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Performance of green gram [*Vigna radiata* (L.) Wilczek] as influenced by Integrated nutrient management under rainfed conditions

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ABSTRACT

The present investigation was undertaken in the experimental field of Department of Agronomy, School of Agricultural Sciences, Nagaland University, Medziphema, Nagaland during kharif season of 2022 to assess the effect of integrated nutrient management on the performance of green gram. The experiment was carried out with triplicates in a completely randomized block design with seven treatments: Recommended dose of fertilizer (T_1), 75% RDF + 25% FYM (T_2), 50% RDF + 50% FYM (T_3), 25% RDF + 75% FYM (T_4), 75% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed (T_5), 50% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed (T_6), 25% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed (T_7) along with control. The soil of experimental area was high in organic carbon, low in available Nitrogen and Phosphorus and high in available Potassium. Results revealed that significant increase in growth, yield attributes and yield of green gram were recorded with the application of 75% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed over other treatments. The gross returns, net returns and benefit: cost ratio was also higher under 75% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed. Hence, integrated nutrient management could be more effective in augmenting mungbean growth, yield and could fetch the most profitable returns in the hills of Nagaland in the summer season.

Keywords: Economics, Green gram, Integrated nutrient management, Phosphotika, Rhizobium, Yield

INTRODUCTION

Pulses has been an important component of Indian agriculture enabling the land to restore fertility by fixing atmospheric nitrogen and adding organic matter through leaf fall and root biomass (Tomar *et al.,* 2023). Green gram [*Vigna radiata* (L.) Wilczek] is third most important leguminous crop after chick pea and pigeon pea that belongs to the family Fabaceae and subfamily Papilionaceae, with the chromosome number 2n= 2x = 22. India is its primary origin and is mainly cultivated in East Asia, South East Asia and Indian subcontinent, and occupies nearly 16 per cent of the total pulse area in India. It is not only rich in protein (20-25%) but its low fat and high fiber content adds to its nutritive value, better palatability, high market price and easy digestibility (Kumar *et al.,* 2022). Despite having numerous benefits, mung bean productivity is decreasing annually for a variety of reasons. In India during 2023-24, about 15.93 lakh ha (39.38 lakh acres) area was covered under greengram as against 15.57 lakh ha (38.47 lakh acres) during the same period in 2022-23. According to Government 3rd advance estimates, greengram production in 2022-23 is at 3.74 million tons (Green gram outlook, 2023). By implementing low-cost sustainable production technology its productivity can be enhanced. Integrated nutrient management includes the intelligent use of organic, inorganic and biological sources so as to sustain optimum yields, improve or maintain the soil physical and chemical properties, and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Mishra *et al.,* 2022). There is tremendous pressure on growers to use integrated nutrient management approach to increase productivity and sustain soil health. Organic amendment offers an alternative or supplementing control tactic to increase production (Meena *et al.,* 2015). Bio-fertilizer such as *Rhizobium* is used for growing good quality pulse produce. Most of bio-fertilizers are found beneficial in the crop

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production; they are named as *Azotobactor, Azospirillum*, Blue Green Algae (BGA) and *Rhizobium. Rhizobium* sp. in the presence of phosphorus not only fixes more nitrogen through an increased number of nodules but also considerably enhances the protein content, dry matter, and seed yield of various legume crops. This bacterial inoculation has ability to fix atmospheric nitrogen in association with plants forming nodules in roots. They belong to the family of rhizobiaceae which are symbiotic in nature and fixes nitrogen @50-100 kg ha^{-1} in association with legumes only (Mishra *et al.,* 2012). Being a legume crop, it necessitates less nitrogen, but phosphorus application is an important input for higher yields per unit area. Keeping these above facts in view, the present study was designed to evaluate the response of biofertilizer *i.e. Rhizobium* and phosphorus-solubilizing bacteria (PSB) for realizing the maximum yield and economics as well as the soil status.

