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Recent Technologies in Production of Natural Resins and Gums: An Overview

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Since inception, ICAR-IINRG is dedicated to produce lac as well as other resins and gum production technologies for the benefit of farmers. Lac cultivation is an age old practice in this country. Traditional ways of lac cultivation is not profitable. As a result, area under lac cultivation has shrinked considerably in comparison to 1940s. In the mean time, several challenges have emerged both for production and utilization in Natural Resins and Gums sector. The Institute, from time to time has catered suitable, farmer friendly technologies to check further shrink in area in the sector. Different factors of production have been analyzed and recommendation has been offered for its suitable outlay. Considerable increase in profitability has taken place due to adoption of these technologies. Following *are few technologies, which may be adopted for increasing total productivity of the land.*

A. Lac Production Technologies:

1. Name of Technology: Exploration of a bushy lac host, *F. semialata*

Problem statement: All the promising lac hosts present were big trees which take 10-15 years to come before attaining inoculable stage. It was thought that lac cultivation could be easier and even integrated to general agriculture if some quick growing bushy host would be available. Bushy host *Flemingia macrophylla* was not performing well. Therefore, search was made intensive for a quick growing bushy lac host.

Description of technology: Ten germlines of *Flemingia spp.* procured from ICRISAT, Hyderabad were tested for their comparative performances of growth and lac yield potential during 1995-96 and 1996-97. These germlines were ICPW 192 (*F. bracteata*), ICPW 193 (*F. macrophylla*), ICPW 194 (*F. macrophylla*), ICPW 196 (*F. macrophylla*), ICPW 198 (*F. macrophylla*), ICPW 200 (*F. paniculata*), ICPW 201 (*F. semialata*), ICPW 202 (*F. stricta*), ICPW 203 (*F. strobilifera*) and ICPW 204 (*F. strobilifera*). Maximum biomass was produced by ICPW 192 (2.83 kg/plant) and minimum was produced by ICPW 193 (0.83kg/plant). F. *semialata* which emerged to be outstanding in lac production subsequently, produced only 1.17 kg biomass/ plant. Sticklac production per plant was 134 g for *semialata* while the range of value for the same was 0.85 to 49 g/plant for other germlines. Subsequently, large scale agronomic trial was done and ultimately handed over to the Institute for transfer of technology.

Applicability/ situations: All throughout the lac growing states. It has registered its presence in 10 state in India i.e. Arunachal Pradesh, Assam, Andhra Pradesh, U.P., Chhattisgarh, Karnataka, Gujarat, Jharkhand, W. Bengal and M.P.

Economics/ Cost involved: Total income in normal cultivation is Rs. 307200/- annually, while net income is likely to be 187000/-. Profitability can be increased further 69% with proper fertilizer management.

Impact and up-scaling: Technology has been disseminated in farmers' field. Presently it is being cultivated on 10 states.

***F. semialata* plants with lac inoculation**

F. semialata plantation

2. **Name of Technology:** Lac cultivation on *kusum*

Problem statement: Lac is a cash crop and its cultivation is an age old practice. The Institute has optimized the input requirement for different operations of lac cultivation.

Applicability/ situations: All throughout the lac growing states of India

Description of technology: For lac cultivation on *kusum* (*S. oleosa*) pruning time is January/ February or June/ July normally before the advent of new shoots. Shoot age for the best performance is 18 months. Normally 20 g broodlac is required per metre inoculable shoot or per cut point. Quality broodlac is bundled in 50 or 100 g each sized at 6" in length and tied to proper place (upper side of branches) with the help of plastic *sutli* tied at both the ends. Insect emergence completes by 21 days after which empty lac sticks are removed. After following proper crop hygene during its growth period of approximately 6 months crop is harvested either in January/ February or June/ July. Important intervention of the Institute in lac cultivation on *kusum* is 4-5 coupe system due to specific requirement of shoot age for *kusum*. Each group of trees (coupe) are pruned at the interval of six months. Partial harvesting is carried out 6 months after inoculation and complete harvesting is done six months after partial harvesting. Thus each coupe will be used once for summer-cum-winter crop and next time for winter-cum-summer crop. Broodlac collected after partial harvesting are utilized for inoculation of the next coupe. Brood obtained by complete harvesting are sold in the market after satisfying farmer's own requirement.

Economics/ Cost involved: The system offers a 352 % capital growth annually. Revolving Fund Scheme of the Institute ran successfully following this technology.

Impact and upscaling: Technology has been disseminated in farmers' field. Presently it is being cultivated on 9 states.

3. **Name of Technology:** Package of practices of broodlac production on palas

Problem statement: Cultivation of *rangeeni* lac is an age old practice. Moreover lac is a cash crop. The Institute has optimized the input requirement for different operations of *rangeeni* lac cultivation.

