

RESPONSE OF SUNFLOWER (*Helianthus annuus* L.) TO PHOSPHORUS APPLICATION IN VERTISOLS

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SUMMARY

Field experiments in vertisols of low, medium and high available soil phosphorus status were conducted to study the response of graded levels of P application to sunflower hybrid (KBSH-1). Effect of P to sunflower in increasing yield and yield attributes was more pronounced in low P status soil. Response equations for seed yield of sunflower at an applied P level have been worked out. Nutrient use efficiency and productive efficiency were also computed. Soil available P status was found to vary significantly only in low P status. Critical P level in soil was found to be 20 kg P ha⁻¹, below which sunflower may respond to phosphorus application.

Key words: critical limit, *Helianthus annuus*. L, phosphorus, vertisols

INTRODUCTION

Sunflower (*Helianthus annuus*. L) is cultivated in different agro-climatic zones of India, differing in soil nutrient status. Phosphorus is one of the most important macronutrients required for optimum plant growth and yield (Tandon, 1987). Vertisols, in general, are known to be phosphorus deficient and capable of fixing the applied P (Murthy, 1988; Shialaja and Sahrawat, 1990). In this study, sunflower crop response to low, medium and high available P status and establishment of critical limit of P in soil were examined.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* (Date of sowing October 24, 2001) with sunflower hybrid (KBSH-1), under rainfed conditions in Raichur district (Karnataka), at three sites (farmers' fields) varying in available soil phosphorus.

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Experimental design followed was randomized block with four replicates, having a plot size of 9 x 6 m. Physical and chemical properties of the soils were: Site I (low available P): pH 8.2, EC 0.29 dSm⁻¹, available P 9.9 kg ha⁻¹ and K 530 kg ha⁻¹; Site II (medium available P): pH 8.2, EC 0.28 dSm⁻¹, available P 24 kg ha⁻¹ and K 540 kg ha⁻¹; Site III (high available P): pH 8.7, EC 0.86 dSm⁻¹, available P 40 kg ha⁻¹ and K 508 kg ha⁻¹. Initial soil samples were collected at 0-20 cm depth after 25 days of basal application of different P₂O₅ levels viz., 0, 15, 30, 45, 60 and 75 kg ha⁻¹. Nitrogen (35 kg ha⁻¹) and potassium (30 kg ha⁻¹) were applied as per recommended doses. Physical, chemical and available soil P status were determined by following standard procedures (Jackson, 1973). Plant height, head diameter, dry matter yield of shoot, seed yield and oil content were recorded. Phosphorus concentration, uptake in shoot and nitrogen, phosphorus, potassium contents and uptake in seed were also determined. Relative per cent increase in shoot and seed yield, nutrient use efficiency (NUE), productive efficiency (PE), apparent recovery of P and available soil P balance were calculated using the below mentioned formulae.

$$\text{Nutrient use efficiency} = \text{Seed yield (kg ha}^{-1}\text{)} / \text{P uptake (kg ha}^{-1}\text{)}$$

$$\text{Productive efficiency} = \frac{\text{Seed yield (kg ha}^{-1}\text{) in treated} - \text{Seed yield (kg ha}^{-1}\text{) in control}}{\text{P uptake (kg ha}^{-1}\text{) in treated} - \text{P uptake (kg ha}^{-1}\text{) in control.}}$$

$$\text{Apparent P recovery} = \frac{(\text{P uptake in fertilized} - \text{P uptake in control})}{\text{P fertilizer applied}}$$

RESULTS AND DISCUSSION

Yield and yield components

Phosphorus application in general resulted in increase in the sunflower plant height, head diameter, shoot dry matter yield and seed yield (Table 1). The response to applied P was more pronounced on soils low in available phosphorus than in the other soils. Gradual increase in shoot dry matter yield over control was observed in low, medium and high available P soils at all the P levels, and was found to be statistically significant. Similar results were reported by Naphade and Naphade (1991) and Shivaprasad *et al.* (1996) with P application. However, seed yield increased significantly up to 60 kg P₂O₅ ha⁻¹ in low P soils. In medium and high P soils, significant increase in seed yield was observed up to 75 and 45 kg P₂O₅ ha⁻¹ respectively. Sarkar *et al.* (1995) reported significant increase in sunflower yield with an increase in P₂O₅ level up to 60 kg ha⁻¹. Seed oil content was also found to be nonsignificant in all soils with increased levels of P application. Similar results were observed with different P levels affecting oil content (Maheswarappa *et al.*, 1985).

