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Efficiency of Phosphatic Fertilizers Differing in Water Solubility, Their Effect on Growth and Nutrients Uptake by Horse Gram [*Macrotyloma uniflorum* (Lam.) Verde.] on an Acid Alfisol

B C MARWAHA

Department of Soil Science and Water Management, Himachal Pradesh Agricultural University, Palampur 176062

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The effect of four phosphatic fertilizers, each applied at 3 rates to horse gram in an acid hill soil of *p*H 5.7, was studied. An increase in the supply of phosphorus usually improved growth and total uptake of N, P, K, Ca and Na by the plants. Among the P sources, nitrophosphate(70% water soluble) followed by superphosphate proved the best in all these respects. Except Fe and Ca, the uptake of all the nutrient elements was higher in seeds than in straw. The magnitude of N uptake was highest and that of Na followed by Fe was extremely low. The Fe content of the dry matter of the plants receiving nitrophosphate or superphosphate generally decreased with increasing P supply.

Key Words: P sources, Horse gram yield, Nutrients uptake

Introduction

In most arid and semi-arid regions the principle nutrient to be applied to legumes and other crops is phosphorus (Arnon 1972). Application of phosphorus is also necessary in acid soils containing excessive amounts of soluble Al and Fe, where the problem of P fixation is usually acute (Kurtz 1953, Lindsay et al. 1962, Taylor et al. 1964). While the application of relatively large quantities of phosphorus could cause iron stress (Brown 1972, Kashirad & Marschner 1974 and Brown & Jones 1975), it enhances the availability of N, P, K and Ca to plants (Kashirad et al. 1978). The effect of phosphorus nutrition on plant development in saline, alkaline and calcareous soils has been studied in detail for some legumes (Maftoun & Bassiri 1975, Kashirad et al. 1978). However, information concerning these aspects of P nutrition of horse gram, particularly in acid soils, is inadequate. The present study was conducted to determine the effect of P sources on the growth and nutrient uptake of horse gram in an acid upland hill soil.

Materials and Methods

A greenhouse experiment was conducted on an acid hill soil in 1978 at Palampur (1290 m a msl). The representative surface sample (0 to 15 cm) of the soil had *p*H 5.7, alkaline $KMnO_4$ extractable N 490 kg/ha, Olsen's P 11 ppm, ammonium acetate extractable K 136 ppm, organic carbon 0.68%, base saturation 64% and C. E. C. 15 me/100g. Air dried and sieved soil was filled into enamelled pots of 8 kg capacity. Four sources of fertilizer p viz. superphosphate (16% P_2O_5), mussoorie rock phosphate (100 mesh, 17.8% P_2O_5), basic slag (5.2 P_2O_5) and nitrophosphate (23% P_2O_5, 70% water soluble) were tried, each being applied @ 45, 67 and 89 ppm P_2O_5 per pot. A uniform basal dose of N and K was also applied in solution form to each pot. The phosphatic treatments alongwith control (no phosphorus treatment) were replicated twice in completely randomized design. Horse gram [*Macrotyloma uniflorum* (Lam.) Verde.] variety HPK-4 was used as the test crop. After establishment of seedlings, these were thinned to retain 5 healthy plants per pot.

The crop was harvested in October, 1978, and dry weight of seeds and straw samples was recorded. Besides, observations on the number of pods and seeds were recorded. Seed and straw samples were analysed for P, K, Ca, Fe and Na concentration (Black 1965). Nitrogen was determined colorimetrically using Nessler's reagent (Li 1966). Based on nutrient concentration and yield data, uptake of all these nutrient elements was computed by using the formula:

$$\frac{\text{Percent nutrient in seeds or straw} \times \text{yield of seeds or straw}}{100}$$

Availability coefficient ratios of different P sources each at two levels, namely 45 and 89 ppm P_2O_5, were computed from the data on seed and dry matter yield by employing the straight lines response model described by White et al. (1956). Nitrophosphate was used as the standard fertilizer. The availability coefficient of phosphorus in other source was thus estimated as a fraction of that in nitrophosphate. For the purpose of computing availability coefficient ratio (ACR) for various sources with respect to phosphorus uptake method of Peaslee (1960) was used.

