Annals of Plant and Soil Research 19(2):175 - 179 (2017)

Effect of phosphorus, sulphur and biofertilizer on yield, quality and uptake of nutrients in cowpea (*Vigna unguiculata*)

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Received: January: 2017, Revised accepted: April, 2017

ABSTRACT

A field experiment was conducted at research farm, R.B.S. College Bichpuri (Agra) Uttar Pradesh during the kharif seasons of 2012 and 2013 to study the effect of phosphorus, sulphur and rhizobium on yield, quality and uptake of nutrients in cowpea (Vigna ungui culata L). The experiment was laid out in split plot design with three replications. Data revealed that the yield attributes, yield and protein content increased significantly with the application of 90 Kg P_2O_5, 40 Kg S ha^{-1} and rhizobium inoculation over their respective controls. Application of 90 kg P_2O_5 ha^{-1} gave 3.83 and 8.70 q ha^{-1} higher grain and straw yield over control. It also increased the content of protein and uptake of nutrients by grain and straw significantly over control. Pods/plant (53.4), grain/pod (12.0) and test weight (61.01 g) of cowpea were the highest with 40 kg S ha^{-1}. Application of 40 Kg S ha^{-1} was more effective in increasing yield and yield attributes than that of 20 kg S ha^{-1}. The highest grain (16.05 q ha^{-1}) and straw (38.49 q ha^{-1}) yields were recorded with 40 kg S ha^{-1} which was 20.4 and 27.2 % higher than that of control. The uptake of nutrients by the crop increased significantly up to 40 kg S ha^{-1}. Sulphur application tended to increase the content and yield of protein in cowpea and maximum values of protein content (20.17 %) and yield (339.8 kg ha^{-1}) were recorded with 40 kg S ha^{-1}). Inoculation with rhizobium proved superior to control (no inoculation) in terms of yield and protein content in cowpea. The uptake of nutrients by the crop increased significantly with inoculation over no inoculation.

Keywords: Phosphorus, sulphur, biofertilizer, yield, nutrient uptake, quality, cowpea.

INTODUCTION

Cowpea (Vigna unguiculata L Walp) is an important legume crop and it has manifold uses such as vegetable, pulse, green manuring and fodder for the live stock. Legumes play prominent role in increasing soil nitrogen level thereby boosting agricultural production. This is obviously due to their ability to fix atmospheric gaseous nitrogen in a symbiotic association with rhizobium. Seed treatment with rhizobium Is now well established as low cost technology for maximizing the pulse production and maintenance of soil productivity. Cowpea is gaining popularity in Indian diet due to its unique stand in appearance better taste and highest protein content. The leguminous crops need phosphorus for rapid and healthy root development. It hastens the maturity and increases the rate of nodulation and pod development. Phosphorus has also an enhancing impact on plant growth and biological yield through its importance as energy storage and transfer necessary for metabolic processes (Singh *et al.* 2014). Phosphorus addition increased the efficiency of plants to photosynthesis, enhances the activity of rhizobia and increases the number of branches and pods/plant, consequently greater yield of pea, fababean (Lal *et al.* 2016).Sulphur is the fourth most important nutrient after N, P and K for Indian agriculture. The high yielding, varieties have been reported to be highly responsive to S. Sulphur has been known for its role in the synthesis of carbohydrates, proteins, vitamins, oils and flour compounds. Sulphur being a constituent of amino acids viz. cystine (27% S), metheonine (21% S) and cystein (26%) play a significant role in nitrogen fixation. Now a lays an increasing frequency of S deficiency has been observed in crops and S may become a factor limiting yield and quality of crops. A suitable combination of major (P) and secondary (S) nutrients is, by and large, the most important single factor that affects the yield and quality of the crops. Therefore the present study was initiated to study the effect of phosphorus, sulphur and biofertilizer on yield, quality uptake of nutrients in cowpea.

