pr. Sc., ICAR-IINRG, Ranchi : Member-Secretary

The following were the Invitees:

- Dr. Nirmal Kumar, Pr. Sc. & Head, ToT Division
- Dr. Soumen Ghosal, Pr. Sc. & Head, LP Division
- Dr. Sanjay Srivastava, Pr. Sc. & Head, PPD Division
- Dr. MZ Siddiqui, Pr. Sc. & I/c, PME Cell

Member-Secretary welcomed the Chairman, members of RAC, and the invitees at the 26th RAC meeting. He expressed his gratitude to ADG (FE), ICAR for the support provided by him for the Institute's growth in terms of research & technology development, HRD and infrastructure development. He expressed the hope that valuable and critical inputs of the RAC would lead to further strengthening the research & outreach activities of the Institute.

Dr. KK Sharma, Director informed the house that all the major recommendations of the 25th RAC had been agreed upon by the Council and appropriate actions have already been initiated at the Institute for the proper implementation of these recommendations. He presented an overview of global NRG scenario, achievements of the Institute during the past one year, and the recommendations of the previous QRT.

Dr. Pitam Chandra, Chairman, in his opening remarks, appreciated the research outcome of the Institute so far, and advised the scientists to organize the activities such that the efforts are oriented towards the goals set for the year ahead. He emphasized the need to take up more farmer-friendly research activities on NRGs for economic prosperity with environmental sustainability. This was followed by the opening remarks from other RAC members.

Dr. NK Sinha, presented the Action Taken Report (ATR) on the recommendations of XXVth RAC meeting. The Chairman & the RAC members appreciated the efforts made by the Institute to implement the recommendations. However, some of the recommendations needed additional budgetary support for bringing them to logical conclusion.

Dr. MZ Siddiqui, Pr. Sc. & I/c PME Cell presented the research progress of all the on-going institutional and

externally funded projects at the Institute. Thereafter, presentations on significant research accomplishments were made by the respective divisional Heads and Project Coordinators.

The following completed and new projects were presented by the respective PIs:

Sl. No.	Project Name	Status of project
1.	Integrated nutrient management and vegetative propagation technique for quick establishment of *kusum* (*Schleichera oleosa*)	Completed
2.	Agronomic interventions influencing lac production in *palas* (*Butea monosperma*) in summer season	New
3.	Genetic manipulation In lac host plant (*F. semialata*) to establish better plant- lac insect interaction	New
4.	Study on infrared drying of seedlac	New

The RAC accepted the recommendations of the completed project and approved the new project proposals. RAC held interactions with the ICAR-IINRG scientists and other stakeholders. Thereafter, the RAC made general observations related to the R&D ecosystem at Institute and recommendations for new research initiatives.

General observations

- The Institute is going to complete 100 years of its establishment in 2024. Preparations may be initiated for holding suitable National and International events during the Centenary celebrations.
- Preparation for the SFC for the next plan is going to begin soon. Institute should start internal deliberations for the formulation of next plan SFC from now onwards.
- With a view to reduce the carbon foot print of lac processing technologies, we should think about incorporating solar energy as green energy for processing purposes. Similarly, the Institute needs to make use of such contemporary technologies as bio-sensors, ITC, AI, biotechnology, and nano-technology for developing sustainable lac production and processing technologies.
- Research division with greater focus on automation and development of sensor based processes and new names of the divisions may be proposed keeping in view their mandates and future relevance.
- Drip irrigation facility may be installed on the whole research farm for sustainable water use for irrigation. The proposal may be pursued under next plan period.
- NABL accreditation of QEL as recommended by the last RAC has not yet been obtained. The same may be completed in a time bound manner. The recommendations of the first meeting of the current RAC may also be implemented in a time bound manner.
- PG/Ph.D. students may be invited to conduct their research work as per the mandate of the Institute in larger number. This may help the Institute in achieving its mandate while mitigating the constraint of the manpower in the short run.
- GIS based Decision Support System may be developed for mapping the spatial and temporal distribution of lac hosts in the country for making further strategies for enhancing lac production.

Recommendations

A. Lac Production Enhancement

Production data for the recent past indicate serious concerns about the negative effect of climate change on production and productivity of lac, especially *rangeeni* type. In this context, studies have been initiated by the Institute for studying nutrient management for host plants vis-à-vis lac production.

1. The RAC felt that there is a need to intensify investigations of nutrient management-host plant-lac insect-lac production nexus to determine the strategies for enhancing lac production.
2. Selection of lac insect population for adaptation to climate change is increasingly becoming essential for sustaining lac production.
3. Integrated cropping systems have been found by the Institute as an excellent mechanism of expanding lac cultivation and enhancing farmers' income. The Institute may undertake more programmes to disseminate the technology of lac production through integrated cropping systems all over the country as well as those based on the survey conducted by the Institute on the lac insect and host plants.

B. Processing of NRGs

1. Utilization of lac by-products (policosanols, laccaic acid, jalaric acids *etc.*) for pharmaco-nutraceutical and agricultural applications needs to be explored following chemical, biochemical and nano-technological interventions. Besides, process may also be standardized for efficient conversion of aleuritic acid to high value iso ambrettolide as perfumery material.

2. The work carried out by the Institute in developing lac formulation for coating on fruits has not reached its logical conclusion and the technology has still not been commercialized. The Institute may pursue the matter further leading to commercialization. Studies on improving the coating compositions and application methods for various selected fruits and vegetables may also be carried out.

3. Lac dye is an important constituent of seed lac which is generally wasted. This dye is natural and it is suitable as colorant for food, pharmaceutical and cosmetic products. The Institute may undertake development of efficient process for extraction and purification of lac dye and its safety evaluation.

C. Technology Dissemination

1. The RAC took note of a few products developed by IINRG, but still waiting to be commercialized. In this context, the recommendation is to validate these products, using global standards, with respect to similar existing products in market for increasing the possibilities of commercialization. Besides, product development in future should be taken up after due consideration of demand side issues.

2. The Institute needs to expand and strengthen linkages with stake holders for their technological needs as well as for technology commercialization.

Interaction with stakeholders during RAC meeting

Institute Management Committee (IMC)

The 54th Meeting of the Institute Management Committee (IMC) was convened in the *Kusmi* Conference Hall of the Institute on June 18, 2019. The following members were present in the meeting:

1. Dr. KK Sharma, Director, ICAR-IINRG, Ranchi : Chairman
2. Dr. Pannalal Singh, Pr. Sc., Nominee of ADG (AE), ICAR, New Delhi : Member
3. Dr. KK Sharma, Pr. Sc. & PC, AINPPR, ICAR-IARI, New Delhi : Member
4. Dr. AK Thakur, Pr. Sc., ICAR-NINFET, Kolkata: Member
5. Dr. SK Giri, Pr. Sc., ICAR-CIAE, Bhopal : Member
6. Dr. Bikash Das, Pr. Sc., ICAR RCER RC, Ranchi : Member
7. Sri Rajesh Sahay, Dy. Director (Finance), ICAR, New Delhi : Member
8. Sri SC Lal, Sr. AO (Actg.), ICAR-IINRG, Ranchi : Member-Secretary

Invited Members

- Dr. Nirmal Kumar, Pr. Sc. & Head, ToT Division
- Dr. Soumen Ghosal, Pr. Sc. & Head, LP Division
- Dr. Sanjay Srivastava, Pr. Sc. & Head, PPD Division
- Dr. MZ Siddiqui, Pr. Sc. & I/c, PME Cell
- Dr. Arnab Roy Chowdhury, Sc.
- Sri Ashwani Garg, F & AO
- Sri K Oraon, Assistant & I/c, Admin-II Section
- Sri Anil Kumar Yadav, Estate Officer

Welcome Address by the Member-Secretary

The meeting started with the welcome address by the Member-Secretary, IMC and formal introduction of the members and the invitees.

Introductory remarks by the Chairman

Dr. KK Sharma, Chairman, IMC & Director welcomed the members present in the meeting. He apprised the members of the significant achievements of the Institute since the last IMC meeting. He mentioned that a lot of new initiatives have been taken in R&D of lac and NRGs like integration of lac with horticulture/agriculture for enhancing income of the farmers, *in-vitro* cytotoxic study of synthesized *Acacia nilotica* and *Jhingun* gums, hydrolyzed *guar* gum as it is good source of dietary fibre, field evaluation of test formulations of *Acacia nilotic*a and *jhingan* gum induced AgNPs *etc*. He also added that Institute is working hard on extension activities and imparted training on lac to more than 3000 beneficiaries under 38 batches. He informed that the Institute`s Magazine *Laksha*-2018 has bagged Second Prize by ICAR under *Ganesh Shankar Vidyarthi Hindi Patrika Puruskar Yojna* (2017-18).

(a) Presentation on research achievements of the Institute: Dr. MZ Siddiqui, Pr. Sc. & I/c, PME Cell presented the research achievements of the Institute. She apprised the members of various research projects being executed under different core programmes.

Besides, she mentioned about the different training programmes being conducted at the Institute and also the events organized.

(b) Presentation on scientific topic: Dr. Arnab Roy Chowdhury, Sc. delivered a lecture on 'Guar gum--A potential source of dietary fibre and prebiotics' which was appreciated by the members. It was informed by a member that export of *guar* gum has recently been affected adversely due to presence of residue of dioxane and suggested that a collaborative project may be contemplated with the Institute having sophisticated instruments like High Resolution Mass Spectroscopy (GC-HRMS) to detect the residue even in very low quantity.

(c) Presentation on financial status of the Institute: Sri Ashwani Garg, F & AO presented the financial status of the Institute. Sri Rajesh Sahay, Member, IMC suggested that ratio of expenditure under Total Grant in Aid-General may be improved so that funds may be utilized properly under targeted time frame.

(d) Report on status of establishments by Admin-I: Presentation was made on the establishment matter especially on revised sanctioned strength and staff in position at ICAR-IINRG, Ranchi.

(e) Confirmation of the proceedings of 53rd meeting of IMC held on 21st December, 2018: The IMC was apprised of the approval and comments made by ICAR on the proceedings of the previous (53rd) meeting of the IMC. The House suggested that follow-up action may be taken by the Institute on the items which require separate proposal to the SMD.

Agenda for 54th meeting of IMC

(a) Construction of two RCC overhead water tanks of 50,000 litres capacity each in the Institute Research Farm– P/E received from RCD, CPWD is Rs. 73.85 lakhs and there is a provision for Rs. 75.00 lakhs in the SFC (and Rs. 140.00 lakhs in approved RCE) for the said work. Since PE is more than 50.00 lakhs, approval of IMC was requested as per norms. After discussion, IMC recommended the proposal.

(b) Distribution of pipe network from overhead water tanks to research plots at the Institute Research Farm – there is a provision for Rs. 21.00 lakhs only in the SFC that has been enhanced to Rs. 70.00 lakhs in approved RCE. In view of urgency of work, recommendation of IMC was requested to allocate additional amount of Rs. 53.67 lakhsas P/E received from RCD, CPWD is Rs. 74.67 lakhs so that work may be got executed. IMC felt that distribution of pipe network from overhead water tanks is necessarily required for research purpose at IRF, as irrigation through open channel will lead to wastage of water which can be efficiently utilized through pipe network. Requisition for RE for the same with full justification may be made to the Council at the earliest. It may be pointed out here that there is a provision of Rs. 348.05 lakhs in RCE for works for FY 2019-20, whereas only Rs. 27.23 lakhs have been allocated for the same.

Information regarding IJSC and Grievance Cell

The IMC was briefed about the Institute Joint Staff Council (IJSC) which has been constituted recently by election process for the period of next 3 years. Its first meeting was also convened on May 22, 2019 in a healthy atmosphere with a fruitful outcome. Besides, Grievance Cell of the Institute was also constituted for redressal of the grievance of the staff for a period of next 2 years. Members from administrative and supporting category have been nominated by the Director as nominations form for election did not come-up from staff side except for the technical category. The matter was ratified by the IMC.

Any other item with permission to Chair

(a) Up-gradation of the Product Demonstration Unit to Research Division: It was presented that presently there are three research divisions and one Product Demonstration Unit (PDU) at the Institute. To strengthen the processing aspect of NRGs and lac, proposal for upgrading the PDU to a research division with greater focus on automation and development of sensor based processes was put-up before the IMC. It was reported that RAC/QRT has already recommended the proposal in this regard. It was also informed that the Institute has already surrendered post of Principal Scientist in the revised cadre strength of the scientific manpower for creating the post of the Head of Division as required. After thorough discussion, IMC recommended for upgrading the PDU to a research division and also reorganizing/renaming the existing divisions keeping in view the mandate and future relevance.

(b) Engagement of Young Professionals (YPs): Keeping in view the shortage of technical manpower, IMC recommended that Young Professionals may be hired as per requirement as sufficient funds are available under research and operations head.

Vote of thanks by Member-Secretary, IMC

The meeting ended with a vote of thanks by the Member-Secretary, IMC.

