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EFFECT OF WEATHER AND APPLICATION OF PRIMARY NUTRIENTS AND LIMING TO *BER* (*ZIZIPHUS MAURITIANA*) ON WINTER SEASON (*AGHANI*) *KUSMI* LAC PRODUCTION

by

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Abstract

An experiment was carried out during 2007-08 to 2009-10 at the research farm of Indian Institute of Natural Resins and Gums, Ranchi (23°23'N longitude, 85°23' E latitude and 650 m above MSL) to find out the effects of different primary nutrients (N, P_2O_5 and K_2O) and liming on established plantation of *ber* (*Ziziphus mauritiana* Lam.) for the production of winter season (*aghani*) *kusmi* crop of *Kerria lacca* (Kerr). Treatments comprised of four levels of N (0,100, 200 and 400 g/ tree), two levels each of P_2O_5 (0 and 150 g/ tree), K_2O (0 and 150 g/ tree) and liming (liming and no liming). Randomized Block Design was used in three replications and effect of years (weather variation) was estimated as the fifth factor. Potassium application led to reduction in male population by 3%. Significant interaction effect in between year and potassium application was noticed on lac yield ratio (output/ input). Potassium application with liming (at soils of higher pH) was found detrimental to lac production, while its application under low soil pH conditions increased lac yield ratio significantly. An increase in yield ratio to the tune of 97% was observed in potassium application on soil pH 4.5 as compared to that in pH 5.6. Lower adsorption of potassium in exchange complex under lower soil pH conditions might have increased the potassium availability to the plant. Eventually, increased translocation of assimilate might have positively affected the nutrition of lac insect and lac yield ratio.

Keywords : *Kerria lacca, Ziziphus mauritiana, yield ratio, primary nutrients, liming*

Introduction

Lac resin, the product of commerce is obtained from lac insect, *Kerria lacca* (Kerr) is the commonly used lac insect in India. Lac finds its application in diverse fields (Ramani et al. 2007 and Sarkar, 2002). There are more than 400 recorded hosts for lac insect, but traditionally, three are most important—*kusum* (*S. oleosa* (Lou.) Oken.), *ber* (*Z. mauritiana* Lam.) and *palas* (*B. monosperma* Lam.) (Roonwal, 1962). Broodlac is the lac encrustation grown on hosts within which gravid females full of eggs before larviposition is the propagating material for lac insect.

In India, lac is cultivated in 50 districts spread over 12 states. A total of 16495 tons of raw lac was produced in 2009-10 (Pal et al., 2010). In Jharkhand, lac cultivation constitutes the second most important source of rural family income (Pal et al., 2007). Due to its diversified uses, demand of lac is increasing globally and price of the commodity is also in its increasing trend.

Lac cultivation is a profitable venture and profitability increases significantly, when lac cultivation is done for broodlac purpose, rather than sticklac (scraped lac encrustation) purpose.

Ber (*Z. mauritiana*) is a very common lac host in many of the states of the country including Jharkhand, West Bengal, U.P. Orissa, A.P., Maharashtra, etc. for lac insect culture. Farmers prefer this host for growing lac due to its abundance and better yield. In Jharkhand, utilization of the host is more than 50% of the available population (Pal and Bhagat, 2006). Indian lac insect *Kerria lacca* is represented by two strains *i.e*. *kusmi* and *rangeeni*, and both the strains grow well on this host. Growing *rangeeni* lac on *ber* trees for *baisakhi* (summer

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season) crop is a common practice. Since yield of *rangeeni* lac is comparatively low and satisfactory brood lac production is not possible in summer, it is advisable to grow winter season (*aghani*) crop of *kusmi* lac on *ber* trees. Average lac productivity per annum is almost two times in *kusmi* lac than *rangeeni* on *ber* trees (Mishra et al., 2000).

Ber trees require to be pruned every year in the month of February for lac inoculation in July for winter season *kusmi* lac crop. Over and above *kusmi* lac exhaust *ber* trees more than *rangeeni* crop, as yield output per unit length is more than that of the later. Therefore, supply of nutrition to the host is a must for scientific lac cultivation on *ber*. The most challenging aspect in lac cultivation is the fact that nutrient required for the growth of the host may be harmful for the lac crop. Besides, these nutrients have been reported to influence growth of mealy bug (Fennah, 1959) and also of lac (Thakur, 1932). The first author demonstrated positive and negative effects of N and K, respectively while the effect of P was indifferent to the growth of mealy bug. So far, very less work has been conducted on the effect of plant nutrients on growth of lac hosts and lac yield. Therefore, the references are very infrequent. Nitrogen, phosphorous and potassium being the primary nutrients are required for plant growth, and also supposed to influence lac yield significantly.

