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Response of green gram (*Vigna radiata*) to fertility levels in acid soil of Nagaland

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ABSTRACT

A field experimental was conducted at Experimental Farm of School of Agriculture Sciences and Rural Development, Nagaland University, Medziphema during kharif season 2017 to study the effect of fertility levels on growth, yield and nutrient uptake of green gram (Vigna radiata L.Wilczek)and soil properties. Nine treatments were evaluated in randomized block design with three replications. Results revealed that the highest plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of grains pod^{-1}, seed, stover and protein yield, nutrients content and their uptake were recorded with 20 kg N+ 50 kg P_2O_5 + 40 kg K_2O + 2 kg B + 656 kg lime ha^{-1}. However, the effect of this fertility level (F_9) was at par with 20 kg N+ 50 kg P_2O_5 + 40 kg K_2O + 656 kg lime ha^{-1} (F_8 fertility level) with regard to seed and stover yield. The F_8 fertility level increased seed, stover and protein yield to the extent of 76.7, 90.6 and 91.6% over control, respectively. Average seed yield under unlimed fertility levels was recorded 506.11 kg ha^{-1}, but average seed yield was recorded 727.62 kg ha^{-1} with application of lime fortified fertility levels. Lime fortified fertility levels enhanced seed yield by 43.8% over unlimed fertility levels. Maximum N, P, K, Ca and B content in seed and stover was recorded with F_9 fertility level except P content in seed. However, difference between F_8 and F_9 fertility levels was at par except for N content in seed and B content. Highest uptake of N, P, K, Ca and B was recorded with F_9 fertility level. The pH, available N, P, K, B and exchangeable Ca contents of the soil increased significantly with application of various fertility levels. However, exchangeable Al and Hand total potential acidity of the soil decreased remarkably with application of lime containing fertility levels.

Key words: Green gram, fertility levels, yield, nutrient uptake, soil properties

INTRODUCTION

Green gram (*Vigna radiata* L.Wilczek) is an important pulse crop of India. Pulses form an integral part of the vegetarian diet of the large population of India, besides being rich source of protein and amino acids; it maintain soil fertility through the process of nitrogen fixation in symbiotic association with *Rhizobium* bacteria which helps in sustaining productivity of agricultural soils. India is the largest producer with more than 54% of world production. There are various reasons for low yield of green gram and balanced nutrient application is one of them. It is well established that for any crop, fertilizer is the most critical input for utilizing the yield potential of improved high yielding varieties. In legumes nitrogen is more useful because it is the main component of proteins and its adequate supply is essential for normal growth and yield. Phosphorus plays a vital role in photosynthesis, respiration, energy storage, energy transfer, cell division, cell elongation, several other processes within plant system and promotes early root formation and helps in atmospheric nitrogen fixation. Potassium status in the soils is uniquely dynamic and elusive and its functions in the plants are complex but not well defined. The deficiency of potassium is becoming nutritional limiting factor in most of the soils.Boron plays a key role in sugar translocation, nitrogen fixation, protein synthesis, sucrose synthesis, cell wall composition, membrane stability and K^+ transporter.Soil acidity is a major problem leading to low crop yields in Nagaland where rainfall is high and leaching of basic cations is prominent. In acid soils there are problems of plant nutrition deficiency (nitrogen, phosphorus, sulphur, calcium, magnesium and molybdenum) and toxicity (aluminium, hydrogen, manganese and iron), due to that majority of crops produce low yield than their potential. Lime application has been recognized as the most important for ameliorating soil acidity which curtails the availability of nutrients in the soil. The quantity of lime depends on the soil type, quality of liming material and crops or cultivars. The liming decreases the toxicity of Al, Mn and increases the supply of N, P, K, S, Ca and Mg to crops. Therefore, an attempt was made to study the

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influence of plant nutrients with and without lime on performance of green gram under acid soil of Nagaland.

