MANAGEMENT OF HOST PLANTS FOR LAC CULTIVATION

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Introduction

Lac is a natural product of commercial importance and traditionally being used since time immemorable. Its use has been mentioned in old epic Mahabharata, the Ain-i-Akbari in 16th Century and in many other places. Modern research has extended its use in the field of varnishes, polishes, pharmaceuticals, confectionery, adhesives, printing inks, electrical and leather industry, fruit and vegetable coating etc. The demand of lac is increasing globally. Export figure of lac in 2009-10 and production figure of the same in 2010-11 were 6422 and 9035 tons respectively. (Pal *et al.*, 2011). Quality of Indian lac is considered to be the best in the world. In order to address the increasing global demand, the lac production and productivity at local level has to be up scaled. Lac has been one of the important non-wood forest produce being utilized by the human society since time immemorial and lac farming provides subsidiary income to mainly poor subsistence level tribal farmers in the forest tracts of the country. It makes a small but significant contribution to the foreign exchange earning of the country, but the most important role that the lac plays in the economy of the country is that roughly 3-4 million tribal people, who constitute the socioeconomically weakest link of Indian population earn a subsidiary income from its cultivation. The practices of lac culture are getting expanded in different regions of newly created Jharkhand state and necessity of a comprehensive account of lac culture was strongly felt by all concerned. The Indian lac insect, *Kerria lacca* (Kerr.) is the commonly used insect for production of lac in India. They are sedentary, phytosuccivorous, thrive on tender twigs and feed on phloem sap of specific host plants namely *kusum* (*Schleichera* *oleosa*), *palas* (*Butea monosperma*), *ber* (*Zizyphus mauritiana*), *Flemingia semialata*, *Ficus* spp and several others. Though the lac insect culture thrives on shoots of only few host trees on commercial scale, more than 400 plant species have been reported worldwide to be the hosts of lac insect. *Rangeeni* and *kusmi* are the two strains of lac insect which are classified on the basis of host specificity.

Production of lac crop is very much dependent on the species of host and obviously on the health status of the lac host. The health of lac host again depends on the fertility status of soil. Besides, there are a number of abiotic factors influencing lac production critically. Few of these factors are beneficial for lac production, few are beneficial for growth of the host tree and rest is beneficial for both. Each of these factors are effective at a critical level for optimum production of lac. Thus, challenges of lac cultivation are different from that of general agriculture due to influence of so many factors. Management of soil and crop in a sustainable manner can only increase profitability in a lac production system. There could be a long list of such factors. These are crop rotation, irrigation and drainage, plant breeding, plant physiology, soil classification, soil fertility, weed control, insect and pest control. Therefore, maximization of production is possible when all these factors are manipulated in a compatible way to harness the positive interaction of factors on lac yield.

Total production of the commodity is very less as compared to its global demand. There could be a lot of causes affecting lac production of the country. Few of these issues are quick raising of lac hosts, proper fertilizer management for establishment, proper fertilization under lac cultivation, manipulation of the effect of direction influencing lac yield, selection of trees for better lac yield, understanding weather for better lac yield, adoption of proper pruning time for different hosts, alteration of hosts, use of proper brood rate for different crops, adoption of proper pruning methods, host propagation and crop sanitation etc.

Quick raising of lac hosts

Planting season: Among the three major lac hosts *kusum* seedlings are the most sensitive as far as survival after transplanting is concerned. The best time for its transplanting is during August- September. Transplanting for *semialata, ber* and *palas* can be done even in June- July. Best survival of seedlings is found when transplanting is done during short recession of rain in the rainy season.

Planting: Trees with bigger crown have bigger spread of root system. Therefore, size of pits also vary depending upon the concerned species. *Kusum* seedlings are transplanted in pits of 1x1x1m^3 dimensions. Size of same for *ber* and *palas* is 45x45x45 cm3. Nursery raised seedlings of *kusum*, *ber* and *palas* are transplanted in the field in monsoon season at an age of 4-12 months. Pits of desired size are dug in April- May and kept exposed to sun for curing and afterwards soil mixed with Farm Yard Manure (FYM) is filled in such a way that the top soil goes to the bottom and vice-versa.

