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RESEARCH ARTICLE

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Influence of Potassium on Growth, Yield, Water Relation and Chlorophyll Content of Greeengram [*Vigna radiate* (L.) Wilczek] in Inceptisols

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ABSTRACT

Background: Mung bean (*Vigna radiata* L.) is an important edible bean in the human diet worldwide. However, its growth, development, and yield may be restricted or limited by insufficient or unbalanced nitrogen (N), phosphorus (P) and potassium (K) fertilization. Under intensive cropping systems, large amounts of K are removed, leading to serious depletion of soil K reserves. Therefore this study was conducted to generate the high yield and to improve yield components via effective and balanced fertilization.

Methods: In this field experimentation during 2014-2016 different levels of potassium through soil application and foliar spray were studied. Three locations were selected on the basis dominance of the crops under rainfed condition.

Result: In the present experimentation there was a significant effect of potash levels on plant height, number of pods per plant, 100-grain weight and grain yield. Significantly the highest grain yield (1120 kg ha^{-1}) was recorded with 20 kg K_2O ha^{-1}, which was at par with 30 kg K_2O ha^{-1}. However, the grain yield with 20 kg K_2O ha^{-1} was reported statistically equivalent yield with two foliar spray of muriate of potash (KCL) at flowering and pod filling stage. The pigments responsible for photosynthesis such as chlorophyll was favourably influenced by soil and foliar application of potassium. The K use efficiency parameters of AE, AR, ENUE and VCR were relatively high with potash application @ 20 kg ha^{-1} thereafter it declines. The positive balance of K is highly predominant in almost all the potassium applied plots which imply that the use of K fertilizers is optimal.

Key words: Chlorophyll content, Foliar spray, Greengram, Nutrient management efficiency, Potassium, Water relation.

INTRODUCTION

Greengram is an important pulse crop having high nutritive value. Its seed contains 24.2% protein, 1.3% fat and 60.4% carbohydrate. It is a short duration crop and can be grown twice a year *i.e.* in spring and summer seasons. The average yield is quite low which requires attention of the crop experts. Among various factors, judicious use of fertilizer is of prime importance. It is evident from the literature that application of major nutrients, *i.e.* NPK improved mungbean yield (Ali *et al*., 1996; Ali *et al*., 2010). Potassium is the third macronutrient required for plant growth, after nitrogen and phosphorus and also plays a vital role as macronutrient in plant growth and sustainable crop production (Baligar *et al*., 2001). Its adequate supply during growth period improves the water relations of plant and photosynthesis, maintains turgor pressure of cell which is necessary for cell expansion, helps in osmotic-regulation of plant cell, assists in opening and closing of stomata (Yang *et al*., 2004), activates more than 120 enzymes (Dobermann and Cassman (2002), synthesizes the protein, creates resistance against the pest attack and diseases (Arif *et al*., 2008) and enhances the mungbean yield (Ali *et al*., 2010). Pulse crops fix atmospheric N, the predominant mechanism to meet their N requirement. However, this capability is jeopardized through insufficient supply of plant nutrients. General recommendations for phosphorus (P) fertilization are made in Maharashtra states of India. However, potassium fertilizer use is limited in pulse crops only 41 per cent of the cropped area under pulses receives about 6.3 kg K_2O ha^{-1}, indicating that lack of adequate K use in pulses is one of the major reasons for their low yields and poor crop quality in India (Singh *et al*., 2016). Under intensive cropping systems, large amounts of K are removed, leading to serious depletion of soil K reserves.

The present study was therefore taken to investigate the effect of different levels of potassium on growth and yield performance of greengram under rainfed conditions of Vidarbha region. Such study will be useful in order to create awareness among the farming community about the judicious use of fertilizer to get maximum production.

