ISSN : 0974-2999

ANNUAL REPORT 2021–22



ICAR-Indian Institute of Natural Resins and Gums
भाकृअनुप – भारतीय प्राकृतिक राल एवं गोंद संस्थान
Namkum, Ranchi - 834 010 (Jharkhand)
नामकुम, राँची - 834 010 (झारखण्ड)

ISSN : 0974-2999

Published by

Dr. KK Sharma, Director

Cover Design and Layout

Dr. Thamilarasi K

Compiled, Edited and Produced by

Dr. Thamilarasi K
Dr. SC Sharma
Dr. Nandkishore Thombare
Dr. Achintya Pramanik
Mr. Tariq Zaman

Administrative Assistance

Mr. SK Yadav

Correct Citation

ICAR-IINRG Annual Report 2021-22
ICAR-Indian Institute of Natural Resins and Gums
Namkum, Ranchi - 834 010 (Jharkhand), India

Note

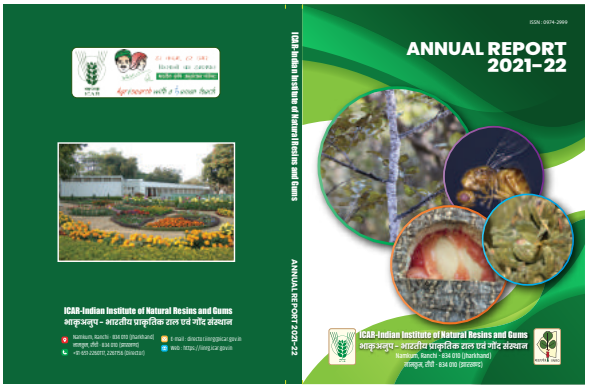
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Printed at

Anapurna Press and Process
Anapurna Building (Jharcraft), 5, Main Road, Ranchi
Tel . 6287999194, E-mail: appranchi.1969@gmail.com

October, 2022



Front Page

(Clockwise from top left)

1. Lac encrustation at Regional Field Gene Bank of State Forest Research Institute (SFRI), Jabalpur
2. *Parasycobia* sp. nov. female
3. Fungi infested inflorescence of *Flemengia semialata*
4. *Moringa* gum exudation from developed blaze

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Preface

With a wide host-plant range and diverse habitat, the insects have developed a specialized ecosystem with multi-trophic complex of flora and fauna. Not only the lac insect, but also the host-plants and various biotic associations play a significant role in determining the quantity and quality of the produce. Therefore, it is imperative to know the role and relationship of each biotic component in lac ecosystem. To have a better understanding of this aspect, lac insects, *Kerria destructor*, *Kerria indicola*, *Kerria chamberlini, Kerria lacca* and lac insect lepidopteran pest, *Eublemma amabilis* were re-described. Two leaf feeding insect pests, the leaf miner, *Acrocercops* nr. *tenera* and the gall midge *Contarinia* sp. of *kusum* tree, the major lac insect host plant and one new species of phytophagous galler wasp, *Parasycobia* from *Ficus religiosa* were identified. Full length coding sequence of acyl carrier protein and decarboxylase 2 were cloned, Polyketide synthase knock down mutant was developed using RNAi technique. qPCR of these insects and HPLC analysis of resin and body pigments indicated a putative role for this gene in lac pigment biosynthesis. Spraying of Plant Growth Regulators (PGRs) in late pruning of *Flemingia semialata,* the quick growing bushy lac-host, increased biological as well as economic attributes of plant and the lac insect both. Whereas moisture stress resulted in male biased sex ratio (25% higher) in *rangeeni* (*baisakhi*) lac strain on potted plants of pigeon-pea variety '*Bahar'*.

Web Portal on Lac Host Plants comprising of 50 lac host plants has been hosted at IINRG website. A new species of lac insect from Madurai, Tamil Nadu on host, *Albizia saman* has been described as *Kerria canalis*. *Kerria rangoonensis* earlier reported from Myanmar was collected from South India and a new lac host plant, *Albizia lucidor* was identified from West Karbi Anglong District in Assam. Fungi barcoding revealed the presence of endophytic fungi and yeast like endosymbiont in lac insects. The entomopathogenic fungi *Cordyceps javanica* isolated from *Archips* sp. (pest of *F. semialata*) was found to be effective against *E. amabilis*. Diversity analysis of aleuritic acid content in fresh lac revealed the maximum yield (19.81%) with 98.78% purity in fresh *Kerria chinensis* and the minimum in *Kerria sharda*. Resin from *kusmi* yellow strain during summer season showed the highest yield after 18 months of storage. *Kinnow* mandarin fruits coated with lac based wax formulation prior to storage under ambient conditions retained their post-harvest quality up to 15 days and is comparable to commercial formulations.

Natural Resins and Gums (NRGs) are well known for their widespread use in the food and pharmaceutical industries. The prospective uses of NRGs and their nanostructures in various aspects of food, water, energy, biotechnology, environment and medicine industries have garnered a great deal of attention recently as these are versatile green materials encompassing diverse functional and structural properties to assemble varied nanostructures. The institute is working on process refinement and value addition of NRGs for their application in varied fields. Encapsulation of beta carotene was achieved by liposome encapsulation technique using dietary fibre from guar gum. Characterization of the encapsulated product revealed the presence of ascorbic acid also as sustained release formulation. Gum Arabic based hydrogel has been synthesized using microwave assisted technique using borax as cross-linker and acrylamide as monomer and potassium persulfate as radical initiator for use as adsorbent for Brilliant Green (BG) dye removal. Lac based non-drying adhesive was prepared for sticky traps. Its higher viscosity as compared to the commercial formulation at elevated temperature makes it less prone to dripping out from the traps. Process refinement of carboxy methyl guar gum derivative revealed that the derivative with higher viscosity and degree of substitution can be prepared with reduced mixing, reaction and drying time having similar pH. Pilot Plant of carboxy methyl guar gum derivative has past its design stage and is under fabrication.

Non-food applications of several important commercially available gums include greener synthesis and stabilization of metal/metal oxide NPs, production of electrospun fibers, environmental bioremediation, bio-catalysis, biosensors, coordination complexes of metal–hydrogels, and for antimicrobial and biomedical applications. The institute has developed nano-composite films reinforced with *piyar*-AgNPs for diversified applications. The film showed promising antifungal activity and found, homogeneous and thermo-stable up to 250 ºC. *Acacia senegal* and *A. tortilis* gum based microencapsulated powders after successfully encapsulating the anthocyanin rich extract retained antioxidant activity of the core material. A light weight, user friendly, manually operated gum tapping blazer has also been developed for gum tapping from *Moringa oleifera* trees showing higher productivity of gum tappers.

Though the current advancement has made a significant improvement, however, several engineered constructs are still at their fantasy and facing challenges due to inefficient mode of action. The current limitations of synthetic counterparts can be tackled by imparting the inherited bioactive features and functional attributes of NRG-based bio-nanostructures. The NRGs have an ability to become excellent biopolymer and can improve the composite properties when combined with various other biomaterials. With their unique structure and functionality, they have opened up a new area of nanostructured material creation.



October, 2022
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 from 5,26,765 tons in 2019-20 to 4,90,070 tons in 2020-21. Total production of lac was observed around 14.75% lower than the previous year. The world trade aggregation of lac, natural gums, resins, gum-resins, balsams and other natural oleo-resins (HS code:1301) revealed that out of 97 exporting countries in the world, India ranks 2nd in export with a share of 16.1% in the total world export value. Similarly, out of 112 importing countries of the world, India ranks 1st in import with a share of 21% 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 reigns 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 more than 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 subcontinent, 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 April 2021, the erstwhile divisions were abolished and the scientific manpower was divided into four divisions, *viz*., Quality and Productivity Improvement Division, Production and Extension Management Division, Application and Product Development Division and Mechanization and Process Engineering Division. The Institute is headed by Director.

Staff

The Institute has a sanctioned strength of 1 Research Management Position (RMP), 42 scientific, 72 technical, 33 administrative and 43 supporting grade staff with a total of 190 sanctioned posts, out of which 26 scientific including RMP, 39 technical, 12 administrative and 23 supporting posts with a total of 100 staff are in position as on December 31, 2021.

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 100 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 Field Gene Bank of the Institute has 90 collections of 69 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 and 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 1050 cultures of 52 lac insect lines lines are being conserved live on potted plants of *bhalia* (*Flemingia macrophyll*a) under protected conditions.

The ICAR-IINRG library has a holding of about 24,780 volumes of scientific journals, 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 Center, Ranchi and others.

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 about the Institute.

Executive Summary

Biodiversity Conservation and Characterization of Lac Insect and NRG Yielding Plants

- 1050 cultures of 52 lac insect lines are being conserved on *Flemingia macrophylla* in Lac Insect Field Gene Bank and 90 collections of 69 host plant species in Lac Host Field Gene Bank of National Lac Insect Germplasm Centre (NATLIGEC).
- The identified lac insect species from Gene Bank, *Kerria destructor* Talukder and Das, *Kerria indicola* (Kapur), *Kerria chamberlini* Varshney and *Kerria lacca* (Kerr) were re-described with photographic illustrations.
- The lepidopteran pest of Indian lac insect, *Eublemma amabilis* was re-described taxonomically with respect to genital characters with photographic illustrations.
- Surveys were conducted for insect pests associated with *kusum* tree, the major lac insect host plant for *kusmi* strain lac insect. Two leaf feeding insect pests, *i.e.* leaf miner, *Acrocercops* nr. *tenera* Meyrick, 1914 (Family: Gracillariidae) and gall midge *Contarinia* sp. (Family: Cecidomyiidae) were recorded.
- Biodiversity survey to document lac associated entomofauna in fig hosts identified one new species of phytophagous galler wasp in the genus *Parasycobia* (Hymenoptera: Chalcidoidea) from lac host plant *Ficus religiosa.* This new species is the second species in the genus *Parasycobia* after *Parasycobia kaurae* Abdurahiman & Joseph 1967.
- Full length CDS (coding sequence) of acyl carrier protein (*acp*) and decarboxylase 2 (*dc2*) were cloned from lac insects. Polyketide synthase knock down mutant of lac insects have been developed using RNAi technique. qPCR of these insects and HPLC analysis of resin and body pigments indicated a putative role for this gene in lac pigment biosynthesis.

Lac Insect-Host Plant Environment for Improved Quality and Productivity

- Spraying of PGRs, NAA 50 ppm and Kinetin 100 ppm are beneficial in late pruning of *Flemingia semialata*. These significantly increased biomass, broodlac weight, broodlac weight/m shoot length, scrapedlac weight/m shoot length and percent scrapedlac/m shoot length in *F. semialata*.
- Moisture stress experienced by lac host plant resulted in male biased sex ratio in *rangeeni* (*baisakhi*) lac strain which was inoculated on potted plants of pigeon-pea variety 'Bahar'. Male insect proportion was 25% higher in moisture stress treatment as compared to adequately irrigated plants.
- Seeds of *F. semialata* were treated with colchicine for variable time period to introduce genetic variation and thereafter, selection of desirable variants for better lac cultivation. Stunted plant height, maximum leaf width, relatively significant shorter inter-nodal length were observed at different concentration of colchicine. Duration of treatment had significant effect on length and width of stomata. Relatively lesser number of stomata was observed at 0.05%, 0.2% and 0.25% for 18 hours and 24 hours treatment, respectively. Plant height had significant positive correlation with leaf width and inter-nodal length.
- Relative abundance and emergence profile of parasitoids and predators associated with lac insect were recorded during *baisakhi* and *katki*, 2021 crops. Two parasitoids (*Aprostocetus purpureus* and *Tachardiaephagus tachardiae*) and one predator *Eublemma amabilis* were found abundant during the crop seasons.

Crop Production System Management and Evaluation

- Upland condition showed enhanced growth in respect to residual pruned out shoot weight compared to lowland (3.6 kg and 2.0 kg, respectively) in *Butea monosperma* (*palas*). Similar trend was observed for shoot diameter (value 1.1 and 1.0 cm) and shoot length (value 54.6 and 45.4 cm).
- Among three factors, only topography showed difference in lac yield ratio - upland and lowland conditions witnessed yield ratio 6.4 and 3.1, respectively. Parasite population in March was noticed to be almost three times in lowland than that in uplands.
- Soil fertility levels did not affect yield ratio significantly in *palas,* but increasing trend was observed with increase in soil fertility levels (value ranged between 4.4 and 5.3). Encrustation thickness was found to

increase 18% in the highest fertility level compared to control and male percent decreased 17% in higher fertility conditions.

- The impact of weather factors on the population of *A. purpureus* on *palas* showed that the maximum temperature, relative humidity (evening) significantly and positively contributed and also played major role (66%) based on 4 week lag data, whereas the population of *A. purpureus* on *ber* showed that the relative humidity (evening) and rainfall significantly and positively contributed and also played major role (59%) based on 4 week lag weather parameters.
- To study various water balance parameters like irrigation, rainfall, deep percolation and evapo-transpiration at Institute Research Farm, low-cost drainage lysimeters were designed, constructed and set up for ascertaining the water requirement of *F. semialata* Roxb.
- Under Lac Integrated Cropping System (LICS) through participatory approach intercropping semialata+okra and semialata+amaranthus performed better than other treatment combinations in summer and rainy season, respectively.

Capacity Building, Technology Dissemination, Impact Assessment and Market Intelligence

- Sixteen Farmers' Training Programmes on 'Scientific lac cultivation, processing and utilization' were organized for 414 farmers from two states *viz*., Jharkhand & West Bengal and one from Nepal.
- Organized "Natural Resin and Gum based Agro-Industrial Attachment Training for Rural Agricultural Work Experience (RAWE)" for 22 B.Sc. (Ag.) students of Birsa Agricultural University, Kanke, Ranchi.
- Organized two Educational programme on "Industrial Training on Natural Resins and Gums" for total 53 students from different universities (10 days Online).
- Eleven on-farm trainings were organized for 754 stakeholders of Jharkhand and Odisha. Twenty on-farm motivational training programmes were organized for 1195 stakeholders of Jharkhand. Thirteen on-campus one day orientation programmes on 'Natural resins and gums' were organized; 525 stakeholders visited the institute.
- Livestock, farm tool-kit, sprayer, vermi- bed, power weeder and rotavator were distributed under SC sub-Plan to 509 farmers in six programmes at different KVKs of Jharkhand.
- Twenty eight "Awareness-cum-Village Survey Programme" for Impact Assessment of the stakeholders were conducted under Capacity Building Programme (CBP). Four lac crop surveillance visits were organized.
- Information related to the NRG production, MSP, transferable technologies, bankable projects, promotional awards, post COVID-19 management aspects, marketing, processing, export and policy issues were disseminated through Market Oriented Technical Advisory Services (MOTAS) to 21 stakeholders. Data on NRG production, processing, EXIM were also sent to IASRI for Agriculture Research Data Book.
- ₹ 13,84,715/- (Thirteen lakh eighty four thousand seven hundred fifteen rupees only) was generated through training charges during the period.
- Utilization of host trees for lac cultivation in the study area was observed to be 18.24, 6.82 and 3.09% for *Butea monosperma* (*palas*), *Ziziphus mauritiana* (*ber*) and *Schleichera oleosa* (*kusum*), respectively, indicating scope for increasing lac production by utilizing more lac host trees and creating gainful employment opportunities.

Synthesis, Process Development and Quality Management

- Rosin derivatives were synthesized and their acid values and colour index were determined. Acid value was found in the range of 43-85; colour was found to be darker and did not match with the standard solution in some cases and softening point was recorded in the range of 27-60 ^{0}C. during FTIR analysis, spectra showed shift of carbonyl group peak of acid to higher frequency, and appearance of hydroxyl group's peaks, indicating the ester formation.
- Gum Arabic based hydrogel was synthesized using microwave assisted technique using borax as cross-linker and acrylamide as monomer and potassium persulfate (KPS) as radical initiator. The resulting gel mass was isolated using acetone, dried and sieved and employed as adsorbent for Brilliant Green (BG) dye removal.
- *Terminalia bellirica* exudate gum (*baheda* gum) after purification gave 70% yield. Reaction conditions with respect to concentration of monomer, cross linker and initiator were optimized.

Value Addition and Product Development

- Encapsulation of beta carotene was achieved by liposome encapsulation technique using dietary fibre from guar gum. Characterization of the encapsulated product revealed the presence of ascorbic acid also as sustained release formulation.
- Various parameters for synthesis of hydrolyzed lac were optimized to get best possible yield of quality non-drying adhesive. Higher viscosity of lac based formulations as compared to the commercial formulation confirmed its stability at elevated temperature (when exposed to sun) and hence they are less prone to dripping out from the traps. The best performing lac based glue formulations were identified through field trials based on maximum insect trapping efficiency in comparison with commercial glue. Overall, the efficiency of the lac formulations was observed as 80% as compared to commercial formulation (Chipku®).

Designing and Development of Farm Tools and Processing Machineries

- Trials were carried out for preparation of Decoloured Dewaxed Lac (DDL) from *kusmi* seedlac in lac- solvent (2-Propanol) ratio as 1:6. Results indicated that DDL yield varied from 69 to 84% with an average of 76.12%. Reduction in colour value of lac (seedlac colour value 12) in DDL varied from 0.7 to 1.6 and maximum colour reduction up to colour value 0.7 was observed. Flow and life of DDL samples prepared in these trials were comparable with shellac. Wax, impurity content and acid value of DDL samples were also better and within acceptable limit for most of the trials.
- Carboxy methyl guar gum derivative was prepared from guar gum. Results revealed that carboxy methyl guar gum derivative with higher viscosity and degree of substitution can be prepared with reduced mixing time (30 min), reaction time 3 h and drying time 3 h having similar pH.
- All the components of carboxy methyl guar gum derivative pilot plant have been designed. Fabrication of the pilot plant is under progress at ICAR – Central Institute of Agricultural Engineering, Bhopal.

Network Project on Harvesting, Processing and Value Addition of NRGs

- Nanocomposite films reinforced with *piyar*-AgNPs were developed for diversified applications through solution casting method and found flat, dense, homogeneous based on morphology including uniform distribution throughout the film thickness and thermostable upto 250 ºC. Developed nanocomposite film showed promising antifungal activity compared to control.
- Forest areas of Ranchi, Jharkhand were surveyed and photographs of season specific plant parts including flowers, fruits, leaves, whole plants and gum exudation from different plant species were taken for preparation of field guide of minor gum and resin plants.
- A light weight, user friendly, manually operated gum tapping blazer was developed for gum tapping from *Moringa oleifera* trees. The blazer was operated easily and blazes with sharp edges on the tree trunk in semi-circular shape of uniform size, reduces manpower requirement, drudgery and time showing higher productivity of gum tappers compared to manual method.
- *Acacia senegal* and *Acacia tortilis* gum based microencapsulated powders were characterized and found successful in microencapsulating the anthocyanin rich extract with retained antioxidant activity of the core material.
- During 2021, trees of *A. senegal, A. tortilis*, *Acacia nilotica, Acacia leucophloea, Prosopis cineraria, Prosopis juliflora, Anogeissus rotundifolia*, etc. were treated by CAZRI gum inducer technology for gum production in 48 villages of 5 district of Rajasthan and farmers earned revenue of ₹52.16 lakhs from sale of gum.
- Experimental trial for gum exudation from lesser known gum producing tree species (*Acacia subporosa* and *P. juliflora*) was conducted and mean gum yield of 179.2 g/tree and 65.5 g/tree were recorded, respectively for *A. subrosa* and *P. juliflora*.
- In agri-horti-silviculture agroforestry model, maximum GBH, plant height and canopy spread were recorded in *Aegle marmelos* (bael) followed by *A. senegal* (kumat), *Citrus limon* (lemon) and *Carissa carandas* (karonda). *C. carandas* recorded maximum survival (%), followed by *A. senegal*, *A. marmelos* and *C. limon*. In silvi-herbal agroforestry model, maximum survival (100%) was recorded for *Terminalia arjuna* (arjun) followed by *A. nilotica* (babool) and *A. senegal*. Growth parameters (GBH, plant height and canopy) were recorded maximum in *A. nilotica* followed by *A. senegal* and *T. arjuna*. Maximum and minimum plant population above ground biomass and seed yield was recorded for *C. limon* and *A. marmelos*. *A. senegal* recorded relatively

more survival (up to 59.5%) than *A. nilotica* (up to 50%) planted (11 years) at farmers field in Garhkundar watershed area. Survival and annual growth data of *A. senegal* based gum gardens showed higher survival (%) in *A. senegal* than *B. monosperma*.

- Guar korma meal was subjected to different treatments to analyse the effect of processing methods on tannin content and observed that tannin content in raw guar korma meal was about 1.73 g/100 g, soaking and roasting reduced tannin content of about 0.93 g/100 g and 0.43 g/100 g, respectively. High temperature treatments (autoclaving and extrusion processing) of guar korma meal indicated extensive reduction in level of tannin to 0.38 and 0.31 g/100 g, respectively. Guar korma meal with reduced tannin may be utilized in food products and cattle feed.
- Incorporation of guar meal and PHGG along with plasticizers for development of guar seed fractions based edible film showed good mechanical properties, barrier and film forming abilities and use of guar meal may be replaced by 40% potato starch in the casting solution as well as in edible film.
- Effect of bore hole angles and diameter classes on oleoresin yield studied and recorded highest oleoresin yield in the diameter class >60 cm (2214.99 g/hole/tree) whereas, lowest in diameter class 30-40 cm (1398.60 g/hole/tree). Mean maximum oleoresin yield was recorded in case of bore hole developed at 40 degree angle (2211.86 g/hole) with minimum for bore hole developed at an angle of 70 degree (1110.09 g/hole).
- Use of gum enhancer was found superior for gum tapping from Dhawara (*Anogeissus latifolia*), Rohini (*Soymida fembrifuing* Roxb.), Saja (*Terminalia tomentosa* Roxb.) and Chironji (*Buchanania lanzan Roxb.*) compared to mechanical technique of gum extraction.
- Extraction of gum from charota (*Cassia tora*) seeds studied and highest and lowest gum yield were recorded as 31.15% and 17.62%, respectively for roasted sample at 140 ºC and 120 ºC.
- Guggul gum sample packed in earthen pot, plastic jar, polythene bag and jute bag were stored in ambient condition and found that maximum number of compounds have been eluted from the guggul sample stored in 2.5 mm thickness earthen pot (19) followed by 14 in plastic jar, 13 in polythene bags and jute bags.
- Gum production from tree species of regional importance studied during the year 2020-2021 in naturally grown trees and plantations of *Butea monosperma, Pterocarpus marsupium, Chloroxylon swietenia* and *Lannea coromandelica* at Forest College and Research Institute, Mettupalayam, Coimbatore and found that gum booster dosage of 400 mg/ml ethephon and 1.2% H_2S0_4 concentration was significantly superior over other treatments in *C. swietenia, P. marsupium* and *B. monosperma*. It was also observed that diameter class of 60-90 cm was superior over 30-60 cm diameter class in terms of gum production.

Network Project on Conservation of Lac Insect Genetic Resources

- Web Portal on Lac Host Plants comprising of 50 lac host plants was hoisted at IINRG website by the Lead Centre.
- Fungi barcoding PCRs revealed the presence of few endophytic fungi *viz*., *Nectria cinnabarina*, *Acremonium* sp., *Acremonium vitellinum* and *Ramichloridium cucurbitae*, *Ramichloridium apiculatum* and yeast like endosymbiont of *Hamiltonaphis styraci* in lac insects.
- Diversity analysis of aleuritic acid content in major lac insect species/strains revealed the maximum yield of aleuritic acid (19.81%) with 98.78% purity in fresh *Kerria chinensis* sample after harvesting and the minimum yield in *K. sharda* (trivoltine lac insect) resin sample. However, on storage, lac resin obtained from yellow strain cultivated during *jethwi* showed the highest yield at 18 months of storage indicating that this strain is suitable for long term storage for aleuritic acid isolation.
- Based on taxonomical study, a new species was described from Madurai, Tamil Nadu on host *Albizia saman* as *Kerria canalis* Rajgopal. *Kerria rangoonensis* earlier described by Chamberlin from Rangoon, Myanmar was collected from different parts of South India and identified with morphological characterization.
- A new host plant (*Albizia lucidor*) was identified for naturally occurring lac insects from West Karbi Anglong District in Assam.
- The entomopathogenic fungi *Cordyceps javanica* isolated from *Archips* sp. (pest of *F. semialata*) was found to be effective against lepidopteran pests *viz*., *Eublemma amabilis*, rice leaf folder *etc*.
- Natural infestation of lac insect on *Calliandra haematocephala* has been reported for the first time in Punjab

- The life cycle and productivity-linked parameters of lac insect (*rangeeni* strain) were studied on *Flemingia semialata, F. macrophylla* and *Ziziphus mauritiana* under Punjab conditions. The duration of *baisakhi* and *katki* crops varied from 210-245 and 98-118 days, respectively.
- *Kinnow* mandarin fruits coated with Citrasol, Formesa and lac based wax formulation prior to storage under ambient conditions retained their post-harvest quality up to 15 days which may help in extending the marketing period for better economic returns as compared to Citrashine and un-coated (control) fruits.
- Out of 38 districts of Bihar, 22 districts showed naturally occurring lac insect in varied proportion mostly on *Ficus religiosa*, *Ficus benghalensis* and rarely on *Z. mauritiana and B. monosperma*. Majority of insects were found dead, but at a few places good live population was noticed. Southern districts of Bihar showed rich diversity in naturally surviving lac insects.
- The host plant, *Acacia nilotica* (*kikar*) showed the lowest summer mortality of lac insects (34.29%), because it offers a good microclimate during the summer, while the summer mortality was highest on *ber* (54.19%).

KVK Khunti

- On farm testing of six developed technologies were conducted in 12.02 ha area and front line demonstrations (FLDs) of eight technologies were carried out in 33.6 ha. Similarly, thirty-five off Campus trainings / awareness programmes were conducted on cultivation of paddy, pigeon pea, *kusmi* lac cultivation, groundnut, soybean, green gram, black gram and vegetable cultivation during *kharif* season, and sixteen off campus trainings on cultivation of chickpea, lentil and rapeseed mustard during *rabi* season in which 2512 farmers participated.
- In addition to the above, extension activities /programmes / events were organized / arranged *viz*., Field Day, International Women's Day, Ambedkar Jayanti, International Yoga Day, Parthenium Awareness Week, Mahila Kisan Diwas, World Food Day, Vigilance Awareness Week, National Unity Day, World Science Day, National Education Day, National Constitution Day, World Soil Day, Kisan Diwas, Plantation of agro-forestry trees, *Aatmanirbhar* Bharat, Poshan Awareness campaign, farmers scientists interface on Climate Resilient varieties, Technologies and practices, address of Hon'ble PM on Natural Farming, Swachhata Pakhwada, awareness on PM Kisan Yojana and Agromet Advisory under DAMU.

कार्यकारी सारांश

जैवविविधता संरक्षण एवं लाख कीट तथा प्राकृतिक राल एवं गोंद उत्पादक पौधें का अभिलक्षण वर्णन

- लाख कीट *फील्ड जीन बैंक* में *फ्लेमिंजीया मैक्रोफाइला* पर 52 लाख कीट प्रजाति का 1050 संवर्धनों को तथा राष्ट्रीय लाख कीट जननद्रव केन्द्र (नैटलीजेक) के लाख परिपालक पौधा फील्ड जीन बैंक में 69 किस्म की 90 संग्रह को संरक्षित किया जा रहा है।
- जीन बैंक से पहचान की गई लाख कीट प्रजाति *केरिया डिसट्रक्टर* तालुकदार एवं दास, *केरिया इन्डीकोला* (कपूर) *केरिया चेम्बरलिनी* वार्ष्णेय तथा *केरिया लैका* (केर) को फोटो चित्रण के साथ पुनर्परिभाषित किया गया।
- भारतीय लाख कीट का *लेपिडोप्टेरन* नाशीजीव *युब्लीमा एमाविलीस* को उसके लैंगिक लक्षणों के साथ फोटो चित्रण सहित वर्गीकरण की दृष्टि से पुनर्परिभाषित किया गया।
- कुसमी लाख प्रजाति का प्रमुख लाख कीट परिपालक कुसुम वृक्ष से जुड़े कीट नाशीजीव का सर्वे किया गया। पत्ती को खाने वाले दो कीट *लीफ माइनर एक्रोसेरपोस* एन आर टेनेरा मेरिक, 1914 (*फैमिली– ग्रेसिडोमाइडी)* एवं गाल मिंज *कौन्टेरिनीया* प्रजाति (*फैमिली – सेसिडोमाइडी)* रिकॉर्ड किया गया।
- लाख से सम्बद्ध इन्टोमोफॉना के प्रलेखन के लिए जैवविविधता सर्वे में लाख परिपालक पौधा *फाइकस रेलिजीओसा* से *पारासाइकोबिया* (*हाइमेनोप्टेरा : चैल्शीडोइडी)* वंश की एक नई प्रजाति *फाइटोफेगस गैलर* हड्डा फीग परिपालक की पहचान की गई है। यह नई प्रजाति *पारासाइकोबिया कौरी* अब्दुर्रहमान एवं जोसेफ 1967 के बाद *पारासाइकोबिया* वंश की दूसरी प्रजाति है।
- लाख कीटों से एसिल वाहक प्रोटीन (ए सी पी) एवं डिकार्बोक्जीलेज 2 (डी सी 2) के पूर्ण विस्तृत सी डी एस (कोडिंग श्रृंखला) का कृंतक बनाया गया। लाख कीटों के नॉकडाउन उत्परिवर्ती *पॉलिकेटाइड सिंथेज* को आर एन ए आई तकनीक का उपयोग कर विकसित किया गया। इन कीटों के क्यू पी सी आर और राल तथा तत्व वर्णक के एच पी एल सी विश्लेषण से लाख वर्णक जैवसंश्लेषण में इस जीन के लिए ख्यात भूमिका का पता चलता है।

उन्नत गुणवत्ता एवं उत्पादकता लाख कीट–परिपालक पौधा पर्यावरण

- *फ्लेमिंजीया सेमियालता* की देर से छंटाई में पी जी आर एस, एन ए ए 50 पी पी एम एवं काइनेटीन 100 पी पी एम का छिड़काव लाभदायक है। इससे *एफ. सेमियालता* में जैवमास, बीहनलाख वजन, बीहनलाख वजन/मीटर प्ररोह लम्बाई, छिली लाख वजन/मीटर प्ररोह लम्बाई एवं छिली लाख/मीटर प्ररोह लम्बाई प्रतिशत में उल्लेखनीय वृद्धि हुई।
- गमले में लगे अरहर की बहार किस्म पर संचारित रंगीनी (बैशाखी) लाख प्रजाति में लाख परिपालक पौधा द्वारा नर झुकाव अनुपात में नमी के दबाव का अनुभव किया गया। समुचित सिंचित पौधों की तुलना में नमी दबाव उपचार में नर कीट अनुपात 25% उच्चतर था।
- आनुवांशिक विविधता लाने के लिए *एफ. सेमियालता* के बीजों को अलग–अलग अवधि के लिए कॉल्चीसीन के साथ उपचारित चयन किया गया एवं लाख की बेहतर खेती के लिए वांछित किस्म का चयन किया गया। कॉल्चीसीन के विभिन्न सान्द्रण में पौधे की छोटी ऊंचाई, पत्ती की अधिकतम् चौड़ाई, अन्तर ग्रंथीय लम्बाई में अपेक्षाकृत उल्लेखनीय कमी देखी गई। रंध्र की लम्बाई एवं चौड़ाई पर उपचार की अवधि का उल्लेखनीय प्रभाव रहा। 0.05%, 0.2% एवं 0.25% पर 18 घंटे एवं 24 घंटे उपचार में रंध्रों की संख्या अपेक्षाकृत कम देखी गई। पौधे की लम्बाई का पत्ती की चौड़ाई एवं गांठ के बीच की लम्बाई में सकारात्मक सह संबंध देखा गया।

- बैशाखी एवं कतकी, 2021 फसल की अवधि में लाख कीट से संबंद्ध परजीवी एवं परभक्षियों की सापेक्ष प्रचूरता एवं प्रादूर्भाव विवरण रिकॉर्ड किया गया। दो परजीवी *(एप्रोस्टोसीटस परप्यूरियस एवं टेकार्डीफेगस टेकार्डी)* एवं एक प्रिडेटर *यूब्लीमा एमाविलीस* फसल के मौसम में प्रचूरता से पाए गए।

फसल उत्पादन प्रणाली प्रबंधन एवं मूल्यांकन

- *ब्यूटीया मोनोस्पर्मा* (पलास) में छंटाई से बचे प्ररोह में उपराउं स्थिति की तुलना में तराउं भूमि के वजन में वृद्धि (क्रमशः 3.6 कि.ग्रा. एवं 2.0 कि.ग्रा.) देखी गई इसी तरह का रूझान प्ररोह व्यास (मान 1.1 एवं 1.0 से.मी.) एवं प्ररोह लम्बाई (मान 54.6 एवं 45.4 से.मी.) में भी रहा।
- तीन पहलूओं में लाख उत्पादन अनुपात में केवल स्थलाकृति में भिन्नता दिखी – उपराउं एवं तराउं भूमि में उपज अनुपात क्रमशः 6.4 एवं 3.1 दिखा। मार्च में तराउं भूमि में परजीवी की संख्या उपराउं भूमि की तुलना में तीन गुणा थी।
- पलास में मृदा उर्वरता स्तर से उपज अनुपात पर उल्लेखनीय प्रभाव नहीं हुआ, लेकिन मृदा उर्वरता स्तर में वृद्धि से बढ़ोतरी का रूझान (4.4 एवं 5.3 के बीच मान) देखा गया। नियंत्रण की तुलना में उच्चतम् उर्वरता स्तर में पपड़ी की मोटाई में 18% वृद्धि देखी गई तथा उच्चतम् उर्वरता स्थितियों में नर में 17 प्रतिशत कमी आई।
- पलास पर *ए. परप्यूरियस* की आबादी पर मौसमी पहलूओं अधिकतम् तापमान, सापेक्ष आर्द्रता (संध्या) का उल्लेखनीय एवं सकारात्मक योगदान देखा गया तथा 4 सप्ताह के आंकड़े के आधार प्रमुख भूमिका (66%) दिखी, जबकि सापेक्ष आर्द्रता (संध्या) एवं बरसात से बेर पर *ए. परप्यूरियस* की आबादी में उल्लेखनीय एवं सकारात्मक योगदान देखा गया तथा 04 सप्ताह के आंकड़े के आधार पर मौसम मानदंडों की प्रमुख भूमिका (59%) दिखी।
- सिंचाई, बरसात, गहरा अन्तःस्रवण एवं वाष्पित–प्रस्वेदन जैसे विभिन्न जल संतुलन के अध्ययन के लिए संस्थान अनुसंधान प्रक्षेत्र में कम लागत का जल निकास *लाइसीमीटर* का अभिकल्पन एवं निर्माण किया गया तथा *एफ. सेमियालता रौक्सब,* में पानी की आवश्यकताओं के निर्धारण के लिए स्थापित किया गया।
- लाख समेकित फसल प्रणाली (एल आई सी एस) के अन्तर्गत सहभागिता पहल अन्तरफसल के माध्यम से *सेमियालता* + भिंडी एवं *सेमियालता* + *एमेरैन्थस* का योगदान ग्रीष्म एवं वर्षा ऋतु में क्रमशः अन्य उपचार संयोजन की तुलना में बेहतर रहा।

क्षमता निर्माण, प्रौद्योगिकी प्रसार, प्रभाव मूल्यांकन एवं बाजार सूचना

- दो राज्यों झारखण्ड एवं प. बंगाल से आए 414 किसानों एवं नेपाल से आए एक किसान के लिए लाख की वैज्ञानिक खेती, प्रसंस्करण एवं उपयोग पर कुल सोलह कृषक प्रशिक्षण कार्यक्रम आयोजित किए गए।
- बिरसा कृषि विश्वविद्यालय, कांके, राँची के 22 स्नातक (कृषि विज्ञान) के विद्यार्थियों के लिए ग्रामीण कृषि कार्य अनुभव (आर ए डब्ल्यु ई) हेतु प्राकृतिक राल एवं गोंद आधारित कृषि–उद्योग सम्बद्ध प्रशिक्षण आयोजित किया गया।
- विभिन्न विश्वविद्यालयों के 53 विद्यार्थियों के लिए दो दिन का ''प्राकृतिक राल एवं गोंद पर औद्योगिक प्रशिक्षण'' विषय पर दो शैक्षणिक कार्यक्रम (दस दिन का ऑनलाइन) आयोजित किया गया।
- झारखण्ड एवं ओडीशा के 754 हितधारकों के लिए ग्यारह प्रक्षेत्र प्रशिक्षण आयोजित किए गए। झारखण्ड के 1195 हितधारकों के लिए बीस प्रक्षेत्र प्रोत्साहन प्रशिक्षण कार्यक्रम आयोजित किए गए। संस्थान का दौरा करने वाले 525 हितधारकों को प्राकृतिक राल एवं गोंद पर परिसर में 13, एक दिवसीय अभिविन्यास कार्यक्रम आयोजित किया गया।
- झारखंड के विभिन्न कृषि विज्ञान केन्द्रों में अनुसूचित जाति उप–योजना के अन्तर्गत छः कार्यक्रमों के अन्तर्गत 509 किसानों को मवेशी, कृषि उपकरण, छिड़काव मशीनें, वर्मी बेड, पावर वीडर एवं रोटावेटर वितरित किए गए।
- क्षमता निर्माण कार्यक्रम (सी बी पी) के अन्तर्गत हितधारकों पर प्रभाव के मूल्यांकन के लिए 28 जागरूकता सह ग्रामीण सर्वे कार्यक्रम आयोजित किया गया।

- बाजार आधारित तकनीकी सलाहकार परामर्श सेवा (एम ओ टी ए एस) के माध्यम से 20 हितधारको को प्रा.रा.गों. उत्पादन, न्यू.स.मू., हस्तांतरण योग्य प्रौद्योगिकी, भरोसा करने योग्य परियोजनाएं, प्रोत्साहन पुरस्कार, कोविड–19 के बाद प्रबंधन पहलूओं, विपणन, प्रसंस्करण, निर्यात एवं नीति मामलों से संबंधित सूचनाओं का प्रसार किया गया। प्राकृतिक राल एवं गोंद उत्पादन, प्रसंस्करण निर्यात–आयात के आंकड़े कृषि अनुसंधान आंकड़ा पुस्तिका के लिए भारतीय कृषि सांख्यिकी अनुसंधान संस्थान भेजा गया।
- इस अवधि में प्रशिक्षण शुल्क के रूप में रू.13,84,715/– (तेरह लाख चौरासी हजार सात सौ पन्द्रह रू.) मात्र की प्राप्ति हुई।
- अध्ययन क्षेत्र के अन्तर्गत लाख की खेती के लिए परिपालक वृक्ष के उपयोग की दृष्टि से *ब्यूटिया मोनोस्पर्मा* (पलास), *जीजीफस मौरिसियाना* (बेर) एवं *श्लीचेरा ओलिओसा* (कुसुम) के लिए क्रमशः 18.24, 6.82 एवं 3.09% उपयोग देखा गया, जो यह संकेत देता है कि ज्यादा लाख परिपालक, वृक्षों के उपयोग से लाख उत्पादन में वृद्धि की एवं रोजगार प्रदान करने की संभावनाएं हैं।

संश्लेशण, प्रक्रिया विकास एवं गुणवत्ता प्रबंधन

- गंधराल व्युत्पन्न का संश्लेषण किया गया तथा उसका रंग सूचकांक एवं अम्लमान का निर्धारण किया गया। अम्लमान 43–85 के बीच पाया गया; रंग गहरा पाया गया तथा कुछ मामले में मानक घोल से नहीं मिला और मृदुल बिंदु 27–60 ^{0}C रिकॉर्ड किया गया। एफ टी आई आर विश्लेषण के दौरान अम्ल के कार्बॉक्सिल समूह शीर्ष के स्पेक्ट्रा में उच्चतर आवृति दिखाता है एवं हाइड्रोकार्बॉक्सिल समूह के शीर्ष की उपस्थिति इस्टर के निर्माण का संकेत देती है।
- माइक्रोवेव असिस्टेड तकनीक से बोरैक्स का क्रॉसलिंकर के रूप में तथा एक्रिलेमाइड का मोनोमर के रूप में उपयोग कर अरबी गोंद आधारित हाइड्रोजेल का संश्लेषण किया गया। प्राप्त जेल मास का एसिटोन उपयोग कर पृथक किया गया, सुखाया एवं चाला गया तथा ब्रिलियंट ग्रीन (बी जी) रंजक को हटाने के लिए अवशोषक के रूप में उपयोग किया गया।
- *टर्मिनेलिया बेलिरिका* गोंद (बहेड़ा गोंद) के शुद्धिकरण के पश्चात् 70% गोंद की प्राप्ति हुई। मोनोमर, क्रॉसलिंकर एवं आरम्भक के सांद्रण के संबंध में प्रतिक्रिया स्थितियों को इष्टतम् किया गया।

मूल्य संवर्द्धन एवं उत्पाद विकास

- ग्वार गोंद के खाद्य रेशा का उपयोग कर लीपोसोम सम्पूटिकरण तकनीक द्वारा बीटा कैरोटिन का सम्पूटिकरण किया गया। सम्पूटिकृत उत्पाद के अभिलक्षण वर्णन से सम्पोषणीय मोचन सूत्रण के रूप में एस्कार्बिक अम्ल की उपस्थिति का पता चला।
- नहीं सूखने वाले ग्लू की सर्वश्रेष्ठ गुणवत्ता प्राप्त करने के लिए हाइड्रोलाईज्ड लाख संश्लेषण के लिए विभिन्न मानदंडों का अनुकूलन किया गया। वाणिज्यिक सूत्रण की तुलना में लाख आधारित सूत्रण की उच्च श्यानता बढ़े हुए तापमान (जब इसे धूप में रखा गया) में स्थिरता की पुष्टि करती है, अतः इनके ट्रैप से पसीज कर बाहर आने की सम्भावना कम है। वाणिज्यिक ग्लू की तुलना में कीट को अधिकतम् पकड़ने की क्षमता के आधार पर किए गए स्थल परीक्षण के माध्यम से सर्वश्रेष्ठ लाख आधारित ग्लू का चयन किया गया। वाणिज्यिक सूत्रण की तुलना में लाख सूत्रण की क्षमता कुल मिलाकर 80% पाई गई।

खेती के उपकरणों एवं प्रसंस्करण की मशीनों का अभिकल्पण एवं विकास

- कुसमी लाख से लाख–घोलक (2–प्रोपैनॉल) 1 : 6 अनुपात से विरंजित मोमरहित लाख (डी डी एल) की तैयारी के लिए परीक्षण किया गया। परिणाम से पता चलता है कि 76.12% औसत के साथ डी डी एल की 69% से 84% प्राप्ति हुई। डी डी एल में लाख के रंग मान (चौरी का रंग मान 12) में कमी 0.7 से 1.6 के बीच रहता है एवं रंग में कमी का अधिकतम रंगमान 0.7 देखा गया। इन परीक्षणों में तैयार किए गए डी डी एल नमूने का

बहाव एवं जीवन अवधि की चपड़ा से तुलना की गई। डी डी एल नमूने का मोम, अशुद्धता अंश एवं अम्ल मान भी बेहतर है तथा सभी परीक्षणों में स्वीकार्य सीमा के अन्दर है।

- ग्वार गोंद से कार्बॉक्सि मिथाइल ग्वार गोंद व्युत्पन्न तैयार किया गया। परिणाम से पता चलता है कि श्यानता एवं वैकल्पन के उच्चतर स्तर के साथ कार्बॉक्सि मिथाईल ग्वार गोंद घटे हुए मिश्रण समय (30 मिनट), प्रतिक्रिया समय 3 घंटा एवं शुष्कन समय 3 घंटा के साथ समान पी एच के साथ तैयार किया जा सकता है।
- कार्बॉक्सि मिथाइल ग्वार गोंद व्युत्पन्न पाइलॉट संयंत्र के सभी अवयवों का अभिकल्पन किया गया है। भाकृअनुप–केन्द्रीय कृषि अभियांत्रिकी संस्थान, भोपाल में पाइलट संयंत्र के निर्माण का कार्य चल रहा है।

प्राकृतिक राल एवं गोंद के निष्कर्षण, प्रसंस्करण एवं मूल्यवर्द्धन पर नेटवर्क परियोजना

- घोल का स्टिंग विधि द्वारा पियार – ए जी एन पी एस संबलित नैनोकम्पोजिट फिल्म विविध उपयोग के लिए विकसित किया गया तथा सम्पूर्ण फिल्म की मोटाई में समान वितरण एवं 250 ^{0}C तक ताप स्थायित्व के साथ चपटा, सघन, समरूप आकारिकी पाया गया। विकसित नैनोकम्पोजिट फिल्म में नियंत्रण की तुलना में आशाजनक प्रतिकवकीय गतिविधि दिखती है।
- लघु गोंद एवं राल पौधों की फील्ड निर्देशिका तैयार करने के लिए राँची, झारखंड के वन क्षेत्रों का सर्वे किया गया तथा समय–समय पर निकलने वाले पौधों के भागों जैसे फलों, पत्तियों, सम्पूर्ण पौधा एवं विभिन्न पौध प्रजाति से गोंद के निष्कर्षण का फोटोग्राफ लिया गया।
- *मोरिंगा ओलिफेरा* वृक्ष से गोंद के निष्कर्षण के लिए एक हल्के वजन का, कार्य में आसान, हस्त चालित गोंद निष्कर्षण ब्लेजर विकसित किया गया है। ब्लेजर से आसानी से कार्य किया जा सकता है तथा यह वृक्ष के तने पर धारदार किनारे से समान बनावट का अर्द्धवृत आकार का चीरा बनाता है तथा मानवशक्ति की जरूरतों, श्रम तथा समय में कमी लाता है एवं सामान्य मानवीय विधि की तुलना में अधिक गोंद उत्पादकता प्रदान करता है।
- *अकेसिया सेनेगल* एवं *अकेसिया टॉरटाइलिस* गोंद आधारित सूक्ष्म सम्पूटित पावडर का अभिलक्षण वर्णन किया गया तथा उसे मुख्य सामग्री के प्रतिऑक्सीकारक गुणों को रखते हुए एन्थोसाइनीन की प्रचूरता वाले सार के सूक्ष्म सम्पूटिकरण में सफल पाया गया।
- वर्ष 2021 में राजस्थान के पाँच जिलों के 48 ग्रामों में *ए. सेनेगल, ए. टॉरटाइलिस, अकेसिया निलोटीका, अकेसिया ल्यूकोफ्लोरा, एनोजीसस रोटन्डीफोलिया* इत्यादि वृक्षों पर गोंद उत्पादन के लिए काजरी गोंद इन्डयुसर प्रौद्योगिकी द्वारा उपचारित किया गया तथा किसानों ने गोंद की बिक्री से रू. 52.16 लाख राजस्व प्राप्त किया।
- अल्प ज्ञात वृक्ष प्रजाति *(एकेसिया सबपोरोसा* एवं *पी जुलीफ्लोरा)* पर गोंद निष्कर्षण के लिए प्रायोगिक परिक्षण किया गया तथा *ए. सबरोजा* एवं *पी. जुलीफ्लोरा* पर क्रमशः 179.2 ग्रा./वृक्ष एवं 65.5 ग्रा./वृक्ष औसत गोंद उत्पादन हुआ।
- कृषि–बागवानी–रेशम उत्पादन के कृषि वानिकी मॉडल में अधिकतम जी बी एच पौध उंचाई एवं वितान का फैलाव *एग्ली मारमेलोस* (बेल) में पाया गया तथा उसके बाद *ए. सेनेगल* (कुमट), *साइट्रस लीमॉन* (निंबू) एवं *केरीसा कैरेन्डस* (करौन्दा) का स्थान रहा। *सी. कैरेन्डस* की उत्तरजीविता (%) सबसे अधिक थी, तथा उसके बाद *ए. सेनेगल, ए. मारमेलॉस* एवं *सी. लीमॉन* का स्थान रहा। रेशम–हर्बल कृषिवानिकी मॉडल में अधिकतम् उत्तरजीविता (100%) *टर्मिनेलिया अर्जुना* (अर्जुन) की रिकॉर्ड की गई, उसके बाद *ए. नीलोटिका* एवं *ए. सेनेगल* का स्थान रहा। वृद्धि मानदंड (जी बी एच, पौध की उंचाई एवं वितान) *ए. नीलोटिका* में अधिकतम् थी तथा उसके बाद *ए. सेनेगल* एवं *टी. अर्जुना* का स्थान रहा। भूमि के उपर बायोमास पौध संख्या तथा बीच का उत्पादन *सी. लिमॉन* एवं *ए मारमेलॉस* का अधिकतम् एवं न्युनतम् रिकॉर्ड किया गया। गढ़कुदार जलछाजन क्षेत्र के किसान के खेत में लगाए गए (11 वर्ष) *ए. नीलोटिका* (50% तक) की तुलना में *ए. सेनेगल* (59.5%) की उत्तरजीविता अपेक्षाकृत ज्यादा रिकॉर्ड की गई। *ए. सेनेगल* आधारित गोंद बागान की उत्तरजीविता एवं वार्षिक वृद्धि आंकड़ा

में *ए. सेनेगल* तथा *बी मोनोस्पर्मा* में उच्चतर उत्तरजीविता (%) दिखी।

- टैनीन अंश के प्रभाव के विश्लेषण हेतु ग्वार कोरमा मील का विभिन्न उपचार किया गया तथा पाया गया कि कच्चे ग्वार कोरमा मील में टैनिन अंश में लगभग 1.73 ग्रा./100 ग्रा. एवं 0.43 ग्रा./100 ग्राम कमी आई। ग्वार कोरमा मील के उच्च तापमान उपचार (ऑटोक्लेविंग एवं उभार प्रसंस्करण) से टैनीन के स्तर में क्रमशः 0.38 एवं 0.31 ग्रा./100 ग्रा. की भारी कमी का संकेत मिलता है। कम टैनीन के साथ ग्वार कोरमा मील को खाद्य उत्पाद एवं पशु चारा के रूप में उपयोग किया जा सकता है।
- ग्वार बीज आधारित खाद्य फिल्म के विकास के लिए ग्वार मील तथा प्लास्टिसाइजर के साथ पी एच जी जी को मिलाने से यांत्रिक गुण, बैरियर एवं फिल्म निर्माण की क्षमता अच्छी दिखती है तथा कास्टिंग घोल के साथ–साथ खाद्य फिल्म में ग्वार मील को 40% पोटैटो स्टार्च द्वारा बदला जा सकता है।
- ओलियो रेजीन उत्पादन पर कोणीय छेद तथा व्यास श्रेणी के प्रभाव का अध्ययन किया गया तथा व्यास श्रेणी > 60 से.मी. में उच्चतम् (2214.99 ग्रा./छेद/वृक्ष) रिकॉर्ड किया गया जबकि व्यास श्रेणी 30–40 से.मी. में न्यूनतम् (1398.60 ग्रा./छेद/वृक्ष) हुआ। 40 डीग्री के कोण पर विकसित बोर होल के मामले में औसत अधिकतम् ओलियो रेजीन उत्पादन (2211.86 ग्रा./छेद) था तथा 70 डीग्री के कोण पर विकसित बोर होल में न्यूनतम् (1110.09 ग्रा./छेद) था।
- गोंद निष्कर्षण की यांत्रिक तकनीक की तुलना में गोंद उत्प्रेरक के उपयोग से धावड़ा *(एनोजीसस लैटिफोलिया),* रोहिणी (*सोयामिडा फेब्रीफिंग रॉक्सब),* साजा *(टर्मिनेलिया टोमेन्टोसा रॉक्सब)* एवं चिरौन्जी *(बुकनौनियां लैंजेन रॉक्सब)* पर गोंद उत्पादन बेहतर रहा।
- चरौता (*केसिया टोरा)* के बीच से गोंद के निष्कर्षण का अध्ययन किया गया तथा 140 ^{0}C / ^{0}F एवं 120 ^{0}C / ^{0}F पर भुने नमूने से क्रमशः उच्चतम् एवं न्यूनतम् (31.15% तथा 17.62%) गोंद उत्पादन रिकॉर्ड किया गया।
- मिट्टी का गमला, प्लास्टिक जार, पॉलीथीन बैग एवं जूट के थैले में सामान्य स्थितियों में गुग्गुल गोंद नमूनों को पैक किया गया तथा पाया गया कि 2.5 मि.मी. मोटाई के मिट्टी के गमले में रखे गुग्गुल नमूने से अधिकतम् (19) संख्या में यौगिक गायब हो गए तथा उसके बाद प्लास्टिक जार (14) तथा पॉलीथीन बैग एवं जूट के थैले (13) का स्थान रहा।
- वन महाविद्यालय एवं अनुसंधान संस्थान, मेट्टुपलयम, कोयम्बटूर में प्राकृतिक रूप से उगे *ब्यूटिया मोनोस्पर्मा टेरोकार्पस मार्सुपियम, क्लोरोजाइलॉम स्वीटेनिया* तथा *लैनिया कोरोमंडेलिका* के क्षेत्रीय महत्व के वृक्ष प्रजातियों के बागान में वर्ष 2020–21 की अवधि में गोंद उत्पादन का अध्ययन किया गया तथा पाया गया कि *सी स्वीटेनिया, पी मार्सुपियम* एवं *बी मोनोस्पर्मा* पर अन्य उपचार की तुलना में 400 मि.ग्रा./मि.ली. इथेफॉन तथा 1.2% गन्धकाम्ल सान्द्रण के गोंद बूस्टर डोज का उपचार बेहतर रहा। यह भी देखा गया कि गोंद उत्पादन की दृष्टि से 60–90 की व्यास श्रेणी 30–60 की व्यास श्रेणी से उच्चतर थी।

लाख कीट आनुवांशिक संसाधन के संरक्षण पर नेटवर्क परियोजना

- मुख्य केन्द्र द्वारा भा.प्रा.रा.गों.सं. वेबसाइट पर 50 परिपालक पौधों की जानकारी के साथ लाख परिपालक पौधों का एक वेब पोर्टल बनाया गया है।
- फन्जाई बारकोडिंग पी सी आर एस से लाख कीटों में कुछ अन्तः पादपी फंजाई जैसे *नेक्ट्रीय सीनेवेरीना, एक्रीमोनियम प्रजाति, एक्रीमोनियम वीटेलियम* एवं *रैमिक्लोरिडीयम कुकुरविटी, रैमिक्लोरिडीयम एपिकुलेटम* जैसे फंजाई तथा *हैमिल्टोनैफिस स्टाईरैसी* के अंतः सहजीवी जैसे खमीर की उपस्थिति का पता चलता है।
- प्रमुख लाख की प्रजाति/प्रभेदों में एल्यूरिटिक अम्ल अंश के भिन्नता विश्लेषण से पता चला कि कटाई के बाद ताजा *कैरिया चाइनेनसिस* नमूने में 98.78% शुद्धता के साथ एल्यूरिटिक अम्ल (19.81%) की अधिकतम् प्राप्ति हुई तथा न्यूनतम् प्राप्ति के शारदा (ट्राईवोल्टाइन लाख कीट) नमूने से हुई। हालांकि भंडारण के बाद जेठवी के दौरान उपजाए गए पीली प्रजाति से प्राप्त लाख राल को 18 माह भंडारण से उच्चतम् प्राप्ति होती है, जो यह

संकेत देती है कि यह प्रभेद एल्यूरिटीक अम्ल के पृथक्करण के लिए लम्बे समय तक भंडारण हेतु उपयुक्त है।

- वर्गीकरण अध्ययन के आधार पर *अल्वीजीया समन* पर मदुरई, तमिलनाडु में *कैरिया कैनेलीस* राजगोपाल के रूप में नई प्रजाति का वर्णन किया गया है। दक्षिण भारत के विभिन्न भागों से संग्रह कर रंगून, मयांमार के चैम्बरलीन द्वारा पूर्व में *कैरिया रंगूनेन्सीस* का वर्णन किया गया है तथा इसके आकारिकी अभिलक्षण वर्णन के साथ इसकी पहचान की गई है।
- असम के एंगलॉग जिले के वेस्ट कार्बी से प्राकृतिक रूप से लाख कीट होने वाला नया लाख परिपालक पौधा (*अल्वीजीया ल्युसीडोर)* की पहचान की गई।
- आर्चीप्स प्रजाति (*एफ. सेमियालता* का नाशीजीव) से कीट रोगजनित फंजाई *कार्डिसेप्स जैवेनिका* को पृथक किया गया, जो लेपिडोप्टेरन नाशीजीवों जैसे *युब्लीमा एमाविलीस,* राइस लीफ फोल्डर इत्यादि के विरूद्ध प्रभावी पाया गया।
- पंजाब में पहली बार *कैलिएन्ड्रा हिमैटोसेफाला* पर प्राकृतिक लाख कीट का ग्रसण देखा गया।
- पंजाब की स्थितियों में *फ्लेमिंजीया सेमियालता, एफ मैक्रोफाइला* एवं *जीजीफस मौरीसियाना* पर लाख कीट (रंगीनी प्रजाति) का जीवन चक्र एवं उत्पादकता से जुड़े मानदंडों का अध्ययन किया गया। बैशाखी एवं कतकी फसल की अवधि में क्रमशः 210–245 तथा 98–118 दिनों की भिन्नता थी।
- सामान्य अवस्था में भंडारण से पूर्व सिट्रासोल, फॉरमेसा एवं लाख आधारित मोम सूत्रण लेपित नारंगी पर किन्नो की कटाई उपरांत गुणवत्ता अगले 15 दिनों तक बनी रही। विपणण की अवधि बढ़ने से सिट्रासाइन एवं अलेपित (नियंत्रण) फलों की तुलना में आर्थिक लाभ बेहतर हो सकता है।
- बिहार के 38 जिलों में से 22 जिलों में अलग–अलग स्थितियों में *फाइकस रिलिजीओसा, फाइकस बेंगालेंसीस* एवं कहीं–कहीं *जीजीफस मैरीसियाना* तथा *बी. मोनोस्पर्मा* पर लाख कीट प्राकृतिक रूप से देखी गई। ज्यादातर कीट मृत पाए गए, परन्तु कहीं–कहीं पर अच्छी जीवित आबादी देखी गई। बिहार के दक्षिणी जिलों में प्राकृतिक उत्तरजीविता वाली लाख कीटों में प्रचूर विविधता पाई गई।
- परिपालक पौधा *अकेसिया नीलोटिका* (कीकर) पर लाख कीट का ग्रीष्म मरणशीलता न्यूनतम् देखी गई (34.29%), क्योंकि यह ग्रीष्मकाल में अच्छा सूक्ष्म जलवायु प्रदान करता है, जबकि बेर पर ग्रीष्म मरणशीलता अधिकतम् (54.19%) रही।

कृषि विज्ञान केन्द्र, खूँटी

- छः विकसित प्रौद्योगिकी का 12.02 हे. प्रक्षेत्र में परीक्षण किया गया तथा आठ प्रौद्योगिकी का 33.6 हे. में फ्रंटलाइन प्रदर्शन (एफ एल डी) किया गया। इसी तरह खरीफ के मौसम में धान, अरहर, कुसमी लाख, मूंगफली, सोयाबीन, मूंग, उरद एवं सब्जी की खेती से संबंधित परिसर से बाहर पैंतीस प्रशिक्षण/जागरूकता कार्यक्रम आयोजित किए गए तथा रबी मौसम के दौरान चना, मसूर एवं रैपसीड सरसों की खेती का परिसर से बाहर सोलह प्रशिक्षण आयोजित किया गया, जिसमें 2512 किसानों ने भाग लिया।
- उपरोक्त कार्यक्रमों के अतिरिक्त प्रक्षेत्र दिवस, अन्तर्राष्ट्रीय महिला दिवस, अम्बेडकर जयन्ती, अन्तर्राष्ट्रीय योग दिवस, पार्थेनियम जागरूकता सप्ताह, महिला किसान दिवस, विश्व खाद्य दिवस, सतर्कता जागरूकता सप्ताह, राष्ट्रीय संविधान दिवस, विश्व मृदा दिवस, किसान दिवस, कृषि–वानिकी पौधों का बागान बनाना, आत्मनिर्भर भारत, पोषण जागरूकता अभियान, जलवायु अनुकूलन किस्मों पर किसानों – वैज्ञानिकों में चर्चा, प्रौद्योगिकी एवं अभ्यास, राष्ट्रीय कृषि पर मा. प्रधानमंत्री का संबोधन, स्वच्छता पखवाड़ा, प्रधानमंत्री किसान योजना पर जागरूकता तथा डी ए एम यू के अन्तर्गत कृषि मौसम परामर्श जैसी प्रसार गतिविधियों/आयोजनों/कार्यक्रमों का आयोजन/प्रबंधन किया गया।

Research Accomplishments

Quality and Productivity Improvement

1. Biodiversity Conservation of Lac Insect and NRG Yielding Plants

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

Diurnal partitioning of starch and sugar in lac inoculated pigeonpea

The total sugar and starch was estimated in pigeonpea plant infested with lac insect and compared with non-infested plants (control). The leaf samples were taken from morning, afternoon and evening period. It was found that morning hour's samples from lac infested plants showed decrease in the total sugar as well as starch content whereas, afternoon and evening sample showed increase in total sugar but decrease in the starch content as compared to control. The percent decrease in the morning total sugar sample was 4.39 and in starch it was 28.02. The percent increase in the afternoon and evening hours total sugar was 1.63 and 9.54, respectively. Whereas, the percent decrease in the afternoon and evening hours in the starch was 19.19 and 18.69, respectively.

Effect of Plant Growth Regulators (PGR) on late pruned *Flemingia semialata*

A study was conducted to ameliorate the growth of *Flemingia semialata* occurred due to late pruning using PGR. The late pruning occurred in *F. semialata* due to seed harvesting. Harvesting of *kusmi* broodlac was carried out in the month of February whereas seed harvesting was carried out in late March or in the beginning of April. After seed harvesting, pruning operation was carried out in *F. semialata*. There is around two months deviation in pruning timing than the recommended *i.e.* February. Obviously, this results into reduction in the period required for growth of shoot at the time of inoculation (recommended is 6 months from the date of pruning to inoculation). To ameliorate the growth in *F. semialata* as affected by reduction in the period, PGR like NAA and Kinetin was sprayed on late pruned *F. semialata* plants and plants where regular pruning was followed (control). The *F. semialata* plants were sprayed with NAA 50 ppm, NAA 100 ppm and Kinetin 100 ppm one month before the scheduled date of lac insect inoculation and morphological data was recorded just before inoculation schedule *i.e.* one month after PGR spraying. The results showed that NAA 50 ppm treatment showed 20.85 % increase in the shoot length followed by Kinetin 100 ppm (19.19%) as compared to control. The shoot length data was also compared within the late pruned *F. semialata* and it was found that NAA 50 ppm recorded highest shoot length (7.12%) followed by Kinetin 100 ppm (5.46%). Thus, we can say that adverse effect of late pruning in *F. semialata* can be overcome by NAA and Kinetin.

Influence of plant growth regulators on morpho-physiology of *Flemingia semialata* (Roxb.) under lac insect (*K. lacca* Kerr) infested condition

The study was carried out on *F. semialata* grown at institute research farm (IRF) of Indian Institute of Natural Resins and Gums (IINRG), Namkum, Ranchi during 2021-22. The plants were sprayed with plant growth promoters and growth retardants on 24thJune 2021 before inoculation. Plants were inoculated with *kusmi* strain of lac insect (*K. lacca* Kerr) in the month of July 2021. Plants with no spraying along with lac insect served as control. The standard cultural package of practices for *kusmi* lac cultivation were followed. The observation on total biomass, total broodlac weight, broodlac weight/m shoot length, scrappedlac weight/m shoot length and % scrappedlac/m shoot length were taken (Table 1.1). The treatment NAA-100 ppm significantly recorded highest total biomass (1935.40 g/plant) followed by Kinetin-200 ppm (1893.20 g/plant), NAA-50 ppm (1883 g/plant), NAA-25ppm (1856 g/plant) as compared to control (11702.40 g/plant).The treatment NAA-25 ppm (494 g/plant) and Kinetin-200 ppm (494 g/plant) significantly recorded highest total broodlac weight followed by TIBA-20 ppm (464 g/plant) and TIBA-10 ppm (452 g/plant) as compared to control (341.90 g/plant). The treatment NAA-25 ppm (229.70 g) significantly recorded highest broodlac weight/m shoot length followed by NAA-50 ppm (201.34 g), TIBA-20 ppm (195.80 g) and Kinetin-200 ppm (195.22 g) as compared to control (168.72 g).The treatment Kinetin-200 ppm recorded the highest scrappedlac weight (86.60 g/m shoot length) followed by NAA-50 ppm (80.00 g/m shoot length) and NAA-100 ppm (79.10 g/m shoot length) as compared to control (44.30 g/m shoot length). The treatment Kinetin-200 ppm recorded the highest percent scrappedlac (46.92%) followed by MH-500 ppm (44.91%), NAA-100 ppm (44.59%) as compared to control (30.87%).

Table 1.1: Effect of plant growth regulators on morpho-physiology of *F. semialata* and lac yield parameters

Treatments	Total Biomass (g/ plant)	Total Broodlac wt (g/plant)	Broodlac wt. (g/m shoot length)	Scrappedlac (g/m shoot length)	% Scrappedlac/m shoot length
NAA 25 ppm	1856.00	494.60	229.70	63.10	27.19
NAA 50 ppm	1883.00	429.80	194.20	80.00	41.22
NAA 100 ppm	1935.40	389.00	178.20	79.10	44.59
Kinetin 100 ppm	1182.00	385.80	195.10	74.20	38.24
Kinetin 200 ppm	1893.20	494.80	189.00	86.60	46.91
TIBA 10 ppm	1594.20	452.60	195.80	73.90	38.71
TIBA 15 ppm	1094.20	464.00	176.80	67.20	37.50
MH 500 ppm	1315.40	427.60	158.10	71.20	44.91
MH 1000 ppm	1563.00	363.00	175.60	73.97	42.97
CONTROL	1702.40	341.90	146.20	44.30	30.86
CD	157.40	50.57	25.80	5.14	9.38
SE (m)	54.65	17.56	8.96	1.78	3.25
SE (d)	77.29	24.83	12.66	2.53	4.61
CV	7.63	9.25	10.54	5.60	18.54

Screening different lac insect germplasms for tolerance to ultra-low doses of systemic insecticides

Lac insect germplasms collected from states where pesticide usage is high are expected to have higher level of tolerance to insecticides due to higher likelihood of indirect exposure to sub-lethal dose over long period of lime. Lac insect germplasms collected from four of the high pesticide consuming states *viz*. Andhra Pradesh, Maharashtra, Punjab and Rajasthan [IINRG-LIK 0018 PFE: Aurangabad (Maharashtra); IINRG-LIK 0063 ZMA: Patiala (Punjab); IINRG-LIK 0020 PFE: Echoda (Andhra Pradesh) and IINRG-LIK 0011 FRE: Udaipur (Rajasthan)] were compared for imidacloprid tolerance with low pesticide consuming states *viz*. Meghalaya, Jharkhand, Madhya Pradesh and Assam [IINRG-LIK 0031 FRE: Nangpoh (Meghalaya); IINRG- LIK 0002 SOL: Ranchi (Jharkhand); IINRG-LIK 0065 SOL: Bankhedi (Madhya Pradesh) and IINRG-LIK 0069: Kharbiolong (Assam)]. Four doses of imidacloprid 17.8 SL (Confidor) *i.e.* 6 ml/10 l, 3 ml/10 l, 1.5 ml/10 l and 0.75 ml/10 l were used to determine level of tolerance in the selected germplasms. Insecticide spray was done at sex differentiation stage (40-60 days after crawler settlement). Surviving male and female cells were counted at the time of sexual maturity (about 21 days after spraying).

The study revealed presence of higher level of tolerance in lac insect germplasms collected from high pesticide consuming states as compared to low pesticide consuming states. While at high dose (6 ml/10 l) no survival was observed in all lines, at recommended dose (3 ml/10 l), at least low level of survival was recorded for germplasms collected from high pesticide consuming states. With exposure to low doses (0.75 ml/10 l) highest female survival was recorded in Maharashtra population (11.3%) while lowest female survival (Fig. 1.1) was recorded for Meghalaya population (1.9%). Male survival was relatively lower as compared to females across all the populations (Fig. 1.2).

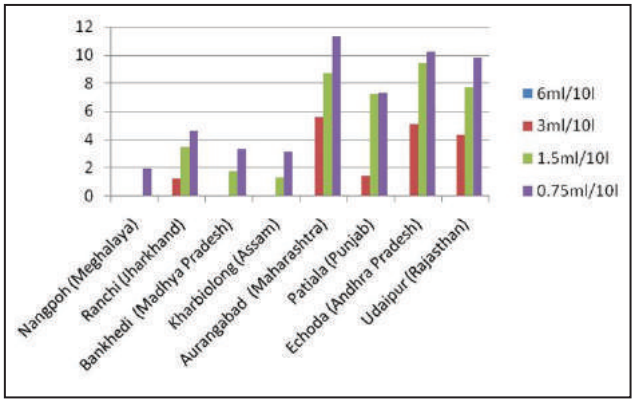


Fig. 1.1: Percent female survival in lac insect germplasms under different concentrations of imidacloprid spray

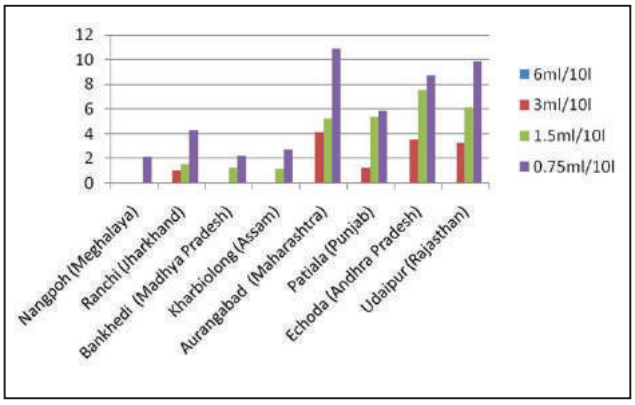


Fig. 1.2: Percent male survival in lac insect germplasms under different concentrations of imidacloprid spray

Maintenance of lac insect gene bank, host plant gene bank and different host plots

90 collections of 69 species are being conserved in the lac host field gene bank.

1050 cultures of 52 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.

Calliandra calothyrsus (95 numbers with spacing of 4×8 meter) and rain tree (*Albizia saman*) (30 numbers with spacing of 8×8 meter) were raised and developed separate plots for further study.

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

Morphological characterization, identification and documentation of lac insects

Lac insect populations with accession numbers IINRG-LIK 0011 and IINRG-LIK 0018, IINRG-LIK 0020, IINRG-LIK 0061, IINRG-LIK 0062 were collected from lac insect gene bank, ICAR-IINRG campus and identified as *Kerria destructor* Talukder and Das, *Kerria indicola* (Kapur), *Kerria chamberlini* Varshney and *Kerria lacca* (Kerr) respectively. One yellow lac population on *ber* from IRF, IINRG and 3 populations collected from Beniyazara on *ber*, *kusum* and *Calliandra* are processed and identified as *Kerria lacca* (Kerr). Identification and redescriptions were done based on the slide mounted adult female specimens. Specimens were observed and photographs are made using Leica DMC 4500 digital camera mounted on Leica DM 1000 LED microscope. The mounted specimens are deposited in IINRG Insect repository.

***Kerria destructor* Talukder and Das**

Material examined: Collected: Gene bank: LIK0011 and LIK0018, Gene bank, ICAR-IINRG, Ranchi (10 ad ♀♀).

Adult female

Mounted material (Fig. 1.3).

Body globular, 3.12-4.55 mm long, 2.38-3.32 mm wide at middle (n=10).

Dorsum: Brachia slightly sclerotized, 231.5-260.7 µm long. Brachial plate circular, diameter 243-285 µm; brachial crater shallow, centre in position, sub-circular, 129-145 µm wide, with a defined rim, dimples medium to large, distinct, 6-9 in number. Anterior spiracle 358 µm long and 143 µm wide. Dorsal spine well developed 286-298 µm long. Anal tubercle well developed; pre-anal plate membranous, supra-anal plate 413-477 µm long, 486-508 µm wide, sclerotized. Anal ring 6 sectored with 10 setae.

Venter: Antennae 46-48 µm long, 3 segmented, segmentation obscure, apical segment flatten with 3 long fleshy setae. Posterior spiracle smaller than the anterior spiracle, born on a sclerotized plate. Marginal duct cluster distinct, 6 in number; arranged in convoluted line; each consisting of 37-46 ducts without any surrounding sclerotization. Perivulvar pore clusters 8-10 in number on each side.

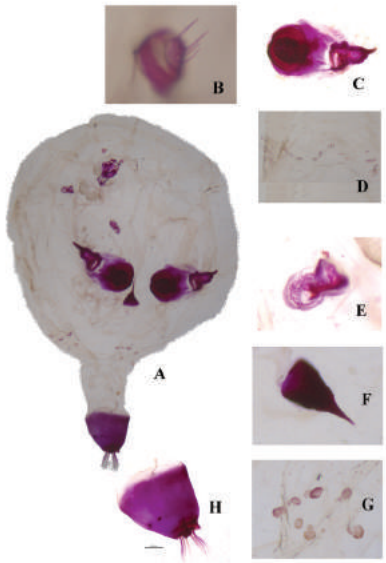


Fig. 1.3: *Kerria destructor* Talukder and Das. A, whole mount. B, antenna. C, brachia. D, marginal duct cluster. E, posterior spiracle. F, dorsal spine. G, perivulvar pore cluster. H, anal tubercle

***Kerria indicola* (Kapur)**

Material examined: Collected: Gene bank: LIK0020, Gene bank, ICAR-IINRG, Ranchi (10 ad ♀♀).

Adult female

Mounted material (Fig. 1.4).

Body globular, 3.31-3.77 mm long, 2.92-3.26 mm wide at middle (n=10).

Dorsum: Brachia elevated, sclerotized, 215-308 µm long. Brachial plate circular, diameter 234-246 µm; brachial crater shallow, centre in position, sub-circular, 125-146 µm wide, with a defined rim, dimples small, obscure, 6-8 in number. Anterior spiracle 405-440 µm long and 162-191 µm wide. Dorsal spine well developed 267-316 µm long. Anal tubercle well developed; pre-anal plate membranous, supra-anal plate 371-446 µm long, 308-415 µm wide, sclerotized, anal ring 6 sectored with 10 setae.

Venter: Antennae 41-48 µm long, 3 segmented, segmentation obscure. Posterior spiracle born on a sclerotized plate. Marginal duct cluster distinct, 6 in number; arranged in convoluted line; each consisting of 36-52 ducts without any surrounding sclerotization. Perivulvar pore clusters 8-10 in number on each side. Ventral duct cluster present, irregular in shape and totaling to 3 pairs.

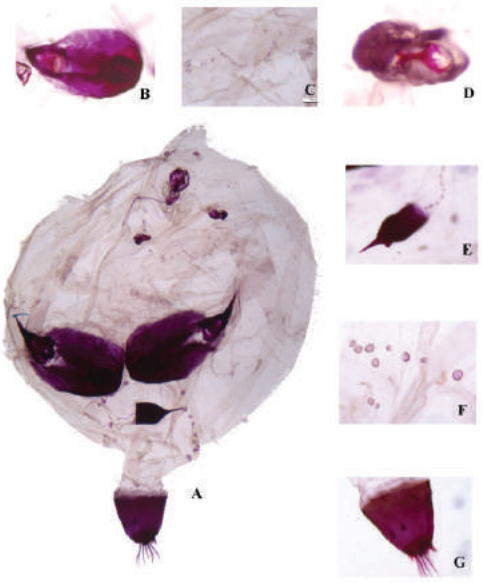


Fig. 1.4: *Kerria indicola* (Kapur). A, whole mount. B, brachia. C, marginal duct cluster. D, posterior spiracle. E, dorsal spine. F, perivulvar pore cluster. G, anal tubercle

***Kerria chamberlini* Varshney**

Material examined: Collected: Gene bank: LIK0061, Gene bank, ICAR-IINRG, Ranchi (10 ad ♀♀).

Adult female

Mounted material (Fig. 1.5).

Body globular, 3.1-3.84 mm long, 2.64-2.94 mm wide at middle (n=10).

Dorsum: Brachia elevated, cylindrical shape and heavily sclerotized. Brachial plate circular, diameter 234-266 µm; brachial crater shallow, centre in position, sub-circular, 139-150 µm wide, with a defined rim, dimples small, distinct, 7-9 in number. Anterior spiracle 495-548 µm long and 162-201 µm wide. Dorsal spine well developed 270-279 µm long; pedicle 122-142 µm long; spine 144-158 µm long. Anal tubercle well developed; pre-anal plate membranous, supra-anal plate 396-471 µm long, 383-425 µm wide, heavily sclerotized.

Venter: Antennae 43-51 µm long, 3 segmented, segmentation obscure, apical segment flatten with 3 long fleshy setae. Posterior spiracle born on a sclerotized plate. Marginal duct cluster distinct, 6 in number; arranged in convoluted line; each consisting of 33-36 ducts with surrounding weak sclerotization. Perivulvar pore clusters 8-10 in number on each side. Ventral duct cluster present, irregular in shape and totaling to 3 pairs.

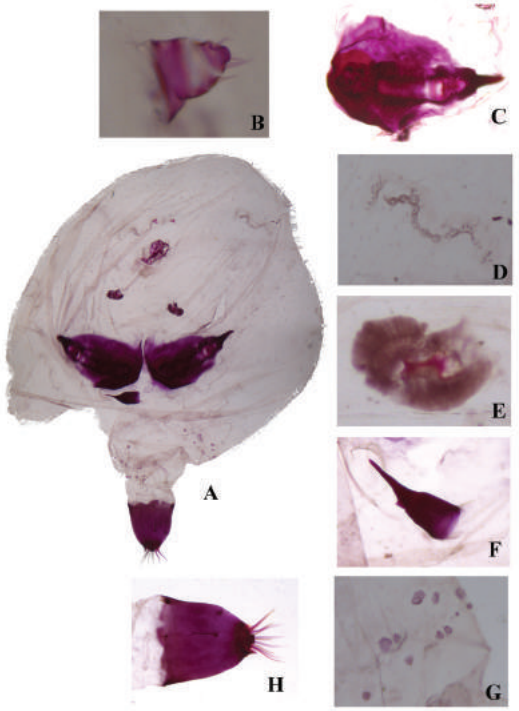


Fig. 1.5: *Kerria chamberlini* Varshney. A, whole mount. B, antenna. C, brachia. D, marginal duct cluster. E, posterior spiracle. F, dorsal spine. G, perivulvar pore cluster. H, anal tubercle

***Kerria lacca* (Kerr)**

Material examined: Collected: Gene bank: LIK0062, Gene bank, ICAR-IINRG, Ranchi (10 ad ♀♀). Coll. Rajgopal, N. N., *Ziziphus mauritiana* (Ber), ICAR-IINRG, 7 slides (19 ad ♀♀). 3 populations collected from Beniyazara on *Ber*, *Kusum* and *Calliandra.*

Adult female

Unmounted material

Lac test brown, each test with a thick, hard resinous covering. Tests occur in aggregations; live mature females elongated and crimson.

Mounted material (Fig. 1.6):

Body large, elongated, 2.5–3.25 mm long, 1.8-2.0 mm wide at apex, 2.25-2.75 mm wide at middle and 1.63-2.12 mm wide at base (n=10).

Dorsum: Brachia elevated, cylindrical and heavily sclerotized, 650-800µm long and 300-360µm wide. Brachial plate circular, diameter 210–260µm; brachial crater shallow, sub-circular, 110-150µm wide, with a defined rim; dimples small, obscure, 8-10 in number. Anterior spiracle 180-210µm long and 100-110µm wide, 450-700µm away from brachial crater. Dorsal spine well developed 350-400µm long and 100–120 µm wide at base; pedicel large, slender, more sclerotized, 150-210µm long; spine 180-210µm long and sclerotized with 2 or 3 spinosities at base. Anal tubercle elongated, well developed; pre-anal plate membranous; supra-anal plate heavily sclerotized, hispid near apex, 430-520µm long, 400-420µm wide. Anal fringe plates short, fringe maximum length 40-80µm. Anal ring 6 sectored with 10 setae. Dorsal duct cluster in a single row of ducts between dorsal spine and anal tubercle, number of ducts uncertain, probably 5 or 6, and each cluster devoid of spermatoid ducts.

Venter: Antennae 40–50µm long, 3 segmented, segmentation obscure; apical segment flattened with 3 long fleshy setae and 2 short setae. Posterior spiracles each 70–100µm long, smaller than anterior spiracles, born on a sclerotized plate, with 45–53 spiracular pores present along one side of each spiracle. Marginal duct clusters distinct, 6 in number, each cluster arranged in a convoluted line consisting of 25-40 ducts with slight surrounding sclerotization. Perivulvar pore clusters: 6-9 on each side of anal tubercle, irregular in shape, each pore with 5–10 loculi. Ventral duct clusters irregular in shape, totaling 3 pairs: first pair anterior to mouthparts, second pair antero-lateral to mouthparts and third pair postero-lateral to posterior spiracle.

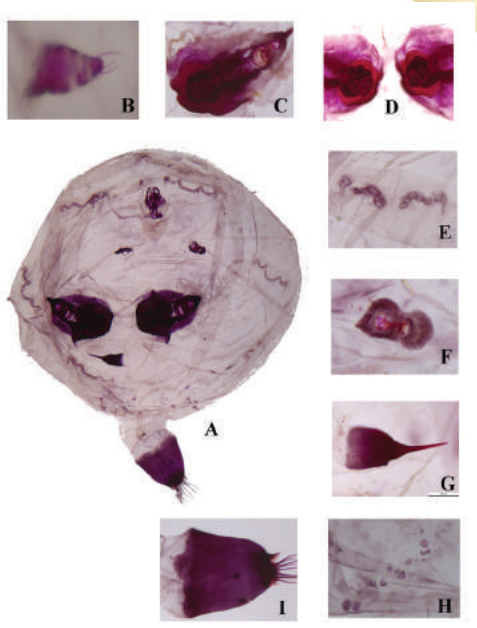


Fig. 1.6: *Kerria lacca* (Kerr). A, whole mount. B, antenna. C, brachia. D, brachial plate, crater with dimples. E, marginal duct cluster. F, posterior spiracle. G, dorsal spine. H, perivulvar pore cluster. I, anal tubercle

Collection, identification and documentation of lac associated fauna

The lepidopteran pest of Indian lac insect, *Eublemma amabilis* is identified and redescribed taxonomically with respect of genital characters which were not studied so exhaustively for its taxonomic aspects till now (Fig. 1.7). The work was carried out with the help of lepidopteran taxonomist Dr. Shashank PR from Division of Entomology, ICAR-IARI, New Delhi.

One beetle store pest was collected at IRF, IINRG and identified with the help of Dr. Mahendran, ICAR-NBAIR, Bengaluru, which belongs to genus *Corticaria* (Latridiidae) feeding on lac encrustation and lac insect body leftovers in *phunki* and scrapped lac.

Collection, identification and documentation of lac host associated insect fauna

Surveys are conducted in the year 2021 for insect pests associated with *kusum* tree, the major lac insect host plant for *kusmi* strain lac insect. During the surveys, we encountered two insect pest populations causing significant leaf damage. They are leaf miner (Lepidoptera) and Leaf gall midge (Diptera). The leaf minor is identified as *Acrocercops* nr. *tenera* Meyrick, 1914 (Family: Gracillariidae), feeding on young leaves by mining leaf between lamina, which intern leads to distortion of the leaves (Fig. 1.8). The gall midge causing severe damage to the young flesh by producing hairy galls on the lower surface of the leaf, it is identified as the new species belong to the

genus *Contarinia* (Family: Cecidomyiidae) and yet to describe morphologically (Fig. 1.9).