Table 1: Growth, yield and oil content of sunflower as influenced by different P doses

P ₂ O ₅ levels (kg ha ⁻¹)	Plant height (m)	Head diame- ter (cm)	Yield (kg ha ⁻¹)		Oil content (%)	% relative yield	
			Shoot	Seed		Shoot	Seed
Low available P							
0	1.02	8.0	648	596	39.89	0	0
15	1.14	9.33	744	1212	39.05	12.90	50.83
30	1.21	10.91	844	1728	40.18	23.22	65.51
45	1.27	11.92	1087	1612	39.07	40.39	63.03
60	1.33	12.92	1231	1780	39.02	47.36	66.52
75	1.39	13.33	1417	1420	39.50	54.27	58.03
C.D. (P=0.05)	0.04	0.95	181	229	NS	-	-
Medium available P							
0	1.27	10.33	531	1026	42.22	0	0
15	1.29	10.08	662	1120	43.36	19.79	8.39
30	1.38	11.50	745	1197	42.67	28.72	14.29
45	1.38	10.50	813	1259	42.24	34.69	18.51
60	1.39	10.60	1005	1349	40.94	47.16	23.94
75	1.34	10.30	1126	1451	41.87	52.84	29.29
C.D. (P=0.05)	NS	NS	148	162	NS	-	-
High available P							
0	1.12	10.0	848	611	41.4	0	0
15	1.26	10.3	1131	679	40.8	25.02	9.43
30	1.37	11.6	1249	1162	43.0	32.11	47.97
45	1.42	11.5	1550	1219	41.3	45.29	49.56
60	1.34	10.5	1664	1072	41.1	49.04	42.66
75	1.25	10.4	2019	1039	40.9	58.00	40.82
C.D. (P=0.05)	NS	NS	24	403	NS	-	-

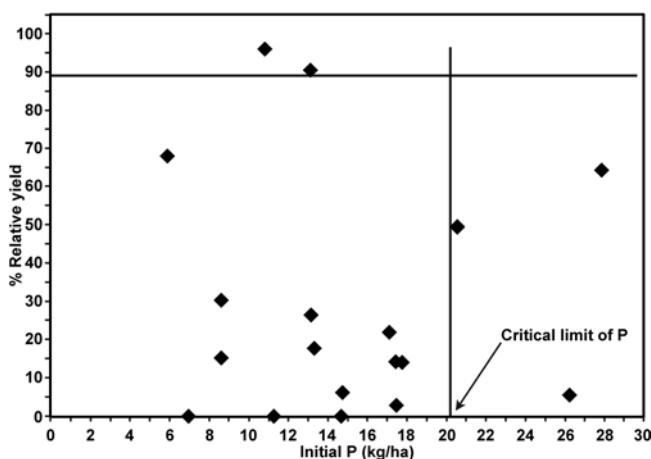


Figure 1: Critical limit of P (kg/ha) in vertisol

P content and uptake

Relative yield and P uptake by sunflower increased as the available P status of soils increased from low to high (Table 2). Phosphorus concentration in shoot varied from 0.045% to 0.061% and was found to be nonsignificant whereas in seed, it ranged from 0.24% to 0.33% and was found to vary significantly only in low P status soil. Significant increase in shoot P uptake was observed at all P doses in all the soils (Table 2). P uptake was also significant in seed, in the different P status soils. Nitrogen and potassium content and uptake in seed were influenced significantly by the different P levels (Table 3). Naphade and Naphade (1992) also reported an increase in N and K concentration and uptake by sunflower due to P application. In general, increasing rates of P application also increased the N and K uptake of sunflower seed.