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MATERIALS AND METHODS

The investigations were carried out from 2014 to 2016 at Pulses Research Unit, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Agriculture Research Station, Buldhana and at Agriculture Research Station, Washim on *Inceptisols* having Available N, 208 to 216 kg ha^{-1}, available P_2O_5 13.70 to 17.30 and K_2O, 308 to 340 kg ha^{-1}, respectively. The quadruplicated experiment was laid out using randomized complete block design. The net plot size was 4.5 x 4.0 m^2. The experiment comprised Absolute control, RDF alone, RDF + 20 kg K_2O ha^{-1}, RDF+30 kg K_2O ha^{-1}, RDF+40 kg K_2O ha^{-1} and RDF + 2% Foliar spray of KCL at flowering stage and RDF + 2% Foliar spray of potassium chloride (KCL) at flowering and pod filling stage. A uniform dose of 20 and 40 kg ha^{-1} of N and P_20_5, respectively was used in all the treatments excluding absolute control. A promising variety of green gram PKV Greengold was sown during the last week of June in 45 cm apart rows using 15 kg seed ha^{-1}. Whole quantity of N, P and K in the form of urea, di-ammonium phosphate and potassium chloride, respectively was side drilled just after sowing. All other cultural practices were kept normal and uniform for all the treatments. Observations were recorded on some important plant parameters like plant height, number of branches plant^{-1}, number of pods plant^{-1}, seed weight plant^{-1}, seed yield and seed protein contents. Nitrogen content of the seeds was estimated using Kjeldhal method, phosphorous by Olsen method and potassium by Flame Photometer method (Jackson 1973). The seed protein estimation was made from N content of the seeds. Leaf water potential was estimated using a Dew point potentiometer (Campbell *et al*., 2007) and the chlorophyll content index was measured by chlorophyll meter CCM-200 (Opti-Sciences, USA) (Cerovic *et al*., 2012). The nutrient management indices agronomic efficiency (AE), apparent recovery (AR), economic nutrient use efficiency (ENUE), relative yield (RY) and value cost ratio (VCR) were calculated by the formula given by Devasenapathy *et al*. (2008). The data collected were statistically analysed using analysis of variance technique and Least Significant Difference (LSD) test at 5% probability to compare the difference among the treatments means.

RESULTS AND DISCUSSION

Yield

The results revealed that application of 30 and 40 kg K_2O ha^{-1} along with recommended dose of N and P_2O_5 recorded significant increase in grain yield of greengram over lower levels of potassium and RDF alone (Table1). However, yield at 30 kg K_2O ha^{-1} was found at par with lower (20 kg K_2O ha^{-1}) and higher (40 kg K_2O ha^{-1}) levels of potassium indicating response of greengram to potassium up to 20 kg ha^{-1}. The yield obtained at application of 20 kg K_2O ha^{-1} and foliar sprays of 2% KCL at flowering and 15 days after first spray (pod filling stage) was found at par. The minimum grain yield was observed where no potash fertilizer was applied. The positive effect of K on crop yield might also be due to its requirement in carbohydrate synthesis and translocation of photosynthesis and also may be due to improved yield attributing characters, shoot growth and nodulation. Billore *et al*.,(2009) observed seed yield of soybean increase 35.6% over control with the application of 49.8 kg K ha^{-1}.Similar findings were observed by Patil and Dhonde (2009) in green gram, Salve and Gunjal (2011) in groundnut, Balai *et al*., (2005), Asghar (1994) in black gram and Saxena *et al*., (1996) in greengram. Manurial schedule of 20:60:20 kg NPK ha^{-1} for sandy loam soils (Saxena *et al*., 1996) was found to be optimum in greengram.

Growth and quality parameters

It was observed that the highest plant height, number of branches, number of pods plant^{-1}, grain weight plant^{-1}except test weight were significantly affected by application of potassium at 40 kg K_2O ha^{-1} and it was found at par with 30 kg K_2O ha^{-1} (Table 2). The test weight was higher with RDF + potash application over RDF alone. K application not only enhanced the availability of other nutrient but also increased the transportation of photosynthates; protein synthesis from source to sink might be the main reason for increase growth and quality parameters. The lowest growth and yield contributing parameters were recorded in no potassium might be due to the reason that high root shoot ratio is associated with potassium uptake (Yang *et al*., 2004).

Protein content (%)

Protein contents of greengram seed were affected significantly by different K levels. As for different treatments are concerned, the foliar application of KCL twice resulted in maximum seed protein contents (24.96%) and minimum in control (18.44%) (Table 1). Among soil application of

Table 1: Grain yield of greengram as influenced by different treatment.