Description of technology: Total available trees should be divided into two separate coupes, located distantly, each to be exploited in alternate years. In each coupe, about 20 % of randomly selected trees should be used for trapping the predators by inoculating them heavily in the month of October/ November and harvesting the immature crop in April next year. Other trees will undergo lac cultivation as per schedule i.e. partial harvesting in June/ July and total harvesting in October/ November followed by pruning and left over lac collection in April next year. Pruning should be done in February/ March and shoots of 2.5 cm diameter should be removed 50 cm away from the base. Trees under broodlac coupe should be inoculated with broodlac @10 g/ m shoot length (250-500 g/ tree) while those under trap subcoupe @20 g/ m shoot length (~1 kg/ tree).

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: By following these interventions 194 and 171 percent capital growth can be expected over traditional system of lac cultivation.

Impact and upscaling: Technology has been disseminated in farmers' field.

4. **Name of Technology:** Technology for *rangeeni* lac production (brood and sticklac) on only *palas* or on *palas* and *ber*

Problem statement: Cultivation of *rangeeni* lac is an age old practice. Moreover lac is a cash crop. The Institute has optimized the input requirement for different operations of *rangeeni* lac cultivation under the specified situation.

Description of technology: All the trees are divided into three groups (coupe) with equal number of trees in each; two are used for broodlac purpose and the remaining for sticklac purpose (immature crop) in summar season. *Ber* trees if available, can be used for summer immature crop. Healthy trees are used in the broodlac coupe. Two broodlac coupe are kept and each is used in alternate years. Normally 1 m broodlac is used for inoculating 12.5 m shoot length (10 g/ m). 250-500 g broodlac is required for inoculating one medium sized tree. Inoculation is done on Oct/ Nov on trees which were pruned in April and broodlac is harvested after one year in same month when crop is mature, allowing self-inoculation in June/ July. Partial harvesting is done in June/ July. Left over small quantity of lac colonies are collected in April i.e. during total harvest/ pruning.

Broodlac inoculation in immature lac coupe of *palas* and *ber* is done @ 20-25 g/ m shoot length; broodlac requirement for a medium sized tree is 1.0 and 1.5 kg, respectively. Time of inoculation and harvest are October and April, respectively.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Use of *palas* and *ber* trees in the ratio of 5:1 for broodlac and sticklac production, respectively, can provide a capital growth of 169 % per annum. The technology has been tested and demonstrated in farmer's field.

Impact and upscaling: Technology has been disseminated in farmers' field.

5. Name of Technology: Production of immature summer crop of *rangeeni* lac on *ber*

Problem statement: Normal crop cycle for summer *rangeeni* crop is Oct/ Nov to June/ July. Continuance of lac crop during summer months is injurious both for the insect and the host. Collection of immature crop during April /May is a better option as it can fetch some money for the farmers.

Description of technology: This is an age old practice of lac cultivation where pruning cum harvesting is done during April/ May and inoculation is done in October/ November. The Institute has standardized rate of inoculation to be 20-25 g/ m shoot length. Summer broodlac of *rangeeni* lac is scarcely produced in specially selected plants and in selected areas. Rainy season *rangeeni* lac crop on *ber* is not recommended due to mismatch of pruning time of *ber* plant and a bad pruning response there from.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved:

Impact and upscaling: Technology has been disseminated in farmers' field.

6. Name of Technology: Production of *kusmi* lac on *ber*

Description of technology: The Institute has made some technological intervention and made the *ber* trees much more useful and profiteering. As per this method, pruning time of *ber* has been shifted to February/ March instead of April/ May as used to be followed in *rangeeni* (immature lac) production system. Subsequently, *kusmi* lac is inoculated in June/ July and harvested during January/ February. With this intervention farmers are able to grow broodlac for *kusmi* lac, which is much better in quality, besides having higher market price. Normally heavy pruning is done in case of *ber*. All the branches of less than 1.25 cm are pruned from point of origin while thicker branches are cut leaving 30 cm from origin. Rate of broodlac inoculation is 20 g/ m shoot length.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Cost of cultivation has been estimated to be Rs 217062/ha and gross income generated is Rs 874950/ha

Impact and upscaling: Technology has been disseminated in few states in farmers' field.

7. Name of Technology: Use of *ber* trees in combination with *kusum* trees

Problem statement: *Kusum* tree is a very good lac host. But all farmers donot possess *kusum* trees and on the other hand many are having *ber* trees. *Kusum* trees can produce lac in both the seasons i.e. in summer and in winter. But, due to defoliation in summer months, ber trees cannot produce broodlac in summer. Therefore, this novel system was developed so that lac cultivation can be continued when farmer is having limited number of *kusum* trees and relatively higher number of ber trees.

Description of technology: Total trees of *kusum* are divided into two sets, with equal number of trees in each set and exploited for summer crop, producing broodlac in alternate years in June/ July. Total *ber* trees are kept in one set and exploited for winter crop, producing broodlac every year during January/ February. For the first time *ber* trees are pruned in January/ February and later on harvesting of broodlac serves the purpose of pruning. It is inoculated in June/ July and crop is harvested during January/ February. Harvested broodlac is used for inoculation of *kusum* tree and *vice-versa*. Thus *ber* trees get a rest period of six months and *kusum* gets a rest period of 18 months. Other technical details of cultivation are like normal lac cultivation on *kusum* and *ber*, respectively.

