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Effect of phosphorus and potassium fertilization on summer greengram (*Vigna radiata*) varieties

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Pulses are of utmost importance in addressing the issue of global food security and promoting sustainable agricultural practices. Among the various options, greengram (*Vigna radiata* L.) is noteworthy due to its nutritional composition, brief growth period, and capacity to enhance soil fertility via nitrogen fixation. India has an estimated area coverage of 46 lakh ha under greengram cultivation and out of which, Nagaland occupies a mere 0.002 lakh ha (DPD 2021). Improving the productivity of greengram is crucial in order to address the growing need for protein-rich food and to promote stability within the agricultural ecosystem. The effective management of nutrients, specifically phosphorus (P) and potassium (K) plays a crucial role in attaining maximum crop productivity and enhancing crop quality (Singh 2017, Sahu *et al.* 2020). Phosphorus plays a crucial role in facilitating energy transfer, photosynthesis, and root development (Sahu *et al.* 2021) whereas potassium governs water absorption, enzyme activation, and the overall vigor of plants (Kumar *et al.* 2022). The complex interplay between different cultivars of crops and essential nutrients has a significant impact on the overall growth, development, and productivity of plants. The importance of tailored management practices to fully optimize the potential of different varieties becomes evident when considering their response to varying nutrient levels.

The present study was carried out in the School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland during the summer of 2021, with the dual objectives of evaluating the performance of different summer greengram varieties and investigating the impact of phosphorus and potassium levels on their growth and yield. Additionally, the economic feasibility of the various treatments was assessed. The research was carried out during the April–July of 2021. The field was laid out in factorial randomized block design with a total of 36 plots with plot size 4 m × 3 m. The mean maximum, minimum temperature, rainfall and relative humidity during the experimental period was 33.1°C, 21.6°C, 22.26 mm and 71.95%, respectively. The initial status of soil indicates medium available nitrogen (250.88 kg/ha), P_2O_5 (32.81 kg/ha) and K_2O (144.64 kg/ha) with high carbon (1.05%) and acidic soil. The experiment consisted of three greengram varieties, viz. G_1: IPM 02-3, G_2: SGC-20 and G_3: SGC-16 which were treated with four doses of phosphorus and potassium, i.e. F_0, control; F_1, 40 kg P_2O_5 + 40 kg K_2O; F_2, 50 kg P_2O_5 + 50 kg K_2O and; F_3, 60 kg P_2O_5 + 60 kg K_2O per hectare. All fertilizers were applied at the time of sowing in a single dose in furrows. Urea was applied in all plots @20 kg/ha. The data were subjected to statistical analysis appropriate to the design by following the procedure laid out by Gomez and Gomez (1984).

Growth attributes: A consistent increase was observed in plant height as the crop advanced (Table 1). Among the varieties, IPM 02-3 exhibited the tallest plants (28.98 cm at 45 DAS and 53.09 cm at harvest), followed by SGC-20 (28.21 cm and 51.93 cm) and SGC-16 (27.64 cm and 51.79 cm). The application of fertilizer had a positive impact on plant height, with all treatments showing higher heights compared to the control. Notably, the highest height (30.73 cm at 45 DAS and 54.87 cm at harvest) was achieved with the 60 kg/ha P_2O_5 and K_2O treatment, which was statistically comparable to the 50 kg/ha P_2O_5 and K_2O treatment at 45 DAS. Interestingly, at harvest, all fertilizer treatments yielded similar plant heights, except for the control. Leaf area index (LAI) exhibited different trends. At 45 DAS, there were no significant effects of variety or phosphorus and potassium levels on LAI. However, by 60 DAS, IPM 02-3 outperformed the other varieties, and all phosphorus and potassium treatments demonstrated statistical differences. The highest LAI was achieved with the application of 60 kg/ha P_2O_5 and K_2O. A gradual increase in dry matter was

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Table 1　Effect of variety and different doses of phosphorus and potassium on growth and yield