Results and Discussion

Crop Yield

The ACR values pertaining to the data on yield of seeds shows that superphosphate, basic slag and rock phosphate were 57, 30 and 24% respectively as efficient as nitrophosphate (table 1). In other words, water soluble sources (superphosphate and nitrophosphate) were far more effective than the relatively insoluble sources (basic slag and rock phosphate) thereby indicating that the degree of water solubility in a particular source has a definite influence on its agronomic effectiveness. However, it is worth mentioning that among the water soluble sources, nitrophosphate of 70% water solubility proved better than superphosphate of 96% water solubility at each level of application. This could possibly be explained on the basis of high P fixing capacity of the test soil, owing to which there would be a tendency for the more soluble P as provided by superphosphate

Table 1 *Availability coefficient ratio (λ) of different phosphatic sources relative to nitrophosphate and estimates of slope ($\hat{\beta}$) of response curvest*

Source of fertilizer phosphorus	Grain yield		Dry matter yield	
	$\hat{\beta}$	λ	$\hat{\beta}$	λ
Mussoorie RP	1.870	0.243	0.455	0.102
Basic slag	2.327	0.302	0.786	0.177
Superphosphate	4,377	0.568	1.532	0.344
Nitrophosphate	7.703	1.000	4.448	1.000

Table 2 *Availability coefficient ratio of graded levels of phosphatic sources relative to nitrophosphate, obtained with respect to phosphorus uptake*

Source of fertilizer phosphorus	ACR at different levels of P application (ppm P_2O_5)					
	45		67		89	
	Grain	Straw	Grain	Straw	Grain	Straw
Mussoorie RP	0.13	0.36	0.25	0.13	0.19	0.25
Basic slag	0.53	0.48	0.21	0.16	0.37	0.32
Superphosphate	0.59	0.83	0.65	0.21	0.62	0.52
Nitrophosphate	1.00	1.00	1.00	1.00	1.00	1.00

Table 3 *Effect of graded levels of different P fertilizers on the magnitude of yield attributes of horse gram*

Rate of P application (ppm P_2O_5)	Source of fertilizer phosphorus	Total No. of pods per pot	Total No. of seeds per pot	Average No. of seeds per pod
0	None	6	11	1.83
45	Superphosphate	22	96	4.37
	Mussoorie RP	17	52	3.06
	Basic slag	23	40	1.74
	Nitrophosphate	50	298	5.96
67	Superphosphate	45	200	4.44
	Mussoorie RP	23	87	3.78
	Basic slag	36	147	4.08
	Nitrophosphate	58	297	5.12
89	Superphosphate	47	202	4.29
	Mussoorie RP	34	159	4.68
	Basic slag	39	140	3.59
	Nitrophosphate	59	268	4.54

Table 4 *Effect of graded levels of different P sources on nutrients uptake (mg per pot) by horse/gram*

Treatment	P uptake		N uptake		K uptake	
(ppm P_2O_5/pot)	Grain	Straw	Grain	Straw	Grain	Straw
Control	0.60	0.33	1.87	8.52	0.26	0.37
M 45	3.88	1.48	11.36	3.41	3.08	2.87
M 67	5.91	1.71	15.62	8.80	2.21	4.05
M 89	14.63	2.29	20.71	5.00	9.63	5.28*
B 45	14.17	1.87	22.79	3.75	5.92	3.34
B 67	9.64	1.91	12.12	4.91	7.35	4.91
B 89	12.55	2.78	27.84*	6.29	4.51	6.64*
S 45	15.84	2.97	31.52*	4.20	5.30	4.26
S 67	27.11*	3.17	35.67**	5.63	6.84	6.45*
S 89	37.14**	3.43	44.15**	8.37	12.40	8.52**
N. 45	26.29*	3.51	70.86**	6.95	13.08*	10.45**
N. 67	30.62*	4.39	38.12**	8.80	31.51**	11.20**
N. 89	56.55**	15.31**	72.83**	25.60	21.08**	20.22**
SEM ±	7.26	2.19	7.21	4.74	4.02	1.46
C.D. 5%	22.18	6.67	22.02	NS	12.27	4.46
C.D. 1%	30.93	9.31	30.70	NS	17.11	6.22

Table 4 *continued*

Treatment	Ca uptake		Fe uptake		Na uptake	
(ppm P_2O_5/pot)	Grain	Straw	Grain	Straw	Grain	Straw
Control	0.04	0.34	0.01	0.12	0.01	0.008
M 45	0.31	2.22	0.04	0.30	0.10	0.030
M 67	0.78	2.99	0.06	0.31	0.06	0.039*
M 89	0.88	5.00*	0.31	0.42	0.28	0.062**
B 45	0.86*	2.52	0.09	0.51	0.09	0.048**
B 67	1.62*	4.02	0.17	0.35	0.10	0.056**
B 89	0.47	5.48*	0.12	0.52	0.17	0.062**
S 45	1.01*	3.36	0.45	1.50*	0.54*	0.063**
S 67	1.37**	5.79*	0.24	0.50	0.49	0.079**
S 89	1.49**	7.11**	0.50	0.71	0.52	0.085**
N 45	2.58**	8.63**	0.41	2.29**	0.75*	0.171**
N 67	1.86**	12.43**	0.42	0.66	0.34	0.148**
N 89	2.94	17.13**	1.24**	1.29*	1.22**	0.202**
SEM ±	0.37	1.49	0.28	0.40	0.17	0.008
C.D. 5%	0.80	4.56	0.86	1.22	0.52	0.023
C.D. 1%	1.11	6.35	1.20	1.70	0.72	0.032

