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Effect of source and level of phosphorus on the yield of sorghum (*Sorghum bicolor*) under dryland conditions

B.S. RASKAR

Water Management Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra 413 722

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ABSTRACT

A field experiment was conducted during 1993–94 to 1995–96 on Vertisol to assess the effects of 2 sources and levels of phosphorus on the yield of winter (*rabi*) sorghum [*Sorghum bicolor* (L.) Moench] under dryland conditions. The grain yield of *rabi* sorghum was not influenced by different sources of phosphorus and recorded 21.94 q/ha and 20.75 q/ha grain yield under single superphosphate and diammonium phosphate respectively. The effect of various levels of phosphorus was significant and the magnitude being 18.93, 21.29, 21.63 and 22.53 q/ha respectively at 15, 30 45 and 60 kg P_2O_5/ha respectively. Similarly, grain and straw yields increased significantly up to 60 kg P_2O_5/ha. As per the equations, the optimum dose of phosphorus for *rabi* sorghum was worked out to be 50.6 kg P_2O_5/ha.

Key words : Winter sorghum, Phosphorus, Yield

Sorghum is the predominant crop of arid areas, which pose a problem of low productivity and instability in yield. Phosphorus next to nitrogen is the most limiting nutrient in Vertisol. The lack of P responses in Vertisols is attributed to their high clay content and immediate fixation (Venkateswarlu, 1987). Limiting soil moisture and crop response to applied P is also attributed to high P-fixing capacity (Sharma, 1988). Under the prevailing high evaporation, the solubility of added P is drastically curtailed as the surface layer gets dried after sowing. The lack of response to applied P is one of the major problems in soil-fertility management in dryland Vertisols (Kanzaria, 1979). The initial level of available P and rainfall situation are very well associated with *rabi* sorghum (Rao and Jayram, 1988) as P is primary element for root development and early establishment of crop which subsequently sustained better even under moisture stress as it occurred in dryland region.

Considering these constraints the present experiment was therefore initiated to study the effect of sources and levels of phosphorus on the yield of *rabi* sorghum under dryland conditions in Vertisols of Maharashtra.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season from 1993–94 to 95–96 at Rahuri to study the effect of sources and levels of phosphorus on the yield of *rabi* sorghum under dryland conditions. The soil of 0–30 cm depth was clayey in texture with pH 8.3, medium in available carbon (0.43%) and P (15 kg/ha), low available N (172 kg/ha) and high available K (666 kg/ha) contents. The treatment comprised 2 sources (single superphosphate and diammonium phosphate) and 4 levels of phosphorus (15, 30, 45 and 60 kg P_2O_5/ha) replicated 3 times in randomized block design. A basal application of 60 kg N/ha was made uniformly to all the plots and necessary adjustment was made in plots receiving diammonium phosphate as source of P. The seed of 'SPV 3', was sown by dibbling at 45 cm × 15 cm spacing. The crop was rainfed and received 179.9, 57.0, 120.2 mm rainfall during the *rabi* season of consecutive crop years. Sowing and harvesting of crop were done on 4 October 1993, 11 October 1994 and 13 September 1995 and 22 February 1994, 14 February 1995 and 29 January 1996 during respective years. The distribution of rainfall was quite favourable, resulting in satisfactory growth and yield during 1993–94 and it was much uneven (erratic) during 1994–95 and 1995–96.

To work out the optimum dose of phosphorus the following quadratic production function was fitted $Y = a + bx - cx^2$, where, Y is dependent variable (yield of sorghum in q/ha) and X is an independent variable (dose of phosphorus in kg/ha). To work out the optimum dose, marginal product was equated to price ratio, i.e. MPP = Px/Py, where, MPP is the marginal physical product; Px is price of per kg phosphorus and Py is price of per kg sorghum (grain). The price of P_2O_5 per kg was considered as average of 2 sources (i.e. Rs 17.62 for SSP and Rs 18.30/kg for DAP) and price of grain was @Rs 5.25/kg.

RESULTS AND DISCUSSION

Growth and yield attributes

Different sources of phosphorus did not

Table 1. Mean growth and yield attributes as influenced by P_2O_5 (Pooled mean)

Treatment	Plant height (cm)	Leaves/ plant	50% flowering (DAS)	Grain weight/panicle (g)	1,000-grain weight (g)
Source of P_2O_5 (kg/ha)					
SSP	187.44	9.11	79.27	46.68	34.00
DAP	189.55	9.35	79.73	48.86	34.58
CD (P = 0.05)	NS	NS	NS	NS	NS
Level of P_2O_5 (kg/ha)					
15	186.44	8.95	78.94	44.54	33.33
30	188.27	9.02	79.32	46.81	33.83
45	189.05	9.33	79.58	48.92	34.50
60	190.22	9.61	80.17	50.81	35.50
CD (P = 0.05)	NS	0.37	0.57	4.02	0.63

Table 2. Grain and fodder yields of *rabi* sorghum as affected by different sources and levels of fertilizer

