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Productivity and profitability of pigeonpea [*Cajanus cajan* (l.) millsp.] genotypes as influenced by phosphorus and sulphur fertilization

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Abstract

A field experiment was conducted on pigeonpea during kharif season of 2004 and 2005 to study the productivity and profitability of pigeonpea genotypes as influenced by phosphorus and sulphur fertilization. Four levels of P (0, 30, 60 and 90 kg P_2O_5/ha), three levels of S (0, 20 and 40 kg S/ha) and three genotypes (UPAS-120, Pusa-992 and Pusa-855) were used in the study. Pusa-855 was found significantly better in respect of yield and economics as compared to all other genotypes. Application of phosphorus @ 60 kg P_2O_5/ha gave significantly higher seed and straw/stalk yield over its lower doses. 40 kg sulphur per hectare gave significantly higher seed yield over control and 20 kg S/ha. However, application of sulphur only up to 20 kg/ha increased straw/stalk yield significantly as compared to control. Genotype Pusa 855 gave maximum net return (Rs./ha 15888) among all three genotypes.

Key words: Genotypes, productivity, net return, yield

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a premium pulse crop in India. Its ability to produce economic yield under limited moisture condition makes crop of dryland agriculture. Despite being the largest producer in the world, the country is in short supply of pulses. To make the nation self sufficient in pulses, productivity levels of pulses need to be increased sustainability from 598 kg/ha to 1200 kg/ha by 2020 (Ali and Kumar, 2005). Although various factors are responsible to enhanse the production of pulses including pigeonpea.

Pigeonpea is one of the major food legume crop of the tropics and sub-tropics. In India, pigeonpea is the second most important pulse crop next to chickpea. It is mainly eaten in the form of split pulse as *dal*. Besides this, in the tribal areas of various states, the use of pigeonpea as green vegetable is very common (Saxena *et al.* 2010). The crushed dry seeds are feed of animals, while green leaves are used as a quality fodder. The dry stems of pigeonpea make an excellent fuel wood.

Pulses are wonderful gift of nature. Pulses are the rich source of protein, specially for vegetarian. Being rich in protein (22-23%) pigeonpea is a good source of nutrition to the pre dominantly vegetarian population in our country. It is mostly consumed in the form of *dal* (split cotyledons). Pigeonpea is an important pulse crop. The evoluation of short duration varieties to pigeonpea have provided the opportunity for multiple cropping in irrigated as well as rainfed areas. Even its short duration varieties responded highly to phosphorus and sulphur. Recently some short duration varieties of about 130-160 days have been developed which have high yield potential (20-30 q/ ha) and harvested by end of November. These varieties fit very well under double cropping system with wheat and other *rabi* crops. In India, pigeonpea among the *kharif* grain legumes, occupies first place is the second most important pulse crop next to chickpea as a whole.

Pigeonpea is the fifth prominent grain legume crop in the world and holds second position in India after chickpea. The low yield of pigeonpea is not only due to its cultivation on marginal land, but also because of inadequate and imbalanced fertilization. Phosphorus is required mainly for root development, nodule formation, seed development and quality improvement of crop. Phosphorus in an important plant nutrient and it affects seed germination, cell division, flowering, fruiting, synthesis of fat, starch and infact most biochemical activities. It also induces root proliferation and nodulation.

Sulphur is an important essential secondary plant nutrient. Importance of sulphur in Indian agriculture is being increasingly emphasized and sulphur has been considered 4th important nutrient has a great impact on production of legumes as most of Indian soils are being reported sulphur deficient in extensively cultivated tracts. In fact, a major factor responsible for sustaining soil productivity in India has been the highly diversified nature of the cropping patterns which either include a pulse or a legume crop as one of the component. Sulphur plays an important role in many physiological process in plant *viz*; synthesis of sulphur containing amino acids (Cysteine, Cystine and Methionine), synthesis of certain vitamins (Biotine and Thiomine), co-enzyme A and in the metabolism of carbohydrates, proteins and fats. Sulphur also promotes nodulation in legumes. Although not a constituent, sulphur is required for the synthesis of chlorophyll. Sulphur application increases drought and cold tolerance in plants due to the process of disulfide linkage. It also helps in the control of diseases and pest. The sulphur deficiency has been recognized as a factor in limiting the yield and quality of grain legumes as around 70% of the S is found in the chloroplast and thus plays vital role in carbon assimilation. Therefore the present investigation was conducted to evaluate the performances of different short duration pigeonpea genotypes to phosphorus and sulphur fertilization in respect of productivity and profitability.

