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Interactive Effect of Potassium and Zinc on Growth, Yield, Quality and Economics of Green Gram (*Vigna radiata* L.) under Semi-arid Region of South-west Haryana

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ABSTRACT

Background: Pulses are having a number of constraints in their production as compared to their potential in India. Green gram is an important pulse crop of the country after chickpea and pigeonpea lacks optimum fertilizer management, which leads in reduced growth and yield. The current study aimed to study the effects of different levels of potassium and zinc application on growth, yield attributes, yield and quality of green gram.

Methods: The field study was conducted during *Kharif* 2018 at Regional Research Station, CCS HAU, Bawal on green gram cultivar MH-421. The experiment was laid out in a split-plot design with three replications and treatments comprising four levels of potassium in main plots (0, 10, 20 and 30 kg K_2O ha^{-1}) and four levels of zinc in subplots (0, 12.5, 25 and 37.5 kg $ZnSO_4$ ha^{-1}).

Result: The results indicated that growth parameters like plant height, number of branches, number of pods, number of seeds and dry matter production were released due to the application of potassium and zinc. The number of nodules, their fresh weight and quality parameters like protein content and seed index significantly increased with the application of potassium up to 20 kg K_2O ha^{-1}, but non-significant increment with zinc application. Seed and straw yield increased significantly with potassium and zinc application up to the levels of 20 kg K_2O ha^{-1} and 25 kg $ZnSO_4$ ha^{-1}, respectively. Higher net monetary returns of Rs. 31528 ha^{-1} with B:C ratio (1.61) was recorded under the treatment combination $K_{20}Zn_{25}$ (20 kg K_2O ha^{-1} along with 25 kg $ZnSO_4$ ha^{-1}). It was concluded that higher green gram yield with better quality and more net return was achieved when potassium and zinc were applied @ 20 kg K_2O ha^{-1} and 25 kg $ZnSO_4$ ha^{-1}, respectively.

Key words: Economics, Green gram, Growth, Potassium, Quality, Yield, Zinc.

INTRODUCTION

Pulses are one of the important segments of Indian agriculture after cereals occupying a key position in vegetarian diet and plays an immense role in economy (Singh *et al*., 2017). Green gram [*Vigna radiata* (L.) Wilczek] is third important conventional pulse crop next to chickpea and pigeonpea, having high nutritive value and is adopted and acclimatized over wide range of agro-climatic zones. It contains about 25% protein, 56.7% carbohydrates, 4.1% fibers, 3.5% minerals, 10.4% moisture, 1.3% fat and appreciable amount of riboflavin, thiamine and little amount of Vitamin B complex (Lokhande *et al*., 2018). India ranks first in both area and production of green gram in world with an area of 5.79 million ha, production of 2.50 million tonnes in 2019-20 with the average productivity 957 kg ha^{-1} (INDIASTAT, 2022). In Haryana, during 2019-20 green gram was grown in an area of 20.17 thousand ha producing 12.00 thousand tonnes with an average productivity of 595 kg ha^{-1} (INDIASTAT, 2022).

Fertilizers are one of the vital inputs for crop production as they supply nutrients in adequate amount and maintains soil fertility (Deb *et al*., 2016). Total K content of the earth crust is about 2.3 to 2.5% (Rao and Srinivas, 2017), but a very small proportion of it become available to plants. Potassium is widely regarded as the “quality element” (Usherwood, 1985) and it is absorbed in the form of K^+ by the plants and play important role in stomatal movement, photosynthesis, protein synthesis, enzymes activation, grain development, biotic and abiotic stresses (Egila *et al.,* 2001). Potassium application is rarely done in pulses despite field studies suggested that application of K_2O (20-40 kg ha^{-1}) helped in attaining higher production (Ali and Rao, 2001). Zinc is one of the essential micronutrients which activates many enzymes like tryptophan synthetase, superoxide dismutase and dehydrogenases as well as stabilization of RNA, DNA and ribosomes (Kumar *et al*., 2017; Kumar *et al*., 2016),

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which are involved in metabolic processes and biochemical pathways (Manisha *et al.*, 2021b). About 43% of the soil samples collected from different parts of India were found to be deficient in zinc (Shukla *et al.*, 2014). By the year 2025, it is assumed that the zinc deficiency is likely to increase from 49 to 63% as most of the cultivated soils are showing the symptoms of zinc deficiency (Manisha *et al.*, 2021a). Zinc increases the productivity, nodule formation mechanism and N-fixation in roots of leguminous crops (Khan *et al.*, 2004). Keeping the above views in mind the current studies were planned to decipher the effects of different levels of potassium and zinc application on growth, yield attributes, yield and quality of green gram.