MATERIALS AND METHODS

The field experimental was conducted during kharif season of 2012 and 2013 at R.B.S.College Research farm Bichpuri, Agra (U.P.). The farm is situated at $27^0 2''$ N latitude, $77^0 9'$ E longitude and in on altitude of 163.4 meter above mean sea level. The experimental site is characterized by semi-arid climate, with extreme temperature during summer (45^0 to 48^0C) and very low temperature during winter (as low as 2^0C).The average rain fall is about 650 mm, most of which is received from June to September. The soil was sandy loam in texture having pH 7.8, EC 0.29 dSm-^{1}, organic carbon 3.6 g kg^{-1}, available N 165 kg ha-$^{-1}$, P 8.5 kg ha^{-1}, K 110 kg ha^{-1} and Zn 0.51 mg kg^{-1}. The experiment was laid out in split plot design with four levels of P (0, 30, 60 and 90 kg P_2 O_2 ha^{-1}), three levels of S (0, 2 and 40 kg S ha^{-1}) and two levels of biofertilizers (no rhizobium and rhizobium) with three replications. A uniform dose of 20 kg N and 40 kg K_2O ha^{-1} was applied through urea and muriate of potash, respectively at the time of sowing. Phosphorus and S were applied through triple super phosphate and elemental sulphur, respectively at the time of sowing. The cowpea seeds were inoculated with rhizobium as per treatments. Cowpea was sown in last week of June in both the years. Other agronomic management practices were followed as per standard recommendation. The crop was harvested at physiological maturity. Yield and yield attributes were recorded at harvest. The grain and straw samples were digested with di acid mixture of HNO_3 and HCl O_4 in 9:1 ratio. Phosphorus was determined by vanadomolybdate yellow colour method (Jackson, 1973), S by turbidimetric method (Chesnin and Yien 1951), K by flame photometer, Zn by atomic absorption spectrophotometer. Nitrogen in plants was determined by modified micro Kjeldahl method. Protein content was computed by multiplying the N content with 6.25.The nutrient uptake was calculated by multiplying the nutrient concentration values with the yield data. The data were statistically analysed using standard procedures of ANOVA at 5% level of significance.

RESULTS AND DISCUSSION

Effect of phosphorus

Growth and yield attributes (pods/plant, grain/pod, test weight), yield of grain and straw increased significantly with P application over control (Table 1). The mean maximum pods/plant. (54.0), grains/pod (13.0) and test weight (61.58 g) were obtained with 90 kg P_2O ha^{-1}. The increase in yield attributes due to P application may be utilization of large quantities of nutrients through their well developed root system and nodules which might have resulted in better plant development and ultimate yield attributes similar results were reported by Kumar *et al.* (2007) and Singh *et al.* (2015). The grain and straw yields of cowpea increased significantly by all the levels of phosphorus over control. Application of 90 kg P_2O_5 ha^{-1} recorded significantly higher yields of grain and straw. The increases in grain and straw yields with 90 kg P_2O_5 ha^{-1} over control were 29.0 and 27.0 %, respectively. The increases in yield may be attributed to the effective metabolic activities coupled with increased rate of photosynthesis leading to better translocation of nutrients in sink. Similar results were reported by Singh *et al.* (2015), Singh *et al.* (2016) in lentil. Application of P levels increased significantly the protein content in cowpea grain and straw and maximum values in gram (20.00%) and straw (6.69%) were recorded with 90 kg P_2O_5 ha^{-1}. Protein yield ranged from 252.6 kg ha^{-1} at control to 340 kg ha^{-1} with 90 kg P_2O_5 ha^{-1}. These findings are in confirmation with those of Singh *et al.* (2016).