Treatment	Grain yield (q/ha)				Fodder yield (q/ha)			
	1993	1994	1995	Pooled	1993	1994	1995	Pooled
Sources of P_2O_5 (kg/ha)								
SSP	32.590	14.204	17.551	21.448	47.358	41.755	47.018	45.377
DAP	30.724	14.283	17.243	20.750	46.803	38.688	46.427	43.972
CD (P = 0.05)	1.822	NS	NS	NS	NS	NS	NS	NS
Level of P_2O_5 (kg/ha)								
15	28.897	12.582	15.312	18.930	45.273	39.282	45.307	43.287
30	31.992	14.578	17.310	21.293	47.775	39.232	46.952	44.653
45	31.758	15.040	18.110	21.636	47.218	39.997	46.820	44.678
60	33.982	14.775	18.857	22.538	48.053	42.375	47.812	46.088
CD (P = 0.05)	2.576	1.296	0.541	1.880	1.956	1.634	NS	1.883
Interaction								
CD (P = 0.05)	NS	NS	0.766		NS	NS	NS	

affect the pooled values of growth and yield attributes statistically (Table 1). The number of leaves/plant, days required for 50% flowering, grain weight/panicle and 1,000-grain weight increased significantly with increase in phosphorus levels. All the yield attributes were found to be significatly higher at 60 kg than at 15 kg P_2O_5/ha, but increased levels of phosphorus did not show extra-ordinary trend under dryland conditions.

Effect of sources on yield

The grain yield under dry-farming conditions in *rabi* season (winter) was not influenced by sources of phosphorus either in the form of single superphosphate or in diammonium phosphate (Table 2). The similar trend was also observed in fodder yield of sorghum. However, during first year of experimentation (1993–94) grain yield of sorghum increased significantly due to application of SSP over the DAP.

Effect of phosphorus

The grain of *rabi* sorghum was significantly increased due to increase in levels of phosphorus and exerted similar influence on fodder yield. The application of 60 kg P_2O_5/ha recorded significantly maximum grain yield (22.53 q/ha) over 15 kg P_2O_5/ha (18.93 q/ha). The sorghum grain yield obtained at 30 kg, 45 kg and 60 kg P_2O_5/ha remained at par with each other. Moisture, being limiting factor in deep soil for *rabi* sorghum grown on residual soil moisture increase in yield was not significantly observed due to higher level of phosphorus. Considering 15 kg P_2O_5/ha base value, the phosphorus-use efficiency was maximum at 30 kg P_2O_5/ha and it decreased with subsequent increasing level of phosphorus. The

magnitude of decreasing P- use efficiency in corresponding years were 6.35,5.46, 6.23 and 6.01 kg grain/kg applied phosphorus at 45 kg P_2O_5/ha and 8.47, 3.65, 5.91 and 6.01 kg grain/kg applied phosphorus at 60 kg P_2O_5/ha dose. Sharma *et al.* (1991) found decrease in per cent utilization of phosphorus with increasing phosphorus level, as plants absorb more phosphorus under P-stress condition to meet their demand. Similar response was observed by Borgohain and Agarwal (1986) incase of kabuli gram.

Response function

The response of phosphorus on yield of *rabi* sorghum was worked out by fitting quadratic production function. The equation thus obtained from 3 years and pooled means were used for estimation of optimum dose:

1993–94

$$Y = 26.81 + 0.1727\ P - 0.0009685\ P^2$$
$$r^2 = 0.42$$

1994–95

$$Y = 9.65 + 0.2354\ P - 0.0025\ P^2$$
$$r^2 = 0.68$$

1995–96

$$Y = 12.97 + 0.1825\ P - 0.0014\ P^2$$
$$r^2 = 0.86$$

Pooled

$$Y = 15.10 + 0.2545\ P - 0.002179\ P^2$$
$$r^2 = 0.75$$

As per above equations, the optimum dose of phosphorus in *rabi* sorghum was worked out to be 71.3, 40.0, 52.6 and 50.6 kg P_2O_5/ha during 1993–94, 1994–95, 1995–96 and pooled respectively.

The corresponding values of optimum yields were 34.2, 15.0, 18.6 and 22.4 q/ha. Under the existing soil and weather conditions, phosphorus levels can be extended to the maximum of 89.5, 46.8, 64.9 and 58.4 kg P_2O_5/ha with the highest grain yield of 37.5, 15.2, 18.4 and 22.5 q/ha during the corresponding years and in pooled data. It was also noticed that, during good amount of rainfall year (1993–94), response to grain yield was highly favourable as 65 mm out of 179.9 mm rainfall, was received during the moisture sensitive growth stage of the crop particularly in the second week of December and thus reflected on maximum yield. However, during 1995–96 though the total rainfall was maximum (120 mm) during crop-growth period, its distribution was not coincided with critical growth stage and all rainfall was received only up to first fortnight of October 1995 and hence the grain yield was less than 1993–94. Rathore *et al.* (1991) reported better utilization of applied phosphorus even up to 60 kg P_2O_5/ha with increasing availability of irrigation waters from IW : CPE 0.6 to 1.0 in wheat crop. Saharawat *et al.* (1998) reported that the *kharif* sorghum yield was maximum of 3.17 tonnes/ha when fertilized with 40 kg P_2O_5/ha in Vertisol.

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