Manures and fertilizers: 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 unavailable condition. Therefore, *ber* plants take more than ten years and *kusum*/ *palas* take 15 years to develop properly for lac cultivation. 40 kg FYM/ vermicompost for *kusum* and 20 kg FYM/ vermicompost for *ber* and *palas* are given per pit during transplanting. Fertilizer scheduling starts from the second year. Nitrogen, phosphorus and potassium @ 100, 100 and 80 g respectively per seedling per year in addition to 20 kg FYM from second year will take care to establish *kusum* seedlings in five years, though commercial lac cultivation starts after few more years. A good plantation of *ber* 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. Care should be taken so that chemical fertilizers are not placed in close vicinity of plants. It should be mixed well with FYM and the entire soil volume dug from the pit in the first year of planting. An application of nitrogen, phosphorus and potassium @ 10, 5 and 10 g/ plant in addition to 2-3 kg FYM at the time of planting will supplement growth of *semialata*. Besides, another 5 g N/plant may be top dressed 30 days after transplanting.

Selection of tree (winter crop)

Larval emergence from broodlac is enhanced in the presence of sunlight. Plants with dense canopy that do not permit sunlight penetration yield less lac particularly during winter and rainy season, as lac insect has a non-preference of branches inside the dense canopy; no matter even if it is succulent. *Ber* trees with sparse canopy facilitate not only ventilation but also sunlight penetration. The growth of lac insect is optimum on *ber* plants having branches exposed to moderate sunshine and warmth. This has to be considered while selecting plants for lac production. Therefore, trees with dense canopy may be pruned judiciously to impart a well ventilated canopy for higher lac yield. The same is true for *kusum* tree also. Therefore, *kusmi* lac yield is more satisfactory in summer season than that in winter season on *kusum* tree.

Like temperature and light, humidity also plays a great role in insect survival. Exposure of lac crop in humid condition for a long period causes mortality of lac crop. Therefore, lac yield on trees located on lowland condition or on the bank of rivers produce less lac. Average lac yield from trees located on upland conditions or on hill slopes or tops have been found to yield even more than twice than that of lowland conditions.

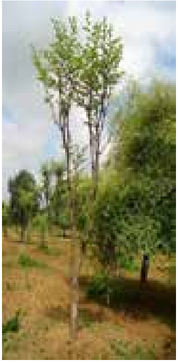

Fig. 1. Erect type *ber* trees

Fig. 2. Bushy type *ber* trees with dense canopy

Exploitation of *ber* for *kusmi* lac production

Ber is a common lac host in many of the states of the country including Jharkhand, West Bengal, Chattisgarh, Madhya Pradesh, Uttar Pradesh, Orissa, Andhra Pradesh and Maharashtra. Lac growers prefer *ber* tree for growing lac due to its abundance, better yield and both *kusmi* and *rangeeni* strains of lac perform well on this host. More than 50 per cent of the available *ber* plants are utilized for lac production (Pal and Bhagat, 2006). Growing *rangeeni* lac on *ber* trees for *baisakhi* (summer season) crop is a common practice in spite of low yield of both raw lac and broodlac. However, by growing winter season (*aghani*) crop of *kusmi* lac on *ber,* the lac productivity per annum can be almost twice more than that of *rangeeni* on it (Mishra *et al.,* 2000). Usually, broodlac yield ratio on *ber* is harvested with an output: input ratio of 6 or more, which is much higher than that obtained from *rangeeni* lac as normally output: input ratio is 3. Output from immature lac cultivation of *rangeeni* lac on *ber* is much lower than that of broodlac cultivation.

Direction affecting lac yield

As mentioned earlier, lac insect prefers well ventilated sites on the plants with moderate sunshine for its settlement. The insect settles on the lower side of horizontal branches to avoid continuous exposure to sunlight. Thus, during broodlac inoculation, over and under exposure to sunlight should be avoided. In the northern hemisphere during July to December months, southern half of the trees remain more exposed to sunshine and thus remain warmer than northern half. Therefore, lac yield on southern half of the *ber* tree is about 10-20 per cent more than that of northern half.