MATERIALS AND METHODS

The experiment was carried during *kharif* season of 2022 at Agronomy farm, SAS, Nagaland University, Medziphema situated at an altitude of 310 meters above sea level with the geographical location at 25˚45′43″N latitude and 95˚53′43″E longitude. The average rainfall varies between 2000-2500 mm annually. The mean temperature ranges from 21˚C- 32˚C during summer and rarely goes below 8˚C in winter due to high atmospheric pressure. The soil was well drained, sandy loam in texture, having pH (4.8), organic carbon (1.38%), available N (210.56 kg ha^{-1}), available P (14.51 kg ha^{-1}), and available K (210.37 kg ha^{-1}). The experiment was laid out in randomized complete block design with 3 replications comprising of 7 different treatments *viz.* T_1 - Recommended dose of fertilizer (RDF) (N, P_2O_5, K_2O – 20-40-40 kg/ha), T_2 - 75% RDF + 25% FYM, T_3 - 50% RDF + 50% FYM, T_4 - 25% RDF + 75% FYM, T_5- 75% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed, T_6 - 50% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed, T_7 - 25% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed along with control. Experimental field was ploughed by tractor drawn cultivator and followed by harrowing with tractor drawn rotavator to obtain good tilth for sowing. The well decomposed FYM was incorporated into the soil as per treatments. The other treatments i.e., *Brady Rhizobium* and phosphorus solubilizing bacteria were applied as seed treatments @ 20g kg^{-1}. The inoculated seeds were dried under shade and sown immediately after drying. The green gram cultivar 'Kopergaon' was sown at 30 cm (row to row) × 10 cm (plant to plant) spacing in plot size of 3.6m × 3m. Healthy, clean and disease-free bio-inoculated seeds were sown and sowing was done manually at a depth of 2-3 cm below the soil surface with the help of hand tynes and covered properly with soils. Nitrogen, phosphorus and potassium at the rate of 20, 40 and 40 kg ha^{-1} in the form of urea, SSP and MOP were applied as per treatments. In order to receive a uniform plant, stand only a light pre-sowing irrigation was applied. Thinning of the crop was done manually at 15 DAS to maintain optimum and uniform plant population. When the crop required necessary field operations like weeding, pest and disease control were carried out. Soil samples were drawn earlier through soil auger before layout of the experiment for the determination of physio-chemical properties of the soil. The observations on growth parameters like plant height, number of leaves $plant^{-1}$, branching habit, dry matter production and ultimately seed yield were recorded following the standard protocols. The economics was calculated based on prevailing market price of inputs and outputs for each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and material used for raising the crop. The cost of labour incurred in carrying out different operations was also included. Data were subjected to analysis of variance (ANOVA) according to the technique defined for simple randomized complete block design (RCBD) as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth attributes

The perusal of data from the study (Table 1) indicated that the integrated nutrient management practices significantly influenced the different growth characters of green gram. Regarding growth parameters a clear-cut trend was observed where the application of 75% RDF

Table 1: Effect of integrated nutrient management on growth parameters of green gram

Treatments	Plant population m^{-2}	Plant height	No. of leaves $plant^{-1}$	No. of primary branches $plant^{-1}$	Dry matter (g $plant^{-1}$)
Control	25.69	37.48	24.57	4.51	5.83
T_1: RDF	31.80	44.54	28.27	5.34	8.22
T_2: 75% RDF + 25 % FYM	31.21	41.36	28.00	5.14	7.67
T_3: 50% RDF + 50% FYM	30.47	40.31	27.33	5.05	7.64
T_4: 25% RDF + 75% FYM	27.93	39.47	26.87	4.85	7.04
T_5: 75 % RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	34.35	48.90	29.50	5.46	9.28
T_6: 50% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	31.89	46.77	28.30	5.20	8.81
T_7: 25% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	29.39	40.50	26.23	4.51	7.59
SEm±	0.70	0.61	0.31	0.03	0.21
CD(P=0.05)	2.13	1.86	0.94	0.12	0.65

