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Effect of balanced use of nutrients on yield, quality and uptake of nutrients by green gram (*Vigna radiata)*

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ABSTRACT

A field experiment was conducted with green gram (Vigna radiata) at Panwari village of Agra district (Uttar Pradesh) during Kharif season of 2013 and 2014 to investigate the effect of balanced use of nutrients on yield, quality and uptake of nutrients by the crop. Seven treatments were evaluated in randomized block design with three replications. The results revealed that the maximum values of growth and yield attributes of green gram were recorded with NPKSMo treatment. The maximum grain and straw yields of green gram were recorded with application of balanced use of fertilizers (NPKS Mo). Significantly lower grain and straw yields were recorded in control plots as compared to other treatments. On an average, balanced use of fertilizers (NPKS Mo) increased the grain and straw yield by 40.3 and 40.1%, respectively over the control. Omitting a nutrient from the balanced use of fertilizers resulted in marked reduction in yields of green gram crop. Decline in mean green gram grain yield was highest with phosphorus omission (32.4%) followed by sulphur (11.5%), potassium (9.3%)N (7.7%) and Mo (7.3%) over the full dose of nutrients (NPK S Mo). Reduction in green gram straw yield due to omission of corresponding nutrients amounted to 33.2 12.6, 9.9, 11.0 and 3.5%, respectively. The quality of produce in terms of protein content improved with NPK + S + Mo and reduced with omission of nutrients, maximum being with N omission. NPK + S + Mo treatment provided the highest net returns (Rs.58766 ha^{-1}) and B:C ratio of 4.94 in green gram crop. The uptake of N, P, K, S and Mo by green gram grain and straw in full dose of nutrients was higher than that of the plot, which received no fertilizers. In general, minimum uptake values of these nutrients were recorded under optimum dose -P treatment. The amounts of organic carbon, available N,P,K,S and Mo in post harvest soil were maximum with NPKSMo treatment. The minimum amounts of organic carbon and available nutrients were recorded under their omission treatments.

Keywords: Balanced use of nutrients, yield, quality, nutrient uptake green gram

NTRODUCTION

Pulses are important sources of protein in the diet of a large section of vegetarian population in the developing countries in general and Indian in particular. Among the many cultivated legumes, green gram is the most important rainfed pulse crop grown on marginal lands. Optimum nutrition is required for getting maximum grain yield and food quality the grain. Development of appropriate nutrient management techniques is necessary to maintain the productivity of green gram crop. Fertilizers played the pivotal role in boosting crop production. The loss of soil health due to imbalanced fertilizer use coupled with large mining of nutrients under intensive cropping system posed a threat to the sustainability of our farming system. Balanced fertilization results in the supply of nutrients in a well balanced ratio, leading to their efficient utilization. Presently application of sulphur and molybdenum has become essential as N and P for legume crops. Sulphur improves the quality of legume crops and plays an important role in formation of sulphur containing amino acids. It has a role to play in increasing chlorophyll formation and aiding photosynthesis. Sulphur also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine. Molybdenum is an essential component of the enzyme nitrate reductase, which catalyzes the conversion of NO_3 to NO_2. It is also a structural component of enzyme nitrogenase, which is actively involved in atmospheric N_2 fixation by root nodule bacteria of leguminous crops. Molybdenum acts an enzyme system which brings about oxidation-reduction reactions, especially the reduction of nitrate to ammonia prior to amino acids and protein synthesis in the cells of plant besides

activator of dehydrogenase and cofactor in the synthesis of ascorbic acid. Molybdenum is considered as one of the constraints in the optimum nodulation of leguminous crops. The concept of balanced fertilization paves the way for optimum plant nutrient supply to realize full yield potential of crop. Keeping in view, an experiment was conducted to study the effect of balanced use of nutrients on yield, uptake of nutrients and economics of green gram.

