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Effect of phosphorus and zinc on plant growth and yield of vegetable cowpea

Kiran, DS Duhan*, MK Rana, Harshita Singh and Makhan Mazoka

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Abstract

The experiment comprising of five phosphorus levels *viz*., 0, 40, 60, 80 and 100 kg/ha; and four zinc levels, *i.e.*, 0, 5, 10 and 15 kg/ha was conducted at Research Farm, Department of Vegetable Science, CCS HAU, Hisar to observe effects on plant height, number of branches per plant, days to 50% flowering, number of pods per plant, pod length, pod girth, pod weight, seeds per pod, seed yield per plant, seed yield per plot and seed yield per hectare. Plant height and number of branches per plant increased with the increase in fertilizer dose. The tallest plant at 45, 60 and at final harvest (39.10, 57.50 and 69.54 cm, respectively) and maximum number of branches per plant (5.73) were recorded when the crop was sown with the application of phosphorus 60 kg/ha and zinc 10 kg/ha. Flowering was delayed significantly with the increase in phosphorus and zinc levels. The maximum number of days to 50% flowering was taken by the crop under phosphorus 60 kg/ha and zinc 10 kg/ha. The number of pods per plant (14.23), number of seeds per pod (13.36), pod weight (18.02), seed yield per plant (43.48), per plot (3.13kg) and per hectare (21.74q/ha) were recorded maximum when the crop was supplied with phosphorus 60 kg/ha and zinc 10 kg/ha.

Keywords: P, Zn, cowpea, flowering, pod, yield

Introduction

Cowpea (*Vigna unguiculata*), popularly known as *lobia* in Hindi, is one of the important leguminous crops grown during summer and rainy season for its long green tender pods, which are used as vegetable and dry seeds as pulse. Its green leaves and plants are also used as fodder and green manure, respectively. Its mature dry seeds are reported as major source of protein (23.09-28.75%), however, they contained some anti-nutritional factors such as hydrates, oligosaccharides and protease inhibitors. Cowpea is well adapted to drier regions of tropics and subtropics, where other food legumes do not perform well. It is grown both in *kharif* and summer season in India due to its short duration, quick growth and high yield potential. Being a shade tolerant crop, it can easily be grown as intercrop in maize, millets, sorghum, sugarcane and orchards. It is best suitable crop as regarded for crop diversification in traditional rice-wheat cropping system. It has the ability to fix atmospheric nitrogen into the soil at the rate of 56 kg/ha, through root nodules containing *Rhizobium* bacteria under favourable conditions, thus, it is also used as green manure crop. In addition, the crop has heavy vegetative growth which covers the ground. Thus it can also be used to prevent so well that it checks soil erosion and to smother the weeds.

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 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 factor 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

Department of Vegetable Science, CCS Haryana Agricultural University, Hisar-125004, Haryana
*Corresponding author, E-mail: dharamveer_duhan@rediffmail.com

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 seed yield and quality of cowpea crop.

Materials and Methods

A field experiment was conducted at Research Farm and Laboratory of the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar during Spring-summer of 2015-16. Soil of the experimental plot was high in pH, poor in organic carbon and available nitrogen, medium in phosphorus and high in potash. The treatments comprising of five levels of phosphorus (0, 40, 60, 80 and 100 kg/ha) and four levels of zinc (0, 5, 10 and 15 kg/ha) were laid out in Randomized Block Design (factorial) keeping phosphorus levels in main plots and zinc levels in sub-plots with three replications. The phosphorus was applied through Di-ammonium phosphate fertilizer and Zinc was applied in the form of Zinc sulfate. The seeds of cowpea cv. Kashi Kanchan were sown at a spacing of 60×30 cm. The recommended dose of basal fertilizers was applied at the time of sowing and the left over nitrogen was applied at the time of flowering. All the recommended cultural practices and plant protection measures were adopted to raise a healthy crop. The observations were recorded on plant height (45, 60 and at final harvest), number of branches per plant, days to 50% flowering, number of pods per plant, pod length, pod girth, pod weight, seeds per pod, seed yield per plant, seed yield per plot and seed yield per hectare. The data were subjected to statistical analysis for the interpretation of results Panse and Sukhatme (1967).

