Biological Forum – An International Journal **15(7): 256-260(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Phosphorus and Potassium Fertilization with different Levels on the Growth and Yield of Summer Green gram (*Vigna radiate* L.) varieties

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The field experiment was conducted at the experimental research farm of the School of Agricultural Science (SAS), Medziphema campus, Nagaland University (Nagaland), India.

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(Received: 20 April 2023; Revised: 09 May 2023; Accepted: 28 May 2023; Published: 05 July 2023)
(Published by Research Trend)

ABSTRACT: Green gram, an important legume crop cultivated globally, relies on adequate phosphorus (P) and potassium (K) for optimal growth, development, and yield. However, determining the appropriate fertilization rates for maximizing green gram productivity remains a challenge. Thus, this research aimed to identify suitable P and K fertilization rates for green gram under Nagaland soil conditions, as well as evaluate different varieties. The study employed a factorial randomized block design replicated thrice. The experiment consisted of two factors: green gram varieties (cv. IPM02-3, cv. SGC-20, and cv. SGC-16) and combined P and K fertilizers applied at varying rates (40, 50, and 60 kg/ha each of P_2O_5 and K_2O). Increasing P and K fertilization rates resulted in a linear increase in growth attributes, yield, and stover yield. The highest seed yield was obtained with the application of 60-60 kg/ha P_2O_5-K_2O. Nonetheless, the 50-50 kg/ha P_2O_5-K_2O treatment yielded 48.7% higher than the control, demonstrating statistical similarity with the highest yield. Among the varieties, IPM 02-3 outperformed the other tested varieties. These findings contribute valuable insights for optimizing green gram production by guiding appropriate fertilization practices and variety selection.

Keywords: Green gram, Growth, Levels, Phosphorus, Potassium, Yield.

INTRODUCTION

Green gram (*Vigna radiata* L.) or mung bean, believed to be originated in the Indian sub-continent is an important crop grown in Indian due to its rich protein source, short duration and its ability to enhance soil fertility. It can be grown as a sole crop or mixed crop as a pulse or as a green manure crop and also for forage purpose. The draught resistance capacity allows green gram to be grown on residual moisture of preceding crops or as a catch crop. This is why green gram is considered one of the most important pulse crop grown in India (Sahu *et al.*, 2021). Increasing the production and productivity of this crop depends on various management strategies and among these, the use of better genotypic traits of the crop plays a crucial role. It may be mentioned that the use of old varieties with less input under various abiotic and biotic stresses may bring down the yield of the crop. Therefore, the use of better yielding varieties under different management may help to increase the production of green gram.

Fertilization is an important aspect of crop production. Green gram being a leguminous plant is self-sufficient in nitrogen (N) through the process of biological nitrogen fixation. Thereby, leaving phosphorus and potassium as the limiting major nutrients. The current scenario of Indian soil fertility is such that 85-90% of soils in India have low–medium phosphorus levels and 90% have medium–high levels of available potassium (Muralidharudu *et al*., 2011). Phosphorus is essential in plant's optimal development and reproduction. It is a major component of several energy-rich nucleotides that are involved in energy transfer. Inorganic phosphate (pi) acts as a primary substrate in the conversion of atmospheric carbon to simple sugar during the process of photosynthesis, which is the utmost source of food for all plant species (Carstensen *et al.*, 2018). Phosphorus also triggers early root growth and promotes the activity of *rhizobia* that results in enhanced N-fixation in green gram. The role of potassium in plants has often been overlooked. However, its impact on the growth and development is immense. Potassium is a co-factor of many enzymes and activates more than 60 enzymes that are linked to various plants' physiological and biological processes. Potassium is involved in the transportation of photosynthates to the storage organs of plants. It also enhances the production of protein, and green gram being a protein-rich pulse requires an adequate potassium supply. Increased water use efficiency, resistance to lodging, and enhanced resistance to biotic and abiotic stress are some of the many roles that potassium plays in plants (Johnson *et al.*, 2022).