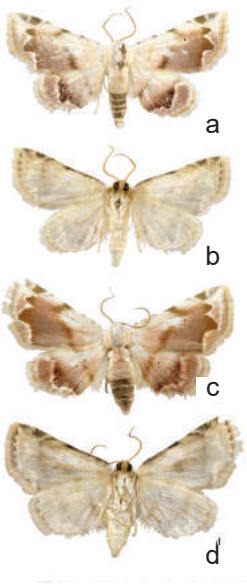


Fig. 1.7: *Eublemma amabilis* (Moore, 1884) a-d; a&d. male adult (a. dorsal, b. ventral view), c&d female adult (c. dorsal, d. ventral view)



Fig. 1.8: *Acrocercops* nr. *tenera* A, Adult. B, Matured larva feeding in galaries. C, Galaries on ventral side of the leaf

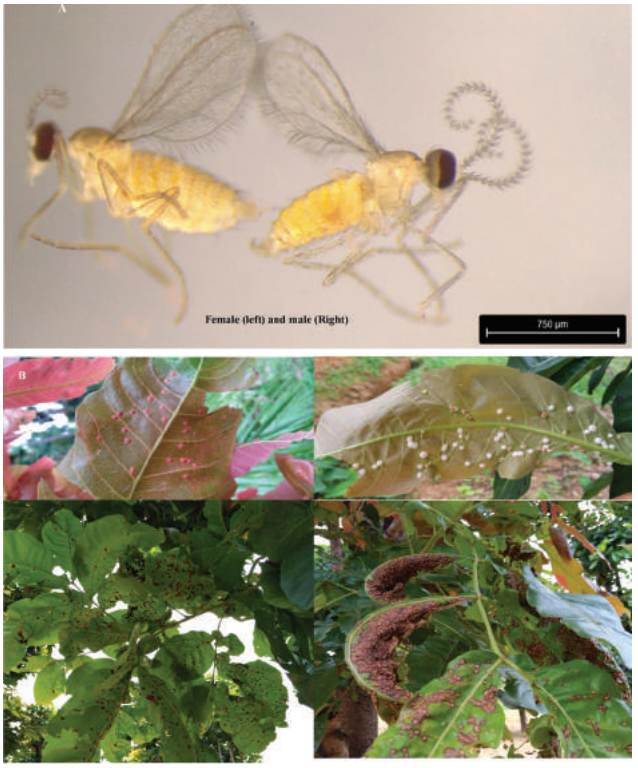


Fig. 1.9: *Contarinia* sp. A, Adult. Male and female B, Damage symptoms on the leaves of kusum tree

Collection, identification and documentation of lac associated insect fauna

Common *Ficus* species are reported to support wild natural lac insect populations in different parts of India and considered as good host for *in-situ* lac insect conservation. Detailed understanding of fig biology as well as fig associated insects is required for sustainable conservation effort. However, little is known about the diversity of lac associated entomofauna in fig hosts. One of the important wild lac host plant species in the genus *Ficus* is *Ficus lacor* Buch.-Ham., 1827. Field surveys were conducted to explore fig wasp diversity associated with lac host plant *F. lacor* at campus and institute research farm of ICAR-IINRG, Ranchi, Jharkhand. About 800 fig wasp (Chalcidoidea: Hymenoptera) specimens were collected from D-phase mature syconia of *F. lacor*. Fig wasp entomofauna of *F. lacor* was found to be represented by 7 genera of fig wasps *viz*. *Eupristina* Saunders 1883 (1 species; pollinator), *Camarothorax* Mayr, 1906 (1 species; galler), *Ormyrus* Westwood, 1832 (1 species; galler), *Otitesella* Westwood l883 (1 species; galler), *Parasycobia* Abdurahiman & Joseph, 1967 (1 species; galler), *Sycophila* Walker 1871 (3 species; parasitoids) and *Sycoscapteridea* Ashmead, 1904 (1 species; parasitoids).

Additionally identified one new species of phytophagous galler wasp in the genus *Parasycobia* (Hymenoptera: Chalcidoidea) (Fig. 1.10) from lac host plant *Ficus religiosa.* This new species is the second species in the genus *Parasycobia* after *Parasycobia kaurae* Abdurahiman & Joseph 1967 which was reported from *F. virens*.

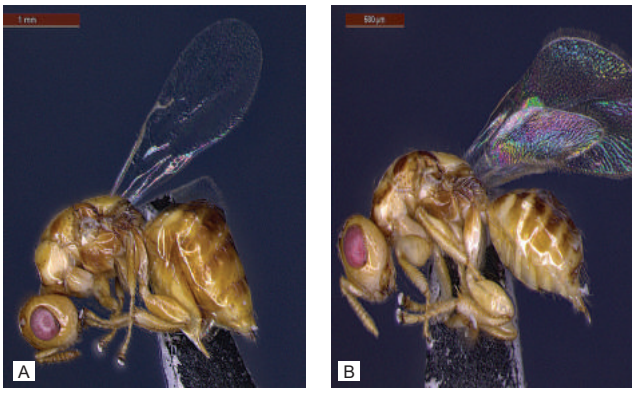


Fig. 1.10: *Parasycobia* sp nov. female (A) and male (B)

2. Lac Insect-Host Plant Environment for Improved Quality and Productivity

2.1 Agronomic interventions influencing lac production in *palas* (*Butea monosperma*) in summer season

Palas tree growth affected by different treatment

For examining growth of *palas* trees due to different topography of land, levels of fertility and different rest periods, growth attributing characters like new shoot/10 cm thick primary branch, shoots per 10 mm prune point, residual pruned out shoot weight and its number, shoot diameter and length, shoot dry matter % and dead shoot/10 cm tree trunk was record and presented in Table 2.1.

Upland condition showed enhanced growth in respect to residual pruned out shoot weight compared to lowland (3.6 kg and 2.0 kg, respectively). Similar trend was observed for shoot diameter (value 1.1and 1.0 cm) and shoot length (value 54.6 and 45.4 cm).

Soil fertility did not show marked different in terms of any of the growth attributes. However, increase was observed with increasing soil fertility in case of new shoot generation and residual pruned out shoots. Decreasing trend was observed in case of dead shoot, where lesser number of dead shoots was observed with higher soil fertility levels.

Rest period also did not show remarkable effect. However, lower rest period (7 months) could show higher number of new shoot compared to more (14 months) rest (31.2 and 26.5, respectively)

Table 2.1: _Palas_ tree growth parameters affected by topography, soil fertility and rest levels during 2021

Treatment Condition	No shoots/10 cm branch thickness	No shoots/10 mm PP thickness (without lac)	No shoots/10 mm PP thickness (with lac)	Average new shoot diameter (mm) in Jun	Average new shoot length (cm) in Jun	No rejected shoots	Rejected shoot wt.(kg)	New flash arrival (Std. week)	Fruits per bunch	No flower bunch per tree	Dry matter percent (April)	Dry matter percent (Jan)	Dead shoot per 10 cm tree trunk dia July 21
U	30.7	1.65	0.86	1.1	54.6	25.2	3.6	13.84	0.79	2.88	41.94	37.4	5.6
L	27.0	1.61	0.69	1.0	45.4	21.1	2.0	14.50	8.80	17.22	37.53	37.7	5.9
CD	4.3 NS	0.27 NS	0.14*	0.1*	5.5*	8.5 NS	0.8*	0.38*	3.44*	5.90*	3.57*	2.0 NS	1.7 NS
F0	25.9	1.81	0.68	1.1	50.6	23.3	2.6	13.88	5.98	13.81	40.18	38.5	7.3
F1	25.3	1.32	0.74	1.1	47.7	25.2	2.9	14.25	1.96	5.25	38.55	36.4	5.3
F2	30.1	1.71	0.84	1.0	51.0	19.1	2.1	14.31	1.63	4.75	38.67	37.7	5.7
F3	34.1	1.67	0.85	1.1	50.8	25.0	3.5	14.25	9.63	16.38	41.54	37.8	4.8
CD	6.1 NS	0.39 NS	0.19 NS	0.1 NS	7.7 NS	12.0 NS	1.1 NS	0.54 NS	4.86*	8.35*	5.05 NS	2.9 NS	2.4 NS
R1	31.2	1.76	0.00	1.0	51.7	-	-	13.88	1.81	4.84	38.67	37.1	5.5
R2	26.5	1.50	1.55	1.1	48.4	-	-	14.47	7.78	15.25	40.80	38.1	6.1
CD	4.3 NS	0.27 NS	0.14*	0.1 NS	5.5 NS	-	-	0.38*	3.44*	5.90*	3.57 NS	2.0 NS	1.7 NS

U: Upland, L: Lowland, F0-F3: Levels of soil fertility, R1, R2: Rest periods
NS: Non-significant; * Significant

Palas tree growth affected by topography, fertility and rest period

Data recorded on shoot length and its diameter revealed that it was 56 and 46 cm under upland and lowland conditions, respectively in December. Difference recorded was significant, but no significant difference was recorded against differences in fertility status and rest periods. However, percent increase in length (compared to July) was found to be significant in case of rest period. Values ranged between 0.13 to 5.22 percent. It indicated that seven months rest period is meager for *palas* trees. Interaction table suggested that in upland condition, shoot length increased with increment in soil fertility. But reverse picture was observed in case of lowland condition. Interaction table also suggested that, upland condition coupled with liming and highest level of fertility produced maximum number of shoots/10 cm trunk (Table 2.2).

Table 2.2: Tree growth parameters affected by different factors

Factors	Shoot length in December	% Increase in length over July	Shoot diameter in December	% Increase in diameter over July	No inoculable shoot per 10 cm trunk diameter	Initial Insect settlement per sq cm	Initial insect mortality percent
U	56.33	3.08	1.22	12.29	2.8	59.3	8.6
L	46.01	2.27	1.11	8.02	1.5	53.0	15.5
CD	5.63*	2.41 NS	0.13 NS	13.17 NS	0.3*	4.8*	2.3*
F0	51.05	0.94	1.09	1.43	1.8	54.5	16.3
F1	50.19	5.02	1.06	-1.40	2.3	53.3	13.3
F2	52.45	3.18	1.16	12.49	2.0	59.3	9.9
F3	50.98	1.56	1.35	28.11	2.5	57.4	8.6
CD	7.96 NS	3.41 NS	0.18*	18.62*	0.5 NS	6.8 NS	3.2*
R1	51.82	0.13	1.12	6.29	-	-	-
R2	50.51	5.22	1.21	14.02	-	-	-
CD	5.63 NS	2.41*	0.13 NS	13.17 NS	-	-	-

U: Upland, L: Lowland, F0-F3: Levels of soil fertility, R1, R2: Rest periods
NS: Non-significant; * Significant

So far as shoot thickness is concerned, remarkable increase in thickness was observed due to variation in soil fertility. Highest level of fertility recorded 23 percent higher thickness. Similarly, percent increase in shoot thickness was affected positively in both the doses of NPK application as compared to control. Values ranged from 1.43 percent in control to 28 percent in highest dose. Also it was observed that upland conditions recorded 86% higher number of shoots/10 cm thick trunk. Variation was observed due to soil fertility, but difference did not touch the level of significance.

Lac insect growth and yield attributes affected by topography, soil fertility and rest period

Among three factors, only topography could increase lac yield ration more than 100 percent. Upland and lowland conditions witnessed yield ration 6.4 and 3.1, respectively. Parasite population in March was noticed to be almost three times in lowland than that noticed in uplands. Encrustation thickness and male percent remained almost similar in both the conditions (Table 2.3).

Soil fertility levels could not change yield ration significantly. However, increasing trend was observed with increase in fertility levels. Value ranged between 4.4 and 5.3. Encrustation thickness was found to increase 18% in highest fertility level compared to control. But, male percent decreased 17 percent in higher fertility condition.

One of the important purposes of the experiment is to see how summer season lac insect mortality due to parasite attack is affected by the factors like topography and soil fertility levels. Weather condition of this year, particularly atmospheric temperature was satisfactory in relation to lac culture. Therefore, neither of the factors could influence lac insect mortality significantly. Parasite count per meter lac stick was observed to be higher (9.1) in lowland conditions compared to upland in March, but difference did not touch the level of significance. However, in the month of April, this difference in parasite count was further narrowed (6.6 and 6.8 per meter)

Parasite count per meter lac sticklac as affected by different treatments *i.e.* land topography (upland and lowland), fertilizer levels ((Control; liming 2 kg; Lime (2 kg) + FYM (30 kg) + 300 g urea + 300 g DAP + 800

g MOP; Lime (4 kg) + FYM (60 kg) + 600 g urea + 600 g DAP + 1600 g MOP per tree) ranged between 2.6 to 11.6 in April and between 2.8 to 9.3 in May. No marked variation was observed among the treatments.

Table 2.3: Lac insect growth and yield attributes affected by topography, soil fertility and rest period 2021

Treat-ment	Initial insect mortality percent	Settlement density per sq cm	Male percent July 21	Parasite count per meter (March)	Parasite count per meter (April)	Borers holes per tree (6 feet height)	Scraplac percent	Encrustation thickness mm	Yield ratio
U	8.6	59.31	32.5	3.4	6.6	0.06	37.9	5.13	6.42
L	15.5	52.98	32.1	9.1	6.8	0.06	29.3	5.13	3.12
CD	2.3*	4.83*	4.7 NS	5.4 NS	6.8 NS	0.10 NS	6.0*	0.45 NS	1.77*
F0	16.3	54.54	34.3	6.6	2.8	0.06	37.3	4.88	4.41
F1	13.3	53.33	34.5	11.6	9.3	0.00	33.5	5.00	5.09
F2	9.9	59.33	32.1	2.6	5.9	0.06	30.5	4.88	4.33
F3	8.6	57.38	28.3	4.1	8.9	0.13	33.1	5.75	5.26
CD	3.2*	6.82 NS	6.7 NS	7.7 NS	9.6 NS	0.15 NS	8.4 NS	0.64 NS	2.51 NS
R1	-	-	-	-	-	0.13	-	-	-
R2	-	-	-	-	-	0.00	-	-	-
CD	-	-	-	-	-	0.10*	-	-	-

U: Upland, L: Lowland, F0-F3: Levels of soil fertility, R1,R2: Rest periods
NS: Non-significant; * Significant

Lac insect growth affected by interaction of topography, fertility and rest period

Lac insect settlement was found to be 13% more in upland conditions than that of lowland condition. Soil fertility status did not affect insect settlement significantly. Lac insect mortality in upland was 55% of that of lowland conditions. Similarly, average mortality in highest fertility level was 52.7% of that in control. Value ranged between 16 percent (control) and 8 percent (highest fertility level). Thus upland conditions help better settlement in one hand and also lower insect mortality in the other (Table 2.4).

Table 2.4: Lac insect settlement and mortality affected by interaction of topography, fertility and rest period

Lac insect mortality percent				
	F0	F1	F2	F3
U	11.9	8.4	9.3	4.6
L	20.8	18.2	10.5	12.7
CD	0.47*			

Settlement per sq cm				
	F0	F1	F2	F3
U	50.2	61.3	59.8	66.1
L	58.9	45.4	58.9	48.7
CD	6.82*			

2.2 Seed deterioration and amelioration strategies during storage in *Flemingia semialata*

Standardization of the package and practices of seed sowing and sowing depth of *Flemingia semialata*

Experiment on *F. semialata* were conducted to standardize the package and practices for raising the large number of seedlings focusing on seed size, sowing depth and subsequent growth. The seeds were visually separated in to three seed sizes; small (≤ 0.01g), medium (~ 0.02 g) and large (≥0.03 g). The experiment consisted of two treatment factors: i) three seed sizes *i.e.* small, medium and large; and ii) six planting depths *i.e.* 0.5 cm, 1.0 cm, 1.5 cm, 2.0 cm, 2.5 cm and 3.0 cm. The resultant eighteen treatment combinations were evaluated.

Parameters measured in the trial included; number of seedling emerged daily after synchronization *i.e.* from twelfth days after planting, seedling height was recorded at weekly intervals started after fourth week and continued to fourteenth week after planting. Seedling dry weight was recorded after fourteenth weeks of planting. To study the plant height and seedling weight, five random selected seedlings were used.

In the beginning, relation of seed size was discussed in respect of planting depth followed by observation on percent emergence, seedling growth, and seedling biomass as a function of seed size and planting depth. Seed size significantly influenced the seedling emergence percentage. It was observed that large seed emerged more rapidly than the small seed (Fig. 2.1). Among different combinations of seed size and sowing depth, large sized seeds (≥0.03 g) planted at 1.5 cm depth showed significant increase in emergence percent (70) than other sowing depths. Likewise, medium sized seed (~0.02 g) germinated well at 1.0 cm (61.7), similarly emergence percent of small sized seed (≤0.01g) observed higher 0.5 cm of soil depth (61). Overall, emergence of large, medium and small sized seeds irrespective of sowing depth was observed 57, 47 and 42 percent, respectively. Irrespective of seed size, maximum germination percent was observed at 1.0 cm soil depth (58) followed by 1.5 and 0.5. (51). Finding envisaged that seed emergence of *F. semialata* significantly affected by seed size (CD=0.86) and sowing depth (CD=1.22).

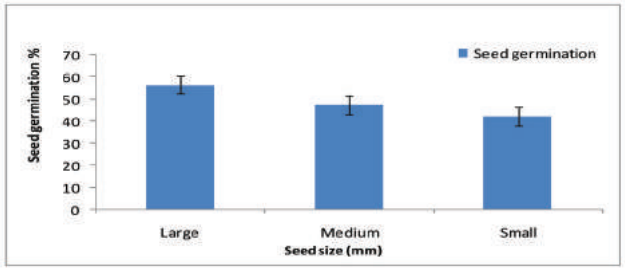


Fig. 2.1: Impact of seed size on seedling emergence

Planting depth also influenced both the rate of seedling emergence and final emergence percentage (Fig. 2.2). Seedling emergence percent decreased with the increasing depth. At the final seedling emergence count 28 days after planting (DAP), planting depths of 0.5 cm (51) and 1.5 cm (51) did not differ significantly, but were significantly higher than the emergence count for 2.0 cm (49) and 2.5 cm (45) depths.

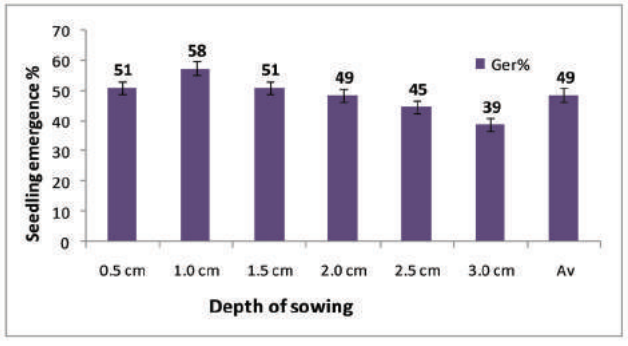


Fig. 2.2: Impact of sowing depth on seedling emergence

A significant influence was also observed with seed size on the seedling height/shoot length (Fig. 2.3) and dry weight (Fig. 2.4); large seed resulted into taller seedlings and bio-mass as compared to small seed. Planting depths also influenced the seedling height. Seedling height decreased with an increasing in planting depth (Fig. 2.3). Large sized seed at 1.5 cm depth observed maximum seedling height (21.5 cm) however medium sized seed at 1.0 cm depth found higher seedling length (18.3 cm) and small sized seed experienced maximum seedling height (14.2 cm) at 0.5 cm of soil depth. Result revealed that the size of the seed and depth of planting and their interaction found to be significant. Fourteen weeks after planting, seedling from large seed had higher percent of dry matter as compared to seedlings from small seeds; however it was at par with medium sized seed. Planting depth significantly influenced seedling dry weight at fourteen weeks after planting (Fig. 2.4). The higher seedling dry matter at 1.5 cm depths planting of larger seed (6.4 g) suggests that seedlings were relatively healthier and could better withstand stress and this could influence the ultimate plant stand after transplanting in the field.

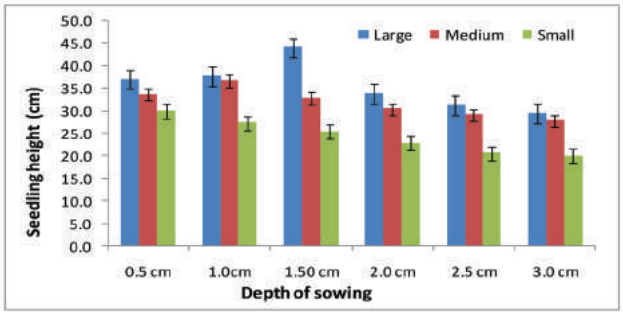


Fig. 2.3: Impact of seed size and sowing depth on seedling height

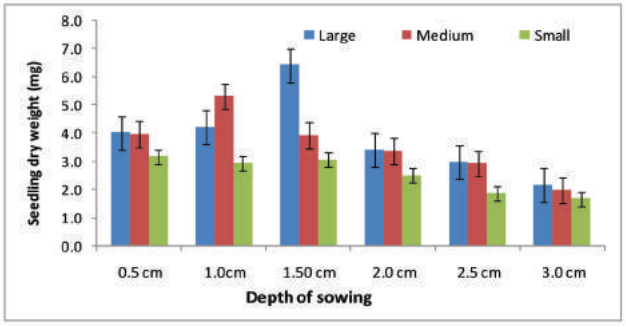


Fig. 2.4: Impact of seed size and sowing depth on seedling dry weight

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

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* in those samples which were collected 20 on *ber* in 11th Standard Meteorological Week (SMW) during sexual maturity period and 58 on *palas* in 25th SMW during crop maturity period when caged during *baisakhi* 2021. In *katki*, 2021, the maximum emergence of *A. purpureus* in two peaks were recorded during sexual and crop maturity period (35 and 43 SMW) when raised on *ber* (15, 11) and *palas* (20, 11) respectively (Figs. 2.5-2.8).

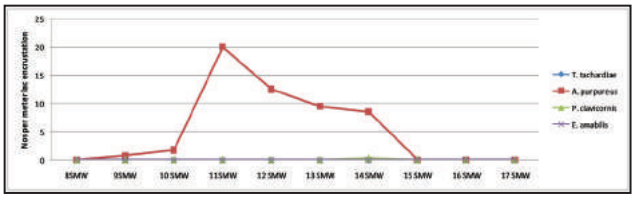


Fig. 2.5: Emergence profile of lac associated fauna on *ber* during *baisakhi* 2021

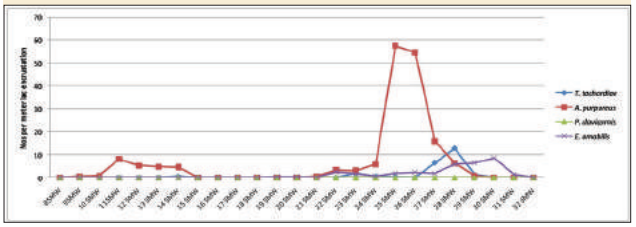


Fig. 2.6: Emergence profile of lac associated fauna on *palas* during *baisakhi* 2021

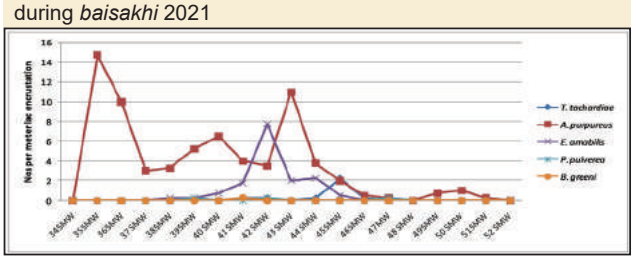


Fig. 2.7: Emergence profile of lac associated fauna on *ber* during *katki* 2021

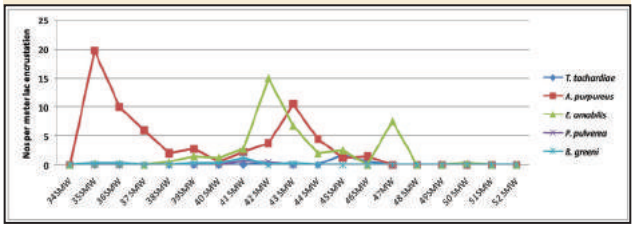


Fig. 2.8: Emergence profile of lac associated fauna on *palas* during *katki* 2021

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* and *katki*, 2021. Higher numbers of *A. purpureus*, *T. tachardiae, T. clavicornis* and *E. amabilis* were recorded in situ caging method (1, 112, 3 and 0) (68, 74, 3 and 14) compared to lab caging (0, 24, 0 and 0) (8, 57, 0.08 and 11) on *ber* and *palas,* respectively during *baisakhi*, 2021. In *katki*, higher numbers of *A. purpureus*, *T. tachardiae, T. clavicornis, E. amabilis, P. pulverea, B. greeni* and *E. claripennis* were recorded in *in-situ* caging (14 ,62, 0.5, 11, 0.17, 3 and 0.33), (29, 39, 0.58, 9, 0, 0.58 and 1) compared to lab caging (1, 23, 0.08, 7, 0.25, 0.08 and 0.0) (0.83, 22, 0, 11, 0.42, 0 and 0.83) on *ber* and *palas,* respectively. Un-emerged *E. amabilis* (immature stages *viz*., larva and pupa) were also recorded more on in-situ caging (4 and 6) compare to lab caging (1 and 2) while pricking/ scrapping of lac encrustation sample on on *ber* and *palas,* respectively during *baisakhi* and *katki*, 2021 (Fig. 2.9 and 2.10).

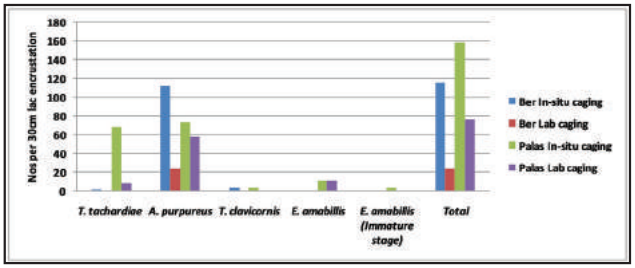


Fig. 2.9: Emergence profile of lac associated fauna using different methods on *ber* and *palas* during *baisakhi* 2021

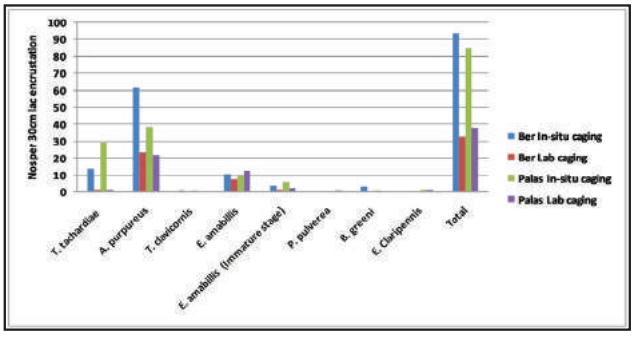


Fig. 2.10: Emergence profile of lac associated fauna using different methods on *ber* and *palas* during *katki* 2021

Forecasting model development for *A. purpureus* population

Stepwise regression analysis was done using pooled weather data of SMW (4 week lag, 5 week lag) with critical period of *A. purpureus* population (SMW 8 to SMW 20) recorded from *palas* and *ber* during *baisakhi* 2011-12 to 2020-21. Fitted best empirical model equations on *palas* and *ber* are as follows in Table 2.5 and 2.6.

Table 2.5: Regression models on the population fluctuation of *A. purpureus* on *palas*

Regression equation	R square	Sig. F	P Value
4 week lag : Y= -85.38 + 0.86 (Max temp) + 1.07 (Eve RH)	0.66	0.0045	Max temp.: 0.058 Eve RH: 0.0093
5 week lag : Y= -22.28+0.418 (Eve RH)	0.55	0.003	Eve RH: 0.003

Table 2.6: Regression models on the population fluctuation of *A. purpureus* on *ber*

Regression equation	R square	Sig. F	P Value
4 week lag : Y=-25.02+0.48 (Eve RH)	0.39	0.002	Eve RH.: 0.002
5 week lag : Y=-27.86+0.52 (Eve RH)	0.44	0.014	Eve RH: 0.014

Forecasting and validation of the population of *A. purpureus* on *palas* and *ber* for the year 2020-21

During the year 2019-20 derived models: Y= -87.28 + 0.88 (Max temp) + 1.11 (Eve RH) from *Palas* (4 Week Lag) and Y= -25.91 + 0.50 (Eve RH) from *ber* (5 Week Lag) were used for predicting population of *A. purpureus* during *baisakhi* crops. Observed value, predicted values are given in Fig. 2.11 and 2.12.

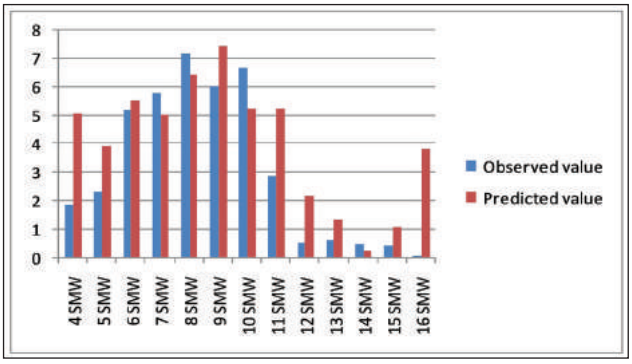


Fig. 2.11: During the year 2019-20 derived models: Y=-87.28+0.88 (Max temp)+1.11(Eve RH) from *palas* (4 week lag) was used for predicting population of *A. purpureus* during *baisakhi* crops

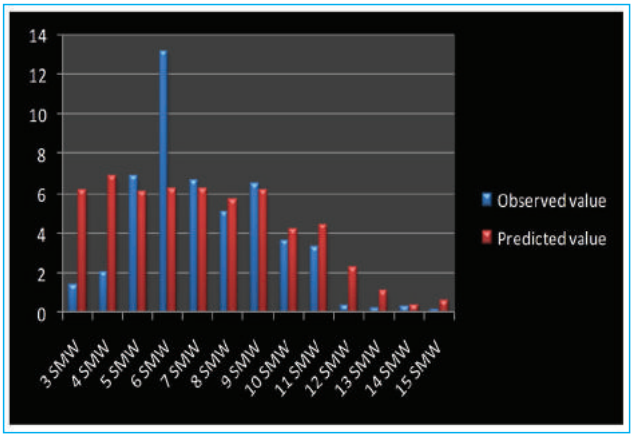


Fig. 2.12: During the year 2019-20 derived models Y=-22.99+0.45(Eve RH) from ber (4 week lag) was used for predicting population of *A. purpureus* during *baisakhi* crops

2.4 *In vitro* production of aleuritic acid

Transcriptome sequencing of lac insects

Transcriptome sequencing of different developmental stages namely, crawlers, settled nymphs and fertilized female lac insects was carried out in triplicates. RNA was isolated from all the samples using Trizol and the RIN value ranged from 7.6 to 9.5. Libraries were prepared using Truseq RNA Sample Preparation Kit (Poly A). Sequencing was carried out on illumina HiSeq X10 platform for read length of PE150. The phred score (Q30) of more than 84% was obtained for almost all the samples.

Cloning of fatty acid desaturase genes from lac insect

One full length gene and 2 partial genes encoding fatty acid desaturase were cloned from lac insect. The full-length gene is of 1264 bp and the partial genes are of 494 and 434 bp. 5` and 3` RACE PCRs for cloning full-length genes are under progress.

2.5 Study of physiological adaptations of *Kerria lacca* (Kerr) under moisture stress

Moisture stress in host plant causes male biased sex ratio in lac insects

Brood lac of the *rangeeni* (*baisakhi*) lac strain was inoculated in potted plants of pigeon pea variety 'Bahar'. Moisture stress experiment was performed with lac inoculated pigeon pea plants under optimum watering (near field capacity) (Fig. 2.13a) and moisture deficit conditions (near wilting point) (Fig. 2.13b) to understand the impact of moisture stress in lac insect physiology. The sex ratio of settled lac insects was counted 90 days after inoculation. While 65% of the live lac insect cells were male in the host plants receiving optimum watering, 90% of the live cells were

male in the host plants which experienced moisture stress. Study of other physiological responses of lac insects under host plant mediated moisture stress is under progress.

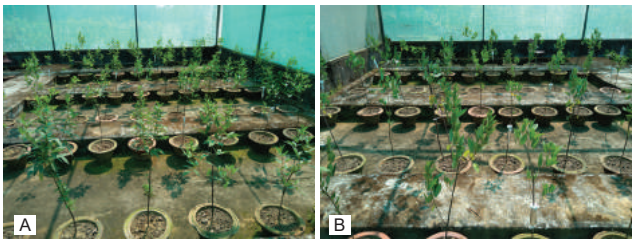


Fig. 2.13: Pigeon pea plants maintained under optimum watering (a) and moisture stress (b)

2.6 Exploratory Study

Genetic manipulation in lac host plant (*F. semialata*) to establish better plant lac insect interaction

Flemingia semialata is promising busy host plant for winter *kusmi* lac cultivation but summer sustainability of *kusmi* lac in summer season is limiting factor. To mitigate this problem the existing line of *F. semialata* should go for genetic manipulation through inter-specific hybridization, however diverse genetic base of this species is not available. In this circumstance it has been planned to manipulate gene through colchicine treatment for getting desirable variants. First experiment was started in 20th September, 2019 with different colchicine treatment and duration. Germination was not satisfactory. House of IRC in 2020 advised that fresh seeds should be procured and pre-treatment with H_2SO_4. Accordingly, seeds were surface sterilized with 80% H_2SO_4 followed by ringing with distilled water in April 2021. Seeds were treated with colchicine aqueous solution (0.05, 0.1, 0.15, 0.2 and 0.25%) for the period of 6, 12, 18, 24 hours. The changes in morpho-physiological traits in treated seeds were recorded in comparison to control.

Stunted plant height was recorded at colchicine treatment @ 0.1% for 6 hours and @ 0.2% for 12 hours, 18 hours and 24 hours. The higher number of leaf was recorded at 0.2% and 0.1% colchicine for 6 hours and 24 hours, respectively. Maximum leaf width was recorded at 0.05%, 0.1%, 0.25% colchicine for 6 hours, 18 hours and 12 hours, respectively. Relatively significant shorter intermodal length was observed at 0.1%, 0.2% and 0.05% colchicine for 6 hours, 12 hours and 18 hours, respectively (Table 2.7). Plant height had significant positive correlated with leaf width and intermodal length. Similarly intermodal length was positively and significantly associated with plant height and number of leaves (Table 2.8).

Table 2.7. Morphological traits of treated plants and control

Duration	Dose	Plant ht (cm)	Number of leaf	Leaf width (mm)	Internodal length (cm)
	0.05	82.5	8	10.7	9.7
6h	0.1	67.0	6	6.9	8.3
	0.2	98.3	13	9.8	11.6
	0.25	75.7	11	8.7	9.7
	Control	**89.3**	**11**	**9.6**	**10.5**
	0.05	64.0	8	7.5	8.6
12h	0.1	62.7	9	6.2	8.4
	0.2	48.5	6	4.2	4.9
	0.25	80.0	12	9.4	8.5
	control	**94.3**	**14**	**8.2**	**11.7**
	0.05	81.5	8	7.9	9.2
18h	0.1	86.8	9	8.5	9.5
	0.2	67.0	10	5.6	10.6
	0.25	102.3	8	7.5	11.1
	control	**78.7**	**10**	**7.0**	**9.9**
	0.05	112.0	7	7.6	11.6
24h	0.1	115.0	9	7.1	14.7
	0.2	68.5	6	4.4	7.3
	0.25	83.7	5	5.5	8.5
	control	**88.7**	**8**	**7.5**	**9.0**
Probability	Treatment	0.67ns	0.34ns	0.18ns	0.83ns
	Duration	1.71ns	0.19ns	0.04*	0.56ns

Table 2.8. Pearson correlations for different plant traits

Traits	Plant ht (cm)	Leaf nos	Lead width	Internode length
Plant ht (cm)	1.00	0.24	0.47*	0.085**
Leaf nos	0.24	1.00	0.56*	0.46*
Lead width	0.47*	0.56*	1.00	0.44
Internode length	0.85**	0.46*	0.44	1.00

There is no significant effect of different concentration of colchicine on Leaf stomata length (Table 2.9) and on leaf stomata width (Table 2.10), however duration of treatment had its significant effect on it

Table 2.9. Effect of different concentration and duration of colchicine treatment on stomata length

Treat	Position	Stomata length (µm)				
		6h	12h	18h	24h	Mean
0.05	Abaxial	21.2	21.7	20.4	20.9	**21.1**
	Adaxial	22.4	20.2	21.5	19.1	**20.8**
0.1	Abaxial	21.8	21.4	20.1	21.0	**21.1**
	Adaxial	22.3	22.2	20.3	21.0	**21.5**
0.2	Abaxial	21.0	22.0	21.4	21.3	**21.4**
	Adaxial	22.7	19.6	21.5	21.9	**21.4**
0.25	Abaxial	23.0	23.0	20.8	20.9	**21.9**
	Adaxial	23.0	23.5	21.5	21.7	**22.4**
Control	Abaxial	23.2	21.3	20.5	20.7	**21.4**
	Adaxial	24.7	21.7	22.5	21.4	**22.5**
Probability	Treatment					0.128 ns
	Duration					0.002**

Abaxial- the lower surface of a leaf, Adaxial- the upper surface of a leaf.

Table 2.10. Effect of different concentration and duration of colchicine treatment on stomata width

Treat	Position	6h	12h	18h	24h	Mean
0.05	Abaxial	13.3	13.4	12.1	13.2	**13.0**
	Adaxial	13.2	13.1	13.4	12.9	**13.2**
0.1	Abaxial	14.6	14.3	12.2	13.9	**13.7**
	Adaxial	13.3	13.7	13.1	12.8	**13.2**
0.2	Abaxial	13.2	13.4	12.9	13.7	**13.3**
	Adaxial	13.7	12.5	12.8	13.7	**13.2**
0.25	Abaxial	13.6	14.8	13.5	11.9	**13.4**
	Adaxial	13.6	14.4	12.6	12.9	**13.4**
Con	Abaxial	13.9	13.1	12.4	13.0	**13.1**
	Adaxial	14.9	13.3	12.9	14.4	**13.9**
Probability	Treatment					0.63ns
	Duration					0.01**

Relatively lesser number of stomata is desirable to prevent transpiration loss of water in adverse situation. The different concentration of colchicine had significant effect on number of stomata in both abaxial and adaxial portion of leaves. It is more evident at 0.05%, 0.2% and 0.25% for 18 hours and 24 hours treatment (Table 2.11).

Table 2.11. Effect of different concentration and duration of colchicine treatment on number of stomata

Treat	Position	6h	12h	18h	24h	Mean
0.05	Abaxial	23	20	21	19	**20.8**
	Adaxial	4	4	4	2	**3.5**
0.1	Abaxial	26	28	24	33	**27.9**
	Adaxial	4	4	4	4	**4.0**
0.2	Abaxial	20	20	21	22	**20.8**
	Adaxial	3	3	2	5	**3.2**
0.25	Abaxial	22	25	22	19	**21.9**
	Adaxial	4	4	3	4	**3.7**
Control	Abaxial	18	18	24	30	**22.4**
	Adaxial	2	3	3	3	**2.8**
Probability	Treatment					0.00**
	Duration					0.57ns

2.7 Externally Funded Project

Identification, cloning and characterization of genes involved in pigment biosynthesis of the Indian lac insect, *Kerria lacca* (Kerr)

Cloning of putative key genes of lac pigment biosynthesis: RACE (Rapid Amplification of cDNA Ends) primers were designed from the transcriptome data for cloning of 3´ and 5´ ends of the genes namely, acyl carrier protein (*acp*) and decarboxylase 2 (*dc2*). Both 3´ and 5´ ends of the cDNAs were cloned from cDNA of the fertilized female lac insects using RLM-RACE kits (Invitrogen). After obtaining the 3´ and 5´ end sequences, they were assembled with the already available partial sequences to obtain the full-length sequences. Full length CDS (coding sequence) of acyl carrier protein (*acp*) and decarboxylase 2 (*dc2*) genes were submitted to NCBI database. The accession numbers obtained were MZ501735 and MZ570477 for *acp* and *dc2*, respectively.

Role of *pks* gene in pigment biosynthesis: RNAi experiments were done for polyketide synthase (*pks*) gene which is one of the early genes which are supposed to be involved in the lac pigment biosynthesis pathway. 1 ml of *pks* ds-RNA at the concentration of 50 ng/µl was injected at one position on the pumpkins harbouring lac insects; similar injections were done at 10 different positions on the whole pumpkin. Same volume of DEPC-water was injected into another pumpkin harbouring lac insects at 10 different positions, which served as a control. qPCR results revealed that the expression level of polyketide synthase genedownregulated to 0.55 fold, 0.37 fold and 0.18 fold in samples collected 1 DAI

(Day after injection), 2 DAI and 3 DAI, respectively in reference to the untreated lac insects. After confirming the reduced level of *pks* expression in treated samples in comparison with control, HPLC analysis of body pigments and resin pigments were carried out. Total peak area obtained for body pigments of control and treated lac insects were computed. It showed that there is a significant reduction of peak area of HPLC chromatograms of treated samples in comparison with control samples (Fig. 2.14a). Total peak area obtained for resin pigments of control and treated lac insects were computed which showed a decreasing trend for the treated samples. Percent reduction in resin pigments was found to be more in day 1 sample followed by day 2 sample and the least reduction in day 3 sample compared to control sample (Fig. 2.14b). It suggests that the *pks* gene would probably have a role in body and resin pigmentation of lac insects.

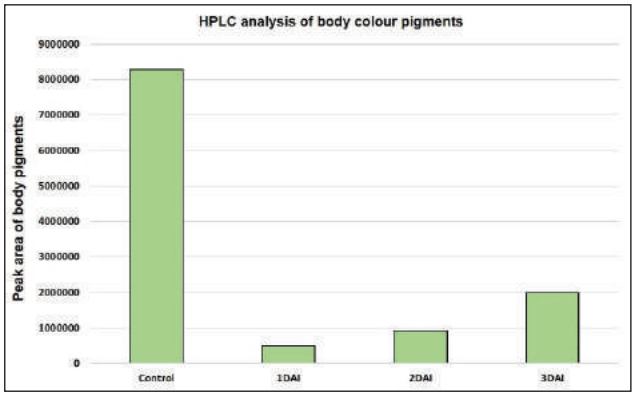


Fig. 2.14a. Peak area of body pigments isolated from polyketide synthase knock down mutant lac insects 1, 2 & 3DAI in comparison with wild type (control)

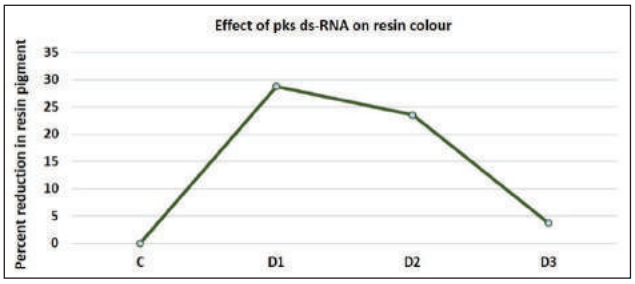


Fig. 2.14b: Percent reduction in resin pigment of *pks* knock down mutants obtained from HPLC chromatogram. C: Control, D1-D3: Treated lac insects 1DAI, 2DAI, 3DAI

2.8 Transfer of Technology Activity

Four field level demonstrations on increasing lac production through application of chemical fertilizers were conducted at Mangubandh, Hurda and Banta villages of Ranchi district. At Mangubandh, demonstration on both *rangeeni* and *kusmi* lac was conducted on *palas* and *ber* trees respectively, while other two villages comprised of demonstration on *rangeeni* lac only. Farmers conveyed that performance of *kusmi* lac was satisfactory. However, mixed response was received for *rangeeni* lac.

Production and Extension Management

3. Crop Production System Management and Evaluation

3.1 Lac integrated cropping system through participatory approach

Lac host *semialata* (*Flemingia semialata*) based cropping system

Relative performance under lac host *F. semialata* based cropping system in summer and rainy season of 2021 were studied at IINRG-Institute Research Farm. For summer season of 2021, intercropping models semialata+okra obtained maximum B: C ratio of 2.39 with net return of ₹ 147650/ha, followed by semialata+bitter gourd with B: C ratio of 1.90 and net return of ₹ 95430/ha and semialata+bottle gourd with B: C of 1.71 and net return of ₹ 52730/ha. For rainy season of 2021, the intercropping model semialata+amaranthus obtained maximum B: C ratio of 2.31 with net return of ₹706071/ha followed by semialata+ridge gourd with B: C ratio of 1.56 and net return of ₹ 30141/ha and semialata+dolichos bean with B: C ratio of 0.48 and negative net return.

Biomass production under lac host *F. semialata* based cropping system in summer season of 2021

Different cropping system significantly influenced total biomass (above and below ground) of the crops ($p<0.05$) in summer season, 2021. Among the intercrops, the maximum total biomass was obtained in intercrop bhindi (4.86 t/ha) followed by intercrop bitter gourd (0.84 t/ha) and intercrop bottle gourd (0.70 t/ha).

Effect of intercropping with *Flemingia semialata* (semialata) on the growth of bottle gourd and bitter gourd

The effect of intercropping with *Flemingia semialata* on the growth of bottle gourd and bitter gourd were studied during summer season of 2021 at Institute Research Farm of IINRG. The results showed that the vine length of sole bottle gourd was significantly higher ($p<0.05$) than intercrop bottle gourd in 45 DAS (Days after Sowing), 60 DAS and 75 DAS with values of 166.87 cm, 371.67 cm and 508.39 cm respectively for sole bottle gourd and 80.40 cm, 234.13 cm and 458.25 cm respectively for intercrop bottle gourd. Fruit length was significantly higher ($p<0.05$) in sole bottle gourd (38.00 cm) than the intercrop bottle gourd (35.14 cm). The result showed that there was no significant difference ($p>0.05$) in fruit diameter between sole bottle gourd and intercrop bottle gourd. The vine length of sole bitter gourd was significantly higher ($p<0.05$) than intercrop bitter gourd in 45 DAS and 60 DAS with values of 66.23 cm and 121.97 cm respectively for sole bitter gourd and 49.23 cm and 99.67 cm respectively for intercrop bitter gourd, while vine length was not significantly ($p>0.05$) different between the sole and intercrop in 75 DAS. Fruit length was found to be non significant ($p>0.05$) between the sole and intercrop bitter gourd while fruit diameter was found to be significantly ($p<0.05$) higher in intercrop (3.96 cm) than sole bitter gourd (3.42 cm).

Evaluation and validation of developed model of the institute in farmer's field

Developed intercropping model viz., semialata+brinjal for summer season, semialata+french bean, semialata+faba bean and semialata+brinjal for winter season were validated at two farmers field of Angara, Ranchi and Remta, Khunti. Birsa Munda from Remta village obtained B: C ratio of 2.06 from semialata+brinjal for summer season while Amar Singh Bhogta from Angara village obtained B:C ratio of 1.67. Birsa Munda obtained B: C ratio of 1.54, 1.47 and 1.64 from semialata+french bean, semialata+faba bean and semialata+brinjal models respectively. Amar Singh Bhogta obtained B: C ratio of 2.16, 2.30 and 2.63 from semialata+french bean, semialata+faba bean, semialata+brinjal models, respectively.

3.2 Characterization and management of sooty mold associated fungi in lac and documentation of other diseases of lac host plants

Sooty mold was regularly monitored at IRF and four samples were collected from different host plants of lac. Isolation of sooty mold associated fungi will be done from those samples after the partial establishment of pathology lab.

Four different stocks of *kusmi* broodlac from two different areas (one stock from Nawadih area and three from IRF) were inoculated on *F. semialata* at IRF to check the incidence of sooty mold infection on *kusmi* lac of two different areas. All the operations were conducted regularly with different number of carbendazim spray at the rate 1 g per liter and sooty mold incidence were observed regularly. Initially sooty mold infection was observed after 60 days after brood lac inoculation (DAI). At no spray treatment the incidence of sooty mold was continuously heavy followed by two spray treatment at 30 DAI and 60 DAI in all the four stocks. This experiment was conducted to confirm the incidence of sooty mold on lac stock

used, to ensure that there should not be any resistance against sooty mold on lac stock, which will be used for further experiments of management of sooty mold.

A fungal infection was observed from the *F. semialata* developing seeds on plant, which makes the infected seeds deformed (Fig. 3.1). That sample has been collected and its pathogen will be isolated after the partial establishment of pathology lab.



Fig. 3.1: Infected inflorescence of *F. semialata*

3.3 Estimation of water requirement and determination of growth-stage-specific crop coefficient (Kc) of *Flemingia semialata* Roxb.

Design, construction and set up of Low-cost drainage lysimeters for study on crop water requirement was carried out (Fig. 3.2).

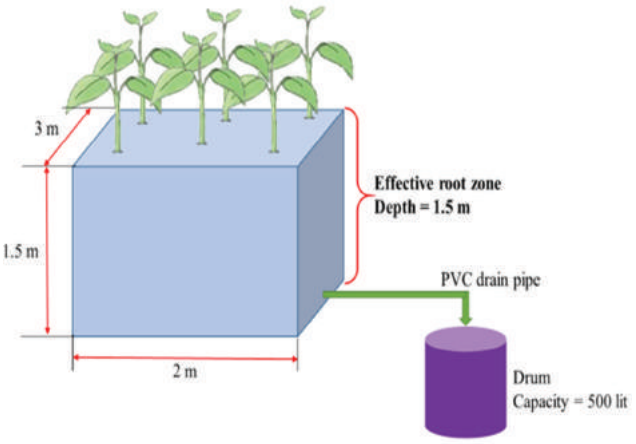


Fig. 3.2: Schematic diagram of the drainage type lysimeter

The low-cost drainage lysimeters were designed, constructed and set up at the Institute research farm, ICAR-IINRG to measure the water requirement of *F. Semialata* Roxb. Total 6 lysimeters were constructed having dimensions 3 m × 2 m × 1.5 m (Length × Width × Depth) and were covered by 500-micron LDPE sheet from all the sides to prevent the lateral and vertical seepage of water from them (Fig. 3.3).

Each lysimeter has a drain pipe (Dia 75 mm) having 50 slopes at its bottom and fall in a collecting tank of 500-litre capacity to collect the deep percolated water of the lysimeter. At the inlet of each drain pipe, there is a nylon mesh of size 10 mesh to prevent piping action during the collection of deep percolation. Around the inlet, a layer of coarse gravel was also provided. It is then followed by a sand bed of 10 cm height, 20 cm width and 1m length up to th centre of lysimeter to give drain filter at its bottom to prevent stratification.

Each lysimeter contains 6 plants with a standard spacing of 1m. A pre-quantified irrigation schedule was carried out to keep the plants in lysimeters in water non-limiting growth conditions.

Collection of climatic data (Rainfall, Tmax, Tmin, RH etc.), soil moisture variation in subsurface soil layers and growth attributes (no. of leaves, shoot diameter, plant height etc) at regular interval in the research plots.

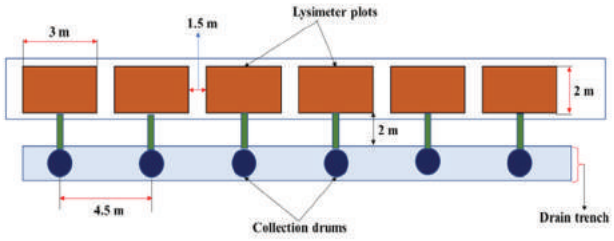


Fig. 3.3: Layout of the experimental plot

Determination of water balance parameters of *F. semialata*

Following the installation of drainage lysimeters, various meteorological and hydrological parameters were studied in order to determine crop water requirements in the research plots. Since the plants were at their initial stage except for soil moisture retention data other parameters of water balance were evaluated and presented in Table 3.1 below.

Table 3.1 Water balance components estimated at 5 days interval

DAT	Crop growth stage	Input component		Output Component		
		Precipitation (P) (in mm)	Irrigation (I) (in mm)	Deep percolation (DP) (in mm)	Runoff (R) (in mm)	Reference ET (ET_0) (in mm)
5	Initial	0	0	0	0	13.64
10	Initial	0	10	0	0	14.34
15	Initial	29	10	0	0	9.5
20	Initial	0	0	0	0	13.12
25	Initial	6.2	10	0	0	9.96
31	Initial	0	10	0	0	15.55

4. Capacity Building, Technology Dissemination, Impact Assessment and Market Intelligence

4.1 Learning, capacity building, extension education and information services on NRGs

ICAR-Indian Institute of Natural Resins and Gums, Namkum Ranchi has conducted different types of training programmes pertaining to scientific lac cultivation, processing and utilization under Capacity Building and Entrepreneurship Development programme (Table 4.1). It continuously assessed the needs of stakeholders and modified the programmes accordingly. Besides many on-campus programmes, field out-reach activities in terms of training, technical guidance, lac crop monitoring etc. were also undertaken. A total of 7029 stakeholders were benefited under various capacity building and skill development programs.

Table 4.1. Details of capacity building and entrepreneurship development programme

Sl. No.	Name of programme	No. of batch/ campus	No. of beneficiaries
1	Farmer's training programme on "Scientific lac cultivation, processing and utilization"	16	414
2	Educational programme on "Rural Agricultural Work Experience (RAWE)" (one Month)	01	22
3	Educational programme on "Online Industrial Training on Natural Resins and Gums" (10 days)	01	16
4	Educational programme on "Natural Resins and Gums" for 37 students from Banaras Hindu University, Uttar Pradesh (10 days).	01	37
5	On-farm training programme on lac cultivation	11	754
6	On-farm Motivational/ Supplementary training programme on lac cultivation	20	1195
7	On-campus one-day Orientation programme on lac cultivation	13	525
8	Lac based product demonstration training	03	03
9	Participation in Exhibition/KisanMela	01	1300
10	Schedule Caste Sub-Plan (SC -SP)	06	509
11	Awareness cum Village Survey Programme for Impact Assessment of the stakeholders under Capacity Building Programme	28	81
12	Lac Crop surveillance conducted	04	04
13	Kisangosthi/Workshop/Educational Programme on lac cultivation	04	2093
14	One To One Programme (OTOP)	76	76
Total		**185**	**7029**

Farmers training programme on "Scientific lac cultivation, processing and utilization"

The programme entitled "Scientific lac cultivation processing and utilization" is 16 one week and it constitutes lac cultivation, processing at farm level and its uses. A total of 414 farmers from different districts of two states *viz*., Jharkhand and West Bengal and one-person from Nepal also participated in the programme. The participants were sponsored by various organizations and details are given below in Annexure 1.

Educational programme on "Rural Agricultural Work Experience (RAWE)" (one Month)

IINRG organized "Natural Resin and Gum based Agro-Industrial Attachment Training for Rural Agricultural Work Experience (RAWE)" for 22 B.Sc. (Ag.) students of Birsa Agricultural University, Kanke, Ranchi. The details are enclosed in Annexure 2.

Educational programme on "On-line industrial training on natural resins and gums" (10 days)

IINRG organized educational programme on "Industrial Training on Natural Resins and Gums" for 16 students from Quantum University, Dehradun, Uttrakhand (10 days online). The details are enclosed in Annexure 3.

On-farm training programme on scientific lac cultivation

IINRG has organized 11 on-farm training programme on lac cultivation in collaboration with various GOs and NGOs of different states. A total of 754 farmers participated from different districts of Jharkhand. The participants were nominated by Forest Divisions of Jharkhand, K.C. Pur, Lac Industrial Co-operative Society Ltd. and ITDA, Nilgiri, Balasore, Odisha. The details are enclosed in Annexure 4.

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

A total of 1195 participants were trained in 20 on-farm motivational/ supplementary training programme on lac cultivation in collaboration with various NGOs and GOs of Jharkhand. The participants represented from Khunti, Hazaribag, Chatra, Ranchi, Gumla, Simdega and W. Singhbhum district of Jharkhand. The details are enclosed in Annexure 5.

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

On-campus, one day orientation programmes (13 nos.) on natural resins and gums were organized in collaboration with GOs and NGOs of Jharkhand and West Bengal states and 525 farmers, school children, college students and executives visited the institute for this purpose. They were nominated by various agencies mentioned in details in Annexure 6.

Product demonstration training

Three lac based product demonstration training organized for three participants of Chhattisgarh, West Bengal and Odisha states on lac wood shine, lac based non-sprit wood varnish, lac glaze and nail polish etc. The details are enclosed in Annexure 7.

Participation in exhibition/*kisan mela*

The Experts from ICAR-IINRG, Ranchi participated in Eastern Zone Regional Agriculture Fair and Agrotech-2021, BAU, Kanke, Ranchi and provided technical expertise on NRG to their stakeholders. A total of 1300 beneficiaries got benefitted and got awareness about the technology of ICAR-IINRG. Need based advisory services were also provided among the various stakeholders. The details are enclosed in Annexure 8.

Schedule Caste Sub-Plan (SC SP)

Selection of Scheduled Caste farmers and distribution of livestock, farm tool-kit, sprayer, sewing machine, honey bee box set with colony, power weeder, vermin bed and rotavator under SC sub-Plan. A total of 1588 farmers participated from 07 programmes in different KVKs of Jharkhand. The details are given below in Annexure 9.

Awareness cum village survey programme for impact assessment of the stakeholders under capacity building programme

Twenty-eight Awareness cum Village Survey Programme for Impact Assessment of the stakeholders conducted at different villages of Ranchi and Giridih districts of Jharkhand. A total of 81 beneficiaries, non-beneficiaries and village Mukhiya were surveyed in the programme. The details are enclosed in Annexure 10.

Diagnostic and crop monitoring visits

Four crop monitoring visits conducted at Chatra, Ranchi and Khunti district of Jharkhand (Annexure 11).

***Kisan gosthi*/workshop/educational programme**

The institute has organized/participated *kisan gosthi*/ workshop/ educational programme on lac cultivation in collaboration with various institutions. A total of 04 such events were conducted, and 2093 stakeholders were benefited (Annexure 12).

One To One Programme (OTOP)

An ICT enabled One to One Programme (OTOP), Market Oriented Technical Advisory Services (MOTAS), diagnostic crop monitoring and benefited 76 stakeholders from different states of India. Laksha Updates initiatives boosted the linkages with stakeholders (Annexure 13).

VIP visit at institute museum

Eighteen VIPs visited the Institute Museum during the period. They were exposed about the latest know-how about natural resins and gums.

4.2 Market Information Support (MIS) and impact assessment of technological interventions for NRGs

Sampling plan: About 610 stakeholders including 384 farmers, 47 market functionaries, 71 processors/ wholesalers/exporters, and 108 resource persons from various institutions interacted through visits and telephonic conversations in 48 districts of 18 states of India. Secondary data on NRG about production were collected from various central and state government organizations.

National scenario of NRGs: A decrease in the production of NRGs was found during 2020-21 in comparison to 2019-20. This decline in production was observed in *guar* gum (7.77%). Consequently, total production of NRGs has decreased from 5, 26,765.25 tons in 2019-20 to 4, 90,070.30 tons in 2020-21 (Table 4.2). A decline of about 6.97 % in the production of NRGs was observed over the previous year. Total production of lac in India was observed higher than the previous year. Production of other resins and gum is also decreased slightly in 2020-21. Overall, NRG production level during 2020-21 is estimated comparatively lower than the previous year. However, lac production increased comparatively.

Table 4.2 Total NRG production during 2016-17 to 2020-21 (in tons)

Name of product	2016-17	2017-18	2018-19	2019-20	2020-21*	Average	% share
Guar gum	601739.67	638877.33	580104.00	502000.00	463000.00	557144.20	95.80
Lac	16352.00	14315.00	18536.50	18944.00	21740.00	17977.50	3.09
Pine resin	5991.84	5124.44	4838.20	4176.00	4000.00	4826.10	0.83
Karaya gum	83.20	31.65	21.18	24.25	22.30	36.52	0.01
Dhawda gum	201.00	79.00	66.00	54.00	46.00	89.20	0.02
Other gums	285.18	77.43	72.02	67.00	62.00	112.73	0.02
Other resins and gums	1140.00	1500.00	1400.00	1500.00	1200.00	1348.00	0.23
Grand Total	**625792.89**	**660004.85**	**605037.90**	**526765.25**	**490070.30**	**581534.24**	**100.00**

**Advance estimates*

International scenario of NRGs: According to ITC calculations based on UN COMTRADE statistics, the world trade aggregation of lac, natural gums, resins, gum-resins and balsams during 2019 was 1435.02 million US dollars. Out of this, the world export aggregation of lac, natural gums, resins, gum-resins and balsams during 2019 was 519.25 million US dollars. Decadal data from 2008 to 2019 on world EXIM aggregation of lac, natural gums, resins, gum-resins and balsams were analyzed and presented in Fig. 4.1 and Fig. 4.2. Since 2012, deceleration in the value of world export aggregation was observed, but it increased in 2017. Stagnation was found in the value of world import aggregation during the similar period.

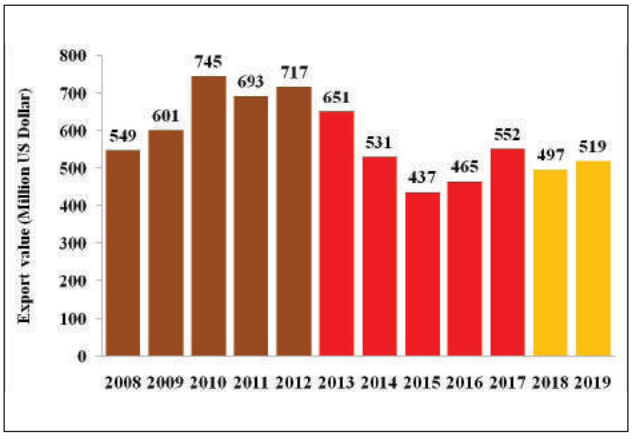


Fig. 4.1: World export flow of lac, natural gums, resins, gum-resins and balsams

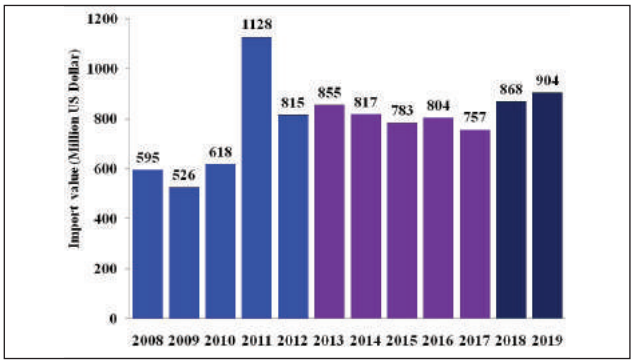


Fig. 4.2: World import flow of lac, natural gums, resins, gum-resins and balsams

Major suppliers of NRGs are contributing about 90% share in international market are France (26.9%), India (16.1%), Indonesia (9.3%), Brazil (7.9%), USA (6.0%), Germany (5.8%), Thailand (3.2%), Greece (3.0%), Italy (2.0%), UK (2.0%), Kenya (1.9%), UAE (1.7%), Uzbekistan (1.5%), China (1.4%) and Singapore (1.2%). Rest of the 10% NRGs are supplied from 82 countries across the world (Fig. 4.3 & Table 4.3).

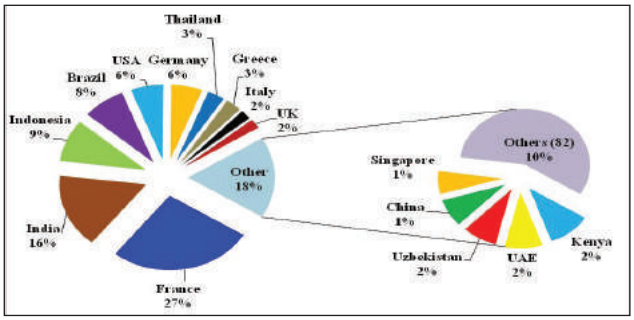


Fig. 4.3: Breakup of the world export aggregation of NRGs

Similarly, the world import aggregation of lac, natural gums, resins, gum-resins and balsams during 2019 was 904.00 million US dollars. Major importers of NRGs comprising about 82% share in the international market are India (21.0 %), France (9.5 %), USA (7.8 %), Portugal (4.7%), Germany (4.4 %), Russian Federation (4.0%), Saudi Arabia (3.5%), UK (2.8%), Viet Nam (2.5%), Bulgaria (2.2%), Spain (2.2%), Singapore (2.0%), Italy (1.8 %), Netherlands (1.5 %), Japan (1.4%), Ireland (1.3%), Slovakia (1.1 %), Switzerland (1.0%) and Canada (1.0%). During 2019, rest of the 17.6% demand of NRGs arose from the 112 countries across the world (Fig. 4.4 & Table 4.3).

Table 4.3 World EXIM trade aggregation of lac, natural gums, resins, gum-resins and balsams *(Value in Million US$)*

Year	Export	Import	Re-Export	Re-Import	Total Trade
2006	669.12	559.72	11.77	0.75	1241.35
2007	470.47	575.00	11.82	1.50	1058.79
2008	548.82	594.65	13.26	0.12	1156.86
2009	601.20	526.39	19.94	0.24	1147.76
2010	745.48	617.75	15.46	0.20	1378.89
2011	693.28	1127.70	15.12	0.55	1836.64
2012	716.89	814.98	17.88	0.24	1550.00
2013	650.94	854.70	17.06	0.31	1523.02
2014	530.78	816.86	10.43	0.37	1358.44
2015	436.70	783.45	5.87	0.58	1226.60
2016	465.03	804.37	9.06	0.20	1278.67
2017	552.39	756.63	5.42	0.19	1314.63
2018	496.60	868.27	15.83	0.42	1381.13
2019	519.25	904.00	11.60	0.18	1435.02

Source: ITC calculations based on UN COMTRADE statistics.

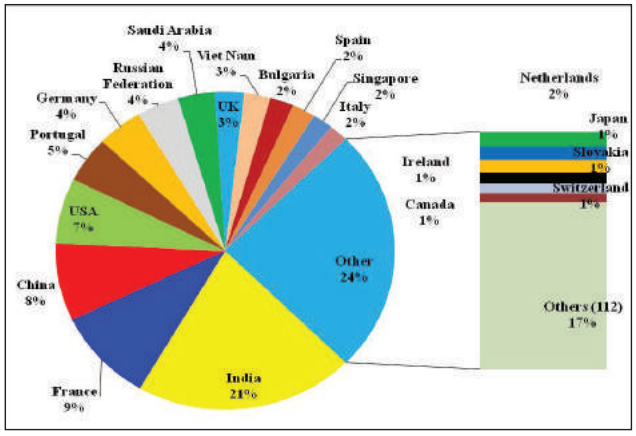


Fig. 4.4: Breakup of the world export aggregation of NRGs

Overseas demand and supply of NRGs

A comparative decline of 26.54% was observed in the volume of total NRG export during 2020-21 and quantity in import basket was decreased by 6.77% over the previous year (Table 4.4). Due to slight fall in price, particularly for guar gum, the total value of NRG export was decreased (24.30%) than the previous year. Similarly, the average annual import quantity of NRGs was 0.90 lakh tons valued ₹785.34 crores during the period 2012-13 to 2020-21 (Table 4.4).

During last 20 years (2000-01 to 2020-21), import of NRGs had a very high stability with growth rates in import quantity (8.12%) as well as value (19.50%). The share of agricultural exports in India's total exports increased from 9.94% in 2010-11 to 14.41% in 2020-21. Agricultural exports increased from ₹1130.05 billion in 2010-11 to ₹3102.72 billion in financial year

2020-21. NRGs as the export commodity contributed 0.72% in total agri-export during 2020-21.

Table 4.4 Total NRGs export and import during 2012-13 to 2020-21

Year	Export		Import	
	Quantity (in tons)	Value (in ₹lakhs)	Quantity (in tons)	Value (in ₹lakhs)
2012-13	340384.75	2176118.62	89746.33	78534.90
2013-14	483060.85	1217055.20	89535.92	96501.64
2014-15	543620.51	963270.94	86189.81	107413.18
2015-16	272462.21	343995.98	96387.62	129169.37
2016-17	329045.55	289060.92	109764.64	137165.89
2017-18	379979.77	406496.80	107399.56	148878.70
2018-19	375412.29	445725.07	100010.17	153290.13
2019-20	246342.47	314623.88	103282.14	166454.53
2020-21	180962.77	238164.89	96288.72	153744.30

Share of NRGs in India's total import of ₹33609.54 billion in 2019-20 and ₹29098.55 billion in 2020-21 has remained stagnant at 0.04% (₹16.65 billion) in 2019-20 and ₹12.43 billion in 2020-21. Similarly, share of NRGs in India's total agri-import increased from 0.84% in 2016-17 to 1.13% in 2019-20, but it declined to 0.80% in 2020-21 due to the disruption of the existing supply chains as a result of the invasion of COVID19.

Share of NRGs in India's total export ₹22198.54 billion in 2019-20 and ₹21539.18 billion in 2020-21) has been decreased from 0.20% (₹45.63 billion) in 2018-19 to 0.10 % (₹32.83 billion) in 2020-21 with an annual deceleration of 3.06% (Department of Commerce, 2021). Similarly, share of NRGs in India's total agri-export has also been decreased from 1.42% in 2016-17 to 0.72% in 2020-21.

Export quantity as well as value of NRGs from India is decreased significantly and import scenario also shows a decrease. Volume of the export of NRGs in terms of the quantity (26%) and earning of foreign exchange is declined (24%) significantly in 2020-21 in comparison to the 2019-20.

On the other hand, the import of NRGs in terms of the quantity is also decreased (7%) slightly and the value of imported NRGs has decreased by 8% in 2020-21 in comparison to the 2019-20. During the year 2020-21, the collection rate announced by the government for gum *karaya* was remained ₹11,400 per quintal. During the 2020-21, price of rosin and turpentine oil ranged from ₹95-128/kg and ₹130 to 150/litre, respectively (HPSFC Ltd.). Based on survey in the markets and processing centres of different lac producing states, the estimated national production of sticklac during 2020-21 was approximately 21,740 tons (Fig. 4.5). Jharkhand state ranks 1st followed by Chhattisgarh and Madhya Pradesh (Fig. 4.6). 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 been improved and it was higher than the MSP declared by GOI (Fig. 4.7). Trends in export of lac and its value added products have been depicted in Fig. 4.8, destination wise export from India illustrated in Fig. 4.9 and source wise import in India is shown in Fig. 4.10, respectively. Composition of the export basket of lac and its value-added products in during 2020-21 presented in Fig.4.11.

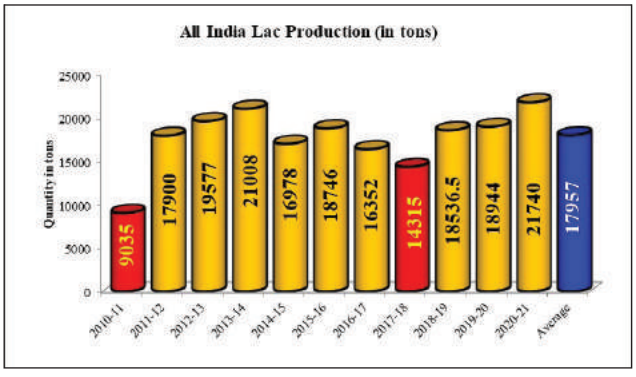


Fig. 4.5: Lac production in India during recent years

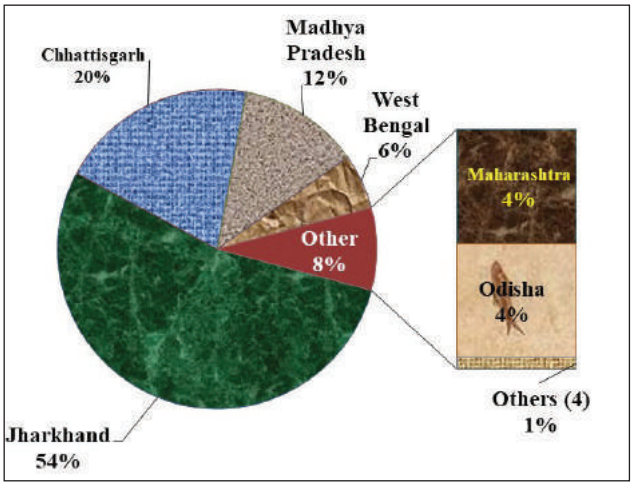


Fig. 4.6: State wise contribution in lac production

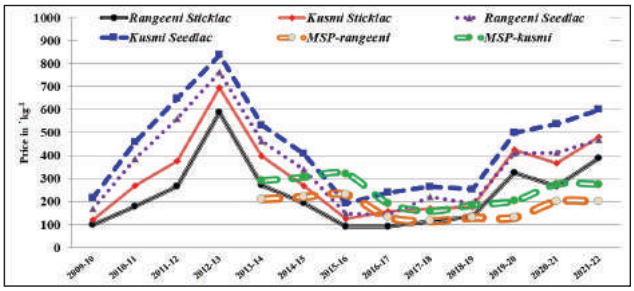


Fig. 4.7: Movement in prices of scrapedlac and seedlac

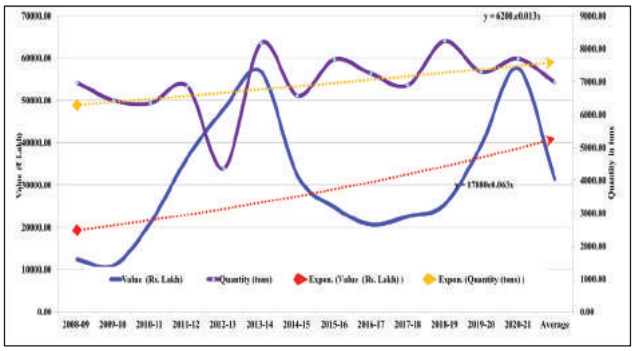


Fig. 4.8: Trends in the overseas demand of lac and its value added products

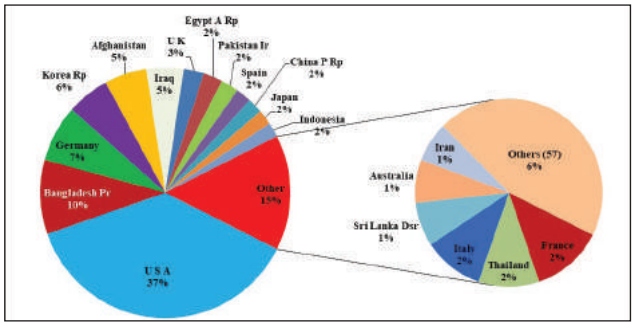


Fig. 4.9: Distribution of the overseas demand of lac and its value added products in 2020-21

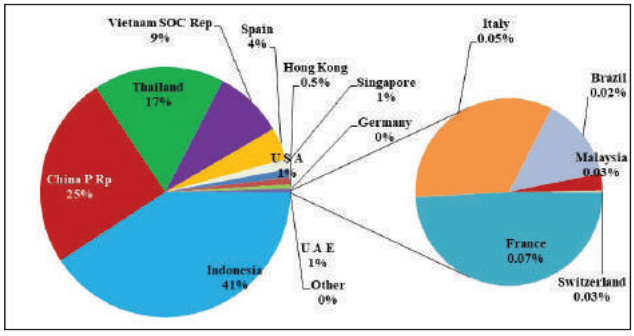


Fig. 4.10: Source wise overseas supply of lac and its value-added products in India during 2020-21

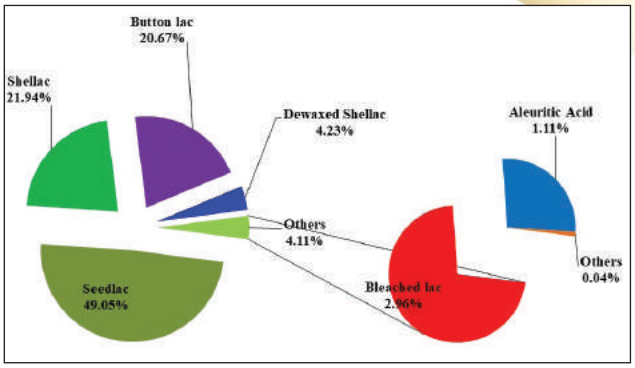


Fig. 4.11: Composition of the export basket of lac and its value-added products in India during 2020-21

Current market scenario, value addition and policy interventions: Price at various levels of the market for the *guar* seed (L), *guar* seed (D), *guar* split and *guar* gum (Powder) was recorded and ranged from ₹20-25/kg for *guar* Churi, ₹30-40/kg for *guar* Korma, ₹40-55/kg for *guar* seed, ₹85-110/kg for guar split and ₹110-130/kg for *guar* gum powder. Presently local as well as overseas demand of the *guar* split has declined and factories for *guar* split are running under capacity. Discussion on various issues including processing, production and marketing of natural tree gums was carried out. Discussion made with the dealers/ suppliers of seedlac for paint and varnish, stone cutting and polishing enterprises, traditional lac bangle clusters, handicraft designers, NRG based exporters, processors/manufactures/wholesalers, traders, experts, farmers, forest dwellers and other concerned officials.

Impact assessment

Socio economic characteristics and utilization pattern: 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 host trees and creating gainful employment opportunities for the migrating rural population at local level. Dissemination of the knowledge through trainings plays an important role in human resource development. Aims of training are to improve upon the skills, knowledge and capabilities of the beneficiaries as well as his neighbors also. This study aimed to analyze the trends of capacity building and skill development programs on scientific lac cultivation and value addition.

Trends in knowledge dissemination among the NRG stakeholders: Time series data set for the period of 2012-13 to 2020-21 on different capacity building and skill development programs comprises

one-week trainings, one-day orientation, product demonstrations, exhibitions, educational and motivational programs.

Trend of the number of stakeholders benefitted under capacity building and skill development programs showed a decreasing trend with its peak level 11,446 stakeholders from different parts of the country during 2012-13 to 5563 stakeholders in 2019-20. In 2020-21, it declined drastically due to pandemic COVID 19. Number of stakeholders benefitted under extension programs showed an increasing trend (Fig 4.12).

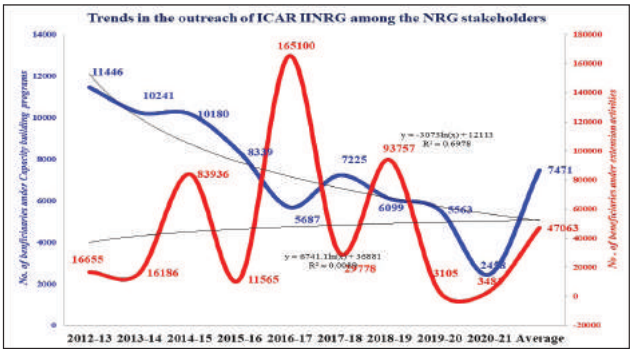


Fig. 4.12: Footprints of NRG based knowledge over the time

The peak levels of the coverage ranged from 0.5 lakh to 1.5 lakh stakeholders during 2014-15 (83,936), 2016-17 (1, 65,100) and 2018-19 (93,757) due to the convergence with corporate sector during *Krishi Vasant*, Global Investors Meet, Momentum Jharkhand, *etc*. Overall, with the existing infrastructure about 8000 stakeholders are being benefitted under capacity building and skill development programs annually. This figure needs to be doubled for extensive coverage of the stakeholders by developing required infrastructure as well as manpower. About 50,000 stakeholders may be covered through extension and other awareness programs. However, post Covid scenario affected the regular trend adversely and it demands the ICT interventions to disseminate the Good Agricultural Practices (GAP) among the stakeholders in the period of new normal.

Survey- cum- awareness program-2021: More than 300 trainees from different districts of Jharkhand state have been contacted under Survey-cum-awareness program during 2021 (Fig 4.13). Extension literatures about scientific lac cultivation have been distributed among the lac growers. Village level interactive sessions with the local representatives and key resource persons were made to record the feedback of the stakeholders. Further, plan of work for "Survey-cum- awareness program" conducted to cover the rest of the lac producing districts. Survey team found that knowledge level of the trainees improved, and few farmers adopted the recommended practices of lac cultivation. Major hurdle in adoption was the timely availability, accessibility and affordability of inputs. Non-trainees were also interviewed for comparative analysis.



Fig. 4.13: Glimpses of the Survey- cum- Awareness Program-2021

Extension activities

NRG Information Cell (NIC) and Market Oriented Technical Advisory Services (MOTAS)

Based on the information generated under market support, a data base has been maintained in the NIC. During 2021, information related to the NRG production, price/minimum support price (MSP), transferable technologies, bankable projects, promotional awards, post COVID 19 management aspects, marketing, processing, export and policy issues have been disseminated through the direct interactive meetings, discussions, writing, telephonic and mails to a total of 21 stakeholders including 8 entrepreneurs, 4 farmers, 3 processors/manufactures/exporters, 3 researchers/research scholars and 2 NGOs from India (Fig. 4.14). Beneficiaries belonged from 12 districts spread over the 9 states (Table 4.5). Few belonged to overseas countries including Nepal and USA. Data on NRG production, processing, EXIM were also sent to IASRI for Agriculture Research Data Book.

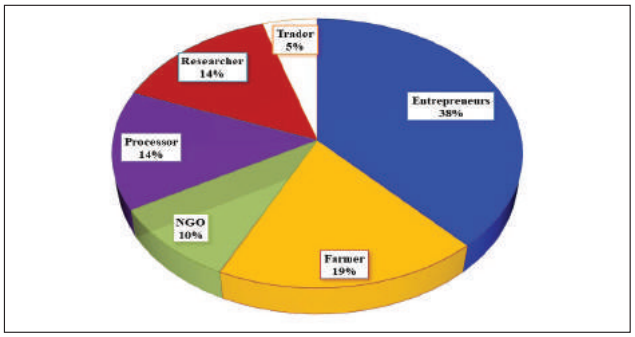


Fig. 4.14: Category wise beneficiaries under NIC and MOTAS

Table 4.5 Details of the activities of NIC and MOTAS under one to one program (OTOP)

State	Organization/ District/Place	Category	No.
Andhra Pradesh	Vijyavada	Entrepreneurs	1
		NGO	1
Assam	Guwahati	Researcher	1
Bihar	Patna	Processor	1
Chhattisgarh	Mahasamund	Farmer	1
	Balarampur	Farmer	1
Jharkhand	West Singhbhum	Entrepreneurs	1
	Ranchi	Processor	1
		Entrepreneurs	1
		Farmer	2
	Chatra	Entrepreneurs	4
Nepal	Jhapa	Entrepreneurs	1
Odisha	Bhubneshwar	Researcher	1
Rajasthan	Bhilwara	NGO	1
USA	Washington DC	Trader	1
	Cornell University, New York	Researcher	1
West Bengal	Kolkata	Processor	1
Total			**21**

ICT based intervention: *Laksha updates*

Keeping in view the importance of ICT enabled interventions; a social media group was initiated 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.

This ICT based intervention made the task simple, speedy and effective in linking the stakeholders with institute to manage the post COVID-19 scenario. Monthly advisories released by the institute and shared regularly with guidelines, metrological advisories and market updates (Fig. 4.15). More than 1500 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.

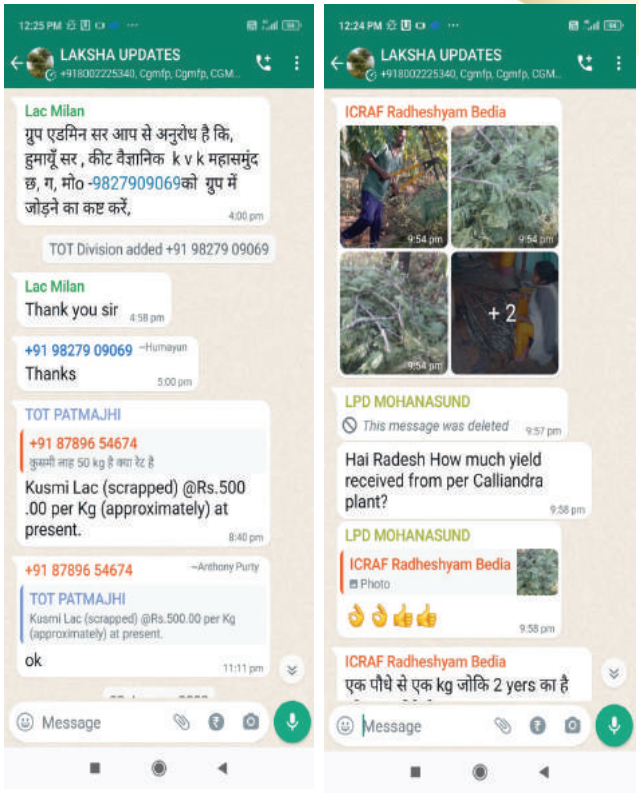


Fig. 4.15: Screenshot of the activities at ICT enabled module *Laksha updates*

4.3 Success story

Details of farmers who have been able to earn substantial income from their farm/enterprises and they are the role models in their area for other farmers.