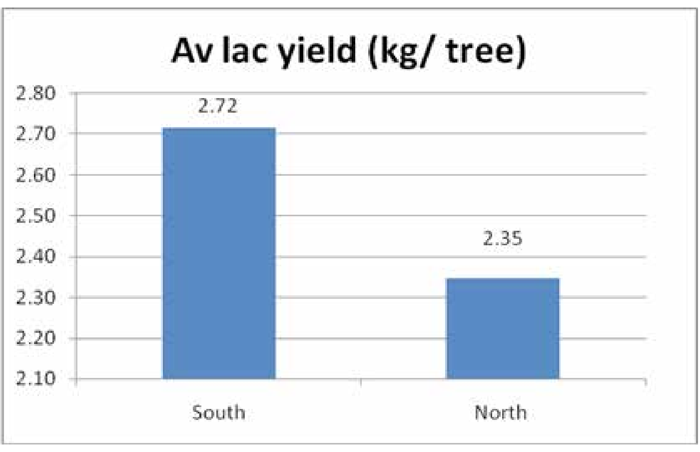

Fig. 4. Lac production on two equal halves of *ber* tree

Canopy management

In the natural stand of *ber*, plants with spreading, semi-erect, erect and umbrella (bushy type) shaped are observed. Spreading type trees are usually vigorous in nature and good producers of lac, provided the insect settlement is not affected due to poor light interception. Erect type trees are most consistent yielders due to good distribution of sunlight and ventilation throughout the canopy. Umbrella shaped or bushy trees are poor lac yielders due to poor distribution of light and improper ventilation inside the canopy. The causes of yield variation are mainly due to branching behaviour, dimension of shoots, internodes length etc. Whatever may be the canopy structure, small shoots ($<$ 1.0 cm basal diameter at maturity *i.e.* 0.7 cm during inoculation) are not good for lac production due to high lac mortality on such shoots. By and large such shoots (60-75%) are unproductive for brood lac. Interception of light can be facilitated if these unproductive shoots are removed. So, by removing such shoots in one hand we can create good environment for lac growth on bigger shoots and on the other hand, wastage of broodlac can be minimized. Similarly, in case of semialata, shoots having basal diameter of approximately 6 mm may be removed for facilitating better ventilation.

Shoot characteristics

Lac production capacity is dependent on the physiological characteristics of host species and on nutrient supply to the host. Texture and size increases with the age of the shoots. Under normal soil fertility condition, when lac cultivation is practiced regularly on shoots with basal diameter ranging from 1.0 cm to 2.5 cm are considered to be the best for different lac hosts. In general, lac survival per cent (living lac encrustation to length of settlement) increases with increase in diameter but length of lac insect settlement decreases as the diameter of the branch increases and tend to settle on secondary branches. Usually, an increase in the diameter of the branch between broodlac inoculation in July to harvesting in February is about 35 per cent in case of *ber*. Therefore, at the time of inoculation branches with diameter varying from 0.75 cm to 1.85 cm are considered to be optimum. Normally best age of shoots for *kusum, ber* and *palas* are 18, 6 and 7 months. Best shoots are neither very tender nor very old. At proper age certain portion of it assumes a characteristic grayish colour. Lac insect encrustation grown on it remains attached very firmly and doesnot detach from stem. Good quality broodlac with smooth encrustation are produced from such shoots.

Use of different insect genotypes

Variation in lac insect strains is observed in relation to colour (crimson and yellow), emergence and harvesting time (crimson early, crimson late, Kulajunga, Nawadih *etc*.), resin colour index, lac productivity etc. Indian Institute of Natural Resins and Gums, Namkum has collections of four well defined such stocks for *kusmi* lac. The early maturing strain of Crimson is recommended for bushy hosts while the late maturing strain is suitable for *ber*. The major difference among the stocks is its maturity time which extends to about 1.0 -1.5 months depending on stocks. Early maturing insects suffer mortality if it emerges during high temperature condition before onset of monsoon. In such cases, farmers have the option to cultivate stocks which matures during monsoon time. Similarly, larva of late maturing strain emerges between last week of March and first week of April. Cultivating such stocks on *ber* render the host to water stress condition particularly during later stages of insect growth. By selecting different strains of *kusmi* lac by lac growers, strategic planning can be done for enhancing productivity and overcoming crop failure.