Treatment	Grain yield (kg ha^{-1})				COC	GMR	NMR	B:C
	Akola	Buldhana	Washim	Pooled	(Rs/ha)	(Rs/ha)	(Rs/ha)	ratio
T_1 - Absolute control	396	539	1147	694	17433	36268	18835	1.98
T_2- 100% RDF	671	1019	1259	983	21817	51365	29548	2.32
T_3- RDF+ 20 Kg K_2O ha^{-1}	789	1170	1403	1120	23563	58544	34981	2.45
T_4- RDF+ 30 Kg K_2O ha^{-1}	830	1190	1482	1168	24148	61005	36857	2.49
T_5- RDF+ 40 Kg K_2O ha^{-1}	879	1200	1510	1196	24738	62508	37770	2.50
T_6- RDF+ 2% KCL (Once)	718	1081	1292	1030	22909	53823	30914	2.32
T_7- RDF+ 2% KCL (Twice)	785	1162	1340	1095	24001	57239	33239	2.36
S. Em$\pm$	25	45	39	22	-	933	933	-
CD at 5%	74	136	116	67	-	2800	2800	-

potassium maximum protein content was recorded with application of 40 K_2O ha^{-1}. As potash has synergistic effect on nitrogen uptake, facilitates protein synthesis and activates different enzymes, therefore**,** protein content increased significantly with each increase in potassium level. Chanda *et al*. (2002) concluded that the application of higher level of potash also increased the protein content of mungbean.

Canopy Chlorophyll Content

Apart from phonological characters potassium fertilizer also improve the cholorphyll content (Table 3). Increase in the potassium levels to greengram from 0 to 40 kg K_2O ha^{-1} progressively increased the canopy chlorophyll content at 30, 45 and 60 DAS. Foliar spray of 2% K_2O once at flowering and twice at flowering and pod filling stage conspicuously increased the chlorophyll content over absolute control.

Leaf Water Potential

Application of potassium at 30, 45 and 60 DAS conspicuously influenced the leaf water potential (Table 3). Potassium applied plant maintained high leaf water potential over control. Positive effect of potassium on leaf water potential was reported by Anac *et al*. (1996). Potassium is indispensable for attaining an optimum potential (turgor) in young leaves which in turn has an impact on plant growth (Mengel and Wolfgang-Arnek1982). Potassium is reported to improve water relations as well as productivity of different crops under water stress conditions (Islam *et al*. 2004).

Nutrient Management Efficiency

Nutrient use efficiency (Table 4) can be expressed by crop Agronomic Efficiency (AE), Apparent Recovery (AR), Economic Nutrient Use Efficiency (ENUE) and Value Cost ratio (VCR). AE refers to the crop yield increase per unit nutrient applied, AR indicates the percentage of nutrient absorbed from externally applied fertilizer nutrient source, ENUE refers to the economic produce grain yield per rupee invested per hectare on particular nutrient fertilizer, VCR

Table 2: Ancillary parameters of greengram as influenced by different treatment (Mean of 3 location).

Treatment	Plant height (cm)	Branches /plant	Pods/plant	Grain weight/ Plant (g)	Pod length (cm)	100-seed Wt (g)
T_1- Absolute control	42.0	3.8	17.0	3.78	7.76	3.554
T_2- 100% RDF	51.0	4.2	21.8	5.28	8.20	3.568
T_3- RDF+ 20 Kg K_2O ha^{-1}	51.5	5.3	24.0	5.66	8.87	3.652
T_4- RDF+ 30 Kg K_2O ha^{-1}	53.6	5.4	26.2	5.95	8.67	3.722
T_5- RDF+ 40 Kg K_2O ha^{-1}	57.4	5.5	27.2	6.22	8.66	3.780
T_6- RDF+ 2% KCL (Once)	54.6	4.7	22.1	5.40	8.36	3.622
T_7- RDF+ 2% KCL (Twice)	55.8	5.2	25.5	5.53	8.53	3.704
S. Em±	0.13	0.23	0.34	0.10	0.05	0.13
CD at 5%	0.40	0.70	1.02	0.31	0.14	NS

Table 3: Canopy Chlorophyll Content Index (CCI) and water potential (MPa) of greengram as influenced by different treatment (Akola).