Table 2: Effect of P doses on phosphate concentration and uptake in sunflower; nutrient use efficiency, productive efficiency and apparent P recovery

P ₂ O ₅ levels (kg ha ⁻¹)	P concentration (%)		P uptake (kg ha ⁻¹)		NUE	PE	Kg seed/kg P
	Shoot	Seed	Shoot	Seed			
Low available P							
0	0.050	0.29	0.32	1.79	2.82	-	-
15	0.051	0.29	0.38	4.00	2.77	2.71	41.1
30	0.047	0.24	0.40	4.67	3.41	3.82	37.7
45	0.048	0.31	0.52	4.51	3.20	3.48	-2.6
60	0.051	0.28	0.63	4.98	3.17	3.38	0.9
75	0.050	0.32	0.71	4.69	2.63	2.50	-2.6
C.D. (P=0.05)	NS	0.04	0.14	1.04			
Medium available P							
0	0.052	0.28	0.27	2.86	3.28	-	-
15	0.059	0.28	0.69	3.17	2.90	1.29	6.3
30	0.057	0.28	0.43	3.39	3.13	2.48	5.7
45	0.047	0.28	0.38	3.47	3.27	3.24	3.1
60	0.050	0.27	0.50	3.63	3.27	3.23	2.5
75	0.045	0.27	0.52	3.73	3.41	3.79	2.6
C.D. (P=0.05)	NS	NS	0.13	NS			
High available P							
0	0.058	0.30	0.49	5.53	3.06	-	-
15	0.059	0.33	0.67	6.72	2.76	1.40	12.8
30	0.061	0.27	0.76	9.57	3.43	3.94	56.7
45	0.053	0.28	0.82	10.24	3.31	3.60	36.0
60	0.047	0.28	0.78	9.00	3.29	3.65	-5.5
75	0.052	0.33	1.05	10.28	2.75	2.40	-7.2
C.D. (P=0.05)	NS	NS	0.14	NS			

Response to applied P

The quadratic response equations for seed yield of sunflower in low, medium and high available P soils were as follows:

$$\text{Low available P: } Y = 610.29 + 48.206X - 0.4978 X^2 \quad R^2 = 0.95$$

$$\text{Medium available P: } Y = 1033.9 + 4.93X + 0.0073 X^2 \quad R^2 = 0.99$$

$$\text{High available P: } Y = 1636.1 + 74.142X - 0.7343 X^2 \quad R^2 = 0.81$$

Where Y is seed yield (kg ha^{-1}) and X is the level of P_2O_5 applied (kg ha^{-1}).

The optimum economic dose computed for low and high available P status soil was found to be 48.41 and 50.50 $\text{kg P}_2\text{O}_5 \text{ ha}^{-1}$, respectively.

Table 3: Nitrogen, potassium content and uptake in sunflower seed as influenced by different P levels

P_2O_5 level (kg ha^{-1})	Concentration (%)		Uptake (kg ha^{-1})	
	N	K	N	K
Low available P				
0	2.34	0.41	14.01	2.15
15	2.57	0.38	20.57	4.73
30	2.62	0.36	43.37	6.91
45	2.92	0.41	40.94	6.29
60	2.87	0.38	46.99	7.30
75	2.96	0.35	39.33	4.97
C.D. (P=0.05)	0.22	0.04	6.63	1.12
Medium available P				
0	2.03	0.37	20.68	3.88
15	2.25	0.41	25.28	3.64
30	2.44	0.41	29.30	4.94
45	2.53	0.42	32.77	5.33
60	2.51	0.38	33.88	5.19
75	2.54	0.40	36.93	5.99
C.D. (P=0.05)	0.22	0.05	5.25	1.02
High available P				
0	2.35	0.36	43.33	6.64
15	2.44	0.39	49.68	7.94
30	2.51	0.40	88.95	14.18
45	2.54	0.39	92.86	14.26
60	2.64	0.41	84.90	13.19
75	2.77	0.35	86.31	10.91
C.D. (P=0.05)	0.21	NS	32.21	4.97

Similarly, the following quadratic response equations for total P uptake (shoot+seed) by sunflower in low, medium and high available P soils were computed.

$$\text{Low available P: } Y = 240 + 11.471 X - 0.1019 X^2 \quad R^2 = 0.93$$

$$\text{Medium available P: } Y = 327.46 + 2.2802 X - 0.014 X^2 \quad R^2 = 0.83$$

$$\text{High available P: } Y = 590.64 + 16.074 X - 0.1268 X^2 \quad R^2 = 0.87$$

Where Y is total P uptake (kg ha^{-1}) and X is the level of P_2O_5 applied (kg ha^{-1}).