Distinguished Visitors

The Institute regularly receives a number of visitors who are briefed about different aspects of lac, natural resins and gums as well as Institute activities. The details of distinguished visitors are as under:

Sl. No.	Name/Designation/Organization	Date
1.	Ms Kalpana Kumari and 16 IAS Officers under *Bharat Darshan* Programme from LBSNAA, Mussorie	January 17, 2019
2.	Ms Cueryl Porter and Ms Penny Jewell, Research Analyst, London W91SD	January 31, 2019
3.	Ms Eric Sultes and Sri Bernhard Hanisch, Zurich-CH, France	February 14, 2019
4.	Dr. KH Rao, Faculty, ICAR-NAARM, Hyderabad	March 06, 2019
5.	Sri Quai du Rhone, CEVIED 69002 Lyon, France	March 08, 2019
6.	Dr. Pitam Chandra, Former ADG (PE), ICAR, New Delhi & Director, ICAR-CIAE, Bhopal	March 15, 2019
7.	Dr. Suresh Walia, Emeritus Sc., ICAR-IARI, New Delhi	March 15, 2019
8.	Dr. Subhash Chander, Professor & Pr. Sc., ICAR-IARI, New Delhi	March 15, 2019
9.	Prof. RN Jagtap, Head, Institute of Chemical Technology, Mumbai	March 15, 2019
10.	Dr. Sanjaya K. Dash, Dean, OUA and T, Bhubaneswar	March 15, 2019
11.	Sri Bommi Reddy, Scientist B, Central Silk Board	March 25, 2019
12.	Dr. P Kaushal, Joint Director, ICAR-NYBSM, Raipur, C.G.	April 27, 2019
13.	Dr. DS Rana, Emeritus Scientist, ICAR, New Delhi	May 31, 2019
14.	Dr. Pannalal Singh, Pr. Sc., ICAR, New Delhi	June 18, 2019
15.	Dr. KK Sharma, Pr. Sc. & PC, AINPPR, ICAR-IARI, New Delhi	June 18, 2019
16.	Dr. AK Thakur, Pr. Sc., ICAR-NINFET, Kolkata	June 18, 2019
17.	Prof. (Dr.) Ajit Kr Pandey, Director, Amity University, Ranchi	July 20, 2019
18.	Dr. Ambrish Gautam, Amity University, Ranchi	July 20, 2019
19.	Dr. HS Gupta, PCCF (Research & Training), Department of Forest, Environment & Climate Change, Govt. of Jharkhand	July 30, 2019
20.	Sri AK Padhi, Chief General Manager (CGM), National Bank for Agriculture and Rural Development (NABARD), Jharkhand	August 01, 2019
21.	Dr. SR Singh, Deputy Director, Chaudhary Charan Singh National Institute of Agricultural Marketing (CCS NIAM), Jaipur	August 30, 2019
22.	Dr. HS Gupta, PCCF (Research & Training), Department of Forest, Environment & Climate Change, Govt. of Jharkhand	August 30, 2019
23.	Sri Sudhir Tripathi, Chairman, Jharkhand Public Service Commission	September 20, 2019
24.	Sri Navin Kumar Singh, IPS, Inspector General of Police (HR), Ranchi (Jharkhand)	September 20, 2019
25.	Sri Suresh Chandel, Ex. MP and Member of Services, ICAR, New Delhi	September 27, 2019
26.	Sri Kumar Anil Bhaskar, Senior Resident Editor, Hindustan Hindi Daily, Ranchi (Jharkhand).	September 30, 2019
27.	Dr. (Smt.) Nileema Pathak, Professor and Former HoD, Department of Sanskrit, Ranchi University, Ranchi (Jharkhand).	September 30, 2019
28.	Dr. Gopal Pathak, Vice-Chancellor, Jharkhand University of Technology, Ranchi (Jharkhand).	October 16, 2019
29.	Dr. A Wadood, Chairman, Division of Agro-meteorology, BAU, Ranchi (Jharkhand).	October 16, 2019
30.	Dr. Deomani Pandey, Associate Professor, Department of Biotechnology, BIT Mesra, Ranchi (Jharkhand).	October 16, 2019
31.	Dr. Nitin Kulkarni, Director, Institute of Forest Productivity, Ranchi (Jharkhand).	October 29, 2019
32.	Dr. Omkar Tiwary, Joint Director, DBT, New Delhi	November 05, 2019
33.	Dr. SK Lavania, Professor, GBPOA&T, Pantnagar	December 27, 2019

Support Services

Institute Research Farm (IRF)

Resource Generation

Broodlac/ Scrapedlac (Rs.)	Fuel Wood (Rs.)	Water + Fuel charges (Rs.)	Lac host plant seeds and seedlings (Rs.)	Other farm produce (Rs.)	Total (Rs.)
4,53,453	13,470	3,400	11,700	14,695	4,96,718

Infrastructure Development

- Developed two new experimental plots with 127 number of *Calliandra calothyrsus* and 30 number of *Albizia saman* (Rain tree) on plots measuring 50m x 50m for each (Fig. 1 and 2).
- A display board of size 6 x 4 feet depicting the map and plots of IRF has been prepared (Fig. 3).
- A display board (6 x 4 feet) depicting the information about IRF (Fig. 4) and an activity chart describing the various activities of IRF in the entire year has been prepared.

Fig. 1: New plot of *Calliandra calothyrsus*

Fig. 2: New plot of Rain tree at IRF

Fig. 3: Map and plots of IRF

Fig. 4: Information about IRF

- Water Harvesting Pond (Plot No. 98 and 98A) was desludged manually in the summer season (May - June 2019) for increasing the water storing capacity.
- New stretches of path of 10 feet width, along the north and southern-west boundary of IRF were prepared (approx. 400m) using JCB machine.
- Two brush cutters and three rickshaw trolleys were purchased for the purpose of removing weeds and carrying farm related items, respectively.

Nursery Management

- *Bhalia* seeds (4.69 kg), *Semialata* (9.5 kg) were produced and *Khair* (8 kg), *Galwang* (5.5 kg), *Ber* (3.3 kg) and *Kusum* (3.09 kg) were collected from different trees.
- In the LIFS plot (No. 55), old *F. semialata* plants (810) were replaced with new ones and *Emblica officinalis* (*Aonla*) trees were replaced with *Ziziphus mauritiana* (*Ber*) (25 numbers).
- Bio-composting by utilizing leaves and cow dung for nursery purpose was done and the biocompost manure is being used in the nursery.

- *Semialata* seedlings (5,235 Nos.), *Calliandra* seedlings (85 Nos.) and *Semialata* seeds (200 g) were provided to scientists for research purpose.
- Seeds and seedlings of lac host plants were sold to farmers, KVK and other organizations. Details are as under:

Lac host plant	Quantity
Semialata seedlings	40,832 Nos .
Semialata seeds	2.7 kg
Bhalia seeds	3 kg
Kusum seedlings	324 Nos .
Kusum seeds	0.5 kg
Ber seedlings	200 Nos .
Ber seeds	0.5 kg
Galwang seeds	0.75 kg

Farm Management

- Executed field related experimental work of the scientists of LPD, ToT and PPD Division including IRF activities as per their requirements.
- Inputs like fertilizers, farm yard manure, farm machinery like tractors with ploughing implements, power tiller and irrigation facilities were provided to the scientists for maintaining their research plots.
- Weeding, cleaning and lime application mixed with chloropyriphos on approx. 7000 lac host plants and other trees.
- Farm related residues are being put for vermi composting for sustainable management of waste. The process of vermi composting has been initiated at IRF in plot No. 24A.
- Wheat (var. HD-2967) and Mustard (var. PM-30) were sown in 1 hectare area each in the unutilized plots of IRF for resource generation (Fig. 5 & 6).

Fig. 5: Wheat sown at unutilized IRF plots

Fig. 6: Mustard sown at unutilized IRF plots

Lac culture

- 3206 kg of *Kusmi* broodlac was inoculated on *Kusum* (245 Nos.) and *Ber* (850 Nos.) for both summer and winter *Kusmi* crops.
- *Rangeeni* broodlac production on *Palas* was done by inoculating 90 kg broodlac on 39 numbers of *Palas* trees from which only 19 kg broodlac was obtained during *baisakhi* 2018-19. Similarly in *Katki*, 19 kg broodlac was inoculated on *Palas* (15 Nos.) and *Ber* (2 Nos.) from which 44 kg broodlac was obtained during *katki* 2019. *Rangeeni* broodlac production is being continued.
- 976.7 kg *Kusmi* scrapedlac and 168.3 kg *rangeeni* scrapedlac was sold to JASCOLAMPF Ltd. 485 kg of scrapedlac and 46 kg summer *kusmi* broodlac were provided to PD Unit and other scientist for experimental/display purpose.
- *Semialata* and *Kusum* seedlings were raised in IRF on demand of Deputy Development Commissioner-cum-District Programme Coordinator, Ranchi for supplying to different beneficiary farmers of Bundu block under MNREGA (Fig. 7). 40,812 *Semialata* and 324 *Kusum* seedlings to 17 different beneficiaries have been supplied for lac cultivation.

Fig. 7: Nursery raised through seed bed for distribution of seedlings under MNREGA

Soil amendment

Green manuring was done using *Dhaincha* and *Sanai*, 120 kg each, in *Kusum* (Plot No. 33-49) and *Ber* (Plot No. 17-29) for soil amendment (Fig. 8 & 9).

Fig. 8: Green manuring with Sanai at ber plots

Fig. 9: Green manuring with Daincha at kusum plots

Quality Evaluation Laboratory

During the period under report a total number of 69 customer's letter (49 external and 20 internal), 322 samples (88 external and 234 internal) of lac, lac-based products and natural gums were received from different Govt. organizations/Private industries/various divisions of the Institute and total 981 (92 external and 889 internal) tests were carried out and a sum of Rs. 55049/- was earned from external sources and Rs. 64750/- from Institute projects. If the charges for the internal samples would have also been realized, much more revenue to the tune of Rs. 168386/- would have been earned bringing the total revenue to Rs. 288185/- towards testing charges. Three trainees were also imparted training on testing and analysis of lac samples and determination of bleached index of seedlac sample.

Prioritization, Monitoring and Evaluation (PME) Cell / Institute Research Information System (IRIS) Cell

The activities performed by PME Cell & IRIS Cell during the period under report were:

- Submission of various time-bound reports:
  - Cabinet Monthly Report to ADG (FE) by 20th of every month
  - Monthly brief updates on progress to DDG (FE) by 20th of every month
  - Half Yearly Progress Report (HYPM)
  - Quarterly Targets & Achievements
  - DARE report, Annually
  - Annual Plan Outcome Budget
  - Preparation & submission of Annual Training Programme for the Year 2019-20 for all the employees of the Institute to the Council
  - Preparation & submission of Annual Physical and Financial Targets and Achievements (April, 2018 to March, 2019) of all the employees of the Institute to the Council
- PME Cell conducted Institute Research Council (IRC) Meeting on January 18-19, 2019 and August 26-27, 2019
- Maintenance of Research Project Files: Institute (18), ICAR-Network Projects (02), ICAR-ICRAF (01), ICAR-DBT (01) and Inter-Institutional (ICAR-IIAB & IINRG) (02)
- Processing of research papers & popular articles for various Journals submitted by the scientists
- Processing of papers submitted by the scientists / staff for conferment of Awards/Honours/ Recognitions etc., to them
- Processing of papers submitted by the scientists for their participation in National/International Conferences/Symposia
- Coordination for conducting RAC, IMC & Director's Conference
- Coordination for HRD Programmes for all the employees (Scientists, Technical & Administrative) of the Institute
- PME Cell provides different services like:
  - LAN and Internet Connectivity to the divisions & sections of the Institute
  - E-mail services
  - Annual Maintenance of Computer Systems, Local Area Networking (LAN), EPBAX, Biometric Devices & CCTVs

- Maintenance of web-based Data Base for Personnel Management Information System (PERMISNET), Enterprise Resource Planning (ERP) and Project Information Management System (PIMS)
- Regular updating of Institute's website with all general information, events, tenders, interviews etc.
- Quarterly updating of CIC website with all relevant information/statements as required under the provisions of RTI Act, 2005 and processing of requests received under RTI
- Reply of Parliament questions and any other last minute reply required to be submitted to SMD.

Library and Documentation Centre

The library of the Institute plays an important role in meeting the information needs of its user. Library of the Institute is a repository of scientific and technical information on natural resins and gums. Besides catering to the needs of Institute scientists, it also renders services to other researchers, academicians, technologists and students as well as lac/gums/resins industrialists from other parts of the country.

Advance/Full Text/Abstracts access of more than 3900 Journals from several publishers has been made available online through *Consortium for e-Resources in Agriculture* (CeRA) to our scientists during the year. Our library is also connected with World eBook Library (WeL) facilitated by National Digital Library (NDL), New Delhi from this year. All regular Institute publications (Annual Reports/ Newsletters/Lac-Resins-Gums Statistics/Laksha/Dorothy Norris Lecture Series *etc.*) have been uploaded on ICAR-Krishi Portal since beginning and are available in PDF form for the internal users. An amount of Rs. 8,697.00, as revenue, has been generated from the sale of publications during the year. The library also continued to exchange of Institute publications with the scientific institutions in and outside the country.

Services provided by the Library to its users

- E-Journals access
- C.D. Searches
- Document Delivery Services
- Reprographic Services
- Bibliographic Services
- Current Awareness Services
- Inter Library Loan Services for resource sharing
- Sale and Distribution of Institute Publications

Journals & Periodicals received

- Foreign Periodicals (Gratis/exchange) - 05
- Indian Periodicals (Gratis/exchange) - 06

Library holdings (as on December 31, 2019)

Documents	Additions	Total Holdings
Books	16	7982
Bound Journals	217	22634
Annual Report	84	4465
IS-Specification	-	184
Thesis	-	13

Estate Section

Estate Section is one of the most important sections of the Institute which provides the following essential services:

- Security of Institute premises
- Power & water supply to offices & residential quarters
- Civil & electrical maintenance of office buildings & residential quarters
- Assistance in engineering research work
- Infrastructure development work in the Institute
- General maintenance & up-keep of Institute premises

Major works carried out during the year 2019

Civil Work

- Renovation of quarter Type-III/9 & 13
- Renovation of septic tank of quarter Type-III/5 & 6
- Renovation of pump house of PDU Campus
- Renovation of extension of transformer room
- Renovation & roof treatment of quarter Type-IV/1
- Roof treatment of *palas* conference hall
- Construction of administrative building of KVK Khunti
- Weather coat & distempering of administrative building, canteen, Type-V hostel and all guard rooms of the Institute (Departmentally)
- Construction of ramp in library, administrative building, Director's office, ToT Division, LP Division, Guest House, Dispensary & PDU old building (Departmentally).

