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Effect of phosphorus and zinc application on yield and nutrients uptake by cowpea

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Abstract

A field experiment was conducted at Raja Balwant Singh College Research farm Bichpuri, Agra during rabi season of 2017-18 to study the effects of phosphorous and zinc application on yield and nutrient uptake of cowpea. The experiment consists of (a) four levels of phosphorous namely- (control) P_0, (20) P_1, (40)P_2 and (60) P_3 Kg P_2O_5 ha^{-1} and (b) three levels of zinc viz. (control) ZN_0, 10 Zn_1, and 20 Zn_2 Kg $ZnSO_4$ ha^{-1}. The results revealed that the application of 60 Kg P_2O_5 ha^{-1} + 20 Kg $ZnSO_4$ ha^{-1} recorded significantly higher grain and straw yield over control. Similarly, the nitrogen, phosphorous, potassium and zinc uptake found higher with increased levels of phosphorous and zinc i.e., 60 kg P_2O_5 ha^{-1} + 20 kg $ZnSO_4$ ha^{-1}. It can be suggested that farmers may be used 60 kg P_2O_5 ha^{-1} + 20 Kg $ZnSO_4$ ha^{-1} for better production and nutrient uptake of cowpea.

Key words: Phosphorous, cowpea, zinc, yield, growth, nutrient uptake

Introduction

Cowpea [Vigna unguiculata (L.) Walp.] commonly known by its vernacular name chowli, is one of the most important pulse crops and plays an important role in Indian diet because it contains about 23.1 per cent protein which is more than two times of cereals. Cowpea is mostly grown as a kharif crop but can be grown as a rabi crop in peninsular India. It may be suitable for rice fallows in Odisha, Madhya Pradesh, Chhattisgarh, Maharashtra, Andhra Pradesh, Karnataka and Tamilnadu. It is the only arid legume of widespread across the continents and growing well in arid and semi-arid regions with wide adaptations. Moreover, crop is known for good regeneration potential and can be grown in kharif, summer and winter seasons. The average productivity of this crop is quite poor as compared to other pulses which is now to the tune of 350 kg ha^{-1}. The cowpea market is US$ 7.21 billion in 2023 and has been forecasted to be US$ 9.43 billion by 2028 with the CAGR of 5.50%. Besides, the value of cowpea as a nutritious fodder, green manure, erosion resisting cover crop and fertility restorer are also well known. In spite of significant importance of this crop, the productivity is very low in India. In recent years cowpea has been included in food security program of different countries. The demand of cowpea is increasing since it is rich in antioxidants, polyphenols, polyunsaturated fatty acids and dietary fibre. In addition, cowpea plays an imperative role in improving soil fertility through biological nitrogen fixation.

Phosphorus (P) plays an important role in many plant processes such as energy metabolism, nitrogen fixation, photosynthesis, respiration and enzyme regulation. It is an essential element required

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for protein synthesis and energy transfer in plants and to improve cowpea yield, as it stimulates growth, nodulation and efficiency of Rhizobium bacteria Nkaa et al. (2014). It is required in large quantity in young cells such as shoot and root tips to increase metabolism and promote rapid cell division. It also helps in flowering and development of fruit and seeds. According to Oti et al. (2004), phosphorus decreases zinc concentration in cowpea grains, thereby affecting its nutritional quality. Application of phosphorus has been reported by several workers to improve cowpea seed yield. Number of factors have been reported to have a direct or indirect impact on seed yield, among which, number of pods per plant, number of seeds per pod and 100 seeds weight are the important one Cobbinah et al. (2011). Moreover, zinc (Zn) which is essential micronutrients for growth and reproduction in plants, animals, and humans, plays a key role in growth, DNA stabilization, gene expression, enzyme activity, protein synthesis and chlorophyll functions. Its deficiency is a major limiting factor in several Asian countries in the cultivation of cowpea Rehman et al. (2012). It is now being recorded as third most deficient nutrient in crop production after nitrogen and phosphorus. In India, zinc deficient soils occupying almost 50% of the agricultural area are a critical constraint in getting higher yield of cowpea since the crop is very sensitive to the deficiency of zinc, which plays a vital role in nitrogen fixation through nodule formation. Its deficiency causes one of the major widespread micronutrient disorders that contribute to public health problems in developing countries Muller and Krawinkel (2005). Considering the above points in view, the experiment was conducted to find out the optimum dose of phosphorus and zinc for higher yield and nutrient uptake of cowpea crop.

