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Effect of sulphur and phosphorus on yield, quality and nutrient status of pigeonpea (*Cajanus cajan*)

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Abstract: *A field experiment was conducted to study the impact of Sulphur (S) and Phosphorus (P) on yield, nutrient status of soil and their contents in pigeonpea (Cajanus cajan) during the year 2008-2009. Seven treatments were studied in Factorial Randomized Block Design with three replications. The treatment combinations were derived from three levels of sulphur (0, 20 and 40 kg S ha^{-1}) and four levels of phosphorus (0, 25, 50 and 75kg ha^{-1}). The experimental soil was medium black, slightly calcareous, clay in texture and slightly alkaline in reaction. The results indicated a significant increase in grain yield (14.81 q ha^{-1}) and straw yield (41.26 q ha^{-1}) of pigeonpea after 20 kg S ha^{-1} and 50 kg P_2O_5 ha^{-1} treatment with common dose of nitrogen @ 30 kg ha^{-1}. The increase in grain and straw yield was 102.77 and 52.87% as compare to higher over control. Maximum number of pods $plant^{-1}$, maximum number of grains pod^{-1} and test weight by this treatment was also observed as compared to control. Application of S and P improved soil fertility status and S alone did not influence P availability. Hence, in order to maintain the fertility status of the soil at high level, combine application of 20 kg S ha^{-1} with 50 kg P_2O_5 ha^{-1} is essential. The residual fertility status of soil is advocated for rainfed pigeonpea crop grown on vertisol in Vidarbha region.*

Key words: *Pigeonpea, Yield, Quality, Soil fertility*
PDF of full length paper is available online

Introduction

Pigeonpea (*Cajanus cajan* L. Mill sp) is important grain legume crop rainfed agriculture in the semi-arid tropics. Although area and production are increased, productivity of pigeonpea remained almost static during last 50 years. Legumes are rich source of protein for common masses especially vegetarian. In complete both grains and stalk of legumes contain good amount of protein and minerals, which are essential for the growth, and development of human and animal body (Anonymous, 2004). Among the legumes, pigeonpea (*Cajanus cajan)* arhar is grown extensively. These crops had wide variations in their morphological characters, root system and nutrients requirements; thereby these crops possess differential capability to utilized plant nutrient from different soil layers, resulting in better use efficiency of the applied nutrient and residual fertility (Singh *et al.,* 2005). In India, pigeonpea account about 20% of the total pulses (Anonymous, 2004).

All the crops of this sequence have high requirement of sulphur and phosphorus. Very limited information is available on the response of these crops by the application of S and P and the effect of judicious use of fertilizer nutrients on environment, it will be more remunerative and environment friendly to exploit the direct, residual and cumulative effect of applied nutrient for getting higher return with considerable nutrient economy and use efficiency (Marok and Dev, 1980). The slow mobility of applied P and its marks fixation results 20-25% recovery so residual effect becomes an important diversion of P management (Singh, 1993).

Presently, S is being required as fourth major nutrient. S, which is mostly applied to oilseed and pulses, has been found to benefit more than one crop in a sequence due to its significant residual response (Singh *et al.,* 2005). S and P have systematic and antagonistic effect with each other on their varying levels of application as well as level of availability in the soil (Marok and Dev 1980; Mariswamy Gowda *et al.*, 2001). Considering the significant role of S and P in sustainable production of pulses crops, an experiment was conducted to study the effect of S and P levels on yield, nutrient status and crude protein content by pigeonpea.

Materials and Methods

An experiment was conducted during *kharif* season for the year 2008-2009 at College of Agricultural Farm, Nagpur. Nagpur is situated in subtropical zone and comes under high rainfall zone of Maharashtra. Most of the rains are received from 11th June to the end of September. Total rainfall received during the studies period was 1231 mm and maximum temperature recorded was 46°C in May and minimum 7.2°C in January.

The physical properties of the experimental soil were dark black in colour, clay texture, coarse sand – 7%, fine sand – 13.75%, silt – 19.50%, clay – 59.75%, clay in texture with considerable amount of smectitte clay minerals 0-30 cm depth. According to soil taxonomy, the soil is classified under group chromostert, sub group typic

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chromostert, family fine, montmorillonite hyper thermic. The chemical properties of soil were pH (1:2.5) – 8.4, EC – 0.44 dSm^{1}, CEC - 51.36 cmol (P^{+}) kg^{-1}, organic carbon – 6.75 g kg^{-1}, available nitrogen (N) – 266.56 kg ha^{-1}, available phosphorus (P) – 16.00 kg ha^{-1}, available potassium (K) – 346.08 kg ha^{-1} and available sulphur (S) – 6.9 mg kg^{-1}. The soil samples were tested with organic carbon content, available N, P, and K as per methods given by Walkey and Black (1946), Subbiah and Asija (1956), Olsen *et al*. (1954). Available S extracted by the method of Williams and Steinbergs (1959) and determined by the method of Chesnin and Yien (1951). Protein content was calculated (N x 0.25). Nitrogen was determined in grain by micro-kjeldahl's method (Jackson, 1973).