Applicability/ situations: All throughout the lac growing states of India

Impact and upscaling: Technology has been disseminated in farmers' field.

8. Name of Technology: Early kusmi breed cultivation on semialata for sustainable lac production

Problem statement:

Description of technology: *Flemingia semialata* has shown great promise for lac production due to its fast growth, tender shoots and suitability for intensive lac cultivation and is a boon to particularly those farmers who do not have lac-host trees but are interested in lac cultivation. However, problem encountered during normal *kusmi* lac production on *semialata* was detachment of the lac encrustation from the twig towards the crop maturity period leading to not only deterioration in quality of broodlac and decrease in the yield of lac but also un-sustainability of broodlac production on this host.

Major recommendations of the technology developed are: (i) Early maturing variety of *kusmi* strain (maturing in June and January - about one month before the normal time *i.e.* July and February) should invariably be used for lac cultivation on *semialata,* (ii) Lac insects should not be allowed to settle on more than 35 % inoculable space of the available shoots, (iii) paired row system of planting should be followed and (iv) Irrigation at fortnightly interval after cessation of the monsoon (December – January) should be provided to lac cultures on *semialata*

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: 44% increase in yield of per meter broodlac and 30.89 % increase in sticklac was recorded and no detachment of broodlac from the stem was observed by following the recommendations. Early harvest also promises better growth and plants are ready on time for inoculation of the next crop. No additional cost is required

More than 40% higher income to the farmers is ensured in comparison to conventional practice. Under paired system of planting lac cultivation can be integrated with vegetable cultivation leading to increased income, better quality broodlac and land use diversification.

Impact and upscaling: Technology developed has been tested under farmer's field in collaboration with NGOs and is being followed by the farmers

9. Name of Technology: Late *kusmi* breed cultivation on *ber* for improved lac production

Problem statement: *Ber* is the most preferred host for lac cultivation among the growers because it can be utilized for both the strains of the lac insect and comparatively, it is also one of the fastest growing lac-host among the tree species with a very good pruning response. Early *kusmi* lac genotypes, if inoculated on *ber* trees are harvested early i.e. in December/ January. This operation has been proved to be incompatible for physiology and pruning response of the host. Therefore, it was worked out how ber trees can be used for a better productivity.

Description of technology: Under this technology for *kusmi* lac cultivation, *ber* is pruned in the month of March / April and late maturing variety of *kusmi* strain of lac insect is inoculated in the month of July-August @ 20 g per pruned point. Recommended package of practice for *kusmi* lac cultivation on *ber* is followed and the crop is harvested in the coming March / April which serves as pruning also. Yield of lac on more than one year old shoots as recommended earlier was not consistent and resulted in unpredictable output. Two main interventions *viz*., use of late maturing breed and four-six month old shoots for inoculation has resulted in sustainability of *kusmi* lac production on *ber*.

Inoculation with late maturing variety of *kusmi* strain (maturing in July / August - about one month after the normal time *i.e.* June / July) delays the lac crop harvesting time to March / April which not only tends to coincide with the pruning time of the tree but also more lac yield (3-26%) was obtained in comparison to early maturing varieties.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: No additional cost is required but higher yield is obtained. Normally, new flush of leaves appear in April from the trees pruned in February. However, continuous rearing of *kusmi* lac on *ber* during winter season has been observed to adversely affect the pruning response of the tree leading to not only deterioration in quality of broodlac but also decrease in the yield of lac. Some of the parameters affected are: (i) Delayed appearance of flush on the pruned tree, (ii) reduced number of new shoots from a pruned point, (iii) reduced length and diameter of the shoots emerging from the pruned point.

Continuous cultivation on *ber* of *kusmi* lac especially of early maturing variety harvested in Jan. / Feb. adversely affects the plant growth parameters leading to decreased output. Cultivation of *kusmi* late variety which matures in March / April showed better performance and sustainable yield without affecting plant growth. Lac culture requires plant-hosts, therefore, cultivation of lac as such not only checks environmental degradation but also rebuilds the ecological balance through planting of tree-hosts.

Impact and upscaling: Technology developed has been tested under farmer's field in collaboration with NGOs and is being followed by the farmers

10. Name of Technology: Integration of lac cultivation on *semialata* with fruit trees

Problem statement: LIFS (Lac Integrated Farming System) is highly remunerative since returns through lac is higher than agricultural crops. Moreover lac production coincides with the seasons when virtually no major agricultural crop produce is available. Thus lac integrated farming systems can contribute towards income security while field crops and fruit trees will provide nutritional security. Besides, it has high potential for generating employment for both men and women particularly in off-agricultural season. Lac is an important source of cash flow to the marginal and small farmers also besides a profitable venture for large farmers

Integrated farming systems play an effective role in the utilization of the natural resources in the most effective manner for sustainable crop diversification of farm enterprises which have less demand on space and time with very limited resources in the rainfed area . Lac integrated farming system is very remunerative as it is low cash and labour input crop with high returns; compatible with existing rural livelihood activities in terms of its labour requirement and encourages conservation of host trees and leads to re-greening of the land. This system will help in domestication of lac production, thus unburdening the forest trees which are prone to heavy pruning and other unscientific lac operations by rural community living at the fringes of forest area