Electrical work

- Maintenance of electrical installation of office buildings & residential quarters

- Maintenance of Genset & associated panels, transformer, overhead LT lines
- Maintenance of street lights & associated panels
- Electrical renovation of pump house of PDU campus
- Change of power cable of new Guest House, LP Division & river bed pump house
- Electric wiring of Admn.-II departmentally
- UPS power connection to all computer power boards in ToT Division
- Change of battery of 7 solar lights

Carpentry work

- Memento show case for Director's office
- Mega case 6'x4'x2' for Biotechnology Laboratory

Welding work

- Repair of spindle metal net in front of Director's office which was damaged due to fall of tree

Security Service

- No major security lapse occurred

General Maintenance

- The work is being outsourced and is monitored by Estate Section so as to ensure that the work is done satisfactorily as per our scope of work.

Jobs entered in job register

- Civil & water supply- 404
- Electrical work-840
- Carpentory work -316
- Welding work -130
- Turner work -334

Health Centre

The Institute has a functional Health Centre in the campus under the chairmanship of Dr. Sanjay Srivastava, Pr. Sc. Dr. Ashok Kumar and Dr. Kailash Prasad have been providing their services as a part time Medical Officers (AMAs) on contractual basis on alternate days in the centre. Most of the medical cases were handled in the centre itself and complicated cases are referred to authorized CGHS hospitals and pathology clinics in the city for expert diagnosis and treatment. The Health Centre is equipped with routine instruments to handle general/ minor dressing, first aid, physical examination of patients, measure B.P., pulse, height, weight, blood sugar, *etc*. In the year 2019, 4576 patients were registered and treated in the Health Centre. Around 81 patients were advised for medical rest and were issued medical fitness. The centre has a computerized inventory system, facilitating retrieval of records like issue of medicine, date of receiving, unregistered patient along with the near date of expiry of medicine, *etc.* This ultimately helps the AMAs in taking better decision while prescribing medicines. Most of the medicines prescribed by AMAs were made available to the patients from the Health Centre itself. Apart from attending to regular employees, pensioners, and contractual staff of various on-going research projects, medical treatment were also provided to trainees and labourers on humanitarian grounds, in case of emergency and casualty. During the reported period, several steps were taken to improve the system and handlings of patients were streamlined.

Institute Technology Management Unit (ITMU)

Under NAIF scheme through which following work done:

- Patent application 1435/KOL/2013 'Pharmaceutical composition for treatment of leukemia prepared from lac dye' was processed through ITMU and response was filed on 06.02.2019 in patent office through attorney Seenergi, IPR Kolkata.
- Organized Techno-Commercial Assessment and Expert Committee Meeting on 07.3.2019 made by Agrinnovate India pvt. Ltd. (AGIN) to assess the technical & commercial feasibility, handholding requirement, preferred modes of commercialization for two ICAR-IINRG technologies rested to them namely i) Fruit coating formulation for kinnow and ii) Lac based nail polish.
- Provisional patent Application No. 201931008616 titled, 'Natural gum based nanocomposite hydrogel having antibacterial and wound healing effects and a method of preparation thereof' was processed and filed in patent office on 05.3.2019 through ICAR approved attorney.
- Details of three Institute's technologies were sent to AGIN for website updation.
- Details of technology licensing of ICAR-IINRG sent to IP&TM Unit of ICAR.
- Information of ICAR-IINRG, Ranchi pertaining to Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology for DARE/ICAR Annual Report 2019-20 prepared and sent to IP&TM Unit, New Delhi.

- Patent application 1333/KOL/2013 'Novel molecular method to differentiate infra-sub-specific forms, *kusmi* and *rangeeni*, of Indian lac insect, *Kerria lacca* and other races and species of *Kerria*' was processed through ITMU and response was filed on 26.11.2019 in patent office through attorney Seenergi, IPR Kolkata.
- Details of ten Institute's technologies compiled and sent to PME Cell for SFC document.
- Organized meeting of ITMC on 05.12.2019.
- Draft reply to FER of patent application 580/KOL/2011 was processed for filing response in patent office and extension of one month for filing response was processed.

Agro-meteorology Unit

Agro-meteorology Unit of the Institute is situated at 23^0 23' N latitude, 85^0 23' E longitude at 650 m altitude. During the year 2019, different weather parameters were recorded and updated daily as well as weekly at the Institute website. Month-wise weather data, daily Self Recording Rain Gauge (SRRG) sheets and daily rainfall data for the year were sent to India Meteorological Department (IMD), Kolkata. The monthly mean relative humidity (RH %), mean temperature (^{0}C) and total rainfall (mm) is given in the Table. Weekly analysis of rainfall has been presented in Figure.

Hottest and coldest months of the year were May and January with mean monthly temperature maximum at 37.5 ^{0}C and minimum at 5.27 ^{0}C, respectively. Maximum temperature for the year was recorded on 10th June (41.0 ^{0}C), while the minimum temperature was recorded on six days in the year, on 16th, 30th and 31st January and 28th, 29th and 30th December (2.5 ^{0}C). During July, relative humidity (RH) was the maximum at 8:30 hours (85.81%), with 81.26 per cent in the 14:30 hours, while the minimum RH was observed at 14:30 hours (53.90), with 61.25 per cent in the 8:30 hours in the month of May. Total annual rainfall was 1366.30 mm. It is pertinent to say that 19th August received maximum daily rainfall *i.e.* 66 mm. Maximum monthly rainfall was observed in August (278.30 mm), whereas lowest rainfall occurred in the month of November (0.80 mm) of the Calendar Year 2019.

Table: Mean monthly meteorological data recorded at the Agro-meteorological Unit of the Institute during 2019

Month, 2019	Temperature		Relative Humidity (%)		Rainfall (mm)
	Min. 8:30 AM	Max. 2:00 PM	Max. 8:30 AM	Min. 2:00 PM	
January	5.27	22.59	71.19	60.48	2.00
February	9.62	26.45	73.50	63.21	55.30
March	13.05	29.96	66.87	60.26	60.40
April	18.31	35.13	65.00	58.37	26.90
May	20.80	37.55	61.26	53.90	44.20
June	22.75	35.61	74.83	68.20	169.60
July	21.66	29.34	85.81	81.26	220.50
August	21.20	28.31	84.39	78.65	278.30
September	20.93	28.37	82.27	78.57	244.60
October	17.35	27.33	77.16	72.65	231.90
November	11.55	26.24	74.70	67.27	0.80
December	8.27	21.79	74.35	66.03	31.80
Total Annual Rainfall (mm)					1366.30

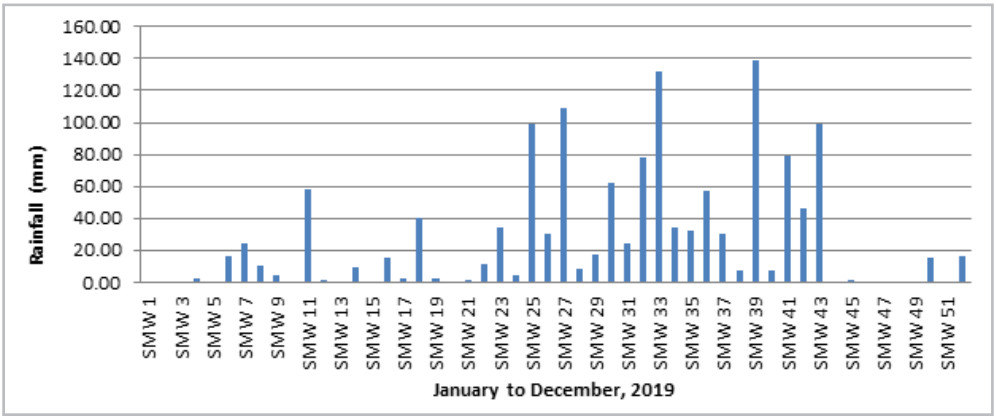

Fig.: Weekly distribution of rainfall for the year, 2019

Krishi Vigyan Kendra (KVK), ICAR-IINRG

23rd KVK of Jharkhand, the foundation of which was laid at Diyankel, Torpa, Khunti, on May 05, 2014 is under the administrative control of ICAR-IINRG, Ranchi. Dr. SP Singh, Sr. Sc. was the first officer-in-charge of KVK. Dr. J Ghosh, Pr. Sc. has been assigned the responsibility of In-charge–cum-Head, KVK on August 01, 2019. Construction of administrative building of KVK is under process. Two posts, one each of SMS Agro-meteorology and Agromet-Observer have been filled on contractual basis under GKMS of IMD, New Delhi. Recruitment of Senior Scientist-cum-Head, SMS/Scientists and other staff of KVK is under process. One post of Assistant is filled on transfer basis from ICAR-IINRG. The training programmes, FLDs, events, mentioned below, were organized/conducted during 2019.

[A] FLDs conducted by KVK

Sl. No.	Season	Crop	Technology	Seed (Kg)	Area (ha)	No of Demo.	No. of farmers (villages)	Yield q/ha Demo.	Yield q/ha non demo.	% Increase over non demo
1.	*Kharif*-2019	Paddy	*Sahbhagi Dhan*	120	4	10	27 (03)	33.2	15.5	114.19
		Pigeon pea	IPA-203	200	10	25	50(05)	-	-	-
		Lac	*Kusmi*	400		25	100(4)	-	-	-
2.	*Rabi*- 2019	Chick-pea	GNG 1458	390	5.5	8	40(3)	-	-	-
		Mustard	Pusa Bold	8	1.5	5	10(2)	-	-	-
3.	Summer-2020	Green gram	IPM 2-3	180	6	30	50(5)	-	-	-

Total 10 demonstrations were conducted on paddy crop during *Kharif* 2019. '*Sahbhagi Dhan*' performed well and gave 114.19% more yield over local variety used by farmers of these region, in rainfed condition.

Paddy at tillering stage

Paddy at maturity stage

Pigeonpea variety IPA-203 (200 kg) was distributed among 50 farmers of five different villages. Brood lac (400 kg) was distributed in four different villages among 100 farmers for winter lac crop. Chick pea GNG 1458 (390 kg) and mustard Pusa Bold (8 kg) was given among 40 and 10 farmers respectively in *rabi* season. Summer green gram IPM2-3 (180 kg) was distributed among 50 farmers at five different villages of Khunti district. These above mentioned crops are planted in 27 hectare and 277 farmers are benefited.

Distribution of green gram seed at Torpa

Mustard crop at farmer's field

Chick pea, pigeonpea and lac crop monitoring at farmer's field

[B] Extension activities conducted

Sl. No.	Activity	Villages covered	Participants
1.	On-campus at ICAR-IINRG (KVK, Khunti) 5 days training of farmers on lac production	3	66
2.	Off campus training of farmers on plantation technology of vegetables and fruit plants	20	1450
3.	Off campus farmers training on vegetable cultivation	02	145
4.	Off campus farmers training on cultivation of paddy, groundnut, soybean, green gram, black gram	20	2059
5.	Off campus farmers training on cultivation of chickpea, lentil and mustard	18	1966
6.	Scientist visits to fields	47	-

[C] Farmers' Trainings

On-campus training

First on-campus training on lac production for 5 days was conducted at ICAR-IINRG during Oct. 15 - 19, 2019 and second training during Oct. 21 - 25, 2019. Total 66 farmers from 3 villages were benefited.

Off campus training

It was conducted on plantation and cultivation technology of vegetables and fruit plants during 2019-20 at different villages of Khunti district, in which 1595 farmers from 22 villages were benefited. During *kharif* season 2019, it was conducted on cultivation of paddy, groundnut, soybean, green gram and black gram in which 2059 farmers from 20 villages were benefited. Trainings on cultivation of chickpea, lentil and mustard were conducted in 18 villages of Khunti district during *rabi* season 2019 in which 1966 farmers were benefited. Total 5620 farmers got benefited through off campus training in Khunti district during 2019-20.

[D] Events/programmes organized

Parthenium Awareness Programme

Parthenium awareness week was organized in District Agriculture Office, Khunti district during August 16-22, 2019. Sri Ashok Samrat, District Agriculture Officer (DAO), Khunti was the Chief Guest on this occasion. 50 farmers, 20 ATM and BTM participated in the programme. Soil testing certificates were distributed among the farmers by DAO. Sri Amresh Kumar, I/c Project Director of ATMA was also present. Similar programmes were also organized at different villages of Khunti district.

Parthenium awareness programme at DAO

Parthenium awareness programme at Bagdu, Khunti

National Animal Disease Control Programme (NADCP)

A detailed programme was planned by Hon'ble Prime Minister on September 11, 2019 in Mathura (Uttar Pradesh) on the occasion of launch of National Animal Disease Control Programme (NADCP) for FMD and Brucellosis along with National Artificial Insemination Programme (NAIP). These programmes were started in India, so that animal should be free from disease and genetic upgradation of indigenous cows can be done. With view to this, NADCP for FMD and Brucellosis and NAIP were organized on September 11, 2019 at Tutikel, Panchayat–sode, Block-Rania. Dr. Sanjay Kumar, Block Animal Husbandry Officer was Chief Guest in this programme. Sri Akash Kumar, Coordinator, Torpa Rural Development Society for Women (TRDS) and Sri Bindeshwar Singh, Social Worker along with 120 farmers were present during the programme.

Parthenium awareness programme at Bagdu, Khunti

'*Vrihad Vriksha Ropan Abhiyan* and *Kisan Gosthi*

Vrihad vriksha ropan abhiyan programme was conducted on September 18, 2019 at Koynara village, Panchayat-Banie, Block–Rania, Khunti and in the premises of KVK, in which more than 200 farmers participated. In this occasion different tree (*teak*, *jamun*, guava, *gamhar*, *mahogany*) were distributed by KVK. Sri Ashok Samrat, DAO was Chief Guest in this programme. Sri Samrat and Dr. J Ghosh, Pr. Sc. & I/c, KVK addressed the farmers emphasizing the importance of plantation and thereby increasing their income.