Results and Discussion

Growth Parameter: The application of phosphorus and zinc had significant ($P<0.05$) effect on seed yield of cowpea. A significant ($P<0.05$) increase in seed yield (21.74 t/ha) was observed only up to 60 kg/ha phosphorus and zinc 10 kg/ha, which was 57.7% higher than the yield of control plot. In present investigation, the levels of phosphorus and zinc significantly influenced the plant height and number of primary branches per plant, which increased with the increase in fertilizer dose. From the present study, it is clear that the increasing level of phosphorus up to 60 kg/ha and zinc up to 10 kg/ha caused a significant increase in plant height, and the tallest plants (39.10, 57.50 and 69.54 cm) at 45, 60 days after sowing and at final harvest and maximum number of branches per plant (5.73) were observed under same treatment. The other growth characters, *i.e.*, number of pods per plant (14.23), pod length (27.81) and pod girth (1.286) were also measured maximum when phosphorus and zinc were applied @ 60 and 10 kg/ha, respectively. The favorable effect of phosphorus on vegetative growth of cowpea might be due to the readily availability of applied phosphorus at early stages of crop growth Raman et al. (2011), better absorption and efficient utilization of other nutrients through its extensive and deep root system developed, and better translocation of assimilates, which increased the activities of meristematic tissue at root and shoot tip and ultimately increased the inter-nodal length caused due to the cumulative effect of phosphorus on the process of cell division Zafar (2003). The results of present study are in conformity with the findings of Magani and Kuchinda (2009) reported an increasing effect on plant height and branching in cowpea with increasing level of phosphorus from 0 to 75 kg/ha and taller plants with the application of phosphorus 60 kg/ha, Kumawat et al. (2014) noted the significantly tallest plant and maximum number of branches in green gram under phosphorus application 60 kg/ha, Rajasree and Pillai (2001) found increased plant height and number of branches per plant in forage cowpea cv. C-152 with enhancing phosphorus level from 0 to 30 or 60 kg/ha and Meena and Chand (2014) noticed increased number of branches per plant in fodder cowpea with each successive dose of phosphorus up to 60 kg/ha.

The application of phosphorus significantly influenced the days taken to flowering in 50% plants. The minimum number of days to 50% flowering was taken by cowpea crop when no phosphorus was applied. Phosphorus application increased the number of days to flower in 50% plants. The maximum days to 50% flowering was taken by the crop supplied with phosphorus 60 kg/ha (Table 1). The reducing number of days to 50% flowering might be due to readily availability of applied phosphorus, which increased the root and shoot growth, which eventually reflected in better vegetative growth and early flowering Magani and Kuchinda (2009).

The data in (Table 1) showed that the increasing level of zinc 0 to 10 kg/ha caused significant increase in plant height at 45, 60 days after sowing and at final harvest of cowpea. The maximum height of plants was recorded in plots supplied with zinc 10 kg/ha. In addition, it is also indicated from the data that the increasing level of zinc up to 10 kg/ha increased the number of branches per plant. The maximum number of branches per plant was recorded with zinc level 10 kg/ha. The obtained results are in good accordance with those of Ram and Katiyar (2013) who reported that the application of zinc 10 kg/ha along with sulphur 40 kg/ha significantly increased the plant height and number of branches per plant in Moong bean. Application of zinc up to 10 kg/ha increased the number of days taken to 50 % flowering and the maximum number of days taken to 50 % flowering was registered with zinc 10 kg/ha, while the minimum number of days taken to 50 % flowering was recorded in the plots where no zinc was applied (Table 1). Zinc is a micronutrient, which is required for plant growth and development relatively in small amount. The favourable effect of zinc on plant growth might be due to its role in many physiological processes and cellular function within plant. Zinc is found involved in a diverse range of enzyme system. The functional role of zinc includes auxin metabolism, influence on the activities of dehydrogenase enzyme, synthesis of cytochrome and stabilization of ribosomal fractions Tisdale et al. (1985). The increase in plant height, number of leaves per plant and days to 50% flowering under zinc sulphate might be due to reason that besides the role of zinc in chlorophyll formation, it also influenced the cell division, meristamatic activity of tissue, expansion of cell and formation of cell wall Singh (1991). He also stated that foliar application of zinc increased the photosynthetic activity, which ultimately resulted in improving the growth of plant. Thalooth et al. (2006) reported that the application of zinc spray increased atmospheric nitrogen fixation and the proportion of protein in the seeds through the improvement of all measurement of