Materials and Methods

The experiment was conducted during the *kharif* seasons 2004 and 2005 at Agricultural Research Farm of R.B.S College, Bichpuri, Agra. The soil was sandy loam, having pH 7.90, electrical conductivity (EC) 1.86 dS/m, organic carbon 0.34% and available N, P_2O_5, K_2O and S 182.0, 29.50, 253.0 and 15.0 kg/ha, respectively. The treatments consisted of three genotypes (UPAS-120, Pusa-992 and Pusa-855), four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5/ha) and three levels of sulphur (0, 20 and 40 kg S/ha).The experiment was conducted in split plot design, where genotypes and levels of phosphorus kept in main plot and sulphur levels in sub plot, replicated three times. Full dose of phosphorus and sulphur as per treatments through dia-ammonium phosphate and elemental sulphur, respectively were applied just before sowing of crop. Supply of 20 kg N ha^{-1} and 40 kg potassium K_2O ha^{-1} were applied for the crop as basal. A uniform dose of nitrogen and potassium @ 20 and 40 kg ha^{-1} were applied through urea and murate of potash. The seed of pigeonpea varieties were treated with thiram @ 3 g/kg seed. The pigeonpea seeds were sown @ 15 kg ha^{-1} by *kera* (dropping the seeds in furrows behind the plough). The light hoeings with *khurpi* were done at 15 and 30 DAS to remove weeds along with thinning operations maintaining plant spacing row to row and plant to plant 60 cm X 20 cm. The next operation was done at 60 days after sowing.The plants from net plot were harvested from the ground level and were left for sun drying *in-situ*. The pigeonpea were threshed manually. Grains were cleaned and weighed for expressing yield in q ha^{-1}. The weight of straw/stalk was recorded separately and used for estimating straw/stalk yield. Number of pods/plant, number of seeds/pod, grain weight/plant, pods weight/ plant, 1000-seed weight, seed yield and straw/stalk yield etc. were recorded. Economics was calculated by using prevailing market prices of inputs used and outputs.

Results and Discussion

Genotypes

The yield attributing characters (number of pods per plant, weight of pods per plant, seed weight per plant, seeds per pod and 1000-seed weight) record significant variation among genotypes. Puse-855 produce more number of pods per plant and grain weight per plant over others. The higher values of these yield attributes resulted in higher seed yield per plant and seed yield per hectare. Genotype Puse-855 produced significantly more number of pods per plant, weight of pods per plant, 1000-seed weight compared with Pusa-992 and UPAS-120. Genotype Pusa-855 scored significantly higher seed productivity over UPAS-120. UPAS-120 was short duration genotype over Pusa-992 and Pusa-855. The seed and straw/ stalik yield obtained with Pusa-855 was significantly higher than same noticed with Pusa 992 and UPAS-120. Higher yield could be obtain with the application of phosphorus 90 kg/ha and sulphur 40 kg/ha. General longer the duration, yielding ability would be higher.

Effect of phosphorus

The yield parameters *viz.* number of pods/plant, seed/pod, weight of pods per plant, seed weight per plant and 1000-seed weight were significantly affected by the levels of phosphorus and sulphur. Application of 90 kg P_2O_5 ha^{-1} being at par with 30 kg P_2O_5 ha^{-1} significantly increased yield attributes viz. pods/plant and grains/pod over 30 P_2O_5 ha^{-1} and control. The maximum grain yield was obtained with application of 90 kg P_2O_5 ha^{-1} being significantly superior over application of 30 kg P_2O_5 ha^{-1} and control. The higher values of yield and yield attributes may be described to the effect of P on root development, energy transformation and metabolic processes of the plant, which, in term, resulted in greater translocation of photosynthates towards the sink development. These results are in conformity with Singh and Ahlawat (2007).