MATERIALS AND METHODS

The field experiment was conducted at Panwari Village of Agra district (Uttar Pradesh) during Kharif season of 2014 and 2015. The experimental soil was sandy loam in texture and alkaline in reaction (pH 7.8). It has soluble salt concentration 0.21 dSm^{-1}, organic carbon 3.9 g kg^{-1}, available N 161 kg ha^{-1}, phosphorus 10.7 kg ha^{-1}, potassium 123 kg ha^{-1}, sulphur 16.8 kg ha^{-1} and Mo 0.04 mg kg^{-1}. The experiment was laid out in randomized block design with three replications. The treatments were T_1 N_{20} P_{60} K_{40} S_{20} Mo_2, T_2, No P_{60} K_{40} S_{20} Mo_2, T_3 N_{20} P_0 K_{40} S_{20} Mo_2, T_4, M_{20} P_{60} K_0 S_{20} Mo_2, T_5 N_{20} P_{60} K_{40} S_0 Mo_2, T_6 N_{20} P_{60} K_{40} S_{20} Mo_0 Urea, diammonium phosphate and muriate of potash were used as sources for N, P and K, respectively. In nitrogen omission treatment phosphorus was applied as single superphosphate, Sulphur (20 kg S ha^{-1}) was applied as elemental sulphur one week before sowing. Molybdenum was supplied @ 2 kg ha^{-1} through sodium molybdate. Green gram crop (K 851) was sown in second week of July in both the years. All standard package of practices were followed for growing a good crop. The crop was harvested at full physiological maturity. At harvest, yield data of the crop (grain and straw) were recorded. The nitrogen content in grain and straw was analyzed by micro Kjeldahl method (Jackson, 1973). Phosphorus, potassium, sulphur and Mo in diacid (HNO_3 $HClO_4$) digest were determined by vanadomolybdate yellow colour method. Flame photometer, turbidimetric method (Chesnin and Yien 1951) and this cyanate method (Jacson 1973), respectively. Uptake of nutrients was calculated by multiplying nutrient contents in grain and straw with their respective yield. The economic analysis of different nutrient management options are in terms of net returns and B:C ratio. The soil samples collected after harvest were analysed for pH, EC, organic carbon, available N,P,K (Jacson 1973), S (Chesnin ana Yien, 1981) and Mo (Grigg 1953). The trend of result was similar during both the years, hence data were subjected to pooled analysis for the results and discussion.

RESULTS AND DISCUSSION

Growth and yield attributes

The plant height of green gram crop ranged from 35.0 to 43.6 cm mean height of the crop was highest (43.6 cm) under NPKSMo treatment and minimum (35.0 cm) under control (Table 1). The maximum pods/plant (17.0), length of pod (9.5 cm) and test weight (61.9 g) were recorded with NPKSM (T_1) treatment and minimum under control. Omission of nutrients from the fertilizer schedule resulted in marked reductions in these yield attributes. Phosphorus and omissions had significantly lower values of these parameters than the T_1 treatment Bonde and Gawande (2017) reported that balanced use of nutrients resulted in significantly higher values of growth and yield attributes.

Table 1: Effect of balanced use of nutrient on growth, yield attributes and yield (q ha^{-1}) of green gram (mean of 2 years

Treatment	Plant height (cm)	Pods/plant	Length of pod (cm)	Test weight (g)	Grain yield	Straw yield
T_1 N_{20} + P_{60} + K_{40} + Mo_2 + S_{20}	43.6	17.0	9.5	61.9	14.75	21.35
T_2 N_0 + P_{60} + K_{40} + Mo_2 + S_{20}	39.7	16.1	9.2	61.5	13.61	19.00
T_3 N_{20} + P_0 + K_{40} + Mo_2 + S_{20}	40.0	13.8	8.8	60.6	9.97	14.26
T_4 N_{20} + P_{60} + K_0 + Mo_2 + S_{20}	39.7	16.0	9.0	61.0	13.38	19.23
T_5 N_{20} + P_{60} + K_{40} + Mo_0 + S_{20}	42.0	16.5	9.6	61.6	13.67	20.61
T_6 N_{20} + P_{60} + K_{40} + Mo_2 + S_0	41.7	16.0	9.5	61.3	13.05	18.66
T_7 Control	35.0	13.7	8.7	60.0	10.51	15.23
CD (P = 0.05)	1.10	0.60	0.20	0.33	2.10	3.05

Yield

The grain and straw yields of green gram ranged from 9.97 to 14.75 and 414.26 to 21.35 q ha^{-1},respectively. Mean grain and straw yields of green gram were highest (14.75 and 21.35 q ha^{-1}) under NPKS Mo (T_1) treatment and lowest (9.97 and 14.26 q ha^{-1}) under NKS Mo (P-omission) treatment (Table 1).The increase in yield of green gram due to full dose of nutrients (T_1) is attributed to improvement in growth, which in turn resulted in higher production and translocation of photosynthates and nutrients, ultimately reflected in to higher grain and straw production. These results corroborate the findings of Singh *et al.* (2014) and Verma *et al.* (2017).The yields of green gram were significantly higher under T_1 treatment as compared to control and other treatments. On an average, the T_1 treatment out-yielded the control by an average of 4.24 q ha^{-1} or 30.0 per cent. The decline in grain yield was maximum with P omission (32.4%) followed by S (12.5%), K (9.3%), N (7.7%) and Mo (7.3%) omissions over the full dose of nutrients (NPK S Mo). Omission of nutrients from the fertilizer schedule resulted in a marked yield loss indicating the significance of replenishment of the nutrients for achieving high yield target. These data confirm that P deficiency is a general feature of green gram crop in Agra district. Bonde and Gawande. (2017) also reported similar results. The effect of S and Mo application on the grain and straw yield of green gram was positive and significant. The increase in green gram grain yield with S and Mo application was higher than the no S and Mo treatment. The increase in yield due to S and Mo may be attributed to low status of S and Mo in experimental soil. Similar results were reported by Singh *et al.* (2017)