MATERIALS AND METHODS

A field experiment was carried out in the Instructional Farm of the SASRD, Nagaland University, Medziphema, Nagaland with green gram (Var. K 851) as the test crop. The experimental soil was sandy loam in texture with pH 5.7,organic carbon 12.3 g kg^{-1} and available N, P and K status 301, 21 and 145 kg ha^{-1}, respectively, available B 0.32 mg kg^{-1}, lime requirement 6.56 t ha^{-1}, total potential acidity 6.9 cmol(p^+) kg^{-1}, exchangeable H, Al and Ca 0.36, 1.29 and 1.12 cmol(p^+)kg^{-1}, respectively. The experiment was laid out in randomized block design with nine fertility levels viz. F_1: control, F_2: 20 kg N ha^{-1},F_3: 20 kg N + 50 kg P_2O_5 ha^{-1}, F_4: 20 kg N + 50 kg P_2O_5 + 40 kg K_2O ha^{-1}, F_5: 20 kg N + 50 kg P_2O_5 + 40 kg K_2O + 2 kg B ha^{-1},F_6: 20 kg N + 656 kg (10% of LR) lime ha^{-1}, F_7: 20 kg N + 50 kg P_2O_5+ 656 kg lime ha^{-1}, F_8: 20 kg N + 50 kg P_2O_5 + 40 kg K_2O + 656 kg lime ha^{-1} and F_9: 20 kg N+ 50 kg P_2O_5 + 40 kg K_2O + 2 kg B + 656 kg lime ha^{-1}. Nitrogen, phosphorus, potassium, boron and lime were applied through urea, single superphosphate, muriate of potash, boric acid and calcium carbonate, respectively and all fertilizers were incorporated into the soil two days prior to sowing of the crop. Seeds were treated with *Rhizobium* culture @ 200g per 10 kg of seed before sowing. The seeds were sown directly to the plots by line sowing on 26th July, 2017 and spacing was maintained at 30 cm for row to row and 15 cm for plant to plant by manual thinning. Weeding was done at regular interval to check the weed growth. The data on plant height, number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds per pod and grain and stover yield were recorded. Plant samples were analyzed for N by Kjeldahl method. Phosphorus, potassium, calcium and boron in plant samples were determined in diacid (HNO_3, $HClO_4$) extract by advocating standard procedures (Jackson, 1973). Nutrient uptake was calculated by multiplying the yield with nutrient content. Plant extracts was used for boron analysis using azomethine-H method (Wolf, 1971). Post harvest soil samples were collected and analyzed for pH, organic carbon, available N, P & K and exchangeable Ca using standard procedures (Jackson, 1973). For available P, soil samples were extracted with Bray P-1 extractant (Bray and Kurtz, 1945) and phosphorus content in soil extract was determined as described by Jackson (1973). Available boron of the soil was determined by azomethine -H method (Baruah and Borthakur, 1997). Exchangeable Al, exchangeable H and total potential acidity were determined by using standard method of analysis described by Baruah and Barthakur (1997). The data were analyzed statistically to compare the treatment effects (Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