Treatment	Chlorophyll Content Index (CCI)			Leaf Water Potential(-MPa)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1- Absolute control	20.11	21.56	28.45	4.97	4.65	6.22
T_2- 100% RDF	22.00	25.42	32.28	4.84	4.38	5.87
T_3- RDF+ 20 Kg K_2O ha^{-1}	22.33	26.19	33.41	4.55	4.19	5.47
T_4- RDF+ 30 Kg K_2O ha^{-1}	23.38	27.28	33.72	4.39	4.00	5.12
T_5- RDF+ 40 Kg K_2O ha^{-1}	23.60	28.27	34.55	4.26	3.91	4.87
T_6- RDF+ 2% KCL (Once)	22.08	25.66	33.37	4.66	4.39	5.40
T_7- RDF+ 2% KCL (Twice)	22.32	26.49	33.63	4.50	4.30	5.10

Table 4: Effect of potassium on nutrient management efficiency of greengram (Mean of 3 location).

Treatment	Relative Yield (%)	Agronomic Efficiency (kg grain /kg K applied)	Apparent Recovery (kg of K uptake/kg of K added)	Economic Nutrient Use Efficiency (kg of grain/Rs invested)	Value Cost Ratio
T_1- Absolute control	-	-	-	-	-
T_2- 100% RDF	-	-	-	-	-
T_3- RDF+ 20 Kg K_2O ha^{-1}	113.98	6.87	0.276	2.89	18.93
T_4- RDF+ 30 Kg K_2O ha^{-1}	118.78	6.15	0.225	2.01	16.94
T_5- RDF+ 40 Kg K_2O ha^{-1}	121.70	5.33	0.241	1.54	14.69
T_6- RDF+ 2% KCL (Once)	104.79	7.88	1.540	17.76	36.23
T_7- RDF+ 2% KCL (Twice)	111.44	9.41	0.847	9.44	42.37

Table 5: Nutrient Uptake (kg/ha) by greengram (Mean of 3 location).

Treatment	N uptake	P uptake	K uptake	Protein content (%)
T_1- Absolute control	36.31	4.12	15.31	20.94
T_2-100% RDF	56.95	6.97	22.23	22.31
T_3- RDF+ 20 Kg K_2O ha^{-1}	66.73	10.04	27.75	23.65
T_4- RDF+ 30 Kg K_2O ha^{-1}	76.95	10.43	28.97	24.35
T_5- RDF+ 40 Kg K_2O ha^{-1}	77.12	10.50	31.87	25.38
T_6- RDF+ 2% KCL (Once)	66.97	9.13	26.85	25.44
T_7- RDF+ 2% KCL (Twice)	69.81	9.68	27.31	26.13
S Em±	4.01	0.48	2.0	0.65
CD at 5%	12.03	1.45	6.0	1.96

refers to value of increased yield to the cost of fertilizer use. The different values for K nutrient use efficiency were related to how much fertilizer was used and how much grain yield or yield increase was obtained by K application. Crop response in terms of per kg of K_2Oapplied ranged from 9.63 to 7.03 kg grain, however, lower level of potassium recorded highest agronomic efficiency over higher level of potash. The greater AE, AR, ENUE and VCR was observed with potash application @ 20 kg/ha thereafter it declines. Regarding VCR application of potash @ 20 kg ha^{-1} gave the highest VCR of 24.85 suggesting that potash @ 20 kg/ha in the form of muriate of potash was found to be optimum dose for recommendation to get increased yield of greengram.