Description of technology: Lac Integrated Farming System (LIFS) Model developed is multi tier horti-lac system comprising of lac host plants (*Flemingia semialata* and *ber Ziziphus mauritiana*) and *fruit* trees *aonla* (*Emblica officinalis* syn. *Phyllanthus emblica*), guava (*Psidium guajava*) and lime (*Citrus aurantifolia* Swing). Paired rows of *semialata* alternate with fruit trees. The components integrated in LIFS have synergistic relationship with each other and complementary in growth characteristics and nutritional requirement. *Aonla* and *ber* have been selected as the top canopy trees as their crown is open, avoiding any inhibition of light to the lower plants and less competitive for moisture being the native of dry sub tropical climate. Guava and lime are next in vertical hierarchy followed by *semialata*. Guava and lime are short statured trees and have narrow canopy, hence do not interfere with growth of *semialata*. Vegetables are used as live mulch underneath *semialata* for retaining soil moisture for longer time and lowering the soil temperature in summer season for lac crop sustainability.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: An expenditure of Rs. 2.35 laks / ha is involved. A net income of more than Rs. 78,000 is generated in the second year of planting which reaches to a peak value of Rs. 6.75 laks / ha in the ninth year

Impact and upscaling: Technology is has been tested at Institute Research Farm and is under evaluation with other vegetable components.

11. Name of Technology: Disease management during lac production

Problem statement: Lac production is influenced positively due to prophylactic spray of fungicide. So far, only one fungicide i.e. carbendazim has been tested for the purpose. Repeated use of a single pesticide can induce resistance of the pathogen. Therefore, idea was conceived to screen few more fungicides for alternative use. During rainy season when Relative Humidity remains high and sooty mold causes reduction in lac crop yield and sometimes complete failure of the crop.

Description of technology: Two fungicides namely Cantaf (hexaconazole) @ 0.5 ml/ liter water and Kavach (chlorothalonil) @ 1 g/ liter water is very effective against sooty mold. Three sprays of these fungicides at 60, 90 and 120 days after lac inoculation or 90, 105 and 120 days after lac inoculation provided economically higher yield in winter crop of *kusmi* lac.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Yield increase due to use of hexaconazole was 38-56 per cent over control. The same value for chlorothalonil was 18-47 per cent.

Impact and upscaling: Technology has been tested by fourteen farmers from 4 villages of Jharkhand and West Bengal

12. Name of Technology: Pest management for improving lac production

Problem statement: Eublemma amabilis, Pseudohypatopa pulveria and Chrysopa medestis are three major predators of lac insect. All pesticides are not suitable to lac crop equally. Therefore, a proper screening is required for proper pest management as some of the already screened pesticides have been banned recently. Alternative methods of pest control are also need of the hour keeping the environment in mind.

Description of technology: Ethofenprox, dichlorvos, indoxacarb, fipronil, spinosad, chlorantraniliprole, emamectin benzoate, novaleuron have been found safe on lac insect and effective in superssing the population of insect predators and parasitoids of lac insect.

Except ethofenprox and dichlorvos, these insecticides can also be applied through treatment of broodlac which will reduce incidence of predators and parasitoids significantly. *Trichogramma* spp. was found effective in suppressing lepidopteran pests of lac (*Eublemma amabilis* and *Pseudohypatopa pulverea*). *Bacillus thuringiensis* var Kurstaki was found effective on lepidopteran pest of lac, if applied under field condition by spray. 60 mesh net bag as a broodlac container was found useful in trapping insect-predators and parasitoid harboring broodlac. This helped to reduce the incidence in new lac crop raised.

Applicability/ situations: All throughout the lac growing states of India

Impact and upscaling: Technology has been disseminated in farmers' field.

13. Name of Technology: Early detection of parasitoid infestation in lac crop

Problem statement: *Aprostocetus purpureus* and *Tachardiaephagus tachardiae* are the two most important parasitoids of lac insects. Timely detection of the parasitoid infection is very much essential for their control. Host dissection and caging of adult lac insects are the existing methods for the detection of parasitoids in lac culture. Host dissection is laborious, whereas caging helps to detect the presence of only adult but not immature stages of parasitoids. Hence, a PCR (polymerase chain reaction) based approach has been developed for detection of these two important parasitoids in lac insect.

Description of technology: The method is very specific to the respective parasitoids and sensitive to very less amount of parasitoid DNA. Hence, the method is able to detect even the immature stages such as eggs and larvae of parasitoids of lac insects. The method is also found to work with field collected infected lac inset samples and were able to differentiate infected lac insects from the uninfected ones that too at a very early stage of infestation, compared to host dissection (microscopic observation) and caging (adult emergence). In rainy season crop of rangeeni lac (*katki* 2014), first incidence of *A. purpureus* was observed at 8 DAI (days after inoculation) through PCR technique. However, microscopic observation revealed the incidence at 28 DAI and adult parasitoid emergence through caging was recorded at 44 DAI.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Cost of the test has been estimated to be Rs 300/ per sample.