Treatment	Plant height		Left area index		Dry matter production (g)		Branches/ plant	Seeds/ pod	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
	40 DAS	Harvest	45 DAS	60 DAS	45 DAS	60 DAS						
G_1	28.98^a	53.09^a	1.10^a	2.73^a	94.64^a	137.98^a	4.64^a	8.85	28.00^a	5.48^a	13.43^a	28.82^a
G_2	28.21^b	51.93^a	1.05^a	2.64^b	93.68^a	136.93^b	4.17^a	7.92	27.01^b	5.08^b	12.87^{ab}	28.14^a
G_3	27.64^b	51.79^a	1.02^a	2.59^c	93.04^a	136.14^b	4.05^a	7.91	26.60^b	4.37^c	12.80^b	25.42^b
F_0	25.01^c	44.56^b	0.96^a	2.22^d	85.44^b	120.38^b	3.56^a	7.41	25.26^d	3.86^c	10.99^c	26.03^b
F_1	27.57^b	53.08^a	0.99^a	2.46^c	96.01^a	140.42^c	4.17^a	7.98^a	26.47^c	4.47^b	12.37^b	26.51^b
F_2	29.79^a	54.37^a	1.07^a	2.74^b	96.90^a	143.82^a	4.40^a	8.40^a	27.61^b	5.74^a	14.25^a	28.65^a
F_3	30.73^a	54.87^a	1.21^a	3.21^a	96.80^a	143.46^a	5.02^a	9.14^a	29.47^a	5.84^a	14.51^a	28.68^a

Means with the same letters in column are not significantly different as per Duncan's multiple range test.
Refer to the methodology for treatment details.

observed in the initial growth phase, intensifying as the crop transitioned to the reproductive stage. At 45 DAS, variety had no significant effect on dry matter, and all phosphorus and potassium treatments were comparable, except for the control. By 60 DAS, IPM 02-3 showcased superior performance and the 50 kg/ha P_2O_5 and K_2O treatment displayed significantly higher dry matter accumulation compared to F_0 and F_1, though it was at par with F_3. Branches per plant did not exhibit significant differences due to variety or fertilizer application. The varying responses in plant height, LAI, dry matter accumulation, and branches per plant could be attributed to the genetic traits of each genotype, coupled with the combined influences of phosphorus and potassium. These factors play pivotal roles in processes such as photosynthesis, cell division, cell enlargement, sugar accumulation and energy storage. Similar findings were also reported by Awomi *et al.* 2012, Gadi *et al*. 2018, Bagadkar *et al*. 2020, Kharkongor and Dhamak 2020.

Yield attributes: Data as presented in Table 1 showed the influence of variety and phosphorus and potassium fertilization on yield and yield attributes. Variety IPM 02-3 displayed highest values over other varieties in terms of seeds/pod, test weight, seed yield, stover yield and harvest index. However, it was found to be at par with SGC-20 in terms of stover yield and harvest index. No significant difference on seeds per pod was observed among the varieties. All phosphorus and potassium treatment recorded significantly higher yield attributes compared to control except for seeds per pods, where no significant difference was observed due to P and K fertilization. Application of 60 kg/ha P_2O_5 and K_2O recorded the highest seed/pod (9.14), test weight (29.47 g), seed yield (5.84 q/ha), stover yield (14.51 q/ha) and harvest index (28.64%). This was, however, statistically similar with the application of 50 kg/ha P_2O_5 and K_2O in attributes including seed yield, stover yield and harvest index. The variation in yield attributes as an