The beneficial effect of phosphorus on production of grain and straw/stalk were observed in this investigation. Higher seed yield was obtained with the application of 90 kg P_2O_5 ha^{-1}. Similar findings were reported by Singh *et al*. (2008), Goud and Kale (2010) and Sathe *et al*. (2011). This is apparently due to increase in yield attributes. Straw/stalk yields were also affected by levels of phosphorus and maximum values were recorded with 90 kg P_2O_5 ha^{-1}. The beneficial effect of phosphorus application on yields obtained in the present investigation, are in close conformity with those of Kumar *et al*. (2007).

Phosphorus application up to 60 kg P_2O_5 ha^{-1} recorded significantly higher seed and straw/stalk yield as compared with lower P doses. Straw/stalk yield, pods/plant, weight of pods per plant, seed weight per plant and seeds/pod were higher at 30 or 60 kg P_2O_5 ha^{-1}over control. Such improvement in seed yield might be probably because of phosphorus improved in the rate of symbiotic N fixation and, in turn, stimulates the growth of plants thereby having beneficial effects of yield attributes and given higher yields. These results are in close conformity with the findings of Dass *et al.* (2005).

The seed production is dependent on yield attributes and all these traits were favorably affected by phosphorus application. Seed yield of pigeonpea increased significantly up to 60 kg P_2O_5/ha. The maximum straw/stalk yield were observed under 90 kg P_2O_5/ha followed by 60 kg P_2O_5/ha, their values were found statistically at par. The greater value of straw/stalk yield at higher dose of P is significantly higher pace of growth in the plots enjoying surplus phosphorus. However, the higher value of grain yield was result of higher value of different yield contributing characters. These findings are in the conformity with the result of Gupta *et al.* (2006).

The seed yield was significantly increased by the application of 90 kg P_2O_5/ha as compared to 30 kg P_2O_5/ha and control. This may be attributed to greater availability of phosphorus due to these treatments and better growth and yield attributes. Maximum seed and stalk yield of pigeonpea was found with application of 90 kg P_2O_5 ha^{-1} which was at par with 60 kg P_2O_5 ha^{-1} and significantly superior over 30 kg P_2O_5/ha and control during both the years of investigation. Similar results have been reported by Deshbhrartar *et al.* (2010) and Mahetele and Kushwaha (2011).

Effect of sulphur

Application of 20 kg S ha^{-1} significantly increased the yield attributes *viz*. pods/plant, weight of pods per plant, seed weight per plant and grains/pod of pigeonpea over no sulpher. The results are in conformity with those of Deshbhratar *et al.* (2010) who also noted increased yield by application of sulphur. Application of sulphur up to 40 kg ha^{-1} significantly increased the number of pods/plant, number of seeds/pod, weight of pods per plant, seed weight per plant, grain and straw/stalk yield over control but statistically at par with 20 kg S ha^{-1}. These results are in conformity with the finding of Tripathi *et al.* (2011). Increase in yield parameters under sulphur fertilization might be due to improved availability of S, which, in turn, enhanced the plant metabolism and photosynthetic activity resulting into better yield (Yadav 2004).

The increase was noted in the seed yield (kg ha^{-1}) with the increase in level of sulphur from 0-20 kg ha^{-1}. However, 40 kg ha^{-1} of applied sulphur did not attribute any significant change over 20 kg S ha^{-1} with regard to seed and straw/stalk yield, but the advantageous effect of various doses of sulphur over control was significant in both the years. The beneficial effect of sulphur application on the yield of seed and straw/stalk obtained in the present investigation, is in close conformity with the findings of Meena *et al.* (2005). The application of 20 kg S/ha increased the straw/stalk yield over control. The boldness of seed of pigeonpea is, thus, promoted appreciably under the application of sulphur (Tripathi and Verma 2007).