Table 1: Effect of phosphorus and zinc on growth and yield of cowpea

Treatments		Plant height at 45 DAS (cm)	Plant height at 60 DAS (cm)	Plant height at final harvest (cm)	Number of branches per plant	Days to 50% flowering	Number of pods per plant	Pod length (cm)	Pod girth (cm)	Pod weight (g)	Seeds per pod	Seed yield per plant (g)	Seed yield per plot (kg)	Seed yield per hectare (q)
P_1 (0 kg/ha)	Z_1	29.63	38.30	45.61	4.23	42.00	8.00	22.41	0.829	6.46	9.15	12.47	0.90	6.24
	Z_2	33.07	46.29	56.16	4.33	43.00	9.23	24.12	0.932	7.93	9.56	16.17	1.16	8.09
	Z_3	35.84	53.51	58.29	4.67	44.00	11.52	25.59	0.989	14.46	11.35	24.19	1.79	12.46
	Z_4	33.86	45.51	56.57	4.27	42.00	9.71	23.97	0.913	10.84	10.88	18.79	1.35	9.40
	Mean	33.10	46.00	54.16	4.38	42.75	9.61	24.02	0.915	9.92	10.23	18.09	1.30	9.05
P_2 (40 kg/ha)	Z_1	30.70	41.71	53.81	4.33	43.00	9.46	24.89	0.848	7.60	10.57	18.02	1.30	9.01
	Z_2	34.56	48.45	57.44	4.47	43.00	10.93	25.15	0.987	11.48	10.84	24.63	1.77	12.32
	Z_3	36.92	55.34	65.22	5.40	45.00	12.90	26.91	1.087	15.19	11.97	33.14	2.39	16.57
	Z_4	35.66	47.70	58.43	4.60	44.00	11.60	24.67	1.015	11.20	11.57	25.88	1.86	12.94
	Mean	34.46	48.30	58.73	4.70	43.75	11.22	25.40	0.984	11.37	11.24	25.42	1.83	12.71
P_3 (60 kg/ha)	Z_1	36.06	46.11	56.96	5.07	44.00	11.47	25.99	0.986	8.92	12.06	27.98	2.01	13.99
	Z_2	36.53	50.85	62.94	5.20	45.00	12.13	26.79	1.025	13.61	12.57	32.89	2.37	16.45
	Z_3	39.10	57.50	69.54	5.73	46.00	14.23	27.81	1.286	18.02	13.36	43.48	3.13	21.74
	Z_4	37.07	49.89	64.10	4.80	45.00	13.10	25.15	0.996	12.34	12.18	32.77	2.36	16.39
	Mean	37.19	51.08	63.38	5.20	45.00	12.73	26.43	1.073	13.22	12.54	34.28	2.47	17.14
P_4 (80 kg/ha)	Z_1	33.48	42.72	52.93	4.47	43.00	10.83	24.25	0.860	7.84	11.63	24.35	1.76	12.18
	Z_2	34.60	47.82	58.03	4.67	43.00	11.10	25.55	0.885	12.11	12.01	26.82	1.93	13.41
	Z_3	38.42	54.75	63.82	5.13	44.00	12.79	26.40	0.950	16.53	12.87	35.84	2.58	17.92
	Z_4	34.92	47.70	61.06	4.76	42.00	11.60	23.86	0.805	11.59	11.64	24.64	1.77	12.32
	Mean	35.35	48.24	58.96	4.76	43.00	10.62	25.01	0.875	12.01	12.04	27.91	2.01	13.96
P_5 (100 kg/ha)	Z_1	31.31	43.65	52.89	4.20	42.00	9.86	23.89	0.797	7.03	9.43	16.02	1.15	8.01
	Z_2	33.45	46.68	56.34	4.53	42.00	10.63	24.56	0.825	11.21	10.52	21.00	1.51	10.50
	Z_3	37.13	53.75	60.77	4.27	43.00	11.93	25.82	0.894	15.08	11.78	27.94	2.01	13.97
	Z_4	33.54	46.90	58.62	4.30	42.00	10.06	23.45	0.757	11.21	11.03	19.80	1.43	9.90
	Mean	33.86	47.74	57.15	4.32	42.25	10.62	24.43	0.818	11.13	10.69	21.19	1.53	10.60
Overall mean	Z_1	*32.24*	*42.50*	*52.44*	*4.46*	*42.00*	*9.92*	*24.28*	*0.864*	*7.57*	*10.57*	*19.77*	*1.43*	*9.89*
	Z_2	*34.44*	*48.02*	*58.18*	*4.64*	*43.00*	*10.80*	*25.23*	*0.930*	*11.27*	*11.10*	*24.30*	*1.75*	*12.15*
	Z_3	*37.48*	*55.04*	*63.53*	*5.04*	*44.00*	*12.67*	*26.50*	*1.041*	*15.85*	*12.27*	*33.06*	*2.38*	*16.53*
	Z_4	*35.01*	*47.54*	*59.76*	*4.55*	*43.00*	*11.21*	*24.22*	*0.897*	*11.43*	*11.46*	*24.38*	*1.75*	*12.19*
Phosphorus		0.56	0.56	1.16	0.274	0.85	0.33	0.87	0.081	0.56	0.35	0.50	0.04	0.25
Zinc		0.48	0.50	1.04	0.245	0.76	0.30	0.77	0.072	0.50	0.31	0.44	0.03	0.22
Phosphorus x Zinc		1.11	1.13	2.33	N.S.	N.S.	0.67	N.S.	N.S.	1.14	0.69	0.99	0.07	0.50

