JFL

Journal of Food Legumes 35(3): 175-179, 2022

Potassium and zinc influence on green gram yield, nutrient content, uptake and post harvest soil fertility in course textured soil of south-west Haryana

Satender Kumar, MK Jat[1], Harender[2], Raj Kumar[2]*, Sawan Kumar[1] and Sandeep Bedwal[1]

[1]Department of Soil Science,
[2]Department of Agronomy, CCS Haryana Agricultural University, Hisar-125004, India

*E-mail: aasiwalraj@hau.ac.in

Received: April 16, 2022
Accepted: October 04, 2022

Handling Editors:
Dr. SS Rathore, ICAR- IARI, New Delhi,
Dr. Narendra Kumar, ICAR-Indian Institute of Pulses Research, Kanpur

ABSTRACT

The soil of semi-arid region of Haryana has poor fertility status with low organic carbon. The recommendations are made only for nitrogen and phosphorous in most states. A field experiment in triplicated split-plot design was conducted during *kharif* 2018 at Regional Research Station, Bawal (CCS HAU) on green gram cultivar 'MH 421' in a loamy sand to investigate the effects of different levels of potassium (K) and zinc (Zn) application on green gram and soil fertility. There were four levels of K in main plots (0, 10, 20 and 30 kg K_2O/ha) and four levels of Zn in sub plots (0, 12.5, 25 and 37.5 kg $ZnSO_4$/ ha). Micronutrients (Zn, Mn and Cu) content were not significantly influenced by the application of potassium except Fe. Whereas the uptake of all the micronutrients under consideration was significantly increased (upto 56.47 % Zn by seed and upto 44.32% Zn by straw) with the potassium application. Zinc application significantly influenced Zn content in seed (upto 29.57 %) and straw (upto 24.37 %) while the uptake of Zn, Mn, Cu and Fe in both seed and straw. Highest seed (1.14 t/ha) and straw yield (1.33 t/ha) were recorded with the application of potassium @ 30 kg/ha, and zinc @ 37.5 kg/ha (1.04 and 1.19 t/ha). After harvest of the crop, availability of all the nutrients increased with the application of potassium and zinc.

Key words: Fertilization, Green gram, Legume, Productivity

INTRODUCTION

Green gram (*Vigna radiata* L. Wikzek) is one of the most important leguminous rainfed crop predominantly grown as *kharif* pulse crop for its protein rich edible seeds. Green gram has wider adaptability, better palatability, higher market price, easy digestibility. Due to its short duration, it can fit well in various multiple and intercropping systems. India stands first globally in both area and production of green gram with an area of 5.79 million ha and production of 2.50 million tonnes in 2019-20 (INDIASTAT 2022). In Haryana, during 2019-20 green gram occupied an area of 20.17 thousand ha producing 12.00 thousand tonnes with an average productivity of 595 kg/ha (INDIASTAT 2022).

The fertility status of soils of semi-arid region of Haryana is poor with low organic carbon. Among production inputs, recommendations for nitrogen (N) and phosphorous (P) fertilizers are made in most states with no potassium (K) application resulting in imbalanced nutrient supply and lower crop yields. Potassium is a macronutrient that plays a dynamic role in plant growth and sustained production of crops; also known as the "quality element" (Usherwood 1985). Potassium has a significant effect on stomatal movement, photosynthesis, synthesis of proteins, water-relations (osmotic adjustment and turgor regulation) in plants; activation of about 60 enzymes; in grain development, plant metabolism as well as pest, disease and drought resistance. Micronutrients play a vital role in the synthesis of chlorophyll, protein, nucleic acid, uptake of other nutrients, as activators of various enzymes mediating carbohydrate and protein synthesis (Patel *et al*. 2011). Zinc (Zn) is constituent of tryptophan, which is a precursor of auxin hormone. The availability of zinc decreases with a rising in soil pH. Even fertile soils have become deficient in zinc because of little or no use of organic matter, use of high analysis fertilizers and intensive cropping systems. Lack of zinc causes deficiency in formation of RNA and protein. Therefore, the plant with lack of zinc is poor in amount of protein. Zinc is an important plant nutrient but about 43 % of the soil samples collected from different parts of India were found to be deficient in zinc (Shkula *et al*. 2014). Information has been accumulating concerning the role of potassium and zinc in cereal crops but very little information is available regarding the nutrition of potassium and its interaction with zinc on the yield and quality of pulses. In view of the facts stated above, the present study was carried to investigate the effects of different levels of potassium and zinc application on, yield, content and uptake of nutrients in green gram and post harvest soil fertility status.