MATERIALS AND METHODS

The study was conducted in *kharif* 2018 at Research Area of Regional Research Station, CCS HAU, Bawal situated in district Rewari in the south-west Haryana which is located at latitude 28.10° N, longitude 76.50° E and 266 m above mean sea level. The climate of Bawal is semi-arid with average rainfall of 577 mm. Experimental site was sandy loam in texture containing 102.37, 11.18 and 170.10 kg ha^{-1}, $KMnO_4$ oxidizable N (Subbiah and Asija, 1956), 0.5 M $NaHCO_3$ extractable P (Olsen *et al.*, 1954) and 1 N NH_4OAC extractable K (Jackson, 1973), respectively as macronutrients and 0.97, 7.64, 6.24 and 0.52 (mg kg^{-1}) DTPA extractable (Lindsay and Norvell, 1978) zinc, iron, manganese and copper, respectively as micronutrients in 0-15 cm depth with pH 8.17 (Jackson, 1973), EC 0.16 dS m^{-1} (Jackson, 1973) and organic carbon 0.17% (Walkley and Black, 1934). The experiment was laid out in split-plot design consisting of 16 treatment combinations with three replications. Four potassium levels @ 0 (K_0), 10 (K_{10}), 20 (K_{20}), 30 kg ha^{-1} (K_{30}) was applied through muriate of potash were kept in main-plot, while four zinc levels in kg $ZnSO_4$ ha^{-1} @ 0 (Zn_0), 12.5 ($Zn_{12.5}$), 25 (Zn_{25}) and 37.5 ($Zn_{37.5}$) were kept in sub-plot. Green gram cultivar MH-421 was sown by maintaining spacing of 30 cm × 10 cm. The crop was raised and managed with all standard package of practices. Recommended dose of fertilizer (RDF) was 15:40 kg for N and P_2O_5 ha^{-1} used (Anonymous, 2018b).

Green gram plants (5 from each plot) were uprooted with the help of the fork without damaging the roots at 40, 50 DAS and at harvesting and weigh the nodule after counting. The same plants were used for recording all growth and yield attributes and average of these observations were worked out. After harvesting and sun-drying of crop, seeds were separated in each plot and calculated it on the hectare basis (q ha^{-1}) for yield estimation. Straw yield was calculated by subtracting grain yield from biological yield of individual plot. Protein content in grain was determined by multiplying nitrogen content in seed (%) by a factor 6.25. Seed index is calculated by counting 100 seeds. The prices of the inputs prevailing at the time of their use were considered for working out the economics of treatments. Net monetary returns (Rs. ha^{-1}) was calculated by deducting the cost of cultivation from gross monetary returns (Rs. ha^{-1}). Benefit-cost ratio was worked out by dividing the gross monetary returns by cost of cultivation. The critical differences for all the parameters were calculated to compare the treatment means by proper methods using online statistical package OPSTAT developed by Sheoran *et al.* (1998).

RESULTS AND DISCUSSION

Crop growth and yield attributes

Result revealed that (Table 1 and 2) the application of different potassium and zinc levels influenced growth and yield attributes of green gram significantly. Plant height (cm), number of branches per plant, dry matter production per plant (g), number of pods per plant were increased significantly at 40, 50 DAS and at harvest with every successive increase in potassium and zinc levels. Highest value of these parameters was recorded under K_{30} and $Zn_{37.5}$ treatment that was statistically at par with the K_{20} and Zn_{25} treatment, respectively and minimum observations recorded in control treatments. It could be attributed to the fact that potassium enhances plant vigour and strengthens the stalk, further it has synergistic effect with nitrogen and phosphorous resulted in better plant growth and a greater number of branches per plant (Goud *et al.*, 2014).

Results (Table 1) showed that the number of nodules and their fresh weight at 40 and 50 DAS were significantly influenced by the application of potassium but the effect of zinc was non-significant. Highest number of nodules and fresh weight of nodules were found under K_{30} treatment (17.07 and 0.111g) followed by K_{20} treatment (15.27 and 0.087g). Both the treatments were statistically at par but significantly superior over the K_0. This might be due to the fact that potassium in plant system enhances enzymes activity as well as activity of cytokinin. The results are in agreement with the findings of Ranpariya and Polara (2018).

Number of seeds per pod (Table 2) was significantly affected by different levels of potassium and zinc. Highest number of seeds per pod was observed under K_{30} (9.43) and $Zn_{37.5}$ (9.32) treatments which were at par with K_{20} and Zn_{25} treatment, respectively. The results are in agreement with the findings of Sadaf and Tahir (2017).

