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# Response of pigeonpea *(Cajanus cajan)* to sources and levels of phosphorus under rainfed condition

**AVNISH KUMAR AND H.S. KUSHWAHA**

*Department of Agronomy, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Madhya Pradesh 485 331*

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## ABSTRACT

A field experiment was conducted during rainy seasons of 1999 and 2000 to study the effect of sources and levels of phosphorus on productivity of pigeonpea *[Cajanus cajan* (L.) Millsp.]. Application of single superphosphate (SSP) produced significantly higher nodules/plant, dry weight of nodules/plant and pods/plant than that of diammonium phosphate (DAP). Application of SSP increased the seed yield, total P uptake and net returns over their respective DAP respectively by 6.1%, 0.53 kg $P_2O_5$/ha and Rs 913/ha. Phosphorus application increased the nodules/plant, dry weight of nodules/plant, pods/plant, seed yield, total P uptake and net returns significantly. Seed yield and net returns increased significantly with P levels up to 40 kg $P_2O_5$/ha, giving 52.4 and 18.3 % and Rs 6,757 and Rs 3,002/ha more over the control and 20 kg $P_2O_5$ respectively. Returns/Re invested was recorded more under 60 and 80 kg $P_2O_5$/ha (Rs 2.76), followed by 40 kg $P_2O_5$/ha (Rs 2.66). The agronomic P-use efficiency (APUE) and apparent P recovery were higher in SSP; however, these were recorded more at lower level of P and decreased with increase in P level. The physiological efficiency of phosphorus (PEP) and phosphorus-use efficiency (PUE) were calculated more in DAP. However, PEP increased with increase in P level.

***Key words :*** Pigeonpea, Phosphorus sources, Yield, Phosphorus uptake, APUE, Apparent recovery, PEP, PUE, Rainfed

Pigeonpea (*Cajanus cajan*) is an important pulse crop, grown intensively in Madhya Pradesh. The evolution of short-duration varieties of pigeonpea have provided the opportunity for multiple cropping in irrigated as well as rainfed areas. Even its shrot-duration variety responds highly to phosphorus (Sarkar *et al.,* 1997). During the past few years the prices of phosphorus are increasing due to decrease in government subsidy on fertilizers, especially of phosphorus and potassium. It has created imbalance of P nutrition and soil-P reserve. Therefore it is necessary to apply P in balanced amount for improving the productivity of pigeonpea.

## MATERIALS AND METHODS

A field experiment was conducted during rainy season *(kharif)* of 1999 and 2000 at Agricultural Research Farm, Rajaula, Chitrakoot, district Satna. The soil was sandy loam, low in organic carbon (0.38 and 0.41%), total N (146 and 156 kg/ha), and available P (12 and 12.5 kg/ha) and K (112 and 116 kg/ha), with pH 7.4 and 7.1 in 1999 and 2000 respectively. The total rainfall was received 815.9 and 750.0 mm during the cropping season (July to December) 1999 and 2000 respectively. The treatments consisted of two sources of phosphorus [single superphosphate (SSP) and diammonium phosphate (DAP)], four levels of phosphours (20, 40, 60 and 80 kg $P_2O_5$/ha) and a control. In all, nine treatments were tested in two-factor randomized block design with three replications. All the doses of phosphorus treatments and recommended doses of nitrogen and potassium were applied basal. The crop 'ICPL 87' was sown on 21 July 1999 and 10 July 2000 and the respective crop was harvested on 14 December 1999 and 2 December 2000. Phosphorus-use efficiency (PUE) was calculated as per Goodroad and Jellum (1988) : PUE = Physiological efficiency × Apparent recovery

## RESULTS AND DISCUSSION

### *Growth, yield attributes and yield*

Single superphosphate application gave more seed yield of pigeonpea, which was 6.1% higher than that of DAP. Similarly, pods/plant were significantly higher under SSP than DAP. Further, the application of SSP recorded greater plant height of pigeonpea (Table 1), which may be

ascribed to favourable improvement in pods/plant and plant height. This could be attributed to extra supply of Ca (20%) and S (12%). Singh *et al.* (1994) also reported superiority of SSP to DAP. Contrary to seed yield, stalk yield was 6.3% more under DAP than SSP.

Seed yield of pigeonpea increased significantly up to 40 kg $P_2O_5$/ha. Pods/plant increased significantly up to 60 kg $P_2O_5$/ha. The statistically non-significant value of seed yield at higher P than at 40 kg $P_2O_5$/ha was probably due to lesser magnitude of P response, because it depends on the amount of moisture available in the soil and is a limiting factor under rainfed condition. Katyal *et al.* (1999) reported similar findings. The maximum stalk yield and plant height were observed under 80 kg $P_2O_5$/ha, followed by 60 kg $P_2O_5$/ha; their values were found statistically at par. The greater value of stalk yield at higher dose of P is owing to significantly higher value of dry matter/plant besides the other growth and yield parameters (Table 1). These findings are in conformity with the result of Sarkar *et al.* (1997).

### Nodulation

Single superphosphate application recorded significantly higher nodules/plant and dry weight of nodules, being respectively 36.4 and 45.6% more than of DAP (Table 1). The higher nodules/plant under SSP might be due to the favourable effect of S supplement on nodule development. The higher dry weight of nodules/plant under SSP was probably due to greater number of nodules/plant.

The maximum nodules/plant of pigeonpea were formed under 80 kg $P_2O_5$/ha, but significantly higher value was observed up to 60 kg $P_2O_5$/ha. Almost similar trend was observed in dry weight of nodules/plant, but their values under 40 and 80 kg $P_2O_5$/ha were non-significant. The nodules/plant with addition of successive doses of P increased because phosphorus helps the plant to develop a more extensive root system and provide favourable condition for nodulation. The increased dry weight of nodules/plant with each increment of P might be due to the formation of vigorous and more nodules/plant on P application. These results are in accordance with those reported by Rathore *et al.* (1992).

