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Effect of phosphorus and sulphur on pigeonpea (*Cajanus cajan*) and succeeding wheat (*Triticum aestivum*) in pigeonpea–wheat cropping system

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ABSTRACT

A field experiment was conducted at New Delhi during 1994–96 on sandy-loam soil analysing low in N and medium in available P, K and S. Pigeonpea [*Cajanus cajan* (L.) Millsp.] receiving 80 kg P_2O_5/ha produced taller plants and more branches/plant than 40 kg P_2O_5/ha, phosphate-solubilizing bacteria (PSB) and no phosphorus. However, pods/plant, seeds/pod, 1,000-seed weight and yield of pigeonpea did not record marked increase beyond 40 kg P_2O_5/ha. Similarly, the growth (plant height, branching and leaf-area index) and yield attributes (pods/plant, seeds/pod and 1,000-seed/weight) and yield of pigeonpea showed favourable response up to 30 kg S/ha only. In wheat (*Triticum aestivum* L. emend Fiori & Paol) grown after pigeonpea, the maximum values of growth (plant height and total tillers/m row length) and yield attributes (productive tillers/m row length, seeds/spike and 1,000-seed/weight) and yield of wheat were recorded with 80 kg P_2O_5, and 60 kg S/ha applied to pigeonpea crop. The highest net return from the cropping system was obtained when pigeonpea was fertilized with 80 kg P_2O_5 and 60 kg S/ha and wheat was grown on residual fertility.

Key words : Pigeonpea, Wheat, Phosphorus, Sulphur

Pulses have to be grown in the multiple cropping systems for sustainable production. The progressive shrinkage of per caput land availability warrants temporal and spatial intensification of cropping. The evoluation of short-duration and input-responsive varieties of pigeonpea have opened up new avenues in this direction, as wheat could be grown in quick succession. Pigeonpea followed by wheat in northern plains is an ideal example of the non-conventional cropping system (Ahlawat *et al.*, 1985).

Pigeonpea, being a deep-rooted crop, is capable of utilizing plant nutrients from deeper layers of soil and leaving them as crop residues in the upper layers. The succeeding shallow-rooted crops, thereby increasing the efficiency of applied nutrients can utilize nutrients so fetched.

Phosphorus and sulphur, unutilized by the crop to which they are added, are partially available to the subsequent crops, and residual effect thus becomes an important dimension of phosphorus and sulphur management. An experiment was therefore conducted to study the effect of phosphorus and sulphur fertilization in pigeonpea and their residual effect on succeeding wheat in pigeonpea–wheat sequence.

MATERIALS AND METHODS

A field experiment was conducted during 1994–96 at the Indian Agricultural Research Institute, New Delhi. The soil was sandy loam having organic carbon 0.365-0382%, total N 0.0371-0.0393%, available P 10.2-10.6 kg/ha, available K 176.0-180.2 kg/ha and available S 14 kg/ha, with pH 7.6. The experiment was laid out in factorial randomized block design with 4 replications. The treatments comprised 5 levels of P [no P, phosphate-solubilizing bacteria (PSB), 40 P_2O_5/ha, 40 kg P_2O_5/ha+PSB and 80 kg P_2O_5/ha] and 3 levels of S (no S, 30 and 60 kg/ha). In pigeonpea crop, all the P was applied at sowing, while S was applied 3 weeks before sowing. The PSB culture 'microphos' containing inoculum of *Pseudomonas striata* was used for inoculating the seed as per treatment. The succeeding crop of wheat was grown without P and S fertilizers. 'Pusa 85' pigeonpea was sown in the last week of June and the following 'HD 2285' wheat in the second week of December. Other management practices were adopted as per recommendations of the crops.

RESULTS AND DISCUSSION

Pigeonpea

Effect of phosphorus: Increasing levels of P up to 80 kg P_2O_5/ha in pigeonpea resulted in a significant increase in plant height and branches/plant (Table 1). However, leaf-area index increased up to 40 kg P_2O_5/ha only. PSB alone and in combination with 40 kg P_2O_5/ha did not cause additional increase in these growth attributes (Table 1). The overall improvement in crop growth with P application seems to be on account of its pivotal role in early formation of roots, their proliferation and increased microbial activity in the root nodules. This might have improved effective utilization of soil nutrients by the crops and greater biological N-fixation through enhancement in nitrogenase activity (Venkateswarlu *et al.*, 1988). Our results are in line with those of Gupta (1990).