Material and Methods

A field experiment was conducted in the Institute Research Farm, Namkum, Ranchi (23°23'N longitude, 85°23' E latitude and 650 m above MSL) during 2007-08 to 2009-10 to evaluate different levels of liming, nitrogen, phosphorus and potassium on established plantation of *ber* for shoot growth and *kusmi* lac production in winter season. Two levels each of liming (liming and no liming), phosphorus (0 and 150 g/ tree) and potassium (0 and 150 g/ tree) were combined with four levels of nitrogen (0, 100, 200 and 400 g/tree) to make 32 combinations replicated thrice. Agriculture lime as recommended by Gupta (1991) was added and mixed with soil every year under tree canopy (4.5×4.0 m^2). Liming was done 2 months before fertilizer application. Since general liming operation was done in the farm during 2006-07 @ 2.0 tons/ ha, pH values of first year were higher than the next two years. This condition facilitated to establish differential role of nutrients under different pH conditions.

Half dose of nitrogen and full dose of K_2O and P_2O_5 were applied after onset of monsoon matching 15 days before lac insect inoculation, which was done during 15-20 July every year. Inoculation with *kusmi* lac was carried out @ 20 g broodlac per metre shoot length and *phunki* (empty broodlac after insect emergence) was removed 21 days after inoculation. Crop protection schedule was followed as per recommendation. First spray was done with endosulfan @ 0.05% and carbendazim 0.01% while second and third sprays were carried out with dichlorvos 0.03% and carbandazim 0.01%.

Shoot dry matter content (%) was estimated by weighing fresh and dry weight separately. For measuring dry weight, fresh shoots were dried in oven at 65°C temperature till constant weight was obtained. Shoots settled with lac insect were sampled at 42 days after inoculation for recording number of males, simply by counting method under magnifying glass within an earmarked area.

To visualize the growth of lac crop as influenced by different soil fertility factors, mortality of lac crop on thick (> 1.0 cm basal diameter) and thin (< 1.0 cm basal diameter) shoots was recorded by counting and reported in terms of percent. Two different sizes of shoots were taken for the study as sustenance of lac varies widely depending upon the shoot size/ diameter.

Harvesting was done manually in the month of February. Dead lac encrustation (unfit for use as broodlac) during growth period was weighed separately for recording rejected broodlac. For recording sticklac yield, 500 g broodlac from each treatment was sampled randomly, scrapped and weighed. Lac encrustation is the covering of lac insect by resin. Encrustation thickness was measured by vernier caliper based on representative samples of five pieces. With growth of the insect, the encrustation thickness keeps on increasing.

Composite soil sampling was done from canopy area of each tree in the month of January every year and were analyzed for different physico-chemical properties. Soil pH was estimated by pH meter and potassium and calcium carbonate content were estimated by standard procedure (Ghosh et al., 1960).

To get a comprehensive picture of different years on different growth and yield attributes, data were subjected to statistical analysis following Randomized Block Design in factorial mode assuming year as the fifth factor.

Results and discussion

Effect of different plant nutrients:

Potassium application reduced male population significantly as compared to control (Table 1). Therefore, female population had gone up indirectly. Since males do not contribute much to resin production, K_2O application can be considered a boon for lac production.

Table 1: Mortality and male % of lac insect as affected by levels of liming, N, P_2O_5, K_2O applications and weather

Factors	Male %	Thin shoot % with dead lac	Thick shoot % with dead lac
L_0	29.38	65.62	20.29
L_1	29.41	62.42	20.74
$CD_{(.05)}$	1.83	5.42	3.37
N_0	29.40	62.88	18.32
N_{100}	29.21	63.01	20.83
N_{200}	28.55	62.18	19.94
N_{400}	30.43	68.00	22.96
$CD_{(.05)}$	2.59	7.67	4.77
P_0	29.77	63.35	20.28
P_{150}	29.02	64.69	20.74
$CD_{(.05)}$	1.83	5.42	3.37
K_0	30.82	65.13	18.66
K_{150}	27.98	62.91	22.37
$CD_{(.05)}$	1.83*	5.42	3.37*
Weather			
I Year	30.80	58.62	52.28
II Year	14.38	57.91	3.65
III Year	43.00	75.53	5.62
$CD_{(.05)}$	2.24*	6.64*	4.13*

*Significant at 5% level

Table 2: Effect of liming, application of N, P_2O_5 and K_2O and weather on lac yield ratio