The experiment was laid out in Factorial Randomized Block Design (FRBD) with seven treatments and three replications. The treatment comprised of three levels of sulphur (S_0- No S application, S_1 - 20 kg and, S_2 - 40 kg S ha^{-1} through elemental sulphur) and four levels of phosphorus (P_0- No P application, P_1- 25, P_2- 50 and P_3- 75 kg P_2O_5 ha^{-1} through diammonium phosphate). The gross plot size was 4.5 x 3.0 m^2, while net plot size was 3.0 x 2.4 m^2, the treatments in the replication are randomly distributed. The pigeonpea variety Coimtore-11 was sown. The fertilizer used for the supplying different levels of sulphur, phosphorus and common dose of nitrogen @ 30 kg ha^{-1} were, applied through elemental sulphur, diammonium phosphate and urea respectively. Urea contain 46% N and DAP contain 18% N and 46% P_2O_5. The seed were dibbled at 30 cm apart keeping 75 cm row-to-row distance. Thinning and gap filing observed were under taken after 15 days from the sowing to ensure the uniform plants population.

The pods were picked at 10 days intervals and yield was calculated by adding 3 pickings and pods plant^{-1} was recorded at grain-formation stage by mean value of 5 plants in each plot.

Results and Discussion

Yield, quality and nutrient status: Sulphur levels application significantly influenced grain yield, straw yield, yield attributed characters like number of pods plant^{-1}, number of grains pod^{-1} (Table 1) as well as quality like test weight and crude protein percentage (Table 2). The mean increases in grain yield (11.8 q ha^{-1}), number of grains (3.35), grain yield plant^{-1} (25.10 kg), test weight (9.925 g) and crude protein percentage (21.102%) was significantly increased upto 20 kg S ha^{-1}. Biswas and Tewatia (1991) also recorded similar results when recommended dose of NPK was combined with 20 kg S ha^{-1}. Similar results were also recorded by Aulakh *et al.* (1990) for soybean crop. Improvement in protein quality of pulses was observed by Shahi *et al*. (2002).

Phosphorus levels application significantly influenced grain yield, straw yield attributed characters like number of pods plant^{-1}, number of grains pod^{-1} (Table 1) as well as quality like test weight and crude protein percentage (Table 2). The mean increase in grains yield (12.65 q ha^{-1}), straw yield (38.39 q ha^{-1}), number of pods plant^{-1} (110.78), number of grains pod^{-1} (3.46), grain yield/ plant (28.39 kg), test weight (10.333 g) and crude protein percentage (21.292%) was significantly increased upto application of 20 kg S ha^{-1} and also were significantly superior over other levels. The results of the present study were in conformity with those earlier recorded by Shrivastava and Verma (1996) and Nadal *et al.* (1987). Similar results were confined recently by Singh and Singh (2002) who observed that the increasing levels of phosphorus *i.e.* greater than 50 kg P_2O_5 ha^{-1} did not increase the yield. Contributions of phosphorus in increasing protein content in pigeonpea were noticed by Matiwade and Sheelavantar (1995).

The interaction between sulphur and phosphorus was found to be significant on grain yield, straw yield and yield attributes characters like number of pods plant^{-1}, number of grains pod^{-1}, yield of grain plant^{-1}, straw yield as well as quality like test weight and crude protein percentage (Table 1,2). At the 20 kg ha^{-1} level of sulphur increasing level of phosphorus upto 50 kg ha^{-1} there by increased grain yield (14.81 q ha^{-1}), straw yield (41.26 q ha^{-1}) and yield attributing characters like number of pods plant^{-1} (115.47), number of grain pod^{-1} (3.67), yield of grains plant^{-1} (33.24 kg), straw yield plant^{-1} (92.83 kg) of pigeonpea after which decreasing trends were found. The mean maximum and minimum yields (grain, straw, yield attributes and quality) were recorded $S_{20}P_{50}$ and S_0P_0 treatment respectively. Addition of sulphur with phosphorus may