1. Ms. Nelan Topno



Village- Sarna Toli, Panchayat- Torpa Purvi, Block- Torpa, District- Khunti, Jharkhand. Mobile No – 7295923546

She is a big landowner in the village of Sarantoli and a role model for women's empowerment. She is not only active in agriculture, but also in poultry farming and lac cultivation. She produces paddy, sweet corn, and vegetables such as potato, tomato, brinjal, bitter gourd, beans, chilli, green peas, garlic, onion, radish, carrot, coriander, and water melon on her 15-acre farm. She cultivates scientific lac on *ber* and *palash* on her 5-acre field. Her annual income is approximately 5 lakh rupees.

2. Shri. Balram Swansi



Village- Manhatu, Panchayat- Banai, Block- Raniya, District- Khunti, Jharkhand. Mobile: 6201046474

Out of his total 12 acre land, 10 acre land is used for both farming and animal husbandry. He has received scientific paddy cultivation training from KVK, Khunti, as well as vegetable and mushroom production training from PRADAN, Torpa, Khunti. He currently owns 5 cows, 4 goats, 20 sheep, and several agricultural implements. In his spare time, he does kitchen gardening and growing fruits such as mangoes and guavas. He cultivates rice on a 6-acre plot of land and vegetables on a 2-acre plot of land. He claims that after following integrated farming, his income has increased by 40%. He now earns 7-8 lakh rupees every year.

Application and Product Development

5. Synthesis, Process Development and Quality Management

5.1 Biodegradation studies of lac resin under soil burial method

Lac samples (sticklac, seedlac and shellac), buried directly in the Institute research farm's soil and pots, were drawn after two years and washed thoroughly with water and cleaned meticulously to remove brick pieces, stones, twigs, etc. Weight loss of the samples were assessed and found 51%, 52% and 26% loss from the samples of sticklac, seedlac and shellac, respectively buried in pot soil, while samples buried in farm soil recorded 41%, 48.5% and 23% loss from sticklac, seedlac and shellac, respectively.

Physicochemical properties such as flow, life under heat, colour index and cold alcohol insoluble % of the samples including control samples were carried out. It was observed that no sample showed fluidity except shellac control sample (15 mm). No life was reported in buried sticklac and seedlac samples. Shellac samples, buried in pot and farm soil, showed life of 31 min and 32 min, respectively. Sticklac, seedlac and shellac control samples showed 43 min, 28 min and 35 min life under heat, respectively. Colour and cold alcohol insoluble % in all the lac samples increased over a period of time.

Biodegradation of lac resin at accelerated condition from CIPET Chennai

Cleaned *Kusmi* scraped lac (36 kg) was procured from IRF for biodegradability study at CIPET Chennai. (The lac was *phunki*, removed from *kusum* plants in the month of March. The *ber kusmi* broodlac was tied to *kusum* plants in the month of February 2021. *Kusmi* lac was harvested from *ber* plants in the month of February for broodlac. 30 kg of scraped lac was washed with soda (4.25 g/kg, golden washing) through Integrated Small Scale Lac Processing unit from PDU campus. Approximately 24 kg of seedlac was obtained after complete drying. 17.3 kg of seedlac was charged for conversion to button lac with the help of M/s IndoLacca Shellac Pvt Ltd, Balrampur, Purulia, WB. Fresh and new cloth was used for making of bags and double layer bag was used for filtering of lac. Approximately 14.9 kg of button lac was obtained. All the three samples (sticklac, seedlac and shellac) 2 kg each, were sent to CIPET Chennai for accelerated Biodegradation study, on April 28, 2021.

5.2 Synthesis of rosin derivative for its application as tackifiers

Rosins have carboxylic acid functionality and multiple carbocyclic rings. Structurally, preferred rosins (also called "rosin acids") include mono-carboxylic acids with the general formula $C_{19}H_{29}COOH$, with a nucleus of three fused six-carbon rings and comprise double bonds that vary in number and location. Examples of rosin acids include abietic acid, neoabietic acid, dehydroabietic acid, pimaric acid, levopimaric acid, sandaracopimaric acid, isopimaric acid and palustric acid. Any type of rosin may be used, including tall oil rosin, gum rosin and wood rosin. In our experiment, gum rosin has been used.

A number of rosin derivatives were synthesized by reaction of rosin with different polyols and molecules at different temperatures and for different time durations. Rosin was reacted with polyols to synthesize rosin ester. The reactions were carried out in the presence/absence of catalyst (Fig. 5.1). The synthesized esters, in some cases, were further reacted with dienophiles to produce adducted rosin ester using Dials-Alder reaction. The adducted rosin ester, in some cases, was further esterified with poly-glycols to produce the modified esters.

Acid values and colour index of the synthesized derivatives were determined. Acid value was found in the range of 43-85. Colour was found to be higher and did not match with the standard solution (in some cases) (Table 5.1).

The derivatives were characterized with FTIR analysis. Spectra showed shift of carbonyl group peak of acid to higher frequency in the form of ester, indicating the ester formation. Peaks for hydroxyl groups in the derivatives were clearly shown in the range of 3400-3600 cm^{-1} in the spectra (Fig. 5.2). Glass transition temperature and softening point were analyzed using DSC. Softening point was recorded in the range of 27-60 °C (Fig. 5.3).

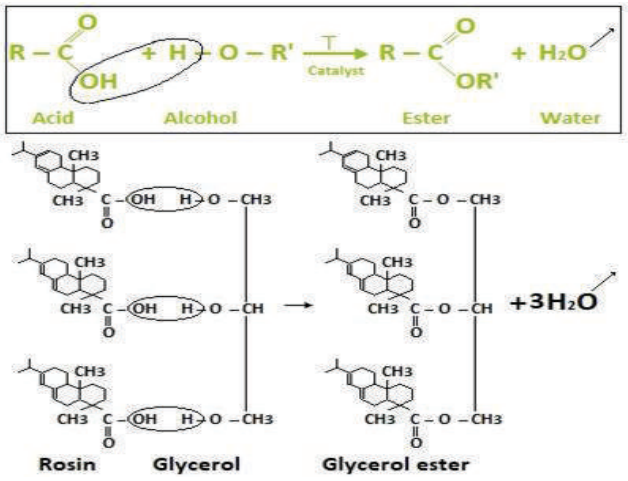


Fig. 5.1: A general reaction of rosin with polyols to form ester

Table 5.1: Acid value and colour index of synthesized rosin derivatives

Codes	Acid Value	Colour index
Rosin	165.00	12 (Xylene)
TF-01	137.21	14
TF-02	8.00	12
TF-03	69.10	11
TF-04	85.76	DNM
TF-05	52.71	DNM
TF-06	47.50	DNM
TF-07	39.98	DNM
TF-08	51.87	DNM
TF-09	16.00	DNM
TF-10	47.92	DNM
TF-11	79.92	17
TF-12	159.97 (Adducted ester)	16
TF-13	57.53	16
TF-14	142.57 (Adducted polyester)	DNM
TF-15	257.27 (Adduct)	17
TF-16	57.11	DNM
TF-17	257.01 (Adduct)	17
TF-18	57.05	DNM
TF-19	154.05 (Adducted ester)	DNM

DNM – Did not match with the standard solution

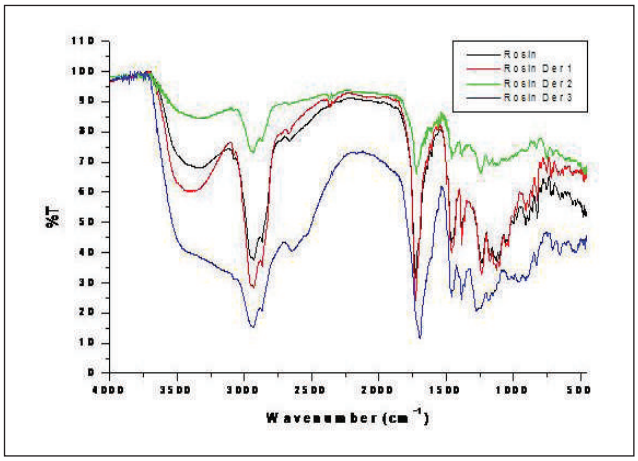


Fig. 5.2: FTIR spectra of rosin modified with polyols and molecules

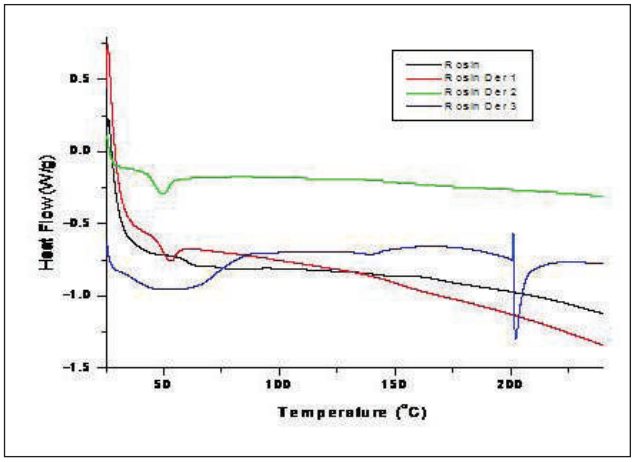


Fig. 5.3: DSC thermograms of rosin with polyols and molecules

Preparation of coating formulations for fruits/ vegetables and supply for its evaluation

As per request from different KVKs of TNAU TN, 84 L coating formulations for fruits and vegetables were prepared, packed and sent to the KVKs for OFT. Rs 1,58,120/- generated through supplying of 134 L samples of fruits and vegetables coating formulations to different KVKs of TNAU Tamil Nadu.

5.3 Synthesis of gum arabic based hydrogel for remediation of dye contaminated water

Gum arabic based hydrogel was synthesized using microwave assisted technique using borax as cross-linker and acrylamide as monomer and potassium persulfate (KPS) as radical initiator. The resulting gel mass was isolated using acetone, dried and sieved and employed as adsorbent for brilliant green (BG) dye removal (Fig.5.4a & b). Structure of BG dye is depicted in Fig. 5.5a.

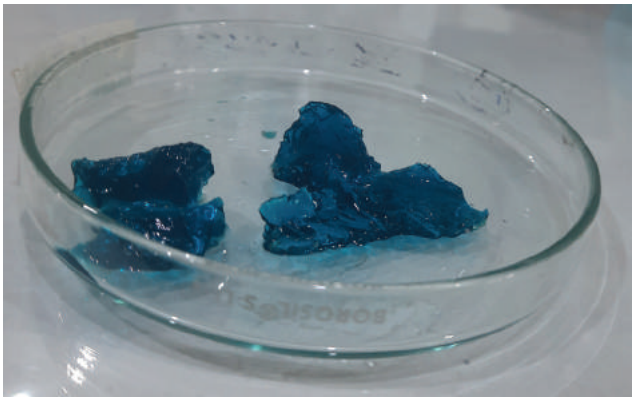


Fig. 5.4a: Gum arabic based hydrogel

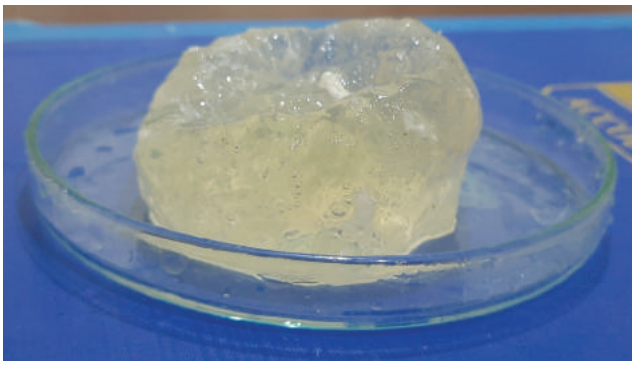


Fig. 5.4b: Gum arabic hydrogel as adsorbent

Adsorption study of BG dye using synthesized hydrogel revealed that it is pH dependent. It was found that optimized condition for dye (BG) gradually increased with increase in pH of the solution which then tends to stabilize above pH=8 (Fig. 5.5b). In low pH condition, low performance was noted which can be because of the repulsion between =N+ moiety and H+ ions.

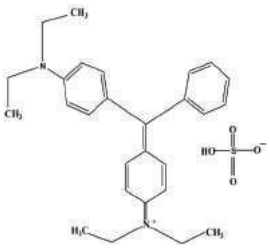


Fig. 5.5a: Structure of brilliant green dye

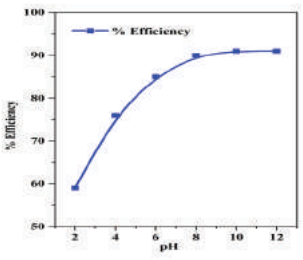


Fig. 5.5b: Effect of pH on adsorption of dye

The effect of temperature was investigated, and it was observed that increase in temperature increased adsorption process (Fig.5.6a). This is probably due to decrease in viscosity of the dye solution and also with higher temperature, dye molecules possessed sufficient energy to undergo interaction with active sites of the adsorbent. The overall process suggested that adsorption was endothermic in nature. Similarly effect of adsorbent dosage was investigated and it was found that beyond the optimized dosage (0.6 g/100ml), the adsorption efficiency practically remains constant (Fig. 5.6b).

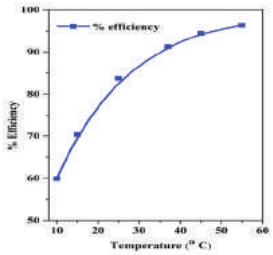


Fig. 5.6a: Effect of temperature on adsorption of BG dye

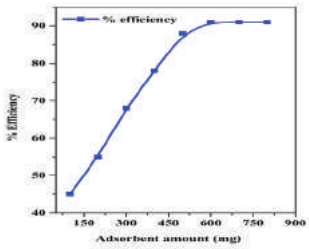


Fig. 5.6b: Effect of adsorbent dosage on BG dye

5.4 Synthesis of *Terminalia bellirica* exudate gum hydrogel-metal nanoparticle composite materials for evaluation in drug release

Terminalia bellirica exudate *baheda* gum (Fig. 5.7a) was purified by dissolving the gum in cold distilled water and precipitating with ethanol, dried in vacuum and finely powdered. Yield of the pure gum *baheda* obtained was 70 percent.

The graft copolymerization of purified *baheda* gum (BG) with acrylic acid under basic conditions has been initiated. *Baheda* gum (1.0 g) was dispersed in NaOH solution (pH 12.5) in three-necked flask equipped with a mechanical stirrer, a reflux condenser, a thermometer under nitrogen atmosphere. The dispersion was heated at 60 °C for 1 h to form colloidal slurry. The hydrogel was prepared by the graft copolymerization of purified natural BG with acrylic acid (NaA) using ammonium persulfate (APS) as initiator and N,N'-methylenebisacrylamide (MBA) as crosslinker (Fig. 5.7b & c). A series of reactions has been conducted for optimization of reaction conditions with respect to concentration of monomer, cross linker and initiator.

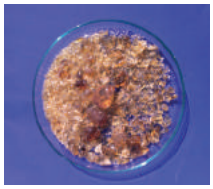


Fig. 5.7a: *Baheda* gum



Fig. 5.7b: Swollen *baheda* gum hydrogel



Fig. 5.7c: Dried *baheda* gum hydrogel pieces

6. Value Addition and Product Development

6.1 Study on natural gum based dietary fibre as encapsulant for delivery of functional feed

Encapsulation of beta carotene was attempted with Partially Hydrolyzed Guar Gum (PHGG) using liposome encapsulation technique. The liposome encapsulation is useful for delivery of functional nutrients due to the low absorption and increased bioavailability rates than traditional oral delivery. The liposome encapsulation requires phospholipid molecule to make a vesicle around the core material. The soya lecithin along with PHGG is used to encapsulate beta carotene using simple liposome encapsulation technique (Fig. 6.1). After encapsulation, the encapsulated beta carotene loaded liposomes are lyophilized to store for longer duration. The load of the beta carotene in the encapsulated liposome is estimated using UV-Vis spectrophotometer and found in the range of 0.5-1.0 mg/ml of the matrix. The encapsulation efficiency is calculated as 78-80%. The liposome prepared with higher PHGG concentration showed higher encapsulation efficiency as compared to the control (44%). The study showed that encapsulation efficiency of liposome formulation with dietary fibre was higher than the control formulation.



Fig. 6.1: Beta carotene encapsulated liposome formulation with PHGG

Characterization of liposome encapsulated beta carotene was carried out using FT-IR spectroscopy, particle size analysis and Field Emission -Scanning Electron Microscopy (FE-SEM). FT-IR spectra of the encapsulated beta carotene showed characteristic coupled C=C-C stretching at 1720 cm^{-1} and 1680 cm^{-1} as per the standard beta carotene sample which confirmed the presence of beta carotene in the encapsulated sample (Fig. 6.2). The particle size analysis data showed that the d_{50} (size of 50% particles) were in the range of 18.27-37.76 µm.

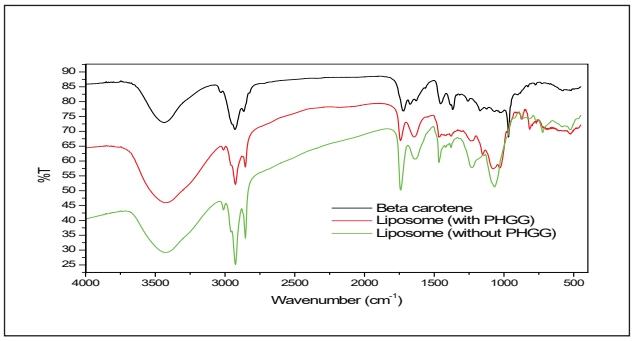


Fig. 6.2: FT-IR spectra of the beta carotene encapsulated liposome formulation

The characterization of the encapsulated beta carotene was carried out by FE-SEM study. The FE –SEM images showed the round shaped vesicles encapsulated beta carotene by PHGG. FE SEM images have shown that the particles maintained a similar spherical-like shape with a smooth or wrinkled surface depending on the drying conditions (Fig. 6.3). Most of the particles did not present a significant incidence of cracks or fissures in the outer surface,

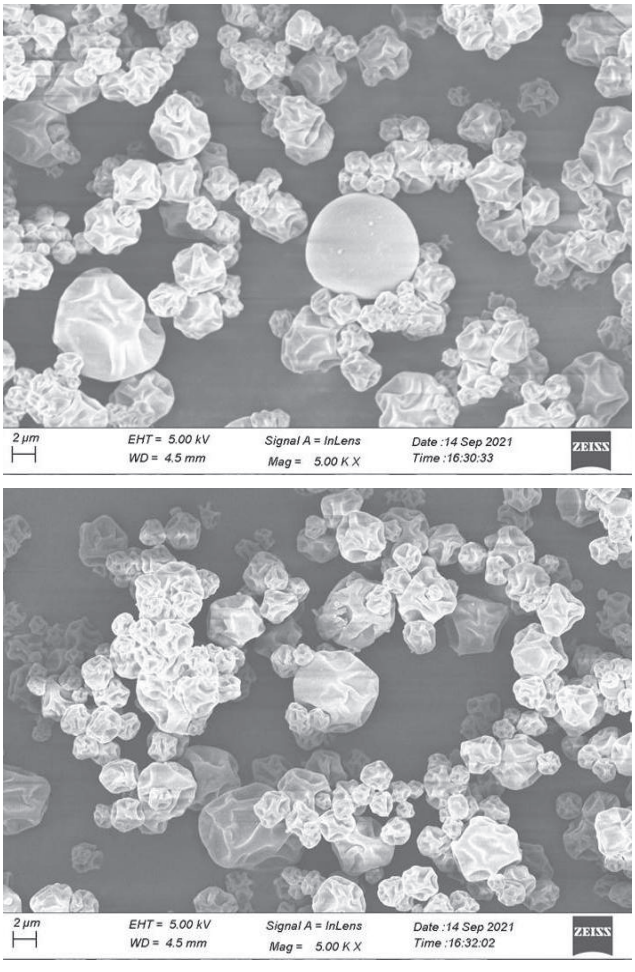


Fig. 6.3: FE-SEM images of PHGG encapsulated beta carotene through spray drying technique

indicating a resistant external physical structure and presenting a more effective protection of the bioactive compounds from oxidation reactions and avoiding their undesired release.

Release study of PHGG encapsulated beta carotene from liposome in the phosphate buffer saline (PBS) medium in pH 7.2 was carried out (Fig. 6.4). The results of the release data showed that the release of beta carotene from the matrix is time dependent. The study recorded 51.8% cumulative release of beta carotene in the medium after 3 hrs. The release of the beta carotene from the control liposome without PHGG was highest in 2hrs after that the degradation of beta carotene was observed.

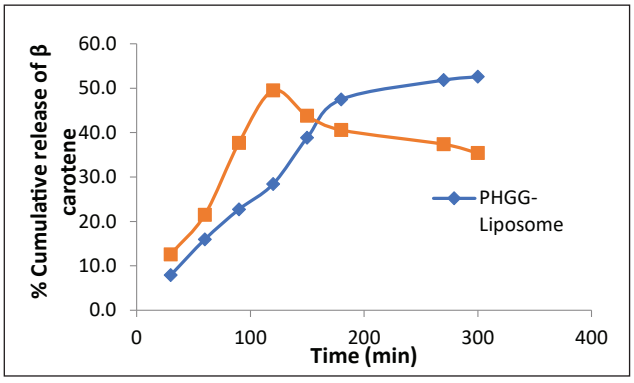


Fig. 6.4: Release study of the beta carotene from encapsulated liposome formulation

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

Several parameters for synthesis of hydrolyzed lac were optimized to get best possible yield of quality non-drying adhesive. The process of hydrolysis was also modified to get different light color shades of the hydrolyzed lac. Different formulations were made from the synthesized hydrolyzed lac and they were characterized by analysis of acid value, tensile strength, etc. The formulations showed decent adhesive power averaging 0.3 kg/cm^2. Viscosity of lac based non-drying adhesive formulation was studied by BrookField viscometer at 40°C and 20 rpm. Natural resin based formulation prepared showed much higher viscosity (130 cP) as compared to the commercial adhesive formulation, Chipku™ (33.7 cP) at 40 °C and 20 rpm (Fig. 6.5). The results showed that, being viscous at the elevated temperatures, the lac based formulations are less prone to dripping out from trap as compared to commercial formulation. FTIR analysis of the three year old sample of hydrolyzed lac was done using Spectrum Two FTIR, Perkin Elmer, UK. Based on FTIR results, it was observed that, no shifting in the spectra or their intensity for the hydrolyzed lac kept at room temperature up to three years, confirmed the stability and good storage life of the synthesized hydrolyzed lac.

Fortification of raw lac to the synthesized hydrolyzed lac resulted in improved adhesion without darkening the color. Glue formulation was prepared by adding suitable vegetable oil based fillers and suitable diluent to hydrolyzed lac. To increase spreading ability on polythene sheet, some vegetable oil fillers were added to the lac based non-drying adhesive. As the hydrolyzed lac is not soluble in vegetable oils, a heat-cool cycle protocol was developed to make these two phases compatible for blending.

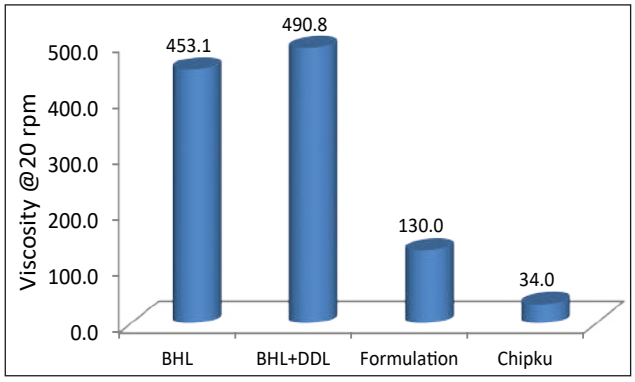


Fig. 6.5: Viscosity of lac based formulations as compared to Chipku®

Field trials of the lac based glue were carried out with yellow colored polythene traps in cylindrical shape. Traps were installed 30 cm above okra and brinjal crop canopy with the help of stick and distance between the two traps was maintained at 5 meters. For the comparison, traps with the commercially available glue (Chipku™) were also used as one of the treatments. Number of insects stuck on the traps were recorded alternate days, up to 10 days from the date of trap mounting. In the okra field, the developed formulations showed fairly good performance in the field trapping 249 to 299 insects on an average as compared to 346 insects trapped by the commercial trap (i.e. up to 86% efficiency as compared to the commercial glue) (Fig. 6.6). Whereas for brinjal crop, it was observed that the two lac based formulations (173 and 196 insects) outperformed Chipku® (52 insects) recording more than triple average number of insects trapped 10 days after installation (Fig. 6.6).

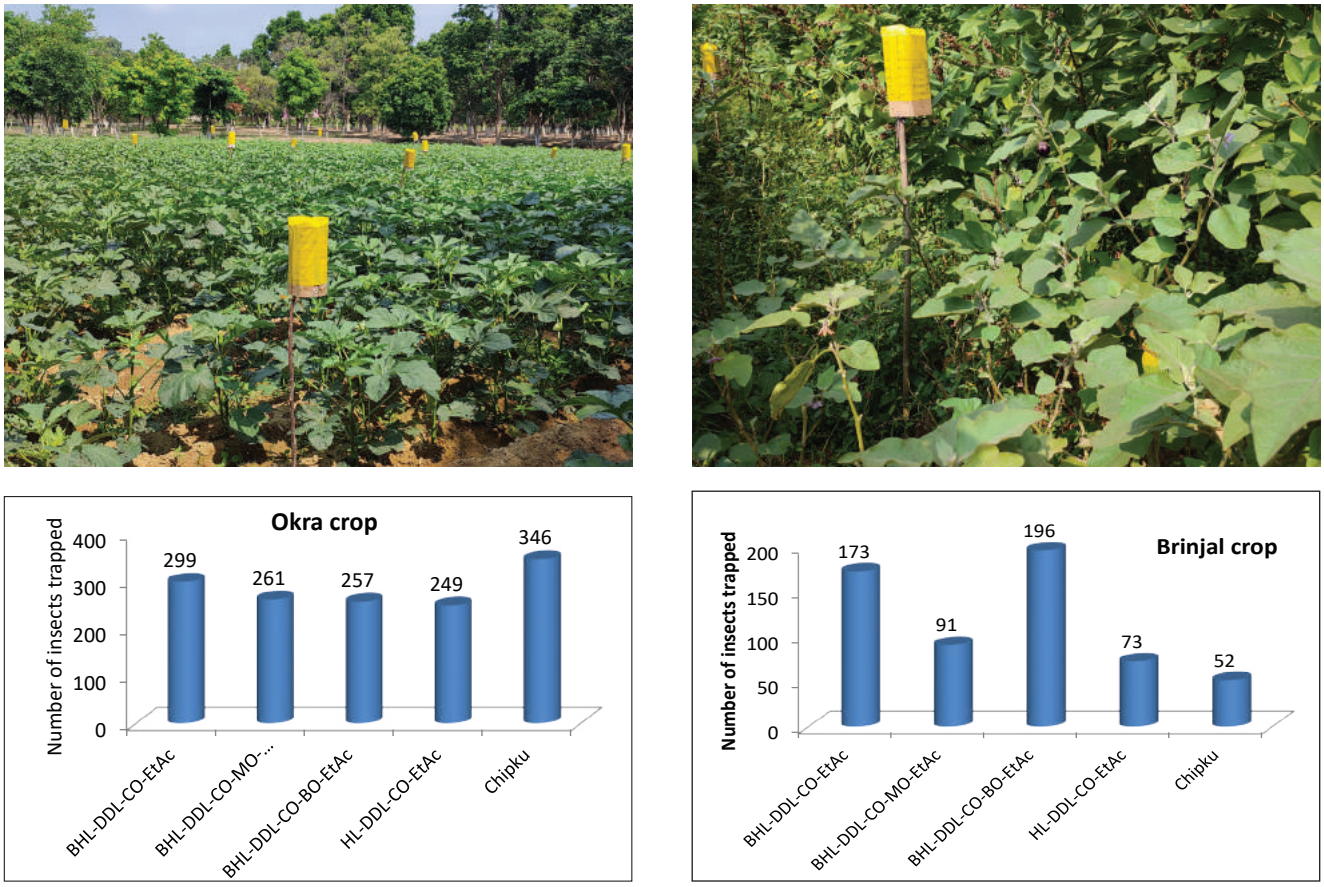


Fig. 6.6: Field trial of sticky insect trap in okra (left) and brinjal (right) crops

Mechanization and Process Engineering

7. Designing and Development of Farm Tools and Processing Machineries

7.1 Establishment of pilot-plant of dewaxed decolourised lac (DDL), for training, demonstration and process refinement

Trials of dewaxed decolourised lac (DDL) preparation were carried out (17 Nos.) with lac-solvent ratio 1:6 using 2-propanol and seedlac having initial color value 12 (Table 7.1). To remove the color of dewaxed decolourised lac solution, 20% charcoal (CDH powder and SRL granular) were used during refluxing of lac solution in solvent. Time duration for charcoal treatment in refluxing was kept 0.5, 1.0, 1.5 and 2.0 h (Fig. 7.1). During the process of dewaxed decolourised lac preparation, thick jeans cloth suitable for up-scaling in place of filter paper of lab process was used for wax removal. Similarly, thick cloth in place of filter paper of lab process was used for hot filtration so that process can be up-scaled.

Table 7.1: Details of quality parameter for prepared dewaxed decolourised lac with different treatments

S. No.	Colour seedlac	20% Charcoal	Reflux time, h	Lac-solvent ratio (w/v)	Yield of DDL (%)	Colour of DDL	Wax (%)	Impurity (%)	Acid value	Flow (mm)	Life (min.)
1	12	CDH	1.5	1:6	77	0.7	0.53	0.66	74.32	140	63
2	12	CDH	1.5	1:6	75	0.7	0.75	0.63	74.37	98	49
3	12	CDH	1.5	1:6	76	0.8	0.39	1.42	74.38	100	54
4	12	CDH	1.0	1:6	75	1.0	0.42	0.42	73.22	65	52
5	12	CDH	1.0	1:6	77	1.2	0.38	0.51	74.38	54	48
6	12	CDH	1.0	1:6	78	CND	0.59	CND	52.61	Nil	Nil
7	12	SRL	0.5	1:6	84	8.0	1.56	1.76	64.96	98	73
8	12	SRL	1.0	1:6	82	6.0	1.40	1.18	66.00	107	75
9	12	CDH	0.5	1:6	76	1.6	0.46	2.80	64.03	28	48
10	12	CDH	0.5	1:6	77	1.2	0.68	0.54	66.05	70	68
11	12	CDH	2.0	1:6	75	1.0	0.51	1.12	66.01	50	57
12	12	CDH	2.0	1:6	73	0.7	0.31	0.56	81.29	125	52
13	12	CDH	2.0	1:6	77	0.8	0.28	0.80	77.43	>150	52
14	12	CDH	2.0	1:6	73	0.7	0.32	0.21	75.98	>150	49
15	12	CDH	0.5	1:6	74	1.0	0.26	2.08	73.38	79	62
16	12	CDH	0.5	1:6	69	0.7	0.22	0.08	77.38	>150	56
17	12	CDH	0.5	1:6	76	0.7	0.25	0.05	77.40	>150	59

CDH- CDH make powder above 300 mesh size, SRL- SRL make granular, CND-Could not be determined

In above trials of dewaxed decolourised lac preparation, yield varied from 69 to 84% by weight of seedlac with mean yield 76.12%. Heat polymerization observed in one trial of dewaxed decolourised lac preparation due to error in manual process and in other two trials higher colour value observed due to granular charcoal which did not reduce colour. However, in other 14 trials of dewaxed decolourised lac preparation using CDH make charcoal powder, reduction in colour value of seedlac from (12) were observed successful varied from 0.7 to 1.6 with maximum colour reduction up to colour value 0.7 which was achieved in even 0.5 h of charcoal reflux. Highest flow and life of dewaxed decolourised lac samples were achieved as >150 mm and 75 min, respectively. Wax, impurity content and acid value of the samples were also found better (within acceptable limit) in most of the trials. Color value of prepared dewaxed decolourised lac also evaluated utilizing Hunter's Lab Colorimeter.



Seedlac


SRL granular charcoal treatment, 0.5 h


CDH charcoal treatment, 0.5 h


CDH charcoal treatment, 1.0 h


CDH charcoal treatment, 1.5 h


CDH charcoal treatment, 2.0 h

Fig. 7.1: Dewaxed decolourised lac prepared using different make charcoal with variation in charcoal treatment duration

7.2 Development of pilot plant of guar gum derivative for training and demonstration

Experimentation on carboxy methyl guar gum derivative preparation

Trials of carboxy methyl guar gum derivative preparation from guar gum powder using reagents with mixing time 30, 60 and 90 min, reaction time (3 h) and drying time (3 h) was carried out to observe the effect of mixing time on difference in quality parameters (viscosity, pH and degree of substitution) of carboxy methyl guar gum derivative. Mean viscosity (cP) of the prepared carboxy methyl guar gum derivative with mixing time 30, 60 and 90 min, reaction time 3 h and drying time 3 h was found to be 3814, 3212.3 and 3017.7, respectively with mean pH value 7 in all the prepared derivatives. Degree of substitution of the prepared guar gum derivative was determined to be 0.13, 0.10 and 0.08% for mixing time 30, 60 and 90 min with reaction and drying time 3 h. Results of experimental trials reveal that carboxy methyl guar gum derivative with higher viscosity and degree of substitution can be prepared with reduced mixing time (30 min), reaction time 3 h and drying time 3 h having similar pH.

Fabrication of carboxy methyl guar gum derivative pilot plant

Fabrication of different components and units based on detailed manufacturing design drawing developed in Pro Engineer CAD Software under development of carboxy methyl guar gum derivative pilot plant initiated in form of collaborative project with association of scientist from ICAR – Central Institute of Agricultural Engineering, Bhopal. Major components of different units *i.e.* mixing-cum-reaction unit, filtration unit, drying-cum-agitator unit and distillation unit fabricated (Fig. 7.2) and rest of the minor components fabrication are under progress including installation of the required brought out components.


Mixing-cum-reaction unit


Filtration unit


Drying-cum-agitator unit


Distillation unit

Fig. 7.2: View of fabricated units under guar gum derivative pilot plant

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

8.1 Lead Centre: ICAR-IINRG, Ranchi

Preparation and characterization of modified *guar* gum nanocomposite films reinforced with *piyar* AgNPs for diversified applications

A number of nanocomposite films reinforced with *piyar*-AgNPs were developed for diversified applications through solution casting method, by varying reactants *i.e.* modified *guar* gum (MGG), plasticizer, *piyar*-AgNPs *etc.*, to study the effect on the physical, mechanical, thermal, barrier and antimicrobial properties of the resulting nanocomposite (NC) films. The developed nanocomposite films are characterized by physical properties (thickness, opacity, color value), UV-Vis, FT-IR spectroscopy, Field Emission-Scanning Electron Microscopy (FE-SEM) and Energy dispersive spectrum (EDS) analysis and Differential Scanning Calorimetry (DSC). The developed nanocomposite films were also characterized by mechanical properties (tensile strength, flexibility). The antifungal evaluations of developed nanocomposite films were carried against *Aspergillus niger*.

Colour value (L, a and b value) of nanocomposite films: Color values (L, a & b) of the developed nanocomposite films were determined using Hunter colorimeter. The 'L' values increased with increasing concentration of the nanoparticles in the films resulted darker color of the films. Further, the films showed negative 'a' values for greenish and positive 'b' values for yellowish color. The color values of developed nanocomposite films are depicted in the Table 8.1. The b value which denotes the yellow colour were increased with the

Table 8.1: Color values of modified *guar* gum-*piyar*-AgNPs nanocomposite films

Treatments of NC film	M GG (gm)	Plasticizer (gm)	Piyar-AgNPs (ml)	L*	a*	b*
Control 1	0.25	0.25	0	22.02	-1.12	-1.05
T1-1	0.25	0.25	3.0	27.97	-2.123	12.83
T1-2	0.25	0.25	6.0	14.19	-0.16	20.28
Control 2	0.50	0.25	0	29.35	-1.70	0.50
T2-1	0.50	0.25	3.0	28.68	-2.57	15.60
T2-2	0.50	0.25	6.0	15.32	-3.16	17.61
Control 2	0.70	0.25	0	30.04	-1.74	2.05
T3-1	0.75	0.25	3.0	18.76	-2.04	22.23
T3-2	0.75	0.25	6.0	38.47	-1.14	29.78

***FE-SEM and EDS analysis of the nanocomposite film*:** Field emission-scanning electron microscope images of the developed nanocomposite films were recorded to obtain the morphological features of the films. Fig. 8.1a shows the SEM images of nanocomposite films. The morphology of the nanocomposite films was flat, dense, and homogeneous. On the other hand, the SEM images of films are characterized by uniformly distributed silver nanoparticles (AgNPs) which are identified as white spots on the smooth surfaces of the nanocomposite films. The FE-SEM images of the cross section of films (Fig. 8.1b) indicated the incorporation of the AgNPs. The SEM image of cross section of films also showed that the formed nanoparticles are uniformly distributed throughout the film thickness. The absorption peak at 20 keV in the EDS spectrum of the nanocomposite film confirms the presence of elemental Ag and the results demonstrate that 0.07% of nanoparticles formed inside the film (Fig. 8.2).

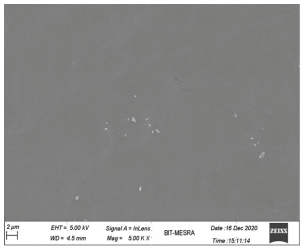


Fig. 8.1a: FE-SEM images of the surface of nanocomposite films

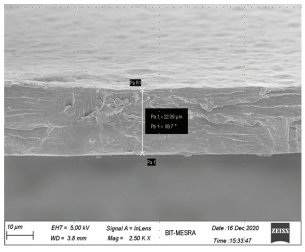


Fig. 8.1b: FE-SEM images of the cross section of nanocomposite films

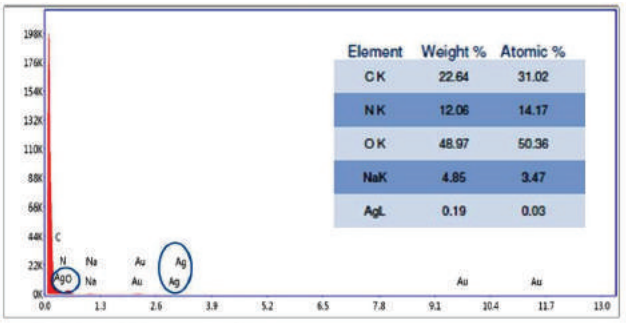


Fig. 8.2: EDS spectra of nanocomposite film

***DSC thermogram of the nanocomposite film*:** The DSC thermogram of the nanocomposite films were carried out to determine the thermostability of the developed films. The DSC thermogram of the nanocomposite films (Fig. 8.3) were shown one endothermic peak at 85.44 ^{0}C and one exothermic peak at 287.20 ^{0}C. The endothermic peak indicates the loss of water and plasticizer molecules from the films whereas the exothermic peak indicated the thermal degradation of the modified guar gum and plasticizer molecules in the films. DSC thermogram also indicated that the onset of the thermal degradation started at 260 ^{o}C. The results indicated that the developed nanocomposite films are thermostable up to 250 ^{0}C.

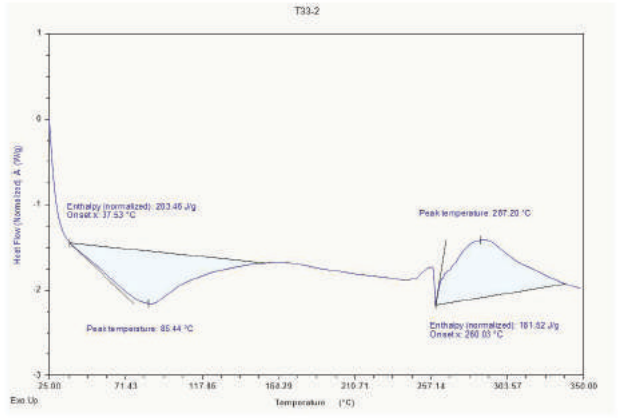


Fig. 8.3: DSC thermosgram of the developed nanocomposite film

***Mechanical properties of the nanocomposite film*:** The mechanical properties of the films are significant as this property directly impacts other properties of the film. The mechanical strength of the polymer films depends on their chemical structure. Packaging films must have good mechanical strength to withstand the external stress during processing, transportation, and usage. Thus, for improved mechanical strength of the modified guar gum, silver nanoparticles impregnated nanocomposite films were developed. Table 8.2 shows the mechanical properties such as tensile strength, modulus, and elongation at break values or break strain of control and nanocomposite films. This table clearly reveals that nanocomposite film has improved mechanical strength *i.e.* tensile strength and modulus than control film. This enhancement of tensile strength and modulus indicates the excellent interaction between polymer matrix and Ag nanoparticles, and intermolecular forces and electrostatic force between Ag nanoparticles and polymer matrix that makes the film strengthened and shows better mechanical properties. Similarly, the break strain or percentage of elongation is more for nanocomposite films. This may be attributed to the fact that Ag metal nanoparticles make the film more flexible. It was noticed than the incorporation of Ag nanoparticles increases the tensile strength and make the film more flexible.

Table 8.2: Mechanical properties of the developed nanocomposite film

Treatment of NC films	Properties	Average Data of three tests
T1-1	Modulus (Mpa)	230.34
	Break Strain (%)	2.22
	Tensile Strength (MPa)	5.17
T1-2	Modulus (Mpa)	902.66
	Break strain (%)	1.65
	Tensile Strength (Mpa)	13.51
T2-1	Modulus (Mpa)	1446.67
	Break strain (%)	2.27
	Tensile Strength (Mpa)	24.36
T2-2	Modulus (Mpa)	1282
	Break strain (%)	2.85
	Tensile Strength (Mpa)	27.1
T3-1	Modulus (Mpa)	153.67
	Break strain (%)	9.29
	Tensile Strength (Mpa)	10.68
T3-2	Modulus (Mpa)	350.83
	Break strain (%)	33.60
	Tensile Strength (Mpa)	18.01
Control	Modulus (Mpa)	190.26
	Break strain (%)	2.11
	Tensile Strength (Mpa)	5.01

***Antifungal evaluation of nanocomposite film*:** The antifungal susceptibility test of developed nanocomposite film was done by agar-well diffusion method. The fungal strain of *Aspergillus niger* was first grown in potato dextrose liquid medium broth and incubated at 30 ^{0}C for 5 days before use. The conical flask containing potato dextrose agar solution was

cotton plugged and autoclaved at 15 psi pressure and 121 °C temperature for 15 min. The plate was sterilized and then seeded with prepared sample of the pathogen with the help of a sterile stainless spreader. Four agar wells of 6 mm diameter were labeled as 1, 2, 3 and C (control). The wells 1, 2 and 3 were loaded with 1 cm2 section of nano- composite films and the well C was loaded with 100 microliter of the Ag solution (Fig. 8.4). The plates were incubated at 37 °C for 96 h and the zone of inhibition (ZOI; mm) that appeared around the wells was recorded (Table 8.3). The results showed that nanocomposite film showed promising antifungal activity as compared to control.



Fig. 8.4: Antifungal activity of the developed nanocomposite films against *A. niger*

Table 8.3: Zone of Inhibition of developed nanocomposite films against *A. niger*

Treatment	ZOI (in mm)
T1-1	0.8
T1-2	2.2
T2-1	0.5
T2-2	1.8
T3-2	1.2
T3-2	2.2
Control	0.5

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

In the year 2020-21, visits were made to surrounding forest areas of Ranchi, Jharkhand and photographs were taken for missing plant parts of some gum-resin trees. During local surveys photographs of season specific plant parts including flowers, fruits, leaves, whole plants and gum exudation of different plant species were taken (Fig. 8.5). Various plant parts of the trees like *Garuga pinnata, Spondias mombin, Acacia sieberiana, Acacia polyacantha, Albizia amara, Albizia lucidior, Bombax ceiba, Delonix regia, Samanea saman, Leucaena leucocephala, etc.* were photographed and the seasons were noted. Due to prolonged lockdown and travelling restrictions during COVID-19 pandemic, survey to different states for photographing remaining plant parts and exploring new plants could not be done.

In order to increase the scope of this study, two centres namely KAU, Thrissur, Kerala, for photographing different plant parts of gum and resin plants of western ghats of Kerala and CAZRI, Jodhpur, Rajasthan, for arranging photographs of different plants parts of the gum- resin producing trees from the arid regions of Rajasthan were involved in the project.

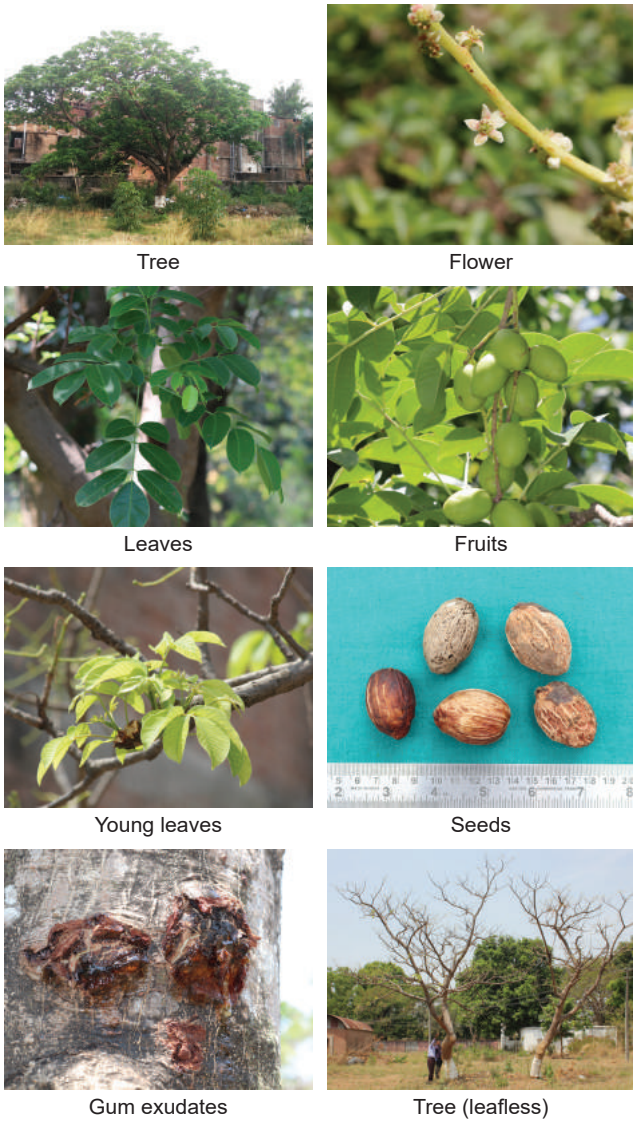


Fig. 8.5: Different plant parts of the *Spondia mombin (aamra)* tree

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

***Improvement in fabricated gum tapping die/ tool*:** Gum tapping die (Fig. 8.6) fabricated based on detailed manufacturing design drawing developed in Pro Engineer CAD Software in collaboration with ICAR – CIAE, Bhopal and further modified (Fig. 8.7) for smooth functioning of the developed gum tapping die/tool based on field evaluation trials of *moringa* gum tapping from *Moringa oleifera* trees at Kankebar, Ramgarh district in Jharkhand. After field evaluation trials of modified gum tapping die/tool in actual field condition for *moringa* gum tapping from *M. oleifera* trees (Fig.8.7), the modified model of gum tapping die/tool further improved to standardize the gum tapping die/tool for gum tapping from selected tree species and stopper mechanism was included in the standardized model of gum tapping die/tool (Fig. 8.8 & 8.9) so that depth of blaze/incision on the tree trunk may be maintained as per requirement.



Fig. 8.6: Developed model of gum tapping die/tool



Fig. 8.7: Modified model of gum tapping die/tool



Fig. 8.8: Improved design of gum tapping die/tool



Fig. 8.9: Standardized model of gum tapping die/tool

Experimentation on moringa gum tapping from M. oleifera trees

Suitable trees (24 Nos.) of *M. oleifera* selected at Kankebar, Ramgarh (Jharkhand) to conduct *moringa* gum tapping experiment from *M. oleifera* trees under the project and initiated in the last week of July 2020 with three replicates and different treatment as detailed in Table 8.4.

Table 8.4: Details of experimental plan for gum tapping from *Moringa oleifera* trees

Tool / method	Drilling diameter (inch)	Inducer application (4 ml)	Patching
Battery operated drilling	½	×	√
		√	√
Hand operated drilling	½	×	√
		√	√
	1	×	√
		√	√
Semi Circular Incision	NA	×	×
Gum tapping die	NA	×	×

During initiation of the above experiment, blaze/ incisions were made on the tree trunk using battery operated drilling machine with ½ inch drill bit, hand operated drilling machine with ½ and 1 inch hand drill, chisel for semicircular incision and using gum tapping die/tool, respectively.

To develop blaze/ incision on the tree trunk of *M. oleifera* trees using developed gum tapping die, the die/tool was placed on the tree trunk 1.0 m above the ground level and hammered thoroughly up to the bark thickness and depth of blaze/incision maintained utilizing stopper mechanism provided in the die/ tool. During operation of the developed die for gum tapping from *M. oleifera* trees, it was observed that blaze/incisions developed easily with sharp edges of the blaze/incision on the tree trunk utilizing developed die/tool as shown in Fig. 8.10 & 8.11 which starts gum oozing within 4 – 5 hours (Fig. 8.12).



Fig. 8.10: Blaze development using gum tapping die



Fig. 8.11: Developed blaze



Fig. 8.12: Gum exudation from developed blaze

***Bore hole development using battery operated drill (½ inch) without and with application of gum inducer*:** To observe the difference in *moringa* gum production without and with application of gum inducer, a bore of size ½ inch diameter and 4-inch depth was developed above 1.0 m from the ground level on the trunk of *M. oleifera* tree using battery operated drill machine and treated as detailed in Table 8.4. Mean yield of *moringa* gum obtained using battery operated drill machine was found to be 3.66 g and 60.17 g. Mean total *moringa* gum production during the experiment duration (August, 2020 – July, 2021) was collected to be 43.91 g and 722.09 g, respectively without and with application of gum inducer which indicates that gum production was 16.45 times higher in trees treated with gum inducer compared to without application of gum inducer.

***Bore hole development using hand operated drill (½ inch and 1.0 inch) without and with application of gum inducer*:** To observe the effect of size of bore hole on *moringa* gum production without and with application of gum inducer, bore of size ½ inch and 1.0-inch diameter and 4.0-inch depth was developed above 1.0 m from the ground level on the trunk of *Moringa oleifera* tree using hand operated drill of size ½ and 1.0 inch and treated as detailed in Table 8.4. Mean yield of *moringa* gum obtained using hand operated drill with ½ inch diameter was found to be 8.12 g and 130.61 g with minimum and maximum mean gum production as 1.62 g (July, 2021) and 21.69 g (March, 2021) and 17.41 g (May, 2021) and 298.82 g (September, 2020), respectively without and with application of gum inducer. However, the same were found 262.51 g and 255.70 g with minimum mean gum production as 20.43 g (March, 2021) and 4.02 g (February, 2021) and maximum mean gum production 89.49 g (October, 2020) and 917.99 g (July, 2021), respectively without and with application of gum inducer for 1.0 inch bore hole developed using hand operated drill. Total *moringa* gum production during the experiment duration (August, 2020 – July, 2021) was collected to be 97.41 g and 1567.33 g for ½ inch bore hole developed while the same were 371.55 g and 3068.45 g, respectively for without and with application of gum inducer which indicates that gum production was 16.09 times and 8.25 times higher in trees treated with gum inducer compared to without application of gum inducer with ½ inch and 1.0 inch hand drill.

***Blaze development through semicircular incision and gum tapping die/tool*:** During the experiment of *moringa* gum tapping from *Moringa oleifera* trees, incisions on the tree trunk above 1.0 m from ground level was developed using chisel and hammer adopting scientific method of *karaya* gum tapping through development of semicircular incision developed and standardized by Kovel Foundation, Visakhapatnam in collaboration with Girijan Cooperative Corporation Limited, Visakhapatnam and using gum tapping die developed at ICAR – IINRG, Ranchi for *moringa* gum tapping based on method developed and standardized by above mentioned organizations. Mean yield of *moringa* gum obtained using chisel for blaze development through semicircular incision and gum tapping die were found as 26.16 g and 59.76 g with minimum and maximum mean gum production as 0.00 g (October, 2020, January to March, 2021) and 2.19 g (October, 2020) and 137.67 g (June, 2021) and 257.85 g (July, 2021), respectively. Total *moringa* gum production during the experiment duration (August, 2020 – July, 2021) was collected to be 313.88 g and 717.15 g, respectively for blaze developed using chisel and gum tapping die. The mean gum production was found 2.29 times higher in case of blaze developed using gum tapping die compared to blaze developed using chisel.

***Comparison of gum yield through different tapping techniques and tapping season*:** It was observed during the experiment that gum started oozing out after couple of days in trees treated using battery operated and hand operated drill without and with application of gum inducer and after 4 – 5 hours in case of blaze developed using chisel for semicircular incision and developed gum tapping die/ tool. The exuded gum was separately collected for each treatment at monthly interval for a period of one year (August, 2020 – July, 2021) and mean gum yield for each treatment worked out. Total maximum gum yield was found for bore hole developed using 1.0 inch diameter hand drill with inducer application (3068.45 g) followed by bore hole developed using ½ inch diameter hand drill with inducer application (1567.33 g), bore hole developed using battery operated drill machine having ½ inch drill bit with inducer application (722.09 g), blaze developed using developed gum

tapping die/tool (717.15 g), bore hole developed using 1.0 inch diameter hand drill without inducer application (371.55 g), blaze developed using chisel (313.88 g), bore hole developed using ½ inch hand drill without inducer application (97.41 g) and bore hole developed using battery operated drill having ½ inch drill bit without inducer application (43.91 g), respectively. During the entire experiment duration, total *moringa* gum yield was collected as 20705.31 g and mean yield 2420.09 g with maximum monthly gum for the month July, 2021 (5010.58 g) followed by June, 2021 (4285.29 g), May, 2021 (2686.88 g), August, 2020 (2132.28 g), September, 2020 (2041.70 g), April, 2021 (1581.96 g), October, 2020 (1281.80 g), December, 2020 (546.97 g), November, 2020 (544.11 g), March, 2021 (487.79 g), January, 2021 (433.92 g) and February, 2021 (313.26 g), respectively.

A regular increasing trend in *moringa* gum yield observed almost in all the treatment with increase in environmental temperature which indicates that *moringa* gum can be tapped throughout the year but higher quantity of gum may be collected during April – September.

Development and maintenance of Resin and Gum Plants Germplasm Farm at IINRG

'Resin and Gum Plants Germplasm Farm' was developed by planting various NRG trees collected from various parts of the country at the Institute and detailed in Table 8.5 and depicted in Fig. 8.13.

Table 8.5: List of resin and gum trees available at the germplasm farm is as follows

Sl. No.	Common Name	Botanical name	Planting Time	No. of plants
RESINS				
1.	Dikamali	*Gardenia resinifera*	Oct. 2016	20
2.	Chir pine	*Pinus roxburghii*	Oct. 2016	15
3.	White dammar	*Vateria indica*	June 2017	02
GUMS				
1.	Gum arabic	*Acacia senegal*	Aug. 2007	63
2.	Babool	*Acacia nilotica* subsp. *adstringens*	Aug. 2007	56
3.	Jhingan	*Lannea coro-mandelica*	Oct. 2016	15
4.	Neem	*Azadirachta indica*	Oct. 2016	12
5.	Behra	*Terminalia bellerica*	July 2018	05
6.	Dhawra/ Ghatti	*Anogeissus latifolia*	Aug. 2007	20
7.	Piyar / Chironji	*Buchnania lanzan*	July 2018	15
8.	Asan/ Saja	*Terminalia tomentosa*	July 2017	10
9.	Karaya	*Sterculia urens*	Aug. 2007	33
10.	Acacia spp.	*Acacia fernasiana*	Oct. 2016	07
11.	Sahjan	*Moringa oleifera*	June 2019	20
GUM- RESINS				
1.	Guggul	*Commiphora wightii*	July 2017	05
2.	Salai	*Boswellia serrata*	Aug. 2007	15
Total				**313**

More than 30 plants of the resin trees like, Pine (*Pinus roxburghii*), Dikamali (*Gardenia resinifera*) and gum trees like, Jhingan (*Lanea coromandellica*), *moringa* (*Moringa oleifera*) and piyar gum (*Buchnania lanzan*) were transplanted to replace dead seedlings at the Resin and Gum plants germplasm farm during rainy season of 2021.



Fig. 8.13: NRG germplasm at ICAR-IINRG, Ranchi

8.2 Project on gum Arabic at ICAR-CAZRI, Jodhpur

Study on gum production from known and lesser-known gum producing tree species of arid zone of Rajasthan

Structural traits (average tree height and GBH) and gum yield of well-known gum-producing tress like *A.*

senegal (Nigerian) and *P. cineraria* were recorded. *A. senegal* (Nigerian) has reported a higher gum yield compared to other tree species Fig. 8.14 to 8.16.



Fig. 8.14: Exudation from *Acacia senegal* (exotic)



Fig. 8.15: Exudation from *Acacia senegal*

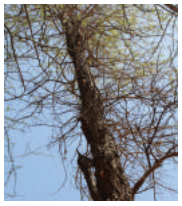


Fig. 8.16: Exudation from *Prosopis cineraria*

Lesser known gum producing tree species*:* In addition to well-known gum yielding tree species there are several tree species which also yield gum but still are underutilized. Gums on these tree species can be used for various agricultural and non- agricultural purposes. This year experiment on gum exudation trials (Fig. 8.17 and 8.18) was conducted in *P. juliflora* and *A. subrosa* with average diameter 32.5 cm and average gum yield of 179.2 g/ tree whereas *P. juliflora* with comparatively young population (DBH= 16.1 cm and average gum yield of 65.5 g. /trees).



Fig. 8.17: Gum exudation from *Prosopis juliflora*



Fig. 8.18: Gum exudation from *Acacia subrosa*

Plantation establishment, maintenance and evaluation of high gum yielding plant type of *Acacia senegal* and *Butea monosperma*

Plantation of high gum yielding plant type of A. senegal: A stand of high gum yielding plant type of *A. senegal* (Nigerian origin) was established on CR farm of CAZRI during monsoon season of 2010. The survival percentage after 11 years was more than 96%. The row-to-row 6 x 6 and plant to plant distance is 3 x 3 m. On an average plant attained height of 6.51 m, GBH of 31.63 cm and average canopy of 4.9 m.

Plantation of Butea monosperma: A block plantation of *B. monosperma* was established in 2013 and growth trends are monitored regularly. The dead plants have periodically been replaced during monsoon season. The row to row and plant to plant distance are viz.: 4 m x 4 m, 6 m x 6 m and 8 m x 8 m (Fig. 8.19).



Fig. 8.19: Plantation stands of *Butea monosperma* under various spacing at ICAR-CAZRI research farm

***Agro forestry trials*:** Eleven year old block plantation of high gum yielding plant type of *A. senegal* (Nigerian origin) was selected. Plantation stand consist 10 (Row) x10 (column) with 6 x 3 m spacing. For vegetable production plots were made in between strip of row –row *A. senegal* trees. Four vegetable crops with three replication and control were grown and yield and solar radation data were also recorded. four crops were selected i.e. Spinach, Cauliflower, Cabbage and carrot. (Fig. 8.20a, 8.20b, 8.20c and 8.20d). The crops like cabbage, cauliflower, spinach and carrot are showing good yield production with tree stands. Further trials for water use efficiency can be conducted.



(a) Tender leaf spinach for harvesting



(b) Cauliflower



(c) Cabbage



(d) Carrot

Fig. 8.20: Matured stage of selected crops

Evaluation of *Acacia senegal* and *Acacia tortilis* gums as wall materials for encapsulation of phytochemicals

A. senegal and *A. tortilis* gum based microencapsulated powders were characterized by FTIR, particle size analysis, anthocyanin and antioxidant content. The average particle size obtained by Dynamic Light Scattering (DLS) was 12654 nm and 14583 nm, respectively, for the A. senegal and A. tortilis microencapsulated powders. After freeze-drying, the

reconstituted emulsions were having an average particle size of 834 nm and 951.3 nm, respectively.

A. Senegal gum and *A. tortilis* gum as wall materials were successful in microencapsulating the anthocyanin rich extract. The samples of A. senegal gum and A. tortilis gum powders showed comparable DPPH radical scavenging activity of 42.5 and 38.8%, respectively. Thus, both the microencapsulated powders retained the antioxidant activity of the core material.

Value addition of gum Arabic through convenient technology

Various types of gum Arabic and *B. monosperma* gum-based value added products were processed for standardization.

Gum Arabic based sweets/confectionary products and mouth freshener were prepared (Fig. 8.21 and 8.22). With the help of hedonic scale, overall mixture of all flavors of processed products with gum Arabic in relation to taste, size and other parameters have been tested. These processed food or food like supplements using gum Arabic serves as a source of additional income generation to rural folk/ stakeholders.

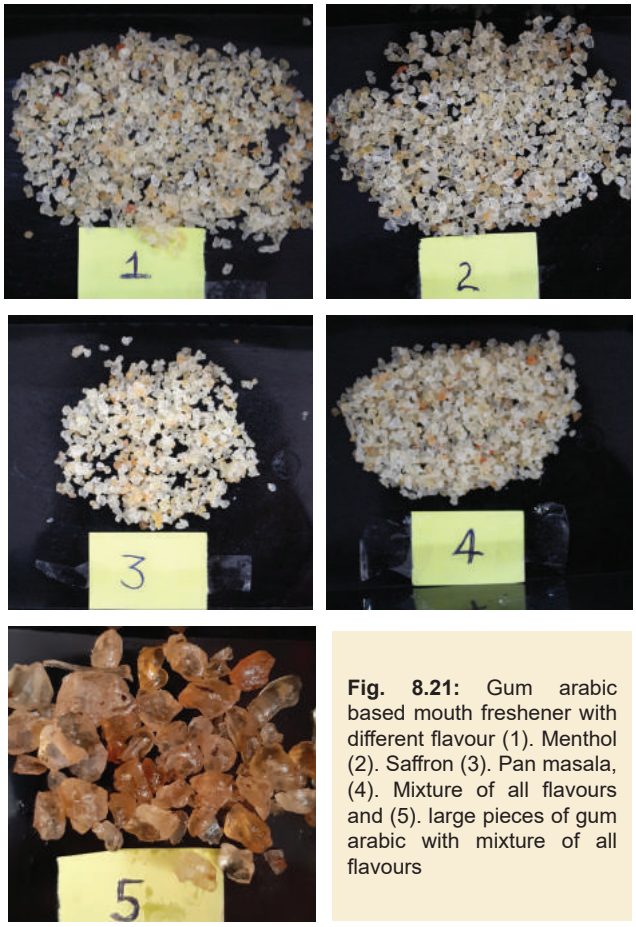


Fig. 8.21: Gum arabic based mouth freshener with different flavour (1). Menthol (2). Saffron (3). Pan masala, (4). Mixture of all flavours and (5). large pieces of gum arabic with mixture of all flavours



Fig. 8.22: Toffee and lollipop prepared from gum of *A. senegal*

B. monosperma gum-based crack healing cream was prepared (Fig. 8.23) which does not possess any side effects. Butea crack healing cream is used by rural folk from very long and is a part of their traditional knowledge. Additionally, it is an herbal product which does not possess any side effect.

The production technology of gum Arabic based processed products has been under process. Once such products are standardized and the technologies get transferred farmers and stakeholders can earn additional income from these products. The products ingredients are easily available in local market.



Fig. 8.23: *Butea monosperma* gum-based crack healing cream

Extension of gum inducing technique in arid regions of Rajasthan

Farmers of 48 villages of 5 districts of Rajasthan adopted the gum-inducing technology on trees like *A. senegal*, *A. tortilis*, *A. nilotica*, *A. leucophloea*, *Prosopis cineraria*, *P. juliflora*,

Anogeissus rotundifolia, etc. for gum production. This technique was effective and they earned revenue of Rs. 52.16 lakhs.

One and Two days' survey was conducted for identifying gum exudation site, gum exudation tree species, and lesser-known tree species at farmers' fields located in nearby areas.

List of training/ demonstration/ survey of CAZRI gum exudation technology during 2021.

On 2nd January, 2021, one-day survey was conducted in Shergarh and Tiwari block of Jodhpur district for identifying lesser known tree species cluster located at farmers' fields.Two days' survey was conducted from 13th to 14th January, 2021, of Jaisalmer district for targeting gum exudation potential village where known gum exudation tree species found at farmers' fields.

8.3 Project centre at ICAR-CAFRI, Jhansi

A. Growth and productivity of agroforestry models

A.1 On-farm agroforestry models

Data on survival and growth of trees planted in various agroforestry models established at central research farm of the institute were recorded. As the horticulture components in horti-silviculture Model-I and II (field no. 20) have been completely vanished due to their proximity to a village and damaged by *anna* cattle, these have been converted in to silvi-herbal model wherein lemongrass (*Cymbopogon citratus*) has been integrated as herbal component.

In agri-horti-silviculture model (field no. 25), maximum GBH (cm), plant height (cm) and canopy spread (m^2) were recorded in *Aegle marmelos* (bael), followed by *Acacia senegal* (kumat), *Citrus limon* (lemon) and *Carissa carandas* (karonda). *C. carandas* recorded maximum survival (%), followed by *A. senegal*, *A. marmelos* and *C. limon*. Pruning of tree's crown was carried out in the month of October *i.e.* before sowing of winter crops. In this model, fruit yields were recorded from 14 plants of *C. limon*, 19 plants of *A. marmelos* and 16 plants of *C. carandas* (Fig. 8.24). A total of 179.00 kg lemon, 53.00 kg karonda and 814.00 kg bael fruits were harvested. The average weight of bael variety CISH B1 was 0.80 kg and variety CISH B2 was 1.50 kg. This year *i.e.* 2020-21 (*rabi* season), wheat (variety HD 2967) was sown. During 2020-21, natural oozing of gum (average 61.76 g/tree from 6 trees) of *A. senegal* was recorded.

In silvi-herbal Model-I (field no. 20), *Terminalia arjuna* (arjun) showed maximum survival (100%), followed by *A. nilotica* (babool) and *A. senegal*. Growth parameters *i.e.* GBH (cm) and plant height (cm) and canopy were recorded maximum in *A. nilotica* followed by *A. senegal* and*T. arjuna*. Survival of *A. senegal* in block plantation on rocky site was found to be 100% and plants attained mean height of 485.4 cm with GBH of 25.4 cm.

During *kharif* season, blackgram (variety KUG 479) was sown in agri-horti-silviculture model (field no. 25) and the recommended package of practices was followed (Fig. 8.25). Plant growth and yield attributes of blackgram were measured at three different distances *viz*., 1.0, 2.5 and 4.5 m from the stem base of *A. senegal*, *A. marmelos* and *C. limon*. Results revealed that tree species significantly affected all studied parameters. Maximum values in terms of plant population, above ground biomass and seed yield were recorded under *C. limon* and minimum under *A. marmelos*. Irrespective of plant species, distance from the tree trunk significantly affected all plant parameters. Maximum plant population, seed yield and above ground dry biomass were recorded at 4.5 m distance from the stem base and their minimum values were recorded at 1.0 m distance. The interaction between tree species and distance had no significant effect on plant population. Maximum yield was recorded at 4.5 m distance of *C. limon* and minimum at 1.0 m distance of *A. marmelos*.

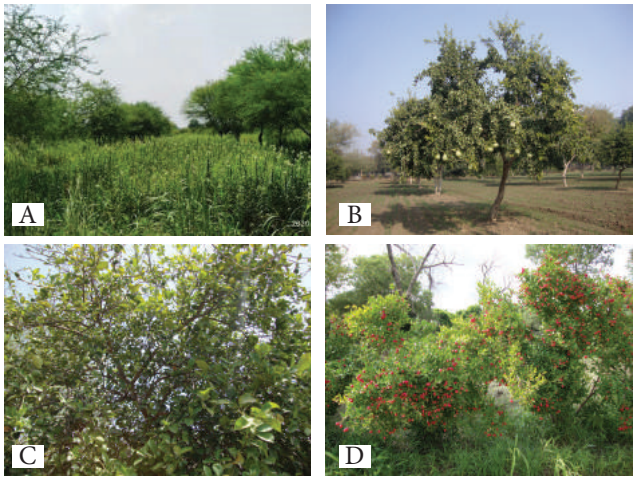


Fig. 8.24: *Acacia senegal* based agri-horti-silviculture models (A- Wheat, B- *Aegle marmelos*, C- *Citrus limon* and D- *Carissa carandas*) at research farm of ICAR-CAFRI, Jhansi



Fig. 8.25: Cultivation of blackgram in agri-horti-silviculture model at research farm during *kharif* season

In silvi-herbal Model-I (field no. 20), *Terminalia arjuna* (arjun) showed maximum survival (100%), followed by *A. senegal* and *Acacia nilotica* (babool). Growth parameters *i.e.* GBH (cm) and plant height (cm) were recorded maximum in *A. senegal*, followed by *A. nilotica* and *T. arjuna*. In silvi-herbal model-II (field no. 20), *T. arjuna* showed maximum survival (100%), followed by *A. nilotica* and *A. senegal*. Highest GBH, plant height and canopy spread were recorded in *A. nilotica*. Survival of *A. senegal* in block plantation on rocky site was found to be 100% and plants attained mean height of 485.4 cm with GBH of 25.4 cm.

In the same model, til (variety RT-351) was cultivated during *kharif* season by adopting standard package of practices (Fig. 8.26). Maximum plant population, seed yield and dry biomass of intercrop was recorded in 10 m × 10 m spacing, followed by 10 m × 5 m and 5 m × 5 m spacing. Planted tree species did not affect plant population and yield; however, significant effect of plant species was recorded on above ground biomass which was found significantly higher under *A. nilotica*. The two-way interactions between spacing and plant species were statistically non-significant.



Fig. 8.26: Cultivation of til (variety RT-351) in rainfed agri-silviculture model at research farm during *kharif* season

Survival of lemongrass in silvi-herbal model

The horticulture components in horti-silviculture Model-I and II in field no. 20 have been replaced with lemongrass as herbal component and model renamed as silvi-herbal model. During rainy season, lemongrass (*C. citratus*) was planted in between two rows of *A. nilotica.* In this model, row to row distance of *A. nilotica* was 20 m from each other, and in the row, it was planted 6 m apart. Between the two rows of *A. nilotica*, lemongrass was planted using randomized block design. To determine best planting spacing, lemongrass was planted by adopting four different spacing treatments *viz.*, 100 cm × 50 cm, 100 cm × 75 cm, 100 cm × 100 cm and 100 cm × 125 cm, and each treatment was replicated four times. In all blocks, row to row spacing was kept 100 cm, and in different treatments, root-slips of lemongrass were planted accordingly (Fig. 8.27).

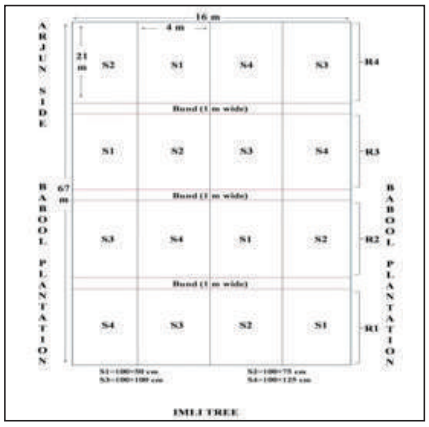


Fig. 8.27: Layout of lemongrass planting in silvi-herbal model

In each replication, a total of 164 root-slips of lemongrass were planted at spacing of 100 cm × 50 cm; 112 at 100 cm × 75 cm, 84 at 100 cm × 100 cm, and 68 at 100 cm × 125 cm. After six months of planting, survival (%) of lemongrass was recorded from each treatment and block. Survival (%) of lemongrass was found maximum in 100 cm × 125 cm (76.38%) followed by 100 cm × 100 cm (69.88%), 100 cm × 75 cm (67.72%) and 100 cm × 50 cm (66.98%) plant spacing, respectively (Fig. 8.28).

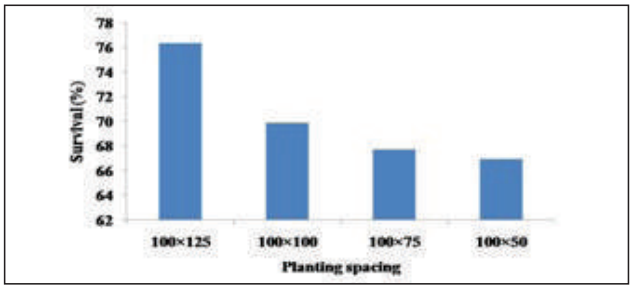


Fig. 8.28: Survival (%) of lemongrass in silvi-herbal model

In *rainfed* agri-silviculture model (field no. 40 & 41) wherein *A. senegal* and *A. nilotica* were planted in three different spacing; maximum survival was recorded by *A. senegal* planted in 10 m × 10 m spacing while in case of *A. nilotica,* it was recorded highest in 5 m × 5 m spacing. After eight years of plantation, higher GBH and plant height were recorded in *A. nilotica* than *A. senegal* in all spacing, barring few exceptions.

A2. Agroforestry models at farmers' fields

After 11 years of planting, *A. senegal* recorded relatively more survival (up to 59.5%) than *A. nilotica* (up to 50%) at Garhkundar watershed area. At the farm of Shri Thakur Das, among planted species, *A. nilotica* recorded higher growth as well as survival, followed by *Psidium guajava* (guava) and *C. carandas*. In this field, many plants have been damaged by mechanized operations with tractor, as the farmer

did not pay attention. On the farm of Shri Himmat, maximum growth and survival (%) was recorded in *Emblica officinalis* (aonla), followed by *A. senegal* and *C. carandas*. At farm of Shri Ghanshyam, *A. senegal* planted showed poor performance in terms of growth; however, survival (%) was comparatively higher than the values recorded from other two fields. At village Ambabai, 37% survival of *A. senegal* with average height of 294.5 cm and average collar diameter of 17.5 cm was recorded.

Gum garden

The survival and annual growth data of *A. senegal* based gum gardens shows higher survival (%) in *A. senegal* than *B. monosperma* in both the gardens. *A. senegal*, planted in new gum garden, attained good girth and showing relatively higher survival (%). Out of 190 plants of *A. senegal* in old gum garden, 31 yielded gum Arabic. Similarly, out of 268 plants of *A. senegal* trees in new gum garden, natural exudation of gum Arabic was observed from 23 trees.

B. Demonstration and development of gum-yielding tree-based agroforestry models

B1. At institute research farm

During rainy season, casualty replacement was done in bio-fence models established. In bio-fence model-1, aiming to optimize the distance apart *A. senegal* and *C. carandas* (1.0, 1.5 and 2.0 m apart), survival of *A. senegal* and *C. carandas* was 93.2 and 50%, respectively. *A. senegal* have attained 13.78 mm collar diameter with 113.6 cm height, and *C. carandas* recorded 3.27 mm collar diameter with 38.2 cm height. In bio-fence model-2, aimed to assess effectiveness of double row fence consisting of *A. senegal* as outer row and *C. carandas* as inner row on field bunds, 83.1 and 79.0% survival of *A. senegal* and *C. carandas*, respectively was observed. In this model, *A. senegal* have attained 13.43 mm collar diameter with 104.8 cm height and *C. carandas* recorded 3.39 mm collar diameter with 28.3 cm height. In bio-fence model-3, aimed to assess the effectiveness of double row fence of *A. senegal* at different spacing, on three sides of field boundary of a well-established *E. officinalis* orchard, the survival in outer row was 90.9, 90.7 and 80.0% in 1.0, 1.5 and 2.0 m spacing, respectively. Similarly, 100.0, 93.0 and 88.0% survival in 1.0, 1.5 and 2.0 m spacing, respectively was recorded in inner row. In this model, planting spacing affected growth of the *A. senegal*. In general, comparatively higher growth in terms of collar diameter and height was recorded from *A. senegal* planted in inner row than that from outer row. In bio-fence model-4 consisting of two rows of *A. senegal* (inner and outer) kept at 1.5 m apart with plant to plant distance of 1.5 m, planted along two sides of a well-established *Punica granatum* (pomegranate) orchard, the survival of 33.9 and 51.9% was recorded from inner and outer rows, respectively. Comparatively higher growth was recorded from *A. senegal* planted in inner row than that in outer row.

B2. At farmers' fields

During rainy season, approximately 35,000 quality seedlings of *A. senegal* were raised in nursery at ICAR-CAFRI, Jhansi, and out of which, 30,000 seedlings were provided to enable "Doubling Farmer's Income (DFI)" for planting in seven districts namely Jhansi, Lalitpur, Jalaun, Hamirpur, Mahoba, Banda and Chitrakut of Bundelkhand, Uttar Pradesh. At each site, 4-5 farmers have been identified for developing horti-silviculture, agri-horticulture and agri-horti-silviculture models. *A. senegal* has also been planted on field boundaries as it acts as bio-fence. Survival (%) of seedlings planted in various villages/ sites during rainy season of 2018 varied from 36.8 (Binwara) to 67.8% (Talbehat) for *A. senegal*, from 26.8 (Parasai) to 50.0% (Dhikoli) for *C. carandas*, from 29.2 (Parasai) to 41.0% (Binwara) for *C. limon*, from 25.0 (Kotkhera) to 30.0% (Dhikoli) for *D. strictus* and 52.0% in *P. guajava*. Survival (%) of *A. senegal*, *C. limon*, *P. guajava* and *P. granatum* planted in the field of 14 farmers of village Parasai varied from 46.0 to 86.7%, 25.0 to 54.0%, 33.3 to 56.4% and 28.0%, respectively.

C. Gum exudation in relation to soil moisture dynamics

Studies on soil moisture content (%) of various gum-yielding tree based agroforestry models was initiated earlier with the aim to assess relation between natural exudation of gums from *A. senegal* and *A. nilotica* with soil moisture content (%). For the purpose, soil samples were collected from two different depths (0-15 and 15-30 cm) of *A. senegal* and *A. nilotica* (within 0.5 m distance from tree trunk) growing in agri-horti-silviculture model (filed no. 25), silvi-herbal model (field no. 20), ranifed agri-silviculture model (field no. 40 & 41) and gum gardens (new and old) at 15 days' interval. Moisture content (%) was determined by gravimetric method and the data recorded so far on moisture content are being presented in Fig. 8.29 to 8.32.

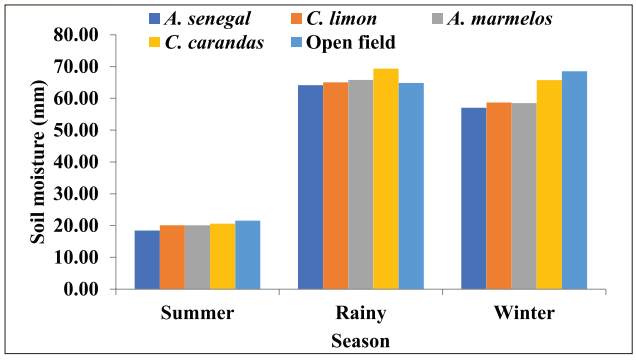


Fig. 8.29: Season-wise soil moisture (mm) in 0-30 cm soil depth in irrigated agri-horti-silviculture model

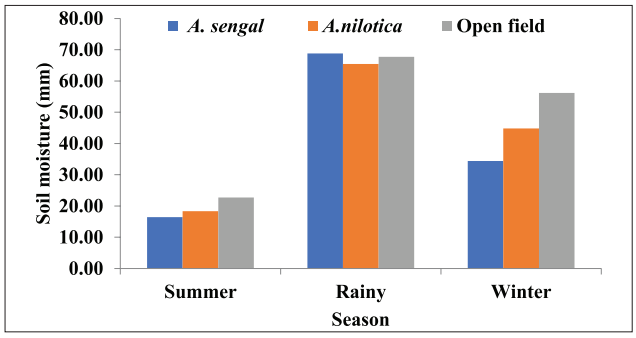


Fig. 8.30: Season-wise soil moisture (mm) in 0-30 cm soil depth in rainfed silvi-herbal agroforestry model

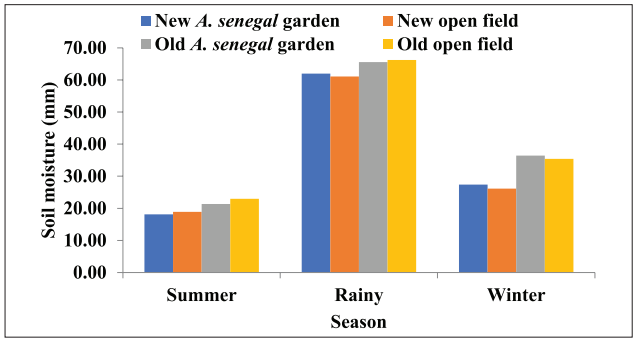


Fig. 8.31: Season-wise soil moisture (mm) in 0-30 cm soil depth in *A. senegal* based gum-gardens

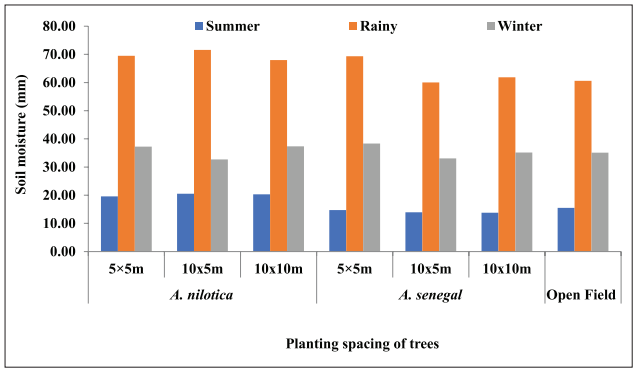


Fig. 8.32: Season-wise soil moisture dynamics (mm) in 0-30 cm depths in gum yielding tree based rainfed agri-silviculture model

D. Soil health of agroforestry models

***Agri-horti-silviculture model*:** A factorial experiment on effect of woody perennials on soil properties was carried out in agri-horti-silviculture model, established at ICAR - CAFRI research farm. Study consisted of three factors *viz.*, plant species (*A. senegal*, *A. marmelos, C. limon* and *C. carandas*), distance from these plant species (0.5, 1.0, 2.0 and 4.0 m) and soil depth (0-15 and 15-30 cm). Effect of these factors on different soil parameters *viz.*, pH, electrical conductivity, organic carbon, major nutrients (available N, P and K) and micro-nutrients (Fe, Mn, Zn and Cu) were assessed. Results revealed that recorded pooled mean of soil pH was maximum in *C. limon* and minimum in *C. carandas* with maximum electrical conductivity (EC) and organic carbon in *A. senegal* and minimum in *C. carandas.* Means of soil pH, EC and organic carbon were recorded in the samples collected from near tree base (0.5 m) while their least values were recorded in soil samples taken from 4.0 m distance from tree base. On the other hand, soil depth showed significant effect on soil pH, EC and organic carbon. Significantly higher pH and organic carbon were recorded from surface layer (0-15 cm) and EC from sub-surface soil layer. All two-way (species × distance, species × depth and distance × depth) and three-way (species × distance × depth) interactions showed significant effects on studied soil parameters. Mean value of available N was recorded maximum in *A. senegal* followed by *A. marmelos, C. limon* and *C. carandas*; available P in *C. limon* followed by *A. marmelos*, *A. senegal* and *C. carandas* and available K in *C. carandas* followed by *A. senegal*, *C. limon* and *A. marmelos.* Highest pooled means of available N, P and K were recorded in soil samples taken from 0.5 m distance of tree base and their minimum values were recorded from 4.0 m distance. Significantly higher available N, P and K were recorded from surface soil (0-15 cm). The two-way interaction between plant species × soil depth was found statistically significant for available N and it was recorded highest in surface soil (0-15 cm) of *A. senegal* and least in sub-surface soil (15-30 cm) of *C. carandas*. Two-way interaction between distance × depth also showed significant effect of available N. At each distance, available N content was recorded significantly higher in surface soil (0-15 cm) than sub-surface soil layer (15-30 cm). In all the studied plant species, maximum P content in soil was recorded at 0.5 cm distance and minimum at 4.0 m distance and in surface soil (0-15 cm) than sub-surface soil (15-3 cm). Mean of available Mn was recorded in *A. senegal;* available Zn in *A. marmelos* which was at par with *C. carandas* and available Cu in *C. limon* and it was found at par with *A. marmelos*.

