International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 376-378

Received: 22-09-2018
Accepted: 23-10-2018

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Effect of different levels of phosphorus on growth, yield and economics of fodder cowpea (*Vigna unguiculata* L. Walp) varieties

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Abstract
The field trial entitled "Effect of different levels of phosphorus on performance of fodder cowpea (*Vigna unguiculata* L. Walp) varieties under lateritic soil of *konkan* region" was carried out during *rabi* season of 2016 at the Agronomy farm, College of Agriculture, Dapoli. The experiment was laid out in split plot design with three replications. The main plot treatment comprised of three cowpea varieties viz., EC-4216, DFC-1 and Shweta while in sub plot, four phosphorus levels *viz*., 20, 40, 60 and 80 kg P_2O_5 ha^{-1} were accommodated. The result revealed that fodder cowpea variety EC-4216 in combination with application of 80 kg P_2O_5 ha^{-1} recorded better growth parameters viz; plant height, number of branches, functional leaves per plant, dry matter accumulation, nodulation and higher green and dry fodder yield q ha^{-1}. Similarly In respect of economics, it was observed that the treatment combination V_1P_4 (EC-4216 + 80 kg P2O5 ha-1) has given significantly highest net returns of Rs 44024.00 ha^{-1} and B: C ratio (1.67).

Keywords: Fodder cowpea, growth parameters, fodder yield, economics

Introduction
Cowpea is a broadly adopted and highly variable crop, cultivated around the world not only as a pulse, but also as a vegetable (both for the grains and green peas), a cover crop, a green manure crop, erosion resisting crop as well as fodder crop and having ability of drought tolerance. The average grain and fodder yield of cowpea in India is 3 q ha^{-1} and 25-45 t ha^{-1} (Ahmad *et al*. 2012) [1]. At present, the country faces a net deficit of 63 per cent green fodder, 24 per cent dry crop residues and 64 per cent feeds (Singh, 2009) [6]. Therefore, cultivation of quick growing good quality forage is an urgent needed to cope up with the shortage of green forages.

There are ample evidences those indicate marked differences between cowpea genotypes and phosphorus uptake. Next to nitrogen, phosphorus is yield limiting nutrient. Cowpea, being the leguminous crop, responds more to phosphorus than nitrogen and potassium. These facts necessitate to determine the adequate supply of phosphorus to the cowpea based on field experimentation for realizing the genetic yield potential of newly evolved varieties.

Materials and Methods
The field experiment was carried out during *rabi* season of 2016 to assess the effect of different levels of phosphorus on the productivity of fodder cowpea varieties. The experiment was laid out in split plot design comprising of twelve treatments replicated three times. The main plot treatment comprised of three cowpea varieties *viz.*, EC-4216 (V1), DFC-1 (V2) and Shweta (V3). The sub plot treatments comprised of four phosphorus levels *viz.*, 20 Kg P_2O_5 ha^{-1} (P1), 40 Kg P_2O_5 ha^{-1} (P2), 60 Kg P_2O_5 ha^{-1} (P3) and 80 Kg P_2O_5 ha^{-1} (P4). Thus, there were in all 12 treatment combinations. The gross plot size was 4.5 m X 3.00 m and net plot size was 3.9 m X 2.4 m, respectively. The soil of the experimental plot was uniform, level and well drained. It was sandy clay loam in texture, medium in available nitrogen (289.7 Kg ha^{-1}), low in available phosphorus (11.80 Kg ha^{-1}), moderately high in available potassium (249.35 Kg ha^{-1}), medium in organic carbon content (0.96 %) and slightly acidic in reaction (pH5.72).The sowing was done in the experimental plot on 21th November, 2016 by drilling method at a distance of 30 cm in between the rows. The other common package of practices was followed time to time and periodical growth observations were recorded and economics were calculated.

Results and Discussion

A) Growth parameters studies

Effect of Growth parameters on varieties

The varieties significantly influenced the mean plant height, number of branches, functional leaves per plant, dry matter accumulation increase at all the stages of crop growth. Variety EC-4216 recorded the significantly the highest plant height, functional leaves per plant, dry matter accumulation increase followed by varieties DFC-1 and Shweta at 60 DAS except number of branches. However, variety DFC-1 was at par with EC-4216 during all the growth stages and variety Shweta was at par with DFC-1 during all the growth stages.

Effect of phosphorus levels on Growth parameters

It was found that, the plant height, number of branches, functional leaves per plant, dry matter accumulation increased significantly with increase in the levels of phosphorus fertilization. Application of 80 kg P_2O_5 ha^{-1}recorded maximum plant height followed by 60 kg P_2O_5 ha^{-1} which were at par with each other, but found significantly superior over rest of the treatments at 60 DAS. This stimulating effect of phosphorus on growth of crop might be due to readily availability of applied phosphorus which promoted cell division, better root growth and meristematic tissue and increased intermodal length at higher level of nutrient. Similar findings were also reported by Shekara *et al*. (2012) [7], Kundu *et al*. (2015) [5], Kumar *et al*. (2012) [4] also reported that plant height of cowpea increased significantly with each successive addition of P2O5 levels. Application of phosphorus at 80 kg P_2O_5 ha^{-1} recorded maximum number of nodules per plant and was significantly superior over 40 and 20 kg P_2O_5 ha^{-1}, but at par with 60 kg P_2O_5 ha^{-1}. All growth parameters were significantly influenced due to phosphorus application which ultimately increased the root proliferation and also favoured the extensive exploitation of treated soil areas for nutrient and moisture while energy obtained from photosynthesis and metabolism of carbohydrates is stored in storage compound (ATP and ADP), which eventually reflected in vigorous vegetative growth. Phosphorus also promoted the development of roots thereby favoring the nitrogen fixation in legumes. This increased amount of nitrogen fixed might be utilized by the host plant for its own growth.