Table - 1(a): Effect of sulphur(S) and phosphorus (P) on yield of pigeonpea

Treatments	No. of pods plant^{-1}	No. of grains pod^{-1}	Grain yield plant^{-1} (kg ha^{-1})	Straw yield plant^{-1} (kg ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
S_0 – No S application	100.62	3.28	22.80	74.68	10.08	33.19
S_1 – 20 kg S through elemental sulphur	103.90	3.35	25.10	77.56	11.18	34.47
S_2 – 40 kg S through elemental sulphur	105.80	3.29	24.75	77.64	11.05	34.50
SE + m	0.24	0.02	0.30	0.09	0.10	0.028
CD (p = 0.05)	0.70	0.06	0.87	0.26	0.29	0.83
P_0 – No P application	90.20	3.08	18.85	64.56	8.42	28.69
P_1 - 25 kg P_2O_5 ha^{-1} through DAP	106.13	3.32	24.06	76.85	10.73	34.16
P_2 – 50 kg P_2O_5 ha^{-1} through DAP	110.78	3.46	28.39	86.37	12.65	38.39
P_3 – 75 kg P_2O_5 ha^{-1} through SDAP	106.64	3.37	25.57	78.37	11.28	34.99
SE + m	0.28	0.02	0.34	0.10	0.11	0.33
CD (p = 0.05)	0.81	0.07	1.00	0.30	0.33	0.96

Table - 1(b): Effect of combined sulphur (S) and phosphorus (P) on yield of pigeonpea

Treatments	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3
	Number of pods plant^{-1}				Number of grain pod^{-1}			
S_0 – No S application	81.27	98.47	109.27	113.47	3.05	3.19	3.36	3.53
S_1 – 20 kg S through elemental sulphur	88.47	107.53	115.47	104.13	3.08	3.33	3.67	3.33
S_2 – 40 kg S through elemental sulphur	100.87	112.40	107.60	102.33	3.11	3.45	3.36	3.25
Mean	90.20	106.13	110.78	106.64	3.08	3.32	3.46	3.37
	S	**P**	**S X P**		**S**	**P**	**SE + m**	
SE + m	0.24	0.28	0.48		0.02	0.02	0.04	
CD (p = 0.05)	0.70	0.81	1.40		0.06	0.07	0.12	
	Yield of grains plant^{-1} (kg)				Straw yield plant^{-1} (kg)			
S_0 – No S application	16.43	18.87	25.99	29.51	60.73	66.99	84.00	87.00
S_1 – 20 kg S through elemental sulphur	17.90	25.17	33.24	24.08	63.91	77.89	92.83	75.63
S_2 – 40 kg S through elemental sulphur	22.22	28.13	25.95	22.71	69.03	85.67	82.88	73.57
Mean	18.85	24.06	28.39	25.57	64.56	76.85	86.37	78.73
	S	**P**	**S X P**		**S**	**P**	**S X P**	
SE + m	0.30	0.34	0.59		0.09	0.10	0.18	
CD (p = 0.05)	0.87	1.00	1.73		0.26	0.30	0.51	
	Grain yield (q ha^{-1})				Straw yield (q ha^{-1})			
S_0 – No S application	7.30	8.42	11.58	13.02	26.99	29.78	37.33	38.67
S_1 – 20 kg S through elemental sulphur	7.99	11.22	14.81	10.70	28.40	34.62	41.26	33.61
S_2 – 40 kg S through elemental sulphur	9.97	12.57	11.57	10.13	30.68	38.07	36.57	32.70
Mean	8.42	10.73	12.65	11.28	28.69	34.16	38.39	34.99
	S	**P**	**S X P**		**S**	**P**	**S X P**	
SE + m	0.10	0.11	0.19		0.28	0.33	0.57	
CD (p = 0.05)	0.29	0.33	0.57		0.83	0.96	1.65	

SE + m = Values are mean ± standard error (SE), CD = Critical difference, S = Sulphur, P = Phosphorous

Table - 2(a): Effect of sulphur and phosphorus levels on quality parameters of pigeonpea

Treatments	Test weight of 100 seeds (g)	Crude protein (%)
S_0 – No S application	9.666	20.993
S_1 – 20 kg S through elemental sulphur	9.925	21.102
S_2 – 40 kg S through elemental sulphur	9.908	21.040
SE + m	0.032	0.027
CD (p = 0.05)	0.090	0.080
P_0 – No P application	9.088	20.698
P_1 – 25 kg P_2O_5 ha^{-1} through DAP	9.867	21.042
P_2 – 50 kg P_2O_5 ha^{-1} through DAP	10.333	21.292
P_3 – 75 kg P_2O_5 ha^{-1} through DAP	10.044	21.147
SE + m	0.036	0.031
CD (p = 0.05)	0.111	0.092

Table - 2(b): Effect of combined sulphur and phosphorus on quality parameters of pigeonpea

Treatments	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
	Test weight of 100 seeds (g)					Crude protein (%)				
S_0 – No S application	8.833	9.200	10.133	10.500	9.667	20.592	20.767	20.175	21.438	20.993
S_1 – 20 kg S through elemental sulphur	9.000	10.000	10.800	9.900	9.925	20.648	20.118	20.613	21.030	21.102
S_2 – 40 kg S through elemental sulphur	9.433	10.400	10.067	9.733	9.908	20.854	20.243	20.088	20.975	21.040
Mean	9.089	9.867	10.333	10.044		20.698	20.042	21.292	21.147	
	S	**P**	**S X P**			**S**	**P**	**S X P**		
SE + m	0.032	0.036	0.063			0.027	0.031	0.054		
CD (p = 0.05)	0.09	0.111	0.18			0.80	0.092	0.16		