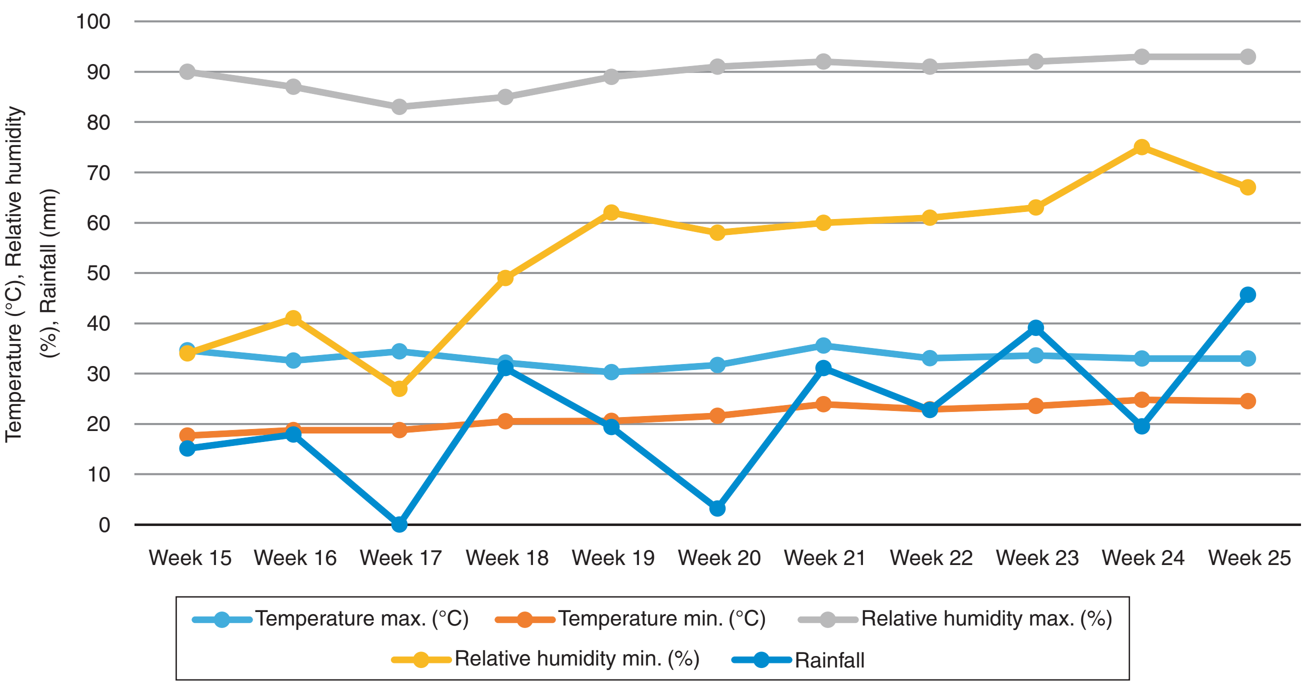

Fig 1　Meteorological observations during the period of experiment (April to July).

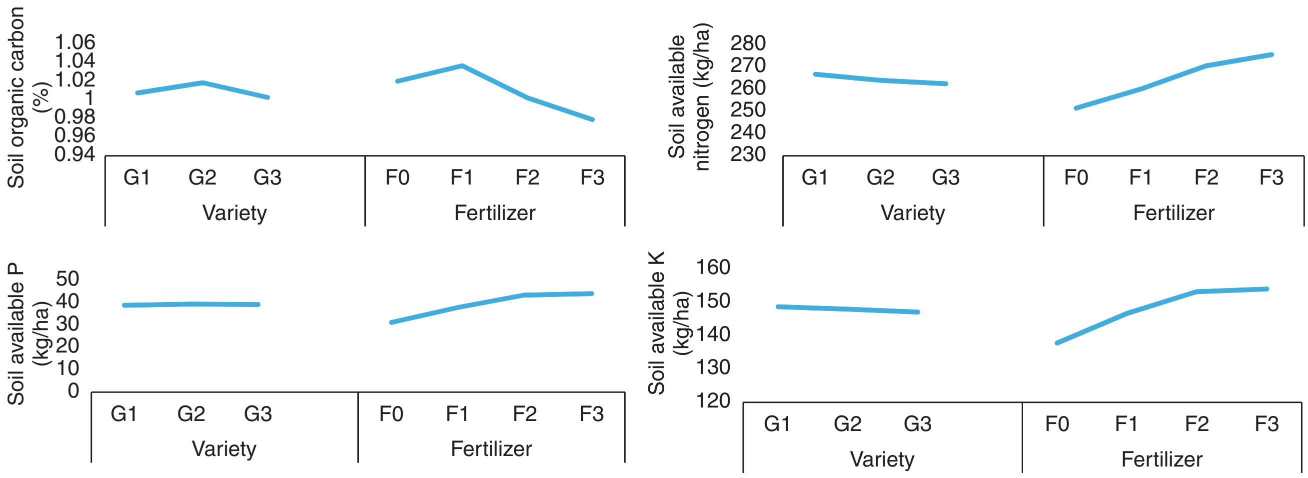

Fig 2 Effect of variety and doses of phosphorus and potassium on soil nutrient dynamics. Refer to the methodology for treatment details.

