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Effect of Potassium and Zinc on Yield, Nutrient Content and Uptake in Green Gram (*Vigna Radiata* L.) in Course Textured Soil of South-West Haryana

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Abstract: The study was conducted during *kharif* 2018 at Regional Research Station Bawal of CCS Haryana Agricultural University, on green gram cultivar MH 421. The total nitrogen, phosphorous and potassium content and uptake in seed and straw were significantly influenced by different potassium and zinc levels. Green gram seed and straw yield increased by increasing potassium and zinc application over control but significantly up to the levels 20 and 25 kg $ZnSO_4$ ha^{-1}. Both K_{20} and K_{30} treatments recorded significantly higher N, P, K content, and uptake of N, P, K in seed as compared to control. Similarly in straw, K_{20} and K_{30} treatments significantly higher N, P and K content and uptake in straw over the control was observed. The availability of particular nutrient increased by application to the soil and also promotes the uptake of other nutrients as well.

Keywords: Green gram, Nutrient content, Potassium, Uptake, Yield, Zinc

Green gram (*Vigna radiata* L. Wikzek) belongs to the family Fabaceae and is grown all around the globe including Southern and Eastern Asia, South and North America, Central Africa, Australia and some parts of China particularly for its protein enriched grains (Dahiya et al 2015). India stands first in both area and production of green gram all around the globe with production of 2.02 million tonnes. 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} (Anonymous 2020). In Haryana, can be grown in *kharif* as well as in summer season due to wide adaptability and short duration. Green gram has wider adaptability, better palatability, higher market price and easy digestibility, so it can play a key role in increasing the economy of farmers (Reddy 2009). Fertilizers are one of the vital inputs required in production of any crop. The supply of nutrients in adequate amount by the chemical fertilizers is intimately linked to the plant growth and development. Potassium is widely regarded as the “quality element” for crop production and plays a dynamic role in plant growth and sustained production of crops. Potassium (K^+) has significant effect on stomatal movement, photosynthesis, synthesis of proteins, and water-relations (osmotic adjustment and turgor regulation) in plants (Marschner 2002), activation of about 60 enzymes, in grain development, plant metabolism as well as pest and disease and drought resistance (Egila et al 2001). Application of Potassium (K^+) is very rarely done in pulses despite field studies that suggested the application of K_2O to the tune of 20-40 kg ha^{-1} is helpful in attaining higher levels of pulse production. Among various micronutrients, Zinc is one also of the seven important elements for plant growth and activates many enzymes which are involved in metabolic processes and biochemical pathways. It acts as a functional, structural or regulatory co-factor for many enzymes and has key role in DNA transcription. Nijra and Nabwami (2015) reported that Zn influences the formation of chlorophyll and auxins which resulted in formation of the growth promoting compounds. About 43 % of the soil samples collected from different parts of India was deficient in zinc. 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 (Arunachalam et al 2013). The current studies were planned to decipher the effects of different levels of potassium and zinc application on content and uptake of nutrients in green gram.

MATERIAL AND METHODS

The field experiment was conducted at research area of Regional Research Station, Bawal which is situated in district Rewari in the south-west Haryana. The research station is located at latitude 28°4' N, longitude 76°35' E and 266 m above mean sea level in South-Western area of Haryana.

The soils in the Bawal region are typically of Aridisols and Entisols orders and Ustochrept group. The initial soil properties of the experiment site were analyzed Soil was loamy sand in texture containing low (102.37), medium (11.18) and medium (170.10) kg ha^{-1} available nitrogen, phosphorus and potassium, respectively The macronutrients available zinc, iron, manganese and copper were 0.97, 7.64, 6.24 and 0.52 mg kg^{-1} at 0-15 cm depth with pH 8.17, EC 0.16 dS m^{-1} and organic carbon 0.17 per cent.