Impact and upscaling: Technology has to be tested / verified.

14. Name of Technology: Winter kusmi lac production on fruit varieties of ber:

Problem statement: Wild *ber* trees are known for *kusmi* lac cultivation but its fruit has no commercial acceptance due to poor edible quality. In order to reduce the risk of failure of lac crop and to harness the benefit of fruits, various *ber* varieties popular for edible fruits were evaluated for winter season *kusmi* lac production.

Description of technology: Out of 24 fruit varieties of *ber*, *Maharwali* proved to be the best fruit variety for winter *kusmi* lac with average broodlac yield ratio of 8.8 (output/ input ratio). It was followed by *Banarasi Pebandi* with mean broodlac output/input ratio of 8.4. Varieties like Thornless, *Katha* and *Seb* x *Gola* F_1 were also found to have good potential for this crop. These *ber* varieties yielded significantly higher broodlac than CAZRI *Gola* (7.4), the most known susceptible fruit ber variety for lac culture, was considered as control in the experiment.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Cost of cultivation is Rs 400/- per tree. With 4m x 4m space among trees for lac culture about 600 plants will be accommodated in one hectare and cost of cultivation will be Rs240000/- per hectare. For the last five years the average cost of winter *kusmi* broodlac is about Rs 200/-.With broodlac output ratio of about 8 in recommended fruit ber varieties, the return from broodlac is Rs 1600 per tree with overall return of Rs 9,60,000 per hectare. The net return from lac culture is Rs 1200/- per tree. Thus from one hectare of plantation, net return comes to be Rs 7, 20, 000 /.

Normally, 70% fruit yield loss takes place in local *ber* varieties due to lac cultivation. So, in the years of lac crop failure, farmers can earn some money by selling fruits. Thus these fruit ber varieties will minimize the risk associated with lac culture.

Impact and upscaling: Technology has been disseminated in farmers' field in 2016.

15. Name of Technology: Hormonal application for complete flower removal in *ber*

Problem statement: The flowering season of *ber* overlaps with the *baisakhi* crop of lac. Lac insect get its required nutrition for growth and development from its host plant. Therefore flowering and fruiting which consumes bulk of photosynthates might affect the growth and development of lac insect which also depends on the same source for nutrition. Moreover, the fruit of wild *ber* plant is not used in market for economic returns. Therefore it was essential to remove this unwanted sink, ie fruit, to improve the availability of the nutrition to lac insect. The efficient way to execute the same could be through removal of flower. Since *ber*, otherwise is commercially grown for its fruit, there was no available methodology for complete removal of its flower.

Description of technology: A method for removal of floral buds from *ber* has been developed wherein, application of NAA @50ppm during flower bud formation stage resulted in complete flower removal in *ber* plants within two weeks of application.The time of application will vary depending on the location. The key stage of application is when the flower bud formation is initiated, generally in the month of September.

Applicability/ situations: Throughout the lac growing states of India during *Baisakhi* crop.

Economics/ Cost involved: Fruiting load on the plant can be reduced by this method, which will ultimately help in better lac yield during *baisakhi* as it has been recorded an increase of 2.3 fold yield ratio. Considering the added cost of the flower removal in cultural operation, an increase of 55-60% in economic return is expected.

NAA @ 50 ppm (0 days)

NAA @ 50 ppm (after 14 days)

Impact and upscaling: Technology requires to be disseminated in farmers' field.

16. Name of Technology: Management of soil fertility for winter season kusmi lac production on ber

Problem statement: Unfertilized trees under continuous *kusmi* lac cultivation suffer mortality and bad health. The technology developed ensures no mortality of host i.e. assured sustainability. The technology checks host mortality and increase lac yield. Therefore, sustainable lac production on *ber* is possible on one hand and increased income will give more economic sufficiency. It will address both social and environmental issues.

Description of technology: Application of 200 g nitrogen, 150 g each of phosphorus & potassium and liming @ 2.25 kg/ tree is recommended for *kusmi* lac production on established plantation of *ber* (4.5x4.0 m^2 spacing) in acid lateritic soils of Jharkhand. Half dose of nitrogen and full dose of phosphorus and potassium are used at the onset of monsoon at 4-6" deep rings dug at 60% of canopy diameter. Rest half of nitrogen is applied on first week of September matching with time of male emergence. Liming is done on the whole canopy area 2-3 months before application of fertilizer.

Continuous *kusmi* lac cultivation leads to reduction of prune bio-mass production by 0.8 kg/ tree/ year under unfertilized condition and increased by 2.9 kg/tree/ year under the recommended dose. In general, tree bio-mass can be increased 65, 130 and 116 percent due to application of lime, nitrogen and potassium application in recommended dose, respectively. Thus, growth of tree can be supplemented by above rate of application. Findings (with different doses) worked well on other hosts like *bhalia*, *palas* etc. At the same time lac production increased significantly (34%).