Pigeonpea fertilized with 40 kg P_2O_5/ha significantly increased the yield attributes, viz. pods/plant, seeds/pods and 1,000-seed weight, and grain yield over no P (Tables 1, 3). Further increase in the level of P to 80 kg P_2O_5/ha did not cause any improvement in yield attributes and yield. The increase in grain yield with 40 kg P_2O_5/ha being 15.0 33.3 and 23.5% respectively over no P in 1994, 1995 and in pooled data. This could be attributed to overall improvement in crop growth as reflected by growth attributes. Moreover, P plays a key role in the root development, energy transformation and metabolic processes of plant and thus resulted in greater transloca-

Table 1. Effect of phosphorus and sulphur on growth and yield attributes of pigeonpea

Treatment	Plant height(cm)		Branches/plant		Leaf-area index		Pods/plant		Seeds/pod		1,000 seed weight (g)	
	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
P_2O_5 (kg/ha)												
0	133.7	131.5	13.5	12.9	1.68	1.63	156.7	154.0	2.35	2.00	63.2	61.7
PSB	138.9	137.9	14.7	13.9	1.73	1.68	164.3	162.6	2.66	2.25	64.2	62.3
40	154.2	150.1	21.2	20.9	1.92	1.90	182.1	180.2	4.00	3.83	70.8	68.8
40 + PSB	158.1	155.2	23.3	22.6	1.96	1.91	188.4	186.9	4.32	4.00	70.9	69.2
80	166.5	163.7	24.9	23.7	2.01	1.98	190.1	189.4	4.42	4.08	72.0	71.4
CD (P = 0.05)	8.3	9.6	2.1	1.4	0.18	0.16	8.3	10.2	0.34	0.40	5.2	5.8
Sulphur (kg/ha)												
0	138.7	136.2	15.8	14.9	1.71	1.66	158.3	156.5	2.75	2.20	66.9	65.5
30	152.9	150.2	20.6	20.3	1.90	1.85	183.0	181.3	3.98	3.60	68.5	67.0
60	159.2	156.7	22.2	21.2	1.97	1.95	187.7	185.8	4.04	3.90	69.3	67.6
CD (P = 0.05)	6.4	7.4	1.6	1.1	0.14	0.13	6.4	7.9	0.26	0.31	NS	NS

tion of photosynthates towards the sink development (Tisdale *et al.*, 1995). Similar observations were also made by Chittapur *et al.* (1994).

Effect of sulphur : Sulphur fertilization in pigeonpea @ 30 kg/ha, being at par with 60 kg/ha, significantly increased growth attributes (plant height, branches/plant and leaf-area index) over no S (Table 1). An improvement in plant growth by S application might be owing to its role in the formation of amino acids, viz. cysteine, cystine, methionine and synthesis of protein, vitamins and chlorophyll (Tandon, 1991). The results confirm the findings of Ramkala *et al.* (1992).

The trend of response to applied S in respect of yield attributes and grain yield was similar to growth attributes (Table 1, 3). The percentage increase in grain yield with 30 kg S/ha over no S was 13.1, 19.3 and 16.1 respectively in 1994, 1995 and in pooled data. The improvement in yield components might have resulted from favourable influence of S on growth attributes and efficient and greater partitioning of metabolities and adequate translocation of nutrients to developing reproductive structures. The increase in grain yield was largely a function of improved and consequent increase in yield attributes. The results are in conformity with those of Singh and Ali (1994).

Wheat

Residual effect of phosphorus: Application of 80 kg P_2O_5/ha to preceding pigeonpea recorded greater residual effect in terms of growth attributes (plant height and tillers/m row length) of wheat when compared with lower levels of P and PSB (Table 2). Similar behaviour was also noticed for yield attributes (productive tillers/m row length, grains/spike and 1,000-grain weight), and grain yield of wheat (Tables 2, 3). The differences

Table 2. Effect of residual phosphorus and sulphur on growth and yield attributes of wheat