Under Nagaland's condition, scant work has been done on phosphorus and potassium in green gram. Therefore, against this backdrop, an investigation was attempted to develop an optimum rate of phosphorus and potassium fertilization and its influence on the growth and yield of green gram and to check the performance of varieties under Nagaland conditions.

MATERIALS AND METHODS

The field experiment was conducted during the summer season of 2021 in the experimental farm of School of Agricultural Research and Rural Development (SASRD), Nagaland University, Medziphema campus (25° 45' 4' ' N latitude, 95° 53' 0' ' E longitude and 310 meters above mean sea level). It lies in the sub-humid tropical climatic zone with short-duration rainfall during the summer season (about 200mm from April to July) and daily mean maximum (30.3-35.6°C) and minimum (17.7-24.5°C) temperature during summer. The soil was acidic with pH 4.6, organic carbon (OC) (1.05%) and low availability of N (250.88 kg/ha), and medium availability of P_2O_5 (32.81 kg/ha) and K_2O (144.64 kg/ha). The experiment was subjected to factorial randomized block design with three replications to evolve a suitable phosphorus (P) and potassium (K) rate *i.e.*, F_0: control, F_1: 40:40 kg/ha P_2O_5:K_2O, F_2: 50 kg/ha P_2O_5:K_2O and F_3: 60 kg/ha P_2O_5:K_2O. In combination with the levels of phosphorus and potassium, three green gram varieties were tested; G_1: IPM 02-3, G_2: SGC-20 and G_3: SGC-16 with total of 36 plots and plot size 4×3m. All fertilizers along with 20kg/ha N in each plot were applied as basal. Uniform cultural practices were maintained for all the treatments. The data were subjected to analysis of variance using XLSTAT 2022.5.1 (1386) in Microsoft Excel 16.0.15831 (64bits) and the treatment were compared at significance level of 5% ($P \leq 0.05$) after analysis by least significant difference. The same software was employed for the analysis of correlation and regression.

RESULTS AND DISCUSSION

Growth Parameters:

*Effect of varieties***:** The effect of varieties was clearly observed on the plant growth parameters such as plant height, number of branches, dry matter production and leaf area index (LAI)as given in Fig. 1. The variety IPM 02-3 registered the highest plant height, dry matter production. This may be because of greater genetic capacity of IPM 02-3 to exhibit better growth parameters. Also, due to higher plant height, a greater number of branches and leaves contributed to higher dry matter production. Similar findings were reported by Dayanand *et al*. (2019).

*Effect of Phosphorus and potassium***:** Under different doses of phosphorus and potassium, application of F_3: 60:60 kg/ha P_2O_5:K_2O recorded the highest plant height, no. of branches and LAI but was statistically similar with F_2: 50:50 kg/ha P_2O_5:K_2O. This could be explained as the higher amount of nutrients applied to soil leading to increased available nutrients in the pool resulting in better uptake of nutrients by plants that helped the plants to exhibit higher growth attribute values. Similar findings were reported by Anand *et al.* (2022); Nikhitha *et al.* (2023). Phosphorus enhances cell division and cell expansion. This, along with the synergistic effect of potassium on increasing enzymatic activities may have resulted in increased growth attributes as a result of increased fertilization.

Phenological attributes

*Days to 50% Flowering and maturity***:**

Effect of varieties: Among the varieties, IPM 02-3 (G_1) recorded the shortest days to 50% flowering (54.67 days) and maturity (70.67 days), whereas variety SGC-16 (G_3) recorded the longest days to 50% flowering (58.42 days) and maturity (72.33 days). The variety IPM 02-3 might have the genetic potential to flower earlier and mature faster leading to an early harvest.

Effect of Phosphorus and potassium: Data on days to 50% flowering and maturity is given in Table 1. No significant difference on days to 50% flowering was observed due to P and K fertilization. Application of60:60 kg/ha P_2O_5:K_2O recorded the shortest days to maturity (70 days) which was statistically similar with the application of F_2: 50:50 kg/ha P_2O_5:K_2O. This may be due to the influence of phosphorus and potassium on early seedling establishment. The longest days to maturity (73.44 days) was recorded in control. (F_0).

