Vegetable Science (2017) 44 (2) : 74-78

Phosphorus and zinc effect on seed yield and quality of vegetable cowpea

Kiran, DS Duhan, VPS Panghal and MK Rana

Received: August 2017 / Accepted: November 2017

Abstract

Cowpea responds to heavier application of phosphorus in Haryana soils since phosphorus plays an important role in nodulation, thus, the experiment comprising of five phosphorus levels *viz*., 0, 40, 60, 80 and 100 kg/ha and four levels of zinc, *i.e*., 0, 5, 10 and 15 kg/ha was conducted at Research Farm of the Department of Vegetable Science, CCS H.A.U, Hisar during spring-summer of 2015. The seed yield per plant (43.48 g), per plot (3.13 kg) and per hectare (21.74 q), germination percentage (90.53%), seed vigour index-I (3113.25) & II (49.73), protein content (26.76), net returns and benefit to cost ratio (2.04) were recorded maximum when the crop was supplied with phosphorus 60 kg coupled with zinc 10 kg/ha, however, the electrical conductivity (1.12 $\mu Scm^{-1} seed^{-1}$) was recorded lowest at same dose of phosphorus and zinc due to slowest ageing process.

Keywords: Cowpea, phosphorus, zinc, germination, protein content, seed yield

Introduction

Cowpea (*Vigna unguiculata*) popularly known as *lobia* is one of the important leguminous crops, as it is a major source of dietary protein (23.09-28.75%). Being quick growing short duration crop, it is cultivated in summer as well as in rainy season for its long green tender pods usually cooked as vegetable and its dry seeds as pulse. In spite of its low grain yield, cowpea is a popular crop among farmers since it improves and sustains soil fertility and provides high quality fodder for livestock (Tarawali et al. 1997; Singh et al. 1997). It is extensively used in the crop diversification in traditional rice-wheat cropping system.

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

Phosphorus is an essential element to increase growth, protein synthesis, energy transfer, nodulation, efficiency of *Rhizobium* bacteria and nitrogen fixation (Nkaa et al. 2014), resulting in higher yield of cowpea. It is required in large quantity in young cells of meristematic tissue to increase metabolism and promote rapid cell division. It also helps in flowering and development of fruit and seeds. However, phosphorus decreases zinc concentration in cowpea grains, thereby affecting its nutritional quality (Oti et al. 2004), therefore, zinc is essential to apply in association with phosphorus since this micronutrient plays an important role in growth and reproduction of plants, animals and humans, 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 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 (Shukla and Yadav 1982). Considering the above points in view, the experiment was conducted to find out the optimum dose of phosphorus and zinc for higher yield of quality seed in vegetable cowpea.

Materials and Methods

Experiment comprising of five phosphorus levels *viz*., 0, 40, 60, 80 and 100 kg/ha and four levels of zinc, *i.e*., 0, 5, 10 and 15 kg/ha was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer of 2015. The 20 treatment combinations were laid out in randomized block design with three replications. The seeds of vegetable cowpea cv. Kashi Kanchan were sown on 26 March 2015 at a spacing of 60x30 cm in plot size of 3.60x3.60 m. The observations were recorded on seed yield per plant, per plot and per hectare, shelling percentage, germination (%), seed vigour index-I and II, electrical conductivity (µS $cm^{-1}seed^{-1}$), accelerating ageing (%) and protein content (%). Soil of the experimental field was high in pH, poor in organic carbon and available nitrogen, medium in phosphorus and high in potash. The recommended dose of The recommended dose of nitrogen fertilizer (25 kg/ha) was applied through urea and applied half as basal at the time of sowing and the left-over nitrogen was applied at the time of flowering. Phosphorus fertilizer was applied in the form of DAP as per treatments as basal dose. All the recommended cultural practices and plant protection measures were adopted to raise a healthy crop. The observations were recorded on seed yield per plant, per plot & per hectare, shelling percentage, germination (%), seed vigour index-I and II, electrical conductivity (µS cm-1seed-1), accelerating ageing (%) and protein content (%) of cowpea seed. The recorded data were subjected to statistical analysis for the interpretation of results (Panse and Sukhatme, 1967).

