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ORIGINAL ARTICLE

ENHANCEMENT OF PRODUCTIVITY AND PROFITABILITY OF CHICKPEA (C*ICERARIETINUM*L.) AS WELL AS SOIL FERTILITY OF COARSE TEXTURED SOILS THROUGH POTASSIUM FERTILIZATION

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Abstract: A series of field experiments, Demonstrations and On Farm Trials (OFT's) were conducted during 2012-13 to 2017-18 at the Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal, Haryana, India and on the farmers' fields to study the response of chickpea to potassium fertilization in coarse textured medium K status soils of South- Western Haryana, India. For research experiments, there were six graded levels of potassium application *viz.,* 0, 10, 20, 30, 40 and 50 kg K_2O ha^{-1} laid out in randomized block design with four replications. The results of field experiments showed that chickpea seed yield increased significantly with application of potassium at 20 kg K_2O ha^{-1}. The increase in mean seed yield was 6.12, 13.87, 16.90, 18.59 and 19.88 per cent due to application of 10, 20, 30, 40 and 50 kg K_2O ha^{-1}, respectively over control. Potassium fertilization also significantly increased the total K uptake by chickpea at each level of potassium application and helped in preventing the depletion of available soil K and enhanced its content in the soil. The mean K use efficiency varied from 43.60 to 58.00 per cent, being maximum with application of 20 kg K_2O ha^{-1} (58.00%). The mean economic data analysis revealed that benefit-cost ratio also increased with potassium application and the additional returns per rupee invested on K at 10, 20, 30, 40 and 50 kg K_2O ha^{-1} levels of potassium were Rs. 16.96, 20.06, 15.02, 12.19 and 11.46, respectively. Based on the results of field experiments, on farm trials and demonstrations were conducted during 2015-16 and 2017-18, respectively, on the farmers' fields with only two treatments *i.e.* 0 and 20 kg K_2O ha^{-1}, with plot size of 0.2 ha under each treatment. On an average, the application of 20 kg K_2O ha^{-1} increased the chickpea yield over control (K_0) by 10.15 to 15.90 per cent under OFT's and Demonstrations.

Key words: Chickpea, Viability, Potassium, Potassium use efficiency (KUE), Grain yield.

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1. Introduction

India is one of the major pulse growing countries of the world, accounting for about one third of total world area under pulse cultivation and one fourth of total world production. Pulses occupy a key position in Indian diet and meet about 30 per cent of the daily protein requirement. Although, being the largest pulse crop cultivating country in the World, India's production of pulses is relatively less in comparison to total cereal crops production. A due attention is required to enhance the pulse production, not only to meet the dietary requirement of protein but also to raise the awareness about pulses for achieving nutritional food security and environmental sustainability. Pulses are also important component to sustain the agriculture production as the pulse crops possess wide adaptability to fit into various cropping systems, improve the soil fertility being leguminous in nature and physical health of soil while making soil more porous due to tap root system. Among the pulses; chickpea is one of the most important *Rabi* crops with high acceptability and wider use. India is the major chikpea producing country and contributing for over 75% of total world chickpea production [Maurya and Kumar (2018)]. Chickpea crop not only

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supplies the protein but also enriches the soil through symbiotic nitrogen fixation. But majority of farmers usually grow pulses on marginal lands with lower rates of fertilizer application and mostly without the applications of potassium. Potassium mainly affects the nodulation of pulse crops thus increases the seed yield through better fixation of nitrogen [Das *et al.* (1975)]. Potassium is the third major element taken up by the plant and absorbed in larger amount as compared to other minerals except nitrogen. It has utmost importance for imparting drought and disease resistance and has synergistic effect with nitrogen and phosphorus [Das (1999)]. Potassium is of utmost importance for water status of plant meristemetic tissues, enables the plant to resist pest and diseases and regulates enzymatic activities and translocation of photosynthates [Mengel and Kirkby (1987)], and considerably improves seed yield of chickpea if applied as a fertilizer [Samiullah and Khan (2003)]. Krauss (1997) called it "The Forgotten Nutrient" signifying the lowered priority bestowed towards research on potassium in certain agriculture zone of the world. Farmers and agricultural researchers have often resorted to blanket application of *K* or have depended on native soil *K*.

In fact, crop removal of potassium often equals or exceeds that of nitrogen. Under intensive cropping with high yielding varieties and higher dose of *N* and *P* application with practically very little or no *K* application, the soils which were considered to be sufficient in available potash, are developing potassium deficiency. The intensive cropping with high yielding varieties make considerable demand on the soil nutrient resources, it is, therefore, quite likely for soils not to be able to maintain sufficiency in available potash for long. Hence, the soils which were rated sufficient in available *K* have begun to show responses to *K* under intensive use of *N* and *P* fertilizer [Tikkoo *et al.* (2015)]. Keeping in view the importance of potash for plants, the present study was carried out to investigate the growth and yield performance of chickpea in coarse textured soils of South-Western Haryana and to create awareness among the farming community about the judicious use of fertilizer to get maximum production and economic returns as well as effect on soil fertility, *K* uptake and KUE.