MATERIALS AND METHODS

The field experiment was conducted at Regional Research Station, CCS HAU Bawal during *kharif* 2018 in district Rewari at 28.10° N latitude and 76.50° E longitude with 266 m above mean sea level in south-western area of Haryana, India. The climate of Bawal is semi-arid with average rainfall of 577 mm. The soil of experimental field had loamy sand texture with a pH of 8.17, electrical conductivity (EC) 0.16 dS/m, organic carbon (OC) 0.17 %, available nitrogen (102.37 kg/ha), available phosphorus (11.18 kg/ha) and available potassium (170.10 kg/ha) as macronutrients; 0.97, 7.64, 6.24 and 0.52 mg/kg available zinc, iron (Fe), manganese (Mn) and copper (Cu), respectively as micronutrients in 0-15 cm depth (Table 2). The experiment was laid out in split plot design in triplications on green gram cultivar MH 421. Sixteen treatments were assigned consisting of four potassium application levels [0 (K_0), 10 (K_{10}), 20 (K_{20}) and 30 (K_{30}) kg K_2O/ha] in main plot and four zinc application levels [0 (Zn_0), 12.5 ($Zn_{12.5}$), 25 (Zn_{25}) and 37.5 ($Zn_{37.5}$) kg $ZnSO_4$/ha] in sub plot. The recommended dose of fertilizer (RDF) was 15:40 kg for N and P_2O_5/ha, respectively (Anonymous 2018). The fertilizers (RDF, K_2O and $ZnSO_4$) were applied at the time of sowing through soil application.

The soil samples were collected at random from the experiment area up to the depth of 0-15 cm from selected plots before overlaying the treatments and after harvesting the crop and analyzed for its various chemical properties. Soil pH and EC were determined in (1:2) soil:water suspension using digital pH meter and direct read type conductivity meter (Jackson 1973), respectively. Soil OC was determined by Walkley and Black (1934) method. Available nitrogen was determined by alkaline permanganate method (Subbiah and Asija 1956), available P by spectrophotometer at 420 nm (Olsen *et al*. 1954), available K by ammonium acetate method using a flame photometer (Jackson 1973). Available Mn, Zn, Cu and Fe content in soil samples was determined by DTPA methods (Lindsay and Norvell 1978) using Atomic Absorption Spectrophotometer. Samples of seed and straw were collected at the time of harvesting and dried (65±2 °C for 48 hr). The dried samples were ground to a fine powder and processed further for estimation of various macronutrients (N, P and K) as well as micronutrients (Zn, Fe, Mn and Cu) content. The micronutrients of plant samples were determined using plant digestion by HNO_3 and $HClO_4$ with the help of Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978). The uptake of micronutrients by seed and straw were calculated by multiplying the nutrient content with their respective yields. The data recorded during the experiment was subjected to statistical analysis by proper methods using OPSTAT software.

RESULTS AND DISCUSSION

Crop Yield

On the basis of yield data (Table 1), it was found that seed and straw yield of green gram was significantly affected with the application of potassium up to K_{20} treatment. The highest seed and straw yields (1.14 and 1.33 t/ha) were recorded with K_{30} treatment followed by K_{20} treatment (1.09 and 1.22 t/ha). Both the treatments were statistically at par with each other but significantly superior over K_0 and K_{10}. The positive effect of potassium in photosynthesis, cell elongation and more over higher nutrients uptake resulted ultimately in production of higher crop yield. The above results found are in conformity with the results of Thesiya *et al.* (2013) who concluded that seed and biological yield was strongly affected by the application of potassium.

Similarly, the seed and straw yield significantly increased with the increasing levels of zinc. Highest seed and straw yield (1.04 and 1.19 t/ha, respectively) was recorded with $Zn_{37.5}$ treatment followed by Zn_{25} (1.01 and 1.18 t/ha, respectively). Both treatments were statistically at par with each other. The lowest seed and straw yield (0.92 and 1.12 t/ha, respectively) was recorded with Zn_0. The treatment $Zn_{37.5}$ and Zn_{25} produced 13.04 % and 9.78 % higher seed yield, and; 6.25 % and 5.38 % higher straw yield over Zn_0, respectively. 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 the role in primordial for reproductive parts and partitioning of photosynthesis towards them which resulted in better flowering and fruiting. These results are concurrent with the findings of Ranpariya and Polara (2018). The interaction between potassium and zinc was found non-significant in case of yield.

