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Fertilizer prescription on soil test basis for targeted yields of mulberry under rainfed condition of West Bengal

P.C. BOSE, R. KAR, S.K. MAJUMDER, R.N. DUTTA AND A.K. BAJPAI

Soil Science and Chemistry Section
Central Sericultural Research and Training Institute
Berhampore – 742101, West Bengal

ABSTRACT

For quantitative evaluation of the efficiency of soil tests and fertilizer responses to rainfed mulberry, variety S_1, through Mitscherlich-Bray equation in red lateritic gravelly soil, field experiments were conducted at Purulia, West Bengal. The Mitscherlich-Bray equation is based on the principle that the native and the added nutrients comprehend different efficiency factors. Results indicated that the greater efficiencies of all the fertilizers barring P over soil contributed more share of biomass production from the applied nutrients. On the basis of soil test values through Mitscherlich-Bray equation, appropriate fertilizer dose for rainfed mulberry has been worked out.

Key words: Fertilizer prescription, Mitscherlich-Bray equation, rainfed condition and targeted yield.

Mulberry suffers from moisture and nutrient stress under rainfed cultivation, which considerably reduces the leaf yield and quality of mulberry leaves in the tropics. Leaf yield potential and quality of mulberry leaves are greatly influenced by the genotypes, cultivation practices adopted, soil moisture and nutrient status of the mulberry garden soils. In view of the depletion of soil moisture availability and irrigation resources in the tropics, the necessity for soil test based fertilizer application has attained significance in recent years. Hence, this soil test crop response study for targeted yields was carried out to find out the soil test based NPK requirements for mulberry grown under rainfed condition of West Bengal for achieving sustainable productivity.

MATERIALS AND METHODS

For quantitative evaluation of efficiency of soil tests and fertilizer responses to mulberry, variety S-1, grown under rainfed red lateritic gravelly soil, through Mitscherlich-Bray equation, three field experiments were conducted with N, P and K series at Purulia, West Bengal. The initial soil characteristics and the concerned references for the analytical methods adapted are presented in Table 1. Mulberry was grown with separate sets of treatments imposed in the different experimental plots of N, P and K series experiments along with FYM @ 10 mt ha^{-1} $year^{-1}$ which are presented in table 2. All the three experiments were laid out in RBD with five replications for N and four replications each for P and K and the plantations were maintained following the recommended package of practices. Treatments were applied in three equal splits. The NPK were applied in the form of urea, single superphosphate and muriate of potash. Leaf and shoot yield data were recorded crop wise. Annually three crops were harvested. Annual biomass yield was computed by pooling three years' data.

Table 1: Initial physicochemical characteristics of experimental soil

Characteristics	N experiment	P experiment	K experiment	Reference of the analytical methods followed
Texture	Sandy loam	Sandy loam	Sandy loam	Black, 1965
pH (1:2.5)	4.95	5.75	5.48	Jackson, 1973
Organic carbon (%)	0.36	0.36	0.35	Black, 1965
Alkaline $KMnO_4$-N (kg ha^{-1})	146	148	139	Subbiah and Asija, 1956
Bray-P (kg ha^{-1})	10	10	13	Jackson, 1973
NH_4OAC-K (kg ha^{-1})	174	185	174	Jackson, 1973

The biomass yield was subjected to Mitscherlich-Bray equation, viz, $\log (A-y) = \log A - c_1 b - cx$, based on the principle that native and added nutrients comprehend different efficiency factors (Bray, 1949).An approximate estimate of A is the maximum yield obtained. By knowing the values of A , y_0 (yield in control plot) and b (soil test value), c_1 (soil efficiency) can be calculated. After assessing the c_1 value, c can be calculated for each level of nutrient added and by making the average

Email: csrtiber@gmail.com

of these values, c (fertilizer efficiency) can be obtained. After finding the c_1 and c values, the quantity of nutrients to be added to obtain maximum possible mulberry yield (Bray, 1949) can be worked out for different soil test values.

Table 2: Treatments of the experiments

N levels (kg ha^{-1} year^{-1})	P_2O_5 levels (kg ha^{-1} year^{-1})	K_2O levels (kg ha^{-1} year^{-1})
0	0	0
50	15	15
100	30	30
150	45	45
	60	60
With a common dose of P_2O_5 and K_2O @ 50 kg ha^{-1} year^{-1} and 50 kg ha^{-1} year^{-1}, respectively	With a common dose of N and K_2O @ 150 kg ha^{-1} year^{-1} and 50 kg ha^{-1} year^{-1}, respectively	With a common dose of N and P_2O_5 @ 150 kg ha^{-1} year^{-1} and 50 kg ha^{-1} year^{-1}, respectively

RESULTS AND DISCUSSION

Quantitative evaluation of coefficient of efficiency factors

The coefficient of efficiency factor for soil (c_1) and fertilizer (c) was worked out by using Mitscherlich-Bray equation (Tables 3, 4 and 5). On comparing the efficiency of soil and fertilizers, barring P the fertilizer efficiency of all other fertilizers was greater over the soil efficiency factor, which leads one to infer that applied inorganic nutrients could be effectively utilized by mulberry. Among the NPK, the native soil nutrient supplying efficiency was greater in respect of P followed by N and K. The reason for increased efficiency of soil P might be due to the application of FYM, which might have contributed for solubilizing the soil P by organic acids produced during its decomposition. The formation of organo-complexes by FYM with applied P-fertilizer helps in prevention of fixation of phosphorus by other cations. Hence, the efficiency of added P-fertilizer was also improved over N and K fertilizers.