Maximum values of available Fe, Mn, Zn and Cu were recorded in soil samples taken from 0.5 m distance and minimum from 4.0 m distance from tree base. Significantly higher available Fe, Mn and Zn were recorded from sub-surface soil layer (15-30 cm) while available Cu content was recorded higher in surface soil layer (0-15 cm). In all studied plant species, values of all the micro-nutrients were recorded maximum at 0.5 cm distance and minimum at 4.0 m distance. In each plant species, availability of Fe, Mn and Zn content was comparatively higher in sub-surface soil layer than that recorded from surface soil layer; however, opposite trend was recorded in case of Cu content. At each distance, availability of Mn, Zn and Cu were relatively higher in 15-30 cm soil depth, barring few exceptions. The three-way interaction (species × distance × depth) was also found significant for Mn, Zn and Cu content in soil.

***Rainfed agri-silviculture model*:** A factorial experiment on effect of gum-yielding plant species on soil properties was carried out in rainfed agri-silviculture model, established at ICAR - CAFRI research farm. Study consisted of three factors *viz.*, plant species (*A. senegal* and *A. nilotica*), planting spacing (5×5, 10×5 and 10×10 m) and soil depth (0-15 and 15-30 cm). Effect of these factors on different soil parameters *viz.*, pH, electrical conductivity, organic carbon, major nutrients (available N, P and K) and micro-nutrients (Fe, Mn, Zn and Cu) were assessed. Results revealed that pooled means of pH and EC were significantly higher in *A. senegal*; however, tree species did not show any significant effect on organic carbon. Maximum values of pH, EC and organic carbon were recorded in 5×5 m, followed by 10×5 m and 10×10 m spacing. Significantly higher values of soil pH and EC were recorded in sub-surface layer of soil (15-30 cm); however, opposite trend was recorded for organic carbon content. The two-way interaction between plant species and planting species was found significant for soil pH and EC. These were recorded maximum in *A. senegal* planted in 5×5 m spacing. Similarly, for organic carbon content, the two-way interaction between plant species and soil depth was found significant. Its significantly higher values were recorded in soil samples collected from 0-15 cm depth of both studied plant species.

Data on individual effects of plant species, planting spacing and soil depth and interactions among them on macro-nutrients (available N, P and K) showed significantly higher N and P from *A. senegal*. The amount of available N, P and K were recorded maximum in 5×5 m spacing and minimum in 10×10 m spacing. Soil depth showed significant effect on all major nutrients. These were recorded significantly higher in surface soil (0-15 cm). Two-way interactions between plant species and soil depth showed significant effect on available N and recorded significantly higher in samples collected from 0-15 cm soil depth. Three-way interaction was also found significant for available N and was found maximum in surface layer soil of *A. senegal* planted in 5×5 m spacing.

Data on individual effects of plant species, planting spacing and soil depth and interactions among them on micro-nutrients (Fe, Mn, Zn and Cu) showed significantly higher value of Fe and Mn content in *A. senegal*, whereas reverse trend was recorded for Zn and Cu. Among spacing, higher values of Fe, Mn and Zn were recorded in 5 × 5 m, and Cu content in 10 × 10 m spacing. Significantly higher values of Fe, Mn and Cu were recorded from 15-30 cm soil depth, and Zn from 0-15 cm soil depth. The two-way interaction between plant species and planting species was found significant for Fe, Mn and Cu. Significantly higher Fe and Mn were recorded from *A. nilotica* planted in all three spacing, barring few exceptions. Higher value of Cu content was recorded from *A. senegal* than that from *A. nilotica*, and its maximum value was recorded from 10 × 10 m spacing and minimum from 5 × 5 m spacing.

Trainings organized

One-day training on "Tapping of *Palas* Gum (Kamarkas)" was organized in collaboration with a NGO "*Srijan*" (Self Reliant Initiatives through Joint Action) at Training Centre of National Rural Livelihood Mission, Sirsaud, block Karera, district Shivpuri (M.P.) on 22 January, 2021. The training was attended by about 60 participants including tribal women from Karera, Shivpuri (M.P.), team members and field workers of *Srijan* and community members of *Ghoomar Group* from Bali block, district Pali (Rajasthan). The main objective of the training was to make community members aware about the *palas* tree and its produces; tapping process of *palas* gum; make use of right tools and marketing of the produce. A lecture to highlight the importance of *palas* trees and its produces, *palas* gum (kamarkas) tapping methods, season of tapping, storage and some value addition processes was delivered (Fig. 8.33) and emphasize on the use of specially designed 'billhook' for gum production from *palas* trees through development of incision on the tree trunk. A field visit was also organized in nearby forest area wherein the technical know-how of using billhook for knotching/making cuts on stem of *palas* trees demonstrated (Fig. 8.34). Some tribal women from Karera (M.P.) as well as Pali (Rajasthan) participated in hands-on-practice of

making incisions on trees for tapping kamarkas (Fig. 8.35).



Fig. 8.33: Expert delivering lecture on tapping of *palas* gum (Kamarkas)



Fig. 8.34: Participation of trainees in field demonstration on knotching of *Palas* trees



Fig. 8.35: Hands-on-practice on using billhook for knotching *Palas* trees by women trainees

8.4 Project on guar gum at VNMKV, Parbhani

Effect of processing methods on tannin content of guar korma meal

The anti-nutritional factors play a defensive role during the growth of plant, however, its consumption in humans and animals can cause ill effects. Guar korma meal was subjected to different treatments to analyses effect of processing methods on tannin content and study reveals that Tannin content of raw guar korma meal was about 1.73g/100g. Soaking reduced the tannin content to about 0.93g/100g (46.24%) which might be ascribed to hydrolysis nature of the water soluble tannin that might leached out into water. Roasting depicted a reduction of tannin to about 0.43g/100g which was higher as compared to that of soaking but was lower as compared to autoclaving and extrusion, which might have been attributed to the activation of tannase which instigated the degradation of tannin content. High temperature treatments *viz* autoclaving and extrusion processing of guar korma meal indicated extensive reduction in level of tannin to 0.38 and 0.31g/100g respectively. The high temperature changes the molecular structures that possibly have a lower extractability due to certain degree of polymerization. Tannin content of guar korma meal were examined by different processing methods where the autoclaving and extrusion showed higher reduction in tannin content of 0.38g/100g (78.23%) and 0.31g/100g (82.08%) respectively. Lowest reduction was observed in soaked sample 0.93g/100g (46.24%). The reduction of tannin in guar korma meal explores its utilization in food products and in cattle feed.

Development of instant tomato soup powder by fortification of partially hydrolyzed guar gum (PHGG) as a soluble fiber source and its characterization

Different combination of tomato soup powder was prepared using various proportion of partially hydrolyzed guar gum (PHGG) as a soluble fiber source (Fig. 8.36) and sensory evaluation of the tomato soup powder formulation were carried out. The results revealed that incorporation of 15 percent partially hydrolyzed guar gum in instant tomato soup powder improved the flow ability, reconstitution properties solubility, water solubility index and wettability along with increase in soluble dietary fiber.

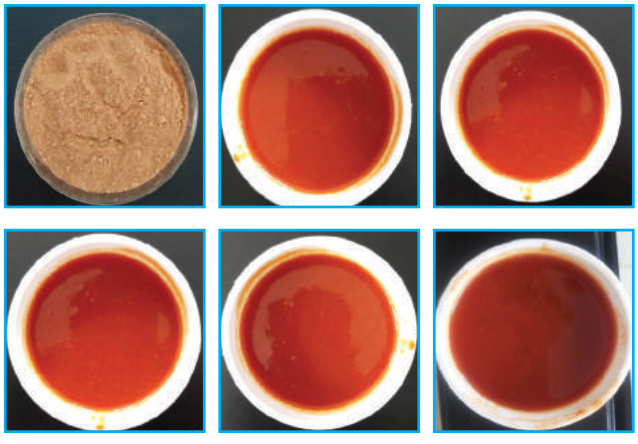


Fig.8.36: Instant tomato soup powder and prepared tomato soup fortified with PHGG as soluble fiber

Instant tomato soup powder can be safely stored up to 90 days at refrigerated condition in polypropylene packaged pouches.

Development of guar seed fractions based edible film

Guar gum fractions *i.e.* detoxified guar meal as a protein source is used in edible coating for enhancing shelf-life and improving post-harvest storage quality of fruits and vegetables. Edible films were developed by pouring a constant volume of casting solution onto a glass plate. The casting solution was composed of various proportions of potato starch, glycerol, PHGG, carboxy methyl cellulose, guar meal, olive oil, where glycerol was employed as a plasticizer and sorbitan monosterate was used as emulsifier. The prepared film was characterized by physical-chemical and mechanical properties. The prepared edible film was evaluated for coating on plum fruit. The coated plum fruit were also analyzed for its sensory evaluation, textural analysis. The results revealed that use of guar meal can be replaced by 40% potato starch in the casting solution as well as in edible film. The addition of guar meal and PHGG along with plasticizers had good mechanical, barrier and film forming abilities. The effect of prepared casting solution as a coating material for plum fruits (Fig. 8.37) revealed that the shelf life was also extended up to 14 days as compare to uncoated fruits without affecting their sensory attributes.

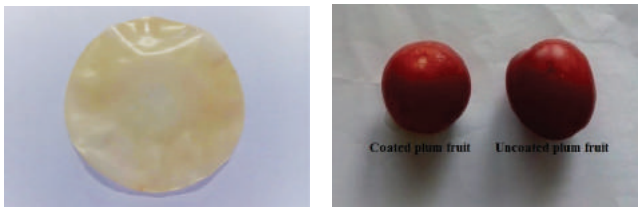


Fig. 8.37: Developed edible films and film coated plum fruit

Effect of feeding different guar korma meal on growth performance on Kaveri chicken

Efficiency in feeding has been the major concern in raising poultry, as the feed constitutes 70 to 75% of production cost. Successful poultry farming predominantly depends on the nutrition and cost effectiveness of the feed. Now a day's cost of feeding in poultry is increasing day by day. Nowadays efforts are being made to find an alternative to soybean meal (SBM) to overcome the dependency on SBM as a major protein source and to cut down the increasing expenses towards the consistent hike in the price of SBM. Because of this the poultry farmers are looking for the alternative protein meals (APM), guar meal is one such feed. The proximate analysis of guar meal korma showed that it is higher in protein, ash and fiber content. The protein, fat, ash and fiber content guar meal korma was observed to be *i.e.* 51.7%, 5.3%, 5.2 % and 5.9% respectively. The mineral composition of guar meal korma like calcium, magnesium, potassium, phosphorous, iron, zinc and manganese contents were found to be 1.13%, 2.45%, 0.92%, 3.1%, 110 ppm, 36 ppm, 16 ppm; respectively. The feeding trial was conducted using poultry feed composed of guar meal as protein source on Kaveri chicken breed (Fig. 8.38). The feeding trials of chicken results revealed that soy meal can be replaced up to 12% with protein rich guar meal korma in poultry feed ration and found to be acceptable for poultry birds.

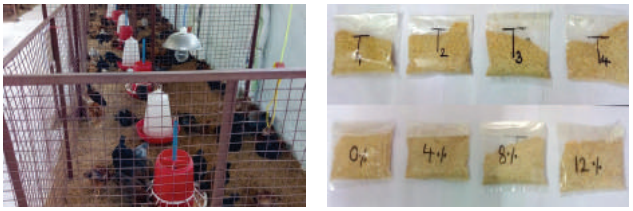


Fig. 8.38: Poultry feed fortified with guar korma meal and poultry feed trial conducted on Kaveri chicken

Technology released and transferred

- Hiranya Food Products Pvt Ltd, Sanpuri, Dist Parbhani (M.S)- Standardization and development of technology for low fat turmeric milk by fortifying guar gum and its quality assessment & also standardization of recipe and packaging of turmeric based immunity booster drink.
- Botanika INDIA, Kalyan Nagar, Basmat Road, Parbhani (M.S)- Standardization and development of technology linseed nutra laddu by fortifying guar gum with respect to formulation, packaging material, and its shelf life.

Extension activities carried out

- Prepared video regarding "Preparation of linseed nutraladdoo by incorporation of guar gum" and uploaded on YouTube (link - https://youtu.be/zA98MtCkcg)



Fig. 8.39: Training on value addition of guar gum in grape processing, vegetable processing and turmeric processing for Woman's Self Help Group

- Conducted (5 days) training on value addition of guar gum in grape processing, vegetable processing and turmeric processing for Woman's Self Help Group (Fig. 8.39).

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

Effect of oleoresin storage on turpentine content in *Pinus roxburghii* Sargent

Natural stand of chir pine located in the University Campus was marked and numbered. 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. Five boreholes at different months *viz.*, May, June, July, September and October were drilled in each tree and yield was recorded at the end of November for all the five boreholes. There were 4 treatments (angles) and each treatment had two replications. With the help of protector (made up of wooden piece), angles were marked with the help of nails on wooden protector. The protector was stuck on the trunk of the tree perpendicularly to mark the angle and hand drill was used to drill a hole at appropriate angles (25°, 40°, 55° and 70°). Each replication comprised of three trees (Fig.8.40). The detail of the experiment conducted is given below (Table 8.6).

Table 8.6: Details of the experiment

Borehole Heights (H)	Diameter (cm)	Angles (°)
H_1 (50cm)	D_1 (30-40)	A_1 (25)
H_2 (100cm)	D_2 (40-50)	A_2 (40)
H_3 (150cm)	D_3 (50-60)	A_3 (55)
	D_4 (>60)	A_4(70)

Effect of borehole angles on oleoresin yield: The effect of different angles on oleoresin yield in borehole method was found to be significant at 5 per cent level of significance (Table 8.7). The highest oleoresin yield of 2182.38 g/season was recorded at an angle A_2 (40°), which was significantly at par with A_3 (1914.74 g/season) and the lowest yield of 1087.53 g/season was observed at A_1 (70°).

Table 8.7: Effect of borehole height on oleoresin yield (g/season) at Nauni (main campus) UHF, Solan by using borehole method

Borehole Angles (A)	Oleoresin Yield (g)
A_1 (25°)	1,669.96 (3.22)
A_2 (40°)	2,182.38 (3.34)
A_3 (55°)	1,914.74 (3.28)
A_4 (70°)	1,087.53 (3.04)
Mean yield (g)	1,713.65 (3.23)
CD (0.05)	405.35 (2.61)
SE(d)	198.36 (2.30)

*values in parenthesis () are log transformed values

Effect of borehole angle and diameter classes on oleoresin yield: The data pertaining to the oleoresin yield as affected by the borehole angle and tree diameter are presented in Table 8.8 The data revealed significant variation in oleoresin yield and diameter of the tree. The highest oleoresin yield of 2214.99 g/hole/tree was recorded in the diameter class >60 cm whereas, lowest oleoresin yield of 1398.60 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 2211.86 g/hole was noticed at an angle of A2 (40°) and mean minimum yield of 1110.09 g/hole in A4 (70°). The interaction between the angle and diameter classes also showed significant effect on oleoresin yield. The maximum oleoresin yield of 2323.20 g/hole was recorded in A_3D_4, whereas the minimum (771.00 g/hole) in A_4D_1.



Fig. 8.40: Drilling of boreholes with wooden protector at different angles *viz.*, 25°, 40°, 55° and 70°

Table 8.8: Effect of borehole angle and diameter classes on oleoresin yield

Borehole Angle (A)	Diameter Classes (D) (cm)				Mean
	D_1 (30-40)	D_2 (40-50)	D_3 (50-60)	D_4 (>60)	
A_1 (25°)	1332.20	1570.53	1966.12	1919.02	1696.97
A_2 (40°)	1981.31	1829.27	1978.67	3058.18	2211.86
A_3 (55°)	1509.88	1915.64	2019.43	2323.20	1942.04
A_4 (70°)	771.00	816.47	1293.31	1559.57	1110.09
Mean yield (g)	1398.60	1532.98	1814.38	2214.99	
				CD (0.05)	**SE(d)**
Borehole Angle (A)				10.16	5.12
Diameter Classes (D)				10.15	5.11
Borehole Angle (A) X Diameter Classes (D)				10.23	20.31

Standardization of storage condition of oleoresin: The oleoresin extracted through borehole method of tapping was stored for different months' intervals (2 months, 4 months, 6 months and 8 months) at three different storage conditions *viz.*, room temperature, freeze and deep freeze conditions in five different containers (Glass, Plastic, Steel, Earthen pot and Tin). The processing of oleoresin for rosin and turpentine was then performed and analyzed for the loss of content during storage at different time intervals. About 25 kg of freshly collected oleoresin extracted from trees was used for this purpose and then stored in different containers under different conditions Fig. 8.41. For each month interval, there were two containers and three samples were processed from each container for further analysis.



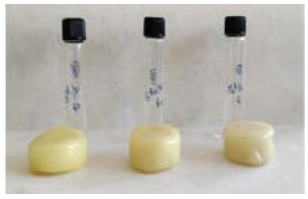
Weighing of oleoresin



Oleoresin stored at room temperature



Oleoresin stored at freeze condition



Turpentine and rosin content

Fig. 8.41: Oleoresin stored under different conditions

Effect of storage conditions and containers on rosin content of oleoresin: The perusal of data revealed significant difference for rosin content of *Pinus roxburghii* from three different storage conditions and for different time period in different storage containers (Table 8.9). Under two month storage conditions, the maximum rosin content (80.96%) was found in tin container at Room Temperature. The minimum rosin content (78.48%) was noticed in tin at deep freeze condition. Under four months storage conditions, the maximum and minimum rosin content were recorded in earthen pot (81.21%) at freeze and in tin (79.11%) at deep freeze condition. For six months storage conditions the maximum (81.78%) and minimum rosin content (79.98%) was found in earthen pot at freeze condition and in tin at deep freeze condition. For eight months storage condition, the maximum rosin content (82.47%) was noticed in earthen pot at room temperature condition and minimum rosin content (80.79%) was recorded in glass under freeze condition.

Effect of storage condition and container on turpentine content of oleoresin: The perusal of data revealed significant difference for rosin content of *Pinus roxburghii* from three different storage conditions and for different time period in different storage containers (Table 8.9). Among two months storage conditions, the maximum turpentine content (21.52%) was found in tin container at deep freeze condition. The minimum turpentine content (19.04%) was noticed in tin also at room temperature. Among four months storage conditions, the maximum and minimum turpentine content was recorded in tin (20.89%) at deep freeze and in earthen pot (18.79%) at freeze condition. For six months storage conditions the maximum (20.02%) and minimum turpentine content (18.22%) was found in tin at deep freeze condition and in earthen pot at Freeze condition. For eight months storage condition, the maximum turpentine content (19.21%) was noticed in glass at deep freeze and minimum rosin content (17.53%) was recorded in earthen pot at room temperature condition.

Table 8.9: Effect of storage condition and container on rosin and turpentine content of oleoresin

Storage conditions	Containers	Rosin content				Turpentine content			
		Duration of storage (months)				Duration of storage (months)			
		2	4	6	8	2	4	6	8
Deep freezer	Glass	78.73	80.18	81.31	81.66	21.27	19.82	18.69	18.34
	Plastic	79.26	80.59	80.97	81.33	20.74	19.41	19.03	18.67
	Steel	79.88	80.32	80.88	81.95	20.12	19.68	19.12	18.05
	Earthen Pot	80.15	80.71	80.99	81.35	19.85	19.29	19.01	18.65
	Tin	78.48	79.11	79.98	81.41	21.52	20.89	20.02	18.59
Freeze	Glass	79.01	80.10	80.39	81.03	20.99	19.90	19.61	18.97
	Plastic	79.63	80.12	80.58	80.98	20.37	19.88	19.42	19.02
	Steel	79.90	80.51	81.76	82.11	20.10	19.49	18.24	17.89
	Earthen Pot	80.37	81.21	81.78	81.98	19.63	18.79	18.22	18.02
	Tin	78.81	79.58	81.28	81.78	21.19	20.42	18.72	18.22
Room temperature	Glass	79.43	79.95	80.33	80.79	20.57	20.05	19.67	19.21
	Plastic	79.70	80.43	81.51	82.02	20.30	19.57	18.49	17.98
	Steel	79.50	80.84	81.53	81.97	20.50	19.16	18.47	18.03
	Earthen Pot	80.76	80.96	81.49	82.47	19.24	19.04	18.51	17.53
	Tin	80.96	80.49	80.93	81.37	19.04	19.51	19.07	18.63
CD (0.05)		0.24	0.26	0.24	0.17	0.23	0.26	0.24	0.16
SE(d)		0.12	0.12	0.11	0.08	0.11	0.13	0.12	0.08

Effect of diameter classes on oleoresin yield in rill method: Natural stand of *chir* pine located in the University Campus were marked and numbered. In this experiment diameter at breast height (dbh) was measured and all the trees were classified into six diameter classes *viz.*, 30-35 cm, 35-40 cm, 40-45 cm, 45-50 cm, 50-55 cm and >55 cm. The effect of diameter (dbh) on oleoresin yield was studied.

The trees were first bark shaved at a convenient height and blazes were marked with the help of blaze frame 32 cm in height and 20 cm in width. A central groove of 4 mm depth and 10-13 mm width was made with the help of central groove cutter. A pair of rills of 2-3 mm depth was made at an angle of 40° with the help of freshening knife. A tin lip of 1.25 cm length was inserted below blaze and a tin cup was hung just below the lip with the help of nail. The rills were made at weekly interval and the chemical stimulants were sprayed with the help of spray bottle (Fig. 8.42).



Fig. 8.42: Rill method of oleoresin tapping experiment at main campus, UHF, Solan

In Rill method, the effect of different diameter classes on oleoresin yield was found significant at 5 per cent level of significance (Table 8.10). The highest oleoresin yield (6.88 kg/season) was noticed in diameter class of >55 cm (D_6) and lowest (3.50 kg/season) was observed in diameter class 30-35 cm (D_1).

Table 8.10: Effect of diameter classes on oleoresin yield

Diameter classes (cm)	Oleoresin Yield (kg)
D_1 (30-35)	3.50
D_2 (35-40)	4.90
D_3 (40-45)	5.97
D_4 (45-50)	6.18
D_5 (50-55)	6.38
D_6 (>55)	6.88
Mean	5.64
CD (0.05)	N/S
SE(d)	1.69

Effect of anatomical characteristics on oleoresin yield

***Healing of Boreholes*:** The width of unhealed portion from lateral sides and from top and bottom of hole was measured with the help of scale. The area of healed portion was calculated by deducting the area of unhealed hole from the standard area of each hole. The initial area of the borehole at the time of drilling, which was used for calculation healed and unhealed portion after one or two years was 4.91 cm^2. The percentage of healed portion was calculated for hole/ tree selected for the study.

***Healing of one year old borehole*:** In one year old borehole, the maximum unhealed portion (4.18 cm^2) was found in LRY R68 and minimum (3.03 cm^2) was noticed in HRY R24 (Table 8.11 and Fig. 8.43). However, the maximum (1.92 cm^2) and minimum healed area (0.80 cm^2) were observed in HRY R24 and LRY R68, respectively. The maximum healing percentage (36.99%) was also recorded in HRY R24.

***Healing of two years old borehole*:** In two year old borehole, the maximum unhealed portion (2.77 cm^2) was found in LRY R87 and minimum (1.60 cm^2) was noticed in HRY R24 (Table 8.11 and Fig. 8.44). However, the maximum (3.37 cm^2) and minimum healed area (2.17 cm^2) were observed in LRY R87 and HRY R24, respectively. The maximum healing percentage (67.99 %) was also recorded in HRY R24.



Fig. 8.43: One year old borehole



Fig. 8.44: Two years old borehole

Effect of wood specific gravity, tracheid length and resin ducts on oleoresin yield

Table 8.12 reveals the significant effect of specific gravity, tracheid length and resin ducts on oleoresin yield in Progeny Experimental Trials. The maximum specific gravity was observed in 37 Kopra P-5 (0.530). However, minimum specific gravity was noticed in 29 Kaldoo P-1 (0.413). The maximum and minimum tracheid length was found in 37 Kopra P-5 (4.14 mm) & 29 Kaldoo P-1, respectively. The maximum

Table 8.11: Healing details of one and two year old borehole

Tree	One year old bore hole			Two year old bore hole		
	Unhealed Area (cm^2)	Healed Area (cm^2)	Healing (%)	Unhealed Area (cm^2)	Healed Area (cm^2)	Healing (%)
HRY R 24	3.03	1.92	36.99	1.60	3.37	67.99
HRY R134	3.16	1.83	35.57	1.72	3.18	63.93
HRY R145	3.39	1.56	29.74	1.91	3.06	61.86
MRY R 4	3.47	1.48	28.71	2.23	2.74	54.23
MRY R48	3.70	1.25	23.67	2.26	2.65	52.61
MRY R 122	3.85	1.17	21.64	2.49	2.49	50.23
LRY R52	3.82	1.17	21.06	2.55	2.43	47.43
LRY R68	4.18	0.80	16.71	2.62	2.30	45.28
LRY R87	4.15	0.81	16.38	2.77	2.17	42.50
CD(0.05)	0.039	0.029	1.776	0.044	0.038	1.752
SE(d)	0.018	0.013	0.831	0.02	0.018	0.819

* HRY: High Resin Yielders; MRY: Medium Resin Yielders: LRY: Low Resin Yielders

resin ducts per mm^2 (1.20 mm^2) was noticed in 37 Kopra P-5 and the minimum resin ducts per mm^2 was observed in 29 Kaldoo P-1 (0.83) and 64 Jai Nagar PT (0.83 mm^2).

Table 8.12: Variation in wood specific gravity and tracheid length and resin ducts of high, medium and low resin yielders on oleoresin yield at Nauni (Main Campus) experimental site

Sl. No.	Progeny	Specific Gravity	Tracheid Length (mm)	Resin Ducts/ mm^2
1	19 leda P-10	0.424	3.14	0.85
2	28 Leda P-8	0.421	2.97	0.84
3	31 Kaldoo P-4	0.523	4.02	1.16
4	34 Chret mansu P-4	0.444	3.37	0.98
5	37 Kopra P-5	0.530	4.14	1.20
6	38 Rukhi P-8	0.477	3.40	1.15
7	41 Sandral P-5	0.457	3.39	0.96
8	57 Dhami Shimla PT	0.422	3.08	0.85
9	59 Kather PT Black Centre	0.524	3.97	1.17
10	53 Bagthan PT Black Centre	0.522	4.09	1.02
11	45 Dibkon P-3	0.416	2.97	0.84
12	21 Kaldoo P-8	0.422	3.08	0.86
13	23 Kaldoo P-3	0.524	4.12	1.16
14	29 Kaldoo P-1	0.413	2.95	0.83
15	30 Leda P-5	0.469	3.42	1.15
16	39 Banethi BT	0.523	4.06	1.03
17	51 Jubble BT	0.455	3.31	0.96
18	40 Kaldoo P-10	0.455	3.38	0.96
19	54 Bagthan PT Black Top	0.524	3.86	1.18
20	58 Bagthan PT Black Base	0.440	3.09	0.86
21	64 Jai Nagar PT	0.420	3.07	0.83
22	27 Kaldoo P-9	0.442	3.29	0.98
Mean		0.482	3.52	1.00
CD (0.05)		0.019	0.20	0.08
SE(d)		0.009	0.10	0.04

Simple correlation coefficient between specific gravity, tracheid length and resin ducts and oleoresin yield are presented in Table 8.13. Out of 7 correlation combinations, all were positively significant at 1% level of significance. The oleoresin yield exhibited positive significant correlation coefficient with specific gravity (0.962), trachied length (0.940) and resin ducts (0.943).

Table 8.13: Simple correlation coefficient between oleoresin yield and specific gravity, tracheid length and resin ducts

	Oleoresin Yield	Specific Gravity	Trachied Length (mm)	Resin Ducts/ mm^2
Oleoresin Yield	1	0.962**	0.940**	0.943**
Specific Gravity		1	0.982**	0.888**
Trachied Length			1	0.841**
Resin Ducts/ mm^2				1

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

Effect of extractives and cell wall constituents on oleoresin yield

In the progeny trial experiment, chir pine trees were marked and wood samples at breast heights were collected for the determination of water & chemical soluble extractives, holocellulose and lignin content.

The data pertaining to effect of extractives and cell wall constituents on oleoresin yield are documented in Table 8.14. The maximum and minimum cold water soluble extractives, hot water soluble extractives and alcohol benzene soluble extractives were observed in 19 Leda P-10 (6.42%) 41 Sandral P-5 (8.78%) &39 Banethi BT (13.85%) and 29 Kaldoo P-1 (4.83%), 31 Kaldoo P-4 (6.22%) & 23 Kaldoo P-3 (9.67%), respectively. Maximum and minimum Holocellulose content were observed in 59 Kather PT Black Centre (68.49%) & 45 Dibkon P-3 (64.19%), respectively, whereas maximum and minimum lignin content were recorded in 29 Kaldoo P-1 (25.84 %) & 37 Kopra P-5 (22.50%), respectively.

Table 8.14: Variation in cold water soluble extractives, hot water soluble extractives, alcohol benzene soluble extractives, holocellulose and lignin content of high, medium and low resin yielders from different sites on oleoresin yield

Sl. No.	Progeny	Cold Water Soluble Extractives (%)	Hot Water Soluble Extractives (%)	Alcohol Benzene Soluble Extractives (%)	Holocellulose Content (%)	Lignin Content (%)
1	19 Ieda P-10	6.42	8.62	13.27	64.91	25.50
2	28 Leda P-8	6.01	8.45	13.66	64.32	25.76
3	31 Kaldoo P-4	5.31	6.22	9.88	67.49	22.73
4	34 Chret mansu P-4	4.93	6.41	10.69	66.11	23.74
5	37 Kopra P-5	5.45	7.71	11.46	68.40	22.50
6	38 Rukhi P-8	5.45	7.50	11.73	68.08	23.44
7	41 Sandral P-5	6.41	8.78	13.69	66.37	23.69
8	57 Dhami Shimla PT	4.92	6.58	10.14	64.42	25.74
9	59 Kather PT Black Centre	5.39	7.51	12.00	68.49	22.55
10	53 Bagthan PT Black Centre	6.16	8.48	13.07	68.01	22.74
11	45 Dibkon P-3	5.94	8.33	13.08	64.19	25.78
12	21 Kaldoo P-8	5.37	7.46	11.75	64.46	25.71
13	23 Kaldoo P-3	4.96	6.33	9.67	68.39	22.61
14	29 Kaldoo P-1	4.83	6.52	10.07	64.19	25.84
15	30 Leda P-5	5.25	6.78	9.89	68.17	23.47
16	39 Banethi BT	6.00	8.67	13.85	66.88	22.89
17	51 Jubble BT	5.06	6.47	10.62	66.12	23.72
18	40 Kaldoo P-10	5.57	7.67	12.09	66.42	23.66
19	54 Bagthan PT Black Top	5.30	7.44	11.81	66.56	22.70
20	58 Bagthan PT Black Base	6.35	8.55	13.66	64.68	25.71
21	64 Jai Nagar PT	6.23	8.44	12.86	64.36	25.75
22	27 Kaldoo P-9	5.84	7.50	11.79	66.04	23.81
CD (0.05)		0.48	0.36	0.67	0.68	0.29
SE(d)		0.24	0.18	0.33	0.34	0.14

Simple correlation coefficients between Water & chemical soluble extractives, holocellulose and lignin content and oleoresin yield are presented in Table 8.15. Out of 15 correlation combinations, four were positively and two were negatively significant at 1% level of significance. The correlation coefficients between rests of the combinations were found to be non-significant. The oleoresin yield exhibited positive significant correlation with holocellulose content (0.929) and strongly negatively correlated with lignin content (-0.947).

Table 8.15: Simple correlation coefficient between oleoresin yield, water and chemical soluble extractives, holocellulose and lignin content

	Oleoresin Yield	CW Soluble Extractives (%)	HW Soluble Extractives (%)	A: B Soluble Extractives (%)	Holocellulose Content (%)	Lignin Content (%)
Oleoresin Yield	1	-0.231	-0.201	-0.238	0.929**	-0.947**
CW Soluble Extractives (%)		1	0.933**	0.903**	-0.220	0.225
HW Soluble Extractives (%)			1	0.971**	-0.229	0.229
A: B Soluble Extractives (%)				1	-0.283	0.235
Holocellulose Content (%)					1	-0.934**
Lignin Content (%)						1

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

CW Soluble Extractives: Cold Water Soluble Extractives, HW Soluble Extractives: Hot Water Soluble Extractives, A: B Soluble Extractives: Alcohol: Benzene Soluble Extractives

Demonstration of borehole technology of oleoresin tapping

The borehole method of oleoresin tapping was demonstrated to the Forest Guards and Range Forest Officers, ACF's and DFO's trainees of State Forest Department of Himachal Pradesh (Fig. 8.45 & 8.46) as detailed in Table 8.16.



Fig. 8.45: Demonstration-cum training on borehole method of oleoresin tapping to the Forest Department Personnel at Forest Working Division, Hamirpur (Himachal Pradesh)



Fig. 8.46: Demonstration cum hands on training on borehole method of oleoresin tapping to the Forest Personnel of Himachal Pradesh State Forest Corporation Limited, Sundernagar

Table 8.16: Details of the training:

Sr No.	Trainees	Date	Number of Trainees
1.	Demonstration cum hands on training on borehole method of oleoresin tapping to the Forest Department Personnel of Himachal Pradesh State Forest Corporation Limited Sundernagar.	25th-26th February, 2021	35

Correlation between oleoresin yield and environmental factors

Simple correlation coefficients between environmental factors *viz*., maximum temperature (max T °C), minimum temperature (min T °C), average relative humidity (RH%), total rainfall (RF mm) and total evaporation (EVP mm) and oleoresin yield are presented in Table 8.17. Out of 15 correlation combinations, two was positively and one negatively significant at 1% level of significance and one was positively significant at 5% level of significance. The correlation coefficients between rests of the combinations were found to be non-significant. The oleoresin yield exhibited positive significant correlation coefficient with maximum temperature (0.565). The negative significant correlation coefficient was observed between oleoresin yield and average relative humidity (-0.149).

Table 8.17: Simple Correlation Coefficient between Oleoresin Yield and Environmental Factors (2010 to 2020)

	Oleoresin Yield	Max Temp. (°C)	Min Temp. (°C)	Av. RH (%)	Total RF (mm)	Total EVP (mm)
Oleoresin Yield	1	0.565**	0.410	-0.149**	0.112	0.006
Max Temp. (°C)		1	0.645	0.527	-0.037	0.480*
Min Temp. (°C)			1	0.876	0.661	0.095
Av. RH (%)				1	0.768**	0.451
Total RF (mm)					1	0.0342
Total EVP (mm)						1

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

8.6 Project on Babool gum at IGKVV, Raipur

Sustainable utilization of gum and resin by establishing improved tapping technique in Dhawara / Ghatti (*Anogeissus latifolia*)

Dhawara: As compared to mechanical methods use of gum enhancer was found to be superior in terms of quantitative and qualitative traits for gum tapping in Dhawara. Semi arc method of tapping was significantly superior amongst the mechanical methods of gum tapping. However, it was not found to be comparable with gum enhancers. Summer season have already created stress via high temperature and low RH%, higher conc. of ethephon @ 5.5% (4 ml) injected at single hole made by hand girmit at 50 and 100 cm from the base surface was found significantly effective to induce higher gum production. However, as compared to 50 cm 100 cm height was found to be superior for higher production of gum. In winter season artificial stress can be created by combined effect of 5.5% ethephon+ H_2SO_4 @10% (4 ml) and it was found to be effective in production of gum even in winter season. Depth of driller was 2-3 cm deep with nail size 10.00 mm was found to be superior.

Development of tapping techniques for sustainable extraction of biopolymer in rohini (*Soymida fembrifuing* Roxb), chironji (*Buchanania lanzanSpreng*) and saja (*Terminalia tomentosa* Roxb.)

Rohina (*Soymida febrifuga* Roxb.): Temperature and RH play significant role in exudation in Rohina. Single cut (control) traditional method of gum tapping was effective in this tree for gum tapping purpose.Use of gum enhancer was found to be significantly superior over traditional method of tapping.Ethephone @ 5% (4 ml) applied at single and triple places on stem at 1 DBH was almost equally effective. Hence, it can be applied at single place for higher production of gum.

Saja (*Terminalia tomentosa* Roxb.): Ethephon @3.9% applied at single place was found to be significantly effective to enhance the gum production as compared to other treatments when applied at single. Use of gum enhancer was found to be superior over traditional method of tapping.

Chironji (*Buchanania lanzan Roxb.*): Mechanical methods are not effective in chironji for gum tapping. Use of gum enhancer was found significantly effective when applied in hot summer, use of ethephone is found to be quite effective when applied in 30-45 days' intervals. Initially (Feb first week) lower level @3.9% was effective but in March its higher level @5.55%

was significantly superior over other gum enhancer for higher production of gum in chironji.

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

Moisture sorption behaviour of babool and karaya gums: The variation in equilibrium moisture content was observed with the variation in equilibrium relative humidity values like many other food materials. At lower temperature and higher relative humidity levels, the variation in EMC was comparatively higher than at higher temperatures for the equal relative humidity levels. Maximum value of EMC of babool gum was observed (33.6%, db) with the set of highest relative humidity (92.3%) at lowest temperature (30°C) and minimum value of EMC was observed (2.8%, db) with the set of lowest relative humidity (10.9%) at highest temperature (60°C). Karaya gum has maximum value of EMC (39.7%, db) with the set of highest relative humidity (92.3%) at lowest temperature (30°C) and minimum value of EMC was noticed (2.5%, db) with the set of lowest relative humidity (10.9%) at highest temperature (60°C) (Table 8.18 and 8.19). Babool gum samples endure in fair condition as fresh sample during the analysis (at less than 70% RH), but some of the Babool gum samples kept at higher humidity levels (more than 75%) were seen to have lost their original physical state and color (Fig. 8.47 to 8.49). No such change was observed in case of Karaya gum. The isotherms of Babool and Karaya gum both exhibited typical type II BET isotherm according to the classification of Brunauer, Deming and Teller (1940) and were noticed sigmoid in shape. No mold growth was observed on both the test gum samples throughout the analysis.

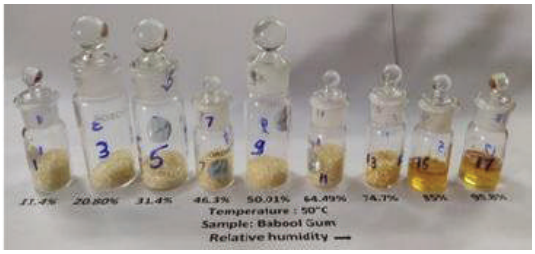


Fig. 8.47: Babool gum samples maintained at 50 °C and different relative humidity (after 3 weeks)

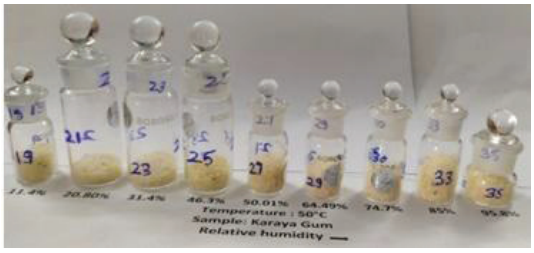


Fig. 8.48: Karaya gum samples maintained at 50 °C and different relative humidity (after 3 weeks)

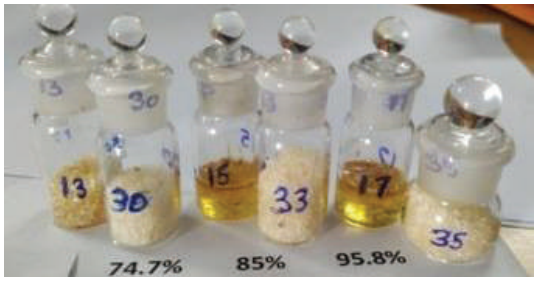


Fig. 8.49: Comparision of babool and karaya gum samples during sorption – adsorption study at 50 °C and different relative humidity (after 3 weeks)

Table 8.18: Equilibrium moisture contents (%, db) for babool gum at different temperatures and water activities

Temperature							
30 °C		40 °C		50 °C		60 °C	
a_w	EMC	a_w	EMC	a_w	EMC	a_w	EMC
0.112	0.057	0.112	0.044	0.114	0.039	0.109	0.028
0.216	0.084	0.226	0.062	0.208	0.058	0.207	0.052
0.324	0.108	0.327	0.098	0.314	0.082	0.292	0.063
0.431	0.127	0.484	0.121	0.463	0.097	0.377	0.084
0.514	0.139	0.554	0.134	0.500	0.110	0.477	0.096
0.630	0.144	0.660	0.140	0.644	0.135	0.631	0.110
0.750	0.204	0.746	0.177	0.747	0.170	0.673	0.162
0.836	0.264	0.823	0.233	0.850	0.225	0.802	0.215
0.923	0.336	0.890	0.300	0.958	0.289	0.958	0.277

Table 8.19: Equilibrium moisture contents (%, db) for karaya gum at different temperatures and water activities

Temperature							
30 ^{0}C		40 ^{0}C		50 ^{0}C		60 ^{0}C	
a_w	EMC	a_w	EMC	a_w	EMC	a_w	EMC
0.112	0.073	0.112	0.064	0.114	0.037	0.109	0.025
0.216	0.102	0.226	0.089	0.208	0.080	0.207	0.075
0.324	0.137	0.327	0.112	0.314	0.095	0.292	0.086
0.431	0.172	0.484	0.157	0.463	0.115	0.377	0.111
0.514	0.189	0.554	0.183	0.500	0.128	0.477	0.121
0.630	0.204	0.660	0.197	0.644	0.180	0.631	0.158
0.750	0.244	0.746	0.220	0.747	0.210	0.673	0.173
0.836	0.334	0.823	0.321	0.850	0.244	0.802	0.214
0.923	0.397	0.890	0.345	0.958	0.325	0.958	0.315

Modeling of moisture sorption data of babool and karaya gums: The parameter obtained using various isotherm models (Fig. 8.50 & 8.51) along with respective error functions. Based on the values of various error functions obtained like adjusted R^2, P, RMSE and SE. GAB equation was found to be the most suitable model to describe the observed data as compared to other four models. Hasley equation showed to be better result for both the test gums after GAB model for the whole range of water activity. BET model was found to be worst equation for both the test gums in describing the sorption behavior.

Studies on extraction of gum from charota (*Cassia tora*) seeds and its characterization

The gum extraction was carried out from the samples having maximum recovery of splits for each temperature. The highest gum yield was obtained 31.15% w/w, in 140 °C roasted sample, whereas the lowest gum yield was obtained 17.62 %, in 120 °C roasted sample. The highest amount of split obtained at roasting temperature of 110 °C for 10 min and to get the highest gum yield roasting should be done at 140 °C 5 min.

***Cassia tora* seed gum properties:** The angle of repose of *C. tora* seed gum was found to be 35.02±0.46°. The bulk and tapped density of *C. tora* seed gum was found to be 0.608±0.019 g/ml and 0.690±0.024 g/ml, respectively. The compressibility (Carr's) Index and Hausner's ratio of *C. tora* seed gum was found to be 11.71±3.39% and 1.13±0.04, respectively. The swelling index of *C. tora* seed gum was found to be 334.9±23.6%. The highest and lowest swelling index was found to be 362%, in 100 °C roasted seed gum sample and 190%, in 200°C roasted seed gum sample, respectively. The pH value of *C. tora* seed gum was obtained 3.01±0.22, which is acidic in nature. The highest and lowest pH value was obtained 3.3, in 170 °C gum sample and 2.56 in 200 °C gum sample. The surface tension of *C. tora* seed gum was obtained 45.61±2.01 dynes/cm. The viscosity of *C. tora* seed gum was obtained 12-120 cps using Brookfield viscometer spindle no. 64 at 5

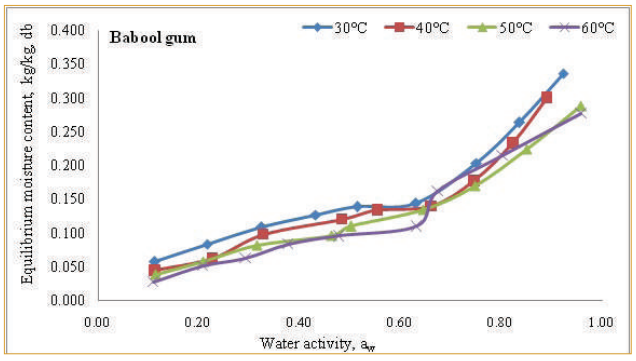


Fig. 8.50: Sorption isotherms of babool gum at different temperatures

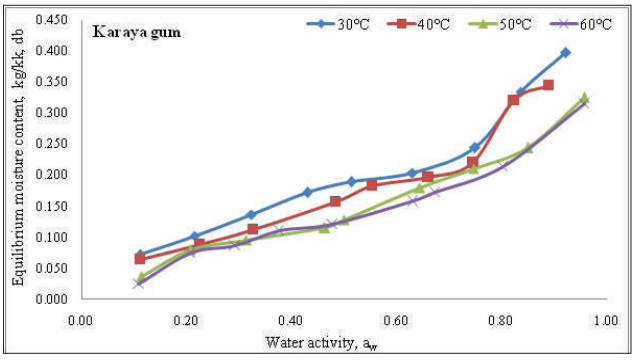


Fig. 8.51: Sorption isotherms of karaya gum at different temperatures

to 50 rpm. The solubility of *Cassia tora* seed gum was determined by using various solvent such as hot water, cold water, ethanol, methanol, ether and acetone. The maximum solubility of gum was found to be 41.35% per 100 ml at hot water and *C. tora* seed gum was odourless and neutral in taste.

Moisture dependent physical properties of charota seeds: The average length, width and thickness of the 100 seeds varied from 4.34-4.57 mm, 1.89–1.95 mm, 1.75 – 1.83 mm, respectively with the increase in moisture content. Arithmetic and geometric mean diameter ranged from 2.68 -2.76 mm and 2.43 – 2.51 mm as the moisture content increased from 4.88 to 22.21% (wb), respectively. Thousand seed weight of charota seed was increased linearly from 12.24 – 15.92 g as the moisture content increased from 4.88 – 22.21% (wb). Sphericity of charota seeds in the present study was ranged from 54.54 to 57.57.

Surface area of charota seeds in the present study was ranged from 16.92 to 18.19 mm2. Maximum aspect ratio (45.22) was found under the moisture content 4.88% and minimum aspect ratio (42.06) was reported at 9.06% and maximum seed volume (25.01) was found under the moisture content 9.06% and minimum volume (22.48) was reported at 4.88%. Bulk density and True density were declined with increase in moisture content from 4.88 to 22.21% (wb). It was ovserved that calculated values of porosity linearly increased with increasing moisture content. The angle of repose showed an increasing trend with moisture content from 4.88 to 22.21% (wb) and the kinetic coefficients of friction for charota seeds increased with increase in moisture content on all four surfaces. The highest coefficient of friction were observed on the rubber (0.49-0.71) followed by the mild steel (0.39-0.51), plywood (0.36-0.44) and were lowest on the glass (0.38-0.43).

Training programme

The details of training programme conducted under the project are depicted in Fig. 8.52 and detailed in Table 8.20 as under.



Fig. 8.52: Training conducted at different KVKs and villages of Chhattisgarh

Table 8.20: Training and Demonstration Activities

S. No.	Place	Date	Duration	Participants
1	Krishi Vigyan Kendra, Dhamtari	Feb. 16, 2021	1 day	34
2	Krishi Vigyan Kendra, Dhamtari (Village Katalbod)	Feb. 17, 2021	1 day	37
3	Krishi Vigyan Kendra, Bhatapara	Feb. 22, 2021	1 day	26
4	College of Agriculture & RS, Bhatapara	Feb. 23, 2021	1 day	52
5	College of Agriculture & RS, Saja (Dist. Bemetara)	Feb. 24, 2021	1 day	32
6	Krishi Vigyan Kendra, Bemetara	Feb. 25, 2021	1 day	30
7	Krishi Vigyan Kendra, Kawardha	Feb. 26, 2021	1 day	44
8	Krishi Vigyan Kendra, Ambagarh Chowki, Dist. Rajnadgaon (Village:- Sonsaytola)	Mar.05, 2021	1 day	33
9	College of Agriculture & RS, Mahasamund	Mar. 06, 2021	1 day	44
10	Krishi Vigyan Kendra, Ambagarh Chowki, Dist. Rajnadgaon (Village:- Kaudutola)	Mar. 18, 2020	1 day	39
11	College of Agriculture & RS, Mahasamund (Village:- Ganikera, Block:- Basna)	Mar. 23, 2021	1 day	41
	Total			**412**

8.7 Project on guggul at JNKVV, Jabalpur

Comparative Liquid Chromatography Mass Spectrometry analysis of guggul gum in storage

Four packing/containers viz. earthen pot, plastic jar, polythene bag and jute bag were used to store fresh guggul gum. All the containers were filled with 250 g of guggul gum and stored at room temperature in the laboratory. Liquid Chromatography Mass Spectrometry (LC-MS) of the samples was done. The results revealed the molecular weights of different compounds eluted at different retention time (RT). Variations among the molecular weights of compounds indicated that the vital role of storage containers and age of guggul. Maximum numbers (19) of compounds have been eluted from the guggul sample stored in earthen pot. The samples of other containers had least numbers of compounds. It was 14 in plastic jar, 13 each in polythene bags and jute bags (Fig. 8.53).



Fig. 8.53: Packing/containers used to store fresh guggul gum

Effect of wall thicknesses of earthen pots on quality of stored guggul

Fresh guggul from Chambal ravines, Morena district of Madhya Pradesh were stored in earthen pots of 2.5 mm, 5.0 mm and 7.5 mm wall thicknesses. After a year of storing the stored samples were analyzed in LC-MS at CSIR-Central Drug Research Institute, Lucknow. The results revealed that the maximum numbers of compounds were identified in guggul samples stored in earthen pots of 2.5 mm thickness.

Guggul nursery and large scale plantation

Nursery raising and plantation was done by Sujagriti Samaj Sevi Sanstha, Morena (Fig. 8.54). NGO-Sujagriti Samaj Sevi Sanstha, Morena adopted the technique of identification of good guggul seeds and nursery preparation developed by the Project. Till date the NGO (Sujagriti Samaj Sevi Sanstha) has raised over 52000 guggul seedlings. Out of these 42,000 seedlings transplanted in Madurai, while the remaining in Morena through community participation.

Survey of gum yielding plants of local importance

A survey was conducted in the forest areas of Shivpuri, Sheopur and Gwalior districts to collect information on gum yielding plants of local importance. In Pohri





Fig. 8.54: Community scale guggul nursery plantation

tehsils, South Kuno Forest, Shivpuri locals collect gums from *Kardahi, Dhawra, Khair, Salai, Babul, Palash, Kullu*. In Sesaipura (Sheopur) forest range *Sehariya*, *Gurjar* and other *Adivasi* of Murawan and Tiktoli villages are gum collectors. They tap *Boswellia serratta* (Salai) tree and collect gum after 20-25 days from the date of tapping. They use a local iron tool for tapping in *B. serratta*. On an average 150-250 g gum per tree is collected. They also collect gum from kardhai, khair, dhawra, palash etc (Fig. 8.55 & 8.56). They do not tap these tree species and wait for natural oozing of gum. They sell these gums to local buyers/traders of Karahal (Sheopur). Gum collectors of Murawan and Tiktoli villages use sickle shape tapping tool (Fig. 8.57). The width of the tool is about 5 cm and 24 cm in length. This semi-circle shaped tool has a thick base. Salai, Kardhai, Palash, Khair, Kullu are the common gum yielding trees of forest of Satanwara, district Shivpuri. Karera, Kolaras, Pichore and Badarbas tehsil of Shivpuri district have less forest. The forests of Ghati gaon, Gwalior has numerous Salai trees.



Fig. 8.55: *Anogeissus pendula*. (Kardhai) tree



Fig. 8.56: *Senegalia catechu* (Khair) tree



Fig.8.57: Local tapping tool

Preparation of guggul library

The JNKVV Centre has developed a guggul library and constantly analyzed to record the changes in its physico-chemical properties.

The next plan of work is for identification of bioactive compounds from these samples. This information will of value to both cosmetic and drug industry. This year the centre has filed a patent application on storage method of guggul.

8.8 Project on tamarind seed gum at TNAU, Coimbatore

Flower and fruiting in florigen applied tamarind germplasm

To induce flowering in tamarind, foliar application of chemicals with different ppm was sprayed, *viz.*, Ethrel @ 200 and 500 ppm, Paclobutrazol @ 500 and 1000 ppm, NAA @ 50 and 100 ppm, Mepiquat chloride @ 200 and 500 ppm. Among the 5 tamarind germplasm sprayed with different florigen chemicals, Urigam was started to flowering earlier followed by Hasanur 06, Mullampadi, Hasanur 09 and PKM 01. The tamarind germplasm responded differently to the various concentrations of treatments. Among the treatments, foliar application of Paclobutrazol with 500 ppm concentrations recorded maximum number of inflorescence per branch (225) with highest number of flowers per branch (855). Inflorescence length was recorded maximum in foliar application of Etherel @ 200 ppm, followed by foliar application of Etherel @ 500 ppm. Foliar application of Mepiquat chloride @ 500 ppm do not showed any significant influence on selected tamarind germplasm. Tamarind germplasm started flowering after application of inducing chemicals, produced various sizes of tamarind flowers and length of inflorescence was recorded maximum in Mullampadi germplasm followed by Hasanur 06. Similarly, highest number of inflorescence per branch was observed in Hasanur 06 followed by PKM 1. Total number of flowers per branch was also recorded maximum in Hasanur 06 germplasm while Urigam and Mullampadi recorded lowest number of flowers per branch. Quantitative study of tamarind revealed significant difference among tamarind germplasm. Hasanur 06 flower inflorescence was recorded with maximum flowers size (13.50 cm) followed by PKM 1 (9.50 mm). Petiole length was highly variable among the germplasm and recorded maximum in Hasanur 06 (9.70 mm) and minimum in Urigam (5.30 mm). In 5 tamarind germplasm planted, Hasanur 06 sprayed with foliar application of Paclobutrazol 500 ppm showed maximum flowering and fruiting in tamarind (Fig. 8.58 & 8.59). Hasanur 06 and PKM 1 showed maximum fruiting percentage.



Fig. 8.58: Spraying growth regulator in different tamarind germplasm

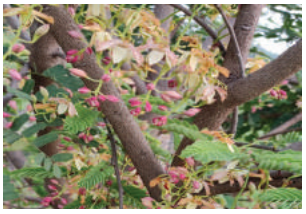


Fig.8.59: Profuse flowering in Hasanur 06 germplasm

Entomological studies on tamarind pod and seed storage

The concentrations of chlorophyll 'a', chlorophyll 'b' and total chlorophyll were estimated in the 34 progenies after three months interval period by adopting the method of Yoshida *et al*., 1976 and expressed as mg per gram of fresh weight. On basis of value for chlorophyll contents (chlorophyll 'a', chlorophyll 'b', total chlorophyll and chlorophyll a/b ratio) it can be concluded that T3 (Paclobutraz0l 500 ppm) was recorded highest in three growth stages and the lowest in T9 (control).

Organoleptic evaluation of value added products from tender tamarind pickle and tamarind flowers gulkand

Tender tamarind pickle was prepared using tender tamarind (500 g), salt (100 g), red chilli powder (50 g), cinnamon, cumin, fenugreek seed and asafetida (each 5 – 8 g). Tender tamarind pickle prepared by washing the tender tamarind and chopping the same in small pieces after washing (Fig. 8.60) and then chopped tender tamarind thoroughly mixed in spices, oil and salt (Fig. 8.61). The mixed tender tamarind with spices, oil and salt was than filled in jars followed by covering with lid. The jar was kept in sun for 4 – 6 days, shaked atleast twice a day and stored at ambient temperature.

To prepare tamarind flowers gulkand, tamarind flower was gently washed with hot water and dried. The washed and dried tamarind flower was than chopped into pieces (Fig. 8.62) and spread in glass bottle. After spreading the washed and dried tamarind flowers, layer of sugar and cardamom powder was evenly spread and the process was continued till end of tamarind flowers. After completion of spreading the flowers and sugar and cardamom powder, the glass bottle was closed with lid and kept in sun for 7 to 10 days followed by mixing the same at alternate day (Fig. 8.63). The prepared tamarind flowers gulkand was stored in refrigerated condition in air tight container.



Fig. 8.60: Deskinned tender tamarind



Fig. 8.61: Tender tamarind pickle



Fig.8.62: Tamarind flower



Fig. 8.63: Tamarind flower gulkand

Both the products (tender tamarind pickle and tamarind flowers gulkand) were evaluated by a panel of semi-trained judges for acceptability of the products based on its appearance, texture, taste, color, aroma and overall acceptability on nine point hedonic scales. Control (Mango pickle) scored highest on all the sensory attributes compared to tender tamarind pickle and observed that scores decreased with increase in amount of tamarind flower probably due to reduction in the peculiar rose flavor. Similar decrease trend in scores was also observed in gulkand prepared using tamarind flower compared to control (rose gulkand).

Studies on assessing gum production from tree species of regional importance

The preliminary assessment of gum production was conducted in naturally grown trees and plantations of *Butea monosperma, Pterocarpus marsupium, Chloroxylon swietenia and Lannea coromandelica*at Forest College and Research Institute, Mettupalayam, Coimbatore (Tamil Nadu). Selected tree species were enumerated for their diameter and were classified into 2 diameter classes *viz.*, 30-60 cm and 60-90 cm. The trees selected for assessing gum production were treated with different level of gum booster. Study revealed that gum booster dosage of 400 mg/ml ethephon and 1.2% H_2S0_4 concentration was found to be significantly superior over other treatments in *C. swietenia, P. marsupium* and *B. monosperma*. Diameter class of 60-90 cm was found to be superior over 30-60 cm diameter class in terms of gum production.

Documentation of entomofauna infesting *Tamarindus indicus* both under field and storage and potential pollinators of tamarind

Total 11 species of insect pests and 3 species of natural enemies were documented under tamarind plantation and seed storage. Among eleven species of insect pests, three species of sucking pests, three species of fruit borers, three species of seed borers/ kernel powder feeder, two species of defoliators were documented in tamarind plantation. Natural enemies include two species of spiders and preying mantids. Sucking pests recorded as one species of mealy bug (*Drosichiella tamarindus* Green.), one species of plant hopper (*Eurybrachis tomentosa* Fab.) and one species of scale insect (*Selanaspidus articulatus*). Borers were recorded as three species *viz., Phycita orthodina* Meyrick, *Virachola isocrates* Fabricius and *Assara albicostalis* Walker and three species of storage pests including two species of seed borer's *viz., Caryedon serratus* Oliver, *Sitophilus linearis* Herbst and a kernel powder feeder, *Tribolium castaneum* Herbst. Defoliators recorded were one species of grass hopper, *Caelifera sp.* and a bagworm, *Pteroma plagiophles* Hampson. Potential pollinators of tamarind *viz., Apisflorea, Apisdorsata, Apiscerana, Amegillazonata, Trigonaspp, Xylocopa sp., Camponotus sp., Sarcophaga sp., Certinahieroglyphica* were visited during the peak period of flowering.

Gum tapping experiment on *Moringa oleifera*

Experimentation on moringa gum tapping from *Moringa oleifera* trees in the region was conducted with different treatments (Fig. 8.64 and 8.65) and observed that maximum gum yield was 42.80 g in Hand drilling with 4ml gum inducer and minimum in drilling without gum inducer application in diameter class of 90-120 cm under non-irrigated condition. In irrigated condition, maximum yield was observed as 102.20 g in hand operated drilling with ½ inch drill and patching, followed by battery operated drilling with ½ inch drill bit and 4 ml inducer application with patching (84.60 g), battery operated drilling with ½ inch drill bit and 2 ml inducer application with patching (63.20 g) and hand operated drilling with ½ inch drill and 2 ml inducer application with patching (57.10 g) whereas minimum in battery operated drilling with ½ inch drill bit and patching with gum yield of 17.90 g in diameter class of 90-120 cm. Within the span of 3 months' observation, diameter class of 90-120 cm produced more gum yield than diameter class of 30-60 cm and 60-90 cm.



Fig. 8.64: Gum exudation in trees treated with inducer



Fig. 8.65: Gum exudates from gum blazer incisors

Augmenting existing tamarind germplasm

During previous year, 9 new tamarind germplasm namely Urigam 112, Red tamarind 1, Red tamarind 2, Red tamarind 3, Red tamarind 4, Vellore 28, Vellore 66, Vellore 1, Kumbam were collected and planted in tamarind gum garden. The biometric measurement for the existing tamarind germplasm (Hasanur 06, Hasanur 09, PKM 01, Javathu Hills, Mullampadi, Urigam, Jamnamathur, Amirthi 1, Amirthi 2, Pernampet and Sweet tamarind) were recorded and correlated with the flowering and fruiting characters.

Assemblage of gum yielding tree species of regional importance

Acrocarpus fraxinifolius, Vachellia nilotica and *Pterocarpus marsupium* were found superior in biometric observation (height and girth at breast height). The tree species planted during the current year were *P. marsupium, B. monosperma, P. cineraria, Acacia ferrugenia and Acacia leucophloea, M. oleifera, Lannea coromendalica and Pterocarpus santalinus.*

8.9 Project on natural dammars at KAU, Thrissur

Resin collection from *Ailanthus triphysa*

Conventional methods such as use of ordinary cups for collection of *Ailanthus* gum-oleoresin from the trees was found to be hard, for keeping its purity. The oleoresin collected in the cup usually contains remnants of insects and plant debris and is difficult to separate from the sticky oleoresin. In order to avoid mixing of impurities in the fresh resin exudation, we tried closed plastic bottles for resin collection directly from the cut ends and was found to be very effective in resin collection without impurities (Fig. 8.66).



Fig. 8.66: Collection of quality *Ailanthus* resin in closed plastic bottles

Regeneration studies on white dammar (*Vateria indica*)

Ripe fruits of white dammar (*Vateria indica*) were collected from standing trees during the month of July. The three valved, 1 seeded fruits are pale brown in colour and the seeds inside show viviparous nature. The ripened and unopened fruits were selected for the study. The fruits, which are ovoid to ellipsoid in shape, are of the average size of 4.18 cm x 3.02 cm, when fresh (Fig. 8.67). About 40 to 42 fruits of normal size weigh one kilogram. For germination study, the fruits were subjected to the different treatments. After different treatments, the seeds were sown in polybags (4x8 inch) filled with potting mixture (Fig. 8.68) and one seed in each polybag was sown with 5 replicates in the last week of July 2021 and kept under observation. Polybags sown seed thus watered on alternate day and germination recorded when radicle protrusion emerged. The study was conducted under shaded nursery condition and data were recorded at every alternate days. In this study, experiment was designed considering Randomized Complete Block Design (RCBD) following the principles of replication and randomization, due to similarity in variation gradient. Regular weeding and watering were performed at some intervals in order to provide congenial conditions for seed germination and post-germination growth of seedlings and germination percentage recorded and found highly effective (Fig. 8.69) in the treatments, T5: GA 1000 ppm (86.66%), followed by the treatment T7: cold water 24 Hrs (80%) and treatment with GA 500 ppm: T4 (76.66%), whereas lowest germination percentage was recorded in T8 (hot water treatment for 5 minutes) with 20% of seed germination.



Fig. 8.67: Mature seeds of *Vateria indica*



Fig. 8.68: Polybags with seeds under different treatments



Fig. 8.69: Germination of seeds under different treatments

Regeneration studies on black dammar (*Canarium strictum*)

The ripe fruits of black dammar (*Canarium strictum*) collected from standing trees start maturing from October to January (Fig. 8.70 & 8.71). The fruits of black dammar were dark blue in colour, 2.5 to 5.0 cm long, pointed at ends, mesocarp fleshy, stone hard, and aromatic and seeds trigonous, usually 3- celled. Normal size fruits of black dammar of about 25 or 30 fruits weigh one kg while about 150 to 175 seeds of normal size weigh one kg.

Seeds were subjected to different treatments for germination studies and de-pulped by soaking in water for two days (48 hours) for all the treatments (Fig. 8.72 to 8.74).



Fig. 8.70: Mature fruits of *Canarium strictum*



Fig. 8.71: Cross section of *Canarium strictum* fruit



Fig. 8.72: Fruits before and after de-pulping



Fig. 8.73: Fruits before and after de-pulping





Fig. 8.74: De-pulping of fruits by water soaking

Treated seeds were sown in polybags (4x8 inch) filled with potting mixture (Fig. 8.75) in three replicates. One seed was sown in each polybag in third week of November and kept under observation. The polybags were watered on alternative days and recorded as germinated when radicle protrusion emerged (Fig. 8.76).



Fig. 8.75: Seeds sown under different treatments



Fig. 8.76: Germination of seeds under different treatments

Data of germination recorded at every alternate day and study was conducted under shaded nursery condition. Randomized Complete Block Design

(RCBD) was used for the experimentation following the principles of replication and randomization, due to similarity in variation gradient.

Regular weeding and watering were carried out at some intervals, in order to provide congenial conditions for seed germination and post-germination growth of seedlings (Fig. 8.77).



Fig. 8.77: Stages of seed germination and seedling establishment

Seed germination was found highly effective in the treatments T5: H_2SO_4 10% (66%), followed by the treatment T1: Control (58%) and treatment with GA 2000 ppm: T7 (56%), whereas lowest germination percentage was recorded in T4 (Treatment with hot water for 3 minutes) with 12% of seed germination.

Development of pedal operated incense stick making machine

Production of incense sticks in the rural sector is difficult, especially in the tribal areas where availability of electric power is meagre. Also, to generate employment in rural areas of the state, hand operated incense stick making machines are more useful and viable. Though a few reports on the production of these types of manual operated machines are available but the product is not available to end user. A manually operated incense stick (agarbathi) making machine was fabricated with the support of Kelappaji College of Agricultural Engineering and Technology (KCAET), KAU, Kerala (Fig. 8.78). Developed agarbathi making machine works on the extrusion principle with continuous flow of paste on bamboo sticks and is an ideal machine for commercial production of incense sticks (Fig. 8.79). The machine is ergonomically designed to transmit the force applied on the foot pedal to the piston of the cylinder which contains agarbatti paste, compressive force then creates extrusion of the incense stick. Developed manually operated agarbathi making machine can produce 20 to 30 incense sticks/min. Cost of the developed manually operated agarbathi making machine is approximately Rs. 7000-8000 which is much less compared to machine available (Rs. 15,000-50,000) in market.



Fig. 8.78: Manually operated agarbatti making machine



Fig. 8.79: Commercial production of incense sticks

Commercial production and training on black dammar *dhoop* cones

As part of value addition of black dammar, size and composition of *dhoop* cones were standardized and commercial production has been started at the production centre attached to College of Forestry (Fig. 8.80). Training on *dhoop* cones production using the moulds also imparted to the beneficiaries.



Fig. 8.80: Commercial production of black dammar *dhoop* cones

Training on black dammar incense sticks and *dhoop* cones production

Two trainees nominated by Kerala State Federation of SC-ST Development Co-operative Limited received training on black dammar incense stick and *dhoop* cones production and successfully completed hands-on-training (Fig. 8.81). Apart from the training, they also briefed about machineries required for manufacturing black dammar incense stick and *dhoop* cones including working principle of the same.



Fig. 8.81: Training for Kerala state Federation of SC-ST Development Co-Operatives Ltd

Publications

Research Papers published

- Ghritlahare MK and Katiyar P (2021). Sustainable extraction of biopolymer using various gum enhancer in rohina (*Soymida febrifuga* roxb.) tree from Mungeli region of Chhattisgarh. *Journal of Plant Development Sciences* 13(2): 89-92.
- Pareek K, Shiran K, Tewari J C, Sharma A and Kumar P (2021). Extraction of *Acacia senegal* MYB transcription factor mRNA by using homology searching approach: An important tree species of arid environment. *IOSR Journal of Biotechnology and Biochemistry* 7(1): 19-24.
- Kshirsagar RB, Jadhav BA and Thakur PP (2021). Nutritional enhancement of crackers by incorporation of guar meal protein isolate. *The Pharma Innovation Journal* 10(9): 479-482.

Papers presented

Following papers were presented in National Web-symposium on Recent Advances in Beneficial Insects, Natural Resins and Gums, ICAR-IINRG, Ranchi, February 25-26, 2021.

- Chowdhury AR, Siddiqui MZ, Maurya S, Ali M and Mate CJ (2021). Synthesis, characterization and antifungal efficacy of jhingan gum-induced silver nanoparticles, p. 133.
- Prasad N, Thombare N, Sharma SC and Kumar S (2021). Karaya gum: Production, processing, properties and applications - A review, p. 123-124.
- Dutt B, Kumar R, Vipasha and Heena (2021). Effect of borehole height, diameter class and drilling month on oleoresin yield in *Pinus roxburghii*, p. 133-134.
- Dutt B, Kumar R, Vipasha and Heena (2021). Effect of extractives and cell wall constituents on oleoresin yield of high, medium and low resin yielders of *Pinus roxburghii* Sargent, p. 99.
- Thombare N, Lohot V, Yogi RK, Kumari U and Sarkar PK (2021). Potential and threats to sal (*Shorea robusta*) forests of India: A review, p. 163-164.
- Thombare N, Kumari U, Sakare P, Chowdhury AR and Prasad N (2021). Indigenous technical knowledge based medicinal uses of natural resins and gums, p. 119.
- Shiran K, Kamlesh Pareek and J C Tewari (2021). Lesser-known gum producing trees for sustainable livelihood security in arid region. p. 147-148.
- Kshirsagar RB, Jadhav BA and Thakur PP (2021). Amino acid profile of guar meal protein isolate, p. 125.
- Kshirsagar B, Thakur, PP and Jadhav BA (2021). Nutritional enhancement of pet food by incorporation of guar meal protein isolate, p. 134.
- Saurabh Swami and Shiran K (2021). *Acacia senegal* gum as wall material for microencapsulation of cinnamon oil. e-Abstracts-SYMSAC X 2021, International Symposium on Spices as Flavours, Fragrances & Functional Foods, Indian Society for Spices, Kozhikode, Kerala, February 09-12, 2021, p. 14.
- Shiran K, Shekh Mukhtar Mansuri, Mahesh Kumar and Kamlesh Pareek (2021). Extrudates with tree gum for enhanced nutritional value-physical and chemical Properties. 4th International conference (online) on Current Approach in Agricultural, Animal Husbandry and Allied Science for Successful Entrepreneurship (CAAHASSE-2021), March 13-15, 2021, p. 97.

Award and Recognition

Following awards were received during the National Web-symposium on Recent Advances in Beneficial Insects, Natural Resins and Gums organized by SANRAG and ICAR-IINRG, Ranchi, February 25-26, 2021.

- Dr. AR Chowdhury, Sc. received a Best poster award, for a poster titled, 'Synthesis, characterization and antifungal efficacy of jhingan gum-induced silver nanoparticles'
- Ms. Usha Kumari, SRF, AINP HPVA NRG received Best poster award for her presentation on 'Indigenous technical knowledge based medicinal uses of natural resins and gums'
- Mr Shiran K received Best oral presentation award for the research paper "Lesser-known gum producing trees for sustainable livelihood security in arid regions"

Patent granted

- A Patent (no. 375197) was granted on 'Jawahar Guggul Blazer' (Application no. 300/MUM/2011) inventors Moni Thomas, on 24.08.2021 from Intellectual Property Rights (IPR), Patent Office, Mumbai.

Network Project on Conservation of Lac Insect Genetic Resources

9.1 Lead Centre: ICAR-IINRG

Pruning response of *Calliandra calothyrsus* and evaluation of lac insect (*kusmi*) on pruned plants:

Evaluation of lac insect *(kusmi)* on pruned plants during *aghani* (winter) crop 2020-2021

Number of shoots, shoot length, shoot diameter were recorded on pruned plants in the month of September, October, November, December 2019 and January, February, March 2020. February and January 2020 month of pruning recorded the longest shoot with more diameter as compared to other months of pruning. *Kusmi* broodlac was inoculated on pruned plants on 21st, July, 2020 during winter (*aghani*) crop. Broodlac ratio obtained was 7.4, 8.1, and 9.1 from different month of pruned plants during January, February and March, 2020, respectively. More numbers of pruned plants (in the month of September, October, November and December 2020) of *C. calothyrsus* died due to water stagnation and cold weather.

Pruning response of *C. calothyrsus* and evaluation of lac insect (*kusmi*) on pruned plants

Pruning was done in fourth week of every month from September 2021 to December 2021. Observations *viz*., time of initial sprouting, collar diameter, main and sub branch diameter, number of shoots, shoot length, shoot diameter were recorded monthly intervals per plant in each month of pruning (Fig. 9.1).

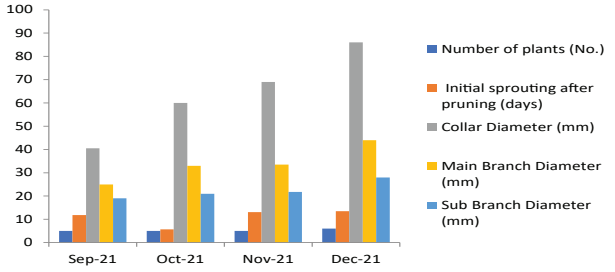


Fig. 9.1: Characteristics of selected plants during different months of pruning

Ants associated with lac crop

Three different ant species were collected on 05th December, 2020, one from *kusmi* lac crop on *Calliandra* and two from *rangeeni* lac crop on *Palas*. (Fig. 9.2, 9.3, and 9.4).



Fig. 9.2: Ant collected from *kusmi* lac crop on *Calliandra* (CKA)

Fig. 9.3: Ant collected from *rangeeni* lac crop on *Palas* (PRAB)

Fig. 9.4: Ant collected from *rangeeni* lac crop on *Palas* (PRAS)

Lac associated insect rearing house

A facility was created to rear lac associated parasitoids and predators for maintaining the populations throughout the year and keep more populations for executing further study.

Barcoding of new lac insect lines

Genomic DNA was isolated from the lac insect samples collected from different locations in Tamilnadu *viz*., Karur (KKR), Sri Rangam (KSR, KlSr2), Madurai (KMU), Trichy (KlTr3) on *Albizia saman*; Madurai Dindigul Road (KlDd5) on *Ficus religiosa* and from Santraganchhi in West Bengal on *Ficus carica* (AAUK-17). Amplification of the *COI* gene using *BCF1-BCR1* primer pair gave around 700 bp amplicon in all the samples and the amplicons were sequenced. After removing low quality reads, the length of good quality *COI* sequences (phred score above 25) obtained were 640 bp for KKR, 664 bp for KSR, 638 bp for KMU, 656 bp for KlSr2, 642 bp for KlTr3, 601bp for KlDd5 and 657 bp for AAUK17 samples. The sequences thus obtained were subjected to BLASTN in NCBI database to search for the best matches. BLASTN analysis of the KKR, KSR, KMU, KlSr2, KlTr3, KlDd5 sequences showed 100% similarity with *Kerria sp.* which was earlier collected from Madurai from a different location and AAUK17 sample was 100% identical with *Kerria lacca* (LIK008). *COI* sequences of these 7 samples were submitted to GenBank and the accession numbers obtained for *COI* sequences of KKR, KSR, KMU, KlSr2, KlTr3, KlDd5 and AAUK17 samples were MZ562670, MZ562671, MZ562672, OM089768, OM089769, OM089770 and MZ501499, respectively (Table 9.1).

Table 9.1: Barcoding of new lac insect lines

Code	Place of Collection	Host	Best match	Product length in bp	E Value	Identity	Cox 1 Accession No.
KKR	Karur	*Albizia saman*	*Kerria* sp. isolate RL009	640	00	100%	MZ562670
KSR	Srirangam	*Albizia saman*	*Kerria* sp. isolate RL009	664	00	100%	MZ562671
KMU	Madurai	*Albizia saman*	*Kerria* sp. isolate RL009	638	00	100%	MZ562672
AAUK-17	Santraganchhi, West Bengal	*Ficus carica*	*Kerria lacca* isolate	657	00	100%	MZ501499
KlSr2	Srirangam, Tirchy	*Albizia saman*	*Kerria* sp. isolate KSR	656	00	100%	OM089768
KlTr3	Thennur Bridge, Trichy	*Albizia saman*	*Kerria* sp. isolate KSR	642	00	100%	OM089769
KlDd5	Madurai, Dindugal Road	*Ficus religiosa*	*Kerria* sp. isolate KSR	601	00	100%	OM089770

Isolation and identification of endophytes from lac host phloem sap

Bark was collected from the lac host plants *viz*., *Flemingia semialata* and *Flemingia macrophylla*. For surface sterilization, it was washed with 70 % ethanol for 2 min, followed by 2% sodium hypochlorite for 1 min and with 0.1% mercuric chloride for 30 sec. Then the bark samples were washed thoroughly with autoclaved double distilled water for 5 times. Washed water was collected for checking any contamination (as a control). Phloem sap was collected from the bark (by centrifugation method) and inoculated in Nutrient broth at 28 ºC. *F. semialata* phloem sap inoculated nutrient broth showed growth 72 HAI (Hours After Inoculation), Then the broth was serially diluted and plated on three different media *viz*., Brain Heart Infusion, Blood Agar and Peptone Yeast Extract Agar media. Colonies were obtained in all the media 72 HAI. For molecular identification of the colonies, 16S rRNA genes were amplified and sequenced. Based on the sequences, they were identified as *Agrobacterium larrymoorei*, *Rhizobium* sp and *Sphingomonas* sp. The 16S rRNA gene sequences were submitted to NCBI GenBank and the accession numbers obtained were MZ496404, MZ496405 and MZ496406, respectively for *A. larrymoorei*, *Rhizobium* sp and *Sphingomonas* sp.

Genomic DNA isolation from single insect: Genomic DNA isolation from single insect is essential for barcoding purpose. Hence, it was tried using different protocols including CTAB method, methods already described in literature for single insects, Qiagen kit. Out of various methods tried, Rugman –Jones *et al*. (2006) method with slight modification (5M NaCl used for removal of protein contamination) gave the better result compared to other methods.

Barcoding of lac-host pests

Gall midge from *kusum*: Gall midge was collected from *kusum* tree during June 2020. Genomic DNA was isolated from the collected gall midge sample. Genomic DNA was amplified with *cox1* universal barcoding primers (Folmer *et al*., 1994). The amplified product of around 700 bp was sequenced. Good quality sequence of 709 bp was obtained which was blasted against the entries in NCBI database. It was found to show maximum similarity with *Cecidomyiidae* sp.

Whitefly on *Flemingia semialata*: *Cox1* barcode sequence of whitefly samples collected from Institute Research Farm on the lac host plant *F. semialata* has been generated and submitted to NCBI GenBank and the accession number obtained was MZ356499.

Identification of Endosymbiotic fungi in lac insects

PCRs with universal ITS primers, 18S rRNA and 28S rRNA primers were carried out to identify the endosymbiotic fungi present in lac insects. Genomic DNA was isolated from the surface sterilized lac insects. Fungi barcoding PCRs revealed the presence of few endophytic fungi *viz*., *Nectria cinnabarina, Acremonium sp., Acremonium vitellinum and Ramichloridium cucurbitae, Ramichloridium apiculatum* and yeast like endosymbiont of *Hamiltonaphis styraci.*

Web portal 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 52 lac-host plants. The compiled information was used for developing web portal. Website of the portal is Indian Lac Insect Host Plant Portal http://14.139.215.35/~lpd/networkcligr/.(Table 9.2).