Yield:

Effect of varieties: The different varieties significantly affected seed yield. The highest seed yield of 545.17 kg/ha was obtained under the variety cv. IPM02-3, which was 7.1% and 24.5% higher than cv. SGC-20 and cv. SGC-12 respectively. These findings are similar to that of Talukdar *et al.* (2020), where IPM 02-3 showed higher seed yield than SGC-16 and SGC-20. Parallel results were documented by Kumari and Chakraborty (2019).

Effect of Phosphorus and potassium: From the data given in Table 1, it is evident that there is a linear increase in yield and yield attributes with increased fertilization rate of phosphorus and potassium.

Compared to control, a significant increase was observed concerning seeds pod^{-1}, seed yield and stover yield with P and K fertilization. The highest seed yield and stover yield were observed at 60:60 kg/haP_2O_5:K_2O application; 584.94 kg/ha and 1451.84 kg/ha respectively and recorded an increment of around 51.5% and 32% respectively over no application of P and K fertilization. 50:50 kg/haP_2O_5:K_2O gave statistically similar values as that of F_3. This may be because the application of 50 kg/ha of P_2O_5 and K_2O each might be sufficient for the plant to execute its best performance. This was supported by the findings of Anand *et al.* (2022). No application of P and K fertilization recorded the lowest seed and stover yield. As seed and stover yield is a result of an interplay of growth and yield contributing attributes, a healthy plant leads to absorption of larger nutrients from the adequate supply of nutrients, eventually leading to increased output. Singh (2017); Singh *et al.* (2019) reported similar findings.

Correlation analysis. The data on correlation is given in Table 2. From the data we can see a significant correlation of plant height at 40 DAS (0.81), plant height at harvest (0.66), leaf area index at 45 DAS (0.85), leaf area index at 60 DAS (0.85), dry matter accumulation at 45 DAS (0.72), dry matter accumulation at 60 DAS (0.76), seeds per pod (0.78) and stover yield (0.87) with seed yield. This suggests a strong positive correlation of seed yield with the growth and yield attributes *i.e.*, an increase in seed yield is directly or indirectly related to an increase in these factors. The relationship between yield attributes and seed yield is given in Fig. 2. Pods plant^{-1}, Seeds pod^{-1} and stover yield significantly affected the seed yield of green gram under study to an extent where it could explain 71.7%, 61.8% and 76.9% variations and contribution towards seed yield respectively. Higher the number of pods plant^{-1}, the higher will be the seeds pod^{-1} resulting in increased seed yield.

Soil fertility analysis. Data on soil fertility status after experimentation is given in Table 3. It is evident that P and K fertilization had little to no change in the pH and OC of the experimental soil. However, a gradual increase in the levels of N, P_2O_5, and K_2O was associated with the increased rate of P and K fertilization. Thus, in addition to having an impact on the crop's development and yield, phosphorus and potassium also significantly improved the soil's fertility status.