influence of variety and phosphorus and potassium could be attributed to the genetically superiority and adaptive capability of the varieties to the local condition, along with the role of phosphorus and potassium in early seed germination, seedling establishment, shoot, flower and seed development. This was supported by the findings of Ranpariya *et al*. (2017), Singh *et al*. (2018), Bhabai *et al.* (2019).

Soil nutrient status and yield: Fig 2 portrays the data pertaining to soil nutrient level as influenced by varieties and different doses of phosphorus and potassium. Additionally, Fig 3 offers a graphical representation of the intricate relationship between soil available nutrients and the yield of greengram varieties. No significant effect of variety on the overall nutrient status was observed during investigation. Meanwhile, P and K levels had a significant effect on soil nitrogen, phosphorus, and potassium content over control. It is evident that a steady incline in the soil nutrient curve is observed with increase in P and K levels, except in the case of organic carbon, which follows a decline curve (Fig 2). Notably, an observable trend emerges (Fig 3), characterized by a consistent upward trajectory in the seed yield curve as soil available nitrogen and potassium levels increase.

Nutrient use efficiency: The data on partial factor productivity presented in Table 2 indicates that the highest seed yield per kg of nutrient applied (11.49 seed yield/kg each of P_2O_5 and K_2O) is observed with treatment F_2 (Since the level of P_2O_5 and K_2O is same, a separated table is not provided and the value is the individual effect of each fertilizer rate and not a combined effect of P and K). This was followed by F_1 and F_3. This suggests that optimal