Table 2: Effect of various treatments on quality and economics of green gram (mean of 2 years)

Treatment	Protein (%)		Protein yield (kg ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
	Grain	Straw			
T_1 $N_{20} + P_{60} + K_{40} + Mo_2 + S_{20}$	26.3	9.5	388	58766	4.94
T_2 $N_0 + P_{60} + K_{40} + Mo_2 + S_{20}$	20.1	7.0	273	51300	4.31
T_3 $N_{20} + P_0 + K_{40} + Mo_2 + S_{20}$	25.7	8.7	256	35135	2.95
T_4 $N_{20} + P_{60} + K_0 + Mo_2 + S_{20}$	25.6	9.1	342	50230	4.22
T_5 $N_{20} + P_{60} + K_{40} + Mo_0 + S_{20}$	26.0	9.0	355	53730	4.51
T_6 $N_{20} + P_{60} + K_{40} + Mo_2 + S_0$	25.8	8.8	337	48359	4.06
T_7 Control	25.1	8.1	264	40791	3.43
CD (P = 0.05)	0.78	0.41	22.5		

Quality

The protein content in grain and straw of green gram varied from 20.1 to 26.3% and 7.0 to 9.5%, respectively. The T_1 treatment (NPKS Mo) had significantly higher protein content in grain and straw over other treatments. The increase in protein content with T_1 (NPKS Mo) treatment might be due to improved nutritional environment in the rhizosphere as well as in plant system leading to enhanced translocation of N and P to reproductive parts (Singh *et al.* 2017). The nitrogen and P omissions had significantly lower protein content than the T_1 treatment. The reductions in protein content in grain and straw were higher due to N omission followed by P omission (Singh and Pandey, 2017).The protein yield increased with balanced use of nutrients (T_1) and maximum value (388 kg ha^{-1}) was recorded with NPKS Mo (T_1) treatment. The increase in protein yield may be attributed to grater production of grain and improvement in protein content due to balanced use of nutrients. The minimum value of protein yield was recorded in P omission treatment (Lal *et al.* 2016).

Nutrient uptake

The nutrients (N,P,K,S and Mo) removal pattern by green gram was almost similar but the magnitude of removal depend upon the nutrient management options (Table 3). Nitrogen, P and K removal by green gram was highest in NPKS Mo (T_1) treatment and lowest in control.The N, P and K uptake by green gram crop was highest in T_1 (NPKS Mo) plot and lowest in control. The nitrogen uptake by grain and straw ranged from 41.5 to 62.1 and 21.4 to 33.3 kg ha^{-1}, respectively. The corresponding increase in P

Table 3: Effect of various treatments on uptake of N, P, K, S (kg ha^{-1}) and Mo (g ha^{-1}) by green gram (mean of 2 years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Molybdenum	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	62.1	33.3	4.9	3.8	13.4	53.4	3.4	2.6	7.2	6.8
T_2	51.3	21.7	3.3	2.6	11.6	47.4	2.8	2.1	5.5	5.7
T_3	41.5	21.4	2.0	1.4	10.4	44.6	2.1	1.6	4.6	4.4
T_4	55.6	29.0	3.6	3.1	8.4	34.2	2.9	2.3	6.1	6.0
T_5	56.4	31.1	4.2	3.5	12.1	50.5	2.6	2.1	5.7	5.6
T_6	51.3	25.8	3.9	2.8	10.6	43.1	2.9	2.3	4.7	4.3
T_7	43.0	21.4	3.2	2.2	8.3	33.0	2.0	1.5	3.7	3.5
CD (P = 0.05)	2.17	1.83	0.18	0.46	0.45	3.22	0.14	0.09	0.19	0.17

