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SOIL FERTILITY MANAGEMENT OF ESTABLISHED *BER* (*ZIZIPHUS MAURITIANA*) PLANTATION UNDER LAC CULTIVATION

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ABSTRACT

Lac cultivation is a profitable option of agriculture for the farmers of Jharkhand, Chhattisgarh, Odisha, Madhya Pradesh, West Bengal etc. An experiment comprising different levels of liming (liming and no liming), nitrogen (0, 100, 200 and 400g/tree), phosphorus (0 and 150g/tree) and potassium (0 and 150g/tree) to make 32 treatment combinations replicated thrice was launched in the research farm of Indian Institute of Natural Resins and Gums, Ranchi (23°23'N longitude, 85°23' E latitude and 650m above MSL) during 2007-10 to generate information on level of soil fertility required to sustain growth of the tree under *kusmi* lac cultivation in the winter season. Findings of the experiment indicated that under control condition, the average bio-mass production per tree started reducing @ 0.81kg/ year and with application of 400g nitrogen, 150g each of phosphorus and potassium along with liming could increase bio-mass production per tree @ 4.36kg/ year under lac cultivation. Chlorophyll Content Index (CCI) was significantly affected by liming. At 45 days after fertilizer application, lime applied trees registered 10 percent increase in chlorophyll content index. Similarly, potassium application could lower shoot dry matter by 1.76 percent, *i.e.* shoot succulency increased. Experimental data revealed that nitrogen application upto 200 g/ tree did not influence termite infestation significantly. However, rates beyond it increased infestation significantly. Due to liming, soil available potassium level, organic carbon, electrical conductivity and pH increased by 12, 7, 12 percent and 0.11 units, respectively. Therefore, increases in growth attributes have been observed under liming.

INTRODUCTION

Ber (*Ziziphus mauritiana*) is a less important fruit crop, but its nutritional value is much superior to many of the common fruits (Bakhshi and Singh, 1974). It is cultivated as a commercial cash crop in the states of Punjab, Haryana, Rajasthan and many other states for fruit production. Besides, its use as a fruit crop, it is used for cultivation of lac in the states of Jharkhand, Chhattisgarh, Odisha, Madhya Pradesh, West Bengal etc. Being a high value commodity, lac cultivation is a very profitable venture. Regardless of its use either for fruit or for the cultivation of lac, it has to undergo pruning operation for a successful crop. Comparatively heavy pruning is practiced in case of lac cultivation. Therefore, the tree has to bear a lot of stress due to lac cultivation. Besides pruning, infestation of termite is another problem for sustained growth of *ber* trees in acid lateritic soils of the country. Further, the stress is elevated multifold in a low fertile and barren land. In the arid region of northwest India, farmers do not apply any manure or fertiliser in *ber* orchards other than that given at planting time (Verma and Gujar, 1994). Regular manuring is, however, essential to replenish the nutrient removal by the tree through lac harvests and annual pruning besides losses from the soil. According to Ahlawat *et al*. (1990), as many as 75 % of the orchards in the arid subtropics were deficient in organic N and 90 % in P_2O_5 but none in K_2O. Under this condition tree health suffers and gradually makes it unsuitable for lac cultivation. Farmers go on cultivating lac without considering the tree health. Regular *kusmi* lac (winter season) cultivation on *ber*, exhausts the tree rapidly and proper shoots are not obtained in subsequent seasons, *i.e.* shoot bio-mass decreases progressively. Under normal condition, lac crop grows 5-6 times its weight on *ber* trees within 6 months. As a result, its adverse effect is observed on fruit production and tree vigour. Ghosal (2007) reported that fruit number, length of shoot and number of secondary branches reduced up to 69, 22 and 35 % respectively, due to lac cultivation.

Maintenance of tree vigour is possible by maintaining proper soil fertility. So far, there has been no report on level of soil fertility required for maintaining vigour of *ber* tree under lac cultivation. However, Dhatt *et al*. (1993) reported that best results have been obtained in young orchards by application of 400g N + 100g P + 200g K per tree for fruit production. Similarly, Lal *et al*. (2003) reported 500g N, 500g P_2O_5 and 50g K_2O/plant was found to be the best for obtaining the highest fruit yield in Rajasthan soils. The available nutrient present in soil influences tree growth and lac yield in differential pattern. Any nutrient responsible for tree growth may not support growth of lac insect and *vice versa*. Too much growth of shoot makes it dense and lac yield suffers (Ghosal and Mishra, 2009), while lac cultivation under lesser growth of shoot in nutrient stress condition make the tree unsuitable for lac cultivation, gradually. Therefore, a balanced fertilization should be done so that neither tree health nor lac production suffers.

Macro nutrients e.g. nitrogen, phosphorus and potassium influences plant growth and fruit yield significantly (Lal *et al*., 2003). Besides, dynamics of soil fertility is complex in nature and variation in soil pH (through liming) is the most important component in it. Application of lime is expected to influence availability of other nutrients significantly (Singha, 2006). It is therefore, important to know role of different soil fertility factors in increasing fertility level of acid lateritic soil of Chhotanagpur.