Tree plantation programme at KVK campus

Swachhta Hi Sewa Awareness Programme

During *Swachhta Hi Sewa* Awareness, KVK organized several programmes at different villages of Khunti district. These programmes were conducted in villages and primary school on October 01, 2019 at Banietoli, Torpa. Forty five farmers and 30 students participated in this awareness programme. The participants were made aware about how to keep our home and our surroundings clean and how plastic is polluting our environment. Sri Rajan Chaudhari, SMS (Agromet), Sri Vidyapati Vidyakar (Technical Assistant) and Sri Ashutosh Prabhat (Agromet Observer) briefed the participants about the ill-effects of plastics on human health and environment.

Tree plantation programme at KVK campus

Fertilizer Application Awareness Programme-cum-Farmers Training

Fertilizer application awareness programme was organized by KVK on October 22, 2019 at ICAR–IINRG campus in which around 150 farmers from different villages of Khunti district took part. Live streaming of the launch of inaugural programme on Fertilizer Application Awareness by Sri Narendra Singh Tomar, Hon'ble Minister, Ministry of Agriculture and Farmers Welfare, Government of India, NAASC Complex, ICAR, New Delhi was shown to the participants. Dr. KK Sharma, Director, ICAR-IINRG was Chief Guest on the occasion. Dr. DK Shahi, Chief Scientist-cum-Chairman, Soil Science & Agricultural Chemistry, Birsa Agricultural University, Ranchi was present as an expert member. Dr. Shahi delivered lecture on Right use of fertilizer on the crops. Dr. KK Sharma, Director expressed views on use and importance of fertilizer in our life besides giving emphasis on integrated soil health management with minimum fertilizer use. Dr. Nirmal Kumar, Pr. Sc. & Head, ToT Division described the importance of nutritional value of the food we eat is directly related to the health of the soil.

Swachhta Hi Sewa awareness programme at Primary School *(Amma panchayat)*

Gramin Krishi Mausam Sewa

Gramin Krishi Mausam Sewa (GKMS) is a newly launched programme by IMD in KVK. This programme was conducted at different villages like Banietoli, Kherkhie, Kotta, Baghia, Tangerkela, Torpa, Balalaung and at DAO in Khunti. Sri Rajan Chaudhari, SMS (Agromet) delivered a lecture on Importance of weather forecast in farming among farmers. In this programme farmers were given necessary suggestions for weather-based farming and to prevent the loss of crops. Around 3050 farmers participated at different village levels and they made aware about maintenance of crops due to the changes in the weather as well as sowing time of crop and how and when to irrigate, perform weeding, spray the pesticides and fungicides etc.

Farmers awareness programme at village Baghia

Farmers awareness programme at ICAR-IINRG

[E] Participation in Conferences/Seminars/ Workshops/Meetings by Dr. J Ghosh, Pr. Sc. & I/c, KVK

- Attended Annual workshop of KVKs of Zone IV, ATARI, Patna, April 16, 2019.
- Attended training programme on Uploading & management/maintenance of KVK website of KVKs of Jharkhand, Birsa Agricultural University, Ranchi, June 28, 2019.
- Participated in workshop on Development of contingent plan for Jharkhand, Directorate of Extension Education, Birsa Agricultural University, Ranchi, July 19, 2019,
- Attended training on PFMS for KVKs, Birsa Agricultural University Ranchi, September 25-26, 2019.
- Participated in 33rd Extension Council Meeting, Birsa Agricultural University, Ranchi, October 16, 2019.

संस्थान के राजभाषा प्रकोष्ठ की गतिविधियां

भारत सरकार के राजभाषा विभाग (गृह मंत्रालय) द्वारा तैयार किए गए वार्षिक कार्यक्रम एवं राजभाषा अधिनियम व नियमों के संबंध में भारतीय कृषि अनुसंधान परिषद, नई दिल्ली से समय–समय पर प्राप्त निर्देशों पर अनुवर्ती कार्रवाई तथा सरकारी कार्य में हिन्दी के प्रयोग को और गति प्रदान करने के लिए संस्थान में राजभाषा प्रकोष्ठ की स्थापना की गई है। इसमें एक वरिष्ठ तकनीकी अधिकारी (रा.भा.), एक अंशकालीन टंकक तथा एक अंशकालीन पदचर कार्यरत हैं। संस्थान में राजभाषा संबंधी क्रिया–कलापों की समीक्षा के लिए संस्थान के निदेशक की अध्यक्षता में संस्थान राजभाषा कार्यान्वयन समिति गठित की गई है, जिसमें विभागों/अनुभागों के अध्यक्ष, सदस्य के रुप में शामिल हैं तथा सहायक मुख्य तकनीकी अधिकारी (रा.भा.) सदस्य सचिव हैं ।

संस्थान 'क' क्षेत्र में है, इसे राजभाषा अधिनियम की धारा 10(4) के अर्न्तगत केन्द्रीय बजट में अधिसूचित किया जा चुका है। संस्थान के सात अनुभागों को शत प्रतिशत कार्य हिन्दी में करने हेतु विनिर्दिष्ट किया गया है एवं प्रवीणता प्राप्त सभी अधिकारियों/कर्मचारियों को अपना–अपना कार्य हिन्दी में करने हेतु व्यक्तिशः आदेश दिये गये हैं। राजभाषा नियम के प्रावधानों के अनुपालन एवं दैनिक कार्य में हिन्दी के प्रयोग में प्रगति लाने तथा इसे सर्वग्राह्य बनाने के लिए राजभाषा प्रकोष्ठ द्वारा निम्नलिखित कार्य सम्पादित होते हैः–

संस्थान राजभाषा कार्यान्वयन समिति की तिमाही बैठकों का आयोजन, कार्यसूची एवं कार्यवृत की तैयारी तथा बैठकों में लिए गये निर्णयों पर अनुवर्ती कार्रवाई। वार्षिक रिपोर्ट के हिन्दी संस्करण का प्रकाशन, राजभाषा की वार्षिक पत्रिका लाक्षा का प्रकाशन, कार्यालय आदेश, परिपत्र, ज्ञापन, निविदा इत्यादि एवं पत्राचार हेतु विभिन्न सामग्रियों का आवश्यकतानुसार अनुवाद। हिन्दीतर अधिकारियों और कर्मचारियों को हिन्दी शिक्षण योजना द्वारा आयोजित प्रशिक्षण एवं नगर राजभाषा कार्यान्वयन समिति के सदस्य कार्यालयों द्वारा आयोजित विभिन्न हिन्दी प्रतियोगिताओं एवं कार्यशालाओं में सहभागिता हेतु प्रेरित करना।

- संस्थान के दैनिक कार्य में हिन्दी के प्रयोग में प्रगति एवं इसे सरल बनाने के लिए राजभाषा प्रकोष्ठ द्वारा निम्नलिखित कार्य सम्पादित होते हैं:
- संस्थान राजभाषा कार्यान्वयन समिति की बैठकों का आयोजन, कार्यसूची एवं कार्यवृत की तैयारी एवं बैठकों में लिए गये निर्णयों पर अनुवर्ती कार्रवाई।
- वार्षिक रिपोर्ट के हिन्दी संस्करण एवं वार्षिक राजभाषा पत्रिका लाक्षा का प्रकाशन, भा.प्रा.रा.गों.सं. समाचार पत्रिका, कार्यालय आदेश, परिपत्र, ज्ञापन, निविदा, सूचना एवं पत्राचार हेतु विभिन्न सामग्रियों का अनुवाद।
- अधिकारियों और कर्मचारियों को नगर राजभाषा कार्यान्वयन समिति के सदस्य कार्यालयों द्वारा आयोजित विभिन्न हिन्दी प्रतियोगिताओं एवं कार्यशालाओं में सहभागिता हेतु प्रेरित करना।
- हिन्दी दिवस, हिन्दी चेतना मास एवं योजनानुसार नगर स्तरीय राजभाषा संबंधी, संगोष्ठी एवं कार्यशाला का आयोजन करना।
- संदर्भ साहित्य, हिन्दी पत्रिका, शब्दकोश, एवं तकनीकी शब्दावली के उपार्जन हेतु कार्य।
- द्विभाषी मुहरों, नामपट्ट के निर्माण अथवा सक्रिय सहयोग करना।
- प्रचार सामग्रियों के हिन्दी रूपान्तर एवं समारोहों के समाचार संकलन एवं मीडिया प्रबंधन का कार्य
- विभागीय विषय पर तकनीकी शब्दावली का निर्माण।
- हिन्दी में वैज्ञानिक गोष्ठी के साथ साथ प्रशासनिक तथा तकनीकी वर्ग के लिए कार्यशाला का आयोजन।
- निदेशक महोदय की अध्यक्षता में वर्ष 2019 में संस्थान राजभाषा कार्यान्वयन समिति की चारों तिमाही बैठकों का आयोजन निम्नलिखित तिथियों को किया गया तथा प्रगति की समीक्षा की गई। तिमाही रिपोर्ट एवं कार्यवृत परिषद सहित अन्य संबंधित कार्यालयों में प्रेषित की गईः

  (क) दिनांक 16.02.2019
  (ख) दिनांक 21.5.2019
  (ग) दिनांक 19.8.2019
  (घ) दिनांक 14.11.2019

जिसके अर्न्तगत निम्नलिखित प्रमुख चर्चायें हुईं तथा सर्वसम्मति से निर्णय लिए गए :–

- संस्थान में हिन्दी में मूल रूप से पत्राचार बढ़ाने के लिए नकद पुरस्कार योजना का अनुपालन।
- वार्षिक कार्यक्रम 2018–19 एवं 2019–20 के प्रस्ताव पर चर्चा।

- गृह पत्रिका लाक्षा–2019 का प्रकाशन।
- वर्ष 2019–20 के लिए नकद पुरस्कार योजना लागू करना एवं वर्ष 2018–19 के प्रतिभागियों के लिए पुरस्कार का निर्धारण।
- नगर स्तरीय हिन्दी संगोष्ठी/कार्यशाला का आयोजन।
- जैविक खेती, स्वास्थ्य संबंधी विषय पर हिन्दी कार्यशाला/व्याख्यान का आयोजन।
- द्विभाषी मुहरों का निर्माण।
- द्विभाषी नामपट्ट की व्यवस्था।
- लाक्षा–2018 के सर्वश्रेष्ठ आलेख का चयन एवं पुरस्कार।
- हिन्दी दिवस/हिन्दी प्रतियोगिताओं का आयोजन।
- प्रवीणता प्राप्त सभी अधिकारियों/कर्मचारियों को व्यक्तिशः आदेश जारी करना।
- सभी कम्प्यूटरों में यूनिकोड या गुगल हिन्दी सॉफ्टवेयर की व्यवस्था।
- अनुवाद के लिए आउटसोर्सिंग।
- हिन्दी पुस्तकों का उपार्जन।
- जाँच–बिन्दु का निर्धारण।
- राजभाषा नियम 8(4) के अन्तर्गत संस्थान के सात अनुभागों एवं प्रौ. ह. विभाग के प्रशिक्षण प्रकोष्ठ को सम्पूर्ण कार्य हिन्दी में करने हेतु विनिर्दिष्ट करना।

राजभाषा प्रकोष्ठ की उपलब्धियां–2019

- "प्राकृतिक राल एवं गोंद– भा.प्रा.रा.गों.सं. समाचार पत्रिका" का सम्पूर्ण अनुवाद किया गया एवं आउटसोर्सिंग द्वारा सम्पूर्ण वार्षिक रिपोर्ट का अनुवाद कराया गया।
- संस्थान की वार्षिक हिन्दी पत्रिका लाक्षा–2019 का प्रकाशन किया गया।
- संस्थान के आगत–निर्गत पत्रों का विस्तृत (अनुभाग/विभाग व क्षेत्रवार) विवरण तैयार कर विहित प्रपत्र में तिमाही रिपोर्ट तैयार की गयी तथा परिषद् समेत सभी संबंधित कार्यालयों को प्रेषित की गयी।
- वैज्ञानिक उपकरणों से जुड़े कम्प्यूटरों को छोड़कर संस्थान के कुछ अन्य कम्प्यूटरों में हिन्दी फॉन्ट लगा दिये गये हैं तथा ज्यादातर कम्प्यूटरों में युनीकोड/गुगल हिन्दी सॉफ्टवेयर डाला गया है।
- समय–समय पर हिन्दी के प्रयोग को प्रोत्साहित करने के लिए विभिन्न प्रकार की हिन्दी प्रतियोगिताओं का आयोजन किया गया।
- हिन्दी में श्रुतिलेखन (डिक्टेशन) देने के लिए पुरस्कार योजना संस्थान में लागू की गई है।
- लाक्षा–2018 के सर्वश्रेष्ठ आलेख के चयन के लिए कमिटी गठित कराई गई तथा सर्वश्रेष्ठ आलेख का चयन कर लेखकों को पुरस्कार प्रदान किया गया।
- सरकारी काम काज मूल रूप से हिन्दी में करने हेतु संस्थान में नकद पुरस्कार योजना लागू की गई, इसमें तकनीकी एवं प्रशासनिक वर्ग के कुल 11 अधिकारियों/कर्मचारियों को पुरस्कार प्रदान किए गए।