Treatment	Plant height (cm)		Total tillers/m		Productive tillers/m		Grains/ spike		1,000-grain weight (g)	
	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
P_2O_5 (kg/ha)										
0	70.5	68.7	96.3	95.4	74.6	73.1	30.2	29.1	42.2	42.1
PSB	73.1	71.8	99.7	101.3	77.0	74.9	32.0	31.8	43.4	43.1
40	75.5	74.5	111.7	111.3	86.6	83.6	35.4	35.0	44.9	45.0
40 + PSB	77.0	75.4	112.9	113.4	88.1	86.2	38.4	37.7	46.2	45.7
80	78.2	78.0	125.4	121.3	97.3	95.3	41.4	40.5	48.3	48.0
CD (P = 0.05)	2.6	2.8	6.2	6.3	7.8	6.5	3.0	2.6	2.4	3.5
Sulphur (kg/ha)										
0	72.0	69.8	99.7	98.8	76.7	74.4	31.8	30.7	43.8	43.3
30	75.5	74.2	109.4	109.1	85.1	82.7	35.2	35.0	45.2	45.0
60	77.5	77.1	118.5	117.7	92.4	90.7	39.7	38.9	46.0	45.9
CD (P = 0.05)	2.0	2.2	4.8	4.8	6.1	5.1	2.3	2.0	1.8	NS

Table 3. Grain yield of pigeonpea and wheat and net return as affected by phosphorus and sulphur fertilization

Treatment	Pigeonpea yield (q/ha)			Wheat yield (q/ha)			Net return (Rs/ha) (mean of 2 seasons)
	1994	1995	Pooled	1994–95	1995–96	Pooled	
P_2O_5 (kg/ha)							
0	15.91	13.81	14.86	28.70	26.46	27.58	16,960
PSB	16.08	15.45	15.77	29.21	28.88	29.05	19,005
40	18.31	18.41	18.36	34.36	32.59	33.48	21,668
40 + PSB	18.45	18.83	18.64	34.87	33.56	34.22	22,693
80	18.68	19.28	18.98	36.90	37.50	37.20	23,788
CD (P = 0.05)	0.75	1.13	0.81	1.93	2.80	1.88	
Sulphur (kg/ha)							
0	15.91	15.05	15.48	29.24	27.40	28.32	18,205
30	17.99	17.95	17.97	33.20	32.70	32.95	21,588
60	18.55	18.47	18.51	36.00	35.31	35.66	22,675
CD (P = 0.05)	0.58	0.88	0.62	1.49	2.16	1.45	

between 40 kg P_2O_5 /ha with and without PSB, and PSB and no P were not perceptible. Over the seasons, the grain yield of wheat increased by 18.8 and 34.9% with 80 kg P_2O_5/ha applied to preceding pigeonpea as compared with 40 kg P_2O_5/ha and no P respectively. The increased vigour and growth of plants (Table 2) resulting from the residual effect of P led to better development of yield attributes and finally led to increased yield of wheat. Singh *et al.* (1983) and Singh and Faroda (1987) also reported similar results.

Residual effect of sulphur : The growth attributes (plant height and total tillers/m row length), yield attributes (productive tillers/m row length, grains/spike and 1,000-grain weight), and yield of wheat increased markedly in linear fashion with increasing level of S up to 60 kg/ha applied to preceding pigeonpea (Tables 2, 3). However, the differences between 60 and 30 kg residuals S, and 30 and 0 kg residuals S in terms of 1,000-grain weight were not marked. Based on 2 seasons, the mean grain yield with 60 kg residual S/ha increased by 8.2 and 25.9% over 30 kg residual S/ha and no S respectively. In general, the marked improvement in productivity of wheat crop with residual sulphur could be ascribed to enhancement of SO^{-2}_4-S content of soil. This might have modified soil environment along with the improvement in physical parameters of the soil conducive for the growth and development of wheat crop.

Economics of pigeonpea–wheat sequence

The maximum net return from the

cropping system was realized with 80 kg P_2O_5/ha applied to pigeonpea. PSB inoculation alone fetched a net return of Rs 19,005, which was Rs 2,045 higher than no phosphorus. Singh and Faroda (1987) also recorded the maximum net returns with higher level of P applied to pigeonpea in pigeonpea wheat cropping system. Further, the highest net return of Rs 22,675 from the cropping system was obtained when pigeonpea crop was fertilized with 60 kg S/ha (Table 3).

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