+ *Rhizobium* @ 20 g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed led to gradual improvement in the growth attributes of green gram and recorded significantly highest plant population (34.35), plant height (48.90 cm) and number of leaves $plant^{-1}$ (29.50) at harvest. Similarly, application of 75% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed resulted in highest number of primary branches $plant^{-1}$ (5.46), dry matter accumulation $plant^{-1}$ (9.28 g) and was found to be statistically at par with 50% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed while control recorded lowest values for all the observations undertaken. Integrated nutrient management practices can lead to higher levels of available nutrients, prompting the conversion of carbohydrates to protein. This boosts meristematic cellular activity, including cell division and elongation, which manifests as increased variables like plant height consequently, there's a rise in dry matter accumulation. The above findings confirm the results of Meena *et al.* (2016) who noted that application of $N_{20} P_{40} K_{40}$ +FYM @ 10 t ha^{-1} and *Rhizobium* significantly increased the growth and yield attributes. These observations were also in accordance with the findings of Singh *et al.* (2022), wherein with the application of different levels of FYM, the 3.0 tones ha^{-1} FYM resulted in significantly higher number of primary branches $plant^{-1}$, dry weight and other growth attributes. Naik *et al.* (2022) also reported that the application of FYM (5 t ha^{-1}) + phosphorus 40 kg ha^{-1} + PSB significantly recorded the highest plant height, number of primary branches per plant, number of leaves per plant, and seed yield.

Likewise, integrated nutrient management practices significantly influenced the LAI, CGR and RGR (Table 2) and noted maximum values (1.33, 2.73; 3.61g m^{-2} day^{-1}, 5.46 g m^{-2} day^{-1}; and 0.09 g g^{-1} day^{-2}, 0.05 g g^{-1} day^{-1}) with the application of 75% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20gkg^{-1} seed at 40 and 60 DAS. It might be due to the fact that INM practices provided proper and adequate plant nutrients which are responsible for better development and growth of plant. The overall improvement in growth components may be due to synergistic effect of combined use of organic and inorganic manures. These observations were in accordance with Dashrath *et al.* (2014), Naragund *et al.* (2020) and Mishra *et al.* (2023) who reported the INM had a significant effect on growth and LAI. Kalsaria*et al.* (2017) mentioned that for obtaining higher yields, use of 30 cm row spacing and fertilizing the crop with 100 % RDF with inoculation of *Rhizobium* and PSB.

Yield attributes and yield

It is evident from the data (Table 3) that integrated nutrient management practices exerted a significance influence on the yield attributes and yield of green gram. The application of 75% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed recorded the maximum number of pods per $plant^{-1}$ (18.33), seeds pod^{-1} (12.27), pod length (9.25 cm). Seed

Table 2: Effect of integrated nutrient management on LAI, CGR and RGR of green gram

Treatment	LAI		CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})	
	40 DAS	60 DAS	20-40 DAS	40-60 DAS	20-40 DAS	40-60 DAS
Control	1.10	2.43	2.87	4.51	0.074	0.019
T_1: RDF	1.28	2.64	3.42	5.34	0.086	0.039
T_2: 75% RDF + 25 % FYM	1.24	2.59	3.34	5.14	0.084	0.037
T_3: 50% RDF + 50% FYM	1.20	2.56	3.28	5.05	0.084	0.032
T_4: 25% RDF + 75% FYM	1.16	2.50	3.16	4.85	0.080	0.028
T_5: 75 % RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	1.33	2.73	3.61	5.46	0.092	0.049
T_6: 50% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	1.30	2.69	3.47	5.20	0.089	0.047
T_7: 25% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	1.18	2.54	3.24	4.51	0.083	0.035
SEm±	0.01	0.01	0.07	0.03	0.002	0.006
CD(P=0.05)	0.02	0.02	0.21	0.12	0.006	0.017