Therefore, an experiment was planned to generate information on rates of nutrients and soil amendments sustaining growth of *ber* tree under lac cultivation. Following were two broad objectives:

How growth of *ber* trees is influenced by different rates of nutrients

How soil fertility status is influenced by application of different rates of nutrients/ ammendments

MATERIALS AND METHODS

A field experiment was conducted in the Institute Research Farm, Namkum, Ranchi (23°23′N longitude, 85°23′ E latitude and 650m 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 150g/ tree) and potassium (0 and 150g/ tree) were combined with four levels of nitrogen (0, 100, 200 and 400g/tree) to make 32 treatment combinations replicated thrice. Agriculture lime as recommended by Gupta (1991) was added and mixed with soil every year under tree canopy (4.5 x 4.0m^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 mode of availability 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 @ 20g 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.

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 all soil physico-chemical properties were estimated by standard procedure (Ghosh *et al*., 1960).

Rainfall received during July to December in three years was 1127, 1045 and 869mm respectively. 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 factors on growth

Influence of different plant nutrients/ amendments on shoot dry matter percent, an important parameter for lac cultivation did not hold good equally to all the factors. Only potassium application could bring an appreciable amount of reduction in the dry matter per cent of inoculable shoots. The lesser the dry matter per cent, the more the shoot will be succulent. Therefore, it can be stated that, inoculable shoot become more succulent due to potassium application, which is supposed to contribute to higher lac production. Similar result has been reported by (Abayomi, 1987) in sugarcane. Increased succulence could be due to increased water uptake on potassium applied trees (Zengin *et al*., 2009). Moreover, it is involved in activating a wide range of enzyme systems which regulate photosynthesis, water use efficiency and movement, nitrogen uptake and protein building (Nguyen *et al*., 2002).
Nitrogen applied @ 400g/ tree affected termite infestation significantly on tree trunk. As compared to control, highest rate of nitrogen application increased termite infestation about 33 per cent. In general, application of nitrogen is known to decrease termite infestation on annual crops (Annon, 2000) where underground plant parts are affected. Therefore, in case of *ber*, soil application of nitrogen might have driven termite infestation on above ground parts *i.e.* tree trunk.
Biomass production is the most important parameter of plant growth. Significant effect of liming, nitrogen and potassium application was noticed on pruned tree biomass increase on third year and mean pruned biomass ratio (percent). Mean tree biomass of pruned branches increased 19% due to no liming and 29% due to liming. Nitrogen application could increase the values from 26-35% due to different levels as against 11% in its control. While the values were 33% and 16% in case of potassium application. Only phosphorus application could not prove its superiority over control. Highly acidic soil of the region might have acted as a barrier to show its effect due to high rate of phosphorus fixation. It is also expected that it will show its effect if applied after liming (Oluwatoyinbo *et al*., 2005). With this trend of increase in biomass, it can be mentioned that liming before monsoon and application of N, P_2O_5 and K_2O @ 400, 150 and 150g/ tree after onset of monsoon may be recommended to cater need of *ber* plantation under lac cultivation. It is worthwhile to mention that under no fertilization biomass production reduced sharply at the end of third year (Fig. 1).

Effect of year (weather) on growth

Mean chlorophyll content index at different time intervals, per cent increase in shoot diameter and length and bio mass production per tree varied significantly due to different years (Table 1), which may be considered as the weather effect. Maximum increase was found in the third year. In fact, rainfall received in the third year was minimum for which sunlight attenuation was maximum. At the same time, run off loss of

Table 1: Plant growth parameters as affected by levels of liming, N, P_2O_5 and K_2O applications

Factors	CCI 15 DAA	CCI 30 DAA	CCI 45 DAA	Percent increase in shoot diameter	Percent increase in shoot length	Termite infestation (Percent coverage)	Shoot dry matter Percent (Aug)	Bio mass (Kg/ tree)	Bio mass increase (on 3rd year kg/ tree)
L0	20.09	22.04	25.25	37.83	41.15	29.65	39.89	12.9	2.50
L1	21.98	24.32	27.95	38.27	42.43	33.78	39.90	14.3	4.14
$CD_{(.05)}$	1.06*	1.78*	2.18*	3.81	4.62	6.15	1.12	1.5	1.86*
N0	21.02	24.01	25.77	35.16	38.42	29.17	40.25	14.3	1.64
N1	20.33	21.65	25.16	39.15	42.58	30.42	40.16	12.2	3.22
N2	20.74	23.29	26.71	39.39	45.22	27.99	39.72	14.5	3.78
N3	22.06	23.77	28.75	38.51	40.94	39.31	39.46	13.4	4.63
$CD_{(.05)}$	1.49	2.52	3.08	5.39	6.53	8.70*	1.58	2.1	2.62*
P0	20.87	22.38	26.13	38.02	42.02	33.33	39.45	13.7	3.80
P1	21.21	23.98	27.07	38.08	41.56	30.10	40.35	13.5	2.84
$CD_{(.05)}$	1.06	1.78	2.18	3.81	4.62	6.15	1.12	1.5	1.86
K0	20.41	23.39	25.97	38.62	43.53	31.94	40.78	13.4	2.10
K1	21.66	22.97	27.22	37.48	40.05	31.49	39.02	13.8	4.54
$CD_{(.05)}$	1.06*	1.78	2.18	3.81	4.62	6.15	1.12*	1.5	1.86*
Y I	19.14	18.70	21.08	39.43	27.56	19.27	39.70	13.0	-
Y II	16.63	22.55	29.89	32.80	40.48	37.81	40.67	11.5	-
Y III	27.33	28.29	28.82	41.92	57.33	38.07	39.32	16.3	-
$CD_{(.05)}$	1.29*	2.18*	2.67*	4.67*	5.66*	7.54*	1.37	1.8*	-