2. Materials and Methods

A field experiment was conducted on the effect of different levels of potassium on Chickpea (C*icerarietinum*L.) yield, economic viability and post harvest soil fertility under coarse textured soils at CCS Haryana Agricultural University, Regional Research Station, Bawal, Rewari, Haryana, India during the *Rabi* seasons from 2012-13 to 2015-16. The experimental crop failed during the crop season of 2014-15 due to heavy rains (670 mm) at maturity stage of crop due to water logging. The initial physic-chemical properties of the experimental field soil are presented in Table 1. The climate of the site is characterized by hot summers and cool winters. The rainfall received during crop growth period was 220.8, 255.3 and 21.1 mm during 2012-13, 2013-14 and 2015-16, respectively.

Table 1: Physico-chemical properties of the experimental soil at 0-15 cm depth (mean of three years).

Soil properties	Mean Value
Soil texture	loamy sand
pH(1:2)	8.25
EC(1:2)	0.20
OC (%)	0.19
Available N (kg/ha)	110.9
Available P (kg/ha)	11.2
Available K (kg/ha)	170.5

The experiment was laid out in Randomized block design with four replications on chickpea cv. HC-1 during *Rabi* seasons of 2012-13 to 2015-16. There were six levels of potassium (*K*) application *viz.,* 0, 10, 20, 30, 40 and 50 kg K_2O ha-1 through muriate of potash (60% K_2O). The crop was sown on 25, 28 and 27th October as per treatments during 2012, 2013 and 2015, respectively; using seed rate of 40 kg ha^{-1} with hand plough at 30 cm apart rows comprised of 10 rows per plot. The chickpea seeds were treated with carrier based *Rhizobium* and *PSB* cultures each at the rate of 50 ml per 10 kg seed and mixed well to ensure the inoculants to stick on the surface of seed. The treated seeds were dried in shade for an hour before sowing. The recommended dose of N @ 15 kg ha^{-1} and P_2O_5 @ 40 kg ha^{-1} were applied through urea and diammonium phosphate fertilizers, respectively. Recommended package of practices were followed to raise the crop. Crop was harvested at physiological maturity, threshed and plot wise yield was recorded. Seed, straw and soil samples were taken and analyzed for *K* concentration in seed and straw and available *K* in soil, respectively. *K* content was estimated by Flame photometer [Richards (1954)]. Economics of the treatments was worked out during 2012-13 to 2015-16 and average values were used for comparing the different treatments. Cost of cultivation, net returns and benefit-cost ratio were computed for different treatments.

The data were subjected to the analysis of variance (ANOVA) described by Fisher (1958) and significant treatment effect was judged with the help of 'F' test at 5% level of significance by adopting the procedure described by Panse and Sukhatme (1985).

On-Farm trials and demonstrations

Based on the results of field experiments conducted at Regional Research Station, Bawal, On Farm Trials (OFT's) and Demonstrations were conducted during 2015-16 and 2017-18 on farmers' fields with control (without *K*) and 20 kg K_2O ha^{-1}. The soils of these villages were sandy to loamy sand, alkaline in reaction, low in organic carbon and low to medium in available *P* and *K*. The total area of each experimental field was 0.4 ha, with 0.2 ha under each treatment. Full doses of *N* and *P* were applied at sowing as basal as per recommendations. The chickpea was sown during October using 40 kg seed ha^{-1}. One to two irrigations and hoeing were done during the crop period. Crop was harvested at physiological maturity, threshed and plot wise seed and straw yields were recorded. Soil, seed and straw samples were analyzed for *K* content.

3. Results and Discussion

Effect of *K* fertilization on crop yield

The results of field experiment showed that chickpea seed and straw yield increased significantly with application of potassium at 20 kg K_2O ha^{-1} (Table 2). However, the seed yields obtained at 30, 40 and 50 kg K_2O ha^{-1} were statistically at par. The mean seed increased from 17.81 q ha^{-1} (control K_0) to 18.90, 20.28, 20.82, 21.12 and 21.35 q ha^{-1}; whereas mean straw yield increased from 21.18 q ha^{-1} (control) to 21.95, 23.15, 23.47, 23.85 and 24.05 q ha^{-1} at 10, 20, 30, 40 and 50 kg K_2O ha^{-1}, respectively. On the basis of pooled data the increase in seed yield was 6.12, 13.87, 16.90, 18.59 and 19.88 per cent and straw yield was 3.64, 9.30, 10.81, 12.61 and 13.55 per cent due to application of 10, 20, 30, 40 and 50 kg K_2O ha^{-1}, respectively, over control. This might be due to improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of nutrients in plant parts. These results are in close conformity with the findings of Srinivasrao *et al.* (2003).