Materials and Methods

A field experiment was conducted at R. B. S College, Agricultural Research Farm, Bichpuri, Agra during Kharif season of 2017-18. The experiment was laid out in randomized block design with three replications on sandy loam soils. The soil had EC 3.1 dS m^{-1}, pH-8.7, organic carbon 0.44 %, available N-225.40 kg ha^{-1}, P-16.5 kg ha^{-1}, K-238.50 kg ha^{-1} and Zn-3.5 ppm. The treatment consisted of (a) four levels of phosphorous namely- (control) P_0, (20) P_1, (40)P_2 and (60) P_3 Kg P_2O_5 ha^{-1} and (b) three levels of zinc viz. (control) ZN_0, 10 Zn_1, and 20 Zn_2 Kg $ZnSO_4$ ha^{-1}. The control plots received no Phosphorous and zinc fertilizer**.** Recommended dose of nitrogen and potassium was given through urea and muriate of potash. The basal dressing of nitrogen and phosphorus was applied to every plot. The phosphorus was supplied through single to the cowpea crop. The zinc was applied as zinc chloride. Intercultural operations were done as and when necessary. The crop was harvested at physiological maturity and grain and straw yields were recorded. The grain, leaf, shoot samples are collected and analyzed nutrient uptake. These observations on yield attributes and nutrient uptake were recorded at harvest. The collected data were analyzed statistically.

Results and Discussions

Grain Yield

It is revealed form Table 1 that grain yield of cowpea increased significantly with increasing the levels of phosphorus over control. The higher grain yield was noted with highest level of phosphorus. The phosphorus levels P_1 (20 Kg P_2O_5 ha^{-1}), P_2 (40 Kg P_2O_5 ha^{-1}), and P_3 (60 Kg P_2O_5 ha^{-1}) resulted 16.74, 31.52 and 44.19 percent enhancement in grain yield of cowpea over control respectively. It may be due to better growth, root development and yield attributing characters by the application of phosphorus. These results are in favor of Singh et al., (2010), Dixit (2011) and Munna et al. (2016). It is inferred from Table 1 that the grain yield of cowpea significantly affected with the application of zinc. The grain yield improved significantly with increasing levels of zinc over control. The zinc levels Zn_1 (10 Kg $ZnSO_4$ ha^{-1}) and Zn_2 (20 Kg $ZnSO_4$ ha^{-1}) resulted 8.70 and 8.48 percent grain yield of cowpea over control, respectively. The maximum grain was obtained under highest zinc level (20 Kg $ZnSO_4$ ha^{-1}). The increase in yield may be attributed to increased availability of zinc to plants due to its addition. Response of crop to zinc application has been

Table 1: Effect of phosphorus and zinc levels on grain and stover yield (q ha^{-1}) of cowpea

Treatments	Grain yield (q/ha)	Stover yield (q/ha)
Phosphorus levels		
P_0	8.70	47.20
P_1	10.30	54.35
P_2	11.60	57.80
P_3	12.71	61.02
C.D.at 5%	0.26	1.23
Zinc Levels		
Zn_0	7.30	40.07
Zn_1	8.70	43.51
Zn_2	8.48	45.10
C.D.at 5%	0.30	0.60

reported by Kumar et al, (2003) and Singh and Yadav (2007).