*Significant at 5% level; CCI: Chlorophyll Content Index; DAA: Days After Application of fertilizer

Table 2: Soil residue of different nutrients as affected by application rates

Factors	N kg/ha	P_2O_5 kg/ha	K_2O kg/ha	$CaCO_3$ (Percent)	Organic C (Percent)	E.C. DSM^{-1}	pH
L0	189.00	28.89	138.13	2.18	0.42	0.16	4.97
L1	203.00	30.16	155.01	2.23	0.45	0.18	5.08
CD	14.00	2.67	11.68*	0.17	0.03*	0.02*	0.13*
N0	197.70	29.89	146.67	2.22	0.44	0.16	5.02
N1	187.67	29.09	148.24	2.19	0.42	0.17	5.01
N2	197.33	29.79	145.76	2.21	0.43	0.17	4.99
N3	202.41	29.34	145.60	2.20	0.44	0.18	5.09
CD	10.35	1.89	8.26	0.12	0.02*	0.01	0.09
P0	197.59	29.53	144.11	2.22	0.43	0.17	5.09
P1	194.97	29.52	149.02	2.19	0.43	0.17	4.96
CD	14.64	2.67	11.68	0.17	0.03	0.02	0.13*
K0	199.72	28.84	141.16	2.23	0.44	0.17	5.06
K1	192.84	30.21	152.00	2.19	0.43	0.17	5.00
CD	14.64	2.67	11.00	0.17	0.03	0.02	0.13
Y I	296.14	37.64	162.98	3.25	0.61	0.17	5.65
Y II	146.09	27.38	128.56	1.82	0.34	0.19	4.87
Y III	146.61	23.56	148.16	1.55	0.34	0.15	4.56
CD	8.97*	1.63*	7.15*	0.10*	0.02*	0.01*	0.08*

*Significant at 5% level

the nutrient was also minimum, as a result of which larger proportion of the applied nutrient could be utilized by the trees and growth of the same was much better on the third year compared to other two years. The particular experiment revealed that growth of *ber* trees and monsoon rainfall were related inversely.

Infestation of termite is a perennial problem for agricultural production system in the lateritic soils of Chhotanagpur plateau. Experimental findings suggested that extent of termite infestation in second and third year was almost twice than that of first year (Table 1). Soil pH during the second and third year was reduced significantly (Table 2), which might have affected population build up of termites and its infestation during the period as termites are the most tolerant to acidity with maximum abundances at low pH (Lavelle *et al.*, 1995).

Effect of nutrient application on soil fertility

Effect of the application of different nutrients and year on soil fertility has been presented on Table 2. Soil fertility level of the first year was significantly superior to other two years due to residual effect of liming done two years before starting the experiment. Results indicated that year was the most important factor influencing soil fertility. It influenced all the fertility attributes i.e. soil available nitrogen, phosphorus, potassium, $CaCO_3$ %, OC %, E.C and pH. Higher pH during first year might have influenced the other fertility factors significantly. With passage of time and runoff losses, the $CaCO_3$ content washed away and pH tended to stabilize, resulting in general reduction of soil fertility condition excepting in case of potassium content of third year, which was found to increase significantly over second year. It could be due to significantly lesser rainfall (Bolland and Russel, 2010) on that year. Incidentally, higher value of soil potassium in first year could be due to higher organic carbon content of soil on that year.

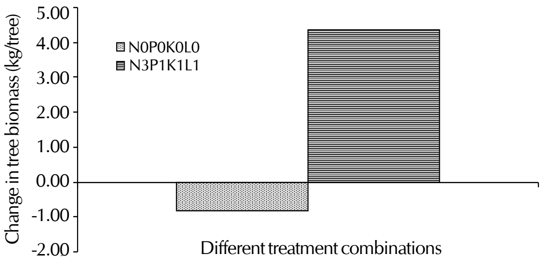

Figure 1: Growth rate of *ber* trees as affected by fertilization rates
Change in biomass production/tree/year due to different treatment combination

Higher organic carbon percent in the first year could be due to higher soil pH on that year, when microbial activity had favoured decomposition of organic matter very efficiently (Stenberg *et al.*, 2000; Fuentes *et al.*, 2006).

The second important factor, which could bring change in soil fertility was liming. It increased the potassium, organic carbon percent, electrical conductivity and soil pH significantly. Mosquera-Losada *et al.,* 2011 had also reported similar findings. Regarding other nutrients *i.e.* nitrogen, phosphorus and potassium, none could bring appreciable change in soil fertility due to their application.

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