The magnitude of response ($\text{kg seed} / \text{kg P applied}$) declined with successive doses of P application over control at all sites. In low, medium and high available P status soils, it ranged from 41.1 to -2.6, 6.3 to 2.6 and 12.8 to -7.2, respectively (Table 2). Nutrient use efficiency and productive efficiency also decreased with increasing doses of P application. In low and high available P soils relatively higher NUE and PE was observed at $30 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ (Table 2). Apparent P recovery declined with increasing rates of P application.

Soil available P and critical limit

Soil available P was found to vary significantly only in low available P status soil after the sunflower crop harvest (Table 4).

Table 4: Available soil P status

P_2O_5 level (kg ha^{-1})	Available soil P (kg ha^{-1})	
	Initial	After crop harvest
Low available P		
0	6.9	18.69
15	8.6	15.78
30	8.6	22.43
45	5.9	15.90
60	13.1	16.52
75	10.8	19.44
C.D. (P=0.05)	NS	1.78
Medium available P		
0	11.21	13.47
15	14.70	12.70
30	13.34	14.79
45	13.09	14.05
60	20.48	23.17
75	27.84	15.29
C.D. (P=0.05)	NS	NS
High available P		
0	14.74	15.78
15	17.49	20.21
30	23.25	15.61
45	17.59	16.89
60	17.47	16.88
75	17.07	17.99
C.D. (P=0.05)	NS	NS

In general, the positive balance of available soil P observed was the result of low P uptake over total quantity of phosphorus applied to the crop. The scatter diagram

procedure (Cate and Nelson, 1965) showed that 20 kg P ha^{-1} was the critical P level (Figure 1), below which sunflower may respond to phosphorus application.

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REACCIÓN DE GIRASOL (*Helianthus annuus* L.) A APLICACIÓN DE FÓSFORO EN LOS SUELOS TIPO VERTISOL

RESUMEN

Los ensayos de campo, en los suelos tipo vertisol, que contenían bajas, medianas y altas cantidades de fósforo, fueron emprendidos con el objetivo de investigar la reacción del híbrido de girasol KBSH-1 en diferentes niveles de aplicación de fósforo. La influencia de fósforo en el aumento del rendimiento y demás componentes, fue más destacada en el suelo de bajo contenido de fósforo. Se elaboró la fórmula de reacción de rendimiento de girasol en el nivel aplicado de fósforo. También fueron calculados la eficiencia de utilización de abono y la eficiencia de producción. La cantidad del fósforo accesible variaba significativamente sólo en el suelo con el bajo contenido de fósforo. Se determinó que el nivel crítico de fósforo en el suelo era 20 kg P ha^{-1} , y que debajo de este nivel, el girasol reaccionaba a la aplicación de fósforo.

**RÉACTION DU TOURNESOL (*Helianthus annuus* L.) À
L'APPLICATION DE PHOSPHORE DANS LE VERTISOL****RÉSUMÉ**

Des expériences dans des sols de type vertisol contenant des quantités de phosphore faibles, moyennes et élevées ont été faites dans le but d'examiner la réaction de l'hybride de tournesol KBSH-1 à différents niveaux d'application de phosphore. L'effet du phosphore dans l'augmentation du rendement et des attributs du rendement a été plus prononcé dans le sol à faible contenu de phosphore. Une formule de la réaction du rendement du tournesol à l'application d'un niveau de phosphore a été établie. De même, l'efficacité de l'utilisation de nutriment et l'efficacité de productivité ont été calculées. La quantité de phosphore disponible ne variait significativement que dans le sol à faible contenu de phosphore. Il a été établi que le niveau de phosphore critique dans le sol était de 20kg P ha^{-1} , niveau sous lequel le tournesol pourrait réagir à l'application de phosphore.