Effect of weather

The weather plays an important role in lac production, particularly during rainy season. Lac insect grows well on moderate weather. Annual rainfall of 1000 to 1500 mm with a moderate temperature (24-27oC) may be considered good for lac cultivation. Experimental evidence suggests that lac yield ratio is inversely proportional to quantum of rainfall received after sexual maturity of lac at Ranchi condition. Initial stage of lac growth is not as sensitive as it is in later stage of growth. A rainfall of 650 mm received during the first three months may be considered good for lac crop. Distribution of rain is also very important for a successful production. A good crop may be expected when 80 per cent of the rainfall occurs before sexual maturity. After sexual maturity growth of the insect takes place at a rapid rate; wax secretion is also increased significantly. Wax after wetting invite growth of sooty mold, which impairs the growth of the insect and ultimately the lac crop dies. In general, lesser rainfall after sexual maturity results in the increased production of lac. Consecutive weeks with more than 50 mm rainfall also affects lac yield. Good lac yield can be expected even with the occurrence of four such weeks in the first three months, beyond which lac yield suffers. Higher rainfall causes increased lac mortality on thick shoots, while low rainfall causes mortality on thinner shoots. Favourable weather for growth of lac insect during less rainfall could be the reason for much mortality of lac on thin shoots (< 0.7 cm) as supply of assimilates is lesser in such shoots as compared to thicker ones.

Effect of different plant nutrients

Continuous lac cultivation on host trees particularly *kusmi* lac on *ber* affects tree health badly in acid lateritic soils of Jharkhand. Pruned biomass production of a medium sized, unfertilized tree under lac cultivation has been found to reduce @ 0.8 kg/tree/year. Plant nutrients influence growth of lac hosts significantly. Since, lac insects grow on the twigs of these hosts, the growth of the former is also influenced significantly due to application of these plant nutrients. Effect of nitrogen and phosphorus is indifferent to yield ratio (broodlac yield per unit inoculation of broodlac). Potassium application plays an important role in increasing lac production, while excess liming has negative correlation with lac yield. However, interaction of liming and potassium application is another important factor governing lac production. Simultaneous application of potassium and lime in relatively higher soil pH (5.6) where calcium carbonate percent has reached more than 3 percent, decreases lac yield. While under low soil pH condition (4.5) potassium application increases lac yield significantly. Thickness of lac encrustation also decreases due to higher rate of liming. Interaction of lime and potassium plays a significant role in crop production. pH dependent charges of soil matrix is very low or even come to positive values when soil pH comes around 4.5. Possibility of soil retention of potassium is very less in this situation. Therefore, response of added potassium is very clear on lac cultivation. On the other hand presence of excess calcium in soil insists plant to uptake calcium in higher quantity which increases plant resistance against insect attack. Thus growth of the insect is affected reducing the thickness of the lac encrustation, which ultimately lowers broodlac quality. Potassium plays a vital role in translocation of assimilates in the plants, thus there is an increase in shoot succulence and percentage of female lac insect in plants situated in potassium rich soil. As lac is mainly produced by female lac insect, there is an increased possibility of higher lac yield due to potassium application. Similar phenomena of determination of sex due to the effect of external factors have been reported in case of other animals also.

Application of 450 g urea, 950 g single super phosphate and 800 g muriate of potash (approximately 200, 150 and 500 g N, P2O5 and K2O) and 2.0- 2.25 kg lime per tree every year will help in maintaining the vitality of the tree (canopy area 4.5 x 4.0 m2) in long run and better growth of healthy shoots for the next crop. Liming with finely ground lime should be done followed by light irrigation 2-3 months before onset of monsoon. Full dose of P2O5 and K2O and half dose of N are applied during monsoon and rest half of nitrogen is applied during male emergence. Experimental evidence support that dry matter production under unfertilized condition decreased 8.7 per cent at the end of third year, while the increasing trend of the same was noticed under fertilized condition (as per above dose) in winter season lac cultivation (*aghani*) in *Z mauritiana*. Fertilizer application is done on the shallow trenches dug at a radius of 60 per cent of canopy radius. As application of nitrogen at higher rates increases termite infestation, it should be avoided. For other hosts, fertilization of above elements can be done proportionately depending on the size of the concerned host.