uptake was from 2.0 to 4.8 and 1.4 to 3.8 kg ha^{-1}. The ranges of K uptake by grain and straw were from 8.3 to 13.4 and 33.0 to 53.4 kg ha^{-1} (Table 3). The higher uptake of N, P and K with T_1 (NPKS Mo) may be attributed to high grain and straw yield and concentrations of N, P and K in crop by providing balanced nutritional environment inside the plant, higher photosynthetic efficiency, which favoured higher yields, resulted in more uptake of nutrients (Verma *et al.* 2017, Bonde *et al.*, 2017). By comparison, total uptake of nutrients under nutrient omission treatments appeared to decrease. In general, the lowest uptake of N, P and K were recorded under T_1-N, T_1-P and T_1-K treatments, respectively. Among these omission treatments, P omission had far greater impact on the uptake of nutrients by green gram crop. This was because the P omission strongly depressed the grain and straw production of green gram (Singh *et al.* 2017). The uptake of S by green gram grain and straw was higher with T_1 (NPKS Mo) over control (Table 3). The sulphur uptake was improved by 1.4 kg ha^{-1} by grain and 1.1 kg $ha^{-1}$by straw with NPK + S + Mo over control. This reduction may be attributed to absence of sulphur dose in this treatment. On an average, sulphur uptake by grain and straw increased by 70 and 73.3% with T_1 over control. The minimum values of sulphur uptake by green gram crop were recorded with control which may be ascribed to lower grain and straw yield of green gram with this treatment. The uptake of Mo by green gram grain and straw was significantly higher in the treatment receiving NPK + S + Mo over other treatments. This increase in Mo uptake by green gram crop may be attributed to higher yields and Mo concentrations with Mo application. Similar results were reported by Singh *et al.*(2014) and Lal *et al.*(2016). The uptake of Mo by green gram grain and straw was reduced with T_1-Mo and control. The lowest values of Mo uptake by green gram grain and straw were noted under control treatment, which may be due to low yield of green gramgrain and straw.

Table 4: Effect of various treatments on soil fertility of post harvest soil (mean of 2 years)

Treatment	EC (dSm^{-1})	pH	Orgainc carbon (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})	Available Mo (mg kg^{-1})
T_1	0.48	7.8	4.7	180	10.5	162	22.5	0.07
T_2	0.47	7.9	3.7	125	10.0	155	20.0	0.066
T_3	0.47	7.9	4.3	170	7.5	150	21.5	0.062
T_4	0.49	7.9	4.3	175	9.8	112	22.0	0.070
T_5	0.49	7.8	4.3	160	9.4	146	20.0	0.062
T_6	0.49	7.8	4.2	150	8.8	135	15.0	0.055
T_7	0.47	7.8	3.9	145	8.0	115	15.5	0.035
CD (P = 0.05)	NS	NS	0.02	4.56	0.27	3.59	0.61	0.011

Economics

The net returns and benefit:Cost ratio obtained from green gram were significantly affected by various treatments (Table 2). Application of T_1 (NPKS Mo) resulted in significantly higher net returns of Rs.58766 ha^{-1} with higher B:C ratio (4.94) over control and other treatment. Omission of N resulted in significantly lower net returns of Rs.51300 ha^{-1} as compared T_1 treatment. The highest returns under NPKS Mo (T_1) treatment might be owing to more yields of green gram which led to proportionally higher gross returns than cost of cultivation. Similar results were reported by Singh *et al.* (2013) and Singh *et al.* (2017) in lentil. The minimum net returns and benefit: cost ratio was observed under T_1-P (NKS Mo) treatment which may be attributed to lower yields of green gram grain and straw.

Soil fertility

Soil-pH and electrical conductivity were not significantly affected bt various treatments. It can be inferred that soil properties are not deteriorated by nutrient management practices (Table 4). Use of differentttt nutrient management ptactices caused a marked change in the organic carbon content, The maximum amount of organic carbon in post harvest soil was noticed with T_1 (NPKS Mo) treatment, This increase in organic carbon content may be attributed to addition of organic carbon through crop residue. Omission of nutrients also reduced the organic carbon content as compared to T_1 treatment. The maximum reduction in organic carbon content was noted in optimum dose – N treatment (T_2). The available N status exhibited marked difference due to various treatments. The maximum and minimum values of available N status were recorded under T_1 and T_2 (optimum-N) treatments, respectively. Omissions of other nutrients also reduced the status of available N in post harvest soil as compared to optimum dose of nutrients (NPKS Mo). Available P status recorded marked variation due to various treatments. Highest available P content of 10.5 kg ha^{-1} was recorded in treatment T_1 (NPKS Mo). This treatment was followed by treatment T_4 (optimum dose-K). The lowest available P content (7.5 kg ha^{-1}) was observed under optimum dose-P treatment. Application of optimum dose of NPKS Mo (T_1) showed significantly higher available potassium status. The lowest amount of available K was recordedin treatment T_4 (optimum dose-K). Available S content was affected significantly by variations in the treatments. The lowest and highest amounts of available S content were recorded under optimum dose-S and T_1 (NPKS Mo) treatment, respectively. The status of available Mo in post harvest soil was higher under T_1 which may be attributed to addition of all the nutrients including Mo in optimum amounts in soil. On the other hand, the lowest amount of available Mo was recorded under control.

It may be concluded from the results that balanced use of nutrients (NPK S Mo) might be beneficial under semi arid condition of Agra region of Uttar Pradesh for achieving higher productivity and profitability of green gram. Nitrogen and phosphorus are the most limiting nutrients and their omission resulted in drastic reduction in productivity and profitability of green gram.

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