Potassium application is directly related to growth, plant biomass and yield in crops, and these results are in agreement with those of Ali *et al.* (2008). The highest seed yield (21.35 q ha^{-1}) in case of 50 kg K_2O ha^{-1} could be attributed to more number of pods per plant and number of seeds per pod. The similar conclusions were drawn by Samiullah and Khan (2003) also.

Effect of K fertilization on K-Uptake and KUE

The pooled data on total *K*-uptake increased with *K* application. Successive levels of potassium significantly increased the *K* uptake with application of potassium up to 20 kg K_2O ha^{-1}. The total *K* uptake by chickpea increased from 51.90 to 73.70 kg ha^{-1}, with increasing levels of potassium from 0 to 50 kg K_2O ha^{-1} (Table 3). The progressive increase in the supply of potassium to the crops resulted in higher availability of this nutrient, resulting in higher biomass yield. The impact of higher uptake of plant nutrients under these treatments has been reflected in the growth and yield performance of the crop. The mean *K*-use efficiency (KUE) also increased with increasing levels of potassium. It was 47.80% with 10 kg K_2O ha^{-1} and increased to 54.15% with application of 20 kg K_2O ha^{-1}. However, KUE decreased to 51.60, 47.93 and 43.60% at 30, 40 and 50 kg K_2O ha^{-1}, respectively. The increased supply of nutrients and good response by the plants resulted in enhanced translocation of nutrients. These results are in close conformity with the findings of Geetha and Velayutham (2009) and Ganga *et al.* (2014).

Effect of K fertilization on available potassium content

Each successive level of potassium increased available *K* content in soil, however, the increase was significant at 20 kg K_2O ha^{-1}. The initial mean available *K* status was 170.50 kg ha^{-1} whereas it was 167.75, 169.18, 170.45, 171.72, 172.18 and 172.45 kg ha^{-1} at 0, 10, 20, 30. 40 and 50 kg K_2O ha^{-1}, respectively. Application of increasing levels of potassic fertilizer from 0 to 50 kg K_2O ha^{-1} significantly increased available potassium content in soil after harvesting crop (Table 3). The application of potassic fertilizers improved the post-harvest buildup of soil available *K* compared to control in chickpea crop. The enhanced status of *K* could be attributed to the higher amount of potassium being added through muriate of potash. The present findings are in consonance with those of Kabir *et al.* (2004).

Table 2: Effect of potassium on seed and straw yield in chickpea in field experiment at Bawal (2012-13 to 2015-16).

K_2O levels (kg ha^{-1})	Seed Yield (q ha^{-1})				Straw Yield (q ha^{-1})			
	2012-13	2013-14	2015-16	Mean	2012-13	2013-14	2015-16	Mean
K_0	14.17	18.25	21.01	17.81	16.85	21.55	25.14	21.18
K_{10}	15.10	19.25	22.35	18.90	17.50	22.10	26.25	21.95
K_{20}	16.30	21.25	23.29	20.28	18.85	23.20	27.40	23.15
K_{30}	16.80	21.85	23.81	20.82	19.30	23.45	27.66	23.47
K_{40}	17.10	22.05	24.21	21,12	20.15	23.85	27.55	23.85
K_{50}	17.35	22.35	24.35	21.35	20.40	24.05	27.70	24.05
CD(P=0.05)	1.13	1.74	2.05	1.64	1.61	1.45	0.99	1.35

Table 3: Effect of potassium on total K uptake and available potassium in chickpea in field experiment at Bawal (2012-13 to 2015-16).

K_2O levels (kg ha^{-1})	Total K uptake (kg ha^{-1})				KUE (%)	Available K (kg ha^{-1})			
	2012-13	2013-14	2015-16	Mean		2012-13	2013-14	2015-16	Mean
K_0	32.82	53.53	69.35	51.90	-	168.80	167.35	167.10	167.75
K_{10}	43.28	67.44	59.32	56.68	47.80	169.50	169.20	168.85	169.18
K_{20}	54.54	64.86	71.10	63.50	58.00	170.95	170.55	169.75	170.45
K_{30}	59.18	69.25	73.74	67.39	51.60	172.35	171.60	171.20	171.72
K_{40}	63.25	72.08	77.88	71.07	47.93	172.95	171.95	171.65	172.18
K_{50}	65.07	73.77	82.26	73.70	43.60	173.10	172.10	172.06	172.45
CD(P=0.05)	3.00	2.30	4.39	3.23	-	1.58	1.59	1.56	1.15

Table 4: Economics of K application in chickpea (2012-13 to 2015-16 average of three years).