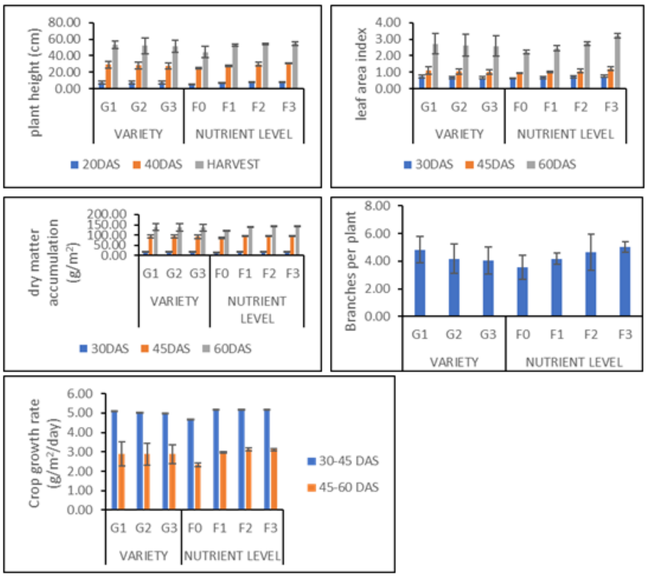

Fig. 1. Plant height (cm), dry matter accumulation (g m^{-2}), leaf area index, branches plant^{-1} and crop growth rate (g m^{-2} day^{-1}) as influenced by variety and phosphorus and potassium fertilization. *Error bar indicates S Em ±.

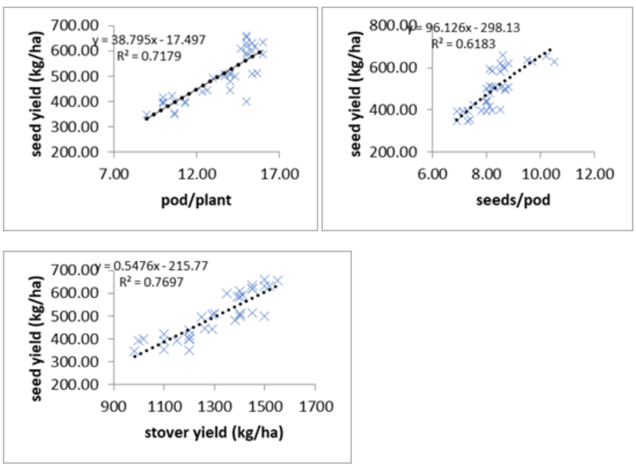

Fig. 2. Relationship of pods plant^{-1}, seeds pod^{-1} and stover yield with seed yield of green gram.

Table 1: Phenological attributes, yield attributes and yield as influenced by variety and phosphorus and potassium fertilization.

Treatment	Seed Pod^{-1}	Seed Yield (Kg/ha)	Stover Yield (Kg/ha)	Harvest Index (%)	Days To 50% Flowering	Days to Maturity
G_1	8.85^{a}	548.08^{a}	1343.6^{a}	28.82^{a}	54.67^{a}	70.67^{b}
G_2	7.92^{b}	508.76^{b}	1287.5^{ab}	28.14^{a}	57.67^{b}	72.00^{ab}
G_3	7.91^{b}	437.90^{c}	1280.2^{b}	25.42^{b}	58.42^{b}	72.33^{a}
LSD ($P \leq 0.05$)	0.271	10.165	56.663	0.855	0.759	1.596
F_0	7.41^{d}	386.08^{c}	1099.99^{c}	26.03^{b}	57.22^{a}	73.44^{a}
F_1	7.98^{c}	447.69^{b}	1237.78^{b}	26.51^{b}	57.00^{a}	71.67^{ab}
F_2	8.40^{b}	574.29^{a}	1425.56^{a}	28.65^{a}	56.89^{a}	71.56^{b}
F_3	9.14^{a}	584.94^{a}	1451.84^{a}	28.68^{a}	56.56^{a}	70.00^{b}
LSD ($P \leq 0.05$)	0.313	11.737	65.429	0.987	0.877	1.843

*Note: different letters after the value within column indicate significantly different from each other, according to least significant difference at 5% probability level.

Table 2: Correlation between growth and yield parameters.