Table 9.2: List of lac-host plants covered in Web portal

Sl.	Family	Host plants	Common name
1	Anacardiaceae	*Mangifera indica*	Mango
2	Annonaceae	*Annona squamosa*	Custard apple
3	Bombacaceae	*Adansonia digitata*	Baobab
4	Burseraceae	*Garuga pinnata*	Kondeyore
5	Euphorbiaceae	*Croton oblongifolius*	Putri
6	Fabaceae	*Butea monosperma*	Palas
7		*Butea monosperma* var *swadi*	Swadi Palas
8		*Butea superba*	Lata palas
9		*Cajanus cajan*	Arhar
10		*Dalbergia oojeinensis*	Sandan
11		*Desmodium pulchellum*	Jatsalpan
12		*Flemingia bracteata*	Madipata
13		*Flemingia chappar*	Galphuli
14		*Pithecellobium dulce*	Jungle jilebi
15		*Leea crispa*	Leea
16		*Flemingia macrophylla*	Bhalia
17		*Flemingia semialata*	Semialata
18	Caesalpinioideae	*Peltophorum ferrugineum*	Copper pod
19	Dipterocarpaceae	*Shorea talura*	Talura
20	Malvaceae	*Eriolaena spectabilis*	
21		*Malvaviscus penduliflorus*	Turk's cap mallow
22		*Thespesia populnea L*	Paras peepal
23	Mimosaceae	*Acacia auriculiformis*	Akashmani
24		*Acacia catechu*	Khair
25		*Acacia farnesiana*	Mimosa bush
26		*Acacia nilotica*	Babool
27		*Acacia tortulis*	Kikar
28		*Albizia lucida*	Galwang
29		*Albizia lebbeck*	Black Siris
30		*Albizia saman*	Rain tree
31		*Calliandra calothyrsus*	Red calliandra
32		*Calliandra haematocephala*	Red powder puff

Sl.	Family	Host plants	Common name
33		*Calliandra haematocephala alba*	White powder puff
34		*Calliandra surinamensis*	Surinam
35		*Prosopis cineraria*	Khejadi
36	Moraceae	*Ficus bengalensis*	Banayan tree
37		*Ficus benjamina*	Black fig
38		*Ficus carica*	Anjeer
39		*Ficus glomerata*	Gular
40		*Ficus microcarpa*	
41		*Ficus mollis*	Soft fig
42		*Ficus religiosa*	Pipal
43		*Ficus rumphii*	Pilkhan
44		*Ficus semicordata*	
45		*Ficus tsiela*	
46		*Ficus tsjakela*	
47	Papilionaceae	*Milletia extensa*	Ganj, Gonj
48	Rhamnaceae	*Ziziphus mauritiana*	Ber
49		*Ziziphus rotundifolia*	Ghont
50	Sapindaceae	*Litchi chinensis*	Litchi
51		*Schleichera oleosa*	Kusum
52	Tiliaceae	*Grewia hirsuta*	Gursikhi

Sub Project 1: Diversity analysis of aleuritic acid content in major lac insect species/ strains and its use for better isolation strategies

Diversity analysis of Aleuritic Acid (AA) content in major lac insect species / strains were carried out. Estimation of the AA content in lac resins of different species *viz*. *K. chinensis*, *K. lacca* and *Kerria sharda* on different hosts like *Ber*, *Palas*, *Kusum* and *F. macrophylla* at different time intervals (0^{th}, 6^{th}, 12^{th} and 18^{th} month) of harvesting revealed that there is variation in AA content, percentage yield and purity with respect to the sample taken. Maximum yield of AA (19.81%) with 98.78 purity was observed in *K. chinensis* after harvesting. Further, a decreasing trend of the yield and purity with respect to the storage period was observed in each sample. (Fig. 9.5), (Table 9.3**)**

In order to check the purity of extracted AA, FTIR and DCS analysis carried out and compared with the pure AA sample. DSC analysis of AA extracted from *kusmi* (*ber*) *jethwi* season carried out and compared with the pure AA sample. DSC analysis of various samples gave following information:(Fig. 9.6 and Fig. 9.7)

Table 9.3: Melting temperature and normalised enthalpy of different aleuritic acid samples

Sample	Melting temperature (^{0}C)	Normalised Enthalpy (J/g)
Pure alueritic acid (AA)	102.18	182.61
Pure aleuritic acid 1	98.80	225.30
AA from extracted *kusmi*	97.42	124.96
AA from *kusmi* seedlac	95.01	188.03
AA from *kusmi* scraped lac	95.12	189.23
AA from *aghani kusmi* seed lac	95.09	39.425

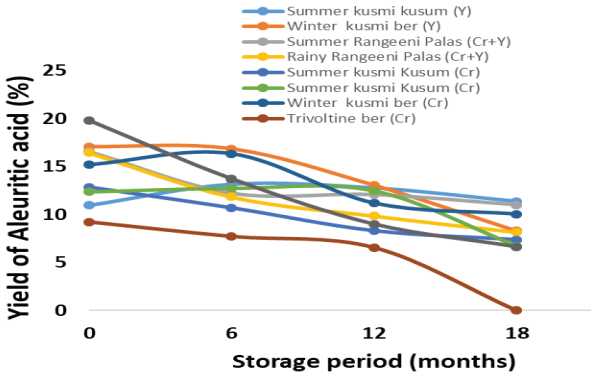


Fig. 9.5: Yield of aleuritic acid *vis-a-vis* the storage of lac resin in various samples

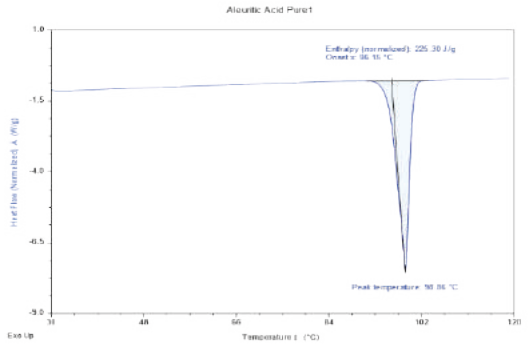


Fig. 9.6: DSC curve of pure aleuritic acid

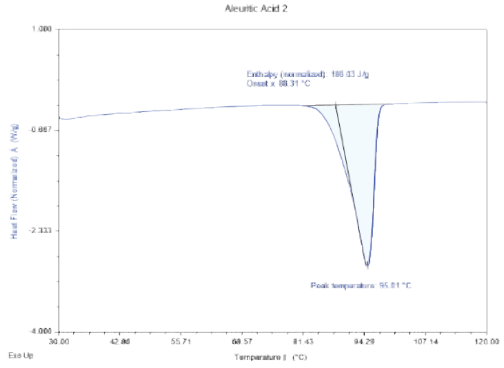


Fig. 9.7: DSC curve of aleuritic acid obtained from *kusmi* seedlac

It is clear from the DSC data that the AA isolated from all the samples contain impurity to the tune of 2-5 per cent when melting temperature and enthalpy of crystallization was compared with that of the pure AA samples. The consolidated table given below indicates the influence of storage of various resins samples on the AA yield and purity. It can be inferred that the yield of the AA was found to be minimum in trivoltine lac resin and maximum yield was obtained from fresh resin on K. chinensis. However, on storage, lac resin obtained from yellow strain cultivated during jethwi showed the highest yield at 18 months of storage. This indicates that this strain can be used for long term storage for AA isolation. (Table 9.4)

Table 9.4: Consolidated result of quality parameters of aleuritic acid obtained from various samples

Host	Strain	Season	Species	Colour	Aleuratic Acid (%)	MP (oC)	Purity from acid value	Alewurat-ic Acid (%)	MP (oC)	Purity from acid value	Aleuratic Acid (%)	MP (oC)	Purity from acid value	Aleuratic Acid (%)	MP (oC)	Purity from acid value
					After harvesting			6 months after harvesting			12 months after harvesting			18 months after harvesting		
Kusum	*Kusmi*	Summer (*Jethwi*)	*K. lacca*	Yellow	10.95	92.6	96.32	13.13	95.2	96.35	12.76	94.5	92.81	11.375	94	95.71
Kusum	*Kusmi*	Summer (*Jethwi*)	*K. lacca*	Crimson	12.37	92.6	93.83	12.74	93.5	96.16	12.48	94.5	87.03	6.69	94.5	96.15
Ber	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Crimson	15.18	92.6	95.86	16.34	91.1	96.50	11.19	95.5	95.00	10.04	96	91.36
Ber	*Kusmi*	Winter (*Aghani*)	*K. lacca*	Yellow	17.07	92.5	93.71	16.84	92.2	98.63	13.06	94.5	92.78	8.31	93.5	92.78
Palas	*Rangeeni* (Seedlac)	Summer (*Baisakhi*)	*K. lacca*	Crimson+ Yellow	16.60	94.5	92.05	12.22	91.5	97.14	12.08	93.5	97.07	11	94.5	96.3
Palas	*Rangeeni* (Seedlac)	Rainy (*Katki*)	*K. lacca*	Crimson+ Yellow	16.46	94.5	97.54	11.84	91.5	97.09	9.85	93	97.15	8.15	92.5	96.04
Ber	*Rangeeni* (Seedlac)	Rainy (*Katki*)	*K. lacca*	Crimson+ Yellow	12.84	94.5	97.49	10.685	91.5	97.10	8.3	93	97.78	7.37	91.5	97.37
Ber	Trivoltine *Kusmi*	-	*K. sharda*	Crimson	9.23	92.5	93.90	7.72	91.5	90.61	6.56	91.5	98.55	No sample for analysis		
F. macro-phylla	Thailand	Rainy	*K. chin-ensis*	Crimson	19.81	92.5	98.78	13.732	89.5	98.74	9.01	89.5	98.55	6.65	96.5	96.08

Sub Project 2: Taxonomic studies of lac insects (Hemiptera: Coccoidea: Tachardiidae) from different Agro climatic zones of India

Identification, morphological characterization and documentation of the lac insects collected from different agro climatic zones

1. Collection and preservation of lac insects for taxonomic studies

The survey for lac biodiversity by different network centers resulted in collection of natural lac insect populations from different locations of the country on different host plants (Table 9.5). Matured female samples were and processed for taxonomic studies.

Table 9.5: Lac samples identified from different locations with host details

Sl. No.	Location and Center collected samples	Host plants	Species identified
1	Madurai, Tamil Nadu (IINRG, Ranchi)	*Albizia saman*	*Kerria canalis*
2	Guntur, Andhra Pradesh (ANGRAU, Guntur)	*Conocarpus lancifolius*	*Kerria thrissurensis* and *K. rangoonensis*
3	Kurnool, Andhra Pradesh (ANGRAU, Guntur)	*Albizia saman*	*Kerria* spp. and *K. rangoonensis*
4	Bengaluru, Karnataka (NBAIR, Bengaluru)	*Annona* spp.	*Kerria rangoonensis*
5	Chikamagalur, Karnataka (KVK, Sirsi)	*Albizia saman*	*Kerria canalis*

2. Taxonomic identification, illustration and description

Identification and description were done based on the slide mounted adult female specimens. All five populations / samples collected in the study are identified. The new species is described from Madurai, Tamil Nadu on host *Albizia saman* (collected on November, 2018) as *Kerria canalis* Rajgopal (Fig. 9.9) and the same species was identified later from the collections from Chikamagalur, Karnataka on *Albizia saman*. *K. rangoonensis* earlier described by Chamberlin from Rangoon, Myanmar, this was only reported from Assam in earlier reports of Varshney from India. (Fig. 9.10) In this study this species is collected from different parts of South India (Table 9.5) and identified with morphological characterization.

3. To establish the systematic repository for lac and other insects associated with lac ecosystems from different agro climatic zones

Lac samples collected from different locations (Table 9.5) are preserved in insect repository in both permanent mount and alcohol preserved specimens for future reference. Along with lac insect's other lac-host plant insect pests from the orders Lepidoptera and Hemiptera are collected and preserved for detailed studies.

Among collected insects, scales insects of different lac insect host plants are identified with the help of ICAR-NBAIR, Bengaluru (Table 9.6). All insect pests infesting lac host plants collected and identified and deposited in IINRG insect repository. (Fig. 9.8)

Table 9.6: List of Insect pests identified from different lac host plants

Sl. No.	Host plant	Insect / mite pest	Family
1	*Kusum*	*Coccus hesperidum*	Coccidae
2		*Serinetha augur*	Coreidae
3		*Tessaratoma javanica*	Tessaratomidae
4	*Flemingia semialata*	*Aleurodicus dispersus*	Aleyrodidae
5		*Icerya aegyptiaca*	Monophlebidae
6		*Neostauropus alternus*	Notodontidae
7	*Ber*	*Aonidiella orientalis*	Diaspididae
8	*Ficus bengalensis*	*Hemilecanium imbricans*	Coccidae
9	*Palas*	*Labioproctus polei*	Margarodidae
10	*Samanea saman*	*Trijuba oculata*	Coccidae



Neostauropus alternus *Aleurodicus dispersus*

Fig. 9.8: Insect pests identified from *Flemingia semialata*

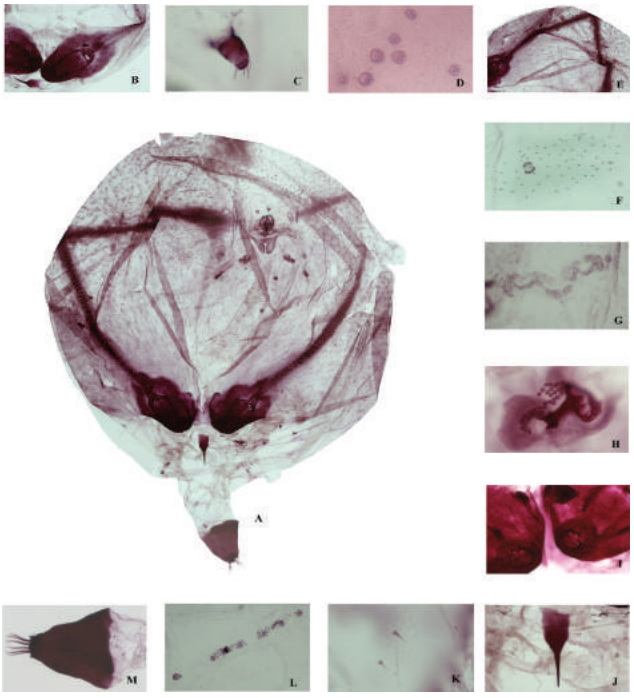


Fig. 9.9: Diagnostic characters of a slide-mounted adult female of *Kerria canalis* sp. nov. A. Whole mount; B. Brachia; C. Antenna; D. Star pores near mouthparts; E. Trailing canellar band; F. Ventral duct cluster; G. Marginal duct cluster; H. Posterior spiracle; I. Brachial plate and crater with dimples; J. Dorsal spine; K. Ventral setae; L. Perivulvular duct cluster; M. Anal tubercle

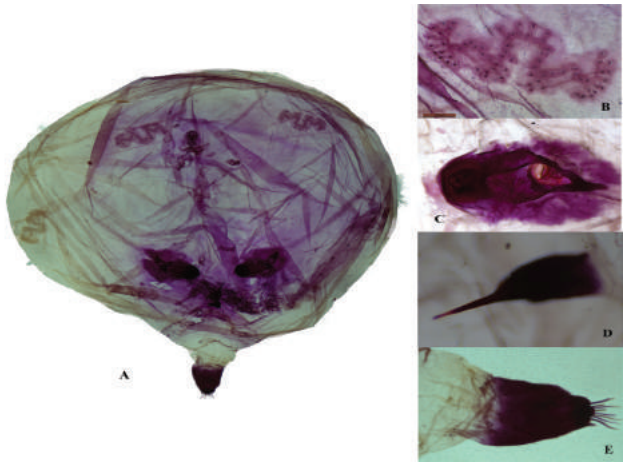


Fig. 9.10: Diagnostic characters of a slide-mounted adult female of *Kerria rangoonensis* (Chamberlin). A. Whole mount; B. Marginal duct cluster; C. Brachia; D. Dorsal spine; E. Anal tubercle

Network Cooperating Centres

9.2 Assam Agricultural University (AAU), Jorhat

Study on life cycle parameters of *K. chinensis* and *K. lacca* on *F. semialata*

Experiments to study the various life parameters of *K. chinensis* on *F. semialata* for the last five years (2016-2021) revealed that the average pre-sexual maturity period (49.2 days v/s 37.5 days), duration of male emergence (92.8 days v/s 52.3 days) and female longevity (194.8 days v/s 167.3 days) were higher in summer season than in winter.

During the survey of West Bengal in 2018, lac insect *K. lacca* was collected from Howrah (AAUK-17) and inoculated at Regional Field Gene Bank (RFGB), AAU, Jorhat. Experiments to study the various life parameters of *K. lacca* on *F. Semialata* revealed that the strain is tri-voltine in nature. Data presented in Table 9.7

Table 9.7: Life cycle parameters of *K. lacca* (AAUK-17) on *F. semialata*

Life cycle parameters in days	2018-2019	2019-2020		2020-2021			2021-22			Pooled Data (2018-2022)		
	Summer 27.10.18 to 21.5.19	Monsoon 21.05.19 to 27.08.19	Winter 27.08.19 to 27.01.20	Summer 27.1.20 to 8.6.20	Monsoon 8.6.20 to 8.9.20	Winter 8.9.20 to 15.2.21	Summer 15.2.21 to 16.6.21	Monsoon 16.6.21 to 23.9.21	Winter 23.9.21 to Cont.	Summer (Jan-Feb/ June-July)	Monsoon (June-July/Sep)	Winter (Sep/Jan-Feb)
Pre-sexual maturity	63	34	34	52	38	30	47	37	35	54	36.33	33
Male emergence	136	41	55	58	43	41	55	45	50	83	43	48.66
Female longevity	201	96	150	134	90	160	104	97	-	146.33	94.33	155

Seasonal incidence of *Eublemma amabilis* during summer and winter season in Assam

Incidence of *E. amabilis* was studied at RFGB, AAU, Jorhat during summer and winter crops of *Kerria chinensis* (Mahd.). Population of natural enemies were recorded from a few randomly selected host plants of *F. semialata* Roxb. The observation was based on the hollow lac cell caused by *E. amabilis* larvae. During both cropping seasons, first record of hollow lac cell was observed from 37-40 days (pre sexual stage of lac insect) onwards to maturity. After 21 days of inoculation, the *phunki* lac was removed and placed in natural enemy emergence cage fitted with glass tubes to study the emergence of adult *E. amabilis*. The maximum emergence of *E. amabilis* adults was recorded during first week of June and third week of December in summer and winter crop, respectively. The predator completed its first generation within one month of inoculation and continued up to maturity with more than four generations. Biological parameters of *E. amabilis* recorded are given in Table 9.8.

Table 9.8: Biological parameters of *E. amabilis*

Parameters	Days
Pre-oviposition period	7-12 days
Oviposition period	11-21 days
Fecundity	29-51 nos.
Incubation period	9-14 days
Total larval duration	27-46 days
Pupal development	8-11 days
Adult longevity a) Female b) Male	 6.5-8 days 5-7 days

Sub project 1: Study on pathogenicity of naturally occurring native isolate of entomopathogenic fungi (EPF) against *Eublemma amabilis* and lac insect

A new native entomopathogenic fungi recorded from lac ecosystem

Cadaver of *Archips* sp. (pest of *F. semialata*) with fluffy fungal growth was collected from the RFGB, AAU, Jorhat. The collected specimen was isolated, pure culture and subsequent sub- culture were done. Pathogenicity study was carried out in different group of insects and were found to be effective (Fig. 9.11 and 9.12). It was found effective against lepidopteran pests *viz*., *E. amabilis* and Rice leaf folder. Morphology and molecular characterization of the native EPF was carried out and identified as *Cordyceps javanica.*



Fig. 9.11: *Cordyceps javanica* infected rice leaf folder



Fig. 9.12: *Cordyceps javanica* infected tea mosquito bug

Sub project 2: Chemical characterization of lac resin produced by *Kerria chinensis* and value addition

Chemical characterization of lac resin produced by *K. chinensis* was done by carrying out qualitative phytochemical tests of water extracts (Table 9.9) and analysis of lac powder with different chemical reagents (Table 9.10).

Table 9.9: Qualitative phytochemical tests of water extract of lac

Sl. No.	Name of tests	Water extract
1.	Carbohydrates a) Molisch's test	 +
2.	Proteins and amino acid a) Ninhydrin test	 -
3.	Resins a) FeCl3 test	 +
4.	Alkaloids a) Wagner's reagent test b) Dragendroff's test	 - -
5.	Flavonoids a) Lead acetate test	 -
6.	Saponins a) Foam test	 -
7.	Tannins a) FeCl3 test b) Lead acetate test	 + -
8.	Phytosterols a) Salkawski's test	 +

+ represents presence of compounds

Table 9.10: Analysis of lac powder with different chemical reagents

Sl. No.	Reagents	Colour observed	pH
1	Lac + water	Reddish brown	4.79
2.	Lac + NaOH in water	Purple	8.20
3.	Lac + HCl in water	Orange	1.52

Optimization of extraction and dyeing parameters of lac dye

A series of experiments were carried out to optimize the extraction parameters such as pH, temperature, extraction time, mordanting concentration, material: liquor ratio *etc*. of lac dye. For dyeing of cotton yarn, water and acid extraction was found to be better as compared to alkaline extraction. Application of water-based lac extraction in cotton yarn with plant based mordants was also carried out and attempts made to dye the Assamese traditional *gamusa* to have a beautiful look (Fig. 9.13 and 9.14).



Fig. 9.13: Application of water-based lac extraction in cotton yarn using natural mordants

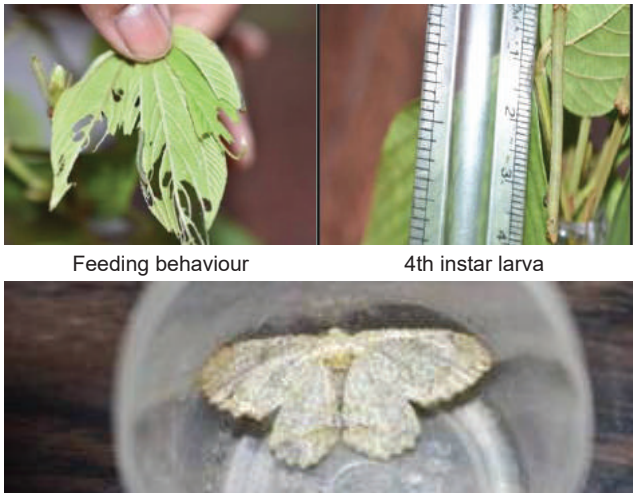


Fig. 9.14: Assamese traditional gamusa

Pest complex study in lac ecosystem

Tea looper, *Biston suppressaria* and black looper or black inch worm, *Hyposidra talaca* are major insect pests of tea crop belonging to the family Geometridae. They were recently recorded in lac ecosystem at RFGB, AAU, Jorhat (Fig. 9.15 and 9.16). Continuous observation on lac host plants showed that these two insect pests feed vigorously and defoliate the leaves of *Flemingia semialata* and *F. macrophylla*. The pests were recorded from January to July, 2021 and the highest infestation was recorded in the month of May, 2021. The early instar larvae cut small holes along the margin whereas the full-grown larvae feed voraciously on mature leaves, from the margin towards the mid rib, leaving the mid rib uneaten. Hence, looking at the severity of infestation, certain aspects of *B. suppressaria*'s biology were studied at temperature 27 ± 1°C, and RH 80 to 85%. The looper caterpillar showed complete metamorphosis. There are four stages in its life cycle *i.e.* egg, larva, pupa and adult. The insect completed its life cycle within 50 to 60 days; the incubation period ranged from 10 to 15 days. The larval period was about 3 weeks and the insect passed through five instars. The pupal period was about 3-4 weeks. The total fecundity of *Biston suppresarria* ranged between 250-350 eggs. Adults lived for 5-7 days. These two pests cause about 80-90% damage to the plant both in the field and the laboratory condition. Thus, the key pests of tea crop might become major pests of *Flemingia* sp. in the near future.

Leaf roller, Tussock moth, White fly, Flea beetle, *Somena scintillans*, were also found to be the pests of lac host plants. Pest calendar is depicted in Table 9.11.



Feeding behaviour 4th instar larva

Adult

Fig. 9.15: Feeding behaviour, larva and adult of *Biston suppresarria*



Infestation by larvae



Adult

Fig. 9.16: Infestation of larvae and adult of *Hyposidra talaca*

Intercropping of lac culture with king chilli

World hottest chilli (king chillies) were intercropped with lac culture under net house condition for augmenting the farmers' income (Fig. 9.17a and 9.17b). Observation was made that while intercropping king chilli with lac culture, king chillies were free from most pest and diseases. Intercropping also utilizes the free space between two rows of host plants. Total of 626.59 g king chillies were harvested from six picking from two plants. The cost of king chilli is around Rs 400 per kg.



Fig. 9.17. a: Intercropping of lac culture with king chilli under net house



Fig. 9.17. b: King chillies

Survey in Assam

During 2021, three districts (Dhemaji, Kokrajhar and West Karbi Anglong) of Assam comprising of fourteen villages *viz.,* Mesaki, Bishmari, Patgaon, Serfanguri, Kalabari, Guabari, Ballimari, Gossaigaon, Joyma, Doloi, Engti Thengkiri, Langerdarg, Tharbari, Aflagaon and five blocks (Jonai, Kokrajhar, Gossaigaon, Dotoma & Amri) were surveyed. Local people reported the occurrence of natural lac insect more than 10 years ago. Broodlac collected during surveys from Langardang, Doloi, Engtithengkiri villages of West Karbi Anglong during last week of October, 2021 was inoculated at RFGB, Dept. of Entomology, AAU, Jorhat. Seeds and seedlings of *Flemingia semialata* (Host plant of lac insects) were distributed to the farmers in Doloi village of West Karbi Anglong (Fig. 9.18 and 9.19). *In-situ* harvesting of *K. chinensis* which was naturally abundant on *peepal*, *Leea* sp. & *Albizia lucidor* during the survey was in progress in West Karbi Anglong district (Fig. 9.20 and 9.21).



Fig. 9.18: Seeds distribution to farmers

Table 9.11: Pest calendar for the year 2021

Sl. No.	Insect Species	January 2021	February 2021	March 2021	April 2021	May 2021	June 2021	July 2021	August 2021	September 2021	October 2021	November 2021	December 2021
1	*Archips* sp.												
2.	*Orgyia* sp.												
3	*Somena scintillans*												
4.	*Hyposidra talaca*												
5.	*Biston suppresarria*												
6.	*Bemisia tabaci Genn.*												



Fig. 9.19: Planting of *F. semialata* sapling



Fig. 9.20: *In-situ* harvesting of *K.chinesis*



Fig. 9.21*: Albizia lucidor* a new host of lac insect

Capacity building

Three hands-on-trainings and one OFT were conducted to generate awareness and to disseminate technology on lac cultivation during 2021. First Training was conducted at Mesaki village of Dhemaji district on 13th February, 2021 with 17 farmers and OFT was also carried out. The 2nd training was conducted at Kokrajharon on 17th March, 2021 with 28 farmers and third training was on 29th November, 2021 at Doloi village of West Karbi Anglong with 39 farmers and four members of KASS, West Karbi Anglong as resource person.

Distinguished Visitors

- Director, Institute of Pesticide Formulation Technology, Gurugram
- OSD of Bodoland & Agricultural Consultant visiting RFGB and Lac laboratory

Institute - industry interface meeting

Das P, Asst. Prof. distributed seeds of *Flemingia semialata* & scrappedlac to Weave-Matrix Social Pvt. Limited, Guwahati and to Puspadhar Kachari, OSD to Promod Bodo, CEM, BTR & Amiya Roy (Agril. Consultant) for cultivation of lac insects.

9.3 Acharya N.G. Ranga Agricultural University (ANGRAU), Guntur

- ✓ Survey was conducted for occurrence of lac insects in Chittoor, Guntur, Kurnool, Anantapuramu and West Godavari, districts of Andhra Pradesh. During the survey occurence of lac insect was observed on *Albizia saman* in Chittoor, Kurnool and Guntur districts of Andhra Pradesh (Fig. 9.22) and Hyderabad of Telangana state. Lac encrustation was also observed on *Conocarpus lancifolius* in Chittoor, Nellore and Guntur districts of Andhra Pradesh. *Eublemma amabilis* infestation was observed in lac insect samples collected from Guntur district (Fig. 9.23).
- ✓ First time reported *Kerria rangoonensis* on *Conocarpus lancifolius* and *Albizia saman* from Andhra Pradesh
- ✓ As a part of survey, identified some parts of East Godavari *(Flemingia semialata)*, Vizianagaram *(A. saman)*, Srikakulam *(A. saman)* and Guntur *(A. saman)* districts as potential areas for the lac cultivation on lac-host indicated in the bracket.
- ✓ Established lac host plants, *Flemingia semialata* and *F. macrophylla* at S.V. Agricultural College, Tirupati, Andhra Pradesh
- ✓ Insect pests associated with different host plants such as *F. semialata, F. macrophylla*, *C. lancifolius* and *A. saman* were recorded under Andhra Pradesh conditions. *Spodoptera*, leaf webber, defoliater, mealy bug, hairy caterpillar, aphid and spiders were recorded on *F. semialata* and *F. macrophylla*. Hairy caterpillar, bark eating caterpillar and bag worms were observed on *C. lancifolius* (Fig. 9.24). Leaf and bark eating caterpillars, mealy bug are observed as pests of *A. saman* at different places of Andhra Pradesh (Fig. 9.25).



Fig. 9.22: Lac insect on *Albizia saman* at Nadikotkur area of Kurnool District (AP)



Fig. 9.23: *Eublemma amabilis* on lac insect on *Albizia saman* in Guntur District (AP)



Bag worm | Bark eating caterpillar damage



Hairy caterpillar | Hairy caterpillar

Fig. 9.24: Insects associated with *Conocarpus lancifolius* at different places in Andhra Pradesh



Leaf eating caterpillar damage | Mealy bug



Bark eating caterpillar | Bark eating caterpillar

Fig. 9.25: Insects associated with *Albizia saman* at different places of Andhra Pradesh

9.4 Central Agricultural University (CAU), Imphal

Study on biology and host preference of lac insect found in Manipur

Study on biology and host preference of existing species of lac insect in Manipur was conducted on five host plants viz., *Cajanus cajan*, *Flemingia macrophylla, F. semialata, Calliandra surinamensis* and *Malvaviscus penduliflorus.* Productivity linked parameters were recorded on twenty plants in the four sets of five pots each sown before the inoculation of broodlac. Results are shown in Table 9.12.

Table 9.12: Mean productivity linked parameters of lac insect on five different host plants in Manipur

Host	Initial density of settlement (per sq. cm)	Initial mortality (%)	Final density of settlement (per sq. cm)	Density at crop maturity (per sq. cm)	Wt. of female cell (in mg)	Fecundity (nos./ cell)	Yield of scrapped lac (in g)
Cajanus cajan	96.97	19.56	75.17	2.94	10.15	192.79	64.40
Flemingia macrophylla	112.89	11.74	94.24	7.85	21.49	318.42	166.84
Flemingia semialata	108.58	14.12	89.48	6.21	17.73	290.65	155.78
Malvaviscus penduliflorus	99.92	16.58	82.59	4.64	11.35	251.39	86.62
Calliandra surinamensis	105.42	15.89	84.51	5.91	14.61	213.25	133.32

Host	Initial density of settlement (per sq. cm)	Initial mortality (%)	Final density of settlement (per sq. cm)	Density at crop maturity (per sq. cm)	Wt. of female cell (in mg)	Fecundity (nos./ cell)	Yield of scrapped lac (in g)
SE (d)	1.119	0.90	1.26	0.51	1.28	11.72	3.48
CD (5%)	2.525	2.01	2.82	1.14	2.85	26.12	7.75

To study the biology of *rangeeni* strain of lac insect, observations on different parameters responsible for the growth and development of the insect on *C. cajan* were recorded. The parameters *viz.,* duration of pre-sexual stages (days), duration of male emergence (days), sex ratio (male %) and life period of the female cell were recorded in rainy season of 2019-2020 on *C. cajan* to find out the behavior of the insect (Table 9.13). Data presented are the mean of four replications.

Table 9.13: Biology of *rangeeni* strain of lac insect on host plant *Cajanus cajan* in Manipur

Part of the twig	Mean duration of pre sexual stages (days)	Mean duration of male emergence (days)	Mean sex ratio (%)	Mean life period (days)
Upper portion	46.6	12.1	26.0	122.0
Middle portion	49.0	13.9	28.1	121.7
Lower portion	51.7	15.9	29.1	123.9
SE (d)	1.09	0.83	0.84	0.84
CD 5%	2.47	1.88	1.90	1.85

Survey for naturally occurring lac insects and host plants

Survey was conducted on both valley and hilly areas of Manipur covering nearly 30 villages for the occurrence of lac insect.

Survey in valley areas: On surveying valley areas *i.e.* Kakching, Bishnupur, Imphal East, Imphal West and Thoubal Districts, host plants like *arhar*, cassod tree, *Acacia*, *Malvaviscus penduliflorus*, *Calliandra surinamensis*, *peepal* tree and subabul were found growing abundantly on the road side. Some of them were found to have live lac insects associated with them and some of the host plants were found to carrying dead lac only (Table 9.14).

Table 9.14: Details of surveys conducted in valleys

Sl. No.	Surveyed Villages	Location tag (GPS)	Host plants	Remarks
A.	Kakching District			
1	Umathel	N-24° 23.656`, E- 93° 54.595`	*Arhar*	Dead lac was found on Cassod tree
		N-24° 23.600`, E- 93° 54.570`	Cassod	
		N-24°23.611`, E-93°54.576`	*Acacia sp.*	
2	Pangaltabi	N-24°21.691`, E-93°53.627`	*Malvaviscus penduliflorus*	
		N-24°20.638`, E-93°53.137`	Subabul	
3	Khorsantabi	N-24°19.822`, E-93°53.040`	*Acacia sp.*	
4	Sugnu wapokpi	N-24°17.984`, E-93°52.619`	*Ber*	
5	Sugnu bazar	N-24°17.663`, E-93°52.482`	*Acacia sp.*	
B.	Bishnupur district			
6	Sendra	N-24°51.4448`, E-93°79.3348`	Cassod, *Calliandra surinamensis*	Dead lac was found
7	Lairenjam	N-24°44.068`, E-93°52.579`	*Hibiscus rosa-sinensis*, *peepal, Malvaviscus penduliflorus*	Live lac along with ant nesting was found
C.	Imphal East district			

Sl. No.	Surveyed Villages	Location tag (GPS)	Host plants	Remarks
8	Mantripukhri	N-24°85.279`, E-93°93.4889`	*Calliandra surinamensis*, peepal tree, Acacia tree	Dead lac found
9	Khabeisoi	N-24°85.1027`, E-93°98.8599`	*Ficus benjamina*	Dead lac found
D.	Imphal West district			
10	Lamphelpat DC Office	N-24°48.722`, E-93°54.768`	*Ber*	Dead lac was found on *ber*
11	Nursery site of College of Agriculture, CAU, Imphal	N-24°81.253`, E-93°88.955`	*Calliandra surinamensis*	Live lac found

Survey in hilly areas: Survey was conducted on some villages of hill districts of Manipur *i.e.,* Chandel district, Senapati District, Ukhrul district, Kamjong District, Tamenglong district and Kangpokpi district. On surveying host plants, *ber*, *peepal*, *Flemingia macrophylla, F. semialata, Acacia*, subabul, *arhar* and *Malvaviscus penduliflorus* were observed. Live lac insects were found on *F. macrophylla* and *arhar* at Chakpikarong- Gamvet-mol road and Chalong lamkhai, respectively in Chandel district. Other host plants were also surveyed in some villages of Chandel district but no lac insect, either dead or live insects was found. In Ukhrul district, villages namely Lambui, Sangshak, sangshal, Sangshak khunou, Leiting, Koso,Phalong Shakok and Phungyar were surveyed. On surveying these villages, live lac insects were found on *peepal* tree at Finch Corner. Many host plants namely; *F. macrophylla*, *M. penduliflorus*, subabul *etc* were found abundantly in the villages where survey was conducted but no lac insects were found on any of them. Kamjong district was resurveyed and only the host plant *M. penduliflorus* was found in Phungyar and Kamjong and no lac was found on them. Villages *viz*; Longsai, Gangluan, Phijang, Duangailong, Gangluan, Namkaolong, Tengkongjang, Taolingpung and Khoupum valley were surveyed. Host plants such as *ber*, *arhar* and *F. macrophylla* were found in these villages. No lac insect was found on any of the host plants. In Senapati district, resurvey was done in areas of Taphou village, Taphoukuki, DC office Senapati, Assam Rifles Camp Senapati, Poulea colony, Karong and Vakho village. Host plants, *arhar*, *Acacia* tree and *M. penduliflorus* were found growing commonly in many of the surveyed villages. Other host plants were seen growing very rarely. No live lac insect was found but dead lac insect was found on *Acacia* tree at Poulea Colony. Host plant *Albizia lebbeck* not recorded in in previous survey, was found growing on Karong areas without any lac insect. Maohing village, Songphejang village, Toriban village, Haokholen veng, Changoubung and Motbung areas of Kangpokpi District were surveyed. *Arhar*, *M. penduliflorus*, and *peepal* tree were found commonly and no lac insect was found to be associated with them.

Study on silk dying with lac dye

For identification of the visible colour range, the absorbance peak of the extracted lac dye was determined by UV- Visible Spectrophotometer and the wavelength of the extracted lac dye was 550 nm. From the present experiment, it was revealed that dyeing of silk with a solution of lac dye and different chemical mordants produce variant shades ranging from light to dark intensity. 24 treatment were tested for evaluation of 1:10 and 1:20 of the w/v of the lac dye using three different mordanting methods (pre-mordanting, meta-mordanting and post-mordanting) at 5% and 10% (w/w of the silk fabric) of the chemical mordant (potassium alum and citric acid). Variant colour in silk fabric dyed with lac dye are greatly influenced by the type of the chemical mordants used and also the mordanting methods. While analyzing the colour intensity of the chemical mordant potassium alum ($KAl(SO_4)_2$), the pre mordanting methods gave darker intensity whereas meta mordanting methods gave lighter shades; in the chemical mordant citric acid meta mordanting gave darker shades and post mordanting produced lighter shades.

It was observed that pre-mordanting methods with 10% potassium alum at the ml ratio of 1:10 of the lac dye produced darker intensity whereas in citric acid meta-mordanting methods with 5% citric acid at the ml ratio of 1: 10 gave darker intensity. Lac dye produced six different shades as it was screened for 24 treatments. However, colour evenness and intensity could develop only in perfect mordant at definite quantity under specific process. The shades of all the treatments were analyzed through Munsell colour chart as given below in (Table 9.15).

Table 9.15: Table showing the hue group or colour obtained in different mordanting methods

w/v of lac dye	Chemical mordant	Parameters	Pre-mordanting	Meta-mordanting	Post-mordanting
1:10	5% Potassium Alum ($KAl(SO_4)_2$)	Munsell value	7.5 RP 2/8	7.5 RP 5/2	2.5 RP 4/4
		Hue group or colour	Red purple	Red purple	Red purple
	10% Potassium Alum ($KAl(SO_4)_2$)	Munsell value	7.5 R 1/2	2.5Y 5/1	2.5 P5/2
		Hue group or colour	Red	Yellow	Purple
	5% Citric acid	Munsell value	5 R 7/4	10R3/3	10R3/4
		Hue group or colour	Yellow red	Red	Red
1:10	10% Citric acid	Munsell value	7.5 RP 7/6	7.5YR 7/12	10R 4/4
		Hue group or colour	Red purple	Yellow red	Red
1:20	5% Potassium Alum ($KAl(SO_4)_2$)	Munsell value	2.5RP 4/3	N6	N5
		Hue group or colour	Red purple	Neutral	Neutral
	10% Potassium Alum ($KAl(SO_4)_2$)	Munsell value	5R 3/1	N7.5	N5
		Hue group or colour	Red	Neutral	Neutral
	5% Citric acid	Munsell value	5R 5/4	5R 7/6	5R 7/4
1:20		Hue group or colour	Yellow red	Yellow red	Yellow red
	10% Citric acid	Munsell value	5R 5/4	5YR 7/6	5 YR 7/3
		Hue group or colour	Red	Yellow red	Yellow red

Conservation of lac insect and hosts plants at Regional Field Gene Bank

New Research field has been established at the college campus because work at the research field located at Lamsang was discontinued. various hosts plants like white hibiscus, *Ficus benjamina*, *Calliandra surinamensis*, *Ficus religiosa*, *Flemingia macrophylla*, *Feamingia semialata*, *Cajanus cajan*, *Malvaviscus penduliflorus* are being grown in the new field (Fig. 9.26).



Fig.9.26: Regional Field Gene Bank at College of Agriculture, Iroisemba, Central Agricultural University, Imphal

Popularization of lac

The Centre participatted in 'Showcasing of Technology Products and interface Scientists-Farmers /FPOs / Agripreneurs' on 27th October, 2021. Importance of lac insects, lac by-products and activities of Imphal Centre were explained to visitors including the Hon'ble Minister of State for Agriculture & Farmers' Welfare Govt. of India Mrs. Shobha Karandlaje and Dr. Anupam Mishra, Hon'ble VC of CAU. (Fig. 9.27).



Fig. 9.27: PI, explaining the importance of lac at an event

9.5 Kerala Forest Research Institute (KFRI), Thrissur

Surveys and lac insect collection

During January 2021 six new locations were reported from Tamil Nadu with lac including four locations with live lac and two with dead lac. The locations with live lac include (i) Krishnarayapuram, Karur district, (ii) Srirangam, Trichirapalli district, (iii) Thenkashi, and (iv) two locations from Madurai. All of these were added in the Regional Field Gene Bank (RFGB) at KFRI, Thrissur. One dead lac was also reported from Madurai. Two dead lac locations were reported from Madurai and Trichy Road, Karur district, respectively. The entire reported samples were collected and brought to laboratory and preserved in 95% alcohol for further identifications.

Karur, Trichy and Madurai, Tamil Nadu: A field visit was organized from January 12- 16, to three districts of Tamil Nadu *in lieu* with earlier reports of live lac insects. Three new locations with live lac could be reported during the survey which includes Krishnarayapuram, Trichy- Karur Main Road (10.95340 ^{0}N, 78.280227 ^{0}E), S.S. Colony, Bypass Road, Sakthi Velammal Nagar, Madurai (9.926203 ^{0}N, 78.09430 ^{0}E) and Srirangam, Trichy (10.85359 ^{0}N, 78.691212 ^{0}E). The sample from Srirangam was collected upon maturation in the month of July. A new location with dead lac was also reported from NH44, Karur (10.940276 ^{0}N, 78.056427 ^{0}E).

Trichy, Thanjavur and Kumbakonam, Tamil Nadu: A field survey was conducted on 27 and 28 February to Trichy, Thanjavur and Kumbakonam, resulted in the discovery of a new live lac insect location in Musiri in the Trichy district of Tamil Nadu (10.961144˚ N, 78.438090˚ E).

Kadayanallur, Thenkashi, Tamil Nadu: The live and mature lac insect samples were collected from Kadayanallur (9.01999˚ N, 77. 31040˚ E) in the Thenkashi district of Tamil Nadu in the month of November and were brought to be maintained at RFGB, KFRI, Thrissur. These samples were not only maintained in the RFGB but also distributed to a new farmer in Tamil Nadu.

Thennur Bridge, Trichy, Tamil Nadu: New live lac insect samples were observed and collected from two *Albizia saman* trees (10.818473˚ N, 78.690722˚ E and 10.818332˚ N, 78.690904˚ E) and one *Ficus religiosa* (10.818253˚ N, 78.6903 ˚ E) from Thennur Bridge, Trichy, Tamil Nadu on November 8, 2021. A dead *Albizia saman* was also observed at 10.818267 ˚N, 78.690347˚ E, due to heavy infestation of lac, which reassures the primary objective of the network project that, naturally occurring lac samples should be collected and genetic resources should be conserved for the protection of the lac species as well as that of the host plants and associated ecosystem.

Dindigul, Tamil Nadu: An earlier reported lac sample from Dindigul, Tamil Nadu (10.356333 ˚N, 77.972992 ˚ E), was obtained during collection visit in the month of November 2021. The collected samples were of about 4 months of maturation.

Since 2015, KFRI has surveyed all the districts of Kerala, Tamil Nadu and the Pondicherry Union Territory, 12 districts of Karnataka and 5 islands of the Lakshadweep Union Territory covering around 6500 kilometers. Of these, lac was reported from 126 locations in Tamil Nadu, 18 locations in the Pondicherry Union Territory, 14 locations in Kerala and 2 locations in Karnataka. No lac was reported from the surveyed areas of the Lakshadweep Union Territory.

In Tamil Nadu, lac has been recorded from 29 districts in 126 locations with Salem and Tiruchirapalli (16 each) with the highest number of records followed by Tiruppur (10), Karur (10) and Nagapattinam (9).

In Kerala, lac was reported from 7 locations in Thiruvananthapuram district, 4 locations in Palakkad and 1 location each in Thrissur, Kollam and Malappuram districts.

In the Pondicherry Union Territory lac was recorded from 13 locations in Puducherry and 5 locations in Karaikkal district. No lac was found in Yanam and Mahe districts during the surveys.

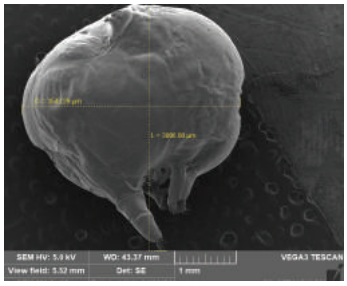
In Karnataka lac has been observed from 2 locations in the Mysore district.

An extensive field survey was carried out on five major islands out of the eleven accessible islands of the Lakshadweep Union Territory in March 2021, covering 5 major islands namely Agatti including Bangaram Atoll and Thinnakara Island, Kavaratti, Amini and Kadmat islands. However, no lac was reported from these places.

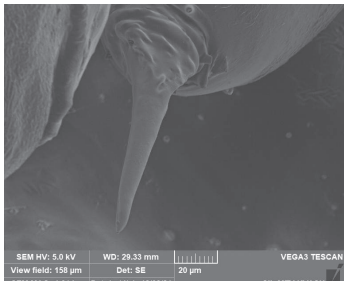
The host plants from which lac has been reported includes *Acacia leucophloea, Acacia planifrons, Albizia amara, Albizia lebbeck, Albizia saman, Amherstia nobilis, Ficus benghalenis, Ficus racemosa, Ficus religiosa, Peltophorum pterocarpum* and *Ziziphus mauritiana.*

Among these lac was reported from 141 rain trees (*Albizia saman*).

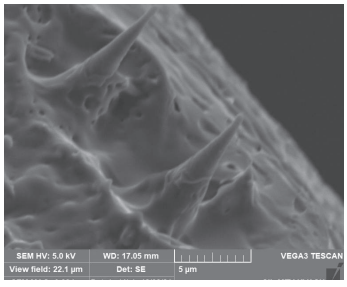
Lac was found in different elevation levels in each state. In Kerala, lac was mainly reported from low elevated areas (3-100 m). Lac from high-elevated area was reported from Karnataka (777 m). Lac recorded places in Tamil Nadu are coming under the range of 100-400 m.



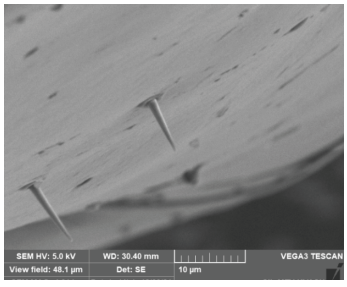
SEM image of whole mature female lac insect collected from A. nobils (Shimshipa). Yellow line indicates measurements of L=Length and D=Diameter



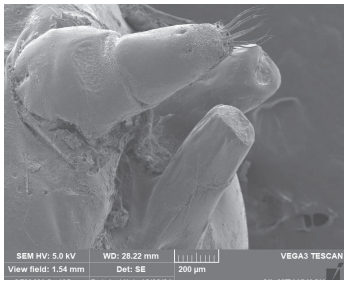
Dorsal spine



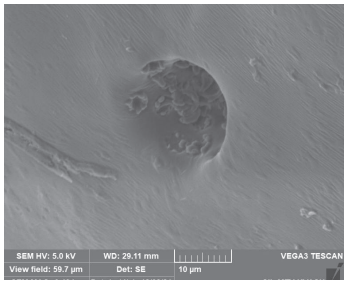
Spine on Brachial plate



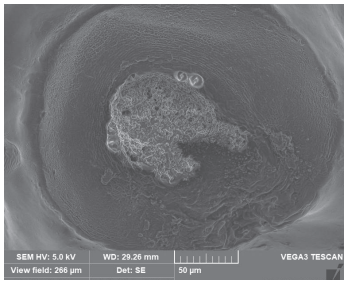
Dorsal setae



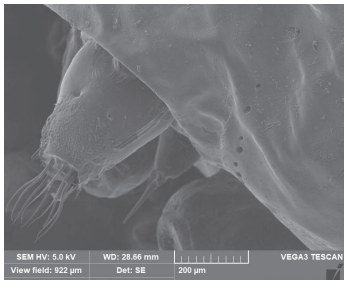
Anal fringes and Brachial plate



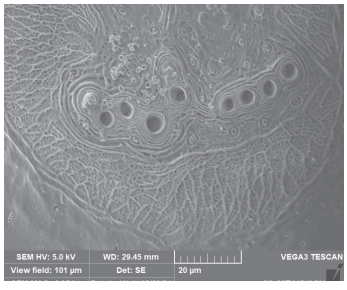
Perivulvar pore cluster with multilocular pores



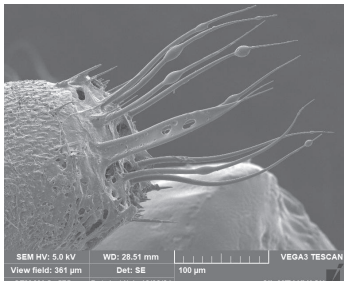
Brachial plate



Anal fringes and Perivulvar pores



Marginal duct clusters



Anal fringes with nodules

Fig. 9.28: SEM images of lac insect and body parts

Scanning Electron Microscopy

All the collected samples in the year 2021 were subjected to Scanning Electron Microscopy (SEM) studies (Fig. 9.28). SEM studies were carried out at College of Veterinary & Animal Sciences, Mannuthy, Thrissur, Kerala in the Central Instrumentation and Analytical Centre. (Fig. 9.29) depicts the graph showing the morphological variation in mature female lac insect on different host plants (*Amherstia nobilis*, *Butea monosperma*, *Calliandra haematocephala* and *Ziziphus m*auritiana) in Kerala.

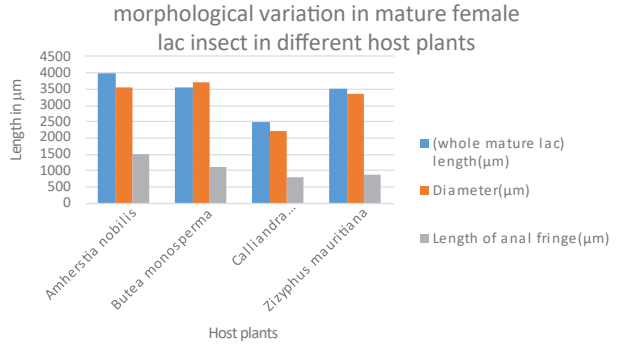


Fig. 9.29: Graph showing the morphological variation in mature female lac insect on different host plants in Kerala

Project Reports: Three MSc (Zoology) students from SN College, Alathoor, Palakkad, Kerala have completed their dissertations on three different topics on lac insects. The titles of their dissertations and the major findings of their projects are as follows:

1. Identification of the strains of *Kerria lacca* collected from three localities in Tamil Nadu and estimation of productivity linked parameters

Identification of Kerria lacca samples collected from three regions Karur, Sri Rangam and Madurai was found to be of rangeeni strain of lac insect. BLASTN analysis of all the sequences showed 100% similarity with Kerria sp. of rangeeni strain which was earlier collected from Madurai from a different location.

In post-harvest productivity linked parameters, F. semialata plants showed sufficiently good live cell weight, maximum fecundity, greater resin weight, higher dry cell weight as well as less mean mortality percentage of crawlers whereas F. macrophylla plants had poor productivity parameters and higher mean mortality percentage.

2. Correlation of sex ratio and maturation of *Kerria lacca* with abiotic factors and physiological characters of major three host plants (*Flemingia semialata, F. macrophylla and Cajanus cajan*) in Kerala

The maturation of *Kerria lacca* females have negative correlation with the abiotic factor humidity. Mean number of females on *Flemingia semialata, F. macrophylla* and *Cajanus cajan* have a positive correlation with the physiological factor girth.

Sex ratio (percentage of male) evaluation in the study areas also varies considerably with the highest sex ratio in *Flemingia semialata* plants at RFGB, KFRI campus and least in *F. macrophylla* plants in Thottapady, Thrissur.

3. Performance of *Kerria lacca* on different host plants in Kerala with study on the morphological variations in the mature female cells

For investigating the performance of *Kerria lacca* on different host plants, enumeration of live crawlers, dead crawlers and maturation of female lac insects were carried out on host plants such as *Albizia saman, Ziziphus mauritiana, Calliandra haematocephala, Butea monosperma, Flemingia semialata, F. macrophylla, Cajanus cajan and Amherstia nobilis* along with study of morphological variations in mature female cells by using Scanning Electron Microscopy.

The results revealed that in *B. monosperma,* mean live lac insects was found to be 75 (lac crawlers per sq. cm), mean dead to be 4 (dead crawlers per sq. cm) and mean maturation to be 14.33 (mature female cells per sq. cm). By investigating the morphology of mature female cells using SEM, the mature female cells collected from *B. monosperma* had a length of 3.55 mm and diameter of 3.72 mm.

Publicity on lac insects

Students of the department of Zoology, from Kerala Varma College, Thrissur paid a visit to KFRI and attended a small workshop on lac insects. They were informed about the life cycle of lac insects, got their hands on preparing broodlac bundles for inoculation and were demonstrated with the products of lac. Since their curriculum includes beneficial insects such as lac, honey bees and silkworms, getting to know about lac with their own eyes amused these students. This is especially due to the unavailability of lac in the state of Kerala.

Training

Five farmers (four in Kerala and one in Tamil Nadu) were given lac cultivation training and their host plants were inoculated with lac collected during collection surveys. Farmers from Kerala successfully completed cultivation and the harvested produce have been collected by KFRI.

Lac museum

A museum has been set up in KFRI with all the essential materials to be displayed for a good understanding about lac insects (Fig. 9.30). These include- lac insect life cycle, byproducts, SEM images, publications and reports, survey maps, host plant details, dead and live collected samples of lac, collection boxes with parasites and parasitoids.



Fig. 9.30: Lac Museum at KFRI, Thrissur

9.5a *Krishi Vigyan Kendra*, Sirsi

***Kusmi* lac cultivation in Mysuru district**

Summer crop: Ten Kg of *kusmi* brood lac procured from IINRG Ranchi was inoculated on *Flemingia* and *ber* trees on 18.2.2021 in Bannikuppe, Mysuru District. Regular insecticide and fungicide spray schedules were followed as per the recommendation. Twenty-two Kg broodlac was harvested on 3.8.2021. Though regular plant protection measures were followed for summer crop, infestation of predator, *Eublemma amabilis* was very serious.

Horizontal spread: Some farmers from H. D. Kote village, Mysuru district have shown interest in summer 2022 crop and about 100 *ber* (*Ziziphus jujuba*) trees are ready for inoculation. Green Agri Tech Rural Development Trust (R) is actively involved in popularization of lac cultivation in Mysuru district. Through trust, first awareness meeting on scope of lac cultivation and uses was arranged on 19.12.2021. Collaborative works will be initiated by KVK Sirsi through network project during 2022.

Popularization of lac to students: B. Sc final year students from Smt. Indira Gandhi Government primary grade Women's college, Sagar, Shivamogga District, Kuvempu University visted KVK Sirsi on 11.12.2021 for their project work on Lac culture and its importance. Appraised the students about lac, uses, host planst of lac insect, status of lac in Karnataka, scope of lac cultivation etc.

Publicity through exhibition: Exhibition was arranged on different forms of lac, lac products, and lac hosts on 6.9.2021 during visit of Shri. BC Patil, Agriculture Minister, GoK to KVK Sirsi and on 18.9.2021 during visit of Mrs. Shobha Karandlaje, Minister of State for Agriculture and Farmers Welfare at Kaighadi, Ankola Tq. Uttara Kannada district.

Distinguished visitors:

1. HH Shri Kadasiddeshwar Swamiji, Siddagiri Math, Kaneri, Kolhapur, Maharashtra on 21.1.2021
2. Shri. BC Patil, Agriculture Minister, GoK on 6.9.2021
3. Mrs. Shobha Karandlaje, Minister of State for Agriculture and Farmers Welfare on 18.9.2021
4. Dr. M. B. Chetti, VC, UAS Dharwad on 6.9.2021
5. Dr. Ramesh Babu, Director of Extension, UAS Dharwad on 6.9.2021

9.6 Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur

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

The diversity of lac insects and its host plants were surveyed in various parts of the arid western plain region of the country. 56 locations from five districts of Rajasthan were identified with the natural occurrence of lac on various hosts viz., bargad (*Ficus benghalensis* Linn.), peepal (*Ficus religosia* Linn.), gular (*Ficus racemosa* Linn.), ber (*Ziziphus mauritiana* Lam. and *Z. jujube* Lam,), babool (*Acacia arabica* Willd) and custard apple (*Annona squamosa* Linn.) during 2021. During survey, the observations on different parameters of host plants were recorded as per the passport data sheet of host plants. The host plants were thoroughly surveyed for the presence of lac insects, their stage, intensity, presence of predators if any and observations were recorded for the parameters of lac insect as per passport data sheet. At all locations, only rangeeni strain was observed on these natural hosts. Among different hosts, peepal and bargad were found be the most frequent (Table 9.16).

Table 9.16: Status of the host plants and lac insect during survey conducted

Host	Plants observed	Frequency of occurrence	Plants with lac insect	Brood status
Peepal	85	Frequent	40	Good
Bargad	34	Frequent	09	Good
Palas	36	Occasional	02	Good
Babul	24	Occasional	01	Good
Ber	38	Occasional	01	Good
Gular	18	Occasional	01	Good
Sitafal	42	Rarely	02	Poor
Total	277		56	

Conservation of lac insect under *in-situ* conditions

Different locations at farmers' field were utilized for *in-situ* conservation of lac insect by artificial inoculation of broodlac on available natural hosts. The broodlac sticks bearing mature female lac insects were collected from the various host plants from Udaipur region during *katki* season and were inoculated on 85 *palas* plants for *in-situ* conservation of lac during 2021-22 (Fig. 9.31).



Fig. 9.31: Lac inoculation on palas trees for in situ conservation

Conservation of lac insect under *ex-situ* conditions

The *ex-situ* conservation of lac insect genetic resources available in the region was done on different hosts available at the Regional Field Gene Bank (RFGB) situated at Department of Entomology, RCA, Udaipur. 554.30 Kg broodlac sticks were collected from different locations and were maintained on *ber* (32), *arhar* (45), *palas* (6), *Flemingia semialata* (78), *F. macrophylla* (49), *Acacia arabica* (10) and custard apple (8 plants) at RFGB. The lac insect resources maintained on different plants were tagged properly for further observations (Fig. 9.32).



Fig. 9.32: Different activities for ex situ conservation of lac at RFGB, MPUAT

Need based / location studies on lac insects and / or host plants

Lac insect was noticed to exist naturally on as many as 14 different hosts in Rajasthan. In-spite of its high natural existence and wide availability of different natural hosts, lac cultivation is not carried out by the farmers because of lack of knowledge on the hosts suitable for lac cultivation under agro-climatic zone of the region. Incidence and lack of management technologies for major predators of lac insect is also one of the major factors for hindering lac production in the region. Therefore, during the present period of investigation studies were conducted to ascertain suitable hosts, to study the biology of lac on custard apple and *arhar* and effect of lac cultivation on yield parameters of *arhar* under following projects:

1. Comparative studies of productivity linked parameters of lac insect, *Kerria lacca* on different hosts prevailing in Southern Rajasthan

The investigation was carried out through *ex situ* inoculation of broodlac on various hosts *viz*., custard apple*, ber, palas, babool, kikar, F. macrophylla* and *F. semialata*. Among which *ber* was found to be the most effective, preferred and superior host compared to other hosts. Initial and final settlement, and mature female cell density recorded on *ber* was 116.5, 106.0 crawlers and 4.9 cells per sq. cm, respectively; while, per cent settlement and per cent mortality was 90.55 % and 8.84 %. While the least effective and preferred host was *F. semialata* in which initial and final settlement and mature female cell density recorded was 64.9, 54.7 crawlers and 2.8 cells per sq. cm, respectively with 83.56 per cent settlement and 15.64 per cent mortality On the basis of different

productivity linked parameters of lac insect, *K. lacca* on different lac hosts prevailing in Southern Rajasthan of arid western plains showed following order of host preference: *ber* > *babool* > *palas* > custard apple > *F. macrophylla*> *kikar* > *F. semialata*. (Table: 9.17).

Table 9.17: Productivity linked parameters of lac insect, *Kerria lacca* on different host plants during *baisakhi* season, 2020-21

Overall Mean	Initial density of settlement	Final density of settlement	Mature female cells density	Percent settlement	Percent mortality	Duration of pre-sexual stages (days)	Duration of male emergence (days)	Female cell size (mm)	Fecundity / female cell	Life period of female cells (days)
Ber	116.50	106.03	4.93	90.55	8.84	48.47	12.47	2.13	413	116
Babool	113.70	103.07	4.07	90.46	9.39	49.53	12.43	1.84	392	118
Palas	98.67	89.30	3.77	90.48	9.51	49.07	12.93	1.75	390	121
Custard apple	86.67	78.03	3.57	89.91	9.92	49.73	13.07	1.71	384	123
Flemingia macrophylla	90.70	80.37	3.20	88.56	11.40	48.77	12.20	1.64	380	125
Kikar	68.57	58.53	2.93	84.68	14.61	49.13	12.40	1.56	376	127
Flemingia semialata	64.87	54.70	2.80	83.56	15.64	50.07	13.20	1.52	368	129
SEm±	1.14	0.52	0.02	0.77	0.10	0.44	0.08	0.02	-	-
CD at 5 %	3.52	1.60	0.05	2.39	0.31	0.04	0.26	0.05	-	-

2. Study on biology and productivity linked parameters of lac insect, *Kerria lacca* (Kerr) on custard apple (*Annona squamosa* Linn.)

The biology of *rangeeni* lac insect was studied on custard apple during 2020-21 in *baisakhi* season. The mean initial density of settlement of crawlers varied from lower portion to upper portion of plant and ranged from 57-154 crawlers per sq. cm with mean initial density of settlement of 102.7, 99.60 and 93.70 crawlers per sq. cm at lower, middle and upper portion of plant, respectively. The final density of settlement of crawlers varied from 51-138 crawlers per sq. cm with a mean final density of 93.60, 90.00 and 84.30 crawlers per sq. cm at lower, middle and upper portion of plant, respectively. The mean per cent settlement of crawlers was 91.2, 90.4 and 89.9 per cent on lower, middle and upper portion of plant, respectively. The mean per cent initial mortality recorded during settlement at lower, middle and upper portion of plants was 8.86, 9.6 and 10.03 per cent, respectively. The duration of pre sexual stages on lower, middle and upper portion of plants was 50.3, 49.5 and 48.8 days, respectively. The mean density of female cells at maturity recorded at lower, middle and upper portion of plant was 3.8, 4.1 and 4.3 female cells per sq.cm, respectively and ranged between 2-6 cells per sq. cm. The total life period of female cells ranged between 113- 125 days (Table 9.18).

Table 9.18: Productivity linked parameters of lac insect on custard apple during *baisakhi* season, 2020-21

Parameters	Mean initial density of settlement (per sq. cm)			Mean final density of settlement (per sq. cm)			Mature female cells density (per sq. cm)		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Mean density ($\bar{x}$)	102.7	99.6	93.7	93.6	90.0	84.3	3.8	4.1	4.3
SD (σ)	25.76	30.31	23.54	23.29	27.24	21.73	1.03	1.60	0.95
SE	8.14	9.58	7.44	7.37	8.61	6.87	0.33	0.50	0.30
Range (R)	68-150	65-154	57-124	61-135	59-138	51-111	2-6	2-6	3-6
	Mean per cent mortality (per sq.cm)			Mean per cent settlement			Duration of pre-sexual stages (days)		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Mean density ($\bar{x}$)	8.86	9.60	10.03	91.16	90.40	89.88	50.30	49.50	48.80

	Duration of male emergence (days)			Fecundity (per female cell)
	Lower	Middle	Upper	
Mean ($\bar{x}$)	12.2	12.6	12.5	392
Range (R)	10 - 15	10 - 15	10 - 14	366 - 422
	Female cell size (mm)			Life period of the female cells (days)
	Lower	Middle	Upper	
Mean ($\bar{x}$)	1.71	1.67	1.86	118
Range (R)	1.1 - 2.5	1.2 - 2.3	1.2 - 2.4	113 - 125

3. Studies on the effect of lac cultivation on yield of pigeon pea (*Cajanus cajan* Linn.)

Life cycle and productivity linked parameters of lac insect, on pigeon pea (C. cajan): The biology of *rangeeni* strain of lac insect was studied on pigeon pea during 2019-2020 and 2020-21 in *baisakhi* seasons. The observations on mean initial density of settlement of crawlers was recorded 7 days after the inoculation of broodlac. Difference in mean initial density of settlement of first instar crawlers on lower, middle and upper portion of plant was recorded. The observed mean initial settlement of first instar crawlers of *rangeeni* strain of lac insect on pigeon pea in *baisakhi* season during 2019-20 and 2020-21 was 79.4, 77.1, 66.4 and 84.2, 81.3, 67.5 crawlers per sq.cm, respectively on lower, middle and upper portion of host plant in three sets of experiment. The mean final density of settlement of first instar crawlers was 73.0, 70.1, 59.5 and 76.9,73.1, 60.0 crawlers per sq. cm in both years, respectively on lower, middle and upper portion of host plant in three sets of experiment. The data revealed that maximum mean final density of settlement of crawlers observed was 76.9 crawlers per sq. cm; while minimum mean final density of settlement of crawlers of *rangeeni* strain of lac insect was 59.5 crawlers per sq. cm on lower portion of pigeon pea. The mean per cent settlement of crawlers in three sets of experiments was 91. 8, 90.7, 89.2 and 91.2, 89.9, 88.8 on lower, middle and upper portion of plant in 2019-20 and 2020-21, respectively.

The first instar crawlers which could not find suitable sites for settlement on host plant did not survive and died due to starvation within a week of its emergence. The observations on per cent initial mortality of first instar crawlers was recorded at 21 days after inoculation of broodlac of *rangeeni* strain of lac insect in *baisakhi* season on pigeon pea during 2019-20 and 2020-21. The per cent mean mortality was observed to be 8.06, 9.04, 10.30 and 8.67, 10.05, 11.15 from lower, middle and upper portion of the plants in three sets of experiment in both years, respectively. The duration of sex differentiation of *rangeeni* strain of lac insect on lower, middle and upper portion of plants in three set of experiments were 49.10, 48.83, 48.23 and 48.97, 48.60, 48.70 days in 2019-20 and 2020-21, respectively. The mean density of female cell recorded at crop maturity was 4.3, 5.0, 4.6 and 5.3, 4.9, 5.2 female cells per sq. cm in 2019-20 and 2020-21, respectively on lower, middle and upper portion of plant in three sets of experiment. The maximum mean density of female cells of *rangeeni* strain of lac insect on pigeon pea, ranged from 4.3 to 5.0 per sq. cm and 4.9 to 5.3 per sq. cm during *baisakhi* season of both years, respectively. (Table 9.19).

Effect of lac cultivation on yield of pigeon pea *(C. cajan):* The mean plant height, number of branches per plant, number of pods per branch, number of seeds per pod, seed yield per plant and weight of 100 seeds in lac inoculated first year experiments were 161.30 cm, 11.53, 4.40, 3.57, 24.13 g and 7.63 g, respectively and in second year were 161.06 cm, 11.63, 4.37, 3.70, 24.00 g and 7.27 g, respectively. Whereas, mean plant height, number of branches per plant, number of pods per branch, number of seeds per pod, seed yield per plant and weight of 100 seeds in control first year experiment were 172.70 cm, 11.90, 4.60, 3.70, 35.80 g and 8.70 g, respectively and in second year were 170.90 cm, 12.30, 4.80, 4.10, 30.10 g and 8.30 g, respectively. The mean seed yield in lac inoculated experiment and control experiment 2019-20 and 2020-21 were 603.33, 603.33 and 895.00, 752.50 kg/ha, respectively. The per cent decrease in both year plant height, number of branches per plant, number of pods per branch, number of seeds per pod, seed yield per plant and weight of 100 seeds in first year lac inoculated pigeon pea were 6.60, 3.08, 4.35, 3.60, 32.59 and 12.26 %, respectively and in second year were 5.75, 5.42, 9.03, 9.96, 19.82, and 12.45 %, respectively. The benefit cost ratio of lac inoculated experiment was more (1.95 and 2.09) than sole seed crop of pigeon pea (1.84 and 1.35) in both years, respectively (Table 9.20 and 9.21).

Table 9.19: Productivity linked parameters of lac insect on pigeon pea during *baisakhi* seasons, 2019-20 and 2020-21

Parameters	Mean initial density of settlement (per sq. cm)			Mean final density of settlement (per sq. cm)			Mature female cells density (per sq. cm)		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
2019-20									
Mean density ($\bar{x}$)	79.37	77.10	66.37	72.97	70.13	59.53	4.27	4.97	4.57
SD (σ)	6.82	4.36	3.35	5.91	3.98	2.61	0.15	0.85	0.67
SE	3.35	2.52	1.93	3.41	2.30	1.51	0.09	0.49	0.38
2020-21									
Mean density ($\bar{x}$)	84.20	81.30	67.53	76.90	73.13	60.00	5.27	4.93	5.20
SD (σ)	5.71	5.41	1.53	5.98	5.43	1.61	0.40	0.25	0.17
SE	3.30	3.12	0.88	3.45	3.13	0.93	0.23	0.15	0.10
Year	**Mean per cent settlement**			**Mean per cent mortality per sq. cm**			**Mean duration (days) of sex differentiation**		
	Lower	**Middle**	**Upper**	**Lower**	**Middle**	**Upper**	**Lower**	**Middle**	**Upper**
2019-20	91.78	90.73	89.16	8.06	9.04	10.30	49.10	48.83	48.23
2020-21	91.15	89.89	88.83	8.67	10.05	11.15	48.97	48.60	48.70

Table 9.20: Effect of lac cultivation on yield parameters of pigeon pea during *baisakhi* season, 2019-20 and 2020-21

Experiment	Mean						
	Plant height (cm)	Branches/ plant (no.)	Pods/ branch (no.)	Seeds/pod (no.)	Seed yield/ plant (g)	Seed yield (kg/ha)	Weight of 100 seeds (g)
A. Lac inoculated all three experiments							
2019-20	161.30	11.53	4.40	3.57	24.13	603.33	7.63
2020-21	161.06	11.63	4.37	3.70	24.13	603.33	7.27
B. Control							
2019-20	172.70	11.90	4.60	3.70	35.80	895.00	8.70
2020-21	170.90	12.30	4.80	4.10	30.10	752.50	8.30
C. Per cent decrease in lac inoculated experiments							
2019-20	6.60 %	3.08 %	4.35 %	3.60 %	32.59 %	32.59 %	12.26 %
2020-21	5.75 %	5.42 %	9.03 %	9.76 %	19.82 %	19.82 %	12.45 %

Table 9.21: Economics of lac cultivation and sole seed crop of pigeon pea during 2019-20 and 2020-21

Experiment	Yield (kg/ha)	Cost of cultivation of crop (₹/ha)	Cost of lac inoculation (₹/ha)	Yield of scrapped lac (kg/ha)	Income from seed (₹/ha)	Income from scrapped lac (₹/ha)	Total income from seed + scrapped lac (₹/ha)	Total cost of cultivation (₹/ha)	Net income (₹/ha)	B:C Ratio
A. Lac inoculated										
2019-20	603.33	18250	15550	324.167	34993.10	64833.30	99826.50	33800	66026.50	1.95
2020-21	603.33	18500	15550	345.833	36199.8	69166.7	105366.47	34050	71316.50	2.09
B. Control										
2019-20	895.00	18250	0	-	51910	0	41470	18250	33660	1.84
2020-21	752.50	18500	0	-	43530	0	43530	18500	25030	1.35

2019-20 & 2020-21: Field preparation: ₹ 4800/ha & 4850/ha, seed price: ₹ 4650/ha, sowing: ₹ 2000 & 2100/-, insect pests and disease management: ₹ 1600/ha & 1650/ha, weed management and intercultural operation: ₹ 2400/ha, harvesting and threshing cost: 2800 & 2850/-, broodlac cost: ₹ 130/kg, MSP of pigeon pea: ₹ 5800/q & 6000/q, selling price of scrapped lac: ₹ 200/kg

Distinguished visitors:

1. Dr. N. S. Rathore, Honorable Vice-Chancellor, Maharana Pratap University of Agriculture and Technology, Udaipur- Rajasthan
2. Dr. Dilip Singh, Dean, Rajasthan College of Agriculture, MPUAT, Udaipur- Rajasthan

9.7 Punjab Agricultural University (PAU), Ludhiana

Survey for collection of information / lac insect / host plants from different parts of Punjab and Delhi

Regular surveys were conducted for collecting the information regarding lac insect and its host plants during the year 2021 in five districts of Punjab and six districts of Delhi. The data on population size (low, moderate or high) were recorded at each location along with characteristics of host plants. GPS coordinates of each location were also recorded.

Punjab

Five lac insect samples were collected from three host plants including *ber* (*Ziziphus mauritiana*), *peepal* (*Ficus religiosa*) and *Calliandra haematocephala* ranging from low to high lac population. The locations from which lac insects observed on these host plants are given in Fig. 9.33. The samples of lac insect collected from different sites of Punjab and the nature of lac population ranging from low to high are given in Table 9.22. Natural infestation of lac insect on *Calliandra haematocephala* has been reported for the first time in Punjab (Fig. 9.34).



Fig. 9.33: Locations of lac insect on different host plants in Punjab

Table 9.22: Status of lac insect in different locations of Punjab visited during 2021

District	Latitude (°N)	Longitude (°E)	Lac insect	
			Host	Population
Ludhiana	30º85.91'	75º84.47'	*Ficus religiosa*	High
	30º90.50'	75º84.69'	*Ficus religiosa*	Moderate
	30º89.95'	75º80.97'	*Calliandra haematocephala*	Low
Kapurthala	31º22.32'	75º76.70'	*Ziziphus mauritiana*	Moderate
Barnala	30º28.21'	75º57.13'	*Ficus religiosa*	High

Low: <100, Moderate: 100-1000 and High: >1000.



Fig. 9.34: Natural infestation of lac insect on *Calliandra haematocephala* – A new host record in Punjab

52 lac insect samples were collected from seven host plants including *ber* (*Ziziphus mauritiana*), *peepal* (*Ficus religiosa*), golden fig (*Ficus benjamina*), *bohr* (*Ficus benghalensis*), *chilkan* (*Ficus retusa*), *pilkhan* (*Ficus virens*) and *kikar* (*Acacia* sp.) ranging from low to high lac population. The locations from which lac insects observed on these host plants are given in Fig.9.35. The samples of lac insect collected from different sites of Delhi are given in Table 9.23.



Fig. 9.35: Locations of lac insect on different host plants in Delhi

Table 9.23 : Status of lac insect in different locations of Delhi visited during 2021

District	Latitude (°N)	Longitude (°E)	Lac insect	
			Host	Population
North Delhi	28º85.96'	77º09.79'	*Ziziphus mauritiana*	High
	28º85.93'	77º09.80'	*Ficus religiosa*	High
	28º85.98'	77º09.90'	*Ficus religiosa*	High
	28º86.03'	77º10.22'	*Ficus benjamina*	High
	28º85.74'	77º10.97'	*Ficus religiosa*	High
	28º85.77'	77º10.93'	*Ziziphus mauritiana*	High
North West Delhi	28º81.01'	77º13.76'	*Ziziphus mauritiana*	High
	28º80.99'	77º13.73'	*Acacia sp.*	High
	28º81.01'	77º13.73'	*Ziziphus mauritiana*	Low
	28º80.98'	77º13.78'	*Ficus virens*	High

District	Latitude (°N)	Longitude (°E)	Lac insect	
			Host	Population
North West Delhi	28°80.74'	77°13.80'	*Ficus religiosa*	High
	28°69.36'	77°15.45'	*Ziziphus mauritiana*	High
	28°69.38'	77°15.50'	*Ficus religiosa*	High
West Delhi	28°64.77'	77°12.76'	*Ficus religiosa*	High
	28°64.80'	77°12.81'	*Ficus religiosa*	Low
	28°65.41'	77°11.72'	*Ficus religiosa*	Low
	28°65.21'	77°12.02'	*Ficus religiosa*	High
	28°65.18'	77°11.94'	*Ficus religiosa*	High
	28°63.98'	77°11.74'	*Ficus religiosa*	High
	28°63.94'	77°11.59'	*Ficus religiosa*	Moderate
	28°63.36'	77°17.38'	*Ficus religiosa*	High
New Delhi	28°64.13'	77°21.85'	*Ziziphus mauritiana*	High
	28°64.12'	77°21.87'	*Ficus religiosa*	High
	28°64.07'	77°21.87'	*Ficus retusa*	Moderate
	28°63.41'	77°22.26'	*Ficus religiosa*	Low
	28°63.00'	77°21.88'	*Ficus religiosa*	Low
	28°63.08'	77°21.74'	*Ficus religiosa*	Moderate
	28°63.23'	77°21.64'	*Ficus religiosa*	Moderate
	28°63.34'	77°21.65'	*Ficus religiosa*	Moderate
New Delhi	28°63.55'	77°21.85'	*Ficus religiosa*	Moderate
	28°63.40'	77°22.28'	*Ficus religiosa*	High
	28°60.06'	77°25.44'	*Ziziphus mauritiana*	High
	28°60.06'	77°25.43'	*Ficus virens*	Low
	28°56.89'	77°21.29'	*Ficus religiosa*	Low
			Ficus religiosa	Moderate
	28°56.93'	77°19.48'	*Ziziphus mauritiana*	High
	28°57.00'	77°18.38'	*Ficus religiosa*	Moderate
	28°57.01'	77°18.35'	*Ziziphus mauritiana*	Moderate
East Delhi	28°61.77'	77°28.73'	*Ficus religiosa*	High
	28°61.98'	77°28.93'	*Ziziphus mauritiana*	High
	28°62.20'	77°29.56'	*Ziziphus mauritiana*	Moderate
South East Delhi	28°57.17'	77°25.91'	*Ficus religiosa*	Low
	28°56.65'	77°26.98'	*Ziziphus mauritiana*	Moderate
	28°56.54'	77°27.03'	*Ficus religiosa*	Moderate
	28°56.35'	77°27.15'	*Ziziphus mauritiana*	Moderate
	28°56.10'	77°27.05'	*Ficus religiosa*	High
	28°56.08'	77°26.75'	*Ficus religiosa*	High
	28°55.55'	77°27.09'	*Ziziphus mauritiana*	Low
	28°55.55'	77°27.07'	*Ficus religiosa*	Moderate
	28°56.17'	77°25.52'	*Ziziphus mauritiana*	High
	28°56.18'	77°25.53'	*Ficus benghalensis*	High
	28°57.86'	77°24.08'	*Ziziphus mauritiana*	Moderate

Low: <100, Moderate: 100-1000 and High: >1000.

Ex-situ conservation / broodlac multiplication at Regional Field Gene Bank

- *Rangeeni* Strain; *Baisakhi* crop: 50 plants were inoculated in *Baisakhi* crop (2020-21) and 59.84 kg broodlac was harvested during July 2021 from seven host plant spp., *Ziziphus mauritiana* (3), *Flemingia semialata* (20) and *F. macrophylla* (20), *Acacia nilotica* (2), *Butea monosperma* (2), *Ficus religiosa* (2) and *Litchi chinensis* (1)
- *Rangeeni* Strain: *Katki* crop: 40 plants were inoculated with broodlac to know the production potential of lac in *Katki* crop (2021). 45.77 kg broodlac was harvested during November, 2021 from six host plant spp., *Ziziphus mauritiana* (3), *Flemingia semialata* (15) and *F. macrophylla* (15), *Acacia nilotica* (3), *Butea monosperma* (3) and *Ficus religiosa* (1) (Table 9.24).

Table 9.24: Quantity of brood multiplied at Regional Field Gene Bank during 2021

Name of host	Total broodlac output (Kg)	
	***Baisakhi* (2020-21)**	***Katki* (2021)**
Ziziphus mauritiana	21.21	18.94
Flemingia semialata	4.39	3.38
Flemingia macrophylla	3.86	2.88
Acacia nilotica	4.51	5.47
Butea monosperma	14.45	11.69
Ficus religiosa	7.89	3.41
Litchi chinensis	3.53	-
Total	59.84	45.77
Grand Total	105.61	

Studies on life cycle and productivity-linked parameters of lac insect (*Rangeeni* strain; *baisakhi* and *katki* crops) on *Flemingia semialata, Flemingia macrophylla* and *Ziziphus mauritiana*

The biological and productivity-linked parameters of *rangeeni* strain (*baisakhi* and *katki* crops) of lac insect were studied on different host plants namely *Flemingia semialata, F. macrophylla* and *Ziziphus mauritiana* at Regional Field Gene Bank (RFGB), Entomological Research Farm, Punjab Agricultural University (PAU), Ludhiana during November, 2020 - July 2021 (*baisakhi* crop) and from July, 2021- November 2021 (*katki* crop).

The results of different biological and productivity linked parameters on *Ziziphus mauritiana* (Table 9.25), *Flemingia macrophylla* (Table 9.26) and *Flemingia semialata* (Table 9.27) are presented as under:

Ziziphus mauritiana

- Initial density of lac insect settlement was observed to be 111.73±1.47 and 93.87±1.92 insects/ cm^2 with initial percentage mortality of 6.35±0.76 and 8.26± 0.48 in *baisakhi* and *katki* crop, respectively
- The mean duration of female and male cell differentiation *i.e.,* duration of pre-sexual stages in *baisakhi* and *katki* crop was 117.33±1.45 (range 117-120 days**)** and 20.00±0.58 (18-23)
- The mean male emergence was observed to be initiated after 158.60±1.16 days (range -154-160 days) in *baisakhi* crop with sex-ratio (% male insects) of 14.37±0.43 and during *katki* crop, it was recorded to be 43.67±1.45 (range 40-46) with 12.00±0.29% male insects (Fig.9.36)
- The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 5.87±0.25/cm^2 and 5.00±0.24/cm^2 in *baisakhi* and *katki* crops, respectively
- Mean weight of female cell after crawler emergence was 10.01±0.22 mg (range 7.87-11.85 mg) in *baisakhi* and 8.03±0.24 (6.50-10.98 mg) in *katki* crop
- The average resin produced by an individual female cell recorded after removing the dead insect body from the cell was 7.46±0.22 mg (range 6.00-10.00 mg) in *baisakhi* crop and during *katki* crop it was 5.78±0.19 mg (range 5.00-6.80 mg)
- The average number of young ones produced by the single female insect ranged from 187 to 392 individuals (264.56±11.36) during *Baisakhi* and 105 to 143 individuals (119.14±2.60) during *katki* crop
- Broodlac yield recorded after crop harvesting was 7.07±0.78 kg/plant during *baisakhi* whereas it was 6.31±0.32 kg/plant during *katki* crop

Table 9.25: Life cycle and productivity-linked parameters of lac insect (*rangeeni*; *baisakhi* and *katki* crops) on *Ziziphus mauritiana*

Parameters	*Baisakhi*		*Katki*	
	Range	Mean ± SE	Range	Mean ± SE
Initial density of settlement (no./cm2)	103-121	111.73±1.47	80-110	93.87±1.92
Final density of settlement (no./cm2)	98-118	104.60±1.72	74-101	86.13±1.47
% Mortality	2.48-15.97	6.35±0.76	1.98-12.63	8.26±0.48
Sex ratio (% male insects)	9-12	14.37±0.43	8-12	12.00±0.29
Density at crop maturity (no./cm2)	5-7	5.87±0.25	4-7	5.00±0.24
Duration of pre-sexual stages (days)	117-120	117.33±1.45	18-23	20.00±0.58
Initiation of male emergence (days)	154-160	158.60±1.16	40-46	43.67±1.45
Longevity of female cell (days)	214-245	237.33±2.14	110-118	114.33±2.33
Female cell weight (mg)	7.87-11.85	10.01±0.22	6.50-10.98	8.03±0.24
Resin output (mg)	6.00-10.00	7.46±0.22	5.00-6.80	5.78±0.19
Fecundity/female (no.)	187-392	264.56±11.36	105-143	119.14±2.60
Broodlac yield /plant (kg)	5.5-8.20	7.07±0.78	5.68-6.78	6.31±0.32

- Mean of 5 replications

Flemingia macrophylla

- Initial density of lac insect settlement was observed to be 77.20±1.17 and 76.33±1.33 insects/ cm^2 with initial percentage mortality of 9.38±1.33 and 10.92± 2.10 in *baisakhi* and *katki* crops, respectively
- The mean duration of female and male cell differentiation *i.e.,* duration of pre-sexual stages in *baisakhi* and *katki* crops was 116.67±1.20 (range 115-119 days**)** and 19.80±1.11 (17-22), respectively
- The mean male emergence was observed to be initiated after 157.67±0.67 days (range -155-159 days) in *Baisakhi* crop with sex-ratio (% male insects) of 11.83±0.62 and it was recorded to be 44.00±0.58 (40 - 45) and 10.97±0.10 in *katki* crop, respectively (Fig. 9.36)
- The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 4.80±0.23/cm^2 and 4.67±0.21/cm^2 in *baisakhi* and *katki* crops, respectively
- Mean weight of female cell after crawler emergence was 8.66±0.25 mg (range 6.30-10.70 mg) in *baisakhi* and 7.48±0.18 (6.5-8.9 mg) in *katki* crop
- The average resin produced by an individual female cell recorded after removing the dead insect body from the cell was 5.95±0.27 mg (range 4.50-7.40 mg) in *baisakhi* crop and during *katki* crop it was 5.36±0.73 mg (range 4.00-6.70 mg)
- The average number of young ones produced by the single female insect ranged from 99 to 150 individuals (121.12±2.93) and 98 to 120 individuals (107.74±1.75) during *baisakhi* and *katki* crops, respectively
- Broodlac yield recorded after crop harvesting was 0.39±0.11kg/plant during *baisakhi* whereas it was 0.35±0.11 kg/plant during *katki* crop

Table 9.26: Life cycle and productivity-linked parameters of lac insect (*rangeeni*; *baisakhi* and *katki* crops) on *Flemingia macrophylla*

Parameters	*Baisakhi*		*Katki*	
	Range	Mean ± SE	Range	Mean ± SE
Initial density of settlement (no./cm2)	60-95	77.20±1.17	59-95	76.33±1.33
Final density of settlement (no./cm2)	53-86	70.13±1.76	51-85	63.73±2.10
% Mortality	4.12-12.57	9.38±1.33	8.53-17.06	10.92±2.10
Sex ratio (% male insects)	4-10	11.83±0.62	6-10	10.97±0.10
Density at crop maturity (no./cm2)	3-6	4.80±0.23	3-5	4.67±0.21
Duration of pre-sexual stages (days)	115-119	116.67±1.20	17-22	19.80±1.11
Initiation of male emergence (days)	155-159	157.67±0.067	40-45	44.00±0.58

Parameters	*Baisakhi*		*Katki*	
	Range	Mean ± SE	Range	Mean ± SE
Longevity of female cell (days)	210-240	234.33±2.85	99-110	106.67±0.88
Female cell weight (mg)	6.30-10.70	8.66±0.25	6.5-8.9	7.48±0.18
Resin output (mg)	4.50-7.40	5.95±0.27	4.00-6.70	5.36±0.73
Fecundity/female (no.)	99-150	121.12±2.93	98-120	107.74±1.75
Broodlac yield /plant (kg)	0.13-0.67	0.39±0.11	0.11-0.67	0.35±0.11

- Mean of 5 replications

Flemingia semialata

- Initial density of lac insect settlement was observed to be 82.20±3.52 and 79.73±3.74 insects/ cm^2 with initial percentage mortality of 9.62±1.41 and 8.48±1.95 in *baisakhi* and *katki* crop, respectively
- The mean duration of female and male cell differentiation *i.e.,* duration of pre-sexual stages in *Baisakhi* and *Katki* crop was 113.67±1.86 (range 110-116 days**)** and 20.20±0.95 (18-22), respectively
- The mean male emergence was observed to be initiated after 158.00±0.58 days (range 154-159 days) in *baisakhi* crop with sex-ratio (% male insects) of 12.40±0.40 and during *katki* crop, it was recorded to be 42.33±1.20 (range 40-44) with 11.17±0.17% male insects (Fig. 9.36)
- The mean density of surviving female lac insects (after initial mortality and emergence of male lac insects) was found to be 4.93±0.29/cm^2 and 4.73±0.39/cm^2 in *baisakhi* and *katki* crops, respectively
- Mean weight of female cell after crawler emergence was 8.94±0.22 mg (range 7.04-11.00 mg) in *baisakhi* and 7.65±0.18 (6.5-8.6 mg) in *katki* crop
- The average resin produced by an individual female cell recorded after removing the dead insect body from the cell in *baisakhi* crop was 6.10±0.19 mg (range 4.98-6.80 mg) and during *katki* crop, it was 5.50±0.27 mg (range 4.30-7.00 mg)
- The average number of young ones produced by the single female insect ranged from 101 to 154 individuals (128.92±4.42) and 98 to 129 individuals (110.14±2.27) during *baisakhi* and *katki* crops, respectively
- Broodlac yield recorded after crop harvesting was 0.41±0.13 kg/plant during *baisakhi* whereas it was 0.36±0.11 kg/plant during *katki* crop

Table 9.27: Life cycle and productivity-linked parameters of lac insect of lac insect (*rangeeni*; *baisakhi* and *katki* crops) on *Flemingia semialata*

Parameters	*Baisakhi*		*Katki*	
	Range	Mean ± SE	Range	Mean ± SE
Initial density of settlement (no./cm2)	65-97	82.20±3.52	59-95	79.73±3.74
Final density of settlement (no./cm2)	53-90	74.27±3.79	50-90	67.93±2.78
% Mortality	7.73-13.58	9.62±1.41	5.12-12.36	8.48±1.95
Sex ratio (% male insects)	6-12	12.40±0.40	5-10	11.17±0.17
Density at crop maturity (no./cm2)	3-7	4.93±0.29	3-6	4.73±0.39
Duration of pre-sexual stages (days)	110-116	113.67±1.86	18-22	20.20±0.95
Initiation of male emergence (days)	154-159	158.00±0.58	40-44	42.33±1.20
Longevity of female cell (days)	216-239	232.00±4.04	98-112	108.33±3.18
Female cell weight (mg)	7.04-11.00	8.94±0.22	6.5-8.6	7.65±0.18
Resin output (mg)	4.98-6.80	6.10±0.19	4.30-7.0	5.50±0.27
Fecundity/female (no.)	101-154	128.92±4.42	98-129	110.14±2.27
Broodlac yield/ plant (kg)	0.21-0.87	0.41±0.13	0.12-0.78	0.36±0.11

Mean of 5 replications

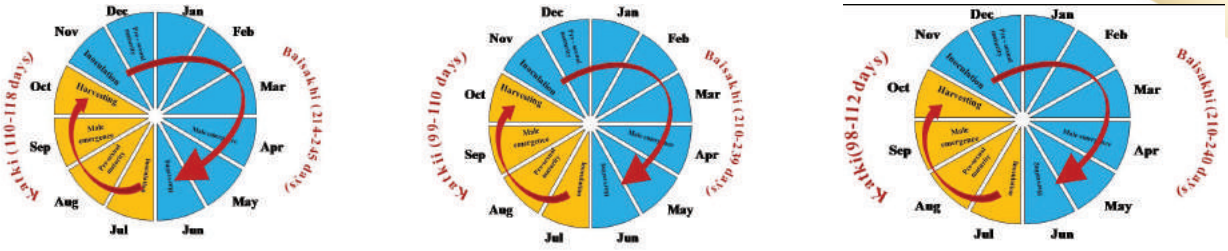


Fig. 9.36: Lac crop cycle on (from left to right) *Ziziphus mauritiana, Flemingia macrophylla* and *Flemingia semialata*

Diversity of natural enemies associated with lac insect in Punjab and Delhi

Studies on the insect fauna associated with lac insect were carried out during 2020-21. 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) fitted with glass tubes. These cages were monitored at regular intervals to record the emergence of parasitoids and predators.