Nutrient content and uptake by seed and straw

The data presented in Table 1 revealed that the micronutrients concentration in seed and straw were non-significantly influenced by the potassium application except Fe. This may be due to the higher initial level of available Fe in soil but the uptake of all micro-nutrient by seed and straw was significantly influenced by potassium levels. Uptake of micro-nutrients by seed and straw i.e. zinc (28.98 and 27.19 g/ha), iron (72.86 and 156.76 g/ha), manganese (16.30 and 28.12 g/ha) and copper (7.70 and 5.94 g/ha) were found statistically higher with the application of 30 kg K_2O/ha which was at par with the lower level of potassium i.e. 20 kg K_2O/ha. This might be due to increasing pattern of seed and straw yield with graded levels of fertilizer, Table 1. Effect of potassium and zinc application on content and uptake of micronutrients in seed and straw of green gram which showed beneficial effect on the absorption and translocation of plant system indicating thereby greater utilization of fertilizer by the crop and the dilution effect. These results are concurrent with the findings of Kannan *et al.* (2014).

Application of zinc significantly influenced the Zn content and uptake by seed and straw both. Significantly higher Zn content in seed and straw (27.21 and 21.79 mg/kg) was recorded under $Zn_{37.5}$ treatment followed by Zn_{25} (26.06 and 21.35 mg/kg), both the treatments were found statistically similar but superior over Zn_0 and $Zn_{12.5}$. Similar results were observed in case of uptake by seed and straw. Results showed that other micronutrient content was not found to be influenced significantly by the zinc application but their uptakes ere significantly influenced by graded levels of zinc. Significantly higher uptake of other micronutrients such as Fe, Mn and Cu by seed and straw was observed under the application of 37.5 kg $ZnSO_4$/ha which was statistically at par with 25 kg $ZnSO_4$/ha. Zinc application increases the root system which is due to the formation and polar transportation of indole acetic acid (IAA) that could affect more absorption. The beneficial role of zinc in increasing cation exchange capacity of roots helps in increasing absorption of nutrients from the soil. The results found are in confirmation with the results of Roy et al. (2017). Application of nutrients to soil promotes better biological and chemical activities in the soil and facilitated better nutrient availability to the crop (Ahmad et al. 2018). Results showed no significant interaction between potassium and zinc with respect to nutrients concentration and their uptake by seed and straw in green gram. Jamal et al. (2018) concluded that N and Zn content in seed and straw significantly increased with the application of zinc levels.

Post-harvest soil fertility

The results from the analysis of soil after harvesting (Table 2) indicated that the available K

Table 1. Effect of potassium and zinc application on content and uptake of micronutrients in seed and straw of green gram

Treatment	Seed yield (t/ha)	Straw yield (t/ha)	Content in seed (mg/kg)				Uptake by seed (g/ha)				Content in straw (mg/kg)				Uptake by straw (g/ha)			
			Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
Potassium levels																		
K_0	0.80	1.00	22.92	45.30	12.53	5.62	18.52	36.60	10.12	4.54	18.74	88.95	18.40	3.90	18.84	89.39	18.50	3.92
K_{10}	0.88	1.05	23.75	50.28	12.93	5.99	21.02	44.50	11.44	5.30	19.56	95.39	19.94	4.10	20.60	100.45	21.00	4.32
K_{20}	1.09	1.22	24.87	57.44	13.54	6.30	27.11	62.61	14.76	6.87	20.28	114.32	20.54	4.30	24.88	140.24	25.20	5.28
K_{30}	1.14	1.33	25.38	63.80	14.27	6.74	28.98	72.86	16.30	7.70	21.99	117.36	21.05	4.45	27.19	156.76	28.12	5.94
S.Em±	0.02	0.03	0.13	2.28	1.46	0.85	0.91	3.89	0.66	0.40	2.13	2.56	1.02	0.61	1.30	12.66	1.40	0.31
CD (p=0.05)	0.10	0.13	NS	7.10	NS	NS	2.75	11.5	1.98	1.11	NS	7.64	NS	NS	3.98	38.00	3.97	0.87
Zinc levels																		
Zn_0	0.92	1.12	21.00	51.00	13.10	6.03	19.34	46.97	12.07	5.55	17.52	99.93	19.47	4.10	20.09	112.02	21.83	4.60
$Zn_{12.5}$	0.95	1.13	22.64	53.75	13.19	6.09	21.69	51.49	12.64	5.83	19.91	103.74	20.26	4.26	21.46	117.12	22.87	4.81
Zn_{25}	1.01	1.18	26.06	55.63	13.37	6.23	26.29	56.13	13.49	6.29	21.35	105.51	21.16	4.35	25.61	124.82	25.03	5.15
$Zn_{37.5}$	1.04	1.19	27.21	56.43	13.60	6.30	28.24	58.57	14.12	6.54	21.79	106.83	21.12	4.40	26.04	127.02	25.35	5.23
S.Em±	0.02	0.02	0.59	1.83	0.94	0.79	1.12	1.56	0.38	0.15	0.39	2.84	1.15	0.53	1.37	2.42	0.66	0.08
CD (p=0.05)	0.04	0.05	1.78	NS	NS	NS	3.26	4.60	0.98	0.41	1.10	NS	NS	NS	4.09	6.90	1.97	0.26