K_2O levels (kg ha^{-1})	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C	Additional returns per Rs. invested on *K*
K_0	41345	76535	35190	1.60	-
K_{10}	41631	81388	39757	1.69	16.96
K_{20}	41917	88015	46188	1.83	20.06
K_{30}	42203	89105	46902	1.84	15.02
K_{40}	42489	90443	47954	1.84	12.19
K_{50}	42775	91725	48950	1.85	11.46

Effect of K fertilization on crop economics

It is evident from the data that gross returns and net returns of chickpea increased with increasing *K* levels which might be due to increasing seed and straw yield with increasing potassium levels. The minimum and maximum gross return of Rs. 76535 ha^{-1} and Rs. 91725 ha^{-1} were recorded with control (0 kg K_2O ha^{-1}) and 50 kg K_2O ha^{-1}, respectively (Table 4). Data also indicated that the total cost of cultivation also followed the same trend. The highest net return (Rs. 48950 ha^{-1}) was recorded from the potassium application of 50 kg ha^{-1}, while minimum net return obtained with 0 kg K_2O ha^{-1}(Rs 35190 ha^{-1}). Similar results were obtained by Vekaria *et al*. (2013). The mean economic data analysis revealed that benefit-cost ratio also increased with potassium application. Whereas, the additional returns per rupee invested on *K* at 10, 20, 30, 40 and 50 kg K_2O ha^{-1} levels of potassium were Rs. 16.96, 20.06, 15.02, 12.19 and 11.46, respectively. The highest additional returns per rupee invested on *K* (Rs. 20.06) was obtained with application of 20 kg K_2O ha^{-1}, owing to higher seed and grain yield (Table 4).

Response of potash in chickpea at farmers' fields

The result of five OFT's during 2015-16 indicated that application of potassium @ 20 kg K_2O ha^{-1} increased the mean seed yield of chickpea by 15.90 per cent over control (Table 5). The demonstration trials during 2017-18 also indicated that application of

Table 5: Effect of potassium application on chickpea seed yield in on-farm trials (2015-16).

S/No.	Location	Yield (q ha^{-1})	
		K_0	K_{20}
1.	Rewari-1	11.00	13.00
2.	Rewari-2	6.00	8.00
3.	Rewari-3	6.40	7.40
4.	Mahindergarh-1	12.50	13.75
5.	Mahindergarh-2	11.25	12.50
Mean		9.43	10.93
Per cent increase in yield		15.90	

Table 6: Effect of potassium application on chickpea seed yield in farmer field demonstrations (2017-18).

S/No.	Location	Yield (q ha^{-1})	
		K_0	K_{20}
1.	Mohindergarh-1	19.00	20.50
2.	Bhiwani-1	13.10	14.50
3.	Rewari-1	19.00	20.60
4.	Rewari-2	16.10	17.80
5.	Nuh-1	15.10	17.25
Mean		16.46	18.13
Per cent increase in yield		10.15	

Table 7: Effect of potassium application on available K status of soils at farmers' fields (2017-18).

S/No.	Initial Av. K (kg/ha)	Av. K at harvest (kg/ha)	
		K_0	K_{20}
1.	167.00	162.80	166.35
2.	166.00	162.10	165.25
3.	189.00	184.95	188.20
4.	189.70	185.15	188.95
5.	182.50	180.55	182.15
Mean	177.92	173.75	177.10

potassium @ 20 kg K_2O ha^{-1} increased the mean seed yield of chickpea by 10.15 per cent over control (Table 6). The analysis of available *K* before and after harvest of chickpea crop from demonstration plots in 2017-18 revealed that there was slight depletion in *K* status in control plots where as under K_{20} there was buildup of potash in the soil as compared to K_0 (Table 7). The mean initial soil available *K* status of the five fields was 177.92 kg K_2O ha^{-1} whereas after the harvest of the chickpea, the mean available *K* status was 173.75 and 177.10 kg K_2O ha^{-1} at 0 and 20 kg K_2O ha^{-1}, respectively.

On the basis of pooled results of research experiments on Chickpea response to *K* application on its productivity, economic viability of Chickpea and post harvest soil analysis of *K* status and further follow-up Demonstrations and OFT's trials at farmers field. It is concluded that application of 20 Kg K_2O ha^{-1} in Chickpea is recommended in coarse textured low to medium potash status soils for the benefit of farmers of India.

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