Punjab: Under Punjab conditions, lac insect associated fauna comprised five species namely *Eublemma amabilis* (Noctuidae: Lepidoptera), *Chrysoperla zastrowi sillemi* (Chrysopidae: Neuroptera), *Tachardiaephagus tachardiae somervilli* (Encyrtidae: Hymenoptera), *Psedohypatopa pulverea* (Blastobasidae: Lepidoptera) and *Tribolium* sp. (Tenebrionidae: Coleoptera). Among these, *Eublemma* was the predominant species under Punjab conditions (Table 9.28).

Delhi: Four natural enemy fauna including *Tachardiaephagus tachardiae* (parasitoid), *Bracon greeni* (hyper-parasitoid), *Eublemma amabilis* (predator) and *Tribolium* sp. (predator) were found to associated with lac insect samples collected from Delhi areas (Table 9.29).

Table 9.28: Natural enemies of lac insects under Punjab conditions

S. No	Name	Predator/parasitoid	Order	% Abundance
1.	*Eublemma amabilis* Moore	Predator	Lepidoptera	31.55
2.	*Pseudohypatopa pulverea (Meyrick)*	Predator	Lepidoptera	24.06
3.	*Chrysoperla zastrowi sillemi (Esben-Peterson)*	Predator	Neuroptera	19.79
4.	*Tribolium sp.*	Predator	Coleoptera	16.04
5.	*Tachardiaephagus tachardiae somervilli (Mahd)*	Parasitoid	Hymenoptera	8.56

Table 9.29: Natural enemies of lac insects under Delhi conditions

S. No	Name	Predator/parasitoid	Order	% Abundance
1.	*Tachardiaephagus tachardiae somervilli* (Mahd)	Parasitoid	Hymenoptera	37.03
2.	*Bracon greeni* Ashmead	Hyper-Parasitoid	Hymenoptera	27.77
3.	*Eublemma amabilis* Moore	Predator	Lepidoptera	18.51
4.	*Tribolium* sp.	Predator	Coleoptera	16.66

Effect of lac based wax formulation coating on shelf life and post harvest quality of *Kinnow* mandarin under ambient conditions

The present study was conducted at PAU Regional Research Station Abohar to improve the shelf life on *kinnow* mandarin and acceptability of lac-based formulation as compared to synthetic waxes (Citrashine, Fomesa, Citrasol) and which are generally used for post-harvest management of *kinnow* mandarin in the commercial belt (Fazilka

District) of Punjab. Wax coating of *kinnow* fruits was done mechanically at commercial waxing plant (Sandhu Grading and Waxing Plant) located at Village Ghallu, Abohar (District Fazilka). In general, wax was applied @ 1 litre for 1 tonne *kinnow* fruits. The treated fruits were stored at ambient conditions (temperature 5.40 °C-14.79 °C, humidity - 61.07 to 81.58%) up to 20 days in corrugated fiber board boxes (45 fruits/ box) and were replicated three times for recording the observations at different time intervals (Fig. 9.37 and 9.38).



Fig. 9.37: Commercial *kinnow* waxing plant at Abohar, Punjab



Fig. 9.38: Wax coating of *kinnow* at laboratory conditions

The values of physiological loss in weight, spoilage percentage (Table 9.30), Total Soluble Solids (TSS) (Table 9.31) increased with increase in the storage intervals. However, juice percentage (Table 9.31), acidity and ascorbic acid (Table 9.32) decreased with increase in the storage intervals. The physiological loss in weight and spoilage percentage were observed to be lower in all waxed fruits as compared control. On the basis of appearance and other quality parameters, *kinnow* fruits were observed acceptable up to 15 days when coated with Citrasol, Formesa and Lac based formulation as compared to Citrashine and control treatments at ambient conditions.

Table 9.30: Effect of wax coating on physiological loss in weight and spoilage percentage in kinnow mandarin at ambient conditions

Treatments	Physiological loss in weight (%)				Spoilage (%)			
	5 days	10 days	15 days	20 days	5 days	10 days	15 days	20 days
Citrashine	3.34	5.42	7.81	10.13	4.44	5.92	7.40	11.11
Formesa	2.74	5.22	7.09	9.16	3.70	5.18	6.67	8.14
Citrasol	3.12	5.26	7.11	9.42	2.22	4.44	5.92	8.88
Lac	3.95	5.96	6.71	9.64	2.96	5.18	6.67	9.63
Control	4.56	6.35	8.26	13.42	5.92	7.40	12.59	21.48

Table 9.31: Effect of wax coating on juice content and total soluble solids in kinnow mandarin at ambient conditions

Treatments	Juice content (%)				TSS (0 Brix)			
	5 days	10 days	15 days	20 days	5 days	10 days	15 days	20 days
Citrashine	48.10	46.59	45.38	44.59	10.66	10.78	11.67	12.23
Formesa	49.21	48.40	47.39	46.38	10.23	10.73	11.43	11.87
Citrasol	49.02	48.96	47.53	46.11	10.43	10.53	11.23	11.53

Treatments	Juice content (%)				TSS (0 Brix)			
	5 days	10 days	15 days	20 days	5 days	10 days	15 days	20 days
Lac	48.78	48.77	46.71	46.26	10.31	10.67	11.58	11.93
Control	47.54	45.59	41.38	38.89	10.80	11.08	12.18	12.87

Table 9.32: Effect of wax coating on acidity (%) and ascorbic acid in kinnow mandarin at ambient conditions

Treatments	Acidity (%)				Ascorbic acid (mg/ 100 ml juice)			
	5 days	10 days	15 days	20 days	5 days	10 days	15 days	20 days
Citrashine	0.846	0.813	0.789	0.753	24.24	23.37	22.87	22.18
Formesa	0.858	0.821	0.791	0.748	24.68	23.90	22.21	22.03
Citrasol	0.861	0.836	0.783	0.740	24.34	23.80	22.67	22.36
Lac	0.851	0.840	0.778	0.742	24.13	23.48	22.36	21.89
Control	0.831	0.806	0.753	0.658	22.82	21.81	20.89	19.89

9.7a ICAR- Research Complex for Eastern Region, Patna

Survey and Collection of lac insect genetic resources from different parts of Bihar

- Survey in all 38 districts of Bihar has been completed for presence of natural lac insects and host plants.
- Out of 38 districts of Bihar, 22 districts showed naturally occurring lac insect in varied proportion mostly on *Ficus religiosa*, *Ficus benghalensis* and rarely on *Ziziphus mauritiana* and *Butea monosperma*.
- Majority of lac insects were found dead, but at a few places good live populations were noticed. Southern districts of Bihar invariably showed rich diversity in naturally surviving lac insects.
- *In situ* conservation of local lac insects at four locations in Patna district namely Sipara and Parsa (Patna Rural block), Punpun (Punpun block), Taregna (Masaurhi block) is being carried out.
- Visited Muzaffarpur, Islampur Road wherein about 300 shops (*Lahti* shop) were found engaged in bangles and other handicraft making. They informed that they procure shellac from Balrampur (Barabhunj) amounting Rs. 5-6 crores every year.

9.8 State Forest Research Institute (SFRI) Jabalpur

1. Survey of Madhya Pradesh for lac insects and host plants

Intensive survey was conducted block wise in Madhya Pradesh for lac insects and their host plants. Forest range officers and farmers in each block at various districts were interviewed to get information about lac insect and their host plant potential areas. Information was also taken from traders in blocks. With this information surveys were undertaken on lac insect, host plant in potential areas in various blocks. Identified lac insect and host plants potential area have been tracked by Global Positioning System (GPS) The data was collected on lac insect population size, stage, crawler period, special characteristics, source/ habitat, frequency, predators, parasitoids, disease symptoms, host plants.

Survey was done in 23 blocks of 11 districts and lac occurrence wasrecorded in 12 blocks of 11 districts in Madhya Pradesh on *palas* (*Butea monosperma*), *kusum* (*Schleichera oleosa*), *ber* (*Ziziphus mauritiana*), *peela gulmohar* (*Peltophorum pterocarpum*) and *kala siris* (*Albizia lebbek*). It was also observed that at almost all locations only *rangeeni* strain was found growing well on these natural hosts. Live lac insects were found in following blocks as given in Table 9.33, Fig. 9.39. The information on lac insect/host plants during each field survey was recorded in passport data sheets and compiled.

Table 9.33: Block wise occurrence of lac insect in Madhya Pradesh

S. No.	District	Block	Host plant	Status	GPS details	
1.	Vidisha	Latori	*pipal*	Natural	E 077^0 24' 44.5"	N 24^0 03' 8.33"
2	Sagar	Bina	*ber*	Natural	E 078^0 12' 26.92"	N 24^0 10' 44.76"
3	Makshi	Shajapur	*pipal*	Natural	E 076^0 08' 8.60"	N 23^0 15' 43.9"
4	Dewas	Dewas	*Peela gulmohar*	Natural	E 076^0 02' 6.82"	N 22^0 57' 6.66"
5	Sheopur	Karahal	*pipal, ber*	Natural	E 077^0 02' 9.74"	N 25^0 29' 47.0"
6	Shivpuri	Badarwas	*pipal*	Natural	E 077^0 52' 43.1"	N 25^0 04' 39.9"
7	Raisen	Udaipura	*pipal*	Natural	E 078^0 30' 43.72"	N 23^0 04' 14.09"
8	Panna	Pawai	*ber*	Cultivated	Kalda	
9	Katni	Dhimarkheda	*palas*	Cultivated	E 080^0 09' 2.53"	N 23^0 35' 6.41
10	Jabalpur	Panagar	*palas*	Cultivated	E 080^0 04' 9.23"	N 23^0 18' 7.53"
11	Betul	Chicholi	*palas*	Natural	77^0 47' 13.25"	N 22^0 03' 59.27"
12	Betul	Betul	*kala siris*	Natural	E 77^0 53' 57.82"	N 21^0 55' 3.94"

2. Collection and conservation of lac insects under *ex-situ* conditions

i. Brood maintenance in Regional Field Gene Bank (RFGB)

Eighteen lac samples collected from Seoni, Mandla, Balaghat, Chhindwara, Hoshanagabad, Dindori, Mandsaur, Jabalpur districts of Madhya Pradesh and Gondia, Bhandara, Parbhani, Aurangabad, Ahmednagar districts Maharashtrawere re-inoculated on another host plants *Flemingia macrophylla* and *Flemingia semialata* plants for maintenance in the RFGB.

ii. New lac sample collections and their conservation

Lac insect samples were collected from total 21 sites of Sagar, Vidisha, Rajgarh, Agar Malwa, Shajapur, Dewas, Sehore, Raisen, Shivpuri, Sheopur, Katni and Panna districts of Madhya Pradesh and inoculated on *bhalia, semialata*, *kusum, ber, palas* and *gular* at SFRI campus during the month of June-July 2021. After inoculation, productivity linked parameters were recorded for each sample of lac insect on host plants. Collected lac samples were also preserved in absolute alcohol for identification of lac insect species.

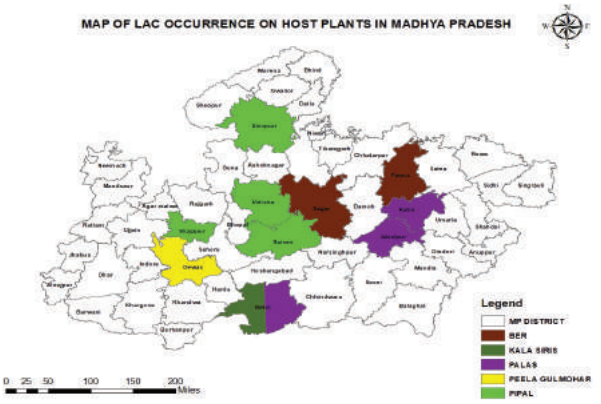


Fig. 9.39: Map showing the occurrence of lac insect on different host plants during 2021

3. Study of productivity linked parameters of collected lac insect on *ber*

Lac insect collections from nine sites of seven districts *i.e.,* Shivpuri, Shahapur, Sagar, Vidisha, Agar Malwa, Sheopur and Gwalior were evaluated on *ber* for productivity linked parameters during *katki* crop (Table 9.34). Inoculation of broodlac samples on *ber* trees were done in first week of July and the crop harvested in last week of October (Fig. 9.40).

- Amongst all the locations, the highest initial density (121.66 crawlers/cm^2) of rainy season *rangeeni* lac was observed in Karahal, Sheopur and the lowest (35 crawlers/cm^2) in Makshi, Shajapur.
- The highest density (42 cm^2) after 21 days of settlement of *rangeeni* lac was observed in Lateri, Vidisha sample and the lowest (17.33 cm^2) in Sagar.
- The highest mortality (79.8%) was reported from Sagar and the lowest (64%) in Lateri, Vidisha.
- The highest male percentage (55%) of *rangeeni* lac was observed from Mohan Barodiya, Agar Malwaand the lowest (25%) in Karahal, Sheopur.
- The highest male cell length (2.38 mm) of lac was from Mohan Barodiya and the lowest (1.80 mm) Makshi Shajapur.
- The highest female density at crop maturity (16 / cm^2) of *rangeeni* lac was in Lateri, Vidisha and the lowest (2 cm^2) in Makshi,Shajapur.

Table 9.34. Study of productivity linked parameters of collected lac insect on *ber* plants at SFRI campus

Sl. No.	Site	District	Host	Initial Density (cm^2)	Initial Mortality (cm^2)	Initial Mortality %	Density of settlement (cm^2)	Male cell length (mm)	% of male	Female density at crop maturity (cm^2)
1	Shivpuri	Shivpuri	*Jangli bargad*	105.2	69.3	65.9	35.8	2.1	38	13
2	Makshi	Shajapur	*pipal*	81.0	59.7	73.7	21.3	1.8	45	02
3	Sagar	Sagar	*pipal*	85.7	68.3	79.8	17.3	1.9	30	7
4	Lateri	Vidisha	*pipal*	116.7	74.7	64.0	42	2.1	34	16
5	Mohan Barodiya	Agar Malwa	*pipal*	90.0	62.0	68.9	28.0	2.4	55	07
6	Sironj	Vidisha	*pipal*	107.3	69.3	64.6	38	1.95	45	06
7	Rannod, Badarwas	Shivpuri	*pipal*	111.7	75.1	67.2	36.6	2.1	38	14
8	Karahal	Sheopur	*pipal*	121.7	95.3	78.3	26.4	2.2	25	5
9	Gwalior	Gwalior	*pipal*	113.0	87.0	77.0	26.0	2.0	42	7



Fig. 9.40: Harvesting of mature lac sample in RFGB

4. Status of lac host plants in RFGB

Lac Host Park was established at SFRI campus in which 13 species of host plants are conserved. 85 host plants of 13 species *viz*., *kusum, palas, ber, gular, black siris, sitaphal* (*Annona squamosa*), *jangli jalebi* (*Pithecellobium dulce*), *safed siris* (*Albizia procera*), *khair* (*Acacia catechu*), *akashmoni* (*Acacia auriculiformis*), *rain tree* (*Albizia saman*), *pipal* (*Ficus religiosa*) and *shisham* (*Dalbergia sissoo*) are maintained in lac host plant park.

- 900 plants of *F. macrophyala* and 350 plants of *F.semialata* are maintained for *ex-situ* conservation of lac insect genetic resources.
- 80 seedlings of *arhar* plants transplanted in polythene bags for lac cultivation trials.

5. Training of adopted/ selected farmers in collaboration with IINRG for *in-situ* conservation

i. Lac cultivation training workshop on scientific method

Capacity building-cum-hand holding training workshop on scientific method was held on 21 June 2021 on lac cultivation at village Sasaipura, Karahal block, Sheopur district of Madhya Pradesh. 61 progressive

farmers, *Van samiti* members and local forest staff from Agra, Palpur, Sheopur, Sewapur, Wasde, Anjnoi, Sawadi, Bhorawan, Maretha, Golipura, Umrikala, Maratha villages participated. Field demonstration of lac cultivation on *khair* was also shown. A session was covered on marketing aspects at local and district level markets.

ii. Interaction with traders, farmers and *van samiti* members

One day interaction meeting with traders, farmers and *van samii* members was organized on 26 November 2021 in lac processing unit Jairamtola, Waraseoni block, Balaghat. During interaction, information on short comings in lac cultivation and scenario of lac cultivation in Balaghat district was collected. DFO Balaghat, one lac processor, three lac traders, 12 progressive lac farmers, three agriculture officers and four Bangle makers participated in the interaction.

6. Need based and location specific studies on lac insects/host plants

i. Socio-economic status of lac growers in Gondia district of Maharashtra.

The study was conducted in Gondia district, which is the major lac producing district of Maharashtra. Thirty one lac producing farmers of two blocks (Aamgaon, Salekesa) were selected at random and interviewed. Relevant information was collected from the lac producers through a pre-tested questionnaire in the year 2021.

Distribution of respondents according to their age: Out of total farmers interviewed 29.03% belonged to senior age group (56-65 years); 25.81% to 36-45 age group, 22.58% to 46-55 age group, 16.13% to old age group (in age <66 years) and 6.45% to young age group (up to 35 years).

Educational status of lac growing farmers: Maximum literacy was reported up to higher secondary school level (35.48%) followed by high school (29.03%), middle school (16.13%), primary (12.90 %) and only 6.46% at graduate level.

Lac host plants holding capacity of lac growers: Regarding availability of *palas* host trees for lac cultivation, 30% of lac growers had 51-100 host plant, 23.33% had 101-200 host plants followed by >25 host trees were owned by 20% farmers, 16.67% farmers <200 host plants and 10% having 26-50 host plant for lac cultivation. However, in case of *ber* host plant majority of farmer (65.22%) had>25 *ber* plants and 21.74% farmers 51-100 *ber* host plants.

Distribution pattern of scale of lac production (Percentage of lac growers): In term of production, maximum lac growers (29.03%) produced >300 kg lac with an average production of 564 kg followed by 16.13% farmers produced 201-250 kg lac with 227 kg average production, 12.90% produced 51-100 kg lac with 69 kg average production, 12.90% lac growers produced 151-200 kg with 182 kg average production, (9.68%) produced 26-50 kg lac with 38.33 kg average production. However, 9.68% lac growers produced lac in <25 kg with 16.66 average production and only 6.45% lac growers produced lac in 251-300 kg with 277.5 kg average production of lac and 3.23% lac growers produce 101-150 kg lac with 120 kg average production.

Source of income of lac growers: The data in Table 9.35 indicate the sources of income to lac growers. Lac is a subsidiary crop for the lac growers who depend on it for meeting cash expenses towards family needs and household requirements. In the selected areas, lac is only next to agriculture as an important source of income.

Table 9.35: Various sources of income of lac growers in Gondia district of Maharashtra

Sl.No.	Particulars	Share in total income (%)
1	Agriculture (Food grain)	56.83
2	Lac cultivation	22.12
3	Salary /Business	7.40
4	Labour	6.58
5	Other Forest produce	0.41
6	Animal husbandry	2.14
7	Vegetable	0.57
8	Others	3.95
	Total	100.00

Distribution of farmers' income from lac cultivation: With respect to information on various income sources, there was wide variation in income. Income of selected farmers of Gondia from lac cultivation is given in Table 9.36.

Table 9.36: Classification of farmers based on income from lac cultivation

Annual income from lac (Rs.)	Percentage of farmers	Average income per annum
Up to 5000	9.68	3,000
5001-10000	9.68	9,000
10,001-20,000	12.90	12,750
20,001-30,000	6.45	24,375

Annual income from lac (Rs.)	Percentage of farmers	Average income per annum
30,001-40000	6.45	40,000
40000-50000	16.13	46,090
>50000	38.71	1,20,425

Percentage contribution of income from lac cultivation to total income: Contribution of lac income to total income of the farmers has been surveyed. As per estimation of income of selected farmers of Gondia district (Table 9.37), 38.71% farmers share of income from lac belongs to Category II, followed by 22.58% farmers belong from category I, 16.13% farmers belong from category V, 12.90% farmers belong from category III and only 9.68% farmers belong from Category IV.

Table 9.37: Percentage contribution of farmers from lac cultivation to total income

Category	Share of income from lac of growers in Gondia	No. of farmers	Percentage of farmers
Category-I	<10%	7	22.58
Category-II	10-20%	12	38.71
Category-III	21-30%	4	12.90
Category-IV	31-40%	3	9.68
Category-V	>40	5	16.13

ii. Socio-economic status of lac collectors of Chargaon village of Katni district (MP)

The study was conducted in Katni district, which is the *ghont* lac producing district of Madhya Pradesh. Twenty lac collecting farmers of Chargaon village of Rethi block of Katni district were selected at random and interviewed. All the relevant information was collected from the lac producers through a pre-tested questionnaire in the year 2021.

Classification of respondents according to their age: 65.38% belonged to middle aged group (36-45 years), 15.38% to young age group (Up to 35 years), 11.54% belonged to 46-55 age group, 3.85% to old age group (in age 66 years) and only 3.85% to senior age group (Age group up to 56-65).

Source of income of lac growers: Amongst the different source of income, Agriculture (44.03%) ranked first followed by labour work (38.09%), lac collection (17.88%).

Lac production status of lac growers: In terms of collection of lac from *ghont* and *palas*, 38.46% lac farmers collected lac between 26-50 kg with average collection of 44 kg, 26.92% collected lac less than 25 kg lac with average collection 18.71 kg, 23.08% collected 51-75 kg with 68.33 kg average collection and only 3.85 per cent farmers collected 100 kg lac with 150 kg average lac collection.

Distribution of farmers' income from lac cultivation: income generated from lac cultivation is shown in Table 9.38.

Table 9.38: Classification of farmers on the basis of income from lac cultivation

Annual income from lac (Rs.)	No. of farmers	Percentage of farmers	Average income per annum
Up to 2,500	5	19.23	1,820
2,600-5,000	10	38.46	4,500
5,001-7,500	8	30.77	6,750
7,501-10,000	2	7.69	10,000
>10,000	1	3.85	15,000

Percentage contribution of income from lac cultivation to total income: Contribution of lac income to the total income of farmers has been surveyed in Katni district is given in Table 9.39.

Table 9.39: Percentage contribution of income from lac cultivation to total income

Category	Share of income from lac in Katni	No. of farmers	Percentage of farmers
Category I	<10%	4	15.38
Category II	10-20%	13	50.00
Category III	21-30%	7	26.92
Category IV	>30%	2	7.69

iii. Socio-economic status of lac collectors in Dindori district of Madhya Pradesh.

The study was conducted in Dindori district, which is the major*kusmi* lac producing district of the Madhya Pradesh. Twenty lac collecting farmers of three blocks (Dindori, Samnapur and Amarpur) of Dindori district were selected at random and interviewed. All the relevant information were collected from the lac producers through a pre-tested questionnaire in the year 2021.

Distribution of respondents according to their age: 55%belonged to 36-45 age group, 20% to 46-

55 age group, 20% to 35 age group and only 5% to senior age group (more than 55 years).

Educational status of lac growing farmers:40%reported literacy up to primary school level, followed by middle school (15%), High school (5%) and 40% were illiterate.

Distribution pattern of scale of lac collection: In term of production, 50% collected 51-100 kg lac with an average production of 68.8 kg followed by 30% farmers who collected 26-50 kg lac with 39 kg average production, 10% collected 151-200 kg lac with 185 kg average production. However, only 5% farmers collected 101-150 kg *kusmi* lac with 110 kg average production.

Source of income of lac growers: The data in Table 9.40 indicated that the sources of income to the lac collector in the Dindori district.

Table 9.40: Various sources of income of lac collectors

Sl. No.	Particulars	Share in total income (%)
1	Agriculture (Food grain)	38.02
2	Lac collection	27.92
3	Forest produce	4.66
4	Labour	29.40

Distribution of farmers' income from kusmi lac collection: Income of selected farmers of Dindori from *kusmi* lac collection is given in Table 9.41.

Table 9.41: Classification of farmers on the basis of income from lac cultivation

Annual income from lac (Rs.)	No. of farmers	Percentage of farmers	Average income per annum
Up to 5,000	0	0	0
5,001-10,000	3	15	7,833
10,001-20,000	9	45	15,766
20,001-30,000	7	35	24,357
>30,000	1	5	53,500

Percentage contribution of kusmi lac collection to total income: Contribution of lac income to total income of the farmers is given in Table 9.42.

Table 9.42: Percentage contribution of income from lac cultivation to total income

Category	Share of income from lac collection in Dindori	No. of farmers	Percentage of farmers
Category I	<10%	0	0
Category II	10-20%	3	15
Category III	21-30%	11	55
Category IV	31-40%	3	15
Category V	>40	3	15

iv. Socio-economic status of lac growers in Balaghat District (MP)

The study was conducted in Balaghat district, which is the major *rangeeni* lac producing district of the Madhya Pradesh. Random sampling technique was employed to select lac growers. Twenty lac collecting farmers of two blocks (Lamta and Balaghat) of Balaghat district were selected at random and interviewed. All the relevant information were collected from the lac producers through a pre-tested questionnaire in the year 2021.

Distribution of respondents according to their age: Out of total farmers interviewed in Balaghat, 35%were belonged to 36-45 age group, 20% to 46-55 age group, 20% to <66 age group, 15% respondents belong to senior age group (56-65) and only 10% of young age group (up to 35 years).

Educational status of lac growing farmers:30% reported literacy up to upto primary school level followed by middle school (25%), high school (20%), higher secondary school (20%) and only 5% lac growers were found graduate.

Lac host plant availability of lac growers: Eighty five percent lac growers have *palas* and 15% lac growers had taken host plants on lease. Regarding availability of *palas* host trees for lac cultivation, 35% of lac growers each had less than 25 and 26-50 host tree followed by 10% farmers having 51-100 host trees and only 5% lac growers had 101-200 host trees. However, 10% farmers had taken >5000 host plants on lease and 5% had taken <5000 host plants on lease from farmers' field

Distribution pattern of scale of lac production: In term of production, 20% farmers produced 301-400 kg lac with an average production 387.5 kg followed by 20% farmers producing 201-300 kg lac with 255 kg average production, 10% producing<500 kg lac

with 775 kg average production. However, only 10% farmers produced 100-200 kg *kusmi* lac with 160 kg average production, 10% produced 26-50 kg lac with 37.5 kg average production and only 5% produced 401-500 kg with 475kg average production.

Source of income of lac growers: The data in Table 9.43 indicates the sources of income to lac growers in the district.

Table 9.43: Various sources of income of lac collectors

Sl. No.	Particulars	Share in total income (%)
1	Agriculture (Food grain)	54.53
2	Lac cultivation	37.75
3	Labour work	6.59
4	Vegetable	1.13

Distribution of farmers' income from lac cultivation: Income of selected farmers of Balaghat from lac cultivation is given in Table 9.44.

Table 9.44: Classification of farmers on the basis of income from lac cultivation

Annual income from lac (Rs.)	No. of farmers	Percentage of farmers	Average income per annum
Upto 10,000	2	10.00	3,500
10,000-20,000	4	20.00	15,063
20,001-40,000	2	10.00	27,500
40,001-60,000	2	10.00	54,000
60,001-80,000	4	20.00	66,875
80,001-1,00,000	3	15.00	91,667
>1,00,000	3	15.00	1,89,167

Percentage contribution of income from lac cultivation to total income: Contribution of lac income to total income of the farmers is given in Table 9.45.

Table 9.45: Percentage contribution of income from lac cultivation to total income

Category	Share of income from lac of growers in Balaghat	No. of farmers	Percentage of farmers
Category I	<10%	2	10.00
Category II	10-20%	7	35.00
Category III	21-30%	2	10.00
Category IV	31-40%	3	15.00
Category V	40-50%	1	5.00
Category VI	<50	5	25.00

Survey of lac traders of Katni and Panna district of Madhya Pradesh

Traders' survey was conducted in Katni and Panna district of Madhya Pradesh to estimate the lac production. Seven lac purchasing traders of Katni were interviewed. Based on survey, it was observed that in Katni district lac is produced on *palas* and *ghont* trees. Majorityof lac (215 quintal) was produced on *palas* tree and only eight quintal on *ghont* tree annually. In case of *palas* lac, lac is mostly cultivated on farmers' field whereas *ghont* lac is collected from forest areas by *van samiti* members in October-November month. In case of Panna district, 130 quintal lac was produced on *palas* and *ber* tree.

Reasons for declining *kusmi* lac production in Madhya Pradesh

A study was undertaken to record the reason behind reduction of *kusmi* lac production in Madhya Pradesh. Data were collected through structured questionnaire method. Reasons recorded are given below:

1. **Problem of Broodlac availability:** The unavailability and / or poor quality of *kusmi* broodlac is a major problem in various *kusum* host potential areas. Also, the farmers are not getting the *kusmi* broodlac on reasonable rate.
2. **Lack of awareness on lac cultivation techniques:** In many areas of like Dindori, Balaghat, Mandla, Chahindwara, Betul, tribal's people practice traditional method of lac cultivation, they are not aware of lac cultivation techniques.
3. **Problem of markets:** The availability of market depends on the location and accessibility of the different lac production areas. *Kusmi* lac is mainly cultivated in remote areas as *kusum* trees are available in the forest area. *Kusmi* lac cultivators are facing problems of accessing the market at the right time because required transport facility is not available mainly in Betul and Dindori districts.

4. **Problem of theft:** Due to the better price of *kusmi* lac, the possibility of theft is more in *kusmi* lac production areas. This problem found to be more in those areas where *kusum* trees are scattered in the forest areas, mostly in Dindori and Mandla districts.
5. **Problem related to climatic factors: C**limate change is major factor in every *kusmi* lac producing areas of Madhya Pradesh. Lac insect dies in summer season due to unexceptional temperature and excessive heat. Therefore, the farmers do not get proper yield. This problem was observed to be more severe in Narsinghpur district.

Success story: Successful adoption of lac production technology for livelihood in Bhandara district Maharashtra

Bhandara district of Maharashtra state has a rich forest cover and *palas* trees are abundant in this area. The farmers were not aware of lac cultivation and had never seen lac. Lac cultivation was introduced to six *samiti* members (Chaitanya Mahila Bachat Gat) by SFRI Jabalpur under NP-CLIGR project during 2019. Initially, 30 Kg broodlac was provided to *van samiti* member for inoculation on 100 *palas* tree. Six families of Malepar village of Bhandara district partially harvested 150 Kg *rangeeni* scrapped lac from *palas* trees in the year 2020; sold it for Rs 33,000 in nearly available market and remaining broodlac used for multiplication on more than 50 *palas* tree. During the year 2021, 135 Kg scrapped lac have been produced worth Rs. 47,250. The average income per family was Rs. 7,875 from lac cultivation. After successful production and marketing, the farmers opined that lac cultivation techniques are very simple, required little time and very less input in comparison to other agricultural crop. The inputs and training was provided by SFRI, Jabalpur under the NP-CLIGR.

9.9 Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Jammu

1. Conservation of lac insects through selfing in Jammu region

Partial broodlac harvesting was practiced on lac bearing host-plants observed during survey and the host-plants in the vicinity without lac were inoculated for sustaining and conserving native strain. (Table 9.46).

Table 9.46: Conservation through selfing in Jammu region

Host	Total plant surveyed (No)	Frequency of occurrence without inoculation	Trees Inoculated in previous season	Presence of lac	Brood Status
Ber	911	25	398	155	Good
Kikar	703	0	303	78	Good
Palash	505	0	215	41	Poor
Shisham	290	0	100	29	Poor
Khair	395	0	95	18	Poor
Calliandra	103	0	35	17	Good

2. Artificial inoculation and conservation

i. In mid hills to escape summer mortality: In artificial inoculation, brood twigs were cut in size 20 - 30 cm in length and tied to fresh tree twigs in such a way that each stick touched the tender branches of trees at several places. This was done on pre pruned *ber* at Dhar Road from Majalta to Billawar and Basholi. A major initiative was taken at Cherni Phari and around areas; succulent branches of *Ficus* sp., *Ber* and *Kikar* at University Rainfed Research Station, Raya and around the Jammu region and at Himachal Pradesh brood twigs were tied with the selected and tagged plants. Details are given in Table 9.47.

Table 9.47: Conservation through artificial inoculation

Host Plant	Inoculated plants (no.)	Presence of lac (no.)	Brood Position
Ber	89	63	Good
Khair	46	12	Not good
Ficus racemosa	23	0	Nil

ii. On *arhar* at SKUAST-J: Artificial inoculation of the brood was done on *arhar* plants that were raised in the Regional Field Gene Bank (RFGB) of the university. A good settlement has been recorded on the *arhar* plants so far.

iii. On *Flemingia semialata* and *F. macrophylla* at SKUAST-J: *Flemingia semialata* and *F. macrophylla* were raised in nursery for rearing lac insects for the purpose of conservation and were then transplanted in the RFGB 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 these plants also.

3. *Ex-situ* multiplication of promising strains for brood purpose

i. Brood farm at Chatha: For the establishment of brood farm at Chatha, the site after cleaning was divided into sub-plots for plantation. Seeds of *Flemingia* procured from IINRG were raised in the nursery beds and seedlings transplanted into field.

ii. Brood farm at Vijaypur: Plants raised in the nursery at Chatha were also transplanted at brood farm at Vijaypur in Samba District for cultivating lac from where farmers can easily get the brood for the inoculation on *Ber* plants in their fields. Some plants have inoculated with broodlac.

a. Inoculation and management of broodlac

- ✓ During mid-October, on the appearance of emergence spots in the tagged infested trees in field, the branches were partially clipped and were made into cuttings of broodlac 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* and *F. macrophylla* in nursery. '*Phunki'* lac was removed after complete emergence and settling of lac insect crawlers on the branches.
- ✓ Periodic management of nursery and potted plants of *F. semialata* and *F. macrophylla* bearing lac insect crawlers was performed. Observation on the maturation and growth of lac insects are being recorded timely.

iii. Regional Field Gene Bank

i. Brood maintenance

Thirteen collections that survived successfully from previous year collections were re-inoculated on *Flemingia* and are being maintained in the RFGB.

ii. New collections and their conservation

The lac insects samples collected from the different lac hosts from various localities were inoculated on different lac host plants at SKUAST- Jammu during the month of June and October 2021. After inoculation, the emergence and settlement data were recorded for each sample of lac insect (Table 9.48). To prevent the infestation of lac insects with different natural enemies and fungi, recommended pesticides were sprayed at different stages of lac insect.

Table 9.48: Details of new lac insect collections

Collection name	GPS location	Settlement density (crawlers/ cm2)	Mean brood cells/30 cm	Mean weight 100 cells (g)	Fecundity (No.)	Resin weight (mg)
Gol Market	32°70´18.45"E 74°85´93.54"N	192.3	58	2.03	168.9	9.08
Bantalab	32°78'48.26"E 74°82'19.98"N	173.5	43	1.95	193.8	7.98
Purkhoo	32°47´13.34"E 74°47´13.34"N	127.8	36	1.61	197.3	6.08
Udheywala	32°74´35.78"E 74°81´19.63"N	102.5	21	1.05	108.8	5.98
Kathua	32°38´61.65"E 75°51´61.73"N	132.7	38	1.75	185.3	7.50
Canal Raod	32°43´47.94"E 74°50´48.17"N	22.4	11	0.81	112.6	5.04
Nagrota	32°47´53.07"E 74°54´54.80"N	43.9	13	0.95	132.8	5.12
Kangra (H.P.)	31°51´07.88"E 76°11´13.32"N	12.7	9	0.39	93.6	3.98
Cherni Pahari	32°67´52.47" E 75°37´67.48"N	182.7	45	1.98	178.9	8.12

Collection name	GPS location	Settlement density (crawlers/ cm2)	Mean brood cells/30 cm	Mean weight 100 cells (g)	Fecundity (No.)	Resin weight (mg)
Chi Chi Mata	32°56´45.39"E 75°09´23.95"N	165.7	39	1.86	159.9	7.35
Ghagwal	32°45'11.48"E 75°26'08.90"N	96.8	18	0.99	116.8	5.89
Railway Station	32°76´21.72"E 74°95´20.67"N	120.8	32	1.35	158.9	7.65
Barmana	31°41´10.50"E 76°83´19.43"N	35.9	12	0.74	98.9	4.65

4. *In-situ and ex-situ* conservation initiative for sustainability

i. Brood multiplication

a. Brood production

Past year collections were subjected to brood production and re-inoculated for further use (Table 9.49).

Table 9.49: Details of broodlac produced

Collection name	Quantity produced (kg)	Reintroduced for conservation in same location (no. of plants)	Demonstrations (no. of plants)
Gol Market	163	72	45
Bantalab	83	43	25
Purkhoo	68	36	25
Udheywala	45	31	13
Kathua	61	42	21
Canal Raod	47	33	17
Nagrota	52	31	18
Kangra (H.P.)	19	19	9
Cherni Pahari	201	85	52
Chi Chi Mata	137	78	39
Ghagwal	73	48	25
Railway Station	58	32	18
Barmana	11	17	8
TOTAL	**1018 KG**	**567**	**315**

b. Plants of *Flemingia semialata* and *F. macrophylla* were raised in nursery

Nurseries of *Flemingia semialata* and *F. macrophylla* were separately raised for rearing of lac insects for conservation and multiplication. 1511 plants were also distributed among the famers.

c. Artificial Inoculation for multiplication on *ber* (398 No.) and *kikar* (303 No.) in Jammu region

Artificial inoculation was done for the multiplication of lac insect. Brood twigs were cut in size 20 - 30 cm in length and tied to fresh tree twigs in such a way that each stick touched the tender branches of trees at several places. This was done on or pre-pruned *ber* and succulent branches of *kikar*, *khair*, *palash* and *peepal* in the Jammu region and also in Himachal Pradesh.

5. Performance of different locally collected lac strains

The lac insect samples collected from various lac hosts of different locations were inoculated on different lac host plants at SKUAST – Jammu. After inoculation the emergence and settlement data were recorded for each sample of lac insect on the host plants. To prevent infestation of natural enemies and fungi insecticides were sprayed on host plants at different stages of lac insects.

A. Lac crop performance on natural host *ber* at Raya

i. Mean number of Sticklac on *ber* per plant at harvest: The mean of number sticklac per plant varied from 18 to 45 in *rangeeni* lac (Fig. 9.41).

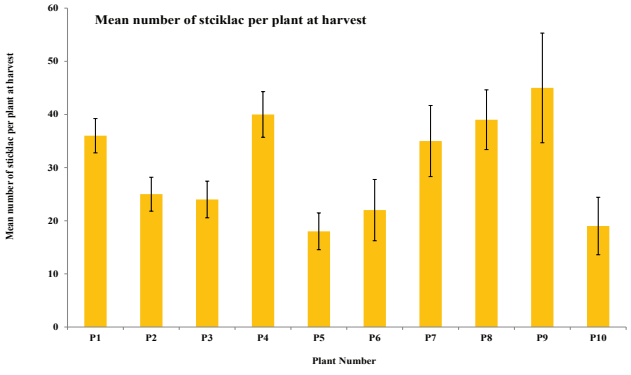


Fig. 9.41: Mean number of sticklac on *ber* per plant at harvest (*katki*)

ii. Weight of sticklac: The mean weight of sticklac per 30 cm varied from 32.65 to 80.82 g in *rangeeni* lac (Fig. 9.42).

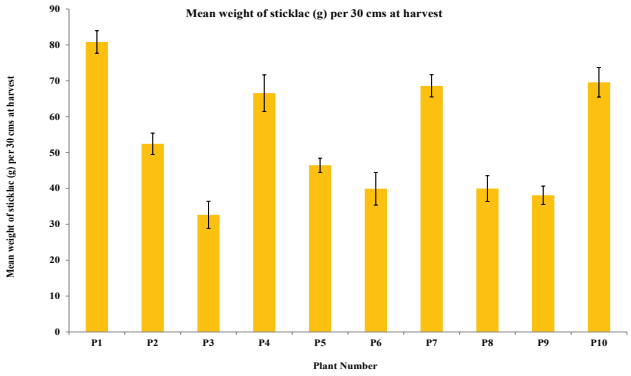


Fig. 9.42: Mean weight of sticklac (g) per 30 cm at harvest

iii. Raw lac per 30 cm sticklac: The mean weight of raw lac varied from 9.66 to 16.87 in *rangeeni* lac (Fig. 9.43).

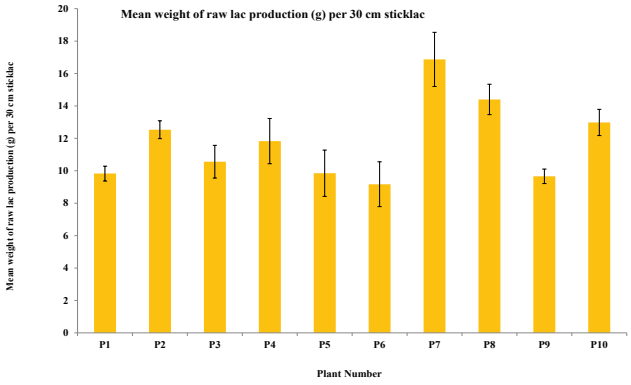


Fig. 9.43: Mean weight of raw lac production (g) per 30 cm sticklac

iv. Mean fresh weight of 100 lac cell: The mean fresh weight (g) of 100 cell of lac insect varied from 3.98 to 6.34 g in *rangeeni* lac (Fig. 9.44).

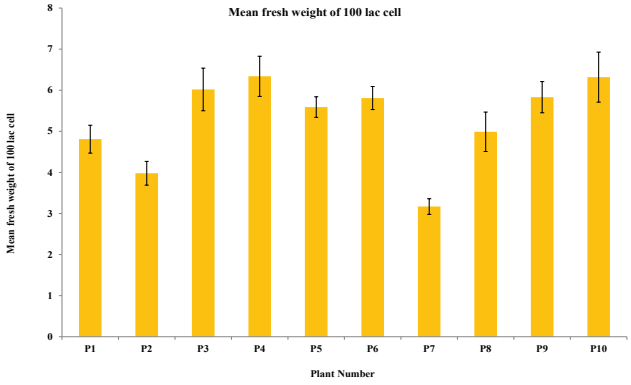


Fig. 9.44: Mean fresh weight (g) of 100 cell of lac insect

B. Effect of temperature on survival of lac insect

Relationship between the temperature and the mortality depicted in Fig. 9.45 showed increased mortality with the increase in temperature. The mortality started increasing from 11th standard week, when the temperature tended to reach 26.9 °C. Among *ber*, *kikar*, *Flemingia* and *arhar,* maximum mortality of 54.19 per cent was recorded in *Ber* followed by *Flemingia, arhar* and *kikar* with per cent mortality of 51.63, 49.53 and 34.29 respectively, when the maximum temperature of 41.7 °C was recorded.

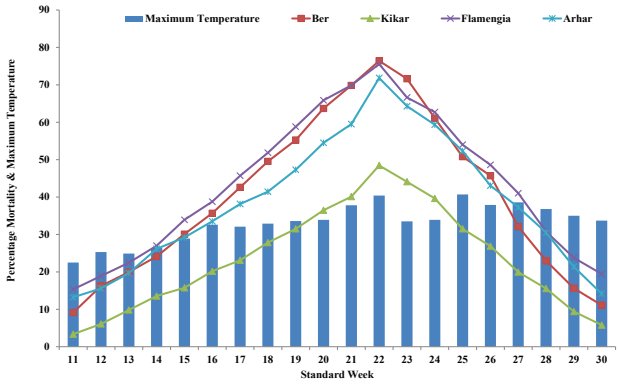


Fig. 9.45: Relation between temperature and mortality of lac insect as observed under field conditions on *ber*, *kikar*, *Flemingia* and *arhar*

C. Parasitism

i. Mean number of parasitoids infested lac cell at 90 days after BLI: Two applications of Indoxacarb (0.5ml/l) significantly reduced the infestation of parasitoids in lac cell of *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 3.54/2.5sq cm to 0.83/2.5sq cm. However, the parasitoid numbers varied from 29 to 45 (Fig. 9.46).

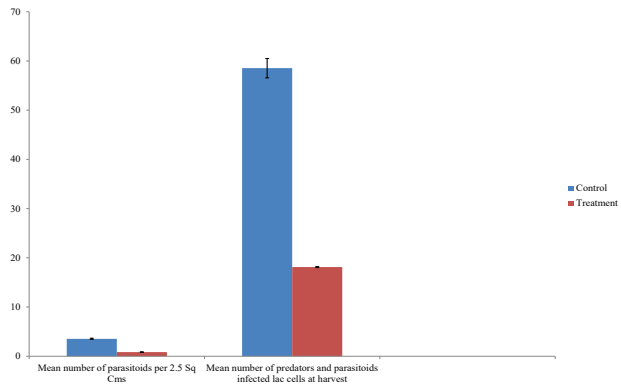


Fig 9.46: Mean number of parasitoids and predators over control at harvest

ii. **Mean number of predator and parasitoids infected lac cell at harvest per 30 cm sticklac:** Pesticide applications significantly reduced the mean number of predators / parasitoids infested lac cells at harvest. It was 58.53 in case of control and was reduced to 18.11 in treated plants at harvest (Fig. 9.46).

D. Popularising lac on limited scale

i. **Trials on lac cultivation:** Five trails were conducted at Research Farm, SKUAST-Jammu and ten trials at selected progressive grower's fields wherein fifty farmers were exposed to lac cultivation while more than five hundred farmers were shown lac being grown / cultivated at selected sites for the demonstration of lac cultivation technologies. Saplings of *Flemingia semialata* and *F. macrophylla* and broodlac were distributed to the potential growers for conservation and multiplication. Seventy-three farmers were provided with broodlac. Thirty-one visits for continuous deliberations with the people of the areas were conducted regarding the presence of lac insect in the area and information was given to them on lac cultivation and its value and uses. Informative pamphlets (952 No.) were also distributed among the participants. Eight interactive sessions were conducted for the farmers.

ii. **Training programmes:** Two one-day training programmes were conducted at Main campus, SKUAST-Jammu in collaboration with IINRG, Ranchi. Progressive farmers were briefed about the importance of lac insect and lac cultivation. They were also informed about the monetary benefits of lac and how can they create their own livelihood while attaining lac cultivation on large scale. Thirty-eight progressive growers actively participated in each training programme. These farmers were given complete demonstration from nursery preparation up to harvesting and inoculation of broodlac on different host plants. Pamphlets were distributed among the farmers containing information about scientific cultivation of lac in vernacular languages.

iii. **Involvement of students:** 54 RAWE students of SKUAST-Jammu were enlightened about the importance of lac insect and lac cultivation. They were briefed about the scientific rearing and handling of the lac insect. Besides this, students from the visiting schools; students of Diploma in Agriculture Training and Diploma in Horticulture Training from Department of Agriculture and Horticulture, J&K Government were taught about lac cultivation. Students from Central University, Jammu visited the RFGB at SKUAST-Jammu.

iv. **Distinguished Visitors:**

- ✓ Sh. Farooq Khan, Advisor to Hon'ble LG UT of J&K
- ✓ Sh. Navin Kumar Choudhary (IAS) Principal Secretary to Government
- ✓ Dr. J. P. Sharma Hon'ble VC, SKUAST-Jammu
- ✓ Dr. Sanjay Kumar, Director CSIR-IHBT, Palampur
- ✓ Sh. Sham Lal Sharma, Former Minister, Government of J&K
- ✓ Dr. J. P. Sharma, Former Director Research and Registrar SKUAST-J
- ✓ A team of scientists from IIT, Jammu
- ✓ Dr. R. S. Chandel, Prof. & Head, Entomology, CSK HPKV, Palampur

Publications

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1. Mohanasundaram A, Sharma KK, Sweta V, Anees K and Rashmi M (2021). Broodlac quality assessment and forecasting of crawler emergence in Indian lac insect *Kerria lacca*. *Indian Journal of Entomology*, 1–5. 84(I):24-28.
2. Rahman T, Das P, Hazarika LK, Kalita S, Sharma KK and Mohanasundaram A (2021). Exploration of native plants of Assam for host preference of lac insect *Kerria chinensis. Indian Journal of Entomology* Doi.: 10.5958/0974-8172.2021.00176.0
3. Rahman T, Das P, Hazarika LK, Sharma KK, Mohanasundaram A and Roy S (2021). Evaluation of certain plant hosts for the lac insect. *International Journal of Tropical Insect Science https://doi.org/10.1007/s42690-021-00438-2*
4. Kashyap P, Das P, Sharma KK, Mohanasundaram A and Hazarika LK (2021). Biology and morphometric study of *Callosobruchus chinensis* on seeds of *Flemingia spp*.: A host plant of lac insect. *Journal of Entomology and zoology studies* 9(1): 1955-1959.
5. Kashyap P, Das P, Sharma KK, Mohanasundaram A, Kumar S and Rahman T (2021). Evaluation of plant products against *Callosobruchus chinensis* infesting stored *Flemingia macrophylla* seeds. *Indian Journal of Entomology.* Doi: 10.5958/0974-8172.2021.00022.5

6. Singh KJ, Singh KI, Haldhar SM, Singh NO and Rustom N (2021). Study on host preference of lac insect species existing in Manipur. *International Journal of Agriculture, Environment and Biotechnology* 14: 387-391.

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12. Lodhi B, Bhatnagar P and Aarmo B (2021). Study on abundance of lac associated fauna in Seoni and Balaghat districts of Madhya Pradesh. *Indian Journal of Entomology and Zoology Studies*. 9 (2): 608-613

13. Bhatnagar P, Lodhi B and Prajapati S (2021). Lac insect occurrence in different agro-climatic zones of Madhya Pradesh. *Indian Journal of Agriculture Research*. 45(2): 324-335

14. Bhatnagar P, Lodhi B, Prajapati S and Aarmo B. (2021). Occurrence of lac insect and its host plants in Madhya Pradesh. *Indian Journal of Entomology*. Online published Ref. No. e20334 (August 2021)

Popular articles

1. Das P, Hazarika LK and Saikia P (2021). Lac based folk medicine use by tribal communities of Assam. SANRAG E-Newsletter, **2**(1): 2-3.

2. Das P (2021). Raharmahar gasot laa kheti (Assamese). Dainik Janambhumi

3. Das P, Borah B, & Saikia P (2021). *Eublemma amabilis* Moore: A major threat to lac culture in Assam. SANRAG E-Newsletter, **2**(2): 5-7.

4. Das P (2021). Boigainik vitit Bogori Gosot Laa Khati. Ghore pothare. Vol 18, pp 4

5. Sajeev TV (2021). Tiny insect, big industry- The tale of lac insect. ENVIS Newsletters 27(4):1-9.

6. डॉ. हेमन्त स्वामी, डॉ. लेखा एवं गौरांग छंगाणी। लाभकारी लाख कीट के प्राकृतिक शत्रु व उनका प्रबंधन (2021)। राजस्थान खेती–प्रताप अप्रेल :11–12

7. डॉ. हेमन्त स्वामी, डॉ. लेखा एवं डॉ. गौरांग छंगाणी। बेर पर लाख उत्पादन (2021)। राजस्थान खेती–प्रताप नवम्बर : 24–27

8. Lodhi B, Aarmo B, Barman R, Singh V and Majumdar A (2021). कुसुम के वृक्षो में लाख उत्पादन की कृषि प्रक्रिया. Vol 21 (02), 3-9.

9. लाख कीट संरक्षण एवं वैज्ञानिक विधि से उन्नत लाख खेती के आर्थिक लाभ संबंधी अध्ययन, मध्य प्रदेश वनांचल संदेश, जनवरी–जून 2021, पृ0 क्र0 70 से 72

10. लाख उत्पादन एवं स्थानीय वन्यप्राणियों की पहचान संबंधी एक दिवसीय प्रशिक्षण कार्यशाला का आयोजन, मध्य प्रदेश वनांचल संदेश, जनवरी–जून 2021, पृ0 क्र0 72

Books

1. Sajeev TV, Muthukumar S, Anuja J, Sharma KK, Mohanasundaram A and Lohot VD (2021). Handbook on lac insects and host plants in Kerala. pp.21. ISBN number (ISBN: 978-81-953863-4-5).

2. Shera PS, Kaur R, Sharma S, Thakur A and Mangat HK (2021). Lac Cultivation. Network Project on Conservation of Lac Insect Genetic Resources, Department of Entomology, Punjab Agricultural University, Ludhiana and ICAR – Indian Institute of Natural Resin and Gums, Ranchi

Bulletins

1. Das P, Kalita S and Saikia, P (2021). Bogori gosot laa kheti (AAU/DR/21/BU/412/2021-22).1-4 pp.
2. Das P, Kalita S &Saikia, P (2021). Boiganik vitit semialata gosot laa kheti. (AAU/DR/21/BU/445/2021-22). 1-4 pp.
3. Dr. R. K. Gupta, Dr. Kamlesh Bali, Dr. Suheel Ahmad Ganai. 2021. Lac cultivation: Its market potential in Jammu. Network Project on Conservation of Lac Insect Genetic Resources, Division of Entomology, SKUAST-Jammu and ICAR- Indian Institute of Natural Resins and Gums.
4. Dr. R. K. Gupta, Dr. Kamlesh Bali, Dr. Suheel Ahmad Ganai. 2021. लाख की खेतीः जम्मू में इस की बाजार संभावना. Network Project on Conservation of Lac Insect Genetic Resources, Division of Entomology, SKUAST-Jammu and ICAR- Indian Institute of Natural Resins and Gums.
5. Telegu bulletin*: Flemingia mokkalapi lakka saagu* (Cultivation Lac insect on *Flemingia*)
6. Telegu bulletin*: Kusum - Schleichera oleosa chetlapi lakka saagu* (Cultivation Lac insect on *Kusum*)

Manuals

1. Das P, Deka M.K & Bhattacharyya S (2021). ENT-312 (1+1) Management of Beneficial Insects 2(1+1). Published by Dean, Faculty of Agriculture, AAU, Jorhat-13.9-13 pp.
2. Das P, Saikia, P (2021). Manual-Lac insects and associated fauna (AAU/DR/21/TM/446/2021-22. Published by Directorate of Research, Studies, AAU, Jorhat-13.1-30 pp.

Extension folders

1. R. K. Gupta, Kamlesh Bali and S. A. Ganai. 2021. Lac Cultivation: How, When and Why in Local vernacular language Page No. 1-4, Directorate of Research, SKUAST-Jammu
2. R. K. Gupta, Kamlesh Bali and S. A. Ganai. 2021. Different host for lac cultivation in Jammu region of Jammu and Kashmir in Local vernacular language Page No. 1-10, Directorate of Research, SKUAST-Jammu
3. बेर पर लाखपालन। डॉ. हेमन्त स्वामी, डॉ. लेखा, डॉ. गौरांग छंगाणी एवं एन एल रेगर

Pamphlet

1. Hemant Swami, Lekha and Gaurang Chhangani (2021) Processing of Lac & its Products: *Kerria lacca* (Kerridae: Hemiptera): Gift of Nature

Papers Presented/Contributed in Conferences/ Symposia/Seminars

1. Das, P (2021). Axomot Laa khetir hombhabonoita. 7th Annual Conference of United Bodo People's Organisation at Mithinga Nwgwr, Uriamghat, Dhansiri in the district of Golaghat, Assam, February 18, p 135

   Following papers were presented in the National Web Symposium on Recent Advances in Beneficial Insects and Natural Resins & Gums, ICAR, IINRG, Ranchi, February 25-26, 2021
2. Aswathy K, Muthukumar S and Sajeev TV (2021). Evaluation of whitefly control methods on *Flemingia semialata*- The host plant for lac production. p. 102.
3. Bhatnagar P and Lodhi B (2021). Lac insect occurrence in different agro-climatic zones of Madhya Pradesh. p. 27.
4. Das P, Saikia P, Hazarika LK, Borah B, Sharma KK and Mohanasundaram A (2021). Life cycle study of *Kerria chinensis* on *Flemingia semialata* Robx. in Assam. p. 82.
5. Ganai SA, Gupta RK, Bali K and Kour R (2021). Collection and performance of locally collected *Kerria lacca* strain on different host plants in Jammu region. p. 37.
6. Lekha, Swami H, Chhangani G and Regar NL (2021). Host plant diversity of lac insect [*Kerria lacca* (Kerr)] in arid western plains of India. p. 54.
7. Lodhi B and Bhatnagar P (2021). Study on abundance of lac associated fauna in Seoni and Balaghat districts of Madhya Pradesh. p. 16.
8. Mangat HK, Thakur A and Shera PS (2021). Biology and Productivity linked parameters of lac insect, *Kerria lacca* (Kerr) on *Flemingia* in semi-arid zone of Punjab. p. 93.
9. Monobrullah, Md. and Kishor DR (2021). Natural occurrence of lac insect in different agro-climatic zones of Bihar. p. 20.

10. Rao SRK, Naresh T, Mohanasundaram A, Panduranga GS, Dhurua S, Jyothula DPB and Rao TS. New record of host-plant for lac insect *Kerria* spp in Andhra Pradesh. p. 32.

11. Roopa SP, Jeer V, Javaregowda and Sharma KK (2021). Survey on natural occurrence of lac insect, distribution and associated host plants in Karnataka. p. 21.

12. Sajeev TV, Maneetha TK, Ratheesh R and Muthukumar S (2021). Occurrence of Lac Insect and its host plants in three South Indian states and Pondicherry Union Territory. p. 50.

13. Singh A, Kaur R, Mangat HK, Thakur A, Sharma S, Mohanasundram A and Shera PS (2021). Natural enemy fauna associated with Lac Insect, *Kerria lacca* (Kerr.) under Punjab conditions. p. 22.

14. Swami H, Lekha, Chhangani G and Regar NL (2021). Diversity of natural enemies associated with lac [*Kerria lacca* (Kerr)] in arid western plains of India. p. 10.

15. Thakur A, Mangat HK, Singh A, Kaur R, Sharma S and Shera PS (2021). Effect of lac cultivation (*rangeeni* Strain: *katki* Crop) on the yield and biochemical parameters of *Cajanus cajan.* p. 39.

16. Vandana Bharathy CV, Anuja Joseph, Sajeev TV and Muthukumar S (2021). A study on the pests of lac insect host plants *Flemingia semialata and Flemingia macrophylla* in Kerala. p. 51.

Publicity

- ***Kisan melas*, Exhibitions, Institute- industry interface meeting**
  - ✓ Displayed lac and lac items in 5 Days North Zone Kisan Mela held at SKUAST-J.
  - ✓ Displayed lac and lac items in Diwali mela at SKUAST-J.
- **Radio/ TV talks**
  - ✓ Dr. R. K. Gupta. 2021. Conducted phone in programme on Lac Cultivation: How, When and Why All India Radio, Jammu in the month of June 2021.
  - ✓ Dr. Kamlesh Bali. 2021. Conducted phone in programme on Different Hosts of Lac Insect All India Radio, Jammu in the month of June 2021.
  - ✓ Dr. RK Gupta conducted phone in programme on Predators and Parasitoids of Lac Insect, All India Radio, Jammu in the month of September 2021.
  - ✓ Dr. Purnima Das delivered a lecture on Scientific lac cultivation in AIR Dibrugarh on June 3, 2021
  - ✓ Dr. KI Singh, CAU, Imphal delivered talk on "Importance of lac insect" in Manipuri version on All India Radio, Farm Programme on 22nd October, 2021.
- **Success stories**
  - ✓ Lac cultivation: Market Potential in Jammu and Kashmir, Early times P. No. 5.

Lectures delivered:

- ✓ Dr. P Das, Asst. delivered a lecture on scientific lac culture technology as resource person under DST sponsored project entitled "Integrated approaches towards addressing sustainable agriculture among the tribal population of Karbi Anglong district of Assam" to aware the tribals about the lucrative nature of lac insect. November 29, 2021.

Human Resource Development

- ✓ Dr. P. Das guided 3 M.Sc. students as major guide and 1 student in M.Sc degree programme as member in major discipline.
- ✓ Dr. P. Das also guided two Ph.D students as a major guide as below.

Sl. No.	Name of the student	Degree Programme	Title of the thesis
1	Priyanka Saikia	M.Sc. (Agri.), 2016-2018	Life cycle of lac insect on different host plants in Assam condition
2	Tanzil Rahman	M.Sc. (Agri.), 2017-2019	Study on native plants as host of lac insect, *Kerria chinensis* (Mahdihassan)
3	Preetipuja Kashyap	M.Sc. (Agri.), 2017-2019	Management of *Callosobruchus chinensis* (L.) (Coleoptera:Bruchidae) a stored grain pest of *Flemingia macrophylla* (Willd.) and *Flemingia semialata* (Roxb.)

Sl. No.	Name of the student	Degree Programme	Title of the thesis
4	Nang Himadri Chowsong	M.Sc. (Agri.), 2018-2020	Morphology of sensilla of lac insect, *Kerria chinensis* (Kerridae:Hemiptera)
5	Binita Borah	Ph.D (Agri.), 2017-continuing	Bio-ecology of *Eublemma amabilis* Moore and evaluation of certain entomopathogenic fungi for its management
6	Priyanka Saikia	Ph.D (Agri.), 2019-continuing	Physico-chemical characteristics & value addition of lac resins

✓ Dr. TV Sajeev guided three M.Sc (Zoology) students as a major guide which are listed below.

Sl. No.	Name of the student	Degree Programme	Title of the thesis
1	Sruthy CJ	M. Sc (Zoology) Sree Narayana College, Thrissur	Identification of the strains of *Kerria lacca* collected from three localities in Tamil Nadu and estimation of productivity linked parameter
2	Smitha S	M. Sc (Zoology) Sree Narayana College, Thrissur	Correlation of sex ratio and maturation of Kerria lacca with abiotic factors and physiological characters of major three host plants (*Flemingia semialata, F. macrophylla* and *Cajanus cajan*) in Kerala
3	Raveena R	M. Sc (Zoology) Sree Narayana College, Thrissur	Performance of *Kerria lacca* on different host plants in Kerala with study on the morphological variations in the mature female cells

List of Research Projects for the Year 2021-22

S I . No.	Project No.	Title of the Project	Name of Investigators	% Time	Year of Start	Year of Completion	*Associated Scientist
QUALITY AND PRODUCTIVITY IMPROVEMENT DIVISION							
Core Programme I: Biodiversity conservation of lac insect and NRG yielding plants							
1.	1.1.070/2020 (Old1.1.072)	Collection, conservation, characterization and evaluation of lac insect/ host plant diversity	Dr. VD Lohot (PI) Dr. J Ghosh Dr. Thamilarasi K Dr. Achintya Pramanik	25 25 25 25	March, 2020	Of continuing nature	Dr. KK Sharma Director
2.	1.1.082/2018 (Old1.1.070)	Taxonomic studies of lac insects (Hemiptera: Coccoidea: Tachardiidae) and associated insect fauna	Mr. NN Rajgopal (PI) Dr. Achintya Pramanik	35 25	June, 2018	Of continuing nature	-
Core Programme II: Lac insect-host plant environment for improved quality and productivity							
3.	1.1.088/2021 (New)	Study of physiological adaptations of Kerria lacca (Kerr) under moisture stress	Dr. Achintya Pramanik (PI) Mr. Sandeep Kumar	25 25	July, 2021	June, 2024	-
4.	1.1.089/2021 (New)	In Vitro Production of Aleuritic Acid	Dr. Thamilarasi K (PI) Ms. Shruti Sinha Mr. Sandeep Kumar Dr. Preeti Srivastava (IIT Delhi)	25 20 50	May, 2021	April, 2024	Dr. AR Chowdhury
5.	1.1.090/2021 (New)	Seed Deterioration and Amelioration strategies during Storage in Flemingia semialata	Dr. NK Sinha (PI) Dr. VD Lohot Dr. J Ghosh	30 20 20	August, 2021	July, 2024	-
6.	1.1.059/2018 (Old1.1.068)	Effect of abiotic factors on lac associated fauna in rangeeni crops (Phase-II)			August, 2018	December, 2021	Dr. Achintya Pramanik
PRODUCTION AND EXTENSION MANAGEMENT DIVISION							
Core Programme III: Crop production system management and evaluation							
7.	1.1.084/2019 (Old1.1.069)	Agronomic interventions influencing lac production in palas (Butea monosperma) in summer season	Dr. S Ghosal (PI) Mr. NN Rajgopal	25 25	March, 2019	May, 2025	-
8.	1.2.058/2019 (Old1.1.071)	Lac Integrated Cropping System through Participatory Approach	Ms. LC Langlentombi (PI) Dr. S Ghosal Dr. NK Sinha Mr. NN Rajgopal	50 25 20 25	April, 2019	March, 2022	-
9.	1.2.091/2021 (New)	Estimation of water requirement and determination of growth-stage-specific crop coefficient (Kc) of Flemingia semialata Roxb."	Er. Pradosh Paramaguru (PI) Dr. Santosh S Mali, FS-RCHPR, Plandu, Ranchi	50	April, 2021	March, 2024	Dr. Soumen Ghosal
10.	1.2.092/2021 (New)	Characterization and management of sooty mold associated fungi in lac and documentation of other diseases of lac host plants	Dr. Rahul R. Bakade	50	April, 2021	March, 2024	Dr. Achintya Pramanik Dr. N Thombare

Core Programme IV: Capacity building, technology dissemination, impact assessment and market intelligence							
11	1.2.076/2017 (Old1.3.052)	Capacity building, skill development, extension education and information service on natural resins and gums	Dr. Nirmal Kumar (PI) Dr. RK Yogi Dr. SKS Yadav	25 25 25	October, 2017	Of continuing nature	-
12.	1.2.077/2017 (Old1.3.053)	Market information support and impact assessment of technological interventions for NRGs	Dr. RK Yogi Dr. Nirmal Kumar	25 25	October, 2017	September, 2021	-
APPLICATION & PRODUCT DEVELOPMENT (APD) DIVISION							
Core Programme V: Isolation, characterization, synthesis and standardization of NRG							
13.	1.3.075/2017 (Old1.2.071)	Synthesis of guar gum hydrogel-nanoparticle hybrid scaffold	Dr. SKS Yadav (PI)	25	July, 2017	September, 2021	-
14.	1.3.093/2021 (New)	Synthesis of Terminalia bellirica exudate gum hydrogel-metal nanoparticle composite materials for evaluation in drug release	Dr. SKS Yadav (PI)	25	August, 2021	July, 2023	
15.	1.3.094/2021 (New)	Synthesis of Gum Arabic based Hydrogel for remediation of dye contaminated water	Dr. Ch. Jamkhokai M (PI)	70	April, 2021	March, 2024	Dr. N Thombare Dr. AR Chowdhury
16.	1.3.095/2021 (New)	Synthesis of rosin derivative for its use as tackifier	Dr. MF Ansari (PI) Dr. AR Chowdhury	30 25	April, 2021	March, 2023	
Core Programme VI: Product diversification and bio waste utilization of NRG							
17.	1.3.083/2018 (Old1.2.072)	Development and evaluation of resin/gum based sticky insect trap	Dr. N Thombare (PI)	25	April, 2018	September 2021	
18.	1.3.086/2019 (Old1.2.075)	Study on natural gum based dietary fibre as encapsulant for delivery of functional feed	Dr. AR Chowdhury (PI) Dr. N Thombare Mr. Ch. Jamkhokai Mate Dr. Biplab Sarkar, ICAR-IIAB	25 25 15 -	September, 2019	August, 2022	-
MECHANIZATION AND PROCESS ENGINEERING (MPE) DIVISION							
Core Programme VII: Designing and development of farm tools and processing machineries							
19.	1.4.073/2017 (Old1.2.070)	Development of pilot plant of guar gum derivative for training and demonstration	Dr. SC Sharma (PI) Dr. AR Chowdhury Dr. N Prasad Er. SK Pandey Dr. SK Giri, CIAE, Bhopal	25 15 25 25 10	April, 2017	March, 2022	
Core Programme VIII: Process refinement, commercialization and entrepreneurship development							
20	1.4.096/2021 (New)	Ultrasound assisted extraction of protein isolates from guar meal for its potential applications in food	Dr. Palmei Gaibimei (PI)	75	April, 2021	March, 2023	Dr. N Thombare
ICAR-Network Projects							
21.	3.4.026/2009 (Old3.2.026)	Network project on Harvesting, Processing and Value Addition of Natural Resins and Gums (ICAR)	Dr. N Prasad (PC & PI) Dr. AR Chowdhury Dr. SC Sharma Er. SK Pandey Dr. N Thombare	25 25 25 25 25	February, 2009	March, 2021	Dr. VD Lohot

22.	3.1.055/2014 (Old3.1.054)	Network project on Conservation of Lac Insect Genetic Resources (ICAR)	Dr. KK Sharma (PC & PI) Dr. VD Lohot Dr. Thamilarasi K	25 25 25	August, 2014	March, 2021	-
KVK, Khunti, Ranchi							
23.	4.2.087/2020	Evaluation and dissemination of agricultural technologies for sustainable livelihood in tribal region	Dr. J Ghosh Dr. NK Sinha Dr. VD Lohot Dr. SC Sharma Dr. RK Yogi	25 10 10 25 10	July, 2020	June, 2025	Dr. Nirmal Kumar
Agri-Business Incubation							
24.	Institute Activity	Agri-Business Incubation under Component-II of NAIF Scheme of ICAR	Er. SK Pandey Dr. SC Sharma	30 25	April, 2019	Continuous in nature	Dr. RK Yogi
Inter-Institutional Projects							
1. ICAR-IINRG, Ranchi and ICAR-IIAB, Ranchi							
25.		Development and evaluation of the efficacy of novel nanoparticles for enhancing yield in rice and Indian major carp	Dr. AR Chowdhury, Co-PI	25	August, 2016	July, 2021	-
2. ICAR-IINRG, Ranchi and ICAR-RCER Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi							
26.		Enhancing food, nutritional and livelihood security of marginal and small farmers in Jharkhand through need based agricultural technologies	Dr. Nirmal Kumar, Co-PI Dr. NK Sinha, Co-PI	15 15	April, 2018	March, 2022	-
3. ICAR-IINRG, Ranchi and ICAR-IIHR, Bengaluru							
27.		Development of storage protocol for extending the marketable period of fruits (Mango, Guava, Fig, Jamun, Muskmelon) and vegetables (Drumstick, Brinjal, Bottlegourd)	Dr. MF Ansari, Co-PI	15	February, 2020	March, 2022	-
		Development of bio-composite packages from horticultural waste		15			
		Aflatoxin management in spices: Development of preventive methods		15	December, 2020	December 2022	
Exploratory Study							
		Genetic manipulation in lac host plant (F. semialata) to establish better plant-lac insect interaction	Dr. J Ghosh, PS, QPI Division	15			

*Indicates scientist concerned would assist/facilitate the study without formally being associated with the project.

Note: One Projects (Nos. 1.2.060-old), under Core Programme-VII, in abeyance, so not listed here.

Explanation for coding of the Project Nos.

i. First number indicate the category of the project (1) Institute (2) Externally funded (3) Network Project (4) KVK
ii. Second number indicate the Division (1) QPI (2) PEM (3) APD (4) MPE
iii. Third number will indicate the project number
iv. Year: Project Starting Year

For example **1.1.070/Year**
- Year → Indicates Project Starting Year
- 070 → Indicates Project Number
- 1 → Indicates Division
- 1 → Indicates Institute Project

Publication and Publicity

Publications

Research papers

- Bakade R, Ingole KD, Deshpande S, Pal G, Patil SS, Bhattacharjee S, Prasannakumar MK and Ramu VS (2021). Comparative transcriptome analysis of rice resistant and susceptible genotypes to *Xanthomonas oryzae* pv. oryzae identifies novel genes to control bacterial leaf blight, *Molecular Biotechnology* 63(8): 719-731.
- Bhatia R, Dey SS, Sharma K, Singh S, Kumar S, Pramanik A, Parkash C and Kumar R (2021). Back-cross introgression of 'Tour' cytoplasm from *Brassica napus* through *in vitro* embryo rescue reveals partial restoration of sterility in *B. oleracea*. *Scientia Horticulturae* 282: 110014.
- Bhatia R, Sharma K, Parkash C, Pramanik A, Singh D, Singh S, Kumar R and Dey SS (2021). Microspore derived population developed from an inter-specific hybrid (*Brassica oleracea* × *B. carinata*) through a modified protocol provides insight into B genome derived black rot resistance and inter-genomic interaction. *Plant Cell, Tissue and Organ Culture (PCTOC)* 145(2): 417-434.
- Chowdhury AR, Siddiqui MZ, Maurya S, Mate CJ and Ali M (2021). Synthesis, characterization and inhibition effects of Jhingan gum-induced silver nanoparticles against powdery mildew of pea. *Indian Phytopathology* 75(1): 109-116.
- Ghosal S and Bhat SS (2021). Effect of PGPR and VAM fungi on seed germination and seedling growth enhancement of *kusum* (*Schleichera oleosa*), *Indian Forester* 147(2): 195-199.
- Khatri K, Warkar SG and Thombare N (2021). Controlled release and release kinetics studies of boron through the functional formulation of carboxymethyl tamarind kernel gum-based superabsorbent hydrogel. *Polymer Bulletin* 79(4): 2287-303.
- Khatri K, Warkar SG and Thombare N (2021). Zinc micronutrient-loaded carboxymethyl tamarind kernel gum-based superabsorbent hydrogels: controlled release and kinetics studies for agricultural applications. *Colloid and Polymer Science* 299(7): 1103-1011.
- Langlentombi LC and Kumar M (2021). A prediction of suitable habitat mapping of *Pinus roxburghii* Sarg. using maxent modeling. *Environment Conservation Journal* 22(3):149-153.
- Langlentombi LC and Kumar M (2021). Inherent vulnerability of forests: a case study from Jharkhand in India. *Journal of Tropical Forest Science* 33(4): 455-460.
- Langlentombi LC, Rajgopal NN and Ghosal S (2021). Effect of shoot number, diameter and lac encrustation thickness on kusmi broodlac yield of *Kerria lacca* from *Flemingia semialata*. *Indian Journal of Entomology* 1-4. Dol.: 10.55446/IJE.2021.31
- Laxmivandana R, Chhaya P, Sharma TR, Sharma KK and Naskar S (2021). Differential proteins associated with plasma membrane in X-and/or Y-chromosome bearing spermatozoa in *indicus* cattle. *Reproduction in Domestic Animals* 56: 928 – 935.
- Naik S, Shashank PR, Rajgopal NN and Meshram NM (2021). Linnean shortfall still a major concern in India: as evident by the micro-moth family Tortricidae (Lepidoptera). *Current Science* 120 (4): 712-715.
- Rajgopal NN, Mohanasundaram A and Sharma KK (2021). A new species of lac insect in the genus *Kerria* Targioni Tozzetti (Hemiptera: Coccomorpha: Tachardiidae) on *Samanea saman* (Fabaceae) from India. *Zootaxa* 4938 (1): 60-68.
- Rajput J, Choudhary R, Kothari M, Al-Ansari N, Dimple D, Makadiya K, Singh PK, Kushwaha NL, Paramguru PK, Rai A and Rana L (2021). Diagnostic and socio-economic analysis of Bhimsagar irrigation scheme: Diagnostic and socio-economic analysis of Bhimsagar irrigation scheme. *Ecology, Environment and Conservation* 27: S320-S330.
- Sarkar B, Mohanty A, Gupta SK, Choudhury AR, Daware A and Bhattacharjee S (2021). Nanotechnology: A next-generation tool for sustainable aquaculture. *Aquaculture* 546: 737330.
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Papers Presented/ Contributed in Conferences/ Symposia/ Seminars

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- Mate CJ (2021). In vitro release kinetics of graft matrices from *Lannea coromandelica* (Houtt) gum for treatment of colonic diseases by 5-ASA**.** p. 132.
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and evaluation of lac insect (*kusmi*) on pruned plants. p. 49.

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- Pandey SK, Sharma SC and Prasad N (2021). Lac processing operations and recent development. p. 137.
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- Sharma SC, Pandey SK and Prasad N (2021). Mechanization status in manufacturing lac based value added products. p. 138.
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- Thombare N, Lohot V, Yogi RK, Kumari U and Sarkar PK (2021). Potential and threats to sal (*Shorea robusta*) forests of India: A review. p. 165.
- Yogi RK, Pandey SK, Yadav SKS, Nirmal Kumar and SharmaKK (2021). Future market potential of aleuritic acid: A natural resin based high value product. p. 136-137.
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- Lohot VD, Thamilarasi K, Ghosh J, Mohanasundaram A, Thakur VV, Prakash Shabnam and Sharma KK (2021).Assessment of changes in leaf biochemical constituents of *palas* (*Butea monosperma*) during different stages of lac insect life cycle. p. 73.

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App developed

❖ Mohanasundaram A, Ghosal S and Sharma KK (2021). A bilingual android application entitled "*lakh ka doctor*" which covers all aspects of lac cultivation and is available in Google Playstore.

Book chapters

❖ Yogi RK, Mohanasundaram A, Monobarullah Md, Chaudhari R, Kumar A, Kumar N and Sharma KK (2021). Production of natural resins & gum in India and climate change: Current status, challenges and prospects. In: Srinivas Rao CH, Srinivas T, Kumar A, Srinivasa Rao N, Rao RVS, Krishnan P and Som SK (Eds.), Climate Change and Indian Agriculture: Challenges, Adaptation and Mitigation Strategies. ICAR-National Academy of Agricultural Research Management, Hyderabad, India. 53-68 pp.

❖ Yogi RK, Kumar Nirmal and Sharma KK (2021). Sustainable production of natural resins and gums in India : Market outlook and commercial relevance. In : Sharma SC, Yadav SKS, Yogi RK, Niranjan Prasad, Sharma KK (Eds.). Sustainable Technological Interventions for Entrepreneurship Development in Tribal Zone. National Institute of Agricultural Extension Management, Hyderabad & ICAR – IINRG, Ranchi. e-BookISBN: 978-93-91668-27-3.

Bulletins

❖ Yogi RK, Kumar N and Sharma KK (2021). Lac, plant resins and gums statistics 2018: At a glance. ICAR-Indian Institute of Natural Resins and Gums, Ranchi (Jharkhand), India. (ISSN No.IS-2454-8782) Bulletin (Technical) No. 1/2021. 01-80 pp.

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❖ Yogi RK, Kumar Nirmal and Sharma KK (2021). Monthly Advisories for NRG based Stakeholder in Jan- Dec 2021: Best Practices for Production, Processing and Marketing of Tribal based Commodities during COVID-19. ICAR-Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand (1-12/2021) 1-10 pp.

Extension folders

- Anmol Kumar Mishra, Shravan Kumar, Satish Chandra Sharma and Niranjan Prasad (2021). All India Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums: Role and Achievements. Extension Folder, ICAR – Indian Institute of Natural Resins and Gums, Ranchi. 1-6 pp.
- Mohanasundaram A, Sharma KK, Ghosh J and Yogi RK (2021). Calliandra calothyrsus – A good

host for lac cultivation in agro-forestry system. ICAR IINRG. 1-6 pp.

- अनमोल कुमार मिश्रा, श्रवण कुमार, सतीश चन्द्र शर्मा एवं निरंजन प्रसाद (2021). प्राकृतिक राल एवं गोंद के संग्रहण, प्रसंस्करण एवं मूल्य संवर्धन पर नेटवर्क परियोजनाः भूमिका एवं उपलब्धियां। प्रसार पत्रक, भाकृअनुप–भारतीय प्राकृतिक राल एवं गोंद संस्थान, राँची, पृष्ठ 1–6
- ए. मोहनसुन्दरम, के. के. शर्मा, ज्योतिर्मय घोष एवं आर. के. योगी (2021). कैलियंडत्र कैलोथिरसस – शि वानिकी प्रणाली में लाख की खेती के लिए एक उपयुक्त पोषक वृक्षएए भा.अनुप – भारतीय प्राकृतिक राल एवं गोंद संस्थान. P4.