कार्यक्रमों का आयोजन

- नगर राजभाषा कार्यान्वयन समिति, राँची के सदस्य कार्यालयों के बीच 16 अक्तूबर 2019 को जलवायु परिवर्त्तन एवं जैवविविधता विषय पर संस्थान में नगर स्तरीय एक दिवसीय हिन्दी संगोष्ठी का आयोजन किया गया। आयोजित कार्यक्रम में राँची शहर के 28 कार्यालयों के 135 अधिकारियों/कर्मचारियों ने भाग लिया। इस अवसर पर दो तकनीकी सत्रों में दो विशेषज्ञों तथा संस्थान के दो वैज्ञानिकों ने अपने विचार व्यक्त किए। खुली चर्चा के दौरान प्रतिभागियों ने भी अपने विचार प्रकट किए तथा इस समस्या पर विस्तृत विचार–विमर्श किया गया।
- आयकर एवं यात्रा भत्ता नियम विषय पर दिनांक 12.02.2019 को तथा मतदाता जागरूकता विषय पर दिनांक 06.4.2019 को हिन्दी कार्यशाला सह व्याख्यान का आयोजन किया गया। तनाव प्रबंधन विषय पर दिनांक 02.8.2019 को हिन्दी कार्यशाला सह व्याख्यान के आयोजन में सहयोग किया गया।

पुरस्कार व सम्मान

- संस्थान की राजभाषा पत्रिका लाक्षा–2018 को भारतीय कृषि अनुसंधान परिषद के 'क' एवं 'ख' क्षेत्र के संस्थानों के बीच गणेश शंकर विद्यार्थी राजभाषा पत्रिका द्वितीय पुरस्कार प्रदान किया गया। पुरस्कार 16 जुलाई, 2019 को परिषद् के स्थापना दिवस के अवसर पर नई दिल्ली में आयोजित समारोह में संस्थान के निदेशक डॉ केवल कृष्ण शर्मा एवं वरिष्ठ तकनीकी अधिकारी डॉ अंजेश कुमार ने

डॉ पंजाब सिंह, पूर्व महानिदेषक, भारतीय कृषि अनुसंधान परिषद् की गरिमामयी उपस्थिति में डॉ त्रिलोचन महापात्र, सचिव, कृ.अनु.शि.वि. तथा महानिदशक, भाकृअनुप, नई दिल्ली से द्वितीय पुरस्कार प्राप्त किया।

निदेशक द्वारा पुरस्कार–ग्रहण

हिन्दी दिवस समारोह–2019

भारतीय प्राकृतिक राल एवं गोंद संस्थान में राजभाषा अधिनियम के अनुपालन एवं कार्यालय कार्य में राजभाषा हिन्दी के प्रयोग में उत्तरोत्तर वृद्धि के लिए संस्थान में दिनांक 01.9.2019 से 30.09.2019 तक हिन्दी चेतना मास का पालन किया गया। इसके अन्तर्गत दिनांक 30.09.2019 को अपराह्न 02.00 बजे हिन्दी दिवस समारोह का आयोजन किया गया।

हिन्दी दिवस समारोह के अवसर पर मुख्य अतिथि के रूप में उपस्थित श्री कुमार अनिल भास्कर, वरीय स्थानीय संपादक, हिन्दुस्तान, हिन्दी दैनिक, राँची ने कहा कि भाषा का विस्तार साहित्य और जीवन में आत्मसात करने से होता है। आज पूरी दुनिया में हिन्दी पत्रकारिता के भविष्य पर सवाल उठ रहे हैं। हिन्दी पत्रकारिता की शुरूआत पवित्र थी, पर आज कोई लक्ष्य नहीं है। भौतिकवाद के दबाव में मीडिया उद्योग बन गई है और समाज को जगाने के काम छोड़ कंज्युमर बना लिया गया है।

इस अवसर पर विशिष्ठ अतिथि डॉ नीलिमा पाठक, प्राध्यापक, संस्कृत विभाग, राँची विश्वविद्यालय ने सभा को संबोधित करते हुए कहा कि हिन्दी को किसी भी प्रकार से तोड़–मरोड़ कर प्रयोग कर सकते हैं। हिन्दी भाषा में उर्दू, तुर्की, फारसी, अंग्रेजी शब्द का प्रयोग हो रहा है। हिन्दी किसी भी भाषा को आसानी से स्वीकार कर लेती है। हिन्दी ने दुनिया भर की भाषाओं के शब्दों को अपने आंचल में समेटा है। यह इतनी समृद्ध भाषा है कि क्षेत्रीय भाषाएं हिन्दी से नाता जोड़ लेती हैं। उन्होंने कहा स्वदेशी आंदोलन के बाद हिन्दी का प्रचार–प्रसार हुआ। वर्तम. ान में फेसबुक व इंटरनेट के बढ़ते प्रभाव से आम लोग अंग्रेजी के करीब आ चुके हैं। देश में हिन्दी बोलने और समझने वालों की संख्या अधिक होने के बावजूद हमें आज हिन्दी दिवस मनाने की जरूरत पड़ रही है।

संस्थान के निदेशक, डॉ केवल कृष्ण शर्मा ने अपने स्वागत भाषण में कहा कि हिन्दी चेतना मास के अन्तर्गत हिन्दी दिवस समारोह का आयोजन किया गया है। संस्थान में लम्बे समय से राजभाषा हिन्दी का प्रयोग होता रहा है। हमारे यहाँ कार्यालय कार्य के साथ–साथ वैज्ञानिक साहित्य में भी हिन्दी का अच्छा प्रयोग हो रहा है। संस्थान द्वारा नियमित अंतराल पर हिन्दी/द्विभाषी पुस्तिकाएं, पत्रक इत्यादि प्रकाशित होते रहते हैं। हिन्दी सर्व प्रसारित भाषा है।

इस अवसर पर सभा को संबोधित करते हुए भारतीय कृषि जैव प्रौद्योगिकी संस्थान, गढ़खटंगा, राँची के निदेशक डॉ तिलक राज शर्मा ने हिन्दी दिवस समारोह के अवसर पर शुभकामनाएं देते हुए कहा कि विश्व की तीसरी सबसे ज्यादा बोली जाने वाली भाषा है। इसके बावजूद हम हिन्दी दिवस मनाते हैं।

हिन्दी चेतना मास की अवधि में दिनांक 11–12 सितम्बर, 2019 को हिन्दी टिप्पण, प्रारूप लेखन, निबंध, अंताक्षरी, पर्याय एवं विपरीतार्थक शब्द प्रतियोगिताओं का आयोजन किया गया। डॉ एम जेड सिद्दीकी, डॉ अर्णब रायचौधुरी, श्री कामेश्वर उराँव, इत्यादि को पुरस्कार प्रदान किया गया। इसके साथ ही समारोह में लाक्षा–2018 में उत्कृष्ठ आलेख का पुरस्कार भी प्रदान किया गया। यह कार्यक्रम संस्थान एवं भारतीय कृषि जैव प्रौद्योगिकी संस्थान, गढ़खटंगा, राँची द्वारा संयुक्त रूप से आयोजित किया गया।

कार्यक्रम का संचालन डॉ अंजेश कुमार, वरिष्ठ तकनीकी अधिकारी एवं धन्यवाद ज्ञापन डॉ मो. फहीम अंसारी, प्रधान वैज्ञानिक एवं अध्यक्ष, हिन्दी दिवस समारोह आयोजन समिति ने किया। इस अवसर पर अन्य संस्थानों के अतिथियों के अतिरिक्त संस्थान के सभी अधिकारियों/कर्मचारियों ने भाग लिया।

अतिथियों द्वारा दीप प्रज्जवलन

जलवायु परिवर्त्तन एवं जैवविविधता विषय पर एक दिवसीय नगर स्तरीय हिन्दी संगोष्ठी का आयोजन

संस्थान में 16 अक्तूबर, 2019 को पूर्वाहन 10.00 बजे जलवायु परिवर्त्तन एवं जैवविविधता विषय पर एक दिवसीय नगर स्तरीय हिन्दी संगोष्ठी का आयोजन किया गया। मुख्य अतिथि के रूप में संगोष्ठी का शुभारम्भ करते हुए डॉ गोपाल पाठक, कुलपति, झारखंड प्रौद्यौगिकी विश्वविद्यालय, नामकुम, राँची ने कहा कि औद्योगीकरण एवं शहरीकरण से सुविधाएं बढ़ी, परन्तु इसके साथ–साथ ढ़ेर सारी कठिनाईयां भी आती गई है। उन्होंने बताया कि विश्व स्तर पर 1974 में पहली बार सभी देशों के शासनाध्यक्ष मिले तथा जलवायु परिवर्त्तन पर चर्चा की एवं इसके लिए कुछ संकल्प सुझाए गए। डॉ पाठक ने कहा कि पर्यावरण संरक्षण के लिए कड़े कानून की जरूरत है। अगर ध्यान नहीं दिया गया तो हर आने वाला दिन भारी पड़ेगा।

समारोह का शुभारंभ मुख्य अतिथि द्वारा दीप प्रज्जवलन के साथ हुआ तथा संस्थान के निदेशक डॉ केवल कृष्ण शर्मा ने पुष्पगुच्छ देकर अतिथियों का अभिनंदन किया। अपने स्वागत भाषण में डॉ केवल कृष्ण शर्मा ने मुख्य अतिथि, अन्य अतिथियों, विशेषज्ञों, विभिन्न कार्यालयों से आये हुए प्रतिभागियों, समाचार माध्यम के प्रतिनिधियों के प्रति आभार प्रकट किया तथा संस्थान की गतिविधियों एवं उपलब्धियों की जानकारी दी। उन्होने बताया कि हमारी समस्या यह है कि हम अपने को प्रकृति के अनुरूप ढ़ालने के बजाय प्रकृति को हीं अपने अनुसार ढ़ालने लगते हैं। इसके कारण समस्याएं दिनों–दिन बढ़ती जा रहीं हैं। डॉ शर्मा ने कहा कि प्रत्येक व्यक्ति को इसके लिए जाग. रूक करने की आवश्यकता है। उन्होंने कहा कि तापमान में विश्वव्यापी वृद्धि से कृषि पर प्रतिकूल प्रभाव पड़ रहा है।

संगोष्ठी को संबोधित करते हुए डॉ तिलक राज शर्मा, निदेशक, भारतीय कृषि जैव प्रौद्योगिकी संस्थान, गढखटंगा, राँची ने कहा कि जलवायु परिवर्त्तन के लिए बढ़ती जनसंख्या भी जि. म्मेवार है। उससे संसाधनों पर बोझ बढ़ रहा है। उन्होंने कहा कि 2050 तक विश्व में दो अरब लोग और बढ़ जाएंगे।

संगोष्ठी का आयोजन नगर राजभाषा कार्यान्वयन समिति (केन्द्र सरकार के कार्यालय), राँची के तत्वावधान में किया गया एवं भारतीय कृषि जैव प्रौद्योगिकी संस्थान, गढ़खटंगा, राँची इस आयोजन के सह–प्रायोजक थे। संगोष्ठी के प्रथम तकनीकी सत्र में व्याख्यान देते हुए डॉ ए बदूद, अध्यक्ष, कृषि मौसम विज्ञान विभाग, बी ए यू, कांके ने बताया कि जलवायु परिवर्त्तन के कारण आए दिन विश्व के किसी न किसी कोने में तूफान, बाढ़ आ रही है। डॉ बदूद ने कहा कि झारखंड में सूखा नहीं, कृषि की दृष्टि से सूखा है। यहां बरसात में औसत वृद्धि हुई है, परन्तु बरसात के दिनों में कमी आई है। उन्होंने बताया कि 1990 से तापमान की वृद्धि में तेजी आई है।

प्रथम तकनीकी सत्र में संस्थान के डॉ वैभव डी लोहोट, वैज्ञानिक ने जलवायु परिवर्त्तन का कीटों पर प्रभाव विषय पर बोलते हुए कहा कि लाख की खेती पर तापमान वृद्धि का बहुत प्रतिकूल असर पड़ रहा है।

संगोष्ठी के द्वितीय तकनीकी सत्र में डॉ देवमणि पाण्डेय, प्राध्यापक, जैव प्रौद्योगिकी विभाग, बी आई टी, मेसरा ने व्याख्यान दिया। उन्होंने जैवविविधता के विभिन्न आयाम पर प्रकाष डाला तथा पर्यावरण संतुलन के लिए व्यापक सामाजिक वानिकी पर जोर दिया।

द्वितीय तकनीकी सत्र में बोलते हुए संस्थान के डॉ राजकुमार योगी, वैज्ञानिक ने पर्यावरण एवं सतत विकास विषय पर बोलते हुए बताया कि संतुलित पर्यावरण से ही विकास में निरंतरता बनी रह सकती है।

संगोष्ठी के बारे में जानकारी देते हुए संयोजक एवं प्रधान वैज्ञानिक डॉ नवलेश कुमार सिन्हा ने कार्यक्रम के उद्देश्यों पर प्रकाश डाला। उन्होंने बताया कि ग्लेशियर के पिघलने के कारण समुद्र का जलस्तर बढ़ रहा है। वनों के अंधाधुन कटाई से जलवायु पर प्रतिकूल प्रभाव पड़ा है।

संगोष्ठी में राँची स्थित केन्द्र सरकार के कार्यालयों के अधिकारियों/कर्मचारियों के अतिरिक्त संस्थान एवं भारतीय कृषि जैव प्रौद्योगिकी संस्थान के वैज्ञानिकों, अधिकारियों ने भाग लिया। समापन सत्र के पूर्व आयोजित खुली चर्चा में प्रतिभागियों ने भाग लिया। इस कार्यक्रम में नगर स्थित केन्द्र सरकार के कार्यालयों क्षेत्रीय पासपोर्ट कार्यालय, तसर अनुसंधान एवं प्रशिक्षण संस्थान, जनगणना कार्य निदेशालय, भारतीय सर्वेक्षण विभाग, मुख्य डाक महाध्यक्ष कार्यालय, झारखण्ड परिमण्डल, महानिरीक्षक का कार्यालय, केन्द्रीय औद्योगिक सुरक्षा बल, केन्द्रीय मनश्चिकित्सा संस्थान, केन्द्रीय रिजर्व पुलिस बल, सी बी आई, केन्द्रीय विद्यालय, महालेखाकार कार्यालय, प्रधान आयुक्त, केन्द्रीय माल एवं सेवा कर, सूक्ष्म, लघु एवं मध्यम उद्यम मंत्रालय, विमानपत्तन प्राधिकारण, श्रमिक शिक्षा बोर्ड, क्षेत्रीय निदेशालय, केन्द्रीय जल आयोग, प्रबोधन एवं मूल्यांकन निदेशालय, वाणिज्यिक लेखा परीक्षा, एन बी पी जी आर, भाकृअनुप–पूर्वी क्षेत्र अनुसंधान केन्द्र, केन्द्रीय भूमि जल बोर्ड

