Effect of phosphorus on growth, yield and nutrient uptake of rainfed mulberry (*Morus alba* l.) and its economics in Chotanagpur plateau of Jharkhand

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ABSTRACT

A field experiment was conducted at Regional Sericultural Research Station, Ranchi, Jharkhand during 2001-2004 to study the effect of graded doses of phosphorus on mulberry (Morus alba L.). Graded doses of phosphate (0 to 60 kg P_2O_5 $ha^{-1}yr^{-1}$) along with recommended doses of nitrogen and potash were applied to a low–P sandy loam yellow-reddish coarse textured soil under rainfed condition. Analysis of three years' pooled data revealed that the growth attributes, yield, nutrient uptake, net return and benefit : cost ratio were influenced significantly due to hosphate application up to 60 kg P_2O_5 $ha^{-1}yr^{-1}$.

Key words : Mulberry, phosphorus, nutrient and rainfed.

Mulberry is the only food plant for silkworm, *Bombyx mori* L. It is an important crop in the Chotanagpur plateau of Jharkhand. It is normally cultivated in yellow reddish coarse textured soil under rainfed condition characterized by low fertility, especially low in P status. Mulberry is classified as one of the crops very sensitive to P deficiency in soil. Mulberry crop responses positively to P application under irrigated condition and this has been reported by some researchers (Kasiviswanathan and Iyengar, 1966; Ray *et al*., 1973); however, report is scanty in this aspect under rainfed condition, particularly in Eastern India. Application of P in the soils of Chotanagpur plateau assumes significance due to their high P fixing capacities and leaching of K. These relationships in plant-soil system vary due to several soil-plant factors. These nutrient interaction effects may be synergistic, antagonistic or simply additive as reported by several workers (Adams, 1980; Tandon, 1987; Rattan and Saharan, 1994) in different crops. Results of studies on the effect of different rates of P application on growth attributes, yields, nutrients uptake, net return, benefit: cost ratio of mulberry and so also the nutrient status of soil are presented in this paper.

MATERIALS AND METHODS

The study was conducted at Regional Sericultural Research Station, Ranchi with mulberry (variety S_1) as the test crop planted at 90 cm x 90 cm spacing in a randomized block design with four replications under rainfed condition during 2001 - 2004 and the plantation was maintained following the recommended package of practices. Initial physicochemical characteristics of experimental soil are given in Table 1.

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Mulberry crop received 150 kg N and 50 kg K_2O/ ha/ year along with FYM @ 10 mt/ ha/ year as per recommendation in all the treatments. Graded doses of P_2O_5 were applied as basal @ 0, 15, 30, 45 and 60 kg/ ha/ year. The NPK were applied in the form of urea, single super phosphate and muriate of potash. Growth attributes, namely, plant height, number of shoots/ plant, number of leaves/ plant and leaf area were recorded. Leaf and shoot yield data were recorded crop wise. Annually three crops were harvested and the annual yield was computed by pooling three years' data. Nitrogen, phosphorus and potassium contents in leaf were analyzed as per the standard procedures (Piper, 1966) and ultimately the uptake of these nutrients was calculated. Initial and post-harvest soil samples were analyzed as per standard procedures (Jackson, 1973; Black, 1965; Subbiah and Asija, 1956). Finally, the benefit : cost ratio has been worked out.

RESULTS AND DISCUSSION

Growth attributes

Plant height increased significantly due to P application from 30 kg to 60 kg P_2O_5 ha/ year over control, the maximum being with 60 kg P_2O_5, whereas number of leaves/ plant and leaf area showed significant increase from 45 kg to 60 kg P_2O_5/ ha/ year over control, the maximum being with 60 kg P_2O_5 (Table 2). Number of shoots/ plant did not increase significantly due to P application.

Productivity

The mulberry leaf yield (pool of 3 years) increased significantly due to P application from 30 kg to 60 kg P_2O_5/ ha/ year over control, the maximum being with 60 kg P_2O_5 and the mulberry shoot yield has also showed the same trend. Moisture contents of leaf increased significantly due to P application of 45 and 60 kg P_2O_5/ ha/ year over control, the maximum being with 60 kg P_2O_5, whereas moisture contents of shoot increased significantly due to P application from 30 to 60 kg P_2O_5/ ha/ year over control, the maximum being with 60 kg P_2O_5 (Table 3).