Popular articles

❖ Following popular articles were published in *Agriculture & Food e-Newsletter*, 2021.

- Langlentombi LC and Rajgopal NN (2021). NTFPs as tools for rural development and climate change mitigation option in India. 3(10): 168-170 pp.
- Rajput J, Kothari M, Dimple, Rai A, Kushwaha NL, Paramguru PK (2021). Temporal variation of water use efficiency in canal command. 3(11): 246-248 pp.

❖ Following popular articles were published in *Just Agriculture* (a multidisciplinary e-Newsletter), 2021 (e-ISSN: 2582-8223).

- Mishra AK, Raj H, Sharma SC and Prasad N (2021). Gum yielding trees, their exudates and uses. 1(7): 1-7, Article id. 23.
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❖ Following popular articles were published in *Laksha*, 2021 (ISSN No. 2454-7840), ICAR-IINRG, Ranchi, p. 120:

- सतीश चन्द्र शर्मा, संजय कुमार पाण्डेय एवं निरंजन प्रसाद। व्यवसायिक रूप से महत्वपूर्ण लाख आधारित मूल्यवर्धित उत्पादों के निर्माण का यंत्रीकरण, पृष्ठ. 30–40.
- सतीश चन्द्र शर्मा, संजय कुमार पाण्डेय एवं निरंजन प्रसाद। कराया गोंद उत्पादन के यंत्रीकरण की स्थिति एवं सुधार की सम्भावनाएं, पृष्ठ. 45–60.
- अनमोल कुमार मिश्रा, सतीश चन्द्र शर्मा एवं निरंजन प्रसाद। मोबाइल एग्रीकल्चर स्कूल एंड सर्विसेज के सफलता की कहानी, पृष्ठ. 74–78.
- नंदकिशोर ठोंबरे, उषा कुमारी, अर्नब राय चौधुरी तथा लोकेश मीना. हाइड्रोजेल तकनीकी से कृषि क्षेत्र में उन्नति की संभावनाएं. लाक्षा 2021. पृष्ठः 61–64.
- अर्णब रॉय चौधुरी एवं रोहित कुमार पांडेय. सहजन की चमतकारी गुण. लाक्षा 2021. पृष्ठः 41–44.
- उषा कुमारी, नंदकिशोर ठोंबरे तथा निरंजन प्रसाद. बेलः अपार आर्थिक संभावनाओं वाला एक वृक्ष. लाक्षा 2021. पृष्ठः 67–71.
- देवब्रत हरी, अर्नब राय चौधुरी तथा एम् जेड सिद्दीकी. भारतीय कृषि का महिलाकरण. कृषक वंदना. जून 2021. पृष्ठः 25–27.

Institute publications

- Rajgopal NN, Thamilarasi K, Mohanasundaram A, Paramaguru PK, Ghosal S, Sinha NK and Sharma KK (eds.) (2021). Souvenir and Book of Abstracts, National Web Symposium on "Recent Advances in Beneficial Insects and Natural Resins and Gums" February 25-26, 2021. Society for Advancement of Natural Resins and Gums, ICAR-IINRG, Ranchi. ISBN: 9-789354-573286, XXXII+166 pp.
- Sharma SC, Yadav SKS, Yogi RK, Prasad N and Sharma KK (2021). Sustainable Technological Interventions for Entrepreneurship Development in Tribal Zone. National Institute of Agricultural Extension Management, Hyderabad & ICAR – IINRG, Ranchi. ISBN: 978-93-91668-27-3, 1-98 pp.
- ICAR-IINRG Annual Report 2020-21, 1-178 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, July-September 2020, ISSN: 0974-2980, 24(3), 1-6 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, October-December 2020, ISSN: 0974-2980, 24(4), 1-12 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, January-March 2021, ISSN: 0974-2980, 25(1), 1-16 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, April-June 2021, ISSN: 0974-2980, 25(2), 1-12 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, July-September 2021, ISSN: 0974-2980, 25(3), 1-12 pp.
- Natural Resins and Gums, ICAR-IINRG Newsletter, October-December 2021, ISSN: 0974-2980, 25(4), 1-12 pp.
- Sharma KK, Thamilarasi K, Mohanasundaram A and Yogi RK (2021). *SANRAG e-Newsletter*, ICAR-IINRG Ranchi.2 (1): 1-9 pp.
- Sharma KK, Thamilarasi K, Mohanasundaram A and Yogi RK (2021). *SANRAG e-Newsletter*, ICAR-IINRG Ranchi.2 (2): 1-10 pp.

Publicity

Tours / Visits

- ❖ Dr. Thombare N, Sc. visited forest area near Jonha village, Angara block, Ranchi for collection of planting material (seedlings, stumps, seeds, etc.) of the gum and resin plants for planting in the NRG plant germplasm of the Institute, June 8, 2021.
- ❖ Dr. SC Sharma, Sr. Sc. visited ICAR – Central Institute of Agricultural Engineering, Bhopal regarding fabrication of guar gum derivative pilot plant including improvement in detailed manufacturing design drawing of gum tapping blazer developed earlier in Pro Engineer CAD software, August 22-29, 2021.

TV / Radio Talk

- Dr. KK Sharma, Director, ICAR-IINRG participated in live panel discussion on doubling farmers' income conducted by DD, Ranchi on March 12, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG delivered a TV talk in phone-in live programme on DD Ranchi on '*Lakh ka mulya sanvardhan avam vipanan vyavastha*' on July 29, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG delivered a TV talk on DD Ranchi on 'Barsat ke mausam mein kusmi lakh ki kheti va labh' on (recorded on August 06, 2021, to be telecast on August 23, 2021).
- Dr. KK Sharma, Director, ICAR-IINRG delivered a Radio talk on AIR Ranchi on '*Arhar par lakh ki kheti*' on (recorded on Sept. 14, 2021, to be broadcast on Sept. 18, 2021).
- Dr. S Ghosal, Pr. Sc. & Head QPI Division delivered a TV talk on '*Rangeeni lac cultivation*' on July 16, 2021 which was telecast on August 08, 2021.

Database

- ❖ National level database of the NRGs production and EXIM data 2021 has been generated, maintained and updated at NRG Information Cell (NIC), PEM Division, ICAR-IINRG, Ranchi.
- ❖ Block level database of beneficiaries under various trainings during previous 10 years and block wise lac host tree as well as broodlac requirement in the state of Jharkhand has been estimated and validated.

- **Lac insect gene sequences submitted to NCBI GenBank database**

Gene	Accession no.
acyl carrier protein (*acp*)	MZ501735
decarboxylase 2 (*dc2*)	MZ570477
cytochrome c oxidase subunit I	MW888719.1
Kerria sp. isolate RL009	

- Soil metagenome data under lac biodegradation study has been submitted to the NCBI Sequence Read Archive (SRA) under accession number PRJNA760653.

Participation of Scientists in Conferences/ Meetings/ Seminars/ Symposia/ Workshops/ Trainings

By Director

Chaired / Convened

- Dr. KK Sharma, Director, ICAR-IINRG chaired the 56th Institute Management Committee meeting (online) of IINRG, Ranchi, March 05, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 21st Meeting of Brushware, Polishes, Lac and Lac Products Sectional Committee CHD 23 (online), April 13, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the online meeting of Institute Research Council of IINRG, Ranchi, April 16-17, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 89th Institute Joint Staff Council meeting, April 29, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 90th Institute Joint Staff Council meeting, July 30, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 22nd Meeting of Brushware, Polishes, Lac and Lac Products Sectional Committee CHD 23 (online), September 06, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 91st Institute Joint Staff Council meeting, October 29, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 23rd Meeting of Brushware, Polishes, Lac and Lac Products Sectional Committee CHD 23 (online), December 08, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired a meeting of Committee to nominate member for Board of Governors, The Jharkhand State Cooperative Lac Marketing and Procurement Federation Limited (JHASCOLAMPF), December 24, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the 92nd Institute Joint Staff Council meeting, December 30, 2021.

Participated

- Dr. KK Sharma, Director, ICAR-IINRG participated in the Review meeting of Officers and staff of DARE and ICAR under the chairmanship of Hon'ble Agriculture and Farmers Welfare Minister held through video conferencing, January 01, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG and PC, NP-CLIGR participated in the meeting of ASCI with SMD officials and institute Directors to discuss draft report of Third Party Evaluation, January 06, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG participated in the video conference meeting to Discuss and Develop Roadmap for Agricultural Mechanization Sector chaired by JS (M & T) and Co-chaired by DDG (Engg.), April 22, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG participated in the video conference meeting for discussion related to MOU between ICAR and MSME chaired by DDG (Engg.), May 12, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG participated in the State Level Committee on National Mission for Sustainable Agriculture under the Chairmanship of Development Commissioner, Jharkhand at Nepal Bhavan, Ranchi for discussion on Rain-fed Area Development, June 29, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG had an interaction meeting with CEO of '*Mukhyamantri Laghu evam Kutir Udyam Vikas* Board' for synergizing efforts between JHASCOLAMPF, JHAMCOFED & IINRG for developing lac, sal and tamarind value-added business models, August 05, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG participated in the meeting of Board of Governors as member convened for amendment in by-laws of JHASCOLAMPF chaired by Secretary, Agriculture and Chairman, JHASCOLAMPF, August 17, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG participated in the MGNREGA meeting under the Chairmanship of Development Commissioner, Jharkhand at Nepal House, Ranchi and suggested to include lac related activities under the scheme, December 23, 2021.

By Others

Participated

- Dr. Achintya Pramanik, Sc. and Mr. Rajgopal NN, Sc. participated in the International Webinar on "Insect Systematics: Importance, Challenges and Way Forward" at ICAR-NBAIR, Bengaluru (Virtual Mode), January 29, 2021.

- Er. SK Pandey, Sc. particpated in Institute-Industry Meet organized by NINFET, Kolkata, March 09, 2021.
- Dr. VD Lohot, Sr. Sc. participated in International Plant Physiology Virtual Symposium on "Physiological Interventions for Climate Smart Agriculture (IPPVS 2021)" organized by ICAR-Sugarcane Breeding Institute, Coimbatore, March 11-12, 2021.
- Dr. RK Yogi, Sc. participated in State Level Unit Cost Committee Meeting on "Agriculture and Allied Sector" organized by NABARD, Ranchi, March 17, 2021.
- Er. SK Pandey, Sc. participated in Workshop organised by MSME, March 19, 2021.
- Dr. AR Chowdhury, Sc. attended 21st Meeting of BIS CHD-23 sectional committee on Brushware, Polishes, Lac and Lac Products through online mode, April 13, 2021.
- Dr. J Ghosh, Pr. Sc. and I/C KVK, Dr. Rahul R. Bakade, Sc., Er. Pradosh K. Paramaguru, Sc. and Dr. R Chaudhari, SMS Agro meteorology participated in District Level Kharif Workshop in DAO Office Khunti, July 23, 2021.
- Dr. SC Sharma, Sr. Sc. participated in राष्ट्रीय अधिवेशन, कोविड–19 जनित परिस्थितियों में देश के आर्थिक विकास एवं आत्मनिर्भरता में कृषि अभियांत्रिकी की भूमिका organized at ICAR – CIAE, Bhopal through virtual mode, July 28-29, 2021.
- Er. SK Pandey, Sc. participated in Workshop on Sensitizing of PMEGP and SFURTI scheme organized by Khadi and Village Industries commission, Ranchi with ICAR-IINRG, Ranchi, August 24, 2021.
- Dr. N Prasad, Project Coordinator & Pr. Sc. attended XXVI Meeting of Regional Committee No. VII for Maharashtra, MP, Chhattisgarh and Goa organized via online mode, August 25, 2021.
- Dr. RK Yogi Sc. attended National Webinar on "Nutritional Security in India Issue and Way forward" organized by ICAR Research Complex for Eastern Region Patna, September 04, 2021.
- Dr. N Prasad, Project Coordinator & Pr. Sc. attended XXVII Meeting of Regional Committee VIII organized via online mode, September 14, 2021.
- Dr. MF Ansari, Pr. Sc. And Dr. AR Chowdhury, Sc. attended the 23rd Meeting of Brushware, Polishes, Lac and Lac Products Sectional Committee of BIS CHD 23 through online mode, September 06 and December 08, 2021.
- Dr. RK Yogi Sc. attended Eastern Region Sensitization Workshop on Agricultural Export organized by National Service Scheme (NSS) Cell and National Agricultural Higher Education Project (NAHEP) of Birsa Agricultural University, Ranchi in collaboration with Agricultural & Processed Food Products Export Development Authority (APEDA) through online mode, October 06, 2021.
- Mr. Rajgopal NN, Sc. and Ms. Langlentombi LC, Sc. attended 02 days International (online) conference on "Insect and Plant Biology: 2021" organised by Mahatma Hansraj Faculty Development Centre, Hansraj College, University of Delhi, October 07-08, 2021.
- Dr. Thamilarasi K, Sr. Sc. acted as a coordinator from ICAR-IINRG, Ranchi (partnering institute) in conducting the International Symposium on Plant Biotechnology - 2021 Towards Improving Agri-Food Industry and Healthcare Products (ISPB -2021) at BIT Mesra, Ranchi, October 27-30, 2021.
- Dr. MF Ansari, AR Chowdhury and Dr. N Thombare attended an interaction meeting with scientists of IIT, Dhanbad (ISM) regarding the collaboration in the project for developing an integrated blockchain and artificial intelligence enabled platform for all stakeholders involved in the lac farming ecosystem in Jharkhand, November 26, 2021.
- Mr. Rajgopal NN, Sc. as resource person assisted in conducting 15 days workshop on "Techniques for Entomological Research" organized by Division of Entomology, ICAR-IARI New Delhi, December 24, 2021 - January 07, 2022.

Human Resource Development

- Dr. S Ghosal, Pr. Sc. & Head QPI Division, Dr. J Ghosh, Pr. Sc. and Dr. NK Sinha, Pr. Sc. participated in DST Sponsored 2 week virtual Training Programme on "Advances in Integrated Watershed Management for Rural Livelihood" at ICAR-IISWC, Research Centre, Udhagamandalam, Tamil Nadu, December 28, 2020-January 8, 2021.
- Dr. J Ghosh, Pr. Sc. and Dr. NK Sinha, Pr. Sc. participated in 5 days DST sponsored online national Training Programme on "Integrated Nutrient Management and Nutrient Budgeting Through Advanced Models to Improve Crop Productivity" at ICAR-IISWC, Research Centre, Udhagamandalam, Tamil Nadu, January 18-22, 2021.
- Er. SK Pandey, Sc. attended online Training on "Sensitization Programme for Agricultural Scientist on Entrepreneurship Development &

Start-Up Eco System organized by NAARM, Hyderabad, July 05-09, 2021.

- Dr. VD Lohot, Sr. Sc. has attended 3 days Training on "MDP on Biodiversity and Environmental Laws for Agricultural Researchers" conducted by NAARM, Hyderabad, June 07-09, 2021.
- Dr. VD Lohot, Sr. Sc. attended 14 days training on "Application of Molecular and Bioinformatics Tools in Agriculture and Allied Sciences" organized by CST, UP Centre of Excellence in Agriculture Biotechnology in collaboration with DBT funded Bioinformatics Infrastructure Facility, College of Biotechnology, July 07-20, 2021.
- Dr. SKS Yadav, Sc. attended International Training Programme on "Bio fortification: A Key to Nutritional Security" organized by National Institute of Agricultural Extension Management (MANAGE), Hyderabad, July 12-14, 2021.
- Ms. Langlentombi LC, Sc. attended Online Training Programme on "Climate Change: Challenges and Response" (for Women Scientists), August 09-13, 2021.
- Dr. AR Chowdhury, Sc. attended 3 days online workshop on 'Response Surface Methodology' organized by ICAR-NAAR, Hyderabad, August 24-26, 2021.
- Dr. RK Yogi, Sc. attended the Virtual Training Program on "Impact Assessment of Agricultural Research and Technologies" by ICAR-NAARM, December 18-22, 2021.

Honours, Awards and Recognitions

For the institute

- ICAR-IINRG received ISO 9001-2015 Quality Management System certificate for the scope of Research and Development activities on Lac and other Natural Resins and Gums in the country including extension services and associated administrative, financial and farm management functions.

For Director

- Chairman, Brushware, Polishes, Lac and Lac products Sectional Committee CHD 23 of Bureau of Indian Standards, New Delhi
- Member, Board of Governors, The Jharkhand State Cooperative Lac Marketing and Procurement Federation Limited (JHASCOLAMPF)
- Member, Regional Advisory Committee on Off Farm Sector in Jharkhand, NABARD, Ranchi
- Technical Member, Forest Biotechnology Expert Committee of DBT
- Guest of Honour in 'Entrepreneurship development programme on commercial cultivation and preservation of strawberry', organized by *Krishi Gram Vikas Kendra*, Rukka, Ranchi, September 07, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the Technical Session-1: Keynote Speakers in 'International Symposium on Plant Biotechnology towards Improving Agri-Food Industry and Healthcare Products (ISPB-2021)' organized by the Department of Bioengineering and Biotechnology, Birla Institute of Technology, Mesra, Ranchi in Hybrid Mode, October 27-30, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG chaired the Technical Session-5: Lac Culture in 'International Symposium on Plant Biotechnology towards Improving Agri-Food Industry and Healthcare Products (ISPB-2021)' organized by the Department of Bioengineering and Biotechnology, Birla Institute of Technology, Mesra, Ranchi in Hybrid Mode, October 27-30, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG co-chaired the Technical Session of AINP on Harvesting Processing and Value Addition of Natural Resins and gums organized by IINRG, Ranchi through virtual platform November 09-10, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG delivered an invited lecture on 'Carrier Opportunity in Entomological Science through lac culture' on June 29, 2021 in 'National e-conference on Career Opportunity in Entomological Science" organized by the Department of Entomology, Veer Kunwar Singh College of Agriculture, Bihar Agricultural University, Sabour during 28-29 June, 2021 in Online Mode.
- Dr. KK Sharma, Director, ICAR-IINRG delivered an invited lecture on 'Recent technological interventions in production of natural resins and gums: An overview' in collaborative training program on 'Sustainable Technological Interventions for Entrepreneurship Development in Tribal Zone' organized by ICAR – IINRG, Ranchi and MANAGE, Hyderabad, August 10-12, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG delivered a special address in the Business Meet - Jharkhand *Vanijya Utsav* to the attending delegates on export potential of lac, gums and resins organized by the Ministry of Commerce & Industry, Government of India along with DGFT and the Government of Jharkhand, September 21, 2021.
- Dr. KK Sharma, Director, ICAR-IINRG delivered a lead lecture on, 'Secondary agriculture with

special reference to natural resins and gums: The shift Indian farming needs' in 'International Symposium on Plant Biotechnology Towards Improving Agri-Food Industry and Healthcare Products (ISPB-2021)' organized by the Department of Bioengineering and Biotechnology, Birla Institute of Technology, Mesra, Ranchi in Hybrid Mode, October 27-30, 2021.

For others

Following scientists received different awards in National Web-symposium on "Recent Advances in Beneficial Insects, Natural Resins and Gums", ICAR-IINRG, Ranchi, February 25-26, 2021.

- Dr. A Mohanasundaram, Sc. received "Young Scientist Award" for the outstanding contribution in the field of lac insect bio-diversity, tritopic interaction and effect of climate change on lac cultivation.
- Dr. Nandkishore Thombare, Sc. received "Young Scientist Award" for the outstanding contribution in value addition of NRGs.
- Dr. Thamilarasi K, Sr. Sc. received Dr. B. Vasantharaj David Foundation Award – 2021 for outstanding contribution in lac molecular biology.
- Dr, A Mohanasundaram, Sc. received best oral paper presentation award for the paper entitled "Vegetative propagation of Flemingia semialata on root stock of F. macrophylla for kusmi lac cultivation under water logged condition".
- Dr. Achintya Pramanik, Sc. received best oral presentation award for the paper presented on 'A unique strategy utilizing native honey bee mediated selection improved floral traits and seed yield of cauliflower (Brassica oleracea var. botrytis) cytoplasmic male sterile lines".
- Mr. Sandeep Kumar, Sc. won the best poster award for the paper on "Exploration of lac insect (Kerria spp.)-Biodiversity and metabolism–A protein structure centric approach"
- Dr. Thamilarasi K, Sr. Sc. received best oral presentation award for the paper on "Identification and validation of a putative lac pigment biosynthesis genes coding for acyl carrier protein".
- Ms. Langlentombi LC, Sc. received best oral presentation award for "Predicting major factors affecting broodlac yield from Flemingia semialata Roxb".
- Dr. RK Yogi, Sc. received best poster presentation award for presentation of study on 'Knowledge footprints of scientific lac cultivation and value addition: a need based approach'.
- Dr. MF Ansari, Pr. Sc. and Head APD Division received best oral presentation award for presentation of research paper entitled "Biodegradation of lac resin using soil burial method".
- Dr. AR Chowdhury, Sc. awarded best poster award for poster presentation titled 'Synthesis, characterization and antifungal efficacy of jhingan gum-induced silver nanoparticles'.

Following scientists were awarded during 'Hindi Diwas Samaroh' organized by the Institute, September 30, 2021.

- Dr. Nandkishore Thombare, Sc. received first prize in the Essay competition.
- Dr. SKS Yadav was conferred the first Prize for Hindi Nibandh Lekhan Pratiyogita.
- Dr. AR Chowdhury, Sc. awarded first prize on extempore competition in Hindi.
- Dr. SC Sharma, Sr. Sc., Er. SK Pandey, Sc. and Dr. N Prasad, Pr. Sc. & Head, MPE Division received best popular article award for the article व्यवसायिक रूप से महत्वपूर्ण प्राकृतिक राल एवं गोंद का प्रसंस्करण published in लाक्षा – 2020 (ISSN : 2454-7840).
- Dr. SC Sharma, Sr. Sc. received ISAE Commendation Medal 2020 conferred by Indian Society of Agricultural Engineering, New Delhi in recognition of his valuable contributions in the field of Energy in Agriculture.
- Dr. SC Sharma, Sr. Sc., Er. SK Pandey, Sc. and Dr. N Prasad, Pr. Sc. & Head, MPE Division received best paper presentation award for the paper presented on "Mechanization status in karaya gum tapping and scope of improvement: A review" in in 55th Annual Convention of Indian Society of Agricultural Engineers (ISAE) on Challenges and Technological Solutions for Ensuring Food, Water and Energy Security" & International Symposium on "Emerging Trends in Agricultural Engineering Education, Research and Extension held at Bihar Agriculture Management & Extension Training Institute (BAMETI), Patna, November 23-25, 2021.
- Ms. Langlentombi LC, Sc. and Mr. Rajgopal NN, Sc. received the best popular article award on the article "NTFPs as tools for rural development and climate change mitigation option in India" given by Agriculture & Food e-newsletter.

Capacity Building / Lectures / Talk delivered

Following lectures were delivered by the Scientists to the B. Sc. (Ag) students of Quantum University, Roorkee, during 10 days 'Summer School on NRG'

organized by the Institute through online mode, January 23-24, 2021.

- Dr. MF Ansari, Pr. Sc. and Head APD Division delivered a lecture on 'Diversified uses of lac and Quality Control of Natural Resins and Gums' on January 24, 2021.
- Dr. AR Chowdhury, Sc. delivered a lecture on 'Characterization techniques of Natural Resins and Gums', January 24, 2021.
- Dr. Nandkishore Thombare, Sc. delivered a lecture on 'Introduction and uses of major NRG plants', January 23, 2021.
- Dr. Nandkishore Thombare, Sc. delivered a lecture on 'Recent advances in application of natural resins and gums in agriculture', January 24, 2021.
- Dr. AR Chowdhury, Sc. delivered a lecture cum demonstration on 'Characterization techniques of natural resins and gums' to Agro-Industrial attachment training for Rural Agricultural Work Experience for B. Sc. (Ag) student from BAU, Ranchi, at ICAR-IINRG, Ranchi, February 08, 2021.
- Dr. MF Ansari, Pr. Sc. and Head APD Division delivered lectures on 'Diversified uses of lac' and conducted a visit to surface coating lab and quality control of natural resins and gums' to Agro-Industrial attachment training for Rural Agricultural Work Experience for B. Sc. (Ag.) students of BAU Ranchi on February 09 and 22, 2021.

Following lectures were delivered by the Scientists to participants/ trainees of Institute of Forest Productivity (IFP), ICFRE, Lalgutwa Ranchi, February 09-10, 2021.

- Dr. Nandkishore Thombare, Sc. delivered a lecture on 'Production, Collection and Processing of Gum', February 09, 2021.
- Dr. MF Ansari, Pr. Sc. and Head APD Division delivered a lecture on 'Lac: A versatile resin', February 10, 2021.
- Dr. RK Yogi, Sc. delivered an online Video talk on "How lac cultivation adds income to farmers" with AgriPortal AgricultureInformation.com, February 17, 2021.
- Dr. N Prasad, Pr. Sc. & Head, MPE Division delivered a lecture on the "Relevance of farm machines/implements in doubling farm income" in Technology and Machinery Demonstration Mela-2021 organized at ICAR-IINRG, Ranchi, March 12, 2021.
- Dr. RK Yogi, Sc. delivered a lecture on "Entrepreneurship opportunity in lac production and processing" at FSRCHPR, Ranchi in a training program on 'Agri-Entrepreneurship opportunities in Jharkhand', March 19, 2021.
- Dr. RK Yogi, Sc. delivered three lectures on "Economics of Lac cultivation & marketing of lac" in one-week training programs on "Scientific lac cultivation, processing and utilization" in collaboration with Forest department, Tundi, Dhanbad & Dumka, ATMA, Khunti, Jharkhand, March, 2021.
- Dr. N Prasad, Pr. Sc. & Head, MPE Division delivered lecture on "Mechanization in Natural Resins and Gums Production for Sustainable Environment" organized on the occasion to commemorate 75th year of India's independence as Bharat Ka Amrut Mohotsav at ICAR – IINRG, Ranchi through virtual mode, July 06, 2021.

Following lectures were delivered by the scientists under online training programme on 'sustainable technological interventions for entrepreneurship development in tribal zone' organized at ICAR - IINRG, Ranchi in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad from August 10-12, 2021.

- Dr. MF Ansari, Pr. Sc. and Head APD Division delivered two presentations namely 'Entrepreneurial opportunities in Lac based coating compositions' and 'Lac based composite and particle board: Entrepreneurship potential' on August 11-12, 2021 respectively.
- Dr. SKS Yadav, Sc. delivered lecture on 'Storage and quality control and of natural resins and gums - An industrial perspective'.
- Dr. AR Chowdhury, Sc. delivered a lecture on 'Natural resins and gums in foods and pharmaceuticals'.
- Dr. Nandkishore Thombare, Sc. delivered a lecture on 'Industrial applications of natural resins and gums'.
- Dr. N Prasad, Pr. Sc. & Head, MPE Division organized a programme on "Lac Processing and Rural Entrepreneurship" followed by lectures on "Scientific cultivation of lac and lac processing at Village" – Sarjamdih, Angraha Block, Ranchi, August 21, 2021.

Following invited talks were delivered during 'हिंदी वैज्ञानिक संगोष्टीः भारत का अमृत महोत्सव– आत्मनिर्भर भारत की ओर बढ़ते कदम' organized virtually by ICAR-NINFET, Kolkata, September 27, 2021.

- Dr. Nandkishore Thombare, Sc. on 'हाइड्रोजेल तकनीकी से भारतीय कृषि क्षेत्र में उन्नति की संभावनाएं'

- Dr. N Prasad, Pr. Sc. & Head, MPE Division on 'प्राकृतिक राल एवं गोंद का महत्व'
- Dr. Thamilarasi K, Sr. Sc. delivered an invited talk on "Bioprospecting of lac pigment genes in the Indian lac insect *Kerria lacca* (Kerr)" in International Symposium on Plant Biotechnology Towards Improving Agri-Food Industry and Healthcare Products (ISPB-2021), BIT, Mesra, Ranchi, October 27-30, 2021.
- Dr. SKS Yadav, Sc. delivered 16 lectures on 'लाख के उपयोग' under Farmers Training Programme on "Advanced techniques for lac cultivation, processing and utilization" during January-December 2021.
- Dr. SKS Yadav, Sc. delivered 2 lectures under Summer Students' Workshop on Natural Resins and Gums during January-December 2021.
- Dr. Rahul R Bakade, Sc. delivered lectures at 18 different training programmes for farmers on "लाख के शत्रु कीट एवम उंके रोक्थाम"

Following training programs were conducted by Dr. Nirmal Kumar, Pr. Sc. & Head, TOT Division, Dr. SKS Yadav, Sc., Dr. RK Yogi, Sc., Dr. Rahul R Bakade, Sc. and Er. P Paramguru, Sc. during 2021.

- 11 On-farm training programme on scientific lac cultivation for 754 stakeholders from Odisha and Jharkhand states.
- 20 On-farm Motivational/ Supplementary training programme on scientific lac cultivation for 1195 stakeholders from Jharkhand states.
- 13 On-campus one-day Orientation programme on scientific lac cultivation for 525 stakeholders from Bihar, West Bengal, Odisha and Jharkhand states.
- 7 Lac based product demonstration training on Aleuritic Acid, Gasket Shellac Compound, Gummy Mass, Lac Wood Shine, Lac Based Non Sprit Wood Varnish, Lac Glaze and Nail Polish for 3 stakeholders from Chhattisgarh, West Bengal and Odisha.
- The technological interventions and current scenario of NRGs during Eastern Zone Regional Agriculture Fair and Agrotech-2021, BAU, Kanke, Ranchi, March 5-7, 2021.
- Lac crop surveillance at four locations across various districts of Jharkhand.
- Dr. RK Yogi, Sc., jointly conducted 28 Awareness cum Village Survey Programme for Impact Assessment of the stakeholders under Capacity Building Programme covering 81 stakeholders in various districts of Jharkhand, 2021.
- Dr. Thamilarasi K, Sr. Sc. guided Ms. Neha Kumari, M. Sc (Biotech) student from Vinoba Bhave University, Hazaribhag for six months dissertation on the topic "Cloning of fatty acid desaturase gene of the Indian lac insect, Kerria lacca (Kerr.)", July 26, 2021 to January 25, 2022.

Following trainings were organized by Er. SK Pandey, Sc. & Training In-charge/Co-ordinator as detailed below:

Participants	Address	Training title	Duration of training
Mr. Sanjay Singh	M/s. Neo Organic (M/s Ohvem Sales Corporation), Raipur, Chattisgarh	Aleuritic acid	March 15, 2021
Md. Sahanawaj Hossain	M/s. Indolacca Shellac Industries Pvt. Ltd., Bardhaman, W.B.	Dewaxed bleached lac	March 15, 2021
Mr. Mahendra Pardhi		Testing and analysis of lac	August 24-September 04, 2021
Mr. Prasun Agarwal	Purulia, W.B.	Aleuritic acid	September 06 - 10, 2021
Md. Sahanawaj Hossain	M/s. Inolacca Shellac Industries Pvt. Ltd., Durgapur, W.B.	Aleuritic acid	December 06 – 10, 2021

Infrastructure Developed

- Dr. Nandkishore Thombare, Sc. as a coordinator of 'Germplasm for resin and gum plants' planted seedlings of gum and resin plants including Piyar (*Buchanania lanzan*), Jhingan (*Lannea coromandelica*), Moringa (*Moringa oleifera*) and Salai (*Boswellia serrata*) at the Resin and gum plant germplasm farm of the Institute during June-July, 2021.
- Equipments like FTIR (₹34,50,000/-) and Hot air oven (₹38,000/-) were purchased and installed during March 2021.

Resource Generation

- Quality evaluation laboratory, IINRG has generated ₹39,294/- (from external samples), ₹1,20,714/- (notional from internal samples) and

₹94,400/-(from training on Testing and Analysis of Lac), Total ₹2,54,408/-.

- Through the sale of 37 copies of book 'Major Gum and Resin Plants of India: A Field Guide' authored by N Thombare, VD Lohot, N Prasad and KK Sharma, from Institute Library a sum total of ₹15,200/- was earned by the Institute during 2021.
- Technology of Gummy Mass, Gasket Shellac Cement Compound, Heat and water proof spiritless varnish for wooden surfaces (MSV005) and IINRG-Lac Nail Shine (Nail polish) was transferred to M/s Ohvem corporation, Chhattisgarh, Mr Md Shahnawaz, MD, M/s INDOLACCA, Balrampur (WB) and Mrs Sukanto Behera from Balasore (Odisha). Process know-how and demonstration was given during March 15-26, 2021. Institute earned revenue of ₹29,500/- (including GST) in the process.

Events

On Farm Training Cum- Field Day Programme

The ICAR- Indian Institute of Natural Resins and Gums Namkum, Ranchi organized on farm training cum field day on "*Calliandra calothyrsus* - A good host in lac integrated agro-forestry system" to promote the necessary awareness among farmers at Mungadhi, Angara block, Ranchi district on 20 January, 2021. The main aim of the event was to improve farmer's technical knowledge and making wider publicity of the models (*Semialata* + Vegetables + Papaya + *Calliandra* + *Ber*) demonstrated at the farmers' field amongst neighboring villages for motivation and adoption of the successful models with the philosophy of "seeing is believing". Chief guest of the programme Dr. Nirmal Kumar, Head, TOT division, ICAR-IINRG, gave his remarks to farmers and emphasized on adoption of new technological interventions for livelihood security. Local representative of Tati Panchayat, Mr. Ramanand Bedia appreciated the work and effort of ICAR-IINRG and ICRAF, Delhi. Lac cultivation experts Dr. S Ghosal, Dr NK Sinha, Dr. J Ghosh, Dr. VD Lohot, Dr. A Mohanasundaram, Dr. RK Yogi, Dr. Nandkishore Thombare, Mr. Rajgopal NN and Ms. L. Chanu expressed their views about different aspects of lac integrated farming. A field visit of the demonstrated plots was conducted for the existing successful lac integrated agro- forestry models. Around 150 farmers from 10 different villages participated in the field day cum training program.



On farm training-cum-field day at Mungadhi, Angara block, Ranchi, January 20, 2021

Kisan Mela-cum-Agricultural Technology Exhibition 2021

Two days Kisan Mela-cum-Agricultural Technology Exhibition -2021 was organized in association with State Agricultural Management & Extension Training Institute (SAMETI), Jharkhand and *Krishi Vigyan Kendra* (KVK), Khunti during 11-12 February, 2021 at ICAR-IINRG, Ranchi.

The *mela* was inaugurated by Shri Hemant Soren, Hon'ble Chief Minister, Government of Jharkhand. Shri Badal Patralekh, Hon'ble Minister, Agriculture, Cooperatives, Animal Husbandry and Fisheries, Government of Jharkhand; Shri Rajesh Kachhap, Hon'ble Member of Legislative Assembly were the Guests of Honour on the occasion. Shri Anuj Agarwal, Chief Operating Officer, ICICI Foundation for Inclusive Growth was the Special Invitee.

During the occasion Shri Hemant Soren, Hon'ble Chief Minister declared in *kisan mela*, that the state government soon pull-out lac from Minor Forest Produces (MFPs) list and classify the natural resins as an agricultural produce. Shri Badal Patralekh, Hon'ble Minister, Agriculture, Cooperatives, Animal Husbandry and Fisheries, Government of Jharkhand, in *mela* stressed on the lac cultivation, as an important source of income to the farmers. Shri Rajesh Kachhap, Hon'ble Member of Legislative Assembly outlined the recent farmer welfare schemes of central and state governments.

During the valedictory session, the Chief Guest, Dr. Omkar Nath Singh, Hon'ble Vice Chancellor, Birsa Agricultural University, Kanke, Ranchi, Guest of Honor Dr. Arunava Pattanayak, Director, ICAR-IIAB, Ranchi and Dr. Subhas Singh, Director, SAMETI, Jharkhand and Dr. Nirmal Kumar, Convener of the event were also present. Dignitaries conferred the Excellent Stall Exhibition Awards, Best Farmer Produce Award and Agri Innovative Entrepreneurs Award to the Winners.

Two days *kisan ghosti* was also organized wherein experts of the various organizations *i.e.* ICAR-IINRG, Birsa Agricultural University (BAU), ICAR-RCER Farming System Research Centre for Hill and Plateau Region, Central Tasar Research and Training Institute (CTRTI), Institute of Forest Productivity (IFP) and ICAR-Indian Institute of Agricultural Biotechnology (IIAB) interacted with farmers and provided on the spot solutions to farm based problems. Progressive farmers, executives, entrepreneurs and winners of the exhibition who are the real torch bearers of the technology spread were felicitated.

More than 1500 farmers including lac growers, women farmers, entrepreneurs, rural youth and officials from the line departments participated in the *mela*.



Stakeholders participating the *mela*



Felicitation of the excellent stall awards by the dignitaries during valedictory function

National Web Symposium on "Recent Advances in Beneficial Insects, Natural Resins and Gums"

The ICAR-Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand and the Society for Advancement of Natural Resins and Gums jointly organized the National Web Symposium on "Recent Advances in Beneficial Insects, Natural Resins and Gums" from 25 to 26 February, 2021.The Symposium was organized in association with the Indian Journal of Entomology, All India Coordinated Research Project on Honeybees and Pollinators and Dr. B Vasantharaj David Foundation.

In the inaugural address, outlining the existence of vast scope for research and development in beneficial insects and NRGs, especially, lac, the Chief Guest, Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR) emphasized on the importance of beneficial insects in agriculture. He urged the scientists to take up the studies on biosystematics, host-parasite interaction, evolution, epigenomics and the impact of technologies disseminated among the stakeholders. The Guest of Honor, Dr. TR Sharma, Deputy Director General (Crop Science), ICAR briefed about the uniqueness of insect genomes and the scope and challenges in studying the insect resistance in crop plants. He also underlined the importance of collaboration in the agricultural sector comprising of beneficial insects and NRGs.

The Guest of Honor, Dr. KK Singh, ADG (Farm Engineering), stressed on the significance and scope of value-addition in NRGs and also emphasized for mechanization in their cultivation. Earlier, in his welcome address, Dr. KK Sharma, Director, ICAR-IINRG, Ranchi, Jharkhand & President (SANRAG) apprised the participants about the Institute's role and achievements.

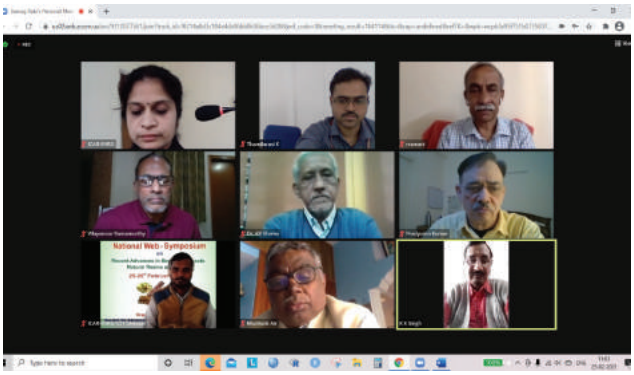
Dr. A Mohanasundaram, Organizing Secretary of the Symposium briefed about the Symposium. The SANRAG Awards were conferred to the various scientists and entrepreneurs for their excellence in their sphere of work during the occasion.

A Mobile App "*Lakh ka Doctor*" was also unveiled to the public in the august presence of the dignitaries on the occasion.

The deliberations of the symposium revolved under the following seven theme areas:

(i) Systematics, conservation, insect behaviour and physiology
(ii) Host-plant, insect and environmental interaction
(iii) Crop improvement using innovative tools including biotechnology, nanotechnology, molecular approaches etc.
(iv) Production system management and impact of climate change
(v) Potential of insects as food and medicinal resources
(vi) Processing, application, value addition and export potential of NRGs
(vii) Role of beneficial insects and NRGs in sustainable livelihood security

The plenary Session was chaired by Dr. R Ramani, Former Director, IINRG, Ranchi and co-chaired by Dr. VV Ramamurthy, eminent taxonomist and former professor at Division of Entomology, Indian Agricultural Research Institute, New Delhi. Numerous valuable recommendations were emerged during the symposium. Dr. S Ghosal acted as convener, Dr. Thamilarasi K and Dr. Rajgopal NN acted as co-conveners, Dr. A Mohansundaram and Dr. NK Sinha acted as organizing secretaries for this symposium.



Snapshot of the participants during the symposium



Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR) addressing the gathering during the symposium

International Women's Day

International Women's Day was organized jointly by KVK, Khunti and IINRG, Ranchi on March 8, 2021 in which the Agricultural State Minister Kailash Chaudhary and Purshottam Rupala along with other senior officials addressed the women farmers, entrepreneurs and villagers throughout the country by virtual mode. In the programme Dr KK Sharma, Director, ICAR-IINRG, Ranchi expressed his thought and said that the women is the foundation of our society and our society must ensure their decision making power and sufficient avenues to progress and prosper. The chief guest of the programme Sister Marilena, Director, Torpa Rural Development Society on this occasion said that the women played a very crucial role in in the time of pandemic and support to their family and society in totally adverse and critical situation. On this occasion the guest of honour Dr. Seema Day, Associate Professor, Ranchi University expressed the deep concern over the grass rooted evil of dowry which is still a part of our society. On this occasion different competitive programme of speech and rangoli competition was organized. On this occasion 10 sprayers were distributed to the women for supporting the farming activity. Dr. Nirmal Kumar, Dr Thamilarasi K and Dr RK Yogi were the resource persons for coordinating the overall programme.



Dignitaries and the awardees during International Women's Day celebrations



Felicitation of a woman farmer during International Women's Day celebrations

Online HRD Program

In collaboration with marketmirchi.com an Online HRD Program entitled "ICT driven Interventions in Marketing of Natural Resins and Gums (NRGs)" was organized on 10 March 2021 by ICAR-IINRG, Ranchi. A total of 93 participants which were quite heterogeneous in regard to profession and from different states attended the event. Dr. KK Sharma, Director, ICAR-IINRG, Ranchi briefed about the current framework of Information and Communication Technology (ICT) in the field of NRGs. He said that application of ICT in the various sectors of economy particularly in mobile based marketing may enhance the Gross Domestic Product of the country significantly. Guest Speaker, Smt Pragati Gokhale, Founder of Mission Mera Mobile Mera Marketing, delivered an expert lecture on ICT driven interventions in marketing of NRGs. She provided detailed information with its mission to strengthen the rural marketing. A list of NRGs for uploading at the web portal (E-Platform) of Mission Mera Mobile Mera Marketing was shared and it has been uploaded under the category of bamboo, herbal & forestry produces. It was great experience for the participants who are directly linked with the farmers and concerned with various issues of marketing. On this occasion, Dr. Nirmal Kumar, convenor presented

his lecture on the need of capacity building and skill development for farmers.

Technology and Machinery Demonstration Mela 2021

Technology and Machinery Demonstration Mela 2021 was organized on 12 March 2021 and more than 150 farmers participated. Director of the Institute, Dr. KK Sharma briefed about the main objective of this fair to make aware the farmers about modern agricultural implements and made aware about various schemes of the government, In this exhibition, rotavator, multi crop thresher, straw chopper shredder, tractor drawn sprayer, three types of seed drill, planter, reaper cum binder, etc. were exhibited. Dr. Nirmal Kumar, convener and Head, Transfer of Technology Division, said that a farmer cannot buy all the machines but can arrange all the machines by sharing the available machines among themselves. Dr. N. Prasad, Head, Processing and Product Development, Division emphasized on the relevance of farm machines/ implements in doubling farm income. Dr. S. Ghoshal, Head, Lac Production Division, Dr. SC Sharma, Sc. briefed about utility and benefits of farm machines/ implements.



Inauguration of Technology and Machinery Demonstration Mela 2021



Interaction of farmers with expert during Technology and Machinery Demonstration Mela 2021

Sensitization/Awareness Program on Scheme of Ministry of MSME, Govt. of India

ICAR-Indian Institute of Natural Resins and Gums, Ranchi organized a Sensitization/Awareness Program on "Scheme of Ministry of MSME, Govt. of India" on 19 March 2021 in collaboration with MSME Development Institute, Kokar, Ranchi. Director of the Institute, Dr. KK Sharma briefed about the main objectives of Sensitization/Awareness Program and its importance for all the line departments, Non-Government Organizations (NGOs), Self-Help Groups (SHGs), Farmers Producers Companies, *etc*. Shri Surendra Sharma, Deputy Director, MSME Development Institute Ranchi presented more than 10 schemes. The benefits of several developmental oriented schemes of the Ministry have significant role to impact the rural economy and livelihood through employment generation. More than a dozen organizations participated in the program including NABARD, JASCOLAMPF, KVIC, JTDS, SAMETI Jharkhand, UDYOGINI, IFP, Forest Department (Jharkhand), TRIFED, JSLPS, PRADAN, *etc*. and shared the detailed information about the ongoing activities.



Sensitization/Awareness Program on Scheme of Ministry of MSME, Govt. of India

World Water Day on 22 March 2021 at Mangobandh, Ranchi

One field day cum awareness program was organized by ICAR-IINRG, Ranchi on World Water Day (22 March 2021) at Mangubandh village, Ranchi. The main objective of this program was "To create awareness among the farmers about the importance of water in life and agriculture". The information like water harvesting and its importance, rooftop rain-water harvesting and advanced water-saving technology particularly drip irrigation systems were explained by Er. Pradosh Kumar Paramaguru (Sc.). Dr. Soumen Ghosal (Pr. Sc. & Head, LPD) explained about importance of irrigation for both lac insect and lac host plants,

how to check the flow of water and low-cost artificial groundwater recharge techniques to farmers. Ms. L Chanu Langlentombi (Sc.) briefed about the need of forest plants in water conservation and establishment of agro-forestry system for environmental security. In this program, farmers were also advised to adopt rainwater harvesting and adopt drip irrigation systems in their houses and fields for improving land & water productivity. Around 40 farmers participated in the programme. Shri Mausam Kumar Ram (TA) and Sandeep Kumar helped in arranging the resources and facilities required during the programme.



Scientists addressing the farmers on World Water Day

Exposure Visit for Jharkhand Administrative Service Probationary Officer Trainees

An exposure visit was organized for 30 Jharkhand Administrative Service (JAS) probationary officer trainees of 6th batch from Sri Krishna Institute of Public Administration, Ranchi on 24 March 2021. The purpose of this visit was to expose the newly recruited officers to the natural resins and gum especially lac sector. JAS officer trainees got live demonstration of lac cultivation at IRF & exposure at institute museum on NRGs.

Dr KK Sharma, Director, ICAR-IINRG briefed about the world's largest research system of ICAR and its network of more than 110 research institutes and centers across the country and ICAR-IINRG deals with natural resins and gums. He convinced about the importance of NRG sector and expect its spread for sustainable development.

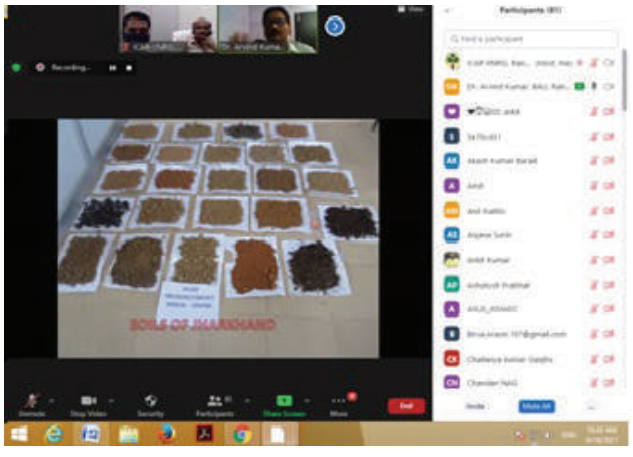
On this occasion, Dr Nirmal Kumar, Head PEM Division briefed about the various extension activities. Dr S Ghosal, Head, QPI Division briefed about the various research activities related to scientific cultivation of lac. Dr N Prasad, Head, MPE Division, Dr SKS Yadav, Training Coordinator and staff of the institute were also present during the interaction session.



Interaction of JAS officer trainees with the scientists of the institute

Online *Kisan Goshthi* On Balanced Use of Fertilizer

On 18th of June 2021 an Online *kisan goshthi* was jointly organized by KVK, Khunti through virtual mode on "Balanced Use of Fertilizers". The main objective of this seminar was to make the farmers aware of the balanced use of fertilizers in the soil. On topics such as judicious use of fertilizers, importance of organic fertilizers, role of fertilizers in the transmission of nutrients to plants, irrigation along with drip method, fertilizer use, crop residue management, soil health card scheme and collection of soil samples. Dr. Arvind Kumar, Dr. P. Mohapatra, Dr. S. Ghoshal, Mr. PK Paramguru, Dr. DK Shahi, Dr. Rajan Chaudhary, through their lectures, made farmers aware of having a sensitive approach towards soil. Dr. Nirmal Kumar presented his views on the subject. A total of 97 people, including 70 farmers, 10 students and 17 institute employees, were present in this *kisan goshthi*.



Experts providing lectures during one of the sessions of online *kisan goshthi*

International Yoga Day-2021 Celebration

As per guidelines received from Ministry of AYUSH and endorsed by the council, the ICAR-Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand, celebrated International Yoga Day-2021 (IDY-2021) on 21 June 2021 following this year's theme "*Yoga at home and Yoga with family*". The message was shared on social media platform and Dr. KK Sharma, Director, ICAR-IINRG, encouraged the staff for doing yoga at home as the Yoga is ray of hope during this pandemic time. Dr. Nandkishore Thombare, Scientist, and Nodal officer, IDY-2021 coordinated the event. Staff of the Institute practiced Yoga at their home and with family as conducting mass Yoga event was not possible due to COVID-19 pandemic. Staff of the Institute actively participated and shared their photos performing Yoga at home with family on the WhatsApp group of the Institute, commemorating the importance of Yoga for our health and peace of mind.







Institute staff practicing Yoga with family at home on IDY-2021

Workshop on "Model of Integrated Farming System, Value Addition and Bank Related Schemes"

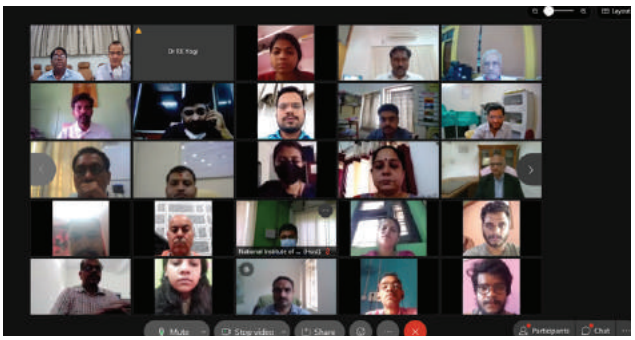
ICAR- IINRG, Ranchi organized a lecture/workshop on 29 July 2021. Deputy District Manager of each district of Jharkhand of NABARD and senior scientists of the institute participated in this lecture. The main objective of this program was to coordinate with the bank schemes related to various farmers' works being done in the research field and take their benefits to the rural areas. In the program, the director of the institute, Dr. KK Sharma presented the scenario of lac crop for integrated agriculture in our country and stressed on the add value addition to the products obtained from the Integrated Farming System as well as add to it various schemes being given by banks/ financial institutions especially big institutions like NABARD in rural areas which helps significantly in improvement in the standard of living of the farmers.



Trainees visiting the museum with expert

Webshop on "Sustainable Technological Interventions for Entrepreneurship Development in Tribal Zone"

ICAR-IINRG, Ranchi, Jharkhand in collaboration with the National Institute of Agricultural Extension Management (MANAGE), Hyderabad organized a Webshop on *"Sustainable Technological Interventions for Entrepreneurship Development in Tribal Zone*" from 10 to 12 August, 2021. In his inaugural address, the Chief Guest, Dr. P Chandra Shekara, Director General, MANAGE, Hyderabad emphasized on promoting the linkages for enhancing the producer's share (mainly forest dwellers of the tribal communities) in the consumer rupee particularly, the Natural Resins & Gums (NRGs) sector. He advised that the lac production along with the other NRGs might be a good option for developing Entrepreneurship in the remote areas. In his presidential address, Dr. KK Sharma, Chairman & Director, ICAR-IINRG, Ranchi outlined the scope of NRG sector for the livelihood security and earning foreign exchange. He regarded the integrated approach of farming as the key for ecological balance and lac cultivation as the best option for alternative agriculture.

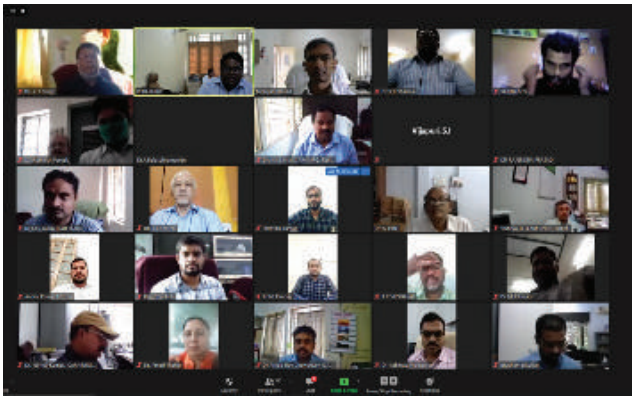


Participants from different organization attending the programme

Dr. Saravanan Raj, Director, MANAGE, Hyderabad urged the participants to disseminate the information further among the stakeholders. 175 participants from the State Agriculture Departments, Cooperative Federations and Agricultural Departments from 26 States and Union Territories participated in the Webshop.

Bharat Ka Amrit Mahotsav

To commemorate 75th years of India's independence as "*Bharat Ka Amrit Mahotsav*", ICAR – Indian Institute of Natural Resins and Gums, Namkum, Ranchi virtually organized lectures on the topic "Mechanization in Natural Resin and Gum Production for Sustainable Environment" and "Processing and Value Addition of Natural Resins & Gums" on July 06, 2021 and August 03, 2021, respectively delivered by Dr. N Prasad, Pr. Sc. And Head, MPE Division and Dr. MF Ansari, Pr. Sc. & Head, APD Division. Dr. N Prasad covered mechanization aspect of Natural Resins and Gums production with major emphasis on tools and equipments and Dr. MF Ansari covered processing and value addition aspect of Natural Resins and Gums of commercial importance including application areas for the same, respectively. The lecture was attended by more than 110 participants.





Officials from different organization attending the programme

Walkathon event

An event of walkathon competition was held on 13 August 2021 by the sports committee of the Institute at Institute Research Farm. On this occasion around 50 staffs of the institute took part in this event. Ms. Chanu won the first prize in the women's category, Mr. Pitrush in the age group above 45 years, and Mr. Michael in the age group below 45 years. The program was coordinated by Dr. S. Ghosal, Pr. Sc. And Head, QPI Division and organized by Mr. Rajagopal NN, Sc.

Parthenium Awareness Week-2021

ICAR- Indian Institute of Natural Resins and Gums (IINRG), Ranchi observed sixteenth 'Parthenium Awareness Week' during August 16-22, 2021. The programme was organized in main campus along with its adjoining areas and different villages through the KVK of the institute. On this occasion, the director of the institute, Dr. KK Sharma emphasized on creating a *Parthenium* free environment. Dr. NK Sinha, Pr. Sc., said that Parthenin and other toxic chemical like sesquiterpene lactones found in parthenium grass are responsible for allergies and dermatitis. Therefore, everyone should be vigilant to prevent the spread of this weed. It should be uprooted and destroyed before flowering. Thereafter, a drive was launched for uprooting of parthenium in nearby areas of the office. All officials of the institute including scientific, administrative, technical and skilled support staffs participated in this important event.



Staff removing parthenium



Staff taking oath during Parthenium Awareness week

Workshop and Interaction Programme for sensitization of SFURTI/KVI Schemes

In collaboration of ICAR-IINRG, Namkum, Ranchi and Khadi Village Industries Commission a workshop was organized at IINRG, Ranchi on 24 August 2021 with the objective for providing employment to the rural youth at their door steps by producing saleable articles and creating self reliance amongst the people and building up of a strong rural community spirit by implementing Khadi and village Industry schemes. The programme was attended by Member of Parliament of Chatara and Ranchi, Mr. Sunil Singh and Mr. Sanjay Seth respectively and both of them appreciated the initiative and encouraged the participants for vouching for the initiative of vocal for local.





Director IINRG Dr. KK Sharma addressing the gathering

Poshan Vatika and Plantation Drive at *Krishi Vigyan Kendra*, Khunti

This event was organized under the joint aegis of IINRG, Ranchi and *Krishi Vigyan Kendra*, Khunti at Diankel, Torpa, Khunti on 17 September 2021 on the context of International Nutritious Cereal Year 2023. Hon'ble Minister of Agriculture and Farmers Welfare, Government of India, Shri Narendra Singh Tomar emphasized that this effort can make India self-reliant. Hon'ble Minister of State for Agriculture and Farmers Welfare, Government of India, Shri Kailash Chaudhary, discussed the qualities available in coarse grains like jowar, bajra, ragi etc. and called for popularizing them among the farmers. Addressing the program, Dr. Trilochan Mohapatra, Director General, Department of Agricultural Research and Education, Government of India also emphasized the role of kitchen garden and millets on the human nutrition. The Pradhan of Torpa block, Mrs. Shishir Topno called for adopting coarse cereals to avoid malnutrition among women. Presiding over the program at *Krishi Vigyan Kendra*, Khunti, Dr. Nirmal Kumar, HOD, showed the way to reduce the cost to increase the income of the farmers and shed light on the development of healthy mind along with healthy body by including nutritious grains in their daily diet. Ms. Langlentombi LC, Sc. provided information about the nutrients available in nutritious cereals like jowar, bajra, ragi, sama, kodo etc. and stressed upon rural women and girls to include it in their diet. Dr. J Ghosh, in-charge *Krishi Vigyan Kendra* informed about the program being run by the institute for the welfare of farmer. IFFCO's Mr. Chandan Kumar emphasized on the use of balanced fertilizers and compost for good crop yield so that along with increasing the yield, the health of the soil is also saved. In this program 100 rural girls and 150 farmers from different villages of Torpa block were served nutritional food made of coarse cereals, one packet each of vegetable seeds and Ber, Guava and Kusum trees were also distributed to each. On this occasion, fruit trees were also planted by the girls in the courtyard of *Krishi Vigyan Kendra.*



Lunch distribution to the participants



Institute staff with participants

98th Institute Foundation Day

ICAR-Indian Institute of Natural Resins and Gums, Ranchi celebrated its 98th Foundation Day on September 20, 2021. While delivering welcome address Dr. KK Sharrma informed the audience that the NRG products 3rd largest export commodity (after rice and wheat) the sector generate 5 million man-days of employment. Dr Ashok Dalwai, the CEO of, National Rainfed Area Authority (NRAA), delivered the Ms Dorothy Norris memorial lecture in honour of the founder director of the erstwhile Indian Lac Research Institute. While welcoming the guests and dignitaries, Dr KK Sharma (Director ICAR-IINRG) apprised of the institute's achievements and highlighted various technologies developed and transferred by the institute. Dr Ashok Dalwai, in the 11thMs Dorothy Memorial Lecture, emphasised that farmers of India should be self-reliant through establishing a solid foundation of secondary agriculture. This institute has a significant role in the future ahead while doing fruitful research on the value addition of agricultural produce. It not only gives employment to the farmers but also increases the income of farm families. Dr Suresh Kumar Chaudhari (DDG, NRM and Engineering) presided over the function. He emphasised that some non-traditional agriculture like lac culture, apiculture, mushroom culture, vermicompost fisheries *etc.*, are having immense potential for doubling farmers' income. The importance of these practices become even more due to rainfed agriculture being the dominant agricultural practice. He justified that there is sufficient background for establishing an institute dedicated to secondary agriculture.

On this occasion, distinguished workers of the institute *viz*. Dr. Thamilarsi K, (Scientific staff), Shri Binod Kumar and Shri Birendra Kumar Singh (Technical staff), Sri Krishna Murari (Administrative staff) and Baiju Oraon (Skilled supporting staff) were awarded certificates and trophies for their commendable contribution in their sphere of work. In this occasion the dignitaries also released a booklet on meteorological advisory.



VC, BAU lighting the lamp during the event



Release of weather related booklet from KVK, Khunti (DAMU)

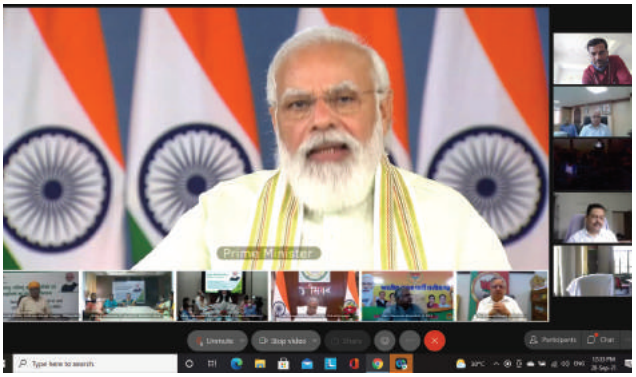
Many distinguished scientists from sister ICAR-organizations, retired staff of the institute and 200 other dignitaries participated in the programme. Dr. S Ghosal, Pr. S. and Head, Quality and Productivity Improvement Division was the convener and Dr. Achintya Pramanik, (Sc.) and Mr. Sandeep Kumar were the co-conveners of the programme.

Discussion on Climate Resilient Varieties, Technologies and Practices and Hon'ble Prime Minister's address to the farmers

Under the joint aegis of ICAR-IINRG, Ranchi and KVK, Khunti, this program was organized at Churgi, Diyankel, Torpa, Khunti on 28 September 2021. Honorable Prime Minister Shri Narendra Modi interacted with farmers from every corner of the country and spoke on various aspects of agriculture and appreciated the efforts of the KVK and the Indian Agricultural Research Institute in the adoption of modern agricultural techniques by the farmers. The Prime Minister talked about the utilisation of the Kisan Samman Nidhi in furtherance of agricultural activities and these improved strains will be helpful in moving towards climate resilient agriculture and malnutrition free India.



Scientists of the institute attending the programme



Hon'ble Prime Minister addressing the farmers

Special *Swachhta* Campaign

ICAR-IINRG and KVK, Khunti jointly organized the "Special *Swachhta* Campaign" from 2 October to 31 October 2021. Four "*Swachhta* Awareness campaigns" were organized in each week in the MGMG adopted villages. About 206 farmers and 195 school children participated in those campaigns.



Cleanliness drive at school premises

World Food Day, October 16, 2021

World Food Day was celebrated at the Institute under the theme 'Safe Food Today for a Healthier Tomorrow', on October 16, 2021. On this occasion a lecture was delivered on 'Good Food Habits' by Dr. Nandkishore Thombare, Scientist, in which tips for having a balanced diet including carbohydrates, proteins and fibres was given. Dr. MF Ansari, Head APD Division and Coordinator of the program highlighted the importance of healthy food for staying away from many diseases. Dr. Niranjan Prasad, Director (Acting), emphasized on having lighter and fibre rich food and appealed audience to avoid junk food to stay fit and healthy.



World Food Day celebration at the Institute on October 16, 2021

Training programme on Advanced Agricultural Implements and Machinery

ICAR-IINRG, Ranchi and KVK, Khunti organized one-day farmers training program on advanced agricultural implements for agricultural work on 29 October 2021. Presiding over the training, Dr. SC Sharma, Sc. discussed in detail about the role of useful agricultural machinery emphasizing on the geographical condition and the need of the farmer and suggested adopting custom hiring as an alternative form of income generation. Er. Anmol Kumar Mishra, SRF and–Dr. Rajan Choudhary explained in detail of the necessary power sources as well as useful advanced agricultural machines for various agricultural works to the farmers of different villages of Khunti district such as Sarnatoli, Kendtoli and Chhattoli. About 55 farmers participated in the event.



Expert giving presentation during the training



Officials discussing with the trainees

13th Annual Workshop of NP on HPVA of NRGs

The 13th Annual Workshop of Network Project on 'Harvesting, Processing and Value Addition of Natural Resins and Gums' (NP-HPVA of NRGs)

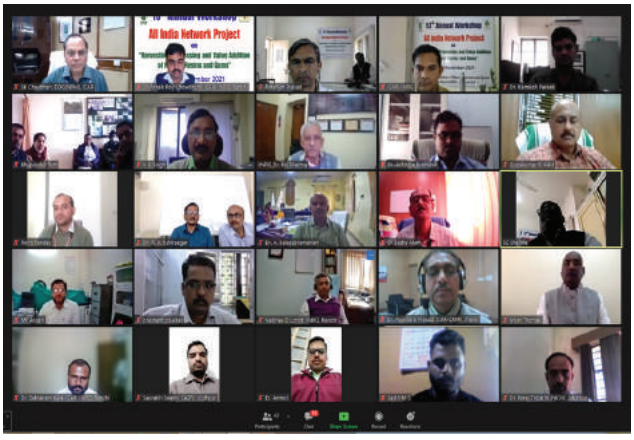
was held during November 09-10, 2021 via virtual online platform (co-ordinated by lead centre ICAR-IINRG, Ranchi) to review the annual progress of the Network Project centres and to discuss the technical programmes for the year 2022–23.

The inaugural session was chaired by Dr. SK Choudhari, DDG (NRM & Agril. Engg.) and co-chaired by Dr. K. K. Singh, ADG (Farm Engineering), and Dr. KK Sharma, Director, ICAR-IINRG, Ranchi. The dignitaries addressed the participants present on virtual platform from different collaborating centres. The meeting started with the welcome address by Dr. N Prasad, Project Coordinator. Dr. SK Choudhari highlighted the importance natural resin and gum and emphasized on connecting stakeholders, consumers and entrepreneurs of the natural resin and gum sector to the project through sensitization programmes, workshops etc. He also focused on developing a plan of action for the project with realistic targets and a timeline including a commercialization plan for developed technologies /products. Dr. KK Singh exhorted on prioritizing the research activities of the project to get results in the form of products, technologies and quality publications. Dr. KK Sharma encouraged cooperating centres to have complete value chain for assigned resin or gum commodity to their centre and also pressed to enhance processing and value addition activities for resin/gum under the project.

Dr. N Prasad presented the Coordinator's Report and ATR on recommendations of 12th Annual Workshop. He also presented an overview of the Network Project and briefed the objectives of the Project and also the number of methodologies/techniques, process/ products, and technologies/patents developed or transferred by the PIs of Network Project to the interested farmers/stakeholders. Also, nine publications and two products developed by different centres under the Network Project were released during the Inaugural Session by the dignitaries.

After the inaugural session and the remarks of the dignitaries, PIs & Co-PIs of the Network Project centres presented the progress for the year 2020 - 21 and technical programme for the year 2022–23 in the Technical Sessions Chaired by Dr. KK Singh, ADG (Farm Engineering) and Co-chaired by Dr. KK Sharma, Director, ICAR-IINRG, Ranchi.

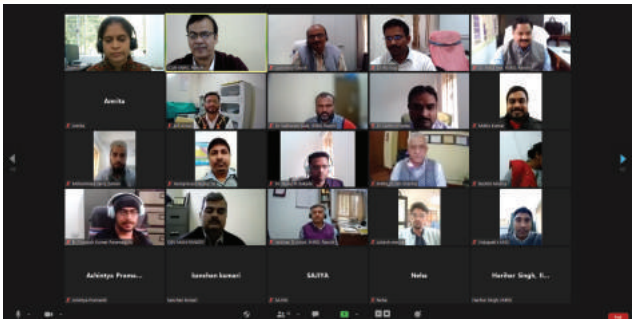
After completion of the presentations, a business session was held to discuss various issues and suggestions by the PIs & Co-PIs of the Network Project centres. The session was chaired by Dr. KK Singh, ADG (FE) and co-chaired by Dr. KK Sharma, Director, ICAR-IINRG, Ranchi. During the concluding session Dr. KK Singh and Dr. KK Sharma gave their concluding remarks based on two days deliberations in the Workshop. Dr. N Prasad, Coordinator, Network Project, briefed about the discussions held during last two days and also appreciated active participation of delegates in the technical session. The meeting ended with a vote of thanks to the chair.



Virtual participation in 13th Annual Workshop of AINP on HPVA of NRG

Webinar on Awareness on Antimicrobial Resistance

ICAR- Indian Institute of Natural Resins and Gums, Ranchi conducted a webinar on "Awareness on Antimicrobial Resistance" as a part of *Azadi Ka Amrit Mahotsav*- Webinar series. World Antimicrobial Awareness Week is being celebrated from 18 to 24 November, 2021 with the Theme for the year 2021 to be "Spread Awareness, Stop Resistance". Hence in order to spread awareness among the scientists of the institute and other research institutes based at Ranchi, this webinar was conducted by IINRG on 24 November 2021. Dr. Thamilarasi K, Senior Scientist, Quality and Productivity Improvement Division of the institute delivered the lecture in which she highlighted the facts about Antimicrobial Resistance (AMR), how AMR poses risks to human and animal health, causes of AMR and how AMR is achieved and transmitted within the environment. She also sensitized the audience about how to prevent the development of AMR at individual level, health care professional level and at policy makers' level. She gave a particular reference to AMR in agriculture; especially the ways in which antimicrobials used in agriculture pose threat to public health due to AMR. The lecture pointed out the need for using alternative strategies to combat AMR in Agriculture. The lecture also stressed the potential of Natural Resins and Gums (NRGs) including lac dye as an alternative strategy to combat AMR.



Participants of the webinar on 'Antimicrobial Awareness'

Swachhta Pakhwada 2021

ICAR-IINRG and KVK, Khunti jointly organized "*Swachhta Pakhwada* 2021" from 16 to 31 December 2021. The employees of ICAR-IINRG, Namkum, Ranchi had participated in *Swachhta Pakhwada* and *Kisan Diwas*. A number of events were organized on cleanliness and about 95 farmers participated in this programme on 23 December 2021.



Cleanliness drive at institute campus



Officials addressing the gathering in the village



Interaction between the experts and villagers



Cleanliness pledge by school students

Zero Budget Natural Farming

Under the joint aegis of ICAR-IINRG, Namkum, Ranchi and KVK, Khunti, the national level Kisan Goshthi on "Zero Budget Natural Farming" was broadcasted live in virtual mode on 16 December 2021. In the seminar, Hon'ble Prime Minister Shri Narendra Modi, while addressing the farmers and other stakeholders, scientists, students associated with the agriculture sector, said that natural farming is a method used in our country since historical times and it is for the rejuvenation for the country. On this occasion, The Home Minister of the country, Amit Shah, stressed on the need to get the support of each and every person of the country to make this movement go ahead. Agriculture Minister Shri Narendra Singh Tomar while giving his views said that in today's time, the cost of farming is increasing due to chemical farming and it is also affecting our soil and human health negatively. On this occasion, Shri Tomar also mentioned about the government's commitments like Kisan Samman Nidhi and providing one and half times MSP of the cost to the produce. Hon'ble Acharya Devvrat, Governor of Gujarat, presented his lecture on Natural Farming in which he informed about the benefits natural farming and presented a short film. A total of 325 people including leading and progressive farmers of Khunti and Ranchi district, including all the employees of the institute, were present on this occasion. Before the end of the program, the importance of cleanliness was discussed under the cleanliness fortnight running in the institute from 16 to 31 December and the people present took the oath of cleanliness.



Live telecast of Zero Budget Natural Farming in *palas* conference hall

Awareness cum *Kisan Goshthis* at different locations under MGMG

ICAR-IINRG, Namkum, Ranchi organized Awareness cum *kisan goshthis* in many villages of different blocks of Ranchi and Khunti including Sarnatoli, Mangobandh, Sarjamdih, Silda, Kendtoli etc. Under the campaign of '*Mera Gaon Mera Gaurav'*, scientific method of lac cultivation, soil health awareness, soil Conservation awareness campaigns and farmer seminars by scientists Awareness campaigns and farmer seminars were organized by the institute in which various teams of scientists and technical staff of the institute visited the villages and discussed the farmer's issues and topics among them in detail and listened to the local problems. Head of the Department, Dr. Nirmal Kumar said that *'Mera Gaon Mera Gaurav'* is working as a bridge between the scientists and the villagers but we have to move forward in the direction of development with the cooperation of each other and not limited to this program so that the development of the villages can be ensured as well as the youth can get the means of employment at their home place.



Newspaper clippings of different programmes under MGMG

Events by KVK, Khunti

First Scientific Advisory Committee (SAC) meeting of *Krishi Vigyan Kendra*, Khunti

The first scientific advisory committee meeting of KVK Khunti was organized by ICAR-IIINRG, Namkum, Ranchi and KVK, Khunti on 09 September 2021 in which different institutes, agricultural universities, officials of various line departments related to agriculture and rural development, in-charge of KVKs of different nearby districts, representatives of farmers' groups, SHGs, etc were participated. Speaking on this occasion, Dr KK Sharma said that all of us will soon start working from this newly constructed building on a permanent basis and with this new initiative, in future we will be able to fulfill the objectives for which the Krishi Vigyan Kendra is established. Dr. Anjani stressed on adopting the schemes of Animal Husbandry and Fisheries Departments running in various KVKs of Bihar State. Welcome speech in the program was given by Dr. Nirmal Kumar and vote of thanks was given by Dr. NK Sinha.



Director ATARI, Dr. Anjani Kumar addressing the gathering

Extension Activities / Other Programme Conducted

World Water Day

One field day-cum-awareness program was jointly organized by the state administration and Seva Welfare Society, or Gram Sabha Limda and KVK Khunti on World Water Day (22 March 2021) at Limda, Karra, Khunti on the theme of "Construction of Bori Bandh by shramdan". Mr Shashi Ranjan, DC Khunti and this program's Chief Guest, urged all farmers to build Bori-Bandh and save water for a secure future. Dr. Nirmal Kumar, Head, TOT Division ICAR-IIINRG, and Dr. Jyotirmoy Ghosh, PS & I/C KVK Khunti informed

farmers about various water-saving strategies. About 257 farmers, state and ICAR officials participated in this programme.





World Water Day at Limda, Karra

Tree Plantation Awareness

A plantation drive was organized jointly by the KVK, Khunti and the IIINRG, Ranchi. While addressing the tree plantation program. Dr. Nirmal Kumar (Head, PEM) emphasised the importance of tree plantation and its impact on creating a sustainable environment while addressing the tree plantation programme. Dr. Jyotirmoy Ghosh (PS & I/C KVK, Khunti) and Dr. Rajan Chaudhari (Agro meteorologist) urged farmers to practise weather-based farming, stating that farmers can only increase their income by using advanced technology developed by scientists. Mr. Chandan Kumar (District Manager, Ranchi, IFFCO), Mr. Dharmendra Singh (KVK-Khunti), Mr. Ashutosh Prabhat (KVK-Khunti), Pinus Topno (Coordinators of Women Development Center), Sangeeta Topno, Marcel Hembrom, and approximately 120 tribal farmers participated in this distribution programme.



Plantation programme on *Har med par ped*

Parthenium Awareness Week

Parthenium Awareness Week (16-22 August 2021) was observed by KVK, Torpa, Khunti in Token village of Khatanga Panchayat, Raniya block, beginning with the distribution of masks and gloves to farmers. Mrs. Seema Kandulna, the head of Khatanga Panchayat, Kandulnaji, praised the awareness session and emphasized Krishi Vigyan Kendra's work with farmers. Dr. Rajan Choudhari, Meteorologist (Krishi Vigyan Kendra, Khunti), and Asutosh Prabhat, Agromet observer, both stated that the gajar grass is hazardous to both humans and animals. Touching this grass also increases the risk of humans contracting tuberculosis and respiratory ailments, including skin diseases. Vindeshwar Singh, coordinator of the Women Development Center, Torpa, and Parshad Mary, Halyani Konagadi of Token village were also present at this programme.



Parthenium Awareness Week (16-22 August)

Women Farmers Day

To double the farmers' income in 2022, an event was organized jointly by *Krishi Vigyan Kendra*, Khunti, Torpa and ICAR-IINRG on 15 October 2021. Dr. N. K. Sinha, Pr. Sci., addressed the farmers, stating that without women, this country's overall progress is impossible and that our country is achieving high levels in agriculture due to the efforts of women farmers. Dr. J. Ghosh and Dr. Vaibhav Lohot discussed about the use of new agricultural techniques that will help farmers to reduce pesticide use in their crops.



Celebration of Women Farmers Day at KVK

BIS Training Programme

The Bureau of Indian Standards, Ministry of Consumer Affairs, Food and Public Distribution, Government of India, hosted a one-day quality check cum training programme on November 22, 2021, at Kisan Training Hall, *Krishi Vigyan Kendra*, Khunti. As an expert in this initiative, Saurabh Rai, Standard Promotion Officer of the Bureau of Indian Standards' Regional Office in Jamshedpur, explained to farmers how to monitor the quality of the items used in their daily farming activities and educate them on some basic methods of inspecting commodities. Dr. Rajan Choudhary, Meteorologist of *Krishi Vigyan Kendra*-Khunti, Ashutosh Prabhat, the weather observer of the centre, Mr. Jayalal Topno, the head representative of Diyakel Panchayat, and 35 farmers attended this programme.



BIS Training Programme

Agriculture and Environment Citizens Face

Krishi Vigyan Kendra- Khunti organized "Agriculture and Environment Citizens Face" programme to commemorate India's Independence Ka Amrit Mahotsav held at Lutheran High School located under Diykel Panchayat of Torpa block on 26 November 2021. The purpose of this program was to motivate students to achieve social, economic, and political justice, freedom of thought, expression, belief, religion and worship, and equality of status and opportunity, as enshrined in the Constitution of India. Different competitions like painting, debate and singing etc. were organized among the school children and they were rewarded. Regarding organizing the program, Dr. J. Ghosh said that by such events in the school, the hidden talents get an opportunity to shine as well as their mental creativity explores.





Group photo of winners with the officials Students took the pledge of cleanliness

World Soil Day

On the occasion of World Soil Day on 5 December 2021, KVK, Khunti, and IINRG, Ranchi, jointly organised an awareness program in Village-Manhatu, Torpa, Khunti. During a soil health session. Dr. Nirmal Kumar, Head, Product and Extension Management, told farmers that they should use balanced fertiliser in the soil so that its health lasts for a long time. Dr. J. Ghosh (I/c KVK) suggested that at this moment, farmers should all use methods like earthworm manure and composting to enrich soil with micronutrients. Dr. Rajan Chaudhary, the center's meteorologist, Ashutosh Prabhat, Agro-met Observer, and 90 farmers, as well as field assistants Sangeeta Topno, Marcel Hembram, and Pinus Topno, attended this awareness workshop.



World Soil Day

Kisan Diwas (23-25, December)

On the occasion of Farmer's Day (23-25, December) *Kisan Gosthi* was jointly organized by KVK, Khunti and IINRG, Ranchi, in Vaski, Patrayur, Chhattoli, Torpa. The nodal officer of the *Swachhta Pakhwada*,

Er. Pradosh K. Paramguru, informed the farmers about the major goals of the cleanliness campaign. Following that, Dr. Jyotirmoy Ghosh, I/c KVK, Khunti, addressed the farmers and advised them to apply a balanced fertilizer to the soil to ensure its long-term health. Dr. Rahul R. Bakade (Plant Pathologist) and Dr. Rajan Choudhary (Meteorologist) both stated that weather-based farming is making farmers more prosperous today because their costs are decreasing and their revenues are increasing. This activity involved approximately 220 students from the Government Middle School in Torpa and 235 farmers from the Patrayur farmer training programmes. Ashutosh Prabhat, *Krishi Vigyan Kendra*- Khunti observer, Hema Kumari, Tejashwini Project worker, and Vindeshwari Devi, Village Swawlamban worker were also present.

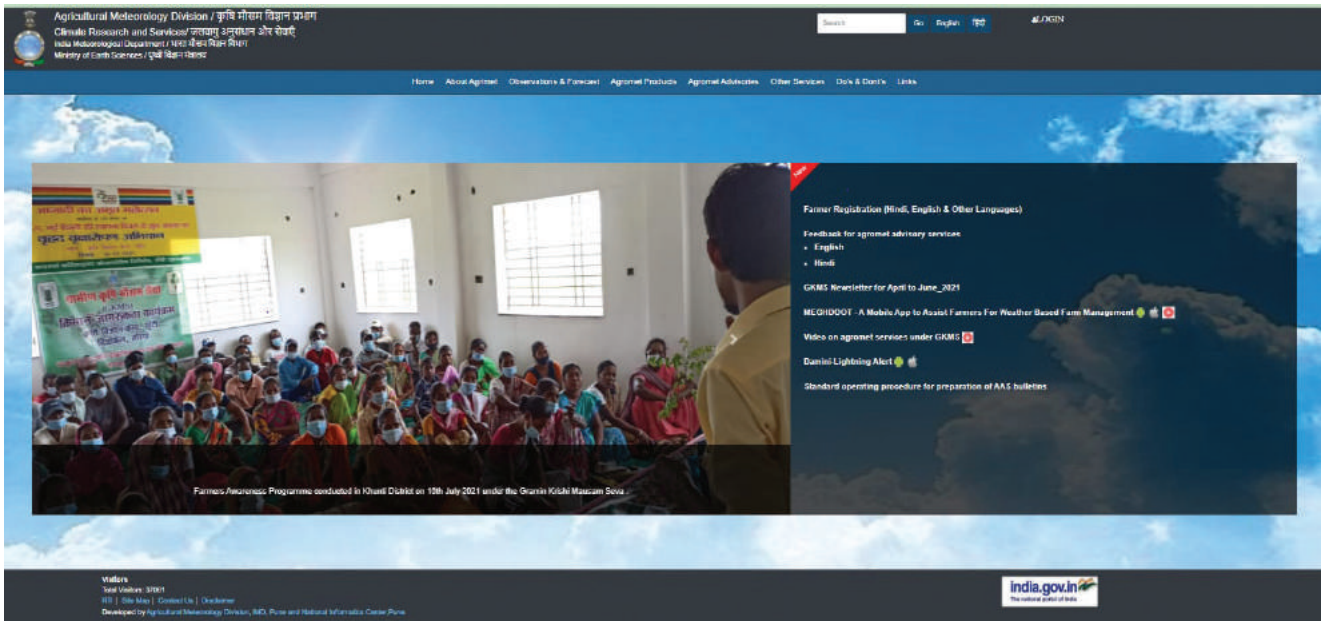


Kisan Diwas (23-25, December)

District Agromet Unit

Gramin Krishi Mausam Seva (GKMS) under the District Agro-met Unit is the programme of IMD in *Krishi Vigyan Kendra*, Khunti. This programme was conducted at different blocks like Torpa, Murhu, Khunti, Raniya, Karra, Arki etc. and at DAO (District Agriculture Office) in Khunti district. Dr. Rajan Chaudhari, SMS, Agrometeorology, delivered a lecture to farmers on the importance of weather forecasting. Farmers were given the necessary suggestions for weather-based farming and crop loss prevention in this programme. Farmer awareness programmes were conducted in 22 different villages, with approximately 1500 farmers receiving information and 49550 Agro-advisory were diseeminated about crop maintenance due to weather changes, as well as crop sowing time and how and when to irrigate, weed, and spray pesticides and fungicides for all blocks in Khunti district.