Results and Discussion

Effect of phosphorus on yield and yield attributing characters: The yield parameters like seed yield per plant, per plot & per hectare were significantly influenced by different levels of phosphorus. The increasing level of phosphorus up to 60 kg/ha significantly increased the yield attributing characters such as seed yield per plant (34.28 g), per plot (2.47 kg) & per hectare (17.14 q) as compared to control treatment. There was an increase in seed yield with the increase in phosphorus up to 60 kg/ha but it decreased thereafter. 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 nitrogen, phosphorus and zinc in reproductive structures, which led to higher content and uptake of these nutrients (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. These results are in line with the results of Singh et al. (2011) in Stover and grain yield of cowpea in Karikari et al. (2015) and Kumawat et al. (2014).

Effect of zinc on yield and yield attributing characters: Application of zinc in cowpea had significant effect on seed yield per plant, per plot and per hectare. The seed yield per plant, per plot and per hectare increased with the increase in zinc level up to 10 kg/ha and maximum seed yield per plant (33.06 g), per plot (2.38 kg) and per hectare (16.53 q) was obtained from the plot where zinc was applied at the rate of 10 kg/ha. 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, number of pod per plant and seed weight, 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 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 plays 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.

Quality parameters

Effect of phosphorus on seed quality

There was a significantly positive influence of phosphorus application on seed quality parameters like shelling percentage, germination percentage, seed vigour index-I & II and protein content in cowpea seeds (Table 1). The maximum shelling and germination percentage (53.08 and 84.00), seed vigour index-I (2995.93) & II (47.27) and protein content (25.05) of seeds were recorded when phosphorus was applied 60 kg/ha and decreased thereafter. These results might be attributed to the fact that phosphorous fertilization often increases nodulation and nitrogen content in legumes. The results of experiment are in line with the findings of Shekara et al. (2012) who observed significantly higher crude protein yield (5.88 q/ha) with the application of phosphorus 90 kg/ha, which was at par with 60 kg/ha (5.66 q/ha) in cowpea, Kumar et al. (2012) who reported that application of phosphorus 60 kg/ha increased crude protein content significantly in cowpea and Dixit et al. (2014) who stated that the application of phosphorus 60 kg/ha in sorghum+cowpea-chickpea cropping system produced protein 1669 kg/ha.

The electrical conductivity decreased with the increase in phosphorus level up to 60 kg/ha and it was recorded maximum at phosphorus 0 kg/ha, while the minimum electrical conductivity was recorded at phosphorus level 60 kg/ha. The effect of phosphorus application on ageing was observed negative. Ageing of cowpea seeds decreased with the increase in phosphorus level and registered fastest with phosphorus 0 kg/ha, whereas, it was registered slowest with seeds harvested from the plots supplied with phosphorus 60 kg/ha (Table 1).

Effect of zinc on seed quality: There was a significant influence of zinc on quality parameter, *i.e.*, shelling percentage, germination percentage, seed vigour index-I & II and protein content in cowpea seeds (Table 1). The maximum shelling and germination percentage (51.72 and 84.36), seed vigour index-I (2859.31) & II (46.71) and protein content (25.24) were recorded when zinc was applied @ 10 kg/ha and decreased thereafter. The improvement in protein content of cowpea seeds due to zinc application might be attributed to enhanced metabolic processes involved in biosynthesis of protein. The results of the present study confirm the findings of Usman *et al.* (2014) who recorded maximum protein content (21.75 %) in green gram with the application of zinc 10 kg/ha. The electrical conductivity decreased with the increase in zinc level up to 10 kg/ha and it was recorded maximum (1.55 $\mu Scm^{-1} seed^{-1}$) in seeds harvested from the plants supplied with no zinc and minimum electrical conductivity (1.36 $\mu Scm^{-1} seed^{-1}$) in seeds harvested from the plants supplied with zinc at the rate of 10 kg/ha (Table 1). The zinc application had a negative effect on ageing of cowpea seeds, which fastened with decreasing level of zinc. The ageing was registered fastest (36.21) with no zinc application, whereas, it was registered slowest (43.27) in seeds harvested from the plots supplied with zinc 10 kg/ha (Table 1).