Growth and yield

A perusal of data (Table 1) indicates that the plant height and branches per plant increased markedly with application of different fertility levels. Maximum plant height (93.67 cm) and number of branches per plant were recorded with 20 kg N+ 50 kg P_2O_5 + 40 kg K_2O + 2 kg B + 656 kg lime ha^{-1}. On the other hand, the lowest plant height and branches per plant were recorded from control. Inclusion of N, P, K and B with or without lime improved the plant height and branches per plant. Potassium and boron application were more effective when applied with lime. Average plant height of unlimed fertility levels (F_2, F_3, F_4 and F_5) was 71.67 cm, but it was 82.17 cm with lime + fertility levels (F_6, F_7, F_8 and F_9). Unlimed fertility levels improved average plant height by 29.5% over control, while lime fortified fertility levels increased the plant height by 48.5% over control. This increase in plant height might be due to greater uptake of nutrients which helps in producing more protoplasm and thereby enhancing rapid cell division and cell elongation which was exhibited in form of increased plant growth. Similar results were reported by Bansal and Ahmad (2015). Number of pods per plant was affected significantly with N+P+K+B application (F_5) over control. All the fertility levels with lime enhanced number of pods per plant significantly over control. Maximum pods per plant recorded with application of F_9 fertility level, but it was at par with F_8 and F_7 fertility levels. Number of seeds per pod was affected significantly with application of F_8 and F_9 fertility levels over control. However, inclusion of each nutrient in the treatment improved the number of seeds per pod. Lime application increased the nutrient solubility uptake which improved the pod and seed formation. These results are in accordance with those of Kurwasra *et al.* (2006). A critical analysis of the data revealed that fertility levels had significant beneficial effect on seed, stover and protein yield of green gram. All fertility levels enhanced stover and protein yield significantly over control and maximum values were recorded at F_9 fertility level. The F_8 (20 kg N + 50 kg P_2O_5 + 40 kg K_2O + 656 kg lime ha^{-1}) proved optimum fertility level and increased seed, stover and protein yield to the extent of 76.7, 90.6 and 91.6%, respectively over control. Average seed yield under unlimed fertility levels was recorded 506.11 kg ha^{-1}, but it was 727.62 kg ha^{-1} with lime + fertility levels. Phosphorus as well as other nutrients improved the root growth which resulted in more absorption of nutrients from soil for effective dry matter production and translocation of photosynthates from leaves to reproductive parts for better development of seeds (Kumawat *et al.*, 2009 and Patel *et al.*, 2013).

Table 1: Effect of fertility levels on growth and yield of green gram

Fertility levels	Plant height (cm)	Branches $plant^{-1}$	Pods $plant^{-1}$	Grains pod^{-1}	Yield (kg ha^{-1})		
					Seed	Stover	Protein
F_1- Control	55.33	7.67	9.33	7.33	438.59	512.96	87.61
F_2- N	69.00	8.67	10.00	8.33	471.45	527.03	104.13
F_3- N+P	72.00	8.67	10.00	10.00	490.52	558.00	111.47
F_4- N+P+K	72.33	9.33	11.00	10.67	509.27	610.53	117.93
F_5-N+P+K+B	73.33	10.33	12.33	11.00	553.05	671.09	133.50
F_6-N + L	73.33	11.33	13.00	11.00	608.03	789.45	141.61
F_7- N+P+L	74.33	11.33	13.33	11.33	744.48	834.69	162.69
F_8-N+P+K+L	87.33	13.67	15.33	14.33	775.03	977.60	167.87
F_9-N+P+K+B+L	93.67	15.33	15.67	15.00	782.92	994.04	186.11
SEm±	3.82	0.85	0.84	1.35	10.52	8.64	5.43
CD (P=0.05)	11.47	2.56	2.53	4.05	30.10	25.91	16.30

N = 20 kg N ha^{-1}, P = 50 kg P_2O_5 ha^{-1}, K = 40 kg K_2O ha^{-1}, B = 2 kg B ha^{-1}, L= 656 kg ha^{-1}