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Lac yield can be increased 34% only due to potassium application in normal soils of the region. Cost of cultivation is Rs 217062/ha and Rs 360815/ha under no intervention of technology and with intervention of technology, respectively. Gross income generated in both the cases are Rs 874950/ha and Rs 1163700/ha. Thus, due to use of fertilizer inputs, an additional income of Rs 288750/ha can be generated. Conventionally lac cultivation is done under no fertilization.

Impact and upscaling: Considering importance of potassium in lac cultivation, the technology has been upscaled. Present recommendation is application of N, P2O5 and K2O @ 200, 150 and 500 g/ tree along with 2.25 kg lime. It has been tested successfully on different villages of Ranchi and Khunti districts of Jharkhand

Plants starts dying due to continuous *kusmi* lac cultivation on *ber*

Method of fertilizer application to *ber* trees

17. **Name of Technology:** Management of soil fertility for winter season *kusmi* lac production on *semialata*

Problem statement: Plant growth suffers very much due to continuous lac cultivation and regular pruning operations there on. As a result, frequent plant mortality takes place and uniform plant density cannot be maintained. The situation is worse in acid lateritic soil. Chemical fertilizer management can improve the situation to a large extent as addition of fertilizer improves plant health and at the same time some important nutrients directly benefit lac crop also.

Description of technology: Liming is the best option for soil management and supporting plant growth in acid lateritic soils. Normally, farmers do not apply soil amendments and fertilizers for plant growth/ lac production. Liming @ 1025 kg/ha and NPK application maximum @ 25-5-30 g/ plant can sustain both plant growth and lac production simultaneously for soils with pH range 4.5 to 5.5. Half dose of nitrogen and full dose of phosphorus and potassium are used at the onset of monsoon. Rest half of nitrogen is applied on first week of September matching with time of male emergence. Liming is done on the whole canopy area 2-3 months before application of fertilizer.

Lime and potassium application is very important for sticklac production on *semialata*. Higher sticklac production to the tune of 41 and 47 percent respectively can be expected over control. However, enhanced growth can be expected through application of boron, lime, nitrogen and NPK combination. For boron 10 kg borax can be applied, if necessary. Higher proportion of thicker shoot can be expected due to application of boron (43%), lime (42%), 25 g/plant nitrogen (44%) and NPK combination (42%) as compared to control. Dry matter of shoot due to application of boron, potassium and NPK combination can be expected to remain 25.9, 25.2 and 25.7 percent respectively. All these values were significantly lower than control (27.3). Besides, over all plant mortality reduced to merely 5 percent in third year due to the intervention as compared to 30 percent in first year.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: With the intervention of technology likely net income from one hectare *semialata* plantation is expected to be around Rs 318440/-. The same under control condition is Rs 187600/- only. Profit of farmers is likely to increase to the extent of 69 percent. Lac cultivation on *semialata* may be treated as an alternative to vegetable cultivation. A lot of positive change is expected in the society in terms of income generation.

Impact and upscaling: Tested successfully on different villages of Ranchi and Khunti districts of Jharkhand

Lac cultivation on *F. semialata*

18. **Name of Technology:** Increasing rainy season *rangeeni* lac yield on *palas* by potassium application in lateritic soils of Jharkhand

Problem statement: Level of available soil potassium in upland areas where *palas* trees are abundant is very low. Earlier work confirmed that winter season *kusmi* lac production on *ber* can be increased by application of potassium @ 150 g/ tree. The same finding was validated for higher rates of potassium application for *rangeeni* lac crop on *palas*.

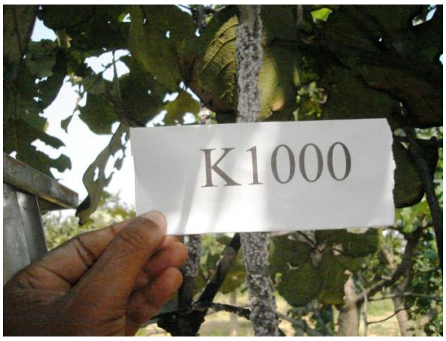
Description of technology: Application of 1000 g K_2O/ tree on rings made at 60% of the canopy diameter and applied during monsoon period improves yield of rainy season *rangeeni* lac up to 3.0-3.9 times as compared to control.

Applicability/ situations: All throughout the acid lateritic lac growing states of India

Economics/ Cost involved: Thus, by spending Rs 25 for a kilogram of potassium per tree one can harvest extra 1.0 kg *rangeeni* broodlac which brings an additional income of Rs 100-150/-

Impact and upscaling: Tested successfully on two villages of Ranchi and Khunti districts of Jharkhand

Sparse settlement of lac under no application of potassium



Dense settlement of lac under application of potassium

19. Name of Technology: Technique for quick raising of *ber* plantation in Jharkhand soil

Problem statement: Majority of the soils of Jharkhand are acidic in nature with pH ranging from 4.5 to 5.5. Root growth of plants is restricted in such condition. Also, most of the soil nutrients remain in less available condition. Frequent grazing is a common affair. Therefore, *ber* plants take more than ten years to develop properly for lac cultivation.