The uptake of nitrogen by cowpea crop increased significantly with increase in the levels of phosphorus compared to control. Application of 90 kg P_2O_2 ha^{-1} resulted in significantly higher nitrogen uptake by the crop which may be attributed to increased N content coupled with higher yield (Lal *et al.* 2016, Singh *et al.* 2016). Increase in phosphorus levels significantly increased the phosphorus uptake by the crop over control and lower levels of phosphorus. The maximum values of phosphorus uptake by grain (10.2 kg ha^{-1}) and straw (8.6 kg ha^{-1}) were recorded with 90 kg P_2O_5 ha^{-1}. Similar results were reported by Singh and Singh (2012) in chickpea, Ali *et al.* (2013) in fababean and Nusakho Nyekha *et al.* (2015) in green gram. The uptake of potassium by the crop increased significantly with 60 and 90 kg P_2O_5 ha^{-1} as compared to control. Comparatively higher potassium utilization was recorded with 90 kg P_2O_5 ha^{-1}. The increase in K uptake might be due to increased K content and yield of cowpea crop with P application (Singh *et al.* 2014). Plant uptake of S increased along with rise in levels of P upto 90 kg P_2O_5 ha^{-1}. The increase in suptake may be due to increase in S content and yield. Similar results were reported by Kumar *et al.* (2007).

Table 1: Effect of phosphorus, sulphur and rhizobium on yield attributes, yield and quality of cowpea (mean of 2 years)

Treatment	Pods/plant	Grains/Pod	1000 grain weight (g)	Yield (q ha^{-1})		Protein content (%)		Protein yield (kg ha^{-1})
				Grain	Yield	Grain	Yield	
Phosphorus (kg ha^{-1})								
0	48.2	9.6	57.01	13.21	32.16	19.12	6.37	252.6
30	50.0	10.1	59.89	15.31	36.75	19.44	6.50	297.6
60	52.8	12.0	60.53	16.13	38.75	19.75	6.56	318.5
90	54.0	13.0	61.58	17.04	40.86	20.0	6.69	340.8
SEm±	0.61	0.25	0.28	0.22	0.71	0.18	0.05	10.75
CD (P=0.05)	1.76	0.73	0.81	0.62	2.03	0.54	0.16	30.20
Sulphur (kg ha^{-1})								
	49.2	10.0	58.05	13.33	30.26	18.50	6.19	246.6
20	51.3	11.5	59.76	15.39	36.74	19.75	6.56	304.0
40	53.4	12.0	61.01	16.05	38.49	20.17	6.81	339.8
SEm±	0.26	0.12	0.35	0.28	0.64	0.25	0.07	13.65
CD (P=0.05)	0.76	0.34	1.00	0.80	1.85	0.73	0.19	38.36
Biofertilizer								
No inoculation	50.5	10.8	58.69	14.22	33.36	19.50	6.50	277.3
Rhizobium	51.9	11.8	60.18	16.46	37.60	19.62	6.56	323.0
SEm±	0.47	0.20	0.30	0.38	1.22	0.05	0.02	15.60
CD (P=0.05)	1.35	0.58	0.85	1.10	3.50	NS	NS	43.83

Effect of sulphur

Data (Table 1) show that application of S significantly increased yield attributes and protein content in cowpea up to 40 kg S ha^{-1}. It increased successively till the maturity of crop due to increase in cell multiplication and cell expansion throughout the entire period of crop. Application of 40 kg S ha^{-1} increased the grain and straw yield by 20.4 and 27.2% respectively over control. The marked response in yield due to sulphur application may be attributed to the deficiency of available S in the experimental soil, as its value was less than the critical limit of 10 mg kg^{-1}. Kumar *et al.* (2007) reported higher yield of cowpea with application of S. Ali *et al.* (2013) reported similar results in faba bean. In the untreated plots, protein content in grain and straw was 18.50 and 6.19 percent, respectively. It was observed that as the levels of S increased from 0 to 40 kg ha^{-1}, there was a significant increase in the protein content in grain and straw (Table 1). These findings are in confirmation with those of Ali *et al.* 92013) and Kumar *et al.* (2007) who reported that protein content increased significantly with S application in faba bean and cowpea, respectively. Protein yield ranged from 246.6 kg ha^{-1} at control to 339.8 kg ha^{-1} with 40 kg S ha^{-1}. The maximum protein yield was recorded with 40 kg S ha^{-1} which may be attributed to higher yield of cowpea (Ali *et al.* 2013).