Crop yield

Seed and straw yield (Table 2) of green gram was significantly affected with the application of potassium and zinc levels. Highest seed 11.42 and 10.38 q ha^{-1}; straw 13.36 and 11.89 q ha^{-1} and biological yield 24.78 and 22.27 q ha^{-1} recorded with K_{30} and $Zn_{37.5}$ treatment, respectively, which was found statistically at par with K_{20} and Zn_{25} treatment, respectively and significantly superior over K_0 treatment. The positive effect of potassium and zinc in photosynthesis partitioning, cell elongation, higher nutrients uptake and more over biosynthesis of indole acetic acid resulted in higher plant height and number of branches per plant and ultimately helped in realization of higher crop yield. The above results found are in conformity with the results of

Table 1: Effect of different potassium and zinc levels on growth and yield attributes of green gram.

Treatments	Plant height (cm)			Number of branches per plant			Dry matter production per plant (g)			Number of nodules per plant		Fresh weight of nodules per plant (g)	
	40 DAS	50 DAS	At harvest	40 DAS	50 DAS	At harvest	40 DAS	50 DAS	At harvest	40 DAS	50 DAS	40 DAS	50 DAS
Potassium levels													
K_0	43.92	47.21	49.18	4.67	5.56	5.83	7.67	8.69	11.84	9.39	10.24	0.041	0.044
K_{10}	47.44	52.92	54.26	4.93	5.67	6.46	8.49	9.67	13.52	10.68	12.14	0.053	0.051
K_{20}	51.83	56.42	57.39	5.46	6.56	7.79	9.83	11.76	16.73	13.74	15.27	0.072	0.087
K_{30}	53.95	58.73	59.34	6.02	6.86	7.85	10.38	12.56	18.22	14.26	17.07	0.081	0.111
S.Em±	0.47	0.51	0.53	0.23	0.25	0.29	0.65	0.57	0.64	0.41	0.47	0.01	0.01
CD (p=0.05)	5.42	4.33	6.18	0.62	0.78	1.4	1.61	2.36	3.15	2.08	1.93	0.02	0.03
Zinc levels													
Zn_0	49.82	52.28	53.92	4.72	5.77	5.97	8.12	9.32	11.94	11.57	12.72	0.057	0.067
$Zn_{12.5}$	50.18	53.72	55.24	4.94	5.98	6.35	9.36	10.18	14.48	12.42	13.13	0.063	0.069
Zn_{25}	51.36	54.48	56.73	5.77	6.28	6.82	10.08	11.42	16.04	13.84	13.76	0.069	0.072
$Zn_{37.5}$	53.24	56.18	58.32	6.09	6.61	7.21	10.82	11.94	17.82	14.71	15.10	0.075	0.085
S.Em±	0.36	0.41	0.45	0.22	0.26	0.27	0.47	0.51	0.61	0.41	0.47	0.01	0.02
CD (p=0.05)	2.23	2.15	2.67	0.82	0.43	0.75	1.79	2.04	2.85	NS	NS	NS	NS

Table 2: Effect of different potassium and zinc level on yield attribute, yield, protein content and seed index of green gram.

Treatments	Number of pods per plant			Number of seeds per pod (At harvest)	Seed yield (q ha^{-1})	Straw yield (q ha^{1})	Biological yield (q ha^{-1})	Harvest index (%)	Protein content	Seed index (100 seed weight) (g)
	40 DAS	50 DAS	At Harvest							
Potassium levels										
K_0	17.30	19.83	33.58	8.40	8.08	10.05	18.13	44.57	20.04	3.76
K_{10}	19.32	22.46	35.84	8.87	8.85	10.53	19.38	45.66	21.01	3.83
K_{20}	20.56	25.58	38.73	9.32	10.90	12.27	23.17	47.04	22.17	4.12
K_{30}	22.72	26.35	39.26	9.43	11.42	13.36	24.78	46.08	22.94	4.26
S.Em±	0.61	0.58	0.63	0.29	0.08	0.08	0.42	0.67	0.10	0.14
CD (p=0.05)	1.92	3.90	2.78	0.83	1.02	1.33	1.71	NS	1.09	0.24
Zinc levels										
Zn_0	19.00	20.68	34.39	8.53	9.21	11.21	20.42	45.10	21.07s	3.77
$Zn_{12.5}$	19.94	23.74	36.28	8.76	9.58	11.29	20.87	45.90	21.42	4.01
Zn_{25}	20.30	25.56	38.17	9.26	10.09	11.83	21.92	46.03	21.73	4.07
$Zn_{37.5}$	20.67	26.43	38.68	9.32	10.38	11.89	22.27	46.61	21.94	4.13
S.Em±	0.57	0.53	0.61	0.25	0.09	0.10	0.46	0.43	0.11	0.15
CD (p=0.05)	1.11	3.80	2.53	0.56	0.49	0.51	0.98	NS	NS	NS

Table 3: Effect of different potassium and zinc levels on economics of green gram.