Experiment layout: The experiment was laid out in split plot design in triplications on green gram cultivar MH 421 with plot size of 4.0 m x 3.6 m. Sixteen treatments were assigned consisting of four potassium application levels (0, 10, 20 and 30 kg K_2O ha^{-1}) and four zinc application levels (0, 12.5, 25.0 and 37.5 kg $ZnSO_4$). The treatments were allotted to various plots with the help of random table. The recommended dose of fertilizer (RDF) was 6-8:16:8 kg for N and P_2O_5 ha^{-1} (Anonymous 2021). The fertilizers (RDF, K_2O and $ZnSo_4$) were applied at the time of sowing through soil application. Diammonium phosphate (DAP), muriate of potash (MOP) and zinc sulphate were used to provide desired levels of nutrients to the crops. The crop was raised with all the standard package of practices (Anonymous 2018) and protection measures also timely carried out as they required.

Collection and analysis of soil samples: The soil samples were collected at random from the experiment area up to the depth of 0-15 cm before overlaying the treatments and after harvesting the crop and were analyzed for its various chemical properties. The standard methods adopted for analysis of physico-chemical properties of soil. Electrical conductivity (EC) and soil reaction (pH) were determined in (1:2) Soil: Water suspension using digital pH meter and direct read type conductivity meter (Jackson 1973). Soil organic carbon content was determined by Walkley and Black (1934) method. Available Nitrogen (N) was determined by alkaline permanganate method (Subbaiah and Asija 1956) and available P content by extracting the soil samples using 0.5 $NaHCO_3$ (pH 8.5) and analyzed by spectrophotometer at 420 nm (Olsen et al 1954). Available K was extracted by using 1N ammonium acetate (pH 7.0) using a flame photometer (Jackson 1973).

Collection and analysis of plant samples: Samples of seed and straw were collected at the time of harvesting and dried (65±2 °C for 48 hr). The dried samples thus obtained were ground to a fine powder and processed further for estimation of various macronutrients (N, P and K). Total Nitrogen content in the digested plant material was determined by colorimetric method using Nessler's reagent as described by Lindner (1944). Total phosphorus in plant sample was determined by Vanado-molybdophosphoric acid yellow colour method as proposed by Koenig and Johnson (1942). Potassium in the acid digest of plant samples was determined by using flame photometer. The Zn, Fe, Cu and Mn of plant samples were determined by using plant digestion obtained from digestion by HNO3 and HClO4 with the help of Atomic Absorption Spectrophotometer (AAS) (Lindsay and Norvell 1978).

The data on concentration of NPK, grain yield and straw yield was used to determine the uptake of nitrogen (N), phosphorus (P) and potassium (K) using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration in grain/straw (\%)} \times \text{grain/straw yield (kg ha}^{-1}\text{)}}{100}$$

Statistical analysis: The data was statistical analysis by using online statistical package OPSTAT (Sheoran et al 1998).

RESULTS AND DISCUSSION

Effect of Potassium

Seed and straw yield: The seed yield was significantly increased due to application of potassium up to K_{20} treatment. Significantly, the highest seed yield (1142 kg ha^{-1}) was with K_{30}, followed by K_{20} (1090 kg ha^{-1}). Both the treatments were statistically at par with each other but significantly superior over control. The increase in seed yield of green gram was 9.53, 34.90 and 41.34 % due to application of K_{10}, K_{20} and K_{30} treatment, respectively over control (Table 1). Application of various levels of potassium increased the straw yield of green gram (Table 2). The straw yield of green gram ranged from 1005 to 1336 kg ha^{-1}. The straw yield was significantly increased due to application of potassium up to K_{20} treatment. The significantly, highest straw yield (1336 kg ha^{-1}) was with K_{30} treatment, followed by (K_{20}) and both the treatments were statistically at par. The lowest straw yield (1005 kg ha^{-1}) was recorded with control (K_0). The K_{30} and K_{20} produced 32.94 and 22.01 % higher straw yield over control respectively. The positive effect of potassium in photosynthesis and cell elongation and more over higher nutrients uptake resulted in higher plant height and number of branches per plant and ultimately helped in realization of higher crop yield. Potassium enhances the plant vigour and strengthens the stalk. The above results found are in conformity with the results of Jadeja et al (2016) and Kumar et al (2018).