The increase in growth and yield of mulberry may be due to the involvement of phosphorus in cell division and development of meristamatic tissue, energy storage, help in promotion of root and shoot growth. Shankar (1997) reported positive effects of phosphorus on stimulating root growth, increasing resistance to drought and many quality parameters and increasing foliage production in mulberry. Further, Radha *et al.* (1988) reported that deficiency of phosphorus in nutrient solution reduced shoot length, root length, shoot weight, root weight and ultimately reduced the total leaf yield, confirming the importance of phosphorus.

Nutrients uptake and ratio

Phosphorus content in mulberry leaf was found significant from 30 to 60 kg P_2O_5 ha/year (Table 4) which corroborates the findings of Subbaswamy *et al.* (1999 and 2001). Nitrogen and phosphorus uptake by mulberry leaf was found to be statistically significant up to 60 kg P_2O_5 / ha/ year (Table 4). Prasad *et al.* (1992) reported that application of phosphate significantly influenced the N and P uptake of mulberry.

The P : N and P : K nutrient uptake ratios in mulberry leaf varied from 0.060 to 0.109 and 0.131 to 0.228, respectively with the graded doses of P. A synergistic interaction effect coupled with a higher or preferential P uptake among these nutrients may be responsible for a gradual increase in these ratios (Table 4).

Soil studies analysis

As mentioned earlier the initial physicochemical characteristics of the experimental soil are presented in Table 1 and the changes in physicochemical properties of the post-harvest soil are presented in Table 5. The pH, EC, organic carbon content of the soil did not show any significant change due to graded levels of phosphorus addition. Available phosphorus content in the P–added plots increased significantly over control. However, its status was statistically on par from 15 to 60 kg P_2O_5 / ha/ year. Mulberry, being a deep-rooted crop is capable of mining P from deeper layers of soil; besides high P fixation capacity as well as the limited soil moisture conditions prevalent in rainfed areas could be ascribed for such a phenomenon. Available N and K contents in the post-harvest soil showed non-significant changes due to P levels. However, a marginal depletion from initial N status was noticed from 30 kg P_2O_5 / ha/ year and K status was noticed at all the P levels. Depletion in soil N and K status may be attributed to crop utilization, volatilization and leaching loss (Table 5). With the application of increasing doses of phosphorus the C : P ratio decreased from 0.543 to 0.209 at 60 kg P_2O_5 / ha/ year (Table 5). Moreover, P : N and P : K ratio increased with graded levels of P. The results are in conformity with the findings of Murthy and Muralidharudu (2005).

Economics

Result indicated that the graded levels of phosphorus have increased both the gross and net economic returns of mulberry production (Table 6). The maximum gross and net incomes of Rs 5340.00 and Rs 3952.00 were obtained by the application of P_2O_5 @ 60 kg/ha/year (Table 6). Though the benefit : cost ratio is maximum in case of 15 kg P_2O_5 / ha/ year but the economic elasticity extends up to 60 kg P_2O_5 / ha/ year (Table 6).

From the above studies, it may be inferred that phosphorus has significant influence on mulberry leaf production and nutrients uptake up to 60 kg P_2O_5 / ha/ year in the low P status sandy loam yellow-radish coarse textured soils under rainfed condition with the highest additional net income of Rs 3952.00 /ha/year. As such, 60 kg P_2O_5 / ha/ year may be adopted in mulberry gardens existing under rainfed conditions of Chotanagpur plateau of Jharkhand to get maximum economic return.