### Phosphorus uptake and efficiency

Single superphosphate fertilization recorded significantly more grain and total P uptake than DAP owing to substantially higher concentration of P in the grain and stalk as well as greater grain yield of pigeonpea. The increase in P uptake by SSP might be due to the synergistic interaction effect of P and S. These results are in agreement with those of Shankaralingappa *et al.* (2000). Single superphosphate also recorded higher APUE and apparent P recovery than DAP, due to greater grain yield and more P uptake. But DAP application recorded higher PEP and PUE owing to greater stalk yield.

The grain and stalk yields and the total P uptake by pigeonpea increased significantly with increase in P level due to higher amount of biomass production and subsequently greater P accumulation by the plant. Shankaralingappa *et al.* (2000) made similar observation. APUE, apparent P recovery and PUE declined because the P applied to pigeonpea is subjected to P fixation. The highest APUE was observed under 20 kg $P_2O_5$/ha, followed by that under 40 kg $P_2O_5$/ha owing to greater grain production per unit of P applied. Almost similar trend was noted for apparent P recovery (Table 2). The phosphorus-

**Table 1.** Effect of sources and levels of phosphorus on plant height, nodulation, yield attributes and yield of pigeonpea (pooled data of 2 years)

| Treatment | Plant height (cm) at 135 days | Nodules/ plant at 45 days | Dry weight of nodules at 45 days (mg/plant) | Pods/plant | Seeds/pod | 100-seed weight (g) | Seed yield (q/ha) | Stalk yield (q/ha) |
|---|---|---|---|---|---|---|---|---|
| Control | 103.2 | 9 | 70.0 | 86.6 | 3.3 | 8.2 | 9.02 | 30.00 |
| *P source* | | | | | | | | |
| SSP | 114.4 | 15 | 116.6 | 123.4 | 3.7 | 8.8 | 14.33 | 34.92 |
| DAP | 108.2 | 11 | 80.1 | 105.7 | 3.5 | 8.9 | 13.51 | 37.14 |
| CD (P=0.05) | NS | 2 | 16.0 | 4.9 | NS | NS | NS | NS |
| *$P_2O_5$ (kg/ha)* | | | | | | | | |
| 20 | 107.6 | 11 | 81.1 | 102.3 | 3.4 | 8.4 | 11.62 | 32.18 |
| 40 | 108.7 | 12 | 97.2 | 109.8 | 3.5 | 8.6 | 13.75 | 33.93 |
| 60 | 111.8 | 14 | 98.5 | 121.7 | 3.6 | 9.0 | 14.85 | 37.25 |
| 80 | 117.1 | 15 | 116.7 | 124.3 | 3.8 | 9.3 | 15.45 | 40.73 |
| CD (P=0.05) | NS | 2 | 21.1 | 7.2 | NS | NS | 20.2 | NS |

SSP, Single superphosphate; DAP, diammonium phosphate

**Table 2.** Effect of sources and levels of phosphorus on P uptake, P efficiencies and economics of pigeonpea (pooled data of 2 years)

| Treatment | P uptake (kg $P_2O_5$/ha) | | | APUE (kg grain/kg $P_2O_5$) | Apparent P recovery (%) | PEP (kg/kg $P_2O_5$) | PUE (%) | Net returns (Rs/ha) | Returns/Re invested |
|---|---|---|---|---|---|---|---|---|---|
| | Grain | Stalk | Total | | | | | | |
| Control | 4.62 | 4.33 | 8.95 | | | | | 7,457 | 1.95 |
| *P source* | | | | | | | | | |
| SSP | 8.43 | 5.84 | 14.27 | 10.62 | 10.64 | 192.29 | 20.45 | 14,845 | 2.67 |
| DAP | 7.72 | 6.02 | 13.74 | 8.98 | 9.58 | 242.70 | 23.26 | 13,932 | 2.63 |
| CD (P=0.05) | 0.05 | NS | 0.37 | | | | | NS | |
| *$P_2O_5$ (kg/ha)* | | | | | | | | | |
| 20 | 6.43 | 5.08 | 11.51 | 13.00 | 12.80 | 186.71 | 23.89 | 11,212 | 2.42 |
| 40 | 8.06 | 5.65 | 13.71 | 11.82 | 11.90 | 181.93 | 21.64 | 14,424 | 2.66 |
| 60 | 8.84 | 6.48 | 15.32 | 9.71 | 10.61 | 205.34 | 21.78 | 15,726 | 2.76 |
| 80 | 9.02 | 6.62 | 15.64 | 8.03 | 8.36 | 256.50 | 21.43 | 16,401 | 2.76 |
| CD (P=0.05) | 0.07 | 0.39 | 0.50 | | | | | 3,211 | |

APUE, Agronomic phosphorus-use efficiency; PEP, physiological efficiency of phosphorus; PUE, phosphorus-use efficiency

use efficiency also followed this trend, probably due to greater P uptake per unit of P added. Though physiological efficiency of P increased with increase in P level, it was highest under 80 kg $P_2O_5$/ha owing to production of more biomass.

### Economics

Single superphosphate application gave Rs 913 more net returns and Re 0.04 higher returns/Re invested compared with DAP, due to greater seed yield of pigeonpea under the respective sources. Net return of pigeonpea increased significantly up to 40 kg $P_2O_5$/ha compared with that under lower P doses. At P level more than 40 kg $P_2O_5$/ha, the net returns was statistically similar (Table 2). This could be attributed to almost similar pattern of grain, straw and stick yields of pigeonpea. Returns/Re invested improved up to 60 kg $P_2O_5$/ha. It was minimum in the control.

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