in soil after crop harvest was significantly increased with the graded levels of potassium. Application of K_{30} (30 kg K_2O/ha) recorded significantly highest available K status (176.40 kg/ha), followed by K_{20} (20 kg K_2O/ha) with a value of 174.95 kg/ha, both the treatments differing non-significantly. While the lowest potassium status (168.76 kg/ha) was recorded under no potassium application *i.e.*, K_0. This might be due to the considerable exchange of K^+ on the exchange sites with other cations on its addition. The application of potassium did not exhibit any significant influence on the pH, EC, OC and available nutrients *i.e.* N, P, Zn, Mn and Cu in soil after harvest. A slight decrease in soil pH value from initial was observed, however the soil Table 2. Effect of potassium and zinc application on soil fertility after harvest of green gram

Table 2. Effect of potassium and zinc application on soil fertility after harvest of green gram

Treatment	pH	EC (dS/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
Potassium levels										
K_0	8.18	0.15	0.17	102.77	11.78	168.76	1.22	7.10	5.70	0.50
K_{10}	8.15	0.17	0.18	103.39	11.98	170.11	1.23	7.68	5.87	0.54
K_{20}	8.08	0.17	0.18	104.03	12.65	174.95	1.25	8.46	6.29	0.56
K_{30}	8.04	0.18	0.18	104.35	12.91	176.40	1.26	8.76	6.63	0.59
S.Em±	0.16	0.02	0.01	3.21	1.28	1.57	0.06	0.28	2.16	0.03
CD (p=0.05)	NS	NS	NS	NS	NS	4.71	NS	0.79	NS	NS
Zinc levels										
Zn_0	8.19	0.18	0.17	102.46	11.85	171.34	0.85	7.80	6.04	0.53
$Zn_{12.5}$	8.09	0.16	0.18	103.23	12.17	171.51	1.10	7.95	5.89	0.55
Zn_{25}	8.08	0.17	0.18	104.37	12.57	171.87	1.40	8.05	6.25	0.56
$Zn_{37.5}$	8.08	0.17	0.18	104.40	12.74	172.22	1.60	8.19	6.31	0.57
S.Em±	0.14	0.01	0.01	2.25	0.83	1.32	0.02	0.16	1.18	0.01
CD (p=0.05)	NS	NS	NS	NS	NS	NS	0.09	NS	NS	NS
Initial status	8.17	0.16	0.17	102.37	11.18	170.10	0.97	7.64	6.24	0.52

EC, OC and available nutrients i.e. N, P, Zn, Mn and Cu in soil increased from the initial value. The soil available Fe increased significantly with the application of potassium up to the level 30 kg K_2O/ha which was at par with lower level of potassium *i.e.* 20 kg K_2O/ha. Similar trend for available K in soil was observed by Kurhade *et al.* (2015) after harvest of crop. The results pertaining to availability of Zn in soil after harvest of crop showed that the status of Zn in soil significantly increased with the application of graded levels of Zn. Application of 37.5 kg $ZnSO_4$/ha ($Zn_{37.5}$) recorded highest available Zn status (1.60 mg/kg) followed by Zn_{25} (1.40 mg/kg), which remained statistically at par with each other and significantly higher than other treatment. Possibly higher mobility, diffusion and solubility of the applied zinc fertilizer might be the reason leading to increase Zn status of soil. The lowest Zn status (0.85 mg/kg) was recorded under Zn_0. While, the application of zinc did not significantly influence the pH, EC, OC and available nutrients i.e. N, P, Fe, Mn and Cu of soil at post-harvest. A balanced application of nutrients had been resulted in highest yield and highest nutrient availability after the harvest of crop. Similar non-significant results were reported by Ranpariya and Polara (2018).