P= Phosphorus level as SSP; Z= Zinc level as Zinc sulfate plant growth, roots and thereby increasing the density of root growth in the soil and increase the numbers of the nodule by increasing the leaf area. The favourable effect was also attributed to the fact that zinc was essential in nitrogen metabolism. The improvement in growth efficiency of plant and its organ might also be due to beneficial effect of foliar application of zinc treatments on the physiological activities and other enzymatic reactions like transformation of carbohydrates and activity of hexokinase of plants, which are responsible for improving the growth of plant and its component organs, ultimately influencing the relative development of plant parts and their growth efficiency. The interaction of phosphorus and zinc significantly influenced the plant height at 45, 60 days after sowing, at final harvest and number of branches per plant, and the interaction was found non-significant in case of number of days taken to 50% flowering (Table 1). The plant height, number of branches per plant and number of days to 50% flowering increased with the increase in phosphorus and zinc combination up to 60 and 10 kg/ha, respectively. The maximum plant height and number of branches per plant was recorded under phosphorus level 60 kg/ha in combination of zinc 10 kg/ha. However, the minimum number of days taken to 50% flowering was recorded in plots where no phosphorus or zinc was supplied.

Yield and related attributing traits: The yield parameters like number of pods per plant, pod weight, pod length (cm), pod girth (cm), number of seeds per pod and hundred seed weight were significantly influenced by different levels of phosphorus, zinc and their combinations (Table 1). The increasing level of phosphorus up to 60 kg/ha significantly increased the yield attributing characters such as number of pods per plant, pod weight, number of seeds per pod and hundred seeds weight. The best results were obtained at phosphorus level 60 kg/ha. This could be due to the increased intensity of nodulation and fixation of nitrogen. The results of present study are in conformity with findings of Karikari et al. (2015) who observed the number of pods per plant of cowpea directly proportional to the rates of phosphorus fertilizer application and Kumawat et al. (2014) who obtained similar results in green gram.

The seed yield per plant, seed yield per plot and seed yield per hectare were significantly influenced by the application of phosphorus (Table 1). There was an increase in seed yield with the increase in phosphorus up to 60 kg/ha but it decreased thereafter. The maximum seed yield was harvested from the plot supplied with phosphorus 60 kg/ha. The beneficial effect of phosphorus application on fruiting of plants and better translocation of desired metabolites to yield contributing parts of the plant might attributed to more seed yield. Application of phosphorus might have improved nutritional environment in rhizospheric as well as in plant system, leading to increased uptake and translocation of nutrients especially of nitrogen, phosphorus and zinc in reproductive structures, which led to their higher content and uptake Sepat and Yadav (2008). This might also be due to better cell division and development of meristematic tissues caused by increased uptake of available nutrients in soil Nataraja et al. (2005). These results were in line with the results of Karikari et al. (2015) and Kumawat et al. (2014).