Description of technology: Research work done in the Institute generated technology with which plantation can be established for lac cultivation in five years if fertilization with nitrogen, phosphorus and potassium @ 100-170-80 g/ plant is done for the first three years by which the plants grows out of reach of cattle. Fertilization at above rate and duration produced basal diameter, approximately 2 times over control and 1.25 times over subsequent lower dose i.e. 50-85-40 g/plant at the end of five years.

Applicability/ situations: All throughout the lac growing states with acid lateritic soils in India

Economics/ Cost involved: Total cost estimated for fertilizing a ber plantation of one hectare comes to around Rs 12000/ per year only.

Impact and upscaling: Afterwards, upscaling was done by adding lime @ 650 g/ tree along with the above recommended rate of fertilizers during transplanting only. Addition of lime can increase vigour 1.5 times than that of trees applied with only fertilizers. Technology is yet to be disseminated in farmers' field.

***Ber* plantation under fertilizer management**

Well fertilized *ber* trees come in inoculable stage in 5-6 years

20. Name of Technology: Increasing winter season *kusmi* lac production through proper selection of *ber* trees

Problem statement: Ventilation and penetration of sunshine within tree canopy are important factors for *kusmi* lac production in winter season. Depending upon the type of *ber* trees, proportion of thin shoot (basal diameter < 7 mm in July) varies from 22 to 42 percent. Therefore, light transmission ratio also varies from 18 to 45 percent. Assimilate supplying capacity of thin shoots is limited. Therefore, mortality of lac is observed on 58- 75% of such shoots. Thus, lac insect settlement on the thin shoots is wasted. At the same time, thin shoots impair ventilation and penetration of sunshine.

Description of technology: Among the four types of *ber* trees, lac yield performance is the best with roof type tree with brood/ brood ratio (13.01) followed by erect (6.64) and semi erect (6.21) types; bushy type is the poorest performer with brood yield/brood used ratio 0.99. High lac mortality is frequently observed on thin shoots and poor ventilation and sunshine predominantly found under bushy type tree canopy. As a consequence production of lac is less on such trees. Shoots of higher diameter can fulfill the need of lac insect in a better way in case of erect type and roof type. Thus, farmers can even avoid selecting bushy type trees for lac cultivation. The technology developed a concept that shade is harmful for lac production in winter/ rainy season.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: The technology cautions the farmers from possible loss if bad hosts are selected. As high as 100 per cent loss can occur due to bad selection of *ber* trees.

Impact and upscaling: Technology has been disseminated in farmers' field. Many farmers and NGO workers were given demonstration on this aspect.

***Ber* tree with dense canopy**

***Ber* tree with erect canopy**

21. Name of Technology: Increasing *kusmi* lac yield on *ber* through pitcher irrigation

Problem statement: Lac hosts remain in stress condition particularly during latter part of the cropping season and lac yield suffers greatly. Mostly, lac cultivation is done on scattered trees, therefore, providing irrigation is not always possible. In this condition, providing irrigation through pitcher can help tree growth and lac yield at the same time.

Description of technology: To derive best result from pitcher irrigation technology, unglazed pitchers of 8-10 liter capacity with lid are buried into the soil with neck protruded from the ground. Cotton wick is inserted at the bottom of the pitcher through hole for oozing water from the pitcher slowly and consistently. Four pitchers are placed at the periphery of the *ber* tree (preferably at $2/3^{rd}$ of the canopy spread).

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Significant increase in broodlac yield takes place due to imposition of pitcher in summer season. An increase of 110 percent in lac yield is possible due to imposition of pitcher in summer months. While, yield increase is marginal (13%) in winter season. Lac is a high value commodity; therefore, farmers can harvest a very good profit out of this technology.

Impact and upscaling: Technology has been disseminated in farmers' field.

Diagrammatic representation of pitcher irrigation

22. **Name of Technology:** Increasing winter season *kusmi* lac production through chemical weed control on *F. semialata*

Problem statement: Winter season *kusmi* lac cultivation on *F. semialata* is a very good option for farmers who want to cultivate lac in association with agricultural crops and also for those who do not possess traditional lac hosts. Due to short stature of the plant, weeds compete for all the resources in its growth period. Excessive growth of weeds leads to loss in lac production also. Chemical control of weeds provide a good option for weeding as manual weeding is a cumbersome process and also a costly affair. Study was conducted to test whether herbicides can be used safely in lac cultivation without any reduction in lac yield.

Description of technology: One spray of glyphosate @ 1.0 kg a.i./ ha in the plantation at 7 to 10 days prior to lac insect inoculation can check weed growth effectively. Weed control efficiency in Glyphosate application is 89%, which is at par to hand weeding. Stick lac production is 11% lesser than hand weeding and 38% higher than unweeded control.

Applicability/ situations: All throughout the lac growing states of India

Economics/ Cost involved: Net return per rupee invested is 2.1, 1.57 and 1.54 due to glyphosate application, weed free condition and unweeded control respectively. Thus, chemical weed control can be adopted safely in lac cultivation.

Impact and upscaling: Technology is yet to be disseminated in farmers' field.

B. Resins and gums production technologies

Tapping technique is considered the the major technique for gum and resin production. There are different methods of tapping for different trees. The prime objective of tapping is to increase production of gums putting a minimum stress on the tree. Different tapping techniques are here under.