Uptake of nutrients

The data presented in Table 5 indicated that total uptake of nutrients in respect of N, P and K was significantly increased with increasing levels of potassium up to 40 kg K_2O ha^{-1}. The highest uptake of nitrogen, phosphorous and potassium was observed at 40 kg K_2O ha^{-1} which was at par with 30 and 20 kg K_2O ha^{-1}. Application of K resulted in significant increase in P uptake due to 20, 30 and 40 kg K_2O ha^{-1} over the control. The results indicated a beneficial effect of K on the absorption of phosphorus by the crop. Singh *et al*. (2016) also reported an increase in P uptake with K application. This increase in K uptake may be ascribed to higher grain and straw production in greengram due to K application (Brar *et al*. 2004).The highest uptake of nitrogen, phosphorous and potassium was observed at 40 kg K_2O ha^{-1} which was at par with 30 and 20 kg K_2O ha^{-1}. Increase in nutrient uptake (NPK) due to application of potassium is mainly for the reason that potash regulates the utilization of other nutrients in the plant system (Thiyagarajan *et al*. 2003).

Soil Properties

Soil organic carbon (SOC), available N, P and K status of soil after harvest of greengram were significantly influenced due to application of potassium over initial status (Table 6). Decline in SOC was noticed only on application of RDF (NP) over RDF + potassium levels, which did not return enough amount of crop residue to soil. The data recorded on SOC from the experiments being conducted at different locations

Table 6: Soil fertility status after harvest of greengram (Mean of 3 location).

Treatment	Organic carbon (g kg^{-1})			Available Nitrogen (kg ha^{-1})			Available Phosphorous ($kgha^{-1}$)			Available Potassium (kg ha^{-1})		
	Akola	Buldhana	Washim	Akola	Buldhana	Washim	Akola	Buldhana	Washim	Akola	Buldhana	Washim
T_1 - Absolute control	4.6	4.6	5.2	204	198	213	13.4	11.7	14.5	339	305	332
T_2- 100% RDF	5.0	4.9	5.4	213	214	224	21.4	17.9	22.2	342	311	341
T_3- RDF+ 20 Kg K_2O ha^{-1}	5.2	5.1	5.6	218	220	230	23.1	21.2	24.5	353	322	348
T_4- RDF+ 30 Kg K_2O ha^{-1}	5.4	5.2	5.9	222	223	233	24.0	22.6	25.4	364	330	356
T_5- RDF+ 40 Kg K_2O ha^{-1}	5.5	5.3	6.0	226	225	235	24.9	24.4	26.3	370	335	360.
T_6- RDF+ 2% KCL (Once)	5.0	5.0	5.4	210	215	225	21.5	17.8	22.3	343	312	341
T_7- RDF+ 2% KCL (Twice)	5.1	5.0	5.4	214	215	228	22.3	19.0	23.5	344	312	342
S Em±	0.07	0.14	0.08	1.68	1.60	0.42	1.12	0.89	0.77	1.70	2.06	2.31
CD at 5 %	0.20	0.42	0.24	5.04	4.80	1.25	3.35	2.68	2.32	5.12	6.17	6.92
Initial soil status	4.9	4.8	5.0	208	210	216	16.1	13.7	17.3	340	308	338

under long term fertilizer experiments revealed that balanced application of nutrients (NPK, NPK +FYM) resulted increase in SOC at all the places (Anonymous 2009). The positive effect on built up of soil fertility were observed due to application of potassium @ 40 kg K_2O ha^{-1} along with recommended N and P_2O_5 over control and NP alone.

Economics

It is evident from the data that maximum and minimum gross return recorded Rs.62508 and Rs.36268 ha^{-1} from potassium level of 40 kg and 0 kg K_2O per hectare respectively (Table 1). The highest net return (Rs.37779) was recorded from the potassium dose of 40 kg/ha which was at par with lower level of 30 kg K_2O ha^{-1} (Rs.36857) and 30 kg K_2O ha^{-1} was at par with 20 kg K_2O ha^{-1} (Rs.34981), while minimum net return obtained with 0 kg/ha (Rs.18875). Similar results obtained by Asgar *et al*. (2007) in chickpea. The benefit: cost ratio recorded with different level of potassium (20, 30 and 40 kg K_2O ha^{-1}) was not much changed.

CONCLUSION

It may be concluded from the results that, in Inceptisols depleting potassium fertility application of K is required to harvest optimum crop yield, nutrient uptake and quality of produce. Application of 20 kg K2O along with recommended dose of (20:40 kg N:P ha^{-1}) was found optimum for maintaining higher greengram yield and quality in Inceptisols of Vidarbha region of Maharashtra.

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