District Agro-met unit under GKMS awareness programme



This photograph was Selected and submitted by DAMU Khunti to Agricultural Meteorological Division, Climate Research and Service, India Meteorological Department and same was selected as Best Picture of FAP by IMD

Meetings of Important Committees

Institute Management Committee (IMC)

The 56th Meeting of the Institute Management Committee (IMC) was convened online in the *Kusmi* Conference Hall of the Institute on 05/03/2021 at 2.30 PM. The following members were present in the meeting:

Dr. K.K. Sharma, Director, ICAR-IINRG, Ranchi	Chairman
Dr. K.K. Singh, ADG (AE), ICAR, New Delhi	Member
Dr. M.H. Siddiqui, Dean (Forestry), BAU, Ranchi	Member
Dr. A.K. Thakur, Pr. Sc., ICAR-NINFET, Kolkata	Member
Dr. S.K. Giri, Pr. Sc., ICAR-CIAE, Bhopal	Member
Mr. Rajesh Sahay, Dy. Director (Fin.), ICAR, New Delhi	Member
Mr. Balmukund Sahay, Ratu Road, Ranchi	Member
Mr. Shailendra Kr. Mishra, West Champaran, Bihar	Member
Mr. S.C. Lal, Sr. AO (Actg), ICAR-IINRG, Ranchi	Member-Secretary

Invited members

- Dr. Nirmal Kumar, PS & In-charge, TOT Division, IINRG, Ranchi
- Dr. Niranjan Prasad, PS and In-charge, PPD Division, IINRG, Ranchi
- Dr. S. Ghosal, PS & In-charge, LP Division, IINRG, Ranchi
- Dr. Fahim Ansari, Pr. Scientist and In-charge, Finance and Account Section, IINRG, Ranchi
- Dr. A. Mohansundaram, Scientist, IINRG, Ranchi
- Mr. Anil Kumar Yadav, Estate Officer, IINRG, Ranchi
- Mr. Kameshwar Oraon, Assistant, Finance and Account Section, IINRG, Ranchi
- Mr. Abhishek Kumar, Assistant and In-charge, Admin-III Section, IINRG, Ranchi

1. Welcome address by the Member Secretary

The meeting started with the welcome address by the Member Secretary, IMC and formal introduction to the Members and the invitees.

2. Introductory remarks by the Chairman

Dr. K.K. Sharma, Chairman, Institute Management Committee and Director, ICAR-IINRG, Ranchi welcomed the members present in the meeting and apprised the members about the latest achievement of the Institute since last meeting of the IMC.

3. Presentation on the financial status of the institute

The Finance and Account Officer, IINRG presented the Financial Status of the Institute. It was informed that there is shortage of funds in the Head of Pension and LTC advance. Shri Rajesh Sahay, Dy. Director (Fin), ICAR told the Institute to send the demand to Council in respect of pensioners and LTC Adv.

4. Report on the status of establishments by Admin-I

The status of establishment was presented by Sri S.C. Lal, I/c, Sr. Administrative Officer.

5. Confirmation of the proceedings of 55th meeting of IMC held on 28.02.2020.

The IMC was apprised that the formal approval of the recommendation of 55th Institute Management Committee is yet to be received from the council. Earlier, the council had made some queries on the proceedings and its reply had already been furnished and now the approval is awaited.

6. Agenda for 56th meeting of IMC

(A) Strengthening of existing bituminous road in the main campus of the institute

As recommended by the previous IMC, the proceedings of which has been approved by the SMD/Council, the first installment of Rs. 16 Lakhs has been deposited with CPWD after getting the estimate duly vetted by the Director (works). However, it is informed by Finance and Account Section of the Institute that there will be shortage of fund for executing the said work due to curtailment of fund in view of COVID-19. It was putup before the IMC that additional fund requirement amounting to Rs. 1.25 crores may be provided by the Council for which recommendation of IMC is required.

After deliberation, it was recommended that additional allocation may be sought from SMD under 'Administrative Expenses: 'Repair and maintenance of Infrastructure', to enable institute release the next installment.

(B) Fencing of the wall of Institute Research Farm

It was presented that most part of the boundary wall round Institute Research Farm (IRF) is unfenced. It is required to fence approx. 1500 meters of the boundary wall with concertina wire at the earliest to avoid any theft of experimental material and farm produce and ensure smooth running of research works. Approval of the IMC was sought for the said work.

The IMC recommended that the said work may be proposed in the next SFC/EFC of the Institute.

(C) Deepening and widening of water harvesting pond at IRF

It was presented that the existing water harvesting pond in the IRF with dimensions 40X30X5 meter is needed to be deepened to collect the extra run off in rainy season. It will also aid in the supply to the proposed overhead tank to be built at IRF. Approval of the IMC was sought for the same.

The IMC recommended the deepening and dressing of the existing water harvesting pond in the IRF, subject to the condition that codal formalities related to the work is observed and subject also to the availability of funds. Since, it is repair and maintenance of existing infrastructure, the same may be met from 'Administrative Expenses: and maintenance of existing infrastructure, after ascertaining the cost of the work and completing all related codal formalities.

(D) Empanelment of hospitals / Investigation Centers located at Ranchi

As per the Council letter No. F. No. 38(9)/2019-per IV dated 28th Sept, 2020 and the suggestion of C/A of the Institute, a list was prepared by a committee at IINRG level for empanelment of some more hospitals/Investigation centers located at Ranchi for easy treatment of the staff of the Institute under CGHS rates and it was put up before the IMC for approval of the same.

The IMC recommended the same in light of the Council letter No. F. No. 38(9)/2019-per IV dated 28th Sept, 2020, subject to the condition that the reimbursement will be restricted to rates prescribed in CS (MA) Rules/ CGHS whichever is lower.

(E) Purchase of oxygen concentrator at IINRG Health Centre

It was presented that keeping in view the pandemic situation due to COVID-19, Oxygen concentrator is urgently required in the Institute Health Centre. It will be used to treat the patient whose Oxygen (O2) level is not optimum for normal living. Approval of the IMC was sought towards purchase of the same.

The IMC recommended to purchase the Oxygen concentrator by matching saving and dropping the equivalent minor item from existing SFC which is yet to be purchased. Accordingly the institute shall move a proposal for consideration by next IMC.

7. Information regarding IJSC and Grievance cell

- IJSC: The IMC was apprised of meetings of the Institute Joint Council (IJSC) called during the reporting period and informed that there is no unresolved issue before IJSC concerning to the welfare of the staff.
- Grievance Cell: The IMC was also apprised that no grievance has been received by the Grievance Cell of the Institute from any category of the staff.

8. Any other item with permission of the Chair

Under this segment, proposal for additional expenditure towards establishment of De-waxed De-colourised Lac was put up as the rate quoted by the L-1 firm i.e. Rs. 34,98,700/- is much higher than the estimated rate. Justification for the proposal was also given that wide circulation of the tender notice was done more than 03 times. It was also emphasized that the said item, approved in the SFC is urgently required for the research purposes.

9. Comments of the members, IMC

The Chairman also invited comments from the Members of IMC. Sri Balmukund Sahay, Member, IMC suggested that Institute should work for the benefit of the Women, farmers and tribals more

and more. The Chairman informed the Hon`ble Members of IMC that Institute is committed to provide its best services to the women and lac farmers and will continue to do so in future too.

10. Vote of thanks by the Member Secretary, IMC

The meeting ended with vote of thanks by the Member-Secretary, IMC.

Research Advisory Committee (RAC)

The XXVIII meeting of the Research Advisory Committee (RAC) of the Institute (third and final meeting of the current RAC) constituted *vide* the council letter No. A. Engg.3/2/2019-IA-II (AE) efile no. 35915 dated February 06, 2019 was held online on March 04-05, 2021 at ICAR-IINRG, Ranchi. The meeting was presided over by the Chairman, RAC Dr. Pitam Chandra, former ADG (PE) & former Director, ICAR-CIAE, Bhopal.

The following members were present:

- Dr. Kanchan K. Singh, ADG (FE), ICAR, New Delhi
- Dr. Subhash Chander, Director, ICAR-NRCIPM, New Delhi
- Dr. Suresh Walia, Emeritus Scientist, ICAR-IARI, New Delhi
- Dr. Sanjaya K. Dash, Dean, OUAT, Bhubaneswar
- Prof. RN Jagtap, Prof-Head, Institute of Chemical Technology, Mumbai
- Dr. Kewal Krishan Sharma, Director, ICAR-IINRG, Ranchi
- Dr. NK Sinha, PS, ICAR-IINRG, Ranchi - Member Secretary

Major recommendation of the RAC

1. Chemical optimization study on lac and NRGs for value addition may be added in future studies.
2. Scientist involved in post-harvest studies should frequently visit the related industry for feedback, interaction on future research needs and possible research collaboration.
3. The Institute should work on development of GIS-based mapping of potential lac host areas.
4. More focus be given on automation and modernizing processing technologies for product development and value addition.

Institute Research Council (IRC)

The Institute Research Council (IRC) Meeting was held on 16-17, April 2021 on online mode and special session was 30th June 2021 to reviewing the progress of the on-going, completed and the new project proposals etc. The IRC was attended by twenty-six scientists from IINRG and two scientists from other institutes were also invited. Fourteen ongoing projects, one completed project and two exploratory studies were reviewed. Seven new project proposals were also discussed and approved. Consequent on renaming and formation of new division, their core programmes were also finalized.



XXVIII RAC meeting in progress through online mode

Distinguished Visitors

The institute regularly receives several 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 Visited
1	Mrs. Neetu	Assistant Director, MSME-DI, Ranchi	01.01.2021
2	Dr. S.K. Sahu	Director, MSME-DI, Ranchi	04.01.2021
3	Dr. J. K. Gupta	Director, KVIC State Office, Ranchi	18.02.2021
4	Mr. Madan Maharjan	KTM, Nepal	09.03.2021
5	Ms. Anjali Mehta & team	Deputy Collector	25.03.2021
6	Dr. G. K. Nair, & team	G.M., NABARD	15.07.2021
7	Mr. Anil Oraon	Head CSR, Tata Steel Ltd., Nuamundi	26.07.2021
8	Ms. Nutan Raj & other Senior officers	DDM, Godda	19.07.2021
9	Dr. Aditya Arya	ARS-1978/IPS-1981	27.08.2021
10	Dr. D.P. Mishra	Mech. Engg. BIT, Mesra	09.09.2021
11	Mr. Mrityunjay Kumar Barnwal	IAS, Registrar, Cooperative Society	10.09.2021
12	Mr. Suresh Besan	CEO, Nesthan, Vijayawada	22.09.2021
13	Mr. Shyam Narayan	Ex A.O. ICAR-IINRG, Ranchi	16.10.2021
14	Mr. Mani Lal Mandal	IPS- SP (ACB), Ranchi	01.11.2021
15	Prof. Shashank Bansal	ISM, Dhanbad	26.11.2021
16	Dr. P.S. Dhawan	Vice Chancellor, VNMKV, Parbhani (M.S.)	20.12.2021
17	Mr. U.N. Singh	G.M. (Const.), GAIL India Ltd., Ranchi	24.12.2021
18	Mr. S.S. Khuntia	D.G.M. (F&S), GAIL India Ltd., Ranchi	24.12.2021

Support Services

Institute Research Farm

Resource generation

Broodlac/ Scraplac (₹)	Fuel Wood (₹)	Water + Fuel charges (₹)	Lac host plant seeds and seedlings (₹)	Other farm produce (₹)	Total (₹)
31,050	10,000	900	52,975	54,950	1,49,875

Infrastructure Development

- Paths of 10 ft width along the West and South boundary of IRF were made using JCB machine

Nursery Management

- Seeds of *bhalia* (2 kg), *semialata* (20 kg) were produced and seeds of *khair* (2 kg), *galwang* (5 kg), b*er* (5 kg), and *kusum* (2 kg) were collected from different trees.
- 235 *semialata*, (plot no.55, 63 and 64) and 250 *khair* seedlings (plot no 91-92 and 99-100) were transplanted for gap filling.
- 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 (2636 nos.), *bhalia* seedlings (300 nos.) b*er* seedlings (231 nos.), *Calliandra* seedlings (145 nos.), *kusum* seedlings (70 nos.) and *semialata* seeds (250 g) were provided to scientists for research purpose or for their distribution amongst farmers under different projects.
- 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	330 Nos.
Semialata seeds	4.25 kg
Bhalia seeds	0.1 kg
Kusum seedlings	572 Nos.
Calliandra seedlings	5 Nos.
Ber seedlings	455 Nos.
Galwan seeds	3.5 kg

Farm Management

- Despite of the Covid-19 scenario and lockdown, viewing the importance of essential farm management and lac culture activities, IRF remained operational while implementing all the prescribed guidelines from the institute.
- Executed field related experimental work of the scientists of QPI, PEM and APD Divisions 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.
- Tractor and other farm machinery were provided on demand and on recommendation of competent authority to CTRTI, Nagri and to other sections of IINRG.
- More than 20 kg of *F. semialata* seeds could be collected by the successful management of pod fly through appropriate and periodic chemical interventions.
- Infestation of white fly on *F. semialata* was observed and managed by spray of systemic insecticides. *Spodoptera* larva infested nursery plants periodically and was managed by spray of chemical pesticides like spinosad.
- Weeding, cleaning and lime application mixed with chlorpyriphos on approx. 5000 lac host plants and other trees.
- The production of vermicompost is being done at IRF in HDPE vermibeds and the same is being applied on vegetable crops grown at IRF. Vermiwash is being sprayed on the nursery plants for improving their robustness and health.
- Wheat (var. HD-2967) and paddy (variety Kala Jeera and Ankur 7434 hybrid) grown on unutilized plots of IRF were harvested and sold for resource generation.



Lac integrated vegetable crop production in *F. semialata* plot



Rice crop grown at IRF



Lac integrated zaid crop production in *ber* plot



Harvesting of wheat at IRF

- Lac Integrated Crop Production**:** Vegetable crops *viz.* bottle gourd, bitter gourd, cucumber etc were grown in integration with *lac* inoculated *be*r trees.

Similarly, onion was grown in integration with *F. semialata* and 460 kg onion bulbs were produced. The produce was sold for revenue generation.

Lac culture

- 1174 kg of *kusmi* broodlac was harvested and 1102 kg inoculated on *kusum* (122 nos.), *ber* (534 nos.) and *F. semialata* plants for both summer and winter *kusmi* crops. Similarly, 396.5 kg of *rangeeni* broodlac was harvested and 283 kg inoculated on *palas* (79 nos.) and *ber* (117 nos.) and *galwang* (50 nos.) for both *baisakhi* and *katki* crops.
- 36 kg scrapped lac and 90 kg brood lac was provided to scientists for their research works and for distributing to farmers under FLD and other projects.

Soil amendment and nutrient management in lac hosts

- Green manuring was done using *dhaincha* and *sanai*, 100 kg each, in *kusum* (plot no. 33-49) and *ber* (plot no. 17-29) for soil amendment.
- Farm yard manure (FYM) and biocompost was applied at lac host plant plots, vermicompost produced at IRF was applied on nursery plants.
- Lime and fertilizer application in 135 no. of *kusum*, 120 *ber* and 55 no. of *palas* trees was done at the onset of monsoon season to enhance productivity of the hosts.

Other activities

250 number of *khair* (*Acacia catechu*) seedlings were transplanted by institute staff under the guidance of The Director at Institute Research Farm plots as a part of tree plantation drives on the eve of World Environment Day on 5th June 2021 and on the eve



Application of lime for soil amendment



Application of fertilizers for nutrient management in lac hosts

of *Vriksharopan Mahotsav* with the theme "*Har medh par Ped*" on 16th July 2021.



Plantation raising activity at IRF on the event of Vriksharopan Mahotsav

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 2021-22 for all the employees of the Institute to the Council
  - Preparation & submission of Annual Physical and Financial Targets and Achievements (April 2020 to March 2021) of all the employees of the Institute to the Council
- PME Cell conducted Institute Research Council (IRC) Meeting on 16-17 April 2021
- PME Cell conducted RAC Meeting on 04-05 March 2021
- Maintenance of Research Project Files: Institute (20), ICAR-Network Projects (2), ICAR-ICRAF (1), ICAR – DBT Bio-CARe Project - (1) and Inter-Institutional (ICAR-IIAB & IINRG) (1), (ICAR-RCER & IINRG) (1), (ICAR-IIHR & IINRG) (1), KVK Khnti – (1), Agri-Business Incubation under Component-II of NAIF Scheme of ICAR- (1)
- 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), E-Office, Support for PFMS.

- 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 playing 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 part 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) facilitate 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,.) since beginning and Research Article/ Bulletins are available in PDF form for the internal users. Annual Reports/ Newsletters/Lac-Resins-Gums Statistics, Laksha' Dorothy Norris Lecture Series are also uploaded on ICAR-Krishi Portal.

Revenue generated was ₹20,089.00 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
- Sale and distribution of Institute publications

Journals & periodical received

- Foreign Periodicals (Gratis/exchange) -03
- Indian Periodicals (Gratis/exchange) -05

Library holdings (as on 31 December, 2021)

Documents	Additions	Total Holdings
Books	02	6986
Bound Journals	-	21634
Annual Report	68	3549
IS-Specification	-	184
Thesis	-	13

Estate Section

Functions of Estate Section

- Management of Security of institute premises
- Power & water supply to offices & residential quarters
- Civil & Electrical maintenance of office buildings & residential quarters
- Provide Assistance in engineering research work
- Planning & supervision of Infrastructure development work in the institute
- Maintenance of electrical Infrastructure i.e. maintenance of overhead electrical lines, Electrical Tubular poles, Transformer, operating panel. Feeder panels, Dg sets.
- Maintenance of water supply infrastructure i.e. water pumps, water pipe lines and civil infrastructure of office buildings and residential quarters.
- Management of General maintenance & upkeep of institute premises

Works (civil) taken up through CPWD during the year 2021

- Roof treatment of museum
- Roof treatment of Bungalow NO.1
- Renovation of LPD Division
- Renovation of Kishan Chhatravas
- Renovation of Type-III/17
- Renovation &roof treatment of Type-II/9,10
- Renovation of biotech lab

Ongoing works

- Renovation of transformer room
- Road carpeting of main campus

- Renovation &roof treatment of right side of library building
- Aluminum partition, false ceiling &flooring in PDU building

Works (civil) taken up departmentally during the year 2021

- Distempering, plastering, putty, PCC work, enamel painting, primer in Qr. Type II (34,35 &36)
- Distempering, Weather coating, enamel painting & primer in Qr. Type V /1& panel room,.
- PCC work of roof, plastering, distempering, primer of canteen building
- putty work, plastering, distempering, primer & enamel painting of doors & windows of corridors in PPD division
- putty, primer, distempering, fixing of floor tiles, enamel painting , plastering, PCC work , Brick work in instrument lab of PPD Division
- weather coat, putty, primer, replastering & enamel painting of doors & windows of type-II/11,12
- Weather coat, primer, PCC, plastering with punning of platform surrounding the trees near *palash* conference hall

Electrical work

- Maintenance of electrical installation of office buildings & residential quarters
- Maintenance of Genset & associated panels,
- Maintenance of street lights, solar lights & associated panels
- Electrical renovation of Qtr. Type-III (14-17) of PDU Campus by CPWD
- Electrical renovation of Pilot plant building. (Ongoing) by CPWD
- Electrical work of transformer room
- 7) Complete electrical surface wiring of instrument lab of PPD Division.(Departmentally)
- 8) On 30th July 21 one big trees fell on overhead lines between pole no. 3-9 After removal of tree branches the overhead lines restrained. Pole No.5&6 were inclined due to weight of tree branches. The poles were restrained and tied with aluminum wires to near tree for support and power supply to office building and residential quarters restored.
- 9) On 15th Sep 21 a big tree fell down on overhead electrical wires between pole no.42 to 51. After removal of tree branched overhead lines were restrained, insulator changed which were broken. Angle arm and clamp of pole No.56 was changed. The overhead lines restrained from pole No.52-56 and power supply restored

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

- Plumbing & water supply - 307
- Electrical work - 495
- Carpentry work - 301
- Welding work - 72
- Turner work& other related work - 295

Most of above works have been completed satisfactorily

Quality Evaluation Laboratory

During the period under report a total no. of 58 customer's letter (41 outside and 17 internal), 122 samples (42 outside and 80 internal), of lac, lac-based products and natural gums have been received from Govt. organization / Private Industries /various division of the institute and total 322 (61 outside and 261 internal), tests have been carried out and a sum of ₹39,294 only has been earned from external source. If the charges for the internal samples would have been charged, more revenue for ₹1,20,714 could be earned and total revenue for ₹1,60,008 would be generated towards testing charges. In addition to the above, two trainees have been imparted training on testing & analysis of Lac samples. Revenue earned from trainees ₹94,400.

Health Centre

The institute has a functional Health Centre in the campus under the Chairmanship of Dr. M.F Ansari (PS). Dr. Kailash Prasad and Dr. (Mrs). Reema K Khalkho 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 are being handled in the centre itself and complicated cases are referred to authorized CGHS hospital and pathology clinics in the city for expert diagnosis and treatment. In the year 2021, several more investigation centres and the hospitals were attached with the institute and the treatment are being provided as per the CGHS rates. 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. Total 1583 patients were registered and treated in the health centre and approx. 900 patients

extra were treated telephonically during corona peak period. Around 76 patients were monitored for blood sugar by test strips method in the centre itself as per the advice of AMAs and 51 number of patients were advised for medical rest and were issued medical fitness certificate. 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 medicines, *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 are also provided to trainees and laborers on humanitarian grounds, in case of emergency and casualty.

Institute Technology Management Unit (ITMU)

Er. SK Pandey, Sc. worked as I/c, Institute Technology Management Unit (ITMU) under NAIF scheme through which following work were done in 2021.

- Details of institute technology and commercialization regarding institute ranking compiled and sent to PME cell for sending this information to headquarter.
- Details of technologies developed during 2014-20 at ICAR-IINRG, Ranchi compiled and submitted to PME Cell for onward transmission to headquarter.
- Details of technologies generated by the institute during 2017-20 compiled and sent to PME Cell for sending the same to headquarter.
- Organized one Institute Technology Management Committee (ITMC) meeting, February 23, 2021.
- Examination filing of patent application (Application no. Temp/E1/9172/2019-KOL) on "Natural gum based nanocomposite hydrogel having antibacterial and wound healing effects and a method of preparation thereof" was filed through attorney M/s. Anjan Sen and Associates, Kolkata, March 17, 2021.
- Complete specification of patent application no. 202031019392 dated 07.05.2020 entitled "Natural resin based novel non-drying adhesive: preparation and application in insect trap" in the name of ICAR-Indian Institute of Natural Resins and Gums was filed through M/s Anjan Sens & Associate, Kolkata, May 06, 2021.
- Technologies generated and commercialized during last eight years since 2012 compiled and sent to PME Cell for inclusion in SFC document of the Institute.
- Information for technology transfer of lac based varnishes for wooden and bamboo items including lac based surface coating formulation for dye/ paints compiled and sent to Nodal officer, NAHEP-CAAST, Navsari Agricultural University, Gujarat.
- Patent application titled "One-step method for the synthesis of reduced graphene oxide using rosin" by CSIR (CSIO) with ICAR -IINRG processed for no objection.
- Examination filing on "Natural resin based novel non-drying adhesive: Preparation and application" (patent application No. 2020231019392) was processed through attorney M/s. Anjan Sen and Associate Kolkata.
- Patent on "Novel molecular method to differentiate infra-subspecific forms, *kusmi* and *rangeeni*, of Indian lac insect, *Kerria lacca* and other races and species of *Kerria*" (application No. 1333/ KOL/2013) was granted with patent No. 382699, November 25, 2021.

NAIF Scheme Component-II: Agri – Business Incubation at ICAR-IINRG, Ranchi

Er. SK Pandey, Sc. worked as PI, ABI project and following work was carried out by him in the year 2021:

- M/s Ohvem Sales Corporation (Neo organic), Raipur, Chattisgarh has been registered in January 2021 under category firm/company for Agribusiness Incubation on aleuritic acid, gummy mass and gasket shellac compound presently for one-year period in F.Y. 2020-21.
- NGO Janhit Sanskritic Kala Kendra, Palamu, Jharkhand has been registered in March 2021 under category NGO for Agri-business Incubation on lac cultivation on various hosts and small scale lac processing presently for one year period.
- Mr. Pankaj Kumar Verma has been registered as incubatee on June 11, 2021 under entrepreneur category for Agribusiness Incubation for on primary processing of lac (Small scale lac processing unit) presently for one year period.
- M/s Indolacca Shellac Industries Pvt. Ltd., W.B. recently established in 2018 has been renewed registration in June 2021 for 2nd year under

category firm/company for Agribusiness Incubation on aleuritic, bleached lac and isoamrettolide for presently one-year period in F.Y. 2020-21.

- M/s Indolacca shellac Pvt. Ltd., W. B. conducted trial for lac dye preparation in September 2021 utilizing the facility of ABI centre, ICAR-IINRG, Ranchi on rental lab payment basis and successfully produced good quality dye.
- Material for DARE/ICAR Annual Report 2021 – 22 compiled and sent to IP&TM Unit, ICAR, New Delhi.
- Progress of ABI Centre, ICAR – IINRG, Ranchi compiled and presented in Annual Review Workshop of ZTMC – Engg under NAIF Scheme of ICAR, October 08, 2021.
- Project profiles of lac dye (2 kg/day), bleached lac (50 kg/day) and aleuritic acid (25 kg/day) revised as per requirement and provided to M/s Indolacca Shellac Industries Pvt. Ltd. W.B.

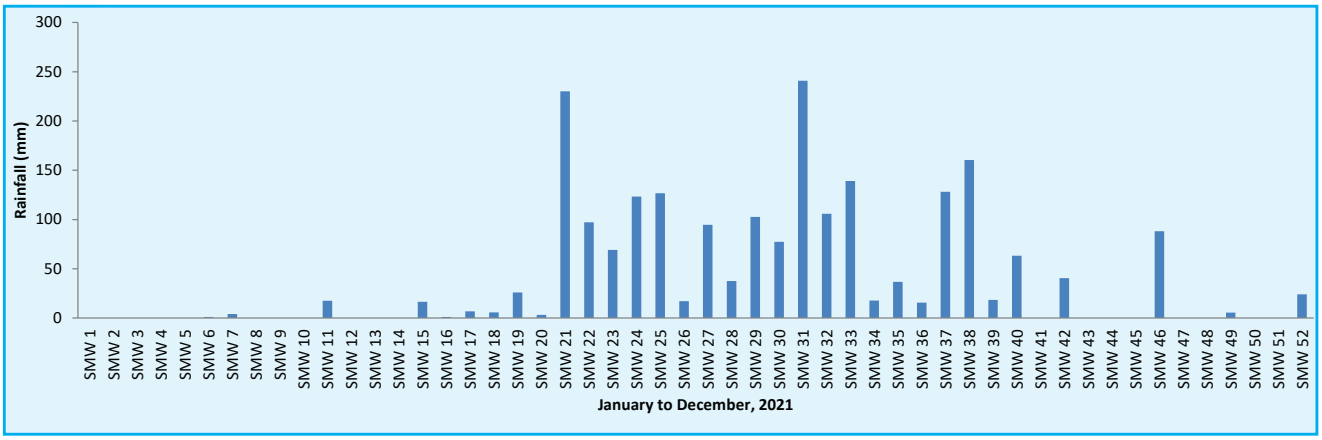
Agro-meteorology Unit

Agro-meteorology Unit of the Institute is situated at 230 23' N latitude, 850 23' E longitude at 650 m altitude. During the year 2021, 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 April and January with mean monthly temperature maximum at 34.9 ^{0}C and minimum at 7.59 ^{0}C, respectively. Maximum temperature for the year was recorded on 28th April (38.2 ^{0}C), while the minimum temperature was recorded on three days in the year, on 15th January and 20th, 21th December (3 ^{0}C). During September, relative humidity (RH) was the maximum at 8:30 hours (84.23%), with 80.3 per cent in the 14:30 hours, while the minimum RH was observed at 14:30 hours (66.67), with 69.77 per cent in the 8:30 hours in the month of October. Total annual rainfall was 2135 mm. It is pertinent to say that 31st July received maximum daily rainfall i.e. 190 mm. Maximum monthly rainfall was observed in July (563 mm), whereas lowest rainfall occurred in the month of January (0 mm) of the Calendar Year 2021.

Table: Mean monthly meteorological data recorded at the agro-meteorological unit of the institute during 2021

Month, 2021	Unit of Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Min 8:30 am	Max 2:00 pm	Max 8:30 am	Min 2:00 pm	
January	7.59	24.08	73.58	69	0.0
February	8.24	26.78	75.14	70.25	5.2
March	13.64	32.3	68.41	65.74	17.5
April	18.23	34.9	63.13	60.13	18.8
May	19.83	32.12	73.29	67.83	315.1
June	21.64	29.88	77.4	76.89	367.1
July	21.58	28.92	81.16	79.12	563.0
August	21.57	29.00	81.16	76.64	296.0
September	21.17	28.08	84.23	80.3	330.7
October	17.64	28.54	69.77	66.67	103.9
November	11.92	24.79	69.9	67.26	88.1
December	8.77	21.52	71.35	67.32	29.6
Total Annual Rainfall (mm)					**2135.0**



Weekly distribution of rainfall for the year, 2021

Krishi Vigyan Kendra (KVK), Khunti, ICAR-IINRG

Assessment, Diffusion and Adoption of Crop Production and NRGs Technologies

A. Trials conducted during the year 2021

1. Findings of OFTs conducted

(i) On farm testing 1 (OFT-1: Drought tolerant varieties of paddy)

Out of four improved varieties of paddy tested at farmers' field all tested varieties were significantly better than farmers' local varieties. Among improved varieties, Sahbhagi Dhan performed best with net return of ₹62460 per hectare with BC ratio of 1.9:1. However, Swarna Shreya is at par with Sahbhagi with BC ratio of 1.8:1 (Table 1). Hence Sahbhagi and Swarna Shreya may be recommended for cultivation in climatic situation of Khunti district.

Table 1: Performance of drought tolerant paddy varieties

Technology option	No of trials	No. of effec-tive tillers/ hill	No. of spikelet per panicle	100 grain wt.(g)	Disease/ insect pest incidence (%)	Yield (q/ha)	Cost of cultivation (₹/ha)	Gross return (₹// ha)	Net return (₹/ha)	BC ratio
Sahbhagi Dhan	3	15	157	2.56	5	47.97±0.4	33000	95460	62460	1.9:1
Swarn Shreya	3	10	152	2.43	4	46.9±0.7	33000	93331	60331	1.8:1
IR64 DRT 1	3	14	148	2.78	6	42.17±0.3	33000	83719	50719	1.5:1
MTU 7029	3	13	150	2.62	6	42.37±0.8	33000	84316	51316	1.6:1
Local	3	9	135	2.35	8	28.6±0.7	33000	56914	23914	0.7:1
CD at 5%						2.2				





Field view of OFT on drought tolerant varieties of paddy

(ii) On farm testing 2 (OFT-2. Integrated weed management in paddy)

Different weed management methods had a significant effect on yield and yield-attributing parameters (Table 2). Effective tillers/hill, number of spikelet per panicle, test weight (100 grain weight), grain yield (q/ha), straw yield (q/ha), cost of cultivation (₹/ha), gross return (₹/ha), net return (₹/ha) observed higher with the treatment Butachlor @1.0kg/ha (3-5 DAT), 2, 4 D @ 400g/ha (25-28 DAT) with BC ratio 1.8:1 followed by treatment hand weeding (20 DAT and 40 DAT) and Butachlor @ 1.5 kg/ha (3-5 DAT) with B: C ratio of 1.6:1 each.

Table 2: Yield components, grain and straw yields and economics of Sahbhagi Dhan variety of paddy in transplanted condition

Technology option	No. of trials	Yield component			WCE % at 90 DAS	Grain (q/ha)	Straw yield (q/ha)	Cost of cultivation (₹)	Gross return (₹/ha)	Net return	BC ratio
		No. of effective tillers/ hill	No. of spikelet per panicle	100 grain wt.							
Manual weeding sometimes (FP)	3	7.46	8.5	2.1	-	30.3	29.45	25000	58782	33782	1.4:1
Two Hand weeding (20 and 40 DAT)	3	14.25	11.2	2.3	88.2	42.3	52.42	32000	82062	50062	1.6:1
Butachlor @1.5 kg/ha (3-5 DAT)	3	11.55	9.4	2.2	64.3	37.5	42.43	28000	72750	44750	1.6:1
Butachlor @1.0kg/ha (3-5 DAT) *fband*2,4 D @400g/ha (25-28 DAT)	3	12.32	10.6	2.1	69.4	42.1	43.8	29200	81674	52474	1.8:1
CD (0.05)	-	2.36	2.6	0.62	-	3.5	2.9	523	3450	1665	



Training and demonstration of weed management of paddy in different areas

(iii) On farm testing 3 (OFT – 3: Pest management in paddy)

Out of four technologies tested to major pest in paddy, clipping of seedling at transplanting was cost effective technology to control major insect infestation in paddy with BC ratio 2.1:1. It can also be controlled by chemical treatment of Chlorantraniliprole 18.5% SC and Flubendiamide 39.35% M (Table 3).

Table 3: Pest Management in paddy and economics of Sahbhagi Dhan variety of paddy in transplanted condition

Technology option	Trials	Insect infestation (no. /m²)				Grain (q/ha)	Cost of cultiva-tion	Gross return (₹/ha)	Net return (₹/ha)	BC ratio
			Natural Enemy	Dead heart	White ear head					
FP (No use of pesticide)	3	Before	5.6	4.3	3.3	29.2	25000	56648	31648	1.3:1
		After	7.0	5.0	5.0					
TO-1: Cultural control (Clip the seedling))	3	Before	5.7	5.1	3.3	40.5	25000	78570	53570	2.1:1
		After	4.3	1.7	2.3					
TO-2: Behavioural (pheromone traps)	3	Before	5.2	5.3	3.3	37.4	25500	72556	47056	1.8:1
		After	5.7	5.7	4.3					
TO-3: Fame (Flubendiamide 480S , 39.35% w/w)	3	Before	5.3	4.9	3.7	42.6	30000	82644	52644	1.8:1
		After	1.3	1.3	1.3					
TO-4: Coragen (Chloran-traniliprole 18.5% SC)	3	Before	5.1	4.7	4.3	44.1	30000	85554	55554	1.9:1
		After	1.3	1.0	0.7					
CD (0.05)			0.92	1.22	0.67	1.7				





Training and demonstration of pest management of paddy

(iv) On farm testing 4 (OFT-4: Pest management in winter *kusmi* lac)

Out of two technologies tested to control pest in winter *kusmi* lac, yield loss due to lac insect predators/ parasitoids and deterioration of broodlac quality was major problem identified. Recent technology of pest management strategies was tested on *ber* trees of 10 farmers for winter *kusmi* lac. Broodlac dipping before inoculation followed by scientific method of lac cultivation gave highest broodlac output ratio of 9.6:1 (Table 4).

Table 4: Pest management in winter *kusmi* lac

Technology	Beneficiaries	Yield (kg/ha)	Gross (₹/ha)	Net (₹/ha)	Cost (₹/ha)	BC ratio
TO-1: Broodlac dipping with Fipronil @1.5 ml per lit of water for 10 to 15 minutes + Scientific practice	10	7113	3912150	3543400	368750	9.6:1
FP: No broodlac dipping + Farmers' practice	10	2750	1512500	346154	343750	1.0:1



Training and demonstration of pest Management and field visit in winter *kusmi* lac



Scientfic lac cultivation on *ber* and *semialata*

(v) On farm testing 5 (OFT-5: Improved varieties of ragi)

All the two improved varieties of ragi tested at farmer's field were significantly better than farmers' local (Table 5). Among improved varieties A 404 performed best with net return of ₹24820 per hectare with BC ratio of 1.5:1. However, VLS-76/79 performs average with net return of ₹20400 per hectare with BC ratio of 1.2:1. Hence A 404 may be recommended for cultivation in climatic situation of Khunti district.



Performance of ragi varieties at farmer's field

Table 5: Performance of improved varieties of ragi

Technology option	No. of trials	Yield component			Disease/ insect pest incidence (%)	Yield (q/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	BC ratio
		No. of effective tillers/hill	No. of spikelets per panicle	Test wt. (100 grain wt.)						
A 404	13	5.7	5	3.5	10	12.68	17000	42820	24820	1.5:1
VLS-76/79	13	4.4	4	3.1	13	11.07	17000	37400	20400	1.2:1
Local	13	3.2	3	2.8	17	6.94	13027	23448	10421	0.8:1
CD 5%						1.32				

(vi) On farm testing 6 (OFT-6: Mechanization of paddy threshing)

The average threshing efficiency by traditional (manual) method of paddy threshing, foot (pedal) operated paddy thresher and motor operated paddy thresher was found 98.81%, 98.26% and 97.79% respectively. Similarly, threshing capacity was found to be 103.45 kg/hr, 150.92 kg/hr and 227 kg/hr for the traditional method of paddy threshing, foot (pedal) operated and motor operated paddy thresher, respectively. The average threshing capacity was found to be maximum in the case with motor operated paddy thresher (Table 6).

Table 6: Mean value of parameters for different mode of paddy threshing

Performance parameters	No. of trials	Threshing efficiency (%)	Capacity, kg/h	Grain straw ratio	Time requirement (threshing paddy crop per hectare),days	Manpower requirement (threshing paddy crop per hectare)	Labour reduction (man - days)/ha	Cost reduction (₹ / ha or ₹ /Unit) @ ₹ 300/- day per man-power
FP: Traditional method of threshing	9	98.81	103.42	0.042	8.5	50	High man power re-quirement	Higher in cost
T1: Foot (Pedal) operated paddy thresher	9	98.26	150.92	0.042	5.5	32	6	5400
T2: Motor operated paddy thresher	9	97.79	227.00	0.042	3.0	19	11	9300

The cost of threshing per hectare was ₹5,700/ha by motor operated paddy thresher and for foot (pedal) operated paddy thresher ₹9,600/ha which is much less as compared by manual/ traditional method of paddy threshing Rs 15,000/ha, thus saving of about ₹9,300/ha and ₹5,400/ha by using motor-operated paddy thresher and foot (pedal) operated paddy thresher, respectively. Similarly considering the manpower requirement for per hectare crop were 50, 32 and 19 for the traditional method of paddy threshing, foot (pedal) operated paddy thresher and motor operated paddy thresher, respectively. Manpower requirement for per hectare crop was very high in manual/ traditional method of paddy threshing. By the use of mechanical threshing options per hectare, manpower reduction can reduce about 31 persons by using motor-operated paddy thresher and about 18 persons by foot (pedal) operated paddy thresher. The overall threshing capacity, minimum labour cost and minimum cost of operation were maximum in the case of threshing with motor operated paddy thresher.



Traditional (manual) method of paddy threshing



Foot (pedal) operated paddy thresher



Motor operated paddy thresher in operation

Findings of FLDs conducted during the year 2021

Reseults of the FLD findings are given in Table 7.

(i) Sahabhagi dhan was sown in 5 ha. land of 55 farmers' field. It gave more than 101 % better grain yield than farmers' local.

(ii) Pigeon pea variety IPA-203were sown in 10 ha. land involving 35 farmers. IPA-203 gave 43% higher yield than farmers' local.

(iii) Fifty kgs of *kusmi* broodlac was inoculated in 50 trees of 21 farmers and adopted scientific lac cultivation practices. Our technology had 92 % higher broodlac yield than farmers' practice.

(iv) Ragi variety-VLS-76/79 was shown in in 10 ha. Land of 54 farmers. VLS-76/79 had 59 % higher yield than local.

(v) Ground nut pea varieties Dharni was sown in 5 ha. land of 67 farmers. Dharni had 108 % higher yield than local

(vi) Horse gram was sown in 4.6 ha. Land of 61 farmers. itgave 44 % higher yield than local.

(vii) Pusa mustard 30 was sown in 2 ha. Land of 5 farmers. Pusa mustard 30 gave 50 % higher yield than local.

(viii) Chick pea variety GNG-1958was sown in 8 ha. Land of 65 farmers. GNG-1458 gave 30 % higher yield than local.

Table 7: Economic yield along with locations, area, beneficiaries etc

Crop	Locations	Name of the technology demonstrated	No. of Farmers	Area (ha)	Yield (q/ha)		% Increase
					Demo	Check	
Paddy (2021)	Ken Toil, Churgi, Diyankel, Manhatu	Sahbhagi	55	5	42.85	21.25	101.65
Pigeon pea (2020)	Silda, Kherkai, Kachchabari	IPA-203	35	10	20.35	14.22	43.11
Lac (2021)	Murhu, Raniya, Torpa, Arki	kusmi	21	0.32	34.89	18.22	91.51
Ragi (2021)	Sarna Toli, Badru Toli, Churgi	VLS-76/79	54	10	11.13	7.01	59
Groundnut (2021)	Ken Toil, Badrutoli	Dharni	67	5	10.61	5.1	108
Horse gram 2021	Ken Toli	Birsa Kulthi 1	61	4.6	5.2	3.6	44.4
Mustard (2020)	Ken Toli,	Pusa mustard 30	5	2	12.23	8.15	50.06
Chickpea (2020)	Sarna Toli, Badrutoli	GNG 1458	65	8	21.21	16.35	29.72

Table 8: Other extension activities

Nature of Extension Activity	No. of activities	Farmers		
		Male	Female	Total
Field Day	2	45	65	110
Kisan Mela	1	1060	490	1550
Kisan Ghosthi	4	245	190	435
Exhibition	1	210	130	340
Workshop	1	20	25	45
Lectures delivered as resource persons	20	550	990	1540
Agro-Advisory Services by DAMU	196	35000	14550	49550
Scientific visit to farmers field	12	25	28	53
Soil health Camp	1	30	75	110
Swachhta Hi Sewa	9	150	195	345
Total	**247**	**37335**	**16738**	**54078**

Table 9: Celebration of important days

Celebration of Important Days	No. of activities	Farmers		
		Male	Female	Total
International Women's Day (8th Mar.)	1	0	115	115
Parthenium Awareness Week (16th to 22nd Aug.)	1	20	50	70
Mahila Kisan Diwas (15th Oct.)	1	4	121	125
World Food Day (16th Oct.)	1	50	35	85
Vigilance Awareness Week (27th Oct. to 2nd Nov.)	1	8	1	9
National Unity Day (31st Oct.)	1	24	26	50
National Constitution Day (26th Nov.)	1	64	25	89
World Soil Day (5th Dec.)	1	5	70	75
Kisan Diwas (23rd Dec.)	1	48	45	93
Total	**9**	**223**	**488**	**711**

Assessment, Diffusion and Adoption of Crop Production and NRGs Technologies

Achievement

- Drought tolerant improved paddy varieties, Swarna Shreya performed best with net return of ₹68730 per hectare and BC ratio of 1.96:1. However, Sahbhagi was found at par with Swarna Shreya with BC ratio of 1.90:1.
- Two treatments, hand weeding (20 DAT and 40 DAT) followed by Butachlor @ 1.0 kg/ha (3-5 DAT), 2, 4 D @ 400 g/ha (25-28 DAT) gave higher grain yield with higher B: C ratio of 1:8 for integrated weed management in paddy.

- Clipping of seedling at transplanting was cost effective technology to control major insect infestation in paddy during pest management in paddy. It can also be controlled by chemical treatment of Fame (Flubendiamide 39.35% M) and Coragen (Chlorantraniliprole 18.5% SC).
- Broodlac dipping with Fipronil @1.5 ml per lit of water for 10 minutes + scientific practice of lac cultivation gave maximum broodlac yield as compared to farmers practices with BC ratio of 2.7:1.
- Motor operated paddy thresher was found suitable for paddy threshing with minimum time and manpower requirement to achieve higher threshing capacity if electricity availability is not a problem. However, foot (pedal) operated paddy thresher may be one of the alternate options for paddy threshing to achieve higher threshing capacity with reduced time.
- Recommended NPK + Lime @ 4q/ha + Sulphur @ 20 Kg/ha + Boron @ 1 Kg/ha gave maximum grain yield of 11.53 q/ha in station trial. The data shows that even with the application of line farmers can harvest optimum grain yield which was significantly higher that state average yield of 9.70 q/ha and at par to national average productivity of 11.34 q/ha.
- All together OFT conducted last year: Six FLDs conducted under KVK, Khunti programme.

DAPSP

Training of SC farmers and input distribution through different agencies in 2021

Skill development programme was organized in six aspirational districts of Jharkhand through different KVKs and NGOs. Altogether 1505 farmers were trained. Animal units like piglets, tool kit, sprayers, vermi-bed, sewing machine, power weeder, rotavator etc were distributed amongst 561 Schedule Caste beneficiaries as per training they received.

Out of 43.71 lakh allocated under general head, ₹33.04 was spent for skill development of scheduled caste beneficiaries. In capital head out of 41.06 lakh allocated under capital head ₹30.31 lakh was spent on distribution of different type of input as per the need of the beneficiaries.

Table 10: Training of SC farmers

KVKs/District (23)	Topic of training	Number of Beneficiaries
Jan 2021		
KVK Garhwa (3)	Pig rearing, Backyard poultry, Mushroom production	90
KVK Chatra (2)	Integrated Farming System	100
KVK Giridih (5)	Backward poultry production, Vegetable production, Goat rearing, Integrated Farming System, vermi-compost preparation	125
KVK Bokaro (1)	Stitching of SC women for entrepreneurship development	30
KVK Palamu (4)	Integrated Farming System Integrated Pest Management on vegetable and fruit crop, Preparation of Bio-pesticides and uses Hi density Orchard management	100
March 2021		
KVK Garwah	Stitching of SC women for entrepreneurship development	30
KVK Chatra	Stitching of SC women for entrepreneurship development	30
August 2021		
KVK Chatra (3)	Stitching of SC women for entrepreneurship development, Integrated Farming System IFS with Horticulture crop	125
KVK Garhwa (4)	Honey Bee, Pig Rearing, Poultry rearing, IFS with Cereal	120
KVK Palamu (6)	Integrated Farming System, INM and IPM, Veg INM andIPM on Horticultural crop, Horticulture based IFS, Preparation of Bio-pesticides, Major fruit cultivation	150

KVKs/District (23)	Topic of training	Number of Beneficiaries
KVK Giridih (3)	Integrated Farming System, INMand IPM, Vegetable crop, INM and IPM Horticulture crop	90
Mobile Agril. School and Services (NGO):(4)	Organic Farming, Integrated Farming System INM and IPM, Veg, INMandIPM, Hor.	100
Nov 2021		
KVK Chatra	Pig rearing	25
Dec 2021		
MASS, Ranchi (6)	Floriculture, Horticulture (fruit), Horticulture (Veg.), Pig rearing, Goat rearing, Poultry	150
KVK Garhwa (8)	Stitching of SC women for entrepreneurship development, Organic Farming, Mushroom cultivation, Maintenance and repair, Pig Farming Goat Farming, Poultry, Integrated Farming System	240
	Total	**1505**

संस्थान के राजभाषा प्रकोष्ठ की गतिविधियाँ

भारत सरकार के राजभाषा विभाग (गृह मंत्रालय) द्वारा तैयार किए गए वार्षिक कार्यक्रम एवं राजभाषा अधिनियम व नियमों के संबंध में भारतीय कृषि अनुसंधान परि÷ाद, 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 सहायक मुख्य तकनीकी अधिकारी (रा.भा.), तथा एक अंशकालीन टंकक कार्यरत हैं। संस्थान में राजभाषा संबंधी क्रिया–कलापों की समीक्षा के लिए संस्थान के निदेषक 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 (पी डी एफ रूप में), 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 हैंः

- 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, शब्दकोष 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 2021 में संस्थान राजभाषा कार्यान्वयन समिति की चार 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–16.01.2021

  (ख) दिनांक–15.06.2021

  (ग) दिनांक–03.08.2021

  (घ) दिनांक–25.10.2021

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 2021–22 के प्रस्ताव पर चर्चा।
- ❖ गृह पत्रिका लाक्षा–2021 का प्रकाशन हेतु प्रेषण।
- ❖ वर्ष 2021–22 के लिए नकद पुरस्कार योजना लागू करना एवं वर्ष 2020–21 के प्रतिभागियों के लिए पुरस्कार का निर्धारण।
- ❖ प्रशासनिक एवं स्वास्थ्य संबंधी विषय पर हिन्दी कार्यशाला/व्याख्यान का आयोजन।
- ❖ द्विभाशी मुहरों का निर्माण।
- ❖ द्विभाशी नामपट्ट की व्यवस्था।
- ❖ लाक्षा–2020 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 सभी आठ अनुभागों को सम्पूर्ण कार्य हिन्दी में करने हेतु विनिर्दिष्ट करना।

राजभाषा प्रकोष्ठ की उपलब्धियाँ–2021–22

- ❖ आउटसोर्सिंग द्वारा सम्पूर्ण वार्षिक रिपोर्ट का अनुवाद कराया गया।
- ❖ संस्थान की वार्षिक हिन्दी पत्रिका लाक्षा–2021 को प्रकाशन हेतु भेजा 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 समय से 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–2020 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

- ❖ एल टी सी नगदीकरण : समस्या एवं समाधान विषय पर दिनांक–16.02.2021 को, वर्तमान परिस्थितियों में राजभाषा कार्यान्वयन की दषा एवं दिशा विषय पर दिनांक–30.06.2021 को, हिन्दी दिवस समारोह का आयोजन दिनांक–30.09.2021 एवं कोरोना : वर्तमान परिदृष्य एवं टीकाकरण की आवष्यकता विषय पर हिन्दी कार्यशाला सह व्याख्यान का आयोजन किया गया।

हिन्दी दिवस समारोह–2021

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–01.09.2021 से 30.09.2021 तक हिन्दी चेतना मास मनाया गया। इसके अन्तर्गत दिनांक–30.09.2021 को अपराह्न 02.30 बजे हिन्दी दिवस समारोह का आयोजन किया गया।

हिन्दी दिवस समारोह के अवसर पर मुख्य अतिथि के रूप में उपस्थित डॉ कमल कुमार बोस, विभागाध्यक्ष, हिन्दी विभाग, संत जेवियर कॉलेज, राँची ने हिन्दी को श्रृंगार एवं अंगार तथा जमीन एवं जमीर की भाषा बताया। डॉ बोस ने कहा कि इस बात में हममें से किसी को कोई संदेह नहीं हो सकता कि हिन्दी ही वह भाषा है जो हमारे देश में सर्वाधिक लोगों द्वारा बोली, समझी एवं लिखी जाती है। उन्होंने कहा कि जब भी हम बात भाषा की करते हैं तो हमें यह जान लेना चाहिए कि भाषा अभिव्यक्ति को व्यक्त करने का सबसे महत्वपूर्ण साधन है। हिन्दी की बात करते समय उस हिन्दी तक सीमित होकर नहीं रह जाना चाहिए जिसको केवल कुछ लोग हीं प्रयोग करते हैं, बल्कि हिन्दी वह भाषा है

जिसको प्रायः हम सभी लोग प्रयोग करते रहते हैं। हिन्दी की प्रगति तभी संभव है जब हम अपने विचारों से हिन्दी को हीन भावना से देखना समाप्त करेंगे।

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 प्रकाषित होते रहते हैं। उन्होंने कहा कि हिन्दी को कृषि एवं किसानों से जुड़ाव के लिए एक महत्वपूर्ण भाषा का स्थान हांसिल है।

हिन्दी चेतना मास की अवधि में दिनांक– 02–03 सितम्बर 2021 को हिन्दी टिप्पण, प्रारूप लेखन, निबंध, अंताक्षरी, पर्याय एवं विपरीतार्थक शब्द प्रतियोगिताओं का आयोजन किया गया तथा विजयी प्रतिभागियों को पुरस्कृत किया गया। इसके साथ ही समारोह में लाक्षा–2020 में उत्कृष्ठ आलेख पर भी पुरस्कार प्रदान किया गया।

श्री बिनोद कुमार ने राजभाषा प्रतिवेदन प्रस्तुत किया एवं धन्यवाद ज्ञापन डॉ सौमेन घोशाल ने किया।

इस अवसर पर अन्य संस्थानों के अतिथियों के अतिरिक्त संस्थान के सभी अधिकारियों/कर्मचारियों ने भाग लिया।

Budget allocation and utilization during the financial year 2021-22

(Figures in lakh rupees)

Head of Expenditure	Other than NEH & TSP		NEH/SCSP		Total	Expenditure
	Approved RE	Expenditure	Approved RE	Expenditure	Approved RE	
IINRG			**SCSP**	**SCSP**		
Grant-in-aid Capital	71.81	71.80	41.06	41.05	112.87	112.86
Grant-in-aid-General	356.47	356.48	43.71	43.71	400.18	400.19
Grant-in-aid Salaries	1308.11	1308.11	0.00	0.00	1308.11	1308.11
Pension	371.27	371.27	0.00	0.00	371.27	371.27
Total	**2107.66**	**2107.66**	**84.77**	**84.76**	**2192.43**	**2192.43**
NWP ON H & PHP & VANR& G			**NEH**			
Grant-in-aid Capital	14.22	14.20	0.00	0.00	14.22	14.20
Grant-in-aid Salaries	0.00	0.00	0.00	0.00	0.00	0.00
Grant-in-aid-General	113.58	113.51	0.00	0.00	113.58	113.51
Total	**127.80**	**127.71**	**0.00**	**0.00**	**127.80**	**127.71**
NWP ON CLIGR			**NEH**			
Grant-in-aid Capital	21.33	21.33	0.00	0.00	21.33	21.33
Grant-in-aid Salaries	0.00	0.00	0.00	0.00	0.00	0.00
Grant-in-aid-General	113.58	113.58	13.11	13.11	126.69	126.69
Total	**134.91**	**134.91**	**13.11**	**13.11**	**148.02**	**148.02**
Table-III (REVENUE GENERATION TARGETS & ACHIEVEMENTS)						
Financial Year		Target for the financial year			Revenue Generated	
2021-22		17			34.93	

Personnel

Details of scientific, technical, administrative and supporting staff (including KVK) as on December 31, 2021

	Sanctioned strength	In position
Scientific		
R.M.P.	1	1
Principal Scientist	3	0
Sr.Scientist	8	4
Scientist	30	21
Total	42	26
Technical		
Category-I	43	24
Category-II	23	15
Category-III	6	0
Total	72	39
Administrative		
Sr.A.O.	1	0
F&AO	1	0
AAO	3	3
Private Secy.	1	1
Security Officer	1	1
J.A.O.	0	0
P.A.	3	0
Assistant	11	6
Sr.Clerk	5	1
Steno Gr.III	1	0
L.D.C.	6	0
Total	33	12
Skilled Support Staff		
S.S.S.	43	23

Cadre	Sanctioned post	In position
Scientific	42	26
Technical	72	39
Administrative	33	12
Supporting	43	23
Total Including R.M.P.	**190**	**100**

PERSONNEL	
Dr. K.K. Sharma	Director
QUALITY & PRODUCTIVITY IMPROVEMENT(QPI) DIVISION	
Dr. S. Ghosal, P.S. & I/c Head	Agronomy
Dr. N.K. Sinha, P.S.	Seed Technology
Dr. J. Ghosh, P.S.	Genetics & Plant Breeding
Dr. V.D. Lohot, Sr. Scientist	Plant Physiology
Dr. (Ms.) Thamilarasi K., Sr. Scientist	Agril.Biotechnology
Dr. Achintya Pramanik, Scientist	Agri. Entomology
Ms. Shruti Sinha, Scientist	Agri. Biotechnology
Mr. Rajgopal N.N., Scientist	Agri. Entomology
Mr. Sandeep Kumar, Scientist	Plant Biochemistry
Mr. S.K.Tripathi, STA	F/F Tech.group
Ms. Naaserah Zeesan, TA	F/F Tech.group
Mr. Vidyapati Vidyakar, TA	Lab.Tech.group
Mr. Harihar Singh, TA	F/F Tech.group
Mr. Anmol Dan Kindo, Technician	Lab.Tech.group
Mr. S.K. Yadav	Private Secretary

PRODUCTION & EXTENSION MANAGEMENT (PEM) DIVISION	
Dr. Nirmal Kumar, P.S. & Head	Agril.Extension
Dr. A. Mohanasundram, Scientist	Entomology
Dr. R.K. Yogi, Scientist	Agril.Economics
Dr. Rahul Bakade, Scientist	Plant Pathology
Mr. S.K. Srivastava, Scientist	L.M.W.E.
Mr. A.K. Rout, Scientist	Agri. Entomology
Ms. Chanu L.L., Scientist	Agroforestry
Mr. P.K. Parmaguru, Scientist	LWME
Mr. P. Patamajhi, ACTO	F/F Tech.group
Mr. S.B. Azad, TO	F/F Tech.group
Mr. Madan Mohan, TO	F/F Tech.group
Mr. Md. Tariq Zaman, TA	F/F Tech.group

APPLICATION & PRODUCT DEVELOPMENT (APD) DIVISION	
Dr. M.Z. Siddiqui, P.S.	Agri. Chem.
Dr. M.F. Ansari, P.S.	Agri. Chem.
Dr. S.K.S. Yadav, Scientist	Agri. Chem.
Dr. A.R. Chowdhury, Scientist	Agri. Chem.
Dr. N. Thombare, Scientist	Agri. Chem.
Mr. C.J. Mate, Scientist	Agri. Chem.
Mr. Md. Ali, Scientist	Agri. Chem.
Mr. Ajay Kumar, STA	Lab. Tech. group
Mr. R.K. Rai, STA	Lab. Tech. group
Mr. Binod Kumar, STA	Lab. Tech. group
Mr. Dewbrath Hari, TA	Lab. Tech. group
Mr. Haraprasad Naiya, TA	Lab. Tech. group
Mr. Lokesh Meena, Technician	Lab. Tech. group

MECHANIZATION & PROCESS ENGINEERING (MPE) DIVISION	
Dr. N. Prasad, P.S.	A.S.P.E.
Dr. S.C. Sharma, Sr. Scientist	F.M.P.E.
Mr. S.K. Pandey, Scientist	Mech. Engg.
Er. Ranjit Singh, Scientist	A.S.P.E.
Er. Priyanka Sakare	A.S.P.E.
Dr. Palmei G.	A.S.P.E.
Mr. Anup Kumar, STA	Lab. Tech. group
KRISHI VIGYAN KENDRA, KHUNTI, RANCHI	
Dr. J. Ghosh, P.S.	Gen.& Plant B. & I/c KVK
Ms. Laxmi Kumari	Assistant
Mr. Ranjan Choudhary	S.M.S.
Mr. Aashutosh Prabhat	Agromate Observer
PME CELL	
Dr. M.Z. Siddiqui	P.S. & I/c
Dr. V. D. Lohot	Sr. Sc. &I/c
Mr. Dipankar Ganguly, ACTO	Lab. Tech. group
Mr. Sunil Kumar, STO	Lab. Tech. group
ESTATE SECTION	
Mr. A.K. Yadav	Security Officer
Mr. Binay Kr., TO	W&Engg Group
Mr. R.K. Ravi, TO	W&Engg Group
Mr. K. Tirkey, TO	W&Engg Group
Mr. A.K. Sharma, Technical Assistant	W&Engg Group
Mr. Sukra Ekka, Sr. Technician	W&Engg Group
Ms. Laxmi Kumari	Assistant
LIBRARY	
Mr. Binod Kumar	STO
HEALTH CENTRE	
Dr. M.F. Ansari	P.S. & I/c
Dr. Reema Khalkho	PMO
Dr. Kailash Prasad	PMO
Mr. C.K. Singh, TO	Medical & Paramedical group
QUALITY EVALUATION LAB.	
Dr. M.F. Ansari	P.S. & I/c
Mr. B.K.Singh, STA	Lab. Tech. group
INSTITUTE RESEARCH FARM	
Dr. Rahul Bakade	Scientist & I/c
Mr. Satish Kumar, TO	F/F Tech.group
Mr. Akash Sinha, T.A.	F/F Tech.group
Mr. Jhirga Oraon, Sr. Technician	W&Engg Group
AUDIT & ACCOUNTS SECTION	
Mr. Kameshwar Oraon	Assistant
Mr. Arjun Gope	Assistant
ADMIN. I SECTION	
Mr. Mahesh Kumar Khubdikar	Sr. Admin. Officer
Mr. S.C.Lal	AAO
Mr. K.M. Kumar	Assistant
Mr. Bandhu Mahto	U.D.C
ADMIN.II SECTION	
Mr. Raghunath Mahto	AAO
Mr. R.K. Toppo	Assistant
Mr. K.P. Kashi	Assistant
ADMIN.III SECTION	
Mr. Abhishek Kumar	Assistant
RAJBHASHA PRAKOSTH	
Mr. Binod Kumar	STO & I/c
DIRECTOR OFFICE	
Mr. Hari Vilas	PA to Director

VEHICLE POOL	
Mr. Arvind Kumar, TO	W.&Engg. group
Mr. Mandeshwar Singh, TO	W.&Engg. group
Mr. R.K.Yadav, TO	W.&Engg. group
Mr. Bandi Lakra, Sr. Technician	W.&Engg. group

JOINING
Mr. Sandeep Kumar has joined to the post of Scientist (Plant Biochemistry) on 13.01.2021
Dr. Kale Shakharam Jagan has joined to the post of Scientist (ASPE) on 01.11.2021
PROMOTION
Mr. Ajay Kumar, STA promoted to the post of TO on 5.6.2021
Mr. Anup Kumar, STA promoted to the post of TO on 6.6.2021
Mr. Birendra Kumar Singh, STA promoted to the post of TO on 5.6.2021
Mr. Binod Kumar, STA promoted to the post of TO on 4.6.2021
Mr. Raj Kumar Rai, STA promoted to the post of TO on 4.6.2021
Mr. Madan Mohan, STA promoted to the post of TO on 4.6.2021
Mr. Sanjay Kr. Tripathi, STA promoted to the post of TO on 5.6.2021
Mr. Arjun Sharma, STA promoted to the post of TO on 29.6.2021
Mr. R.K.Ravi, STA promoted to the post of TO on 29.6.2021
Mr. H.L. Bhakta, TO promoted to the post of STO on 01.01.2021
Mr. Anil Kr Sharma, Sr.Technician promoted to the post of Technical Assistant on 30.12.2020
Mr. Bandi Lakra, Sr.Technician promoted to the post of Technical Assistant on 23.06.2020
Mr. Jhirga Oraon, Sr.Technician promoted to the post of Technical Assistant on 23.06.2020
Mr. Arun Kr. Tripathi, Assistant promoted to the post of Asstt. Admin. Officer on 06.09.2021
CLEARANCE OF PROBATION PERIOD & CONFIRMATION
Mr. Akash Sinha, Technical Assistant on 31.08.2020
Ms. Naaserah Zisan, Technical Assistnt on 01.09.2020
Mr. Chunmun Sinha, Technical Assistnt on 13.09.2020
Mr. Md. Tariq Zaman, Technical Assistnt on 31.10.2020
Mr. Devbrat Hari, Technical Assistant on 12.11.2020
Mr. Vidyapati Vidyakar, Technical Assistant on 04.12.2020
Mr. Harihar Singh, Technical Assistant on 07.12.2020
Mr. Hara Prasad Naiya, Technical Assistant on 12.12.2020
Mr. Mousam Kr. Ram, Technical Assistant on 15.01.2021
Mr. Lokesh Meena, Technician on 09.01.2021
Mr. Anmol Dan Kindo, Technician on 15.01.2021
TRANSFER
Dr. A. Mohana Sundram, Scientist releived from ICAR-IINRG, Ranchi on 04.04.2021 to Join at ICAR-NRCB,Tirchi, Tamilmadu.
Er. Ranjeet Singh, Scientist releived from ICAR-IINRG, Ranchi on 05.05.2021 to Join at ICAR-IARI, Barhi, Hazaribagh.
Mr. Hari Vilas, P.A. releived from ICAR-IINRG, Ranchi on 01.10.2021 to Join at ICAR-NBPGR, Lucknow.
Dr. Palmei Gaibimei, Scientist releived from ICAR-IINRG, Ranchi on 08.10.2021 to Join at ICAR-IARI,R.C., Aasam.
Ms. L.C. Lalgentombi, Scientist releived from ICAR-IINRG, Ranchi on 16.10.2021 to Join at ICAR-NEH,RC, Imphal, Manipur.
Mr. Mahesh B. Khubdikar, S.A.O. releived from ICAR-IINRG, Ranchi on 30.10.2021 to Join at ICAR-CIFT, Kochi.
RETIREMENT
Mr. S.K. Mukherjee, Ex-STA on 31.01.2021
Mr. Suresh Pandit, Ex-SSS on 31.01.2021
Mr. H.L. Bhakta, Ex-STO on 28.02.2021
Mr. Rama Kant Singh, Ex-T.A. on 28.02.2021
Mr. S.C. Lal, Ex-Asstt. Administrative Officer on 31.03.2021
Ms. Janki Devi, Ex-SSS on 31.03.2021
Mr. Gopal Mahto, Ex-SSS on 30.04.2021
Mr. Mahavir Mahto, Ex-Sr.Technician on 31.05.2021
Dr. M.Z. Siddiqui, Ex-P.S. on 30.06.2021
Mr. A.K. Sinha, Ex-CTO on 31.07.2021
Mr. P.V.D. Tirkey, Ex-STA on 31.07.2021
Mr. Chaitu Kachhap, Ex-SSS on 31.08.2021
Mr. Raj Kumar Rai, Ex-TO on 30.09.2021
Mr. Arjun Sharma, Ex-TO on 30.11.2021

DEATH
Late Jataru Mahto, Ex-S.S.S. on 12.04.2021
Late Biraj Mahto, Ex-SSS on 12.11.2021

Appendix

Annexure 1: Farmers training programme on "Scientific Lac Cultivation, Processing and Utilization"

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of partici-pants
March	1	Forest department, Tundi, Dhanbad, Jharkhand	Jharkhand	01.03.21-.5.03.21	10	-	10
	2	ATMA, Khunti, Jharkhand Note- 13911 – one trainee absent w.e.f. 10.03.2021. Certificate not prepared.	Jharkhand	08.03.21-12.03.21	18	-	18
	3	Forest department, Dumka, Jharkhand	Jharkhand	22.03.21-26.03.21	11	01	12
		Private	Nepal	22.03.21-26.03.21	01	-	01
July	4	JLG Ltd., Purulia, West Bengal	West Bengal	26.07.21-30.07.21	24	-	24
August	5	Forest Department, Giridih and Garhwa	Jharkhand	24.08.21-28.08.21	21	01	22
September	6	JLG Ltd., Purulia, West Bengal	West Bengal	31.08.21-04.09.21	26	-	26
	7	JHASCOLAMPF, Ranchi	Jharkhand	06.09.21-10.09.21	31	-	31
	8	JHASCOLAMPF, Ranchi	Jharkhand	14.09.21-18.09.21	30	-	30
	9	JSPLS-JOHAR, Jharkhand	Jharkhand	21.09.21-25.09.21	16	12	28
October	10	JHASCOLAMPF, Ranchi	Jharkhand	27.09.21-01.10.21	23	-	23
		JHASCOLAMPF, Ranchi	Jharkhand	27.09.21-01.10.21	01	-	01
	11	JSPLS-JOHAR, Jharkhand	Jharkhand	04.10.21-08.10.21	10	18	28
	12	JHASCOLAMPF, Ranchi	Jharkhand	18.10.21-22.10.21	31	-	31
	13	JHASCOLAMPF, Ranchi	Jharkhand	26.10.21-30.10.21	19	-	19
November	14	JHASCOLAMPF, Ranchi	Jharkhand	08.11.21-12.11.21	20	-	20
December	15	JHASCOLAMPF, Ranchi	Jharkhand	06.12.21-10.12.21	38	07	45
		Private, Ramgarh	Jharkhand	06.12.21-10.12.21	01	-	01
	16	JHASCOLAMPF, Ranchi	Jharkhand	13.12.21-17.12.21	36	08	44
				Total	**367**	**47**	**414**

Annexure 2: Educational programme on "Rural Agricultural Work Experience (RAWE)" (one month)

Month	Course No.	Sponsoring Organization	State	Period	M	F	No. of partici-pants
March	1	"Natural Resin and Gum based Agro-Industrial Attachment Training for Rural Agricultural Work Experience (RAWE)" for B.Sc. (Ag.) students of Birsa Agricultural University	Jharkhand	01.02.2021 to 02.03.2021	04	18	22
				Total	**04**	**18**	**22**

Annexure 3: Educational programme on "On-Line Industrial Training on Natural Resins and Gums" (10/15 days)

Course No.	Sponsoring Organization	State	Period	M	F	No. of partici-pants
1	Quantum University, Dehradun, Uttrakhand	Uttarakhand	17.06.21 - 26.06.21	06	10	16
2	Banaras Hindu University Varanasi, Uttar Pradesh	Uttar Pradesh	27.12.21 - 05.01.22	18	19	37
				06	**10**	**53**

Annexure 4: On-farm training programme on lac cultivation

Camp No.	District, State	Nominating Agency	Venue (Village, Block)	Date	M	F	No. of Partici-pants	Expert
1	Dhanbad, Jharkhand	Forest department, Tundi, Dhanbad	Forest Range Office, Tundi, Dhanbad	24.03.21	40	27	67	Sh. AK Sinha
2	Gumla, Jharkhand	Forest department, Palkot, Gumla	Forest Range Office, Palkot, Gumla	25.03.21	92	35	127	Sh. AK Sinha & Sh. M. Mohan
3	Gumla, Jharkhand	Forest department, Raidih, Gumla	Forest Range Office, Raidih, Gumla	26.03.21	54	06	60	Sh. AK Sinha & Sh. M. Mohan
4	Giridih, Jharkhand	Forest department, Giridih	Forest Range Office, Bengabad, Giridih	12.08.21	28	-	28	Sh. SB Azad & Sh. M. Mohan
5	Garhwa, Jharkhand	Forest department, Garhwa	Forest Range Office, Ranka, Garhwa	23.08.21	41	15	56	Sh. SB Azad & Sh. M. Mohan
6	Dumka, Jharkhand	Forest department, Dumka	Training Hall, Dumka	01.10.21	10	60	70	Sh. P. Patmajhi
7	Dumka, Jharkhand	Forest department, Dumka	Madhuvan, Mashalia, Dumka	02.10.21	15	40	55	Sh. P. Patmajhi
8	Garhwa, Jharkhand	Forest department, Garhwa	Forest department Training Hall, Garhwa (South)	15.11.21	25	20	45	Sh. P. Patmajhi
9	Dhanbad, Jharkhand	Forest department, Tundi	High Tech Nursery site, Tundi, Dhanbad	15.12.21	30	19	49	Sh. P. Patmajhi
10	Mayurbhanj, Odisha	K.C.Pur, Lac Industrial Co-opretive Society Ltd.	Chirupada, Thakurmunda, Mayurbhanj	21.12.21	70	80	150	Sh. P. Patmajhi
11	Balasore, Odisha	ITDA, Nilgiri	Ashoknala, Nilgiri	22.12.21	44	03	47	Sh. P. Patmajhi
				Total	**449**	**305**	**754**	

Annexure 5: On-farm Motivational/ Supplementary Training Programme on Lac Cultivation

Camp No.	District, State	Nominating Agency	Venue (Village, Block)	Date	M	F	No. of Partici-pants	Expert
1	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	GEL Church Parisar, Koinara, Rania, Khunti	18.01.21	29	21	50	Sh. AK Sinha

Camp No.	District, State	Nominating Agency	Venue (Village, Block)	Date	M	F	No. of Partici-pants	Expert
2	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	GEL Church Parisar, Koinara, Rania, Khunti	19.01.21	29	21	50	Sh. P. Patmajhi
3	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	Training Hall, ATMA, Khunti	22.01.21	42	11	53	Sh. AK Sinha
4	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	Training Hall, ATMA, Khunti	23.01.21	68	02	70	Sh. P. Patmajhi
5	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	Gram Sabha, Chabutra, Arki, Khunti	27.01.21	10	41	51	Sh. AK Sinha
6	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	Training Hall, ATMA, Khunti	28.01.21	72	03	75	Sh. P. Patmajhi
7	Khunti, Jharkhand	ATMA, Khunti cum Director, DAO	Gram Sabha, Chabutra, Arki, Khunti	29.01.21	48	18	66	Sh. AK Sinha
8	Hazaribag, Jharkhand	Forest department, Hazaribagh	Lac Processing Hall, Morangi, Daru forest Range, Hazaribagh (East)	19.02.21	29	31	60	Sh. AK Sinha & Sh. M. Mohan
9	Chatra, Jharkhand	Forest department, Chatra	Gram Panchayat Bhawan, Kataiya & Lac Processing Unit, Kataiya, Chatra	20.02.21	95	32	127	Sh. AK Sinha & Sh. M. Mohan
10	Ranchi, Jharkhand	JASCOLAMPF, Ranchi	RKM School, Banta, Silli	15.07.21	32	8	40	Sh. AK Sinha
11	Hazaribag, Jharkhand	JASCOLAMPF, Ranchi	Govt. Primary School, Churchu, Hazaribag	20.07.21	44	6	50	Sh. AK Sinha
12	Khunti, Jharkhand	JASCOLAMPF, Ranchi	Van Dhan Vikash Kendra, Siladon	04.08.21	08	20	28	Sh. SB Azad & Sh. M. Mohan
13	Gumla, Jharkhand	JASCOLAMPF, Ranchi	CFC, Kamdara, Gumla	06.08.21	05	45	50	Sh. P. Patmajhi
14	Khunti, Jharkhand	JASCOLAMPF, Ranchi	Leads Resource Centre, Murhu	11.08.21	20	45	65	Sh. P. Patmajhi
15	Simdega, Jharkhand	JASCOLAMPF, Ranchi	Biru LAMPS Hall, Simdega	12.08.21	31	25	56	Sh. P. Patmajhi
16	Ranchi, Jharkhand	JASCOLAMPF, Ranchi	Ladnaperi Lamps, Namkum	21.08.21	18	10	28	Sh. SB Azad & Sh. M. Mohan
17	Ranchi, Jharkhand	JASCOLAMPF, Ranchi	Angan Bari Kendra, Jonha, Angara	01.09.21	26	-	26	Sh. P. Patmajhi
18	Khunti, Jharkhand	JASCOLAMPF, Ranchi	Training Hall, Ulihatu, Arki	07.09.21	20	50	70	Sh. SB Azad
19	W.Sing-hbhum, Jharkhand	JASCOLAMPF, Ranchi	Panchyat Bhwan, Jhinkpani	08.09.21	20	55	75	Sh. P. Patmajhi
20	Ranchi, Jharkhand	MSME-SFURTI	Karambu Middle School, Bundu	10.12.21	55	50	105	Sh. P. Patmajhi
				Total	**701**	**494**	**1195**	

Annexure 6: On-campus one-day Orientation Programme on Lac Cultivation

Camp No.	District, State	Nominating Agency	Date	M	F	No. of Participants
1	Ranchi, Jharkhand	BAU, Kanke, Ranchi	11.01.21	03	01	04
2	Khunti, Jharkhand	WOTOR, Murhu, Khunti	20.01.21	50	25	75
3	Chatra, Jharkhand	KVK, Chatra	26.02.21	38	-	38
4	Khunti, Jharkhand	D.A.O. Khunti	12.03.21	38	24	62
5	Ranchi, Jharkhand	Forester Training School, Mahilong, Ranchi	16.03.21	51	05	56
6	Bhagalpur, Bihar	KVK, Sabour, Bhagalpur	16.03.21	33	07	40
7	Palamu, Jharkhand	KVK, Chiyanki, Palamu	27.03.21	17	15	32
8	Jhalda, Purulia, W. Bengal	Progressive farmers	30.07.21	25	-	25
9	Khunti, Jharkhand	WOTOR, Khunti	22.09.21	25	20	45
10	Balasore, Odisha	ITDA, Balasore, Odisha	26.10.21	05	02	07
11	Gumla, Jharkhand	KVK, Bishunpur	29.11.21	30	-	30
12	Ranchi, Jharkhand	R. K. Mission University	07.12.21	21	09	30
13	Ranchi, Jharkhand	Sai University, Ranchi	24.12.21	45	36	81
			Total	**381**	**144**	**525**

Annexure 7: Lac Based Product Demonstration Training

Sl.No.	Name & Address	Sponsoring Agency	Duration	Subject
1	Dr. Rajesh Shukla, S/o Late Shri Tameshwar Shukla from M/s Ohvem Sales, Raipur (Chhattisgarh) 9479101996, (O) 0771-40063004, e-mail-neoorganics10@gmail.com	M/s Ohvem Sales, Raipur (Chhattisgarh)	15.03.2021 to 25.03.2021	Aleuritic Acid Gasket Shellac Compound Gummy Mass
2	Mohammad Sahanawaj Hossain, Son of Md. Imtiaj Hossain from M/s Indolacca Shellac Industries Pvt. Ltd., Paschim Bardhaman (West Bengal), Mob.- 9176561782, e-mail- info@indolacca.com	M/s Indolacca Shellac Industries Pvt. Ltd., Paschim Bardhaman (West Bengal)	15.03.2021 to 16.03.2021	Lac Wood Shine Lac Based Non Sprit Wood Varnish Lac Glaze
3	Mrs. Basumati Behera, Doughter of Shri Niranjan Behera from M/s Maa Mangla Lacquer Ornament Unit, Kochila Khunta, Mayurbhanj (Odisha), Mob.-7008454728, e-mail-skbehera410@gmail.com	M/s Maa Mangla Lacquer Ornament Unit, Kochila Khunta, Mayurbhanj (Odisha)	22.03.2021 to 26.03.2021	1. Nail Polish
07 Lac based product demonstration training organised for three persons in three batches.				

Annexure 8: Participation in Exhibition/KisanMela

Sl.	Name of the programme with venue	Duration	Male	Female	Total	Participated by
1	Eastern Zone Regional Agriculture Fair and Agrotech-2021, BAU, Kanke, Ranchi	05.03.2021 to 07.03.2021	700	600	1300	P.Patmajhi, Sh. Ashutosh Prabhat
		Total	**700**	**600**	**1300**	

Annexure 9: Schedule Caste Sub-Plan (SC-SP)

Camp No.	Venue (Village& block)	District, State	Date	No. of Partici-pants	Remarks
1	KVK, Garhwa	Garhwa, Jharkhand	16.03.21	225	Distribution of 50 Sprayer, 75 farm tool kit and 100 vermi bed among selected Schedule Cast members under DAPSC Sub Plan.
2	KVK, Chatra	Chatra, Jharkhand	16.03.21	25	Distribution of 25 Sewing Machine among selected Schedule Cast members under DAPSC Sub Plan.
3	KVK , Bengabad, Giridih	Giridih, Jharkhand	18.03.21	175	Distribution of 25 Sprayer, 50 farm tool kit and 100 vermi bed among selected Schedule Cast members under DAPSC Sub Plan.
4	KVK, Garhwa	Garhwa, Jharkhand	30.03.21	50	Honey bee box set with colony has been sent to KVK, Garhwa for distribution among selected and trained Schedule Cast members under DAPSC Sub Plan.
5	KVK, Chiyanki, Palamu	Palamu, Jharkhand	22.10.21	07	Live stock (05 pig Unit) and power weeder (02 nos.) distributed among 07 selected Schedule Cast members under Schedule Cast Sub Plan
6	KVK, Garhwa	Garhwa, Jharkhand	23.10.21	27	Live stock (21 pig Unit); Power weeder (04 nos.) and Rotavator (02 nos.) distributed among 27 selected Schedule Cast members under Schedule Cast Sub Plan
			Total	**509**	

Annexure 10: Awareness cum Village Survey Programme for Impact Assessment of the Stakeholders under Capacity Building Programme

Camp No.	Village (block)	District, State	Date	Beneficia-ries	Non-benefi-ciaries	Village Mukhiya	Total
1	Bandua, Namkum	Ranchi, Jharkhand	16.03.21	02	01	01	04
2	Dudardag, Namkum	Ranchi, Jharkhand	16.03.21	04	02	01	07
3	Ulatu, Namkum	Ranchi, Jharkhand	16.03.21	01	01	01	03
4	Lali, Namkum	Ranchi, Jharkhand	16.03.21	01	01	01	03
5	Humta, Bundu	Ranchi, Jharkhand	17.03.21	01	01	01	03
6	Ghagrabera, Bundu	Ranchi, Jharkhand	17.03.21	02	01	01	04
7	Besradih, Bundu	Ranchi, Jharkhand	17.03.21	02	01	01	04
8	Husirhatu, Bundu	Ranchi, Jharkhand	17.03.21	06	01	01	08
9	Salaiya, Rajdhanwar	Giridih, Jharkhand	19.03.21	01	01	01	03
10	Karapahri, Sariya	Giridih, Jharkhand	19.03.21	02	-	01	03
11	Singdih, Sariya	Giridih, Jharkhand	19.03.21	02	-	-	02
12	Golhaiya, Jamua	Giridih, Jharkhand	19.03.21	02	-	01	03
13	Tekratoli- Gosaintoli, Nagri	Ranchi, Jharkhand	20.03.21	01	-	01	02
14	Kurgi, Itki	Ranchi, Jharkhand	20.03.21	01	-	01	02
15	Hulsu Barkatoli, Lapung	Ranchi, Jharkhand	20.03.21	01	-	01	02
16	Pokta, Lapung	Ranchi, Jharkhand	20.03.21	-	-	01	01
17	Batubasnadih, Tamad	Ranchi, Jharkhand	23.03.21	01	-	01	02

Camp No.	Village (block)	District, State	Date	Beneficia-ries	Non-benefi-ciaries	Village Mukhiya	Total
18	Gango, Tamad	Ranchi, Jharkhand	23.03.21	01	-	01	02
19	Jintu, Sonahatu	Ranchi, Jharkhand	23.03.21	01	01	01	03
20	Halmad Barwatoli, Silli	Ranchi, Jharkhand	24.03.21	02	01	01	04
21	Badalu, Rahe	Ranchi, Jharkhand	24.03.21	02	01	01	04
22	Raidaga,, Chanho	Ranchi, Jharkhand	25.03.21	01	-	01	02
23	Soparan- Newartoli, Chanho	Ranchi, Jharkhand	25.03.21	01	-	01	02
24	Lahna, Ratu	Ranchi, Jharkhand	27.03.21	01	-	01	02
25	Borya, Kanke	Ranchi, Jharkhand	27.03.21	01	-	-	01
26	Barwe, Ormanjhi	Ranchi, Jharkhand	27.03.21	01	-	01	02
27	Nagratoli, Ranchi	Ranchi, Jharkhand	31.03.21	01	-	-	01
28	Barakawali, Khijri, Namkum	Ranchi, Jharkhand	31.03.21	01	-	01	02
			Total	**43**	**13**	**25**	**81**

Annexure 11: Lac Crop Surveillance Conducted

Camp No.	Village (block)	District –State	Date	Crop	Observation
1	Kataiya Forest area	Chatra, Jharkhand	20.02.21	*Rangeeni* crop on *Butea monosperma*	*Rangeeni* lac (*baisakhi* crop) inoculated on palas is good in condition. Heavy settlement on unpruned tree. Stage- male emergence.
2	Lotehatu, Bundu	Ranchi, Jharkhand	17.03.21	*Kusmi* crop on *Schleichera oleosa* & *Ziziphus mauritiana*	*Kusmi* lac inoculated on *kusum* & *ber*. Development good and male emergence complete.
3	Bada Baru, Khunti	Khunti, Jharkhand	12.08.21	Kusmi crop on Schleichera oleosa	Settlement of Kusmi lac on beris in good condition.
4	Bundu, Sonahatu & Silli of Ranchi and Jhalda in W. Bengal	R.C.Lac Growers and Processors, Ranchi	12.10.21	*Rangeeni* crop on *Butea monosperma*	Rangeeni lac (katki crop) was in good condition

Annexure 12: *Kisan Gosthi*/Workshop/Educational Programme on Lac Cultivation

Camp No.	District –State	Nominating Agency	Venue (Village, Block)	Dated	No. of Partici-pants	Name of programme
1	Ranchi, Jharkhand	IINRG, Ranchi	Football Ground, ICAR-IINRG, Namkum, Ranchi	11.02.21	1200	Kisan Mela-cum-Agricultural Technology Exhibition-2021
2	Ranchi, Jharkhand	IINRG, Ranchi	Football Ground, ICAR-IINRG, Namkum, Ranchi	12.02.21	850	Kisan Mela-cum-Agricultural Technology Exhibition-2021
3	Jaipur, Rajsthan	IINRG, Ranchi	Lakh Chudi Vypar Mandal, Jaipur	25.07.21	25	Common Interest Group Meeting (CIG)
4	Bhilwada & Ajmer, Rajsthan	IINRG, Ranchi	RITCO Gum Industry, Bhilwada & Ajmer	27.07.21	18	Focused Group Discussion (FGD)
				Total	**2093**	

Annexure 13: One to One Programme (OTOP)

Sl.No.	Detail	No. of beneficiaries
1	An ICT enabled One to One Programme (OTOP), Market Oriented Technical Advisory Services (MOTAS), diagnostic crop monitoring and benefited 76 stakeholders from different states of India also *Laksha* Updates initiatives boosted the linkages with stakeholders	76
	Total	**76**