B) Yield studies

Effect of green forage yield on varieties

The various levels of phosphorus influenced green forage yield significantly. The data presented in Table -1revealed that application of 80 kg P_2O_5 ha^{-1} recorded significantly higher green forage yield in terms of q ha^{-1}. However, application of Phosphorus at 20 kg P_2O_5 ha^{-1} recorded the significantly lowest quantity of green forage yield. The maximum yield due to higher application of phosphorus, might be due to the combined effect of taller plants, more number of branches and more number of leaves per plant. Since the green forage yield is the combined result of these three contributory characters, the yield in the present experiment was increased with increased level of phosphorus. These findings are in conformity with those reported by Shekara *et al*. (2012) [7], Shekara *et al*. (2013) [8], Jha *et al*. (2014) [3], Kundu *et al*. (2015) [5] and Godara *et al*. (2016) [2].

Effect of Dry forage yield on varieties

The dry fodder yield at harvest indicated that, the dry fodder yield of cowpea was significantly influenced due to phosphorus fertilization. Application of 80 kg P_2O_5 ha^{-1} significantly increased the dry fodder yield in terms of q ha-1 followed by application of 60, 40 and 20 kg P_2O_5 ha^{-1} in that descending order of significance. This might be due to the fact that phosphorus influenced the physiological activity of the dry matter accumulation also increased with phosphorus application and it was optimum at maturity stage due to diversion of food material from source to sink. These result confirm the findings of investigator Shekara *et al*. (2013) [8], Kundu *et al*. (2015) [5] and Godara *et al*. (2016) [2].

C) Economics of the treatment

Net return

Effect of varieties

Data regarding net profit indicated that, variety EC-4216 recorded numerically highest net profit (Rs/- 40078.52 ha^{-1}) followed by variety DFC-1 (Rs/- 36493.97 ha^{-1}) and Shweta (Rs/- 34967.23 ha^{-1}), respectively.

Effect of phosphorus levels

Net returns were found numerically maximum with the application of 80 kg P_2O_5 ha^{-1} (Rs/- 41513.24 ha-1) as compared to application of 60 kg P_2O_5 ha^{-1} (Rs/- 39716.81 ha-1), 40 kg P_2O_5 ha^{-1} (Rs/- 36290.45 ha-1) and 20 kg P_2O_5 ha^{-1} (Rs/- 30939.84 ha-1), respectively.

B: C ratio

Effect of varieties

The higher B: C ratio was recorded due to the variety EC-4216 (1.63) as compared to variety DFC-1 (1.58) and Shweta (1.56).

Effect of phosphorus levels

The data presented in Table 30 revealed that the application of 80 kg P_2O_5 ha^{-1} was very much remunerative which has given the highest B: C ratio of 1.64 followed by the treatment 60 kg P_2O_5 ha^{-1} (1.61), 40 kg P_2O_5 ha^{-1} (1.58) and 20 kg P_2O_5 ha^{-1} (1.53), respectively

Table 1: Effect of different levels of phosphorus on growth parameters, yield and economics of fodder cowpea varieties at 60 DAS as influenced by different treatments.

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of functional leaves plant^{-1}	Dry matter plant^{-1} (g)	Number of nodule plant-^{1}	Green fodder yield (q ha^{-1})	Dry fodder yield (q ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
A. Varieties									
V_1: EC-4216	81.42	7.65	37.65	11.59	23.33	240.93	43.48	40078.52	1.63
V_2: DFC-1	77.07	7.21	36.70	10.60	22.08	229.56	38.66	36493.97	1.58
V_3: Shweta	75.13	6.88	34.39	9.03	20.33	224.72	36.26	34967.23	1.56
S.E.M ±	1.22	0.11	0.57	0.24	0.34	2.21	0.65		
C.D. at 5 %	4.77	0.41	2.23	0.92	1.33	8.67	2.57		
B. Phosphorus levels(kg ha^{-1})									
P_1: 20	72.71	6.57	33.11	7.78	18.78	207.04	33.57	30939.84	1.53

P_2: 40	76.59	7.09	36.27	9.59	20.78	226.25	37.49	36290.45	1.58
P_3: 60	79.24	7.48	37.00	11.24	23.22	239.97	41.44	39716.81	1.61
P_4: 80	82.94	7.84	38.61	13.01	24.89	253.67	45.36	41513.24	1.64
S.E.M ±	1.28	0.17	0.69	0.52	0.62	4.14	1.31		
C.D. at 5 %	3.80	0.49	2.04	1.55	1.84	12.31	3.89		
Interaction	NS	NS	NS	NS	NS	NS	NS		

Conclusion

On the basis of present investigation following broad conclusions can be drawn that fodder cowpea variety EC-4216 in combination with application of 80 kg P_2O_5 ha $^{-1}$ recorded better growth parameters (plant height, number of branches, functional leaves per plant, dry matter accumulation, nodulation) and higher levels of Green and dry fodder yield q ha^{-1} along with better net returns and B: C ratio

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