Factors	Yield ratio	Rejected yield ratio	Sticklac to brood ratio	Sticklac to Sticklac ratio	Encrustation Thickness (cm) (kg/ ha)	Soil available K_2O	Soil pH	Calcium carbonate (%)
L_0	5.90	1.76	4.08	8.57	0.63	138.13	4.97	2.18
L_1	5.58	1.86	4.19	8.50	0.63	155.01	5.08	2.23
$CD_{(.05)}$	0.75	0.27	0.60	1.17	0.02	11.68*	0.13*	0.17
N_0	5.90	1.88	4.17	8.62	0.63	146.67	5.02	2.22
N_{100}	5.35	1.67	3.88	8.23	0.64	148.24	5.01	2.19
N_{200}	6.08	1.79	4.39	8.93	0.64	145.76	4.99	2.21
N_{400}	5.63	1.91	4.09	8.35	0.61	145.60	5.09	2.20
$CD_{(.05)}$	1.07	0.39	0.85	1.65	0.03	8.26	0.09	0.12
P_0	5.85	1.83	4.10	8.56	0.63	144.11	5.09	2.22
P_{150}	5.63	1.79	4.17	8.50	0.64	149.02	4.96	2.19
$CD_{(.05)}$	0.75	0.27	0.60	1.17	0.02	11.68	0.13*	0.17
K_0	5.56	1.85	3.99	8.14	0.63	141.16	5.06	2.23
K_{150}	5.92	1.77	4.28	8.93	0.63	151.98	5.00	2.19
$CD_{(.05)}$	0.75	0.27	0.60	1.17	0.02	11.68*	0.13	0.17
Weather								
I Year	4.90	1.77	3.31	5.71	0.58	162.98	5.65	3.25
II Year	5.16	0.99	4.53	7.81	0.68	128.56	4.87	1.82
III Year	7.15	2.68	4.56	12.07	0.64	148.16	4.56	1.55
$CD_{(.05)}$	0.92*	0.34*	0.74	1.43*	0.03*	7.15*	0.08*	0.10*

*Significant at 5% level

Simultaneously, its effect on inoculable shoots on which insect grows was also examined. Results indicated that dry matter percent of shoots with K_2O application decreased significantly as compared to no application. It signified that succulence of such shoots increased due to K_2O application. Unlike other insects, sex determination in case of lac insect does not take place during birth; rather it takes place at later stages of growth (before male emergence). Increased succulence might have created favourable condition for lac insect to draw much more nutrition from such shoots than control. In case of honey bee, it is established that special nourishment with royal jelley and water is required for proper development of queen bee as compared to other sub-casts, as the former has to lay eggs in large quantity and also it lives a considerably longer period (Bin et al., 2008, Haddadi et al., 2006). The same phenomenon might have occurred in case of lac insect for which the succulent shoots (meets up extra water requirement) obtained by K_2O application have favoured growth of lac insect by supplying proper food and eventually gave rise to more female. Since K_2O helps in efficient translocation of assimilates and maintains water relation in the cells, shoot succulence increases considerably.

Lac insect mortality on thin and thick shoots in relation to liming, nitrogen and phosphorus application was found to vary a meager and effect was non-significant. However, due to potassium application, lac crop on 22.4% shoots of bigger size (thick) were affected (Table 1) as against 18.7% in control. The difference was significant and it could be attributed to short supply of assimilate. Shoots of potassium applied trees became more succulent as a result of which lac crop on those shoots got a very favourable condition for development due to potassium application. Demand of assimilate had been more than supply and ultimately lac crop died. Inoculation at recommended rate is meant for average soil condition. But soils which are favourable as far as K_2O nutrition is concerned, may not hold good to this rate of inoculation. In such condition brood rate should be reduced so that lesser number of insects can settle per shoot which will be able to cater adequate nutrition to the insects settled on it.

Lac yield ratio is the powerful index regarding influence of any factor on lac yield. It is the ratio of lac yield obtained to that of lac inoculated. Factors like nitrogen, phosphorus and potassium application did not influence lac yield significantly. But interaction effect of year and potassium was found significant (Table 6). Interaction effect of liming and potassium on yield ratio of three years (Table 3, 4, 5 and 7) has been presented separately. Over all effect and that of first year was found to be significant.