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

Treatments (kg/ha)		Seed yield			Germination	Shelling	Vigour index		EC	Accelerating	Protein
		(g/plant)	(kg/plot)	(q/ha)	(%)	(%)	I	II	($\mu Scm^{-1} seed^{-1}$)	ageing test	Content (%)
	Z_0	12.47	0.90	6.24	72 (57.9)*	42.38	2286.2	38.68	1.89	33.75	20.99
	Z_5	16.17	1.16	8.09	78 (61.8)	44.47	24.32.5	44.64	1.76	38.30	21.35
P_0	Z_{10}	24.19	1.79	12.46	81 (64.5)	48.10	26.27.2	46.66	1.43	41.11	24.67
	Z_{15}	18.79	1.35	9.40	77 (61.6)	46.79	2579.7	43.23	1.62	53.05	23.15
	Mean	**18.09**	**1.30**	**9.05**	**77 (61.4)**	**45.43**	**2481.4**	**43.30**	**1.68**	**37.80**	**22.54**
	Z_0	18.02	1.30	9.01	74 (59.6)	45.47	2469.7	41.65	1.56	35.85	21.43
	Z_5	24.63	1.77	12.32	80 (63.2)	49.51	2583.4	45.64	1.73	39.80	22.81
P_{40}	Z_{10}	33.14	2.39	16.57	85 (67.0)	52.87	2870.2	47.54	1.40	43.55	25.00
	Z_{15}	25.88	1.86	12.94	79 (62.7)	51.35	2711.4	44.34	1.55	39.20	23.36
	Mean	**25.42**	**1.83**	**12.71**	**79 (63.1)**	**49.80**	**2658.7**	**44.80**	**1.56**	**39.60**	**23.15**
	Z_0	27.98	2.01	13.99	81 (64.4)	49.09	2874.1	44.43	1.21	41.00	24.22
	Z_5	32.89	2.37	16.45	85 (67.1)	53.71	2948.5	48.61	1.31	43.60	25.08
P_{60}	Z_{10}	43.48	3.13	21.74	91 (72.1)	56.02	3113.3	49.73	1.12	47.90	26.76
	Z_{15}	32.77	2.36	16.39	80 (63.3)	53.53	3047.9	46.30	1.28	39.86	24.15
	Mean	**34.28**	**2.47**	**17.14**	**84 (66.7)**	**53.08**	**2995.9**	**47.27**	**1.23**	**43.09**	**25.05**
	Z_0	24.35	1.76	12.18	73 (59.0)	46.35	2695.4	41.85	1.45	35.10	22.03
	Z_5	26.82	1.93	13.41	78 (61.8)	50.67	2742.9	44.89	1.31	38.30	25.13
P_{80}	Z_{10}	35.84	2.58	17.92	83 (65.6)	54.28	2998.4	45.26	1.36	42.20	24.43
	Z_{15}	24.64	1.77	12.32	77 (61.2)	52.89	2836.3	43.68	1.42	37.59	23.91
	Mean	**27.91**	**2.01**	**13.96**	**78 (61.9)**	**51.05**	**2818.2**	**43.92**	**1.39**	**38.30**	**23.87**
	Z_0	16.02	1.15	8.01	73 (58.8)	43.68	2373.1	40.94	1.66	34.90	21.56
	Z_5	21.00	1.51	10.50	76 (60.7)	45.86	2502.0	42.94	1.51	37.00	22.29
P_{100}	Z_{10}	27.94	2.01	13.97	82 (65.0)	47.32	2687.5	44.36	1.49	41.60	25.36
	Z_{15}	19.80	1.43	9.90	74 (59.2)	49.76	2551.4	38.74	1.56	35.35	21.82
	Mean	**21.19**	**1.53**	**10.60**	**76 (60.9)**	**46.66**	**2528.5**	**41.74**	**1.56**	**37.21**	**22.76**
	Z_0	**19.77**	**1.43**	**9.89**	**75 (59.9)**	**45.40**	**2539.7**	**41.51**	**1.55**	**36.21**	**22.05**
Zinc mean	Z_5	**24.30**	**1.75**	**12.15**	**79 (62.9)**	**48.85**	**2641.9**	**45.35**	**1.53**	**39.40**	**23.33**
	Z_{10}	**33.06**	**2.38**	**16.53**	**84 (66.9)**	**51.72**	**2859.3**	**46.71**	**1.36**	**43.27**	**25.24**
	Z_{15}	**24.38**	**1.75**	**12.19**	**77 (61.6)**	**50.86**	**2745.3**	**43.26**	**1.49**	**38.01**	**23.28**
CD at 5% P		0.50	0.04	0.25	1.9	1.9	31.5	0.07	0.03	0.53	0.59
CD at 5% Z		0.44	0.03	0.22	1.7	1.7	28.2	0.06	0.03	0.48	0.53
Interaction P x Z		0.99	0.07	0.50	N.S.	N.S.	63.0	0.13	0.06	1.07	1.19

*The values for germination percentage given in the brackets are the transformed values