SE + m = Values are mean ± standard error (SE), CD = Critical difference, S = Sulphur, P = Phosphorous

Table - 3: Effect of sulphur and phosphorus application on residual fertility status of soil

Treatments	Residual available nutrient status			
	Nitrogen (kg ha^{-1})	Phosphorus (P_2O_5) (kg ha^{-1})	Potassium (K_2O) (kg ha^{-1})	Sulphur (mg kg^{-1})
S_0 – No S application	261.71	19.48	350.00	8.23
S_1 –20 kg S ha^{-1} through elemental sulphur	269.36	19.67	369.60	8.86
S_2 –50 kg S ha^{-1} through elemental sulphur	262.27	19.43	369.60	9.52
SE + m	0.50	0.09	1.11	0.024
CD (p = 0.05)	1.45	ND	3.27	0.07
P_0 – No phosphorus application	263.82	16.87	371.47	8.36
P_1 – 25 kg P_2O_5 ha^{-1} through DAP	260.34	20.23	367.73	8.81
P_2 - 50 kg P_2O_5 ha^{-1} through DAP	264.82	20.81	352.80	9.09
P_3 - 75 kg P_2O_5 ha^{-1} through DAP	268.80	20.21	360.27	9.29
SE + m	0.57	0.01	1.29	0.027
CD (p = 0.05)	1.68	0.29	3.78	0.08

SE + m = Values are mean ± standard error (SE), CD = Critical difference

maintain8 favorable balance between the applied nutrient in the plant for its optimum growth and sulphur enhanced the utilization of P by its effect on metabolism. Similar results were reported by Nayak and Dwivedi (1990) and Biswas and Tewatia (1991).

Residual fertility status of soil: Use of manures and fertilizers is the kingpin of our strategy of achieving the enhanced productivity and assured sustainability. In this strategy one aspect, which has been neglected, in part is the balance use of fertilizers. The combined application of sulphur and phosphorus has significantly influenced the residual fertility status of soil. The results (Table 3) related that, significantly maximum available nitrogen (269.36 kg ha^{-1}) was recorded due to application of 20 kg S ha^{-1} over control and 40 kg ha^{-1} (Kene *et al*., 1990). The maximum availability of phosphorus (19.67 kg ha^{-1}) was recorded due to application of 20 kg ha^{-1}. Sulphur alone did not significantly influence, Potassium (369.60 kg ha^{-1}) was recorded due to application of 20 and 40 kg S ha^{-1}. It indicates that application of increasing level of sulphur improved the soil sulphur status. The direct and residual effect of S was more pronounced in cotton-wheat sequence grown by sandy loam soil by the addition of S @ 30 kg ha^{-1} with recommended NPK to crops (Singh *et al*., 2004). The individual application of phosphorus significantly affected the residual availability of sulphur and phosphorus. Maximum available of phosphorus (20.81 kg ha^{-1}) was observed in treatment of 50 kg P_2O_5 ha^{-1}. The residual availability of nitrogen was maximum (268.80 kg ha^{-1}) by application of 75 kg P_2O_5 ha^{-1} and was significant over other levels of phosphorus (Katyal *et al*., 1999). While maximum available sulphur (9.29 mg kg^{-1}) was noted in the treatment 75 kg P_2O_5 ha^{-1} and available sulphar (9.52 mg kg^{-1}) was observed by the application of 50 kg S ha^{-1}. The residual availability of potassium was high (371.47 kg ha^{-1}) in P_0 treatment and was significant over other phosphorus levels but they were at par with other P level treatment.

Irrespective of the crop present increased in grain and straw yield, yield attributes and quality due to $S_{20}P_{50}$ treatment compared to control recorded increasing trend both under a residual effect across a year of experimentation (Table 1). Percent increase in yield across the year may be ascribed to improvement in available nutrients especially S and P under controlled plot (Table 3). Percent increase in yield and quality across a year was more conspicuous due to recommended dose of S and P. Combine application of S and P markedly higher increase in grain and straw compare to alone application of S and P. Jat *et al*. (2005) also reported similar trend in yield due to residual effect of S, P and other nutrients.

Applications of sulphur combined with phosphorous fertilizer 20 kg S ha^{-1} with 50 kg P_2O_5 ha^{-1} improve soil fertility, significantly increased in grain and straw yield also improves the percentage of crude protein content as well as significantly influence the residual fertility status of soil.

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