Soil pH of the newly limed area was 5.6 in first year as against 4.8 and lower in subsequent years. Results depicted in interaction tables indicated that on higher pH in the first year, neither liming nor potassium application was good for lac yield and on lower pH in subsequent years, potassium application was beneficial. There had been higher percent of calcium carbonate and available soil potassium in the first year (Table 2), compared to other years. Higher uptake of calcium and potassium due to external application might have imparted resistance to *ber* trees against growth of lac insect. But, in lower pH (i.e. on second and third year), these two inputs were present in lesser amount in the soil and thus application of potassium proved to be beneficial as it helped translocation of food materials for the insect. When the soil test values for available potassium was lesser (Table 2), applied potassium had given good response in terms of lac yield ratio. In addition, due to lower pH on second and third year, the CEC of the soil decreased and more fraction of applied potassium came to soil solution instead of being adsorbed in exchange complex. This phenomenon had increased potassium uptake, which takes place by diffusion mechanism in the soil. General lac production trend in second and third year suggested that (lower rainfall and pH condition) only liming is the worst treatment (Table 5), while a combination of liming and potassium application is the best treatment. Same kind of results are found in potassium and year interaction (Table 6) where potassium application has shown

Table 3: Liming x potassium interaction on yield ratio in 2007-08

	L_0	L_1
K_0	6.78	4.33
K_{150}	4.52	3.99
$CD_{(0.05)}$	1.65*	

*Significant at 5% level

Table 5: Liming x potassium interaction on yield ratio in 2009-10

	L_0	L_1
K_0	6.66	5.56
K_{150}	7.85	8.30
$CD_{(0.05)}$	NS	

Table 7: Liming X potassium interaction on yield ratio (over all)

	L_0	L_1
K_0	6.06	5.74
K_{150}	5.05	6.10
$CD_{(.05)}$	1.0*	

*Significant at 5% level

Table 4: Liming x potassium interaction on yield ratio in 2008-09

	L_0	L_1
K_0	4.75	4.79
K_{150}	5.08	6.02
$CD_{(0.05)}$	NS	

Table 6 : Year X potassium interaction on yield ratio

	K_0	K_{150}
I Year	5.65	4.16
II Year	4.91	5.41
III Year	6.11	8.20
$CD_{(.05)}$	1.30*	

*Significant at 5% level

Table 8: Weather parameters during major growth period in different cropping years

	2007-08				2008-09				2009-10			
	Mean Temp (^{0}C)		Mean R.H. (%)	Rainfall (mm)	Mean Temp (^{0}C)		Mean R.H. (%)	Rainfall (mm)	Mean Temp (^{0}C)		Mean R.H.	Rainfall (mm) (%)
	Max	Min			Max	Min			Max	Min		
July	32.0	22.9	81.5	365.7	30.4	22.5	83.0	486.9	22.6	30.3	81.7	225.6
Aug	30.5	22.7	85.5	362.6	30.8	22.7	82.5	309.2	22.2	28.8	81.3	273.0
Sep	29.6	22.3	84.0	369.4	31.7	21.5	77.0	248.6	23.3	29.5	76.4	283.9
Oct	29.3	16.4	64.0	29.3	31.1	18.4	66.0	0.3	20.0	29.2	58.8	63.7
Nov	27.1	13.3	63.0	0.0	29.0	10.5	65.0	0.0	12.4	26.1	68.2	23.6
Dec	25.2	7.0	51.5	0.0	27.4	9.1	57.0	0.0	6.1	22.8	56.0	0.0

negative results in first year and positive results in next two years in medium and low pH conditions, respectively.

Quality parameter of Broodlac has been represented by lac encrustation thickness (Table 2). Significantly lower thickness of encrustation was observed on first year. Higher soil pH values due to liming and subsequently higher availability of calcium could be the reason for the reduced thickness of encrustation. Therefore, excess of liming can affect negatively on encrustation thickness and eventually on brood quality as the brood with more thickness can give birth to more number of crawlers.

Effect of Weather:

Yield data shown in Table 2 revealed that highest yield ratio was obtained in third year, which was 45.9% and 38.5% higher than that of first and second year respectively. Weather differences influenced lac crop mortality significantly on thick and thin shoots (Table 1). Lac mortality on thick shoots was found to be the highest (52%) in first year and the least (3.6%) in the second year. Perusal of data indicated that lac mortality in the first year was affected significantly on thick shoots. Since lac production is higher on thick shoots, lac yield ratio was affected drastically in the first year. Other similar yield ratios were also affected in the similar pattern. Comparatively higher rainfall in first year after male emergence (in September) might have created favourable condition for the growth of sooty mold and caused considerable damage to lac crop (Table 8).

However, reverse picture was found in case of lac mortality on thin shoots. The higher lac mortality on thick shoots during high rainfall years (first year) could be due to unfavourable weather condition. But, higher mortality of lac on thin shoots in the year of less rainfall (third year) could be due to insufficient supply of assimilate. Since thick shoots are affected during high rainfall year and lac yield from thick shoots is also high, lesser rainfall could be considered better for winter season lac cultivation. Rainfall pattern of third year was favourable for lac insect growth due to lesser rainfall spread over a longer period. As a result, thin shoots were very much exhausted by lac cultivation and mortality of lac took place due to short supply of food.

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