1. Tapping of Rosin:

Tapping of rosin can be divided broadly in two ways – Light/continuous tapping and heavy tapping. In light tapping one channel method is practiced when tree girth ranges in between 0.9 – 1.8 m and two channel methods are practiced when tree girth exceeds 1.8 m. These channels continue to produce gum till 5 years of age. After end of 5 years, a new set of channels are made for gum production. Then, new sets are separated at a gap of 10 cm. The other method is heavy tapping. As the name suggests much more injury/ wound is made on tree for gum production. Depending upon methodology adopted, there are four types of heavy tapings.

Box method – A box shaped hole of dimension 10 cm x 10 cm is made at the trunk of the tree. Resins is secreted and collected at the box.

Cup and lip method – In this method outer bark from an area of 60x15 cm is removed and made the surface smooth. A liplike structure of galvanized iron is inserted in a place 25 m below the upper end. South or South west side is preferred. In order to open up clogged resin ducts and aid in smooth and continuous flow of resins, other channels are freshened at definite intervals.

Rill method – Bark shaved from 45x30 cm in area and left over bark thickness is around 2 mm. Blaze is made at a height of 15 cm from ground. Control grooves are cut out by groove cutter and the lip is the fixed with the help of nail. Subsequently freshening of groove is done as and when required. The depth of the rill is about 2 mm into wood. After freshening, a 1:1 mixture of dilute H_2SO_4 (20%) and dilute HNO_3 (20%) is released on freshly cut rills with bottle. Exudation starts soon after rills are made.

Bore hole method – In this method a narrow bore is made in the trunk for resin extraction. Basal portion of trunk (10 cm above ground) is selected for the purpose. Dimension of hole is 15 cm in depth and 2.5 cm in diameter. A little slope is kept in the hole to facilitate coming up of resin exudates. For stimulating production of resins, a mixture of sulphuric acid and ethaphone is sprayed inside the hole (1-2 ml/hole). Exudates are collected in a container. This method is less stressful and free from fire hazard/insect or pest attack. Prolonged resins flow can be ascertained in this method. So it can conserve the tree species in a better way. Collection of gum is done during April to November months. Yield can be expected to the tune of 5 Kg/tree/blaze in rill method. Other method can give 1.5 Kg/blaze to 3 Kg/blaze

2. **Dammar:** On trunk of *sal* trees (*Shorea robusta*) 3-5 narrow strips of bark are removed from 90-120 cm above ground. In 12 days grooves are filled up. White liquid resins come out and turn brown on drying. Fully productive trees can produce 4-5 kg dammar/tapping i.e. in a month. Three production seasons are June/July, October and January.

3. **Guar gum:** The gum is extracted from cotyledon of guar (*C. tetragonoloba*) seeds. It is a leguminous crop and can be grown less fertile soils also. Rain during planting and during maturity is essential for proper germination and seed development. Too much precipitation during growth period increases vegetative growth and production is affected adversely. An average yield of 500-700 kg/ha can be expected from an averages stand.

4. **Gum Arabic:** The tree (*Acacia senegal*) produces gum under heat, dryness, wound and disease attack. After exudation, the gum concretes to tears. Tapping is done by incision of 60x5 cm area few weeks ahead of time. Trees 4.5 – 6 m high and 5-25 years old may be selected for tapping. Incision and stripping away of bark is done from the branches. Gum starts oozing out in 3-8 weeks. Gum is collected manually. Ideal time of collection is from November to May. During rainy season, no gum is collected, since tree remains in flowering condition.

   For tapping gums from A. Senegal trees under bore hole method, base of tree the trunk is selected. Normally site of tapping is kept at 40-50 cm above ground. A small hole 1.2 cm diameter and 2.5 cm deep is made on the trunk having an inclination of 45^o towards inner side. Treatment for tapping is done in the month of March. As a precautionary measure, a shallow cut is given. Oozing out of gum starts from 7-10 days after incision. Normally, tears are collected manually. To increase gum yield, holes are treated with ethephone @ 480 mg/4 ml and injected through syringe. To prolong the effect of treatments, the holes are plugged with clay or wax.

5. **Gum ghatti:** – Producer tree (*Anogeissus latifolia*) are usually not tapped. Gums are collected, which come out due to injury during summer. Usual time of collection is March to Mid June. An yield of 1-2 Kg gum/years may be expected from a tree.

6. **Gum karaya:** Incision of dimension 1x1' is made on bark of the tree (*Sterculia urens*). Gums starts coming out immediately upto several days. Rate of flow is maximum in first 24 hours. Best time is April to June. When tree girth is 1.5 – 2 m, it can yield 2-5 kg gum from two blazes.

7. **Guggul gum:** Gum-resins residues are found in ducts located in soft bark of the tree (*Comiphora spp.*). Resins ducts occur in the bark portion near cambial layer. A diameters of 7.5 cm of the plant is considered good for tapping. Usually 1.5 cm deep circular incision not beyond the bark is made manually or with spear for tapping. Product is collected at an interval of 10-15 days.

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