A marked increase in N uptake by grain (55 kg ha^{-1}) and straw (41.9 kg ha^{-1}), P (9.9 and 7.7 kg ha^{-1}), K (13.8 and 66.9 kg ha^{-1}) and S (7.2 and 5.8 kg ha^{-1}) was recorded with the application of 40 kg S ha^{-1} (Table 2). Since the nutrient uptake is a function of their content in crop plant and yield of plant. The increase in these parameters due to application of S led to an increased uptake of nutrients. These results are in conformity with the finding of Ali *et al.* (2013) who reported increased uptake of N, P, K and S by faba bean.

Table 2: Effect of phosphorus, sulphur and rhizobium on uptake of nutrients (kg ha^{-1}) by cowpea (mean of two years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Phosphorus (kg ha^{-1})								
0	40.4	32.8	7.0	5.8	9.9	51.4	4.6	4.2
30	47.6	38.2	8.4	6.9	11.8	60.2	5.8	5.1
60	51.0	40.6	9.3	7.7	12.7	65.1	6.6	5.8
90	54.5	43.7	10.2	8.6	13.6	69.4	7.3	6.5
SEm$\pm$	1.42	1.21	0.70	0.56	1.35	2.29	0.44	0.35
CD (P=0.05)	4.09	3.40	2.02	1.59	3.88	6.59	1.27	1.02
Sulphur (kg ha^{-1})								
0	39.4	29.9	6.8	5.1	9.8	47.8	4.5	3.6
20	48.6	38.5	8.6	6.9	12.0	61.0	6.1	4.8
40	55.0	41.9	9.9	7.7	13.8	66.9	7.2	5.8
SEm$\pm$	2.13	1.81	0.47	0.38	0.68	1.15	0.55	0.44
CD (P=0.05)	6.11	5.04	1.35	1.06	1.99	3.38	1.58	1.26
Biofertilizer								
No inoculation	44.4	34.7	7.7	6.0	10.9	54.7	2.4	4.3
Rhizobiem	51.7	39.5	9.5	7.1	12.9	63.1	6.5	5.2
SEm$\pm$	2.25	1.11	1.03	0.83	1.92	3.26	0.6.2	0.48
CD (P=0.05)	7.90	3.12	NS	NS	NS	NS	1.79	NS

Effect of biofertilizer

The yield attributes were significantly increased with rhizobium inoculation over no inoculation (Table 1). This might be owing to their additive effect of nitrogen fixed from the atmosphere which in turn stimulated the yield attributes. Similar results were reported by Choudhary *et al.* (2013) and Singh *et al.* (2015). Data showed that the grain and straw yields of cowpea increased significantly with inoculation of rhizobium over no inoculation. The increases in yield due to rhizobium inoculation were 15.7 and 12.9% over no inoculation. The increase in yield might have resulted from the growth regulating substances produced by biofertilizer besides fixation of additional nitrogen from atmosphere thereby increasing nitrogen availability in the soil throughout the crop growth. Similar results were reported by Choudhary *et al.* (2013) and Singh *et al.* (2015).The uninoculated control show the protein content in grain and straw as 19.50 and 6.50 % which increased to the level of 19.62 and 6.56 % in rhizobeium inoculation treatment (Kumar *et al.* 2007). Inoculation of biofertilizer increased the nitrogen uptake by grain and straw significantly over no inoculation treatment, which might be because of better growth and development of the plant and adequate N availability in soil (Table 2) Kumar *et al.* (2007) reported similar results in cowpea. There were increases in phosphorus and potassium uptake by cowpea grain and straw with the rhizobium inoculation over no inoculation. It showed synergistic effect of the inoculants on phosphorus and potassium utilization by the cowpea crop. Similar results have been reported by Kumar *et al.* (2007). The uptake of S also improved with rhizobium inoculation, which may be attributed to increased yield.

The study suggests that the application of P.S. and rhizobium inoculation increased the grain and straw yield, protein content of cowpea. Application of 90 kg P_2O_5 ha^{-1}, 40 kg S ha^{-1} and rhizobium inoculation gave the highest yield and protein content in cowpea.

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