Table 2: Total seed yield, net monetary returns and B:C ratio as influenced by different phosphorus and zinc doses in cowpea

Sr. No.	Treatments	Variable cost (Rs./ha)	Treatment cost (Rs./ha)	Total cost (Rs./ha)	Yield (q/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
1.	P_0Z_0: DAP 0 kg/ha + $ZnSo_4$ 0 kg/ha	44309.00	0.0	44309.00	6.24	43656.48	652.52	0.01
2.	P_0Z_5: DAP 0 kg/ha + $ZnSo_4$ 58.32 kg/ha	44309.00	1749.60	46058.60	8.09	56609.60	10551.00	0.23
3.	P_0Z_{10}: DAP 0 kg/ha + $ZnSo_4$ 116.64 kg/ha	44309.00	3499.20	47808.20	12.45	87178.90	39370.70	0.82
4.	P_0Z_{15}: DAP 0 kg/ha + $ZnSo_4$ 174.96 kg/ha	44309.00	5248.80	49557.80	9.40	65779.73	16221.93	0.33
5.	$P_{40}Z_0$: DAP 225 kg/ha + $ZnSo_4$ 0 kg/ha	44309.00	1485.00	45794.00	9.01	63065.08	17271.08	0.38
6.	$P_{40}Z_5$: DAP 225 kg/ha + $ZnSo_4$ 58.32 kg/ha	44309.00	3234.60	47543.60	12.32	86212.85	38669.25	0.81
7.	$P_{40}Z_{10}$: DAP 225 kg/ha + $ZnSo_4$ 116.64 kg/ha	44309.00	4984.20	49293.20	16.57	115979.60	66686.40	1.35
8.	$P_{40}Z_{15}$: DAP 225 kg/ha + $ZnSo_4$ 174.96 kg/ha	44309.00	6733.80	51042.80	12.94	90566.26	39523.46	0.77
9.	$P_{60}Z_0$: DAP 337.5 kg/ha + $ZnSo_4$ 0 kg/ha	44309.00	2227.50	46536.50	13.99	97943.28	51406.78	1.10
10.	$P_{60}Z_5$: DAP 337.5 kg/ha + $ZnSo_4$ 58.32 kg/ha	44309.00	3977.10	48286.10	16.44	115110.32	66824.22	1.38
11.	$P_{60}Z_{10}$: DAP 337.5 kg/ha + $ZnSo_4$ 116.64 kg/ha	44309.00	5726.70	50035.70	21.74	152175.79	102140.09	**2.04**
12.	$P_{60}Z_{15}$: DAP 337.5 kg/ha + $ZnSo_4$ 174.96 kg/ha	44309.00	7476.30	51785.30	16.39	114706.25	62920.95	1.22
13.	$P_{80}Z_0$: DAP 450.0 kg/ha + $ZnSo_4$ 0 kg/ha	44309.00	2970.0	47279.00	12.17	85213.43	37934.43	0.80
14.	$P_{80}Z_5$: DAP 450.0 kg/ha + $ZnSo_4$ 58.32 kg/ha	44309.00	4719.60	49028.60	13.41	93877.61	44849.01	0.91
15.	$P_{80}Z_{10}$: DAP 450.0 kg/ha + $ZnSo_4$ 116.64 kg/ha	44309.00	6469.20	50778.20	17.92	125422.53	74644.33	**1.47**
16.	$P_{80}Z_{15}$: DAP 450.0 kg/ha + $ZnSo_4$ 174.96kg/ha	44309.00	8218.0	52527.00	12.32	86246.58	33719.58	0.64
17.	$P_{100}Z_0$: DAP 562.5 kg/ha + $ZnSo_4$ 0 kg/ha	44309.00	3712.50	48021.50	8.01	56071.47	8049.97	0.17
18.	$P_{100}Z_5$: DAP 562.5 kg/ha + $ZnSo_4$ 58.32 kg/ha	44309.00	5462.10	49771.10	10.50	73504.28	23733.18	0.48
19.	$P_{100}Z_{10}$: DAP 562.5 kg/ha + $ZnSo_4$116.64 kg/ha	44309.00	7211.70	51520.70	13.97	97784.53	46263.83	0.90
20.	$P_{100}Z_{15}$: DAP 562.5 kg/ha + $ZnSo_4$174.96 kg/ha	44309.00	8961.30	53270.30	9.90	69284.55	16014.25	0.30