Nutrient content and uptake by seed and straw: Potassium application caused significant increase in the nutrient content (N, P, K and Fe) in seed of green gram. The content of nutrients increased with the highest level i.e. 30 kg K_2O ha^{-1} but it was at par with 20 kg K_2O ha^{-1}. The total nitrogen, phosphorous and potassium uptake and content in seed was significantly influenced by different potassium levels. Both K_{20} and K_{30} treatments recorded significantly higher N (3.55 and 3.67 %), P (0.48 and 0.50 %) and K (1.14 and 1.16 %) t and uptake of N (38.70 and 41.91 kg ha^{-1}), P (5.23 and 5.71 kg ha^{-1}) and K (12.43 and 13.25 kg ha^{-1}) in seed as compared to control.

In case of straw, K_{20} and K_{30} treatments recorded significantly higher N (1.33 and 1.43 %), P (0.22 and 0.24 %) and K (1.40 and 1.47 %) content and uptake of N (16.32 and 19.10 kg ha^{-1}), P (2.70 and 3.21 kg ha^{-1}) and K (17.17 and 19.69 kg ha^{-1}) in straw over the control. The increase in concentration of N and P might be due to the synergistic effect of potassium on these nutrients and the increase in K concentration and uptake is due to the direct application of potassium which increases its availability to plants. Comparable results were also reported by earlier researchers (Khurhade et al 2015, Ranpariya and Polara 2018, Adsure et al 2018, Chaudhari et al 2018).

Effect of Zinc

Seed and straw yield: Application of zinc also significantly affected the seed yield of green gram. Significantly, the highest seed yield (1038 kg ha^{-1}) was recorded with $Zn_{37.5}$ treatment followed by Zn_{25} (1009 kg ha^{-1}), both treatments were statistically at par. The lowest seed yield (921 kg ha^{-1}) was recorded with control (Zn_0). The $Zn_{37.5}$ and Zn_{25} treatment produced 12.70 and 9.55 % higher seed yield over control. The interacting effect between potassium and zinc was found non-significant. Similarly, in straw yield, significantly highest straw yield (1189 kg ha^{-1}) was with $Zn_{37.5}$ treatment, followed by (1183 kg ha^{-1}) with Zn_{25} treatment. However, treatments $Zn_{37.5}$ and Zn_{25} were statistically at par with each other but superior over the control. The lowest straw yield (1121 kg ha^{-1}) was with control (Zn_0). The increase in straw yield was 0.71, 5.53 and 6.07 % due to application of $Zn_{12.5}$, Zn_{25} and $Zn_{37.5}$ treatments, respectively over control. Zinc plays a vital role in plant nutrition, which is clear from its involvement in process of photosynthesis and sugar translocation. The increase in seed yield might be due to role of zinc in biosynthesis of indole acetic acid and especially due to role in primordial for reproductive parts and partitioning of photosynthesis towards them which resulted in better flowering and fruiting. Similar trend was observed by Buriro et al (2015), Sangapa and Angadi (2016), Islam et al (2017), and Ranpariya and Polara (2018). The interaction effect of potassium and zinc levels was found non-significant on straw yield of green gram.

Nutrient content and uptake by seed and straw: Results showed that nutrients content was not found to be influenced significantly by the zinc application but their uptakes were influenced significantly by graded levels of zinc except P because application of Zn did not show any particular trend with respect to P uptake and content. Phosphorus and zinc have antagonistic effect on each other. The application of zinc @ 25 kg $ZnSO_4$ ha^{-1} showed significantly higher values of

Table 1. Effect of potassium and zinc application on seed yield (kg ha^{-1}) of green gram

Potassium levels (kg K_2O ha^{-1})	Zinc levels (kg $ZnSO_4$ ha^{-1})				Mean
	Zn_0	$Zn_{12.5}$	Zn_{25}	$Zn_{37.5}$	
K_0	775	798	820	840	808
K_{10}	852	870	887	930	885
K_{20}	995	1019	1159	1188	1090
K_{30}	1062	1146	1170	1192	1142
Mean	921	958	1009	1038	
CD (p=0.05)	Potassium (K)= 102; Zinc (Zn)=49; K × Zn=NS				

Table 2. Effect of potassium and zinc application on straw yield (kg ha^{-1}) of green gram