	Treatment combinations	Cost of cultivation (Rs ha^{-1})	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C
K_0Zn_0	0 kg K_2O ha^{-1} + 0 kg $ZnSO_4$ ha^{-1}	48813	55034	6221	1.13
$K_0Zn_{12.5}$	0 kg K_2O ha^{-1} + 12.5 kg $ZnSO_4$ ha^{-1}	49900	56635	6735	1.13
K_0Zn_{25}	0 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	50989	58208	7219	1.14
$K_0Zn_{37.5}$	0 kg K_2O ha^{-} + 37.5 kg $ZnSO_4$ ha^{-1}	52078	59613	7535	1.14
$K_{10}Zn_0$	10 kg K_2O ha^{-1} + 0 kg $ZnSO_4$ ha^{-1}	49195	60478	11283	1.23
$K_{10}Zn_{12.5}$	10 kg K_2O ha^{-1} + 12.5 kg $ZnSO_4$ ha^{-1}	50281	61693	11412	1.23
$K_{10}Zn_{25}$	10 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	51370	62941	11571	1.23
$K_{10}Zn_{37.5}$	10 kg K_2O ha^{-1} + 37.5 kg $ZnSO_4$ ha^{-1}	52457	65945	13488	1.26
$K_{20}Zn_0$	20 kg K_2O ha^{-1} + 0 kg $ZnSO_4$ ha^{-1}	49574	70550	20976	1.42
$K_{20}Zn_{12.5}$	20 kg K_2O ha^{-1} + 12.5 kg $ZnSO_4$ ha^{-1}	50662	72205	21543	1.43
$K_{20}Zn_{25}$	20 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	51752	83280	31528	1.61
$K_{20}Zn_{37.5}$	20 kg K_2O ha^{-1} + 37.5 kg $ZnSO_4$ ha^{-1}	52838	83378	30540	1.58
$K_{30}Zn_0$	30 kg K_2O ha^{-1} + 0 kg $ZnSO_4$ ha^{-1}	49955	75393	25438	1.51
$K_{30}Zn_{12.5}$	30 kg K_2O ha^{-1} + 12.5 kg $ZnSO_4$ ha^{-1}	51042	81077	30035	1.59
$K_{30}Zn_{25}$	30 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	52120	82790	30670	1.59
$K_{30}Zn_{37.5}$	30 kg K_2O ha^{-1} + 37.5 kg $ZnSO_4$ ha^{-1}	53218	83447	30229	1.57

Thesiya *et al.* (2013) and Ranpariya and Polara (2018). The interaction between of potassium and zinc was found non-significant in case of yield. No significant effects of different potassium and zinc application were observed on harvest index of green gram.

Effect on quality

Application of potassium significantly increased the protein content and seed index (Table 2). Maximum protein content (22.94%) and seed index (4.26 g) was recorded with K_{30} treatment, followed by K_{20} treatment and both were found statistically at par to each other but significantly superior over rest of the treatments. This might be due to the synergistic effect of potassium on nitrogen which facilitates uptake and assimilation of N into simple amino acids and amides, higher photosynthetic activity, followed by efficient transfer of metabolites and subsequent accumulation of these metabolites in the seed with the resultant increase in the size and weight of individual seed. The results are in agreement with the findings of Kurhade *et al*. (2015). Application of zinc increased the protein content (21.07 to 21.94%) and seed index (3.77 to 4.13) but effect was non-significant with successive increase in dose.

Economics

The perusal of data in Table 3 indicates that highest gross monetary returns (Rs. 83447 ha^{-1}) were fetched under $K_{30}Zn_{37.5}$ treatment followed by $K_{20}Zn_{37.5}$ (Rs.83378 ha^{-1}) treatments. The net monetary return (Rs.31528 ha^{-1}) and the B:C ratio (1.61) was maximum found under $K_{20}Zn_{25}$ treatment.

CONCLUSION

Based on the research findings, it may be concluded that the application of 20 kg K_2O ha^{-1} and 25 kg $ZnSO_4$ ha^{-1} in green gram was found optimum in term of growth, yield attributes, yield, quality and economics (highest net benefit) in coarse-textured medium K status soil.

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