Processes of lac cultivation on different hosts

Pruning is a very important operation for successful lac cultivation. Normally, pruning of *ber* is done in the month of February or March for trees to be inoculated in the month of July. But, in case of *kusmi* lac strains that emerge in the month of August, pruning may be delayed. Unexploited *ber* trees which are unpruned for past several years can be pruned up to mid April for inoculation in July for winter season *kusmi* lac but in the following years pruning should be done in the month of February or March. Pruning of *ber* trees is not recommended in June-July as summer season *kusmi* lac cultivation is not feasible on it. For immature *rangeeni* lac cultivation, normal pruning time is April-May. But, February pruned trees can also be used for this purpose for inoculation in Oct-Nov.

Both the crops of *kusmi* lac insect can be grown successfully on *kusum* tree. Therefore, harvesting cum pruning operation is done either in the month of Jan-February or in June-July.

Similarly, in case of *rangeeni* lac both the crops can be grown on *palas* tree. Pruning time is very much specific for *Palas* tree. Shooting response is seen properly when pruning is done during April-May.

Semialata has been established to be a very good lac host for winter season *kusmi* lac crop. A good harvest of the same can also be obtained from summer crop under irrigated condition. Harvesting cum pruning operation can be done during Jan-Feb and Jun-July depending on the crop.

Good quality broodlac inoculation with suitable rate is one of the key factors in achieving success in lac cultivation. It should be free from predators and pests. Inoculation at higher rate will affect tree health. For *kusmi* lac cultivation on *kusum* and *ber* normal broodrate irrespective of seasons is 20 g/m shootlength. Little variation exists in broodrate as well as process in case *rangeeni* lac cultivation. Inoculation rate for summer crop is much lower i.e. 10 g/ m shootlength. Therefore, a medium sized tree can be inoculated with 500 g broodlac/ tree so that both the lac and the tree remain safe in summer. In Jun-July, partial harvesting is done and self-inoculation is allowed for the next crop. For fresh inoculation on *palas* trees, rate of inoculation is 15-20 g/ m shootlength i.e. brood rate just doubles for rainy season crop. Unlike summer crop, total harvesting is done in rainy season crop. Very small spots of settlements are left on branches for immature harvesting cum pruning during April-May. If the farmer is interested to harvest immature lac in summer season, broodrate to be used for *palas* and *ber* is much higher i.e. 20-25 g/ m shootlength. Immature crop is harvested before advancement of summer. Therefore, the objective of using higher broodrate is maximizing production. At the same time, tree health is protected by harvesting lac crop before advancement of summer. While lac cultivation in *palas*, one should remember that pruning time should be April-May whatever may be the crop and harvest time. *Semialata* is a bushy lac host. Therefore, broodrate used is 20 g/plant in the first year and 50 g/ plant from second year onwards.

Ber tree cannot produce broodlac during summer. Similar problem is associated with *semialata* plants without irrigation facility. Therefore, farmers having only these hosts will not be able to grow broodlac throughout the year. They face shortage of broodlac for inoculation during June-July for *kusmi* and/or *rangeeni* lac. The problem can be sorted out only by arranging *kusum* tree and *semialata* plants under irrigated condition for summer *kusmi* crop and *palas* trees for summer *rangeeni* crop. The problem of *rangeeni* crop of course can be solved to some extent by using ficus trees for summer crop.

Normally, inoculation on *kusum* tree is done when the shoot attains an age of 18 months. The same for *ber*, *palas* and *semialata* is approximately 6 months. If the farmer inoculates all the hosts he possesses then no host tree will be available for lac cultivation in the next season. Therefore, farmer should maintain at least two coupe for majority of hosts on which lac cultivation is possible keeping the season in mind. Since *kusum* trees take 18 months to cultivate lac for the second time, it requires 4/5 coupe system for growing lac throughout the year. Both immature crop and broodlac can be harvested from *palas* trees. Therefore, three coupe system is followed in case of *rangeeni* lac cultivation on *palas*. First two coupe are used for broodlac production purpose in alternate years. The third coupe is maintained for cultivation of immature crop. Crop cycle is as follows:

Pruning in April (1st year) in the first coupe • Light inoculation in first coupe during November (1st year) • Pruning in April (2nd year) in second and third coupe• Self inoculation in July (2nd year) in first coupe• Full crop harvesting in November (2nd year) in first coupe, light inoculation in second coupe and inoculation at higher rate of in third coupe • Pruning in first coupe in April (3rd year) and total harvesting in third coupe. Farmer can include *ber* trees in the third coupe for harvesting immature lac crop.

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