Price of cowpea seed= Rs. 7000/quintal, DAP 225 kg/ha @ Rs. 6.60 = Rs. **1485,** DAP 337.5 kg/ha @ Rs. 6.60= **Rs. 2227.5,** DAP 450 kg/ha @ Rs. 6.60= **Rs. 2970,** Zinc Sulphate 58.32 kg/ha @ Rs. 30 = **Rs 1749,** Zinc Sulphate 116.64 kg/ha @ Rs. 30 = **Rs. 3499.2,** Zinc Sulphate 174.96 kg/ha @ Rs. 30 = **Rs. 5248.**

Interactive effect of phosphors and zinc on seed yield and quality: The perusal of data indicates that the interactive effect of phosphorus and zinc on shelling percentage, germination percentage, seed vigour index-I & II and protein content in cowpea seed was found significant (Table 1). The highest shelling and germination percentage (56.02 and 90.53), seed vigour index-I (3113.25) & II (49.73) and protein content in cowpea seed (26.76) was obtained under the treatment phosphorus 60 kg/ha in association with zinc 10 kg/ha. The electrical conductivity was recorded lowest (1.12 $\mu Scm^{-1} seed^{-1}$) in the seed harvested from the plot supplied with phosphorus 60 kg/ha in combination with zinc 10 kg/ha, while the highest electrical conductivity (1.89 $\mu Scm^{-1} seed^{-1}$) was recorded in seed harvested from the plots where no phosphorus and zinc was applied (Table 1). Therefore, the interactive effect of phosphorus and zinc application on ageing was considered negative. Ageing of seeds of cowpea was registered fastest (33.75) with control treatment, whereas, it was registered slowest (47.90) with seeds harvested from the plots supplied with phosphorus 60 kg/ha in combination of zinc 10 kg/ha.

Economics: The maximum net returns (Rs. 1,02,140.09 /ha) and benefit to cost ratio (2.04) was obtained from treatment phosphorus 60 kg/ha + zinc 10 kg/ha, followed by the treatment phosphorus 80 kg/ha+zinc 10 kg/ha, however, the additional cost of high dose of phosphorus+zinc fertilizer increased (Table-2). The increase in net returns might be due to higher seed yield obtained under the treatment, which directly contributed to net returns (Puniya et al. 2014).

Conclusion

From the present study, it is concluded that cowpea crop grown with 60 kg of phosphorus + 10 kg of zinc was found economically best for obtaining higher seed yield with better seed quality parameters. The highest benefit cost ratio (Rs. 2.04) was recorded with 60 kg of phosphorus + 10 kg of zinc over control treatment.

सारांश

हरियाणा की मिट्टी में अधिक फॉस्फोरस खाद के लोबिया की फसल पर प्रयोग का अनुकूल प्रभाव को ज्ञात करने हेतु अध्ययन किया गया चूकि फॉस्फोरस खाद पौधे की गाँठ बनने में महत्वपूर्ण भूमिका निभाता है। परिक्षण करने के लिए सब्जी विज्ञान विभाग के प्रयोगात्मक प्रक्षेत्र पर वर्ष 2015 में खरीफ मौसम के दौरान पाँच फॉस्फोरस के स्तरों जैसे 40, 60, 80 एवं 100 किलोग्राम/हे. तथा जिंक के चार स्तरों जैसे 0, 5, 10 एवं 15 किलोग्राम/हे. को समाहित कर किया गया। अध्ययन से स्पष्ट हुआ कि प्रति पौधा बीज उपज (43.48 ग्राम), प्रति भूखंड (3.13 किलोग्राम) और प्रति हेक्टेयर (21.74 कुन्तल), अंकुरण प्रतिशत (93.53 प्रतिशत), बीज ओज गुणांक I (3113.25) II (49.73) और प्रोटीन की मात्रा (26.76 प्रतिशत) और लाभ लागत अनुपात (2.04) को अधिकतम दर्ज किया गया था जबकि फसल को फॉस्फोरस 60 किग्रा के साथ जस्ता 10 किग्रा/हेक्टेयर के साथ दिया गया जबकि, फास्फोरस और जस्ता उर्वरक के समान स्तर पर बीज विद्युत चालकता (1.12 डी एम एम$^{-1}$) निम्नतम दर्ज की गयी थी जो कि इसकी धीमी उम्र बढ़ने की प्रक्रिया का एक कारण है।

References

Dixit AK, Kumar S, Rai AK and Palsaniya DR, (2014) Productivity and profitability of fodder sorghum + cowpea-chickpea cropping system as influenced by organic manure, phosphorus and sulphur application in Central India. Range Manage Agrofores 35: 66-72.