Economics

Data regarding the details of economic analysis revealed that all fertilizer treatment gave highest gross return as compared to control. Amongst treatments, application of 90 kg P_2O_5 ha^{-1} gave the maximum return over the cost of the treatments followed by the application of 60 kg P_2O_5 ha^{-1}. Application of either phosphorus or sulphur alone could not produce similar economic returns as obtained in case of their combined application, indicating the importance of both the nutrients for pigeonpea for obtaining higher yield and economic return. The highest gross return, net return and return per rupee invested was obtained with 90 kg P_2O_5 ha^{-1} and 40 kg S/ha and this treatment was significantly superior to 30 kg P_2O_5 ha^{-1} and 20 kg S/ha.

Net return of pigeonpea increased up to 90 kg P_2O_5 ha^{-1} over control and P @ 30 kg P_2O_5 ha^{-1}. Return per rupee invested was also followed the same trend. This was due to greater increase in gross return as compared with lesser increase in cost of cultivation. Nimje (2003) reported that application of P @ 90 kg P_2O_5 ha^{-1} enhanced the net return of pigeonpea.

Highest gross return was found highest with 90 kg P_2O_5 and 40 kg S/ha treatment combination followed by 60 kg P_2O_5 and 20 kg S/ha. Similarly highest net return also was received with 90 kg P_2O_5 and 40 kg S/ha followed by 60 kg P_2O_5 and 20 kg S/ha. Higher gross return with Pusa 855 with 90 kg P_2O_5 and 40 kg S/ha was due to its respective higher seed and straw/stalk yield. Whereas, higher net return was due to relatively higher level of gross return.

On the basis of two years data, it was concluded that the pigeonpea genotype Pusa-855 showed the superiority over rest of genotypes UPAS 120 and Pusa 992 in respect of yield attributes, seed yield and economics. Higher yield could be obtain with the application of phosphorus up to 60 kg/ha and sulphur

Table 1: Effect of phosphorus and sulphur fertilization on productivity and economics of pigeonpea genotypes.

Treatment	Pods /plant /plant	Seeds /pod /plant	Pod weight (g)	Grain weight (g)	1000-seed weight (g)	Seed yield (kg/ha)	Straw /stalk yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Return/ rupee invested (Rs.)
Genotypes											
UPAS120	192.31	2.95	29.23	14.71	73.40	1365	5072	23960	34794	10834	1.45
Pusa 992	180.22	2.90	27.83	13.97	70.95	1326	4492	23960	31560	7600	1.32
Pusa 855	197.14	3.32	31.15	16.64	78.80	1593	5561	23960	39848	15888	1.67
CD (P=0.05)	6.70	0.14	1.32	0.62	2.78	52	179	-	-	-	-
P levels (kg P_2O_5/ha)											
0 158.73	2.38	23.38	10.71	70.53	1103	4468	23960	35401	11441	1.48	
30 175.83	2.96	28.56	14.84	74.66	1403	5044	25726	46141	20415	1.79	
60 191.66	3.40	32.54	17.18	76.05	1583	5318	26759	50474	24715	1.88	
90 194.32	3.48	33.12	17.70	76.29	1619	5375	27921	53656	25725	1.93	
CD (P=0.05)	7.25	0.15	1.52	0.72	3.21	60	207	-	-	-	-
S levels (kg S/ha)											
0 158.26	2.84	27.56	13.89	72.44	1265	4793	23960	35401	11441	1.48	
20 180.42	3.13	30.05	15.5.	75.13	1488	5170	25159	41408	17259	1.64	
40 189.86	3.20	30.60	15.94	76.40	1535	5205	26359	44733	18374	1.70	
CD(P=0.05)	5.57	0.10	1.01	0.48	2.20	18.25	129	-	-	-	-

40 kg/ha to harness the existing agro-resources and to produce the crop in their higher quantity and to explore maximum net return. From the present study, it was concluded that Pusa-855 was the most suitable genotype of pigeonpea for cultivation.

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