Stover yield

It is evident from Table 1 that the stover yield of cowpea increased significantly with increasing levels of phosphorus as compared to control. The highest level (60 Kg P_2O_5 ha^{-1}) P_3 proved better over rest of the treatments. The phosphorus levels P_1 (20 Kg P_2O_5 ha^{-1}), P_2 (40 Kg P_2O_5 ha^{-1}), and P_3 (60 Kg P_2O_5 ha^{-1}) resulted 15.12, 22.49 and 29.20 percent more stover yield of cowpea over control, respectively. The increase in yield may be attributed to increase availability of phosphorus to plants due to its addition. These results are also reported by Singh et al, (2010), Dixit (2011) and Munna et al. (2016). It is noted from Table 1 that the stover yield of cowpea significantly increased with the application of zinc. The stover yield of cowpea increased significantly with improving the levels of zinc over control. The maximum stover yield was recorded under Zn_2 (20 kg $ZnSO_4$ ha^{-1}) level of zinc. The zinc levels Zn_1 (10 kg $ZnSO_4$ ha^{-1}) and Zn_2 (20 kg $ZnSO_4$ ha^{-1}) resulted 8.65 and 12.58 percent straw yield of cowpea over control, respectively. The soil was used in this study was deficient in available Zn and therefore significant response of cowpea to applied-Zn is quite understood able. These results are in favor of Kumar et al, (2003) and Singh and Yadav (2007).

Nutrients uptake studies:

Nitrogen uptake

It is noted from Table 2 that nitrogen uptake by cowpea increased significantly with increasing levels of phosphorus over control. The phosphorus levels P_1 (20 kg P_2O_5 ha^{-1}), P_2 (40 kg P_2O_5 ha^{-1}), and P_3 (60 kg P_2O_5 ha^{-1}) resulted 77.71, 135.98 and 171.58 percent more nitrogen utilization of cowpea over control, respectively. The maximum nitrogen utilization by cowpea was noted under highest level of phosphorus P_3 (60 kg P_2O_5 ha^{-1}) followed by P_2 (40 kg P_2O_5 ha^{-1}), P_1 (20 kg P_2O_5 ha^{-1}) and P_0 (control). These results are in favour of Kumawat and Kumawat (2009) and Singh (2010). Further, the data presented in Table 2 reflects that the nitrogen uptake by cowpea increased significantly with increasing levels of zinc as compared to control. The zinc levels Zn_1 (10 kg $ZnSO_4$ ha^{-1}) and Zn_2 (20 kg $ZnSO_4$ ha^{-1}) resulted 53.71 and 125.42 percent more nitrogen utilization of cowpea over control, respectively. The maximum nitrogen uptake observed in Zn_2 (20 kg $ZnSO_4$ ha^{-1}) followed by Zn_1 (10 kg $ZnSO_4$ ha^{-1}) and Zn_0 (control). Similar to these finding Singh (2010), Khare and Dixit (2011) and Singh et al, (2013).

Phosphorus uptake

The Table 2 indicate that phosphorus uptake by cowpea improved with each higher level of phosphorus. The maximum phosphorus utilization by cowpea was noted under highest level of phosphorus P_3 (60 kg P_2O_5 ha^{-1}). The phosphorus levels P_1 (20 kg P_2O_5 ha^{-1}), P_2 (40 kg P_2O_5 ha^{-1}), and P_3 (60 kg P_2O_5 ha^{-1}) resulted 60.21, 92.73 and 134.44 percent more phosphorus utilization of cowpea over control, respectively. Similar results were observed by Kumawat and Kumawat (2009) and Singh (2010). In general, the data presented in Table 2 reveal that the phosphorus uptake by cowpea increased significantly utilization by cowpea was recorded with Zn_2 (20 kg $ZnSO_4$ ha^{-1}) level of zinc. The zinc levels Zn_1 (10 kg $ZnSO_4$ ha^{-1}) and Zn_2 (20 kg $ZnSO_4$ ha^{-1}) resulted 8.48 and 93.81 percent more phosphorous utilization of cowpea over control, respectively. Similar to these findings Singh (2010), Khere and Dixit (2011) and Singh et al, (20013).