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Table 1. Initial physicochemical characteristics of experimental soil

Characteristics	Status	Methods followed
Texture	Sandy loam	Black, 1965
PH (1:2.5)	5.75	Jackson, 1973
EC (dS m^{-1})	0.12	Jackson, 1973
Organic carbon (g kg^{-1})	3.6	Black, 1965
Alkaline $KMnO_4$-N (kg ha^{-1})	248.0	Subbiah and Asija, 1956
Bray-P (kg ha^{-1})	10.0	Jackson, 1973
NH_4OAC-K (kg ha^{-1})	185.0	Jackson, 1973

Table 2. Effect of different phosphorus levels on growth attributes of mulberry

Levels of P_2O_5 (kg/ha/year)	Plant height (cm)	No. of shoots/ plant	No. of leaves/ plant	Leaf area (sq. cm/ leaf)
0	129.23	7.23	156.14	98.74
15	133.85	7.67	166.93	101.48
30	139.57	7.89	179.33	105.14
45	142.23	8.04	191.17	109.55
60	150.65	8.17	199.50	115.84
S.Em. (±)	**3.00**	**0.29**	**7.93**	**2.45**
LSD (P=0.05)	**9.26**	**NS**	**24.42**	**7.54**

Table 3. Effect of different phosphorus levels on yields and moisture contents of mulberry

Levels of P_2O_5 (kg/ha/year)	Leaf yield (mt/ha/year)	Shoot yield (mt/ha/year)	Leaf moisture (%)	Shoot moisture (%)
0	6.37	3.26	65.08	60.66
15	7.14	3.68	65.36	62.16
30	7.63	3.95	65.28	63.66
45	8.55	4.73	66.72	63.66
60	9.04	5.36	67.13	65.01
S.Em. (±)	**0.33**	**0.16**	**0.23**	**0.49**
LSD (P=0.05)	**1.02**	**0.49**	**0.72**	**1.51**

Table 4. Effect of different phosphorus levels on nutrients contents and uptake of mulberry

Levels of P_2O_5 (kg/ha/year)	Nutrients concentrations (%)			Uptake of nutrients (kg/ ha/ year)			Nutrients uptake ratio	
	N	P	K	N	P	K	P:N	P:K
0	3.83	0.23	1.75	85.19	5.12	38.93	0.060	0.131
15	3.88	0.29	1.80	95.96	7.17	44.52	0.075	0.161
30	3.75	0.34	1.83	99.34	9.01	48.48	0.091	0.186
45	3.77	0.35	1.78	107.27	9.96	50.65	0.093	0.197
60	3.86	0.42	1.84	114.70	12.48	54.67	0.109	0.228
S.Em. (±)	**0.02**	**0.03**	**0.02**	**3.88**	**0.33**	**0.29**	**-**	**-**
LSD (P=0.05)	**NS**	**0.08**	**NS**	**11.92**	**1.02**	**NS**	**-**	**-**

Table 5. Physicochemical properties of the post-harvest soil

Levels of P_2O_5 (kg/ha/year)	pH	EC (dS m^{-1})	Organic carbon (g kg^{-1})	Available nutrient contents (kg ha^{-1})			C:P	P:N	P:K
				N	P	K			
0	5.90	0.15	3.91	266.0	7.20	181.0	0.543	0.027	0.040
15	5.75	0.13	3.72	251.0	11.52	176.0	0.323	0.046	0.065
30	5.80	0.16	3.57	242.0	13.37	172.0	0.267	0.055	0.078
45	5.60	0.16	3.34	235.0	14.34	168.0	0.233	0.061	0.085
60	5.60	0.11	3.16	228.0	15.11	165.0	0.209	0.066	0.091
S.Em. (±)	**0.01**	**0.01**	**0.01**	**0.96**	**0.75**	**0.61**	**-**	**-**	**-**
LSD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**2.31**	**NS**	**-**	**-**	**-**

Table 6. Economics of different phosphorus levels to mulberry

Levels of P_2O_5 (kg/ha/year)	Increase in leaf yield over control (mt)	Increase in monetary return over control (Rs.)	Cost of treatments (Rs.)	Net profit/ return (Rs.)	Benefit: Cost ratio
0	-	-	-	-	-
15	0.77	1540.00	347.00	1193.00	3.44: 1.00
30	1.26	2520.00	694.00	1826.00	2.63: 1.00
45	2.18	4360.00	1041.00	3319.00	3.12: 1.00
60	2.67	5340.00	1388.00	3952.00	2.85: 1.00

Cost. Mulberry leaf -is Rs. 2.00/ kg, Cost Single super phosphate (SSP) is Rs. 3.70/kg

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