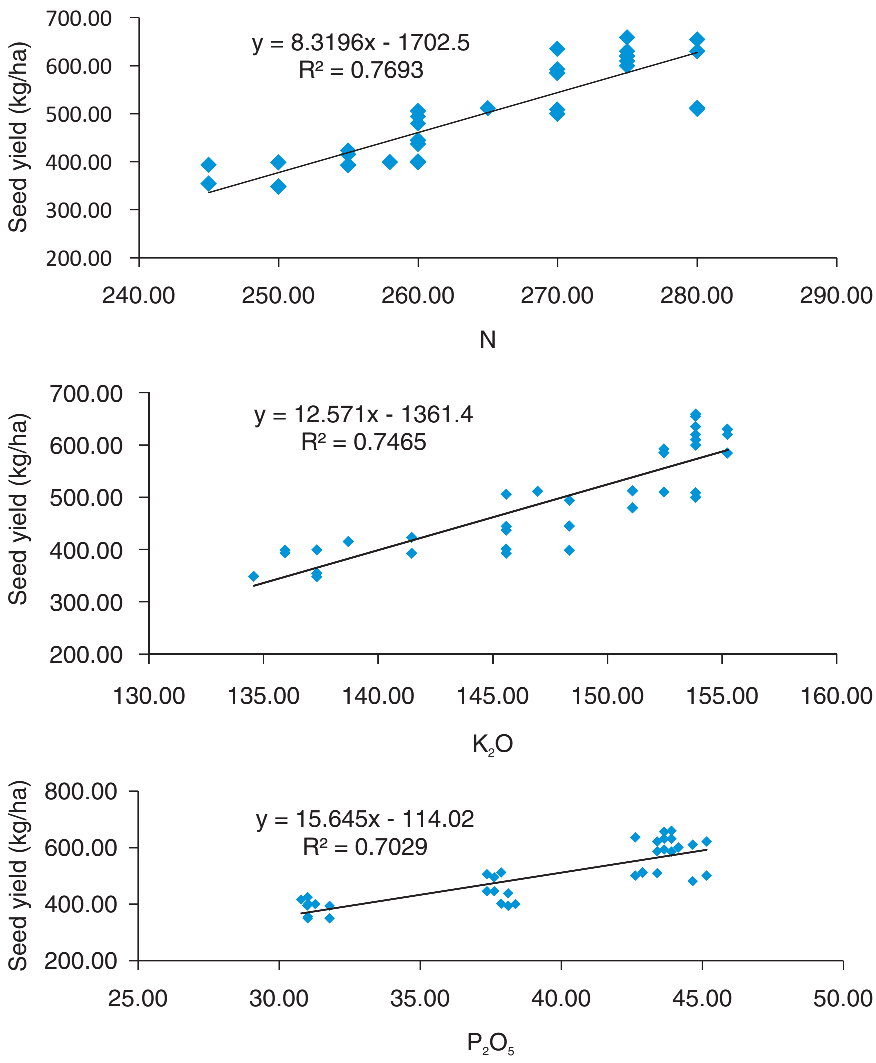

Fig 3 Relation between soil available nutrient and seed yield of greengram.

Table 2 Partial factor productivity (PFP) and economics of treatments

Partial factor productivity (kg yield/kg nutrient applied)					Net return (₹/ha)					B:C ratio				
Nutrient × Variety	G_1	G_2	G_3	Mean PFP	Nutrient × Variety	G_1	G_2	G_3	Mean net return	Nutrient × Variety	G_1	G_2	G_3	Mean B:C ratio
F_0	0.00	0.00	0.00	0.00	F_0	21597	19712	14785	18698^{c}	F_0	0.89	0.82	0.61	0.77^{c}
F_1	12.59	11.05	9.93	11.19	F_1	30848	24075	19117	24680^{b}	F_1	1.23	0.96	0.76	0.98^{b}
F_2	12.76	11.75	9.95	11.49	F_2	45466	39908	29982	38452^{a}	F_2	1.80	1.58	1.19	1.52^{a}
F_3	10.64	10.17	8.44	9.75	F_3	45317	42164	30788	39423^{a}	F_3	1.78	1.66	1.21	1.55^{a}
Mean PFP	9.00	8.24	7.08		Mean net return	35807^{a}	31465^{b}	23669^{c}		Mean B:C ratio	1.42^{a}	1.25^{b}	0.94^{c}	

Means with same letters in column and in row, indicate not significantly different as per Duncan's multiple range test. Refer to the methodology for treatment details.

nutrient utilization is achieved with 50 kg/ha P_2O_5 and K_2O, underscoring its efficiency.

Economics of treatment: Data on economics of treatment is presented in Table 2. Among the different varieties examined, it is evident that IPM 02-3 stands out with the highest net return of ₹35807.00 and B:C ratio of 1.43. Following closely, SGC-20 showcases net returns of ₹31464 and a B:C ratio of 1.25, while SGC-16 records net returns of ₹23668 and a B:C ratio of 0.94.

When evaluating the impact of different phosphorus and potassium levels, the application of 60 kg/ha P_2O_5 and K_2O yields the highest net return of ₹39423 and an elevated B C ratio of 1.55. Interestingly, application of 50 kg/ha P_2O_5 and K_2O produces similar financial outcomes. The parity in net return and B:C ratio achieved with the 50 kg/ha P_2O_5 and K_2O application suggests that an optimal balance can be struck without the need for the higher nutrient dosage.

SUMMARY

This experiment suggests that the utilization of the greengram variety IPM 02-3 is advantageous due to its superiority in terms of performance and adaptability over other varieties investigated. Additionally, application of 50 kg/ha P_2O_5 and K_2O demonstrates comparable performance and profitability to application of 60 kg/ha P_2O_5 and K_2O, making it an economically favourable option. Soil fertility analysis revealed P and K's role in enhancing nutrient dynamics. The relation between soil nutrient levels and greengram yield underscores the multifaceted relationship. In summary, genetic factors, coupled with optimal nutrient management, synergistically affect the growth and yield of greengram.

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