Table 2: Effect of phosphorus and zinc levels on nitrogen, phosphorus, potassium and zinc uptake (kg ha^{-1}) by cowpea

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Zn cuptake (kg/ha)
Phosphorus levels				
P_0	69.37	23.40	75.47	18.11
P_1	123.28	37.49	93.26	21.01
P_2	163.70	45.10	114.08	27.30
P_3	188.40	54.86	125.05	32.50
C.D.at 5%	6.85	2.70	4.90	0.160
Zinc Levels				
Zn_0	62.31	24.41	68.46	16.10
Zn_1	95.79	26.48	78.10	24.80
Zn_2	140.46	48.67	85.10	27.41
C.D.at 5%	8.50	2.40	4.90	1.15

Potassium uptake

It is inferred from Table 2 that potassium uptake by cowpea with increasing levels of phosphorus over control. The maximum potassium uptake by cowpea crop was noted under P_3 (60 kg P_2O_5 ha^{-1}) level of phosphorus followed by P_2 (40 Kg P_2O_5 ha^{-1}), P_1 (20 Kg P_2O_5 ha^{-1}) and P_0 (control). The phosphorus levels P_1 (20 kg P_2O_5 ha^{-1}), P_2 (40 kg P_2O_5 ha^{-1}), and P_3 (60 kg P_2O_5 ha^{-1}) resulted 23.57, 51.15 and 65.69 percent more potassium utilization of cowpea over control, respectively. Similar results were observed by Kumawat and Kumawat (2009) and Singh (2010). In general, the Table-2 shows that the potassium utilization by cowpea crop increased significantly with increasing the levels of zinc. The zinc levels Zn_1 (10 kg $ZnSO_4$ ha^{-1}) and Zn_2 (20 kg $ZnSO_4$ ha^{-1}) resulted 14.13 and 24.30 percent more potassium utilization of cowpea over control, respectively. The maximum potassium uptake observed in Zn_2 (20 kg $ZnSO_4$ ha^{-1}) followed by Zn_1 (20 kg $ZnSO_4$ ha^{-1}) and Zn_0 (control). Similar to these findings Singh (2010), Khere and Dixit (2011) and Singh et al (2013).

Zinc uptake

It is evident from Table 2 that zinc uptake by cowpea crop increased significantly with increasing levels of phosphorus in comparison to control. The maximum zinc uptake by cowpea crop was recorded under highest level of phosphorus. The maximum zinc uptake by cowpea crop was noted under P_3 (60 kg P_2O_5 ha^{-1}) level of phosphorus followed by P_2 (40 kg P_2O_5 ha^{-1}), P_1 (20 kg P_2O_5 ha^{-1}) and P_0 (control). The phosphorus levels P_1 (20 kg P_2O_5 ha^{-1}), P_2 (40 kg P_2O_5 ha^{-1}), and P_3 (60 Kg P_2O_5 ha^{-1}) resulted 16.01, 50.74 and 79.45 percent more zinc utilization of cowpea over control, respectively. These results were observed by Kumawat and Kumawat (2009) and Singh (2010).

Further, evaluation of data presented in Table 2 shows that the zinc uptake by cowpea crop enhanced significantly with increasing levels of zinc. The maximum zinc uptake by cowpea was recorded under Zn_2 (20 kg $ZnSO_4$ ha^{-1}) level of zinc. The zinc levels Zn_1 (10 kg $ZnSO_4$ ha^{-1}) and Zn_2 (20 kg $ZnSO_4$ ha^{-1}) resulted 54.03 and 70.24 percent more zinc utilization of cowpea over control, respectively. The maximum zinc uptake observed in Zn_2 (20 kg $ZnSO_4$ ha^{-1}) followed by Zn_1 (20 kg $ZnSO_4$ ha^{-1}) and Zn_0 (control). Similar to these finding Singh (2010), Khare and Dixit (2011) and Singh et al, (2013).

Conclusion

The better production of cowpea can be obtained by adopting the treatment combination as 60 Kg P_2O_5 ha^{-1} + 20 Kg $ZnSO_4$ ha^{-1}. The soil application of phosphorus and zinc improved the content and their uptake by cowpea crop.

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