Variables	PH40	PHH	LAI45	LAI60	DM45	DM60	Days to maturity	50% flowering	Seed per pod	Stover yield	Seed yield
PH40	1										
PHH	0.780**	1									
LAI45	0.816**	0.581**	1								
LAI60	0.869**	0.678**	0.951**	1							
DM45	0.788**	0.798**	0.574**	0.699**	1						
DM60	0.822**	0.833**	0.641**	0.745**	0.961**	1					
Days to maturity	-0.500**	-0.432**	-0.642**	-0.622**	-0.499**	-0.527**	1				
50% flowering	-0.313	-0.270	-0.411*	-0.272	-0.227	-0.181	0.417*	1			
Seed per pod	0.765**	0.631**	0.819**	0.813**	0.710**	0.686**	-0.706**	-0.558**	1		
Stover yield	0.914**	0.740**	0.823**	0.861**	0.784**	0.824**	-0.527**	-0.247	0.770**	1	
Seed yield	0.861**	0.668**	0.856**	0.852**	0.725**	0.765**	-0.611**	-0.478**	0.786**	0.877**	1

Note: PH40: plant height at 40DAS; PHH: plant height at harvest; LAI45: leaf area index at 45DAS; LAI60: leaf area index at 60DAS; DM45: dry matter accumulation at 45DAS; DM60: dry matter accumulation at 60DAS. *Significant at Probability level 5%; **Significant at probability level 1%.

Table 3: Soil Nitrogen (kg/ha), phosphorus (kg/ha), potassium (kg/ha) and soil organic carbon (%) as influenced by variety and phosphorus and potassium fertilization.

Treatment	Available soil nitrogen	Available soil phosphorus	Available soil potassium	Soil organic carbon
G_1	266.67^{a}	38.91^{a}	148.70^{a}	1.01^{a}
G_2	264.00^{a}	39.35^{a}	148.01^{a}	1.02^{a}
G_3	262.50^{a}	39.16^{a}	147.09^{a}	1.00^{a}
S.Em ±	1.303	0.163	0.464	0.108
LSD ($P \leq 0.05$)	4.433	0.553	1.578	0.060
F_0	251.44^{b}	31.20^{b}	137.79^{c}	1.02^{a}
F_1	260.00^{b}	37.82^{b}	146.67^{b}	1.04^{a}
F_2	270.56^{a}	43.45^{a}	153.25^{a}	1.00^{a}
F_3	275.56^{a}	44.07^{a}	154.01^{a}	0.98^{a}
S.Em ±	1.505	0.188	0.536	0.020
LSD ($P \leq 0.05$)	5.119	0.639	1.822	0.069

*Note: different letters after value within column indicate significantly different with each other according to least significant difference at 5% probability level.

CONCLUSIONS

Results from the study gave a hint that different fertilization rates of phosphorus and potassium had varying degrees of interaction with the crop leading to different outcomesconcerning growth and yield. Application of P and K nutrientshad a positive role in increasing the plant attributes such as plant height, LAI, and dry matter which in turn had a positive correlation with seed yield and stover yield. It can be concluded that increasing the fertilizer doses of phosphorus and potassium to 60 kg/ha to boost the production need not necessarily be done as 50 kg/ha could bring almost better crop performance and also increase profitability. Further, the adoption of green gram cv. IPM 02-3 under Nagaland conditions in the summer season will be beneficial owing to the better adaptability.

FUTURE SCOPE

Further research on the impact of soil properties and nutrient interactions on fertilisation rates would contribute to a deeper comprehension of nutrient management in the cultivation of green gramme in Nagaland. Valid recommendations can be derived by conducting a long-term experiment that examines the response of green gram to varying levels of phosphorus and potassium across multiple sites.

Acknowledgement. I would like to express my heartfelt gratitude to the department of Agronomy, School of Agricultural Sciences and Rural Development, as well as to Professor Tongpang (Head of Department), Dr. Debika Nongmaithem (Supervisor), and my advisory committee for granting me the opportunity to carry out my research and for their unwavering guidance throughout the duration of my study.
Conflict of Interest. None.

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How to cite this article: N. Anthony Baite, D. Nongmaithem, Saya D., Sentisuba and Imnatenjen Aier (2023). Phosphorus and Potassium Fertilization with different Levels on the Growth and Yield of Summer Green gram (*Vigna radiate* L.) varieties. *Biological Forum – An International Journal, 15*(7): 256-260.