CONCLUSIONS

On the basis of experimental finding, it is concluded that application of potassium and zinc fertilizers influence the content and uptake of micro-nutrients and yield in green gram (*Vigna radiata* L.). Highest seed and straw yield were recorded with the application of potassium @ 30 kg/ha, similarly zinc @ 37.5 kg/ha. Graded levels of potassium application significantly increased the Fe content both in seed and straw. Zinc application was associated with zinc content and uptake in both seed and straw. Uptake of all the micro-nutrients under consideration was significantly increased with potassium and zinc application at graded levels, also essentially increasing the availability of the applied nutrient and improving the overall soil fertility status in coarse textured medium K status soil.

ACKNOWLEDGEMENT

The necessary facilities and services provided by the Regional Director, RRS Bawal and Professor and Head, Department of Soil Science, CCS HAU, Hisar is duly acknowledged.

REFERENCES

Ahmad F, Ahmad J, Ali SM, Iqbal S, Mehmood Z and Abbas W. 2018. Influence of Different Levels Phosphorous and Zinc on Yield and Yield Attributes of Mung Bean [*Vigna radiata* L.]. Juniper Online Journal Material Science. **5**(1): 001- 004.

Anonymous. 2018. Package and Practices of *kharif* crops. CCSHAU, Hisar, Astral Publishing Private Limited, New Delhi. pp. 288.

INDIASTAT. 2022. State/Season-wise Area, Production and Productivity of Moong in India (2019-2020). https://www.indiastat.com/table/agriculture/state-season-wise-area-production-productivity-moo/1409247

Jackson ML. 1973. Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi, India. pp 327-350.

Jamal A, Khan MI, Tariq M and Fawad M. 2018. Response of Mung Bean Crop to Different Levels of Applied Iron and Zinc. Journal of Horticulture and Plant Research. **3**:13-22.

Kannan S, Mishra A and Verma M. 2014. Effect of multi micronutrient mixtures on nutrient status of post-harvest soil of black gram. Madras Agricultural Journal. **44**(3): 173-175.

Kurhade PP, Sethi HN and Zadode RS. 2015. Effect of different levels of potassium on yield, quality, available nutrient and uptake of blackgram. International Journal of Agricultural Sciences. **11**(1): 175-178.

Lindsay WL and Norvell WA. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal. **42**: 421-428.

Olsen SR, Cole CV, Watanabe FS and Dean LA. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular U.S. Department of Agriculture 939.

Patel MM, Patel IC, Patel RI and Acharya SS. 2011. Effect of zinc and iron on yield and yield attributes of rainfed cowpea (*Vigna unguiculata* L. Walp). Annals of Arid Zone. **50**(1):17-19.

Ranpariya VS and Polara KB. 2018. Effect of Potassium, Zinc and FYM on Content and Uptake of Nutrients of Summer Green Gram (*Vigna radiata* L.) at Different Growth Stages under South Saurashtra Region of Gujarat. International Journal of Pure and Applied Bioscience. **6** (1): 997-1002

Roy PD, Lakshman K, Narwal RP, Malik RS and Saha S. 2017. Green Gram (*Vigna radiata* L.) productivity and grain quality enrichment through zinc fertilization. International Journal of Current Microbiology and Applied Sciences. **6**(6): 643-648.

Shkula AK, Tiwari PK and Chandra P. 2014. Micronutrients Deficiencies vis-à-vis Food and Nutritional Security of India. Indian Journal of Fertilisers. **10**(12): 94-112.

Subbiah BV and Asija GL. 1956. A rapid procedure for the determination of available nitrogen in soils. Current Science. **25**: 259-60.

Thesiya NM, Chovatia PK and Kikani VL. 2013. Effect of potassium and sulphur on growth and yield of blackgram (*Vigna mungo* L.) under rainfed condition. Legume Research. **36**(3): 255-258.

Usherwood NR. 1985. The role of potassium in crop quality. Potassium in agriculture : 489-514.

Walkley AJ and Black CA. 1934. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. **37:** 29-3