Potassium levels (kg K_2O ha^{-1})	Zinc levels (kg $ZnSO_4$ ha^{-1})				Mean
	Zn_0	$Zn_{12.5}$	Zn_{25}	$Zn_{37.5}$	
K_0	987	998	1013	1023	1005
K_{10}	1028	1034	1073	1077	1053
K_{20}	1149	1153	1300	1305	1227
K_{30}	1318	1329	1345	1351	1336
Mean	1121	1129	1183	1189	
CD (p=0.05)	Potassium (K)= 133; Zinc (Zn)=51; K × Zn=NS				

Table 3. Effect of potassium and zinc application on content and uptake of macro nutrients in seed of green gram

Treatments (kg ha^{-1})	Seed NPK content (%)			Seed NPK uptake (kg ha^{-1})		
	N	P	K	N	P	K
Potassium levels (kg K_2O ha^{-1})						
K_0	3.21	0.43	0.93	25.94	3.47	7.51
K_{10}	3.36	0.44	1.03	29.74	3.89	8.76
K_{20}	3.55	0.48	1.14	38.70	5.23	12.43
K_{30}	3.67	0.50	1.16	41.91	5.71	13.25
CD (p=0.05)	0.17	0.03	0.11	3.93	0.59	1.68
Zinc levels (kg $ZnSO_4$ ha^{-1})						
Zn_0	3.37	0.47	1.06	31.04	4.33	9.76
$Zn_{12.5}$	3.42	0.47	1.06	32.76	4.50	10.15
Zn_{25}	3.47	0.48	1.07	35.01	4.84	10.80
$Zn_{37.5}$	3.51	0.46	1.08	36.43	4.77	11.21
CD (p=0.05)	NS	NS	NS	2.91	NS	0.61
C. V. %	8.74	10.38	9.66	11.14	14.52	8.26

Table 4. Effect of potassium and zinc application on content and uptake of macronutrients in straw of green gram

Treatments (kg ha^{-1})	Straw NPK content (%)			Straw NPK uptake (kg ha^{-1})		
	N	P	K	N	P	K
Potassium levels (kg K_2O ha^{-1})						
K_0	1.00	0.16	1.10	10.05	1.61	11.06
K_{10}	1.14	0.18	1.19	12.00	1.79	12.53
K_{20}	1.33	0.22	1.40	16.32	2.70	17.17
K_{30}	1.43	0.24	1.47	19.10	3.21	19.64
CD (p=0.05)	0.17	0.03	0.10	2.98	0.56	2.53
Zinc levels (kg $ZnSO_4$ ha^{-1})						
Zn_0	1.13	0.20	1.26	12.67	2.24	14.12
$Zn_{12.5}$	1.22	0.20	1.28	13.77	2.26	14.45
Zn_{25}	1.26	0.21	1.30	14.91	2.48	15.38
$Zn_{37.5}$	1.30	0.20	1.31	15.46	2.38	15.58
CD (p=0.05)	NS	NS	NS	1.12	NS	0.87
C. V. %	8.52	10.33	9.82	11.66	13.65	12.32

uptake of nitrogen (35.01 kg ha^{-1} and 14.91 kg ha^{-1}) and potassium (10.80 kg ha^{-1} and 15.38 kg ha^{-1}) by seed and straw. This might be due to the increasing pattern of straw yield with graded levels of fertilizers or may be due to the dilution effect. Similar results were observed by earlier scinetists (Chavan et al 2012, Roy et al 2017, Ranpariya et al 2018, Ahmed et al 2018).

CONCLUSION

Both the seed and straw yield of green gram significantly increased with the application of potassium and zinc up to the 20 kg K_2O ha^{-1} and 25 kg $ZnSO_4$ ha^{-1}. The application of potassium @ 20 kg ha^{-1} and zinc sulphate @ 25 kg ha^{-1} significantly increase the nutrient content and uptake in seed and straw of green gram in coarse textured medium K status soil. The higher content of potassium was in straw than seed whereas higher content of nitrogen, phosphorus were observed in seed than straw. The, the higher uptake of N, P and K was observed in straw than seed.

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