इत्यादि के अधिकारियों सहित दोनो संस्थान के विभागाध्यक्ष, वैज्ञानिकों, तकनीकी कार्मिकों तथा वरिष्ठ अधिकारियों समेत कुल 28 कार्यालयों के 135 कार्मिकों ने भाग लिया।

संगोष्ठी का उद्देश्य जलवायु में लगातार हो रहे परिवर्त्तन का आम जनजीवन के साथ–साथ जैवविविधता पर पड़ रहे असर के प्रति लोगों को जागरूक करना था। संगोष्ठी का संचालन आयोजन समिति के सचिव एवं वरिष्ठ तकनीकी अधिकारी, डॉ अंजेश कुमार ने तथा धन्यवाद ज्ञापन वरिष्ठ वैज्ञानिक, डॉ मदन कुमार, भारतीय कृषि जैव प्रौद्योगिकी संस्थान, गढ़खटंगा, राँची ने किया।

डॉ केवल कृष्ण शर्मा, निदेशक द्वारा संबोधन

Budget

Budget allocation and utilization during Financial Year 2019-20

Head of Expenditure	Other than NEH & TSP		NEH/SCSP		Total	
	Approved RE	Expenditure	Approved RE	Expenditure	Approved RE	Expenditure
IINRG			**SCSP**	**SCSP**		
Grant-in-aid Capital	105.00	102.83	66.51	56.20	171.51	159.04
Grant-in-aid Salaries	1296.33	1296.10	0.00	0.00	1296.33	1296.10
Pension	316.27	316.26	0.00	0.00	316.27	316.26
Grant-in-aid-General	550.00	540.93	39.75	32.94	589.75	573.87
Total	**2267.60**	**2256.12**	**106.26**	**89.14**	**2373.86**	**2345.26**
NWP ON HPVA of NRGs						
Grant-in-aid Capital	8.60	8.10	1.12	1.12	9.72	9.22
Grant-in-aid Salaries	0.00	0.00	0.00	0.00	0.00	0.00
Grant-in-aid-General	147.56	146.61	14.59	14.59	162.15	161.20
Total	**156.16**	**154.71**	**15.71**	**15.71**	**171.87**	**170.42**
NWP ON CLIGR						
Grant-in-aid Capital	21.00	12.94	1.12	1.12	22.12	14.06
Grant-in-aid Salaries	0.00	0.00	0.00	0.00	0.00	0.00
Grant-in-aid-General	161.50	161.46	16.53	16.53	178.03	177.99
Total	**182.50**	**174.40**	**17.65**	**17.65**	**200.15**	**192.05**
REVENUE GENERATION TARGETS & ACHIEVEMENTS						
Financial Year		**Target for the Financial Year**		**Revenue Generated**		
2019-20		**135.41**		**45.02**		

Personnel

Details of scientific, technical, administrative and supporting staff (including KVK) as on December 31, 2019

Scientific	Sanctioned strength	In position
RMP	1	1
Pr. Scientist	6	2
Sr. Scientist	15	5
Scientist	26	20
Total	48	28
Technical		
Category-I	43	29
Category-II	23	18
Category-III	6	
Total	72	47
Administrative		
Sr. AO	1	1
F & AO	1	1
AAO	2	2
Private Secretary	1	1
Security Officer	1	1
JAO	1	-
PA	2	-
Assistant	11	8
Sr. Clerk	5	4
Jr. Clerk	6	-
Steno Gr. III	2	1
Total	33	19
Skilled Support Staff		
SSS	84	43
Cadre	**Sanctioned post**	**In position**
Scientific	48*	28
Technical	72	47
Administrative	33	19
Supporting	84	43
Total	237	137
*Including RMP		

PERSONNEL	
Dr. KK Sharma	**Director**
LAC PRODUCTION DIVISION	
Dr. S Ghosal, Pr. Sc. & I/c Head	Agronomy
Dr. NK Sinha, Pr. Sc.	Seed Technology
Dr. VD Lohot, Sr. Sc.	Plant Physiology
Dr. (Ms) Thamilarasi K, Sr. Sc.	Agril Biotechnology
Dr. A Mohanasundaram, Sc.	Agri Entomology
Sri Asish Kr Raut, Sc.	Agril Entomology
Er. SK Srivastava, Sc.	SWCE
Ms Shruti Sinha, Sc.	Agril Biotechnology
Ms LC Langlentombi, Sc.	Agroforestry
Md PA Ansari, STO	F/F Tech Group
Sri SK Tripathi, STA	F/F Tech Group
Ms Naaserah Zeeshan, TA	F/F Tech Group
Ms Kumari Soni, TA	Lab Tech Group
Sri Vidyapati Vidyakar, TA	Lab Tech Group
Sri Harihar Singh, TA	F/F Tech Group
Sri SK Yadav	Private Secretary
PROCESSING & PRODUCT DEVELOPMENT DIVISION	
Dr. N Prasad, Pr. Sc. & Head	ASPE
Dr. S Srivastava, Pr. Sc.	Agril Chem
Dr. (Ms) MZ Siddiqui, Pr. Sc.	Agril Chem
Dr. MF Ansari, Pr. Sc.	Agril Chem
Dr. SC Sharma, Sr. Sc.	FM & Power
Er. SK Pandey, Sc.	Mech Engg
Dr. AR Chowdhury, Sc.	Agril Chem
Dr. Nandkishore Thombare, Sc.	Agril Chem
Sri CJ Mate, Sc.	Agril Chem
Sri Md. Ali, Sc.	Agril Chem
Er. Ranjit Singh, Sc.	ASPE
Er. Anamika Thakur, Sc.	ASPE
Er. Priyanka Sakare, Sc.	ASPE

Sri Ajay Kumar, STA	Lab Tech Group
Sri RK Rai, STA	Lab Tech Group
Sri Anup Kumar, STA	Lab Tech Group
Sri Binod Kumar, STA	Lab Tech Group
Ms Asha Kumari, TA	Lab Tech Group
Sri Dewbrath Hari, TA	Lab Tech Group
Sri Haraprasad Naiya, TA	Lab Tech Group
TRANSFER OF TECHNOLOGY DIVISION	
Dr. Nirmal Kumar, Pr. Sc. & I/c Head	Agril Extension
Dr. J Ghosh, Pr. Sc.	Gen & Plant Breeding
Dr. SKS Yadav, Sc.	Agril Chem
Dr. RK Yogi, Sc.	Agril Economics
Sri P Patamajhi, STO	F/F Tech Group
Sri DK Singh, STO	F/F Tech Group
Sri AK Sinha, STO	F/F Tech Group
Sri SB Azad, TO	F/F Tech Group
Sri MadanMohan, STA	F/F Tech Group
Md Tariq Zaman, STA	F/F Tech Group
***KRISHI VIGYAN KENDRA* (KVK)**	
Dr. J Ghosh, Pr. Sc.	I/c Head
Smt. Laxmi Kumari	Assistant
Sri Ranjan Choudhary	SMS
Sri Ashutosh Prabhat	Agromet Observer
PME CELL	
Dr. MZ Siddiqui, Pr. Sc.	I/c PME Cell
Sri Dipankar Ganguly, ACTO	Lab Tech Group
Sri Sunil Kumar, ACTO	Lab Tech Group
ESTATE SECTION	
Sri AK Yadav	Security Officer
Sri HL Bhakta, TO	W & Engg Group
Sri BinayKumar, TO	W & Engg Group
Sri Arjun Sharma, STA	W & Engg Group
Sri RK Ravi, STA	W & Engg Group
Sri K Tirkey, STA	W & Engg Group
Sri PVD Tirkey, STA	W & Engg Group
Sri RK Singh, STA	W & Engg Group
Sri AK Sharma, STA	W & Engg Group
Sri M Mahto, STA	W & Engg Group
Sri Sukra Ekka, STA	W & Engg Group
Sri Chunmun Sinha, TA	W & Engg Group

RAJBHASHA PRAKOSTH	
Dr. Anjesh Kumar, ACTO	P & E Group
HEALTH CENTRE	
Dr. S Srivastava, Pr. Sc.	I/c Health Centre
Dr. Rima Khalkho	AMA
Dr. Kailash Prasad	AMA
Sri CK Singh, STA	Medical & Paramedical Group
QUALITY EVALUATION LAB (QEL)	
Dr. S Srivastava, Pr. Sc.	I/c QEL
Sri BK Singh, STA	Lab Tech Group
INSTITUTE RESEARCH FARM (IRF)	
Dr. A Mohanasundaram, Sc.	I/c IRF
Sri Satish Kumar, TO	F/F Tech Group
Sri Sunil Kumar Mukherjee, STA	F/F Tech Group
Sri Akash Sinha, TA	F/F Tech Group
Sri Jhirga Oraon, STA	W & Engg Group
AUDIT & ACCOUNTS SECTION	
Sri Ashwani Garg	F & AO
Sri Kameshwar Oraon	Assistant
Sri Arjun Gope	Assistant
ADMIN. I SECTION	
Sri Mahesh B Khubdikar	Sr. Administrative Officer
Sri SC Lal	Asstt. Administrative Officer
Sri KM Kumar	Assistant
Sri Bandhu Mahto	UDC
ADMIN. II SECTION	
Sri Raghunath Mahto	AAO/DDO
Sri RK Toppo	Assistant
Sri KP Kashi	Assistant
ADMIN. III SECTION	
Sri Abhishek Kumar	Assistant
Sri Samal Kumar	Assistant
Sri KK Deonath	UDC
DIRECTOR OFFICE	
Sri Hari Vilas	Steno to Director
VEHICLE POOL	
Sri Arvind Kumar, TO	W & Engg Group
Sri J Tewari, STA	W & Engg Group
Sri Mandeshwar Singh, STA	W & Engg Group
Sri RK Yadav, STA	W & Engg Group
Sri Bandi Lakra, STA	W & Engg Group

LIBRARY	
Sri Binod Kumar	STO

A. JOINING
Sri Ashwani Garg has joined to the post of Finance & Accounts Officer on 18.03.2019
Sri Mahesh B Khubdikar has joined to the post of Sr. Administrative Officer on 20.05.2019

B. PROMOTION
Dr. MF Ansari, Sr. Sc. promoted to the post of Pr. Sc. on 29.07.2016
Dr. J Ghosh, Sr. Sc. promoted to the post of Pr. Sc. on 21.01.2017
Dr. SKS Yadav, Sc. promoted to the next higher RGP on 16.01.2005
Dr. VD Lohot, Sr. Sc. promoted to the next higher RGP on 08.01.2016
Dr. Thamilarasi K., Sr. Sc. promoted to the next higher RGP on 26.06.2017
Dr. SC Sharma, Sc. promoted to the next higher RGP on 15.12.2018
Sri Sunil Kumar, STO promoted to the post of ACTO on 27.03.2018
Sri P Patamajhi, STO promoted to the post of ACTO on 26.07.2018
Dr. Anjesh Kumar, STO promoted to the post of ACTO on 01.01.2019
Sri KP Kashi, UDC promoted to the post of Assistant on 15.01.2019
Sri Krishna Murari Kumar, UDC promoted to the post of Assistant on 15.01.2019

C. APPOINTMENT
Sri Lokesh Meena has joined to the post of Technician on 09.01.2019
Sri Mausam Kumar Ram has joined to the post of Technical Assistant on 15.01.2019
Sri Anmol Dan Kindo has joined to the post of Technician on 15.01.2019

D. TRANSFER
Er. Anamika Thakur, Scientist relieved from ICAR-IINRG, Ranchi on 28.02.2019 to join at ICAR, New Delhi
Sri Amrendra Kishore, AAO relieved from ICAR-IINRG, Ranchi on 16.04.2019 to join at DOGR, Pune

E. RESIGNATION
Ms Asha Kumari, TA resign from service on 08.05.2019
Ms Kumari Soni, TA resign from service on 09.09.2019

F. RETIREMENT
Sri PA Ansari, STO on 31.01.2019
Sri J Tewari, STA on 31.01.2019
Sri Deodas Ram, SSS on 31.01.2019
Dr. Samarpal Singh, Sr. Sc. on 31.05.2019
Sri Kameshwar Saran, SSS on 31.05.2019
Sri DK Singh, STO on 30.11.2019
Smt. Mariam Lakra, SSS on 30.11.2019

G. DEATH
Late KK Deonath, EX-UDC on 25.04.2019
Late Mangu Tirkey, Ex-SSS on 15.05.2019
Late Lalu Mahto, EX-SSS on 23.09.2019

Appendix

Annexure-1: Farmers training programme on Scientific lac cultivation, processing and utilization