Nutrients content and their uptake

Nitrogen content in grain and stover of green gram increased significantly by fertility levels (Table 2) over control. Nitrogen content ranged from 3.20 to 3.80% in seed and 1.07 to 1.14% in stover. Maximum N content in seed and stover was recorded with F_9treatment. Total N uptake by green gram enhanced significantly with various fertility levels over control and maximum nitrogen uptake was recorded with F_9. Increase in nitrogen uptake by the crop due to F_9 was 110.7% over control. Significant improvement in nitrogen uptake was recorded with fertility levels along with lime treated plots in comparison to unlimed plots. Phosphorus content of seed and stover improved significantly with fertility levels and highest values were recorded under F_8 and F_9fertility levels, respectively. Phosphorus uptake by green gram increased significantly with fertility levels over control. Maximum P uptake was recorded with F_9fertility level but it was at par with F_8. Phosphorus uptake by green gram enhanced from 1.82 kg ha^{-1} in control to 5.76 kg ha^{-1} at F_9fertility level. Potassium content in seed and stover of green gram increased significantly by fertility levels and varied from 1.13 to 1.28% and 1.28 to 1.40% in seed and stover, respectively. Potassium uptake in green gram increased significantly with the application of fertility levels and maximum K uptake (23.95 kg ha^{-1}) was recorded at F_9. Calcium content and its uptake by green gram increased significantly by fertility levels. All fertility levels with lime increased calcium content significantly over other fertility levels and maximum calcium uptake was recorded with F_9 fertility level. Boron content and its uptake were influenced significantly with fertility levels. Significantly higher boron content was found in boron treated plots (F_5 and F_9). Highest boron uptake was recorded with F_9 fertility level, which increased boron uptake by 131.6% over control. Higher nutrient uptake with fertility levels may be attributed to enhanced crop yield and nutrients content in seed and stover. Similar results were obtained by Nyekha*et al.* (2015) and Kamboj and Malik (2018).

Table 2: Effect of fertility levels on nutrient composition and total uptake of green gram

Fertility levels	N content (%)		P content (%)		K content (%)		Ca content (%)		B content (mg kg^{-1})		N uptake (kg ha^{-1})	P uptake (kgha^{-1})	K uptake (kgha^{-1})	Ca uptake (kgha^{-1})	B uptake (gha^{-1})
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover					
F_1-Control	3.20	1.07	0.27	0.13	1.13	1.28	0.25	0.13	12.48	8.61	19.51	1.82	11.55	1.78	9.90
F_2- N	3.53	1.12	0.29	0.20	1.13	1.29	0.27	0.14	13.62	8.32	22.53	2.43	12.15	2.00	10.79
F_3-N+P	3.63	1.09	0.42	0.22	1.15	1.33	0.27	0.15	13.50	8.63	23.93	3.24	13.05	2.11	11.43
F_4- N+P +K	3.70	1.13	0.40	0.22	1.24	1.39	0.27	0.16	14.07	9.31	25.74	3.41	14.75	2.34	12.86
F_5-N+P+K+B	3.87	1.13	0.40	0.22	1.26	1.40	0.28	0.18	16.23	10.24	28.94	3.68	16.33	2.74	15.84
F_6-N+L	3.73	1.12	0.33	0.15	1.20	1.35	0.35	0.21	13.66	8.63	31.49	3.21	17.92	3.81	15.29
F_7- N + P + L	3.50	1.13	0.41	0.21	1.18	1.36	0.36	0.23	13.20	9.39	35.46	4.94	20.17	4.59	17.64
F_8- N+P+K+L	3.47	1.13	0.43	0.21	1.27	1.39	0.36	0.24	12.83	8.48	37.89	5.39	23.42	5.20	15.56
F_9-N+P+K+B+L	3.80	1.14	0.42	0.25	1.28	1.40	0.37	0.25	15.53	10.83	41.10	5.76	23.95	5.34	22.93
SEm ±	0.06	0.01	0.008	0.02	0.01	0.01	0.01	0.03	0.37	0.28	0.87	0.18	0.28	0.14	0.97
CD (P=0.05)	0.19	0.03	0.02	0.06	0.03	0.05	0.04	0.10	1.12	0.86	2.63	0.54	0.86	0.43	2.92