The effect of zinc on yield attributing characters like number of pods per plant, pod weight, number of seeds per pod and hundred seeds weight was found significant. There was an increase in number of pods per plant, pod weight, number of seeds per pod and hundred seed weight with increasing level of zinc up to 10 kg/ha. The best results were registered with zinc 10 kg/ha, which helped in translocation of constituents from one to other parts of the plant, thus, zinc was a responsible factor to increase the seed yield (Table 1). This might be due to the increase in size and weight of seeds under the influence of zinc by rapid translocation and storage of food material in seeds. These results are in agreement with the findings of Ram and Katiyar (2013) who reported increased number of pods per plant in moong bean with increasing level of zinc up to 10 kg/ha and Moswatsi et al. (2013) who reported that increasing level of zinc increased pod fresh weight as compared to the lower zinc levels. Application of zinc in cowpea had significant effect on seed yield per plant, seed yield per plot and seed yield per hectare, which increased with the increase in zinc level up to 10 kg/ha and were obtained maximum from the plot where zinc was applied at the rate of 10 kg/ha (Table 1). The increase in seed yield with the application of zinc might be due to its important role in regulating the auxin concentration and nitrogen metabolism in plants. The substantial increase in seed yield might be due to better growth and development of plant parts in terms of plant height and branches per plant, which might have increased the yield attributes and ultimately enhanced the seed yield significantly. Kasthurikrishna and Ahlawat (2000) reported that zinc application increased the grain yield of pea probably owing to the influence on auxin synthesis, nodulation and nitrogen fixation, which promoted plant growth and development, thereby favourably influenced the grain yield. The increase in seed yield due to zinc application might be due to the enhanced synthesis of carbohydrates and protein and their transport to the site of seed formation. Safak et al. (2009) stated that zinc is an activator of many enzymes involved in photosynthesis, cell elongation and cell division. Zinc treated crops were more vigourous than the untreated crops and had better growth since zinc play a key role in stabilizing RNA and DNA structure and involves in the biosynthesis of growth promoting hormones such as IAA and gibberellins Mousavi (2011). Upadhyay and Singh (2016) obtained the highest grain yield with the application of zinc because zinc influenced the synthesis of IAA in plants that indirectly enhanced the growth and development and uptake of nutrients in plants. Similar results were reported by Ram and Katiyar (2013) who obtained the maximum seed yield of moong bean crop in both the years with the application of zinc 10 kg/ha along with sulphur 40 kg/ha, respectively. The interaction of phosphorus and zinc had a significant influence on yield and yield attributing characters like number of pods per plant, pod weight, number of seeds per pod, hundred seeds weight, seed yield per plant, seed yield per plot and seed yield per hectare (Table 1). The best results were recorded when phosphorus was supplied at the rate 60 kg/ha in combination with zinc 10 kg/ha. From the present study, it is concluded that cowpea crop can be successfully grown when phosphorus was supplied at the rate 60 kg/ha in combination with zinc 10 kg/ha.

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वर्तमान परीक्षण में पाँच फॉस्फोरस की मात्रा के स्तरों अर्थात 0, 40, 60, 80 और 100 किग्रा./हेक्टेयर, और चार जिंक की मात्रा के स्तरों, यानी 0, 5, 10 और 15 किग्रा./हेक्टेयर तथा इनके आपसी संयोजकों का आपसी मूल्यांकन सम्बंधित प्रयोग, वर्ष 2015 के खरीफ मौसम में किया गया। यह प्रयोग सब्जी विज्ञान विभाग, चौधरी चरण सिंह हरियाणा कृषि विश्वविधालय, हिसार में किया गया। इस परीक्षण के दौरान पौधों की ऊँचाई, पौधों की शाखाओं की संख्या, 50 प्रतिशत फूल आने की अवस्था, फली की संख्या प्रति पौध, फली की लंबाई व चौड़ाई, फली का वजन, बीज उपज प्रति फली, बीज उपज प्रति पौध, प्रति भूखंड और बीज उत्पादन प्रति हेक्टेयर आदि गुणों का अवलोकन किया गया। परिणाम से स्पष्ट हुआ की पौध की लंबाई और शाखाओं की संख्या में वृद्धि, उर्वरकों की मात्रा में वृद्धि के साथ बढ़ी। पौधों की अधिकतम लंबाई 45 व 60 दिन बाद और फसल पकने की अवस्था पर (क्रमशः 39.10, 57.50 और 69.54 सेमी.) और पौधों की शाखाओं की संख्या में ज्यादा वृद्धि (5.73) दर्ज की गयी जबकि फॉस्फोरस 60 किग्रा./हेक्टेयर की मात्रा के साथ जस्ता की मात्रा 10 किग्रा./हेक्टेयर के साथ प्रयोग किया गया था। खाद की मात्रा बढ़ाने पर फूलों के आने की अवस्था पर विपरीत प्रभाव हुआ। पचास प्रतिशत फूल, अधिकतम संख्या में तब मिले जब फॉस्फोरस व जस्ता की मात्रा 60 किग्रा. और 10 किग्रा./हेक्टेयर दिया गया। पौधों में फलियों की संख्या (14.23), प्रति फली बीजों की संख्या (13.36), फली का वजन (18.02 ग्राम), बीज उपज प्रति पौध (43.48), बीज उपज प्रति भूखंड (3.13 किलोग्राम) और प्रति हेक्टेयर (21.74 कुन्तल/हेक्टेयर) की अधिकतम सीमा में दर्ज किये गए, जब फसल को फॉस्फोरस और जस्ता क्रमशः 60 किग्रा व 10 किग्रा./हेक्टेयर की दर के साथ दिया गया।

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