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of participants
January	1	CGMFP, Raipur (farmers from Bastar)	Chhattisgarh	07.01.19-11.01.19	14	-	14
February	2	Forest department, Dumka (DFO, Dumka)	Jharkhand	04.02.19-08.02.19	08	-	08
		Mukhyamantri Laghu Evam Kutir Udyog Vikas Board, (Jharkhand) (Khunti-09, Nowamundi-14)	Jharkhand	04.02.19-08.02.19	23	-	23
	3	JSPLS-JOHAR, Jharkhand	Jharkhand	19.02.19-23.02.19	18	37	55
March	4	*Mukhyamantri Laghu Evam Kutir Udyog Vikas Board*, (Jharkhand) (Simdega, Gumla, Ranchi, Deoghar districts)Note- 13425 & 13426- two trainees absent *w.e.f.* 05.03.2019. Certificate not prepared.	Jharkhand	04.03.19-08.03.19	42	04	46
		Private- 01, Mandar, Ranchi	Jharkhand	04.03.19-08.03.19	01	-	01
	5	*Mukhyamantri Laghu Evam Kutir Udyog Vikas Board*, (Jharkhand) Note- 13428 & 13461- two trainees absent *w.e.f.* 27.03.2019. Certificate not prepared.	Jharkhand	26.03.19-30.03.19	38	03	41
April	6	ATMA, Sahebganj, Jharkhand & *Zila Vanopaj Sahakri Sangh Maryadit*, Balrampur, Chhattisgarh Note- 13497, 13499, 13507 & 13519 – four trainees absent *w.e.f.* 10.04.2019. Certificate not prepared.	Chhattisgarh	08.04.19-12.04.19	43	11	54
	7	CGMFP, Raipur, Chhattisgarh	Chhattisgarh	15.04.19-19.04.19	29	-	29
May	8	JSPLS-JOHAR, Jharkhand	Jharkhand	20.05.19-24.05.19	13	35	48
		Private, Bundu, Ranchi	Jharkhand	20.05.19-24.05.19	01	-	01
June	9	JSPLS-JOHAR, Jharkhand	Jharkhand	24.06.19-28.06.19	19	08	27
August	10	NIRMAN, Gumla	Jharkhand	26.08.19-30.08.19	15	09	24
		Private, Sholapur, Maharashtra	Maharashtra	26.08.19-30.08.19	01	-	01
October	11	KVK, Khunti – ST Sub-Plan	Jharkhand	15.10.19-19.10.19	17	23	40
	12	KVK, Khunti – ST Sub-Plan	Jharkhand	21.10.19-25.10.19	20	06	26
December	13	KVK, Garhwa under SC-Sub-Plan	Jharkhand	17.12.19-21.12.19	18	04	22
Total					**320**	**140**	**460**

Annexure-2: HRD programme on Lac cultivation and processing (One Week)

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of participants
January	1	*Guru Ghasi* Das University, Bilaspur, C.G.	Chhattisgarh	21.01.19-25.01.19	19	04	23

Annexure-3: Training programme on Lac cultivation & primary processing of lac (One Week)

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of participants
February	1	World Food Programme (Forest Department) Jharkhand	Jharkhand	28.01.19-01.02.19	51	-	51
March	2	World Food Programme (Forest Department) Jharkhand Note- 0067, 0101 & 0102- three trainees absent *w.e.f.* 26.02.2019. Certificate not prepared.	Jharkhand	25.02.19-02.03.19	54	08	62
	3	World Food Programme (Forest Department) Jharkhand Note- 0157, 0158 & 0159 three trainees absent *w.e.f.* 13.03.2019. Certificate not prepared.	Jharkhand	12.03.19-16.03.19	34	12	46
April	4	World Food Programme (Forest Department) Jharkhand Note- 0196, 0197, 0204 & 0205 four trainees absent *w.e.f.* 03.04.2019. Certificate not prepared.	Jharkhand	01.04.19-06.04.19	35	26	61
		Private- Odisha	Odisha	01.04.19-06.04.19	01	01	02
	5	World Food Programme (Forest Department) Jharkhand Note- 0274, one trainee absent *w.e.f.* 24.04.2019. Certificate not prepared.	Jharkhand	22.04.19-27.04.19	42	05	47
May	6	World Food Programme (Forest Department) Jharkhand Note- 0280, 0281, 0294-0298, 0300 & 0301 nine trainee absent *w.e.f.* 30.04.2019. Certificate not prepared.	Jharkhand	29.04.19-04.05.19	40	-	40
	7	World Food Programme (Forest Department) Jharkhand Note- 0310, 0311, 0317 & 0336 four trainee absent *w.e.f.* 14.05.2019. Certificate not prepared.	Jharkhand	13.05.15-18.05.19	36	04	40
June	8	World Food Programme (Forest Department) Jharkhand Note- 0355, one trainee absent *w.e.f.* 19.06.2019. Certificate not prepared.	Jharkhand	17.06.19-22.06.19	45	-	45
July	9	World Food Programme (Forest Department) Jharkhand	Jharkhand	08.07.19-13.07.19	34	17	51
	10	World Food Programme (Forest Department) Jharkhand	Jharkhand	22.07.19-27.07.19	26	21	47
Total					**398**	**94**	**492**

Annexure-4: Educational programme on Industrial training on natural resins & gums (10/15 days)

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of participants
June	1	14th Summer Workshop on Natural Resins and Gums (10 days)- B.Sc. Ag students from Institute of Agriculture, Banaras Hindu University (BHU), Varanasi, U.P.	U.P.	27.05.19-05.06.19	11	08	19
		ICAR-IINRG, Namkum, Ranchi	Jharkhand	27.05.19-05.06.19	06	01	07

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of participants
July	2	15th Summer Workshop on Natural Resins and Gums (10 days)- undergraduate students of B.Sc. (Ag.) and B.Sc. (Forestry) from five different universities, namely, Quantum University, Roorkee (Uttarakhand), Himgiri Zee University, Dehradun (Uttarakhand), Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad (Uttar Pradesh), Doon Business School, Dehradun (Uttarakhand) and Jharkhand Rai University, Ranchi (Jharkhand)	Uttarakhand, U.P. and Jharkhand	27.06.19-06.07.19	13	28	41
		ICAR-IINRG, Namkum, Ranchi	Jharkhand	27.06.19-06.07.19	03	02	05
Total					**33**	**39**	**72**

Annexure-5: On-farm training programme on Scientific lac cultivation

Camp No.	District –State	Sponsoring/ Nominating Agency	Venue (Village, Block)	Date	M	F	No. of Participants
1	Khunti, Jharkhand	Forest Department, Khunti	*Kisan Bhavan*, Rania	27.01.19	81	09	90
2	Ranchi, Jharkhand	Forest Department, Khunti	Range Office, Bundu	31.01.19	52	-	52
3	Khunti, Jharkhand	Forest Department, Khunti	Range Office, Khunti	05.02.19	53	-	53
4	Dumka, Jharkhand	Forest Department, Dumka	Dumka Damini Forest Range, Kathikund	22.02.19	79	01	80
5	Pakur, Jharkhand	Forest Department, Pakur	Polytechnic College, Pakur	09.03.19	150	50	200
6	Godda, Jharkhand	Forest Department, Godda	Biodiversity Park, Godda	11.03.19	60	10	70
7	Saraikela, Jharkhand	Forest Department, Saraikela	*Van Chetna Bhawan*, Saraikela	15.03.19	52	03	55
8	Jamtara, Jharkhand	Forest Department, Jamtara	RFO Training Hall, Kundhit	16.03.19	30	28	58
9	Simdega, Jharkhand	Forest Department, Simdega	RFO Guest House, Simdega	28.03.19	65	-	65
10	Chatra, Jharkhand	Forest Department, Chatra (South)	Range Office, Chatra	29.03.19	69	30	99
11	Sahebganj, Jharkhand	Forest Department , Sahebganj	RFO Office, Barhet	31.03.19	90	05	95
12	Giridih, Jharkhand	Forest Department, Giridih	Peertand, Range Office	05.04.19	45	-	45
13	Hazaribag, Jharkhand	Forest Department, Jharkhand	Forest Guard Training College, Kanhari Pahar	20.12.19	25	07	32
Total					**851**	**143**	**994**

Annexure-6: On-farm motivational/supplementary training programme on Lac cultivation

Camp No.	District –State	Nominating Agency	Venue (Village, Block)	Date	M	F	No. of Participants
1	Hazaribag, Jharkhand	SUPPORT, Hazaribag	Training Hall, Mandu	18.03.19	09	44	53

Camp No.	District –State	Nominating Agency	Venue (Village, Block)	Date	M	F	No. of Participants
2	Palamu, Jharkhand	Forest Department, Palamu	Kundri Lac Farm	27.04.19	30	15	45
3	Hazaribag, Jharkhand	SUPPORT, Hazaribag	Samudauik Bhavan, Kalutang, Dadi, Hazaribag	13.07.19	45	08	53
Total					**84**	**67**	**151**

Annexure-7: On-campus one day Orientation programme on Lac cultivation

Camp No.	District –State	Nominating Agency	Date	M	F	No. of Participants
1	Ranchi, Jharkhand	FTS, Mahilong, Ranchi	07.01.19	62	-	62
2	Ranchi, Jharkhand	RK Mission, Ranchi	19.01.19	20	-	20
3	Ranchi, Jharkhand	FTS, Mahilong, Ranchi	25.01.19	58	01	59
4	Ranchi, Jharkhand	Sarla Birla Public School, Ranchi	29.01.19	28	12	40
5	Ranchi, Jharkhand	Surendra Nath Centenary School, Ranchi	06.02.19	94	106	200
6	Hazaribag, Jharkhand	St. Columbas Collage, Hazaribag	06.02.19	55	30	85
7	Purulia, W. Bengal	ADA Office, Barabazar	11.02.19	35	32	67
8	Ranchi, Jharkhand	Paramvir Albert Ekka Govt. Middle School, Namkum	07.03.19	50	69	119
9	Ranchi, Jharkhand	Devdash Mehec. Syngenta Foundation India, Ranchi	07.03.19	17	05	22
10	Siwan, Bihar	ATMA, Siwan, Bihar	16.03.19	24	-	24
11	Kolhapur, Maharashtra	Maharashtra College of Agriculture, Kolhapru	27.03.19	16	12	28
12	Ranchi, Jharkhand	DSPMU, Ranchi	28.03.19	07	01	08
13	Ranchi, Jharkhand	RK Mission Vivekananda Educational & Research Institute, Ranchi	10.04.19	20	15	35
14	Ranchi, Jharkhand	Extension Training Centre, Hehal, Ranchi	11.04.19	19	01	20
15	Ranchi, Jharkhand	Progressive farmers	15.04.19	18	-	18
16	Bandel, West Bengal	KBSK, Bandel, West Bengal	26.05.19	18	-	18
17	Bandel, West Bengal	KBSK, Bandel, West Bengal	28.05.19	18	-	18
18	Sambalpur, Odisha	Progressive farmers	28.05.19	06	-	06
19	Bandel, West Bengal	KBSK, Bandel, West Bengal	11.06.19	22	-	22
20	Ranchi, Jharkhand	KVS, Ranchi (Teachers)	15.06.19	20	27	47
21	Khatkhati, Assam	KVS, Khatkhati, Assam	15.06.19	10	-	10
22	Bhubneshwar, Odisha	ATMA, Bhubneshwar, Odisha	26.06.19	20	05	25
23	Ranchi, Jharkhand	YBN University, Ranchi	17.08.19	02	01	03
24	Ramgarh, Jharkhand	SUPPORT, Ramgarh	17.08.19	02	18	20
25	Ranchi, Jharkhand	Collection and conservation of lac insects	19.08.19	10	07	17
26	Ranchi, Jharkhand	BAU, Kanke, Ranchi	21.08.19	08	02	10
27	Ranchi, Jharkhand	KVS, Namkum	26.08.19	14	20	34
28	Gumla, Jharkhand	Progressive farmers	29.08.19	15	09	24
29	Ranchi, Jharkhand	St. Xavier College & others	29.08.19	05	05	10
30	Ranchi, Jharkhand	MJS, FPO, Tamar	11.09.19	14	-	14

Camp No.	District –State	Nominating Agency	Date	M	F	No. of Participants
31	Ranchi, Jharkhand	Ranchi University, Ranchi	13.09.19	02	01	03
32	Purulia, W. Bengal	Vivekananda Vikas Kendra, Purulia	16.09.19	12	08	20
33	Ranchi, Jharkhand	Bishop's West Cott Girls School, Doranda	19.09.19	53	-	53
34	Ranchi, Jharkhand	Sachidananda Gyan Bharti Model School, Kusai, Doranda	19.09.19	30	31	61
35	Ranchi, Jharkhand	St. Anthony School, Doranda	19.09.19	56	40	96
36	Ranchi, Jharkhand	Project High School, Bargawana	19.09.19	46	34	80
37	Ranchi, Jharkhand	St. Thomas School, Dhurwa	19.09.19	50	-	50
38	Ranchi, Jharkhand	Amity Institute of Biotechnology, Amity University, Ranchi	19.09.19	12	20	32
39	Ranchi, Jharkhand	St. Annes Intermediate College, Purulia Road, Ranchi	19.09.19	-	52	52
40	Ranchi, Jharkhand	Paramvir Albert Ekka Govt. School, Namkum	19.09.19	35	58	93
41	Ranchi, Jharkhand	Kasturba Gandhi School, Namkum	19.09.19	-	58	58
42	Ranchi, Jharkhand	SPP School, Sidroul, Namkum	19.09.19	59	27	86
43	Ranchi, Jharkhand	Vivekananda Vidya Mandir, Ranchi	19.09.19	95	60	155
44	Ranchi, Jharkhand	Mazzarello School, Namkum	19.09.19	-	10	10
45	Ramgarh, Jharkhand	Agaragati, Ramgarh Cantt, Ramgarh	21.09.19	17	04	21
46	Ranchi, Jharkhand	St. Annes Intermediate College, Purulia Road, Ranchi	26.09.19	05	357	362
47	Ranchi, Jharkhand	K.V.S. Namkum	17.10.19	21	21	42
48	Behrampur, W.B.	CSRTI, Behrampur, West Bengal	21.10.19	19	23	42
49	Ranchi, Jharkhand	Forest Training School, Mahilong, Ranchi	21.10.19	62	03	65
50	Ranchi, Jharkhand	Yogoda Satsang Vidyalaya, Ranchi	23.10.19	50	-	50
51	Ranchi, Jharkhand	Extension Training Centre, Hehal	23.10.19	38	02	40
52	Ranchi, Jharkhand	XISS, Ranchi	29.10.19	39	34	73
53	Ranchi, Jharkhand	Lac Integrated Agro forestry System for Livelihood Security- ICRAF Project	30.10.19	22	01	23
54	Ranchi, Jharkhand	Yogoda Satsang Vidyalaya, Ranchi	06.11.19	-	29	29
55	Ranchi, Jharkhand	Yogoda Satsang Vidyalaya, Ranchi	07.11.19	-	40	40
56	Hazaribag, Jharkhand	Holly Cross KVK, Hazaribag	13.11.19	10	15	25
57	Ranchi, Jharkhand	RK Mission, Morhabadi, Ranchi	14.11.19	34	-	34
58	Raipur, Chhattisgarh	IGKV Chhattisgarh	20.11.19	21	12	33
59	Hazaribag, Jharkhand	KVK Hazaribag under SC Sub Plan	21.11.19	24	-	24
60	Giridih, Jharkhand	KVK, Giridih under SC Sub Plan	27.11.19	24	-	24
61	Ramgarh, Jharkhand	PTPS College, Patratu, Ramgarh	01.12.19	02	11	13
62	Chatra, Jharkhand	KVK Chatra under SC Sub Plan	04.12.19	06	14	20
63	Ranchi, Jharkhand	BAU, Kanke, Ranchi	09.12.19	11	11	22
64	Ranchi, Jharkhand	BAU, Kanke, Ranchi	10.12.19	07	12	19
65	Garhwa, Jharkhand	KVK Garhwa under SC Sub Plan	19.12.19	25	-	25
66	Hazaribag, Jharkhand	Forest Department, Hazaribag	21.12.19	29	07	36
		Total		**1623**	**1373**	**2996**