The increased efficiency of N and K fertilizers over soil efficiency was also observed which might be due to the adsorption of NH_4^+ and K^+ on the decomposition of FYM. The increased efficiency coefficient of N was also reported by Bangar (1998), which indicated higher share from applied nutrients than soil.

Calibration of nutrient requirement based on soil fertility status

After the estimation of efficiency coefficient factors for soil and fertilizer, the factors were fitted into the Mitscherlich-Bray equation for calibrating the quantity of nutrients to be applied based on the soil test value (Table 6). From the Table, it is possible to work out the doses for a given soil test value (b) for obtaining the maximum possible yield (Bray, 1949). Ghosh and Misra (1996) found out the P requirement for a specific yield by knowing the P soil test value and other parameters of this equation, viz, A, c_1 and c.

Table 3: Mulberry biomass yield and efficiency coefficients of soil and nitrogen fertilizer

N (kg ha^{-1} year^{-1}) Applied (x)	Yield (mt ha^{-1} year^{-1}) (y)	Calculated log y	1/x	c_1	c	c_1/c
0	11.53	-	-	0.00176	-	
50	16.66	1.221	0.0200		0.00386	
100	19.52	1.290	0.0100		0.00355	0.4648
150	22.16	1.345	0.0067		0.00393	
LSD(0.05)	**0.97**					
Mean				**0.00176**	**0.00378**	

Theoretical maximum yield (A): 25.85 mt ha^{-1} year^{-1}

Table 4: Mulberry biomass yield and efficiency coefficients of soil and phosphatic fertilizer

P_2O_5 (kg ha^{-1} $year^{-1}$) applied (x)	Yield (mt ha^{-1} $year^{-1}$) (y)	Calculated log y	1/x	c_1	c	c_1/c
0	10.83	-	-	0.01142	-	
15	14.01	1.1464	0.0667		0.00804	
30	15.15	1.1804	0.0333		0.00580	
45	16.74	1.2238	0.0222		0.00578	1.7515
60	18.56	1.2686	0.0167		0.00645	
LSD(0.05)	**0.82**					
Mean				**0.01142**	**0.00652**	

Theoretical maximum yield (A): 23.94 mt ha^{-1} $year^{-1}$

Table 5: Mulberry biomass yield and efficiency coefficients of soil and potassic fertilizer

K_2O (kg ha^{-1} $year^{-1}$) Applied (x)	Yield (mt ha^{-1} $year^{-1}$) (y)	Calculated log y	1/x	c_1	c	c_1/c
0	11.75	-	-	0.00152	-	
15	14.35	1.1569	0.0667		0.00782	
30	15.32	1.1853	0.0333		0.00509	
45	16.32	1.2127	0.0222		0.00521	0.2529
60	17.86	1.2519	0.0167		0.00591	
LSD(0.05)	**0.73**					
Mean				**0.00152**	**0.00601**	

Theoretical maximum yield (A): 22.68 mt ha^{-1} $year^{-1}$

Table 6: Equations for calibration of quantities of nutrients to be applied based on soil test values

Nutrients	Equations
Nitrogen	$\frac{\text{Log A} - \log(\text{A-y}) - (0.00176\text{b})}{0.00378}$
Phosphorus	$\frac{\text{Log A} - \log(\text{A-y}) - (0.01142\text{b})}{0.00652}$
Potassium	$\frac{\text{Log A} - \log(\text{A-y}) - (0.00152\text{b})}{0.00601}$

Fertilizer recommendations

The site-specific N, P and K fertilizer recommendations, based on c_1 for b, and c for x through Mitscherlich-Bray equation, were computed based on the percentage of theoretical maximum mulberry biomass yield (Tables 7, 8 and 9) and specific leaf yield target for mulberry (Table 10) for the common range of soil test values from 100 to 400 kg ha^{-1} of alkaline $KMnO_4$-N, from 10 to 70 kg ha^{-1} of Bray-P and 100 to 700 kg ha^{-1} of NH_4OAC-K, respectively.

With an increase in soil test values for N, P and K, there was a corresponding decrease in N, P and K requirements. It is credible to enhance the fertilizer use efficiency and economize its use for sustainable mulberry production. In order to achieve high percentage relative yields, the equation can very well be suited under the conditions of low to high soil fertility. This has an added advantage in determining fertilizer requirements under high buildup of available nutrients in intensive cropping. This could serve as a wonderful tool for fertilizer recommendations for mulberry.

Table 7: Nitrogen fertilizer recommendation chart for mulberry

Soil test value N (kg ha^{-1})	Mulberry biomass yield, % of theoretical maximum		
	70	75	80
	Fertilizer N (kg ha^{-1} year^{-1}) required		
100	92	113	138
150	69	90	115
200	45	66	92
250	22	43	69
300	1	20	46
350	0	0	22
400	0	0	0

Table 8: Phosphatic fertilizer recommendation chart for mulberry

Soil test value P_2O_5 (kg ha^{-1})	Mulberry biomass yield, % of theoretical maximum		
	70	75	80
	Fertilizer P_2O_5 (kg ha^{-1} year^{-1}) required		
10	63	75	90
20	45	57	72
30	28	40	55
40	10	23	37
50	0	5	20
60	0	0	2
70	0	0	0

Table 9: Potassic fertilizer recommendation chart for mulberry

Soil test value K_2O (kg ha^{-1})	Mulberry biomass yield, % of theoretical maximum		
	75	80	85
	Fertilizer K_2O (kg ha^{-1} year^{-1}) required		
100	75	91	112
200	50	66	87
300	24	40	61
400	0	15	36
500	0	0	11
600	0	0	0

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