Soil properties

The pH of the post harvest soil ranged from 5.6 to 6.1 (Table 3). Lime + fertility levels enhanced pH significantly as compared to other fertility levels. Organic carbon content of soil was not affected significantly with various fertility levels. Available N status ranged from 323 to 395 kg ha^{-1}. Highest nitrogen content was reported with F_7fertility level, which increased nitrogen content by 22.9% over control. Phosphorus and lime application enhanced nitrogen fixation which resulted in improved nitrogen status of the soil. Available phosphorus, potassium and boron ranged from 20.5 to 33.2 kg ha^{-1}, 140 to 177 kg ha^{-1} and 0.31 to 0.46 mg kg^{-1}, respectively. Exchangeable calcium content of the soil was affected significantly with fertility levels. Fertility levels + lime (F_6, F_7, F_8 and F_9) enhanced exchangeable calcium. Addition of external input of P, K, boron and calcium might be increased their quantity in the soil. Lime application reduced soil acidity which resulted in increased solubility of phosphorus, potassium and boron. Similar findings have been also reported by Gadi *et al.* (2018). Exchangeable Al, H and total potential acidity of soil reduced significantly with various fertility levels. Lime + fertility levels (F_6, F_7, F_8 and F_9) significantly decreased exchangeable Al, H and total potential acidity over other fertility levels. Average H, Al and total potential acidity of unlimed fertility levels (F_2, F_3, F_4 and F_5) was 0.29, 1.27 and 8.1 cmol(p^+) kg^{-1} while, with lime + fertility levels (F_6, F_7, F_8 and F_9) the values were 0.25, 1.20 and 6.5 cmol(p^+) kg^{-1}, respectively. Lime + fertility levels decreased H, Al and total potential acidity by 13.7, 5.5 and 19.7%, respectively in comparison to unlimed fertility levels.These findings are in accordance with those of Sharma *et al.*(2006).

Table 3: Effect of fertility levels on soil properties and available nutrients

Fertility levels	pH	OC (g kg^{-1})	N (kg ha^{-1})	Ph (kg ha^{-1})	K (kg ha^{-1})	Exch. Ca^{2+} cmol(p+)kg^{-1}	Boron (mg kg^{-1})	Exch. H^+ cmol(p+) kg^{-1}	Exch. Al^{3+} cmol(p+)kg^{-1}	TPA cmol(p+)kg^{-1}
F_1	5.6	12.2	323	20.5	140	1.11	0.31	0.30	1.27	8.1
F_2	5.7	12.2	349	20.0	141	1.13	0.32	0.29	1.26	8.2
F_3	5.6	12.2	365	29.9	143	1.13	0.32	0.29	1.27	8.0
F_4	5.7	12.4	366	28.6	169	1.14	0.32	0.27	1.27	7.9
F_5	5.7	12.3	389	30.1	171	1.15	0.44	0.30	1.27	8.4
F_6	6.1	12.2	393	23.3	150	1.21	0.32	0.26	1.20	6.2
F_7	6.1	12.2	397	30.2	152	1.23	0.34	0.25	1.21	6.8
F_8	6.1	12.4	396	32.6	175	1.23	0.34	0.25	1.20	7.0
F_9	6.1	12.4	395	33.2	177	1.24	0.46	0.26	1.21	6.2
SEm±	0.05	0.05	7.8	0.23	1.2	0.004	0.008	0.007	0.009	0.39
CD (P=0.05)	0.15	NS	23.4	0.69	3.7	0.012	0.02	0.021	0.028	1.06

The results of the present study lead to a conclusion that application of 20 kg N+ 50 kg P_2O_5 + 40 kg K_2O + 2 kg B + 656 kg lime ha^{-1} produced higher seed, stover and protein yield of green gram. The N, P, K, Ca contents and their uptake improved remarkably by fertility levels. Available N, P, K, Ca and B status of the post harvest soil also improved with fertility levels. Lime + fertility levels increased soil pH and reduced exchangeable Al, H and total potential acidity remarkably. Hence, application of 20 kg N+ 50 kg P_2O_5 + 40 kg K_2O + 656 kg lime ha^{-1} may be recommended for better yield of green gram in Nagaland.

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