Karikari B, Arkorful E and Addy S (2015) Growth, nodulation and yield response of cowpea to phosphorus fertilizer application in Ghana. J Agron 14: 234-240.

Kasthurikrishna S and Ahlawat IPS (2000) Effect of moisture stress and phosphorus, sulphur and zinc fertilizers on growth and development of pea (*Pisum sativum* L.). Indian J Agron 45: 353-356.

Kumar A, Yadav PK, Yadav RK, Singh R and Yadav HK (2012) Growth biomass production and quality characters of cowpea as influenced by phosphorus and sulphur fertilization on loamy sands of semi-arid subtropics. Asian J Soil Sci 7: 80-83.

Kumawat SR, Khistriya MK, Yadav SL and Kumar M (2014) Effect of sulphur and phosphorus on growth and yield attributes on summer green gram [*Vigna radiata* (L.) Wilczek]. Int J Agric Sci 10(2): 770-773.

Mousavi SR (2011) Zinc in crop production and interaction with phosphorus. Aust J Basic Appl Sci 5: 1503-1509.

Nkaa FA, Nwokeocha OW and Ihuoma O (2014) Effect of Phosphorus fertilizer on growth and yield of cowpea (*Vigna unguiculata*). J Pharm Biolo Sci 9(5): 74-82.

Oti NN, Uzoho BU and Opara CC (2004) Determination of phosphorus requirement of cowpea using P-sorption isotherm. Int J Agri Rural Dev 5: 77-85.

Panse VG and Sukhatme PV (1967) Statistical Methods for Agricultural Workers, 2nd Edition, ICAR, New Delhi.

Puniya MM, Shivran AC, Khangarot SS, Kuri BR and Choudhary SP (2014) Effect of phosphorus and zinc fertilization on productivity and nutrient uptake of moth bean. Agric Res 35(1): 58-61.

Ram S and Katiyar TPS (2013) Effect of sulphur and zinc on the seed yield and protein content of summer mung bean under arid climate. Int J Sci Nature 4(3): 563-566.

Rehman A, Farooq M, Cheema ZA, Wahid A, (2012) Role of boron in leaf elongation and tillering dynamics in fine grain aromatic rice. J Plant Nut 36: 42-54.

Safak C, Hikmet S, Bulent B, Oseyin A and Bither C (2009) Effect of zinc on yield and some related trades of Alfa Alfa. J Turkish Agric 14: 136-143.

Sepat S and Yadav SS (2008) Phosphorus and sulphur management in mothbean (*Vigna aconitifolia*) under rainfed condition. Annals Agri Res 29: 38-42.

Shekara BG, Sowmyalatha BS and Bharatkumar C (2012) Effect of phosphorus levels on forage yield of cowpea. J Hort Letters 2: 12-13.

Singh A, Baoule AL, Ahmed HG, Dikko AU, Aliyu U, Sokoto MB, Alhassan J, Musa M and Haliru B. (2011) Influence of phosphorus on the performance of cowpea varieties in the Sudan Savanna of Nigeria. Agric Sci 2: 313-317.

Singh BB and Tarawali SA (1997) Cowpea: An integral component of sustainable mixed crop/livestock farming systems in West Africa and strategies to improve its productivity. In: Renard, C., Ed., Crop Residues in Sustainable Mixed Crop-Livestock Farming Systems, CAB International in Association with the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) and the International Livestock Research Institute (ILRI), 79-100.

Shukla, UC and Yadav, OP (1982). Effect of phosphorus and zinc on nodulation and nitrogen fixation in chickpea (*Cicer arietinum* L.). Transactions of 12th International Congress on Soil Science 6: 54-55.

Tarawali SA, Singh BB, Peters SM and Blade SF (1997) Cowpea haulms as fodder. In: Singh, B.B., Mohan -Raj, D.R., Dashiell, K.E. and Jackai, L.E.N., Advances in Cowpea Research, Co-publication of IITA and Japan International Research Center for Agricultural Sciences (JIRCAS), Ibadan, Nigeria, 313-325.

Upadhyay RG and Singh A (2016) Effect of nitrogen and zinc on nodulation, growth and yield of cowpea. Leg Res 39(1): 149-151.

Usman M, Tahir M and Majeed, MA (2014) Effect of zinc sulphate as soil application and seed treatment on green gram (*Vigna radiata* L.). Pak J Life Soc Sci 12(2): 87 91.