Annexure-8: Lac based product demonstration training

Sl. No.	Name & Address	Sponsoring Agency	Duration	Subject
1.	Sri Sanjay Behl, S/o Late Sat Pal Behl , M/s SPS Agro Care, Doranda, Ranchi (Jharkhand)	M/s SPS Agro Care, Doranda, Ranchi (Jharkhand)	10.06.2019 to 15.06.2019	Lac processing, Dewaxed bleached lac, Aleuritic acid & De-waxed de-colourized lac
2.	Sri Baliram Sahu, S/o Sri Sunder Singh Sahu, Gitpahar, Charama, Kanker (Chhattisgarh) Mob. No. 8959649310	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Sri Surya Kumar Dhruv, S/o Sri Bansilal Dhruv, Chapeli, Charbhanta, Charama, Kanker (Chhattisgarh), Mob. No. 9691928375	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Sri Budhdev Nayak, S/o Late Ashwini Kumar, Bargari, Charama, Kanker (Chhattisgarh) Mob. No. 7879146894	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Smt. Subhadra Salam, W/o Sri Devcharan Salam from Badigori, Lilejar, Charama, Kanker (Chhattisgarh) Mob. No. 9406316952	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Smt. Nirabai Kange, W/o Sri Sunil Kange, Markatola, Nilejhar, Charama, Kanker (Chhattisgarh) Mob. No.7646817267	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Smt. Jawanti Topno, W/o Sri Samuel Topno, Kotbo, Kamdara, Gumla, (Jharkhand) Mob. No. 9955593569	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Smt. Kumulina Topno, W/o Shri Umblan Topno from Kotbo, Kamdara, Gumla, (Jharkhand) Mob. No. 8809142404	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Smt. Sulekha Devi, W/o Shri Pitamber Suhu from Nawatoli, Kamdara, Gumla, (Jharkhand) Mob. No. 7667755463	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Smt. Sunita Soren, W/o Shri Bhuteshwar Soren from Suru Nawatoli, Kamdara, Gumla, (Jharkhand) Mob. No. 9334551753	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
	Mrs. Saraswati Devi, W/o Shri Santosh Sahu from Nawatoli, Kamdara, Gumla, (Jharkhand) Mob. No. 6205584146	UDYOGINI, Jharkhand	05.08.2019 to 09.08.2019	Lac processing
3.	Sri MSS Aditya S/o Madhusudhana Rao , M/s Aditya Traders, Rajahmundry, Danavaipeta, East Godavari, (Andhra Pradesh) Mob. No. 9676640555(O), 9494125188(R)	M/s Aditya Traders, Rajahmundry, Danavaipeta, East Godavari, (Andhra Pradesh)	26.08.2019 to 12.09.2019	Lac processing, Dewaxed bleached lac, Dewaxed decolourized lac, Lac dye, Lac based varnishes (Lac Wood Shine) and Shellac Gasket Cement Compound (from Hydrolyzed lac)

Sl. No.	Name & Address	Sponsoring Agency	Duration	Subject
4.	Md. Sahanawaj Hossain	M/s Indo LACCA Shellac Industries Private Limited, New Delhi	06.11.2019 to 15.11.2019	Lac dye (Tech. grade)
5.	Md. Sahanawaj Hossain	M/s Indo LACCA Shellac Industries Private Limited, New Delhi	25.11.2019 to 04.12.2019	Testing and analysis of Lac
Total/Persons 05/14				

Annexure-9: *Kisan* gosthi/Workshop/Educational programme on lac cultivation

Camp No.	District –State	Nominating Agency	Venue (Village, Block)	Dated	No. of Participants	Name of programme
1	Ranchi, Jharkhand	RK Mission, Angara	RK Mission, Angara	07.02.19	1500	*Kisan gosthi*
2	Ranchi, Jharkhand	RK Seva Ashram	Behrajara, Rahe, Ranchi	15.02.19	535	*Krishi* Machinary Exhibition
3	Gumla, Jharkhand	KVK, Gumla	Bishunpur Campus	15.03.19	355	ARYA, Annual day function
4	Ranchi, Jharkhand	ICAR-IINRG, Ranchi	Beradih, Namkum, Ranchi	29.03.19	40	Workshop on lac cultivation, value addition and marketing
Total					**2430**	

Annexure-10: Lac crop surveillance conducted

Camp No.	Village (block)	District –State	Date	Crop	Observation
1	Kundri Lac Farm	Palamu, Jharkhand	27.04.19	*Rangeeni* crop on *Butea monosperma*	Approx 10000 palas trees inoculated in the month of October-November, 2019
2	Sangwar, Palamu	Palamu, Jharkhand	22.08.19	*Rangeeni* crop on *Butea monosperma*	Crop condition is good
3	Kundri Lac Farm	Palamu, Jharkhand	22.08.19	*Rangeeni* crop on *Butea monosperma*	Crop condition is good
4	Sogod, Namkum	Ranchi, Jharkhand	25.09.19	*Kusmi* crop on *Schleichera oleosa* & *Butea monosperma*	Advised to spray pesticides on *kusmi* crop on *kusum* and *ber*
5	Kundri Lac Farm	Kundri, Palamu	26.10.19	*Rangeeni* crop on *Butea monosperma*	Crop condition is average
6	Chainpur, Kulatand	Hazaribag, Jharkhand	20.12.19	*Kusmi* crop on *Schleichera oleosa* & *Butea monosperma*	Crop condition of *aghani* 2019-20 is very good

Annexure-11: Technical guidance/advisory

Sl. No.	Stakeholder	Nature of Advisory
1	Sri Deepak Kumar, M/s Aadhya International, Mumbai	Fruit coating, Shellac emulsion paint for internal coating and lac based varnishes

Sl. No.	Stakeholder	Nature of Advisory
2	Sri Mahesh Sharma, Lac Industrialist	Value addition of lac and Isoambrettolide
3	Sri Ashish Keshari, Keshari Shellac Industries, Mumbai	Processing and value addition of lac
4	Forest Department, Ranchi, Jharkhand	Lac cultivation and value addition
5	Sri Ronak Rathor, Kadma, Jamshedpur, Jharkhand	Natural nail polish
6	M/s Singhaniya Lakh Industry, Industrial Area, Katghora, Korba (Chhattisgarh)	Dewaxed decolourized lac & Aleuritic acid
7	M/s CK Lac Industry, 96, Mangejhari, Waraseoni (Madhya Pradesh)	Shellac emulsion paint for internal coating and dewaxed decolourized Lac
8	M/s Tofs Magnacraft Enterprises, 139, Naya Toli, Tupudana, Ranchi (Jharkhand),	Nail polish, Dewaxed decolourized Lac
9	Udyogini, Khunti, Jharkhand	Training on lac processing & value addition
10	Ms Meenakshi Sahu, KGVK, Ranchi	Training on lac cultivation and processing
11	Sri DP Bose, DIC, Purulia, West Bengal	De-waxed bleached lac
12	Sri Aditaya Kr Sahu, Kolebira, Simdega	Value addition of lac

Annexure-12: Details of the activities of NIC and MOTAS under one to one program (OTOP)

Name of the State	Name of the District	Category	Number
Chhattisgarh	Korba and Raipur	GOs	2
	Bilaspur and Jashpur	Farmer	2
	Kanker	NGO	1
Delhi	New Delhi	Research	1
	New Delhi	Processor/exporter	1
Jharkhand	Jamshedpur	Research	1
	Khunti	Processor/exporter	2
	Khunti	Research	1
	Khunti	Trader	3
	Khunti	NGOs	1
	Ranchi	Entrepreneurs	2
	Ranchi	Farmer	1
	Ranchi	GOs	1
	Ranchi	Researcher	6
	Simdega	Farmer	2
	Palamu	FPO	1
Maharashtra	Solapur	Farmer	1
Rajasthan	Jaipur	Entrepreneurs	2
	Jhunjhunu	GOs	1
Uttarakhand	Dehradun	Processor/exporter	1
West Bengal	Kolkata	Processor/exporter	1
Australia		Researcher	1
China		Processor/exporter	1
Total			**36**

Annexure-13: Participation in exhibition/*Kisan mela*

Sl. No.	Name of the programme with venue	Duration	No. of Participants	Participated by
1	State Level Agricultural Fair-Agrotech 2019 *Kisan Mela*, BAU, Kanke, Ranchi. Jointly organized by ICAR-IINRG, ICAR-IIAB, ICAR-RCER,RC, Plandu & CURRS, Hazaribag	02.02.19-04.02.19	5000	Dr. N Kumar, Dr. SKS Yadav, Dr. RK Yogi, Dr. SKS Yadav, Sri P Patmajhi, Sri AK Sinha, Sri DK Singh, Sri SB Azad, Sri M Mohan, Sri Tariq Zaman and others
2	*Rashtriya Rajbhasha Takniki Seminar,* CTR&TI, Nagri, Ranchi	06.02.219	150	Sri AK Sinha & Sri Tarique Zaman
3	Annual *Kisan mela*-2019, RK Mission Ashram Getelsud, Ranchi	07.02.19-08.02.19	12700	Sri P Patmajhi & Sri S Meena
4	*Krishi Kumbh*-2019, Gandhi Maidan, Motihari, Bihar	09.02.19-11.02.19	3000	Sri AK Sinha & Sri Tarique Zaman
5	*Krishi Takniki Avam Yantra Pradershani*, Ramkrishna Seva Ashram, Rahe, Ranchi	15.02.2019	500	Dr. N Kumar, Dr. SKS Yadav, Dr. RK Yogi, Sri P Patmajhi, Sri AK Sinha, Sri DK Singh, Sri SB Azad, Sri M Mohan, Sri S Meena
6	Annual *kisan mela* cum-exhibition-2019, CRURRS, Hazaribag, Jharkhand	19.10.2019	105	Sri P Patmajhi & Sri S Meena
		Total	**21,455**	

Annexure-14: Front Line Demonstration (FLD)

Camp No.	Venue (Village & Block)	District –State	Date	Observation
1	Kalutand Samudayik Bhawan, Dadi	Hazaribag, Jharkhand	13.07.19	Selected farmers having *ber* trees for lac cultivation
2	Kalutand, Dadi	Hazaribag, Jharkhand	17.07.19	Taken 50 kg *kusmi* broodlac from IRF and given to Sri Jitendra Kumar Mahto for distribution among the beneficiaries of Kalutand, Dadi, Hazaribag
3	Kalutand, Dadi	Hazaribag, Jharkhand	19.08.19	Ethofenprox 10% E.C. – 2X500 ml Carbendazim- 50% W.P.- 1X500 gm

Annexure-15: Details of the activities conducted under Schedule Caste Sub Plan (SCSP)

Sl. No.	Particulars	Venue	Duration	Details of Beneficiaries	
				Number	Districts covered
1	Village Surveys for household identification	Jharkhand	One month	800	
2	Workshop	KVK Chatra	One day	100	Chatra
3	Visit conducted at for mobilizing the SC households for their up-liftment through recommended practices	KVK Hazaribag	One day	100	Hazaribag

Sl. No.	Particulars	Venue	Duration	Details of Beneficiaries	
				Number	Districts covered
4	Training under Scheduled Caste Sub plan (SCSP) on Recent advances in management practices of horticultural crops	ICAR-RCER, Ranchi Centre, Plandu, Ranchi	12-16th November, 2019	25	Hazaribag
			19-23rd November, 2019	25	Bokaro
			26-30th November, 2019	25	Latehar
			3-7th December, 2019	20	Chatra
			17-21st December, 2019	24	Garhwa
			6-10th January, 2020	24	Palamau
			13-17th January, 2020	22	Ranchi
			20-24th January, 2020	22	Ranchi
			27-31st January, 2020	21	Khunti
5	One day workshop-cum-animal unit distribution programme		24th January, 2020	17	Ranchi
			28th January, 2020	20	Hazaribag
			29th January, 2020	20	Bokaro
			6th February, 2020	21	Khunti

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