M, B, S and *N* denotes source of fertiliser P, which being Mussoorie rock phosphate, basic slag superphosphate and nitrophosphate respectively.
* Significant at 5% ** Significant at 1% *NS.* Nonsignificant

to become fixed i.e., it gets converted in the form of relatively less available phosphate reaction products, rather quickly than the relatively less soluble nitrophosphate. In nitrophosphate granules, $CaHPO_4$ (monetite) dissolves slowly and persists relatively unchanged in the vicinity of fertilizer granules (Hundal et al. 1979). Consequently, there was less fixation of nitrophosphate-P than superphosphate in the acid soil under study.

Similarly, the ACR values computed for the phosphorus uptake data reveal the superiority of nitrophosphate followed by superphosphate over basic slag and rock phosphate (table 2).

The differences in the yield of seeds with different sources could further be attributed to the variation in the number of pods per plant and number of seeds per pod, which being higher with both the water soluble sources (table 3). As regards the effect of rates of P application, the magnitude of yield attributes was found to increase with increasing supply of P, thereby suggesting the importance of P application on the growth and seed formation in horse gram.

Nutrients Uptake:

A perusal of the data presented in table 4 shows that uptake (nutrient concentration in seeds or straw × yield of seeds or straw) of N, P, K, Ca and Na both in the seeds and dry matter increased with increasing P supply, irrespective of the source of fertilizer. However, the increases were significant only with respect to nitrophosphate and superphosphate. The magnitude of N uptake followed by P was noticeably high and that of Na followed by Fe was extremely small.

Another peculiar feature of the present data is that the uptake of Fe in straw exhibited a generally declining trend with an increase in P supply, especially through nitrophosphate and superphosphate, thereby suggesting that high P levels interfere with the uptake of iron by horse gram plants. This observation is in line with those of Brown (1972) and Brown and Jones (1975).

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References

Arnon I 1972 In *Crop Production in Dry Regions* Vol. 2, pp 683 (London: Leonard Hill)

Black C A (ed) 1965 In *Methods of Soil Analysis. Part 2,* (USA: Am. Soc. Agron., Inc.)

Brown J C 1972 Competition between phosphate and the plant for Fe from Fe^{+2} ferrozine; *Agron. J.* **64** 240–243

Hundal H S, Arora B R and Sekhon G S 1979 Efficiency of phosphate fertilizers differing in water-solubility of P in rice; *J. Indian Soc. Soil. Sci.* **27** 330–333

Kashirad A, Bassiri A and Kharadnam M 1978 Responses of cowpeas to application of P and Fe in calcareous soils; *Agron. J.* **70** 67–70

—— and Merschner M 1974 Iron nutrition of sunflower and corn plants in mono and mixed culture; *Pl. Soil* **41** 91–101

Kurtz L T 1953 Inorganic P in acid and neutral soils. Soils and fertilizer phosphorus in crop rotation; *Agron. Monograph* **4** 59–80

Li L T 1966 Rapid chemical method for determining N, P and K in plant tissues; *J. Taiwan Agri. Res.* **15** 1–5

Lindsay W L, Frazier A W and Stephenson H F 1962 Identification of reaction products from phosphatic fertilizers in soils; *Soil Sci. Soc. Am. Proc.* **26** 446–452

Maftoun M and Bassiri A 1975 Effect of phosphorus and Ryzelan on the growth and mineral composition of chickpeas; *Agron. J.* **67** 556-559

Peaslee D E 1960 Behaviour of phosphate rock in soils and its availability to plants; *Diss. Abstr.* *2a 415 c. f. Soils and Fertilizers* **24** 141 (1981)

Taylor A W and Gurney E L 1964 The dissolution of calcium aluminium phosphate; *Soil Sci. Soc. Am. Proc.* **26** 63–64

White R W, Kampthrone D, Black C A and Webb J R 1956 Fertilizer evaluation II. Estimation of availability coefficients; *Soil Sci. Soc. Am. Proc.* **20** 179–186