inoculation with *Rhizobium* and phosphotika might have played a pivotal role in various plant processes, including starch cell division, enhanced sugar utilization, and the rate of photosynthesis through increased availability of nutrient which ultimately resulted in better yield attributing characters of the crop. Significantly higher seed yield (862 kg ha^{-1}), stover yield (2094 kg ha^{-1})and harvest index (29.15%) was also observed in the treatment which showed maximum yield attributing characters while control plot, where no extra nutrient was added showed the lowest values in all yield attributes and ultimately yield. The notable rise in mungbean crop yield can be attributed to the direct impact of organic manures, inorganic fertilizers, and biofertilizers on enhancing dry matter production throughout different growth stages. This enhancement is primarily due to increased photosynthetic efficiency which facilitated greater movement of photosynthates from the source to the sink sites, ultimately resulting in higher yields and contributing positively to the characteristics of the yield. The above findings are in accordance the findings of Nyekha *et al.* (2015), Meena *et al.* (2016) and Kalsaria *et al.* (2017) where *Rhizobium* and PSB treatments increased the yield attributes and seed yield significantly. An improvement in the yield of seeds is also linked to the cumulative effect of number of pods $plant^{-1}$, pod length and number of $seedspod^{-1}$. The above observation was found to be in conformity with the findings of Mishra *et al.* (2023) who observed that integrated use of organic manures along with optimum doses of chemical fertilizers increased the growth parameters and yield of green gram.

Table 3: Effects of integrated nutrient management on yield attributes and yield of green gram

Treatment	Pods $plant^{-1}$	Pod length (cm)	Seeds pod^{-1}	Test weight (g)	Seed yield ($kgha^{-1}$)	Stover yield (kg ha^{-1})	Harvest index (%)
Control	11.53	7.68	8.40	27.52	423.33	1165.33	26.63
T_1: RDF	15.33	8.34	9.47	30.76	693.67	1622.33	28.08
T_2: 75% RDF + 25 % FYM	15.66	8.44	10.27	31.13	761.00	1844.67	27.96
T_3: 50% RDF + 50% FYM	15.53	8.48	9.93	31.74	730.33	1739.00	28.01
T_4: 25% RDF + 75% FYM	13.96	7.88	10.00	28.66	648.67	1591.33	28.33
T_5: 75 % RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	18.33	9.25	12.27	31.63	862.00	2094.00	29.15
T_6: 50% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	17.01	8.93	10.60	31.55	819.33	1986.67	28.46
T_7: 25% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	15.00	7.91	9.60	29.41	530.00	1441.33	27.52
SEm±	0.40	0.02	0.27	0.97	6.13	8.45	0.84
CD(P=0.05)	1.23	0.08	0.82	NS	18.60	25.65	NS

Table 4: Effect of integrated nutrient management on economics of green gram

Treatments	Total cost of cultivation (₹ ha^{-1})	Gross Return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit cost ratio
Control	21310.85	33994.83	12683.98	0.59
T_1: RDF	24681.70	55416.18	30734.48	1.25
T_2: 75% RDF + 25 % FYM	24892.98	60860.22	35967.24	1.44
T_3: 50% RDF + 50% FYM	24996.27	58376.35	33380.08	1.34
T_4: 25% RDF + 75% FYM	25153.56	51895.43	26741.87	1.06
T_5: 75 % RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	23842.98	68942.10	45099.12	1.89
T_6: 50% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	23000.27	65525.97	42525.70	1.85
T_7: 25% RDF + Rhizobium @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed	22157.56	42542.83	20385.27	0.92

Economics

Adoption of cultivation practices depends on the economic feasibility. The cost of cultivation varied according to different treatments (Table 4). The highest gross return (₹ 68942.10 ha^{-1}) and net return (₹45099.12 ha^{-1}) was recorded in treatment (75% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed). Benefit cost ratio followed similar trend with highest value (1.89) under 75% RDF + *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed. The results are conformity with the findings reported by Kalal (2020).

In terms of expenditure incurred for cultivation, the highest cost of cultivation (₹ 25153.56 ha^{-1}) was recorded in treatment receiving 25% RDF + 75% FYM. The resultant increase in the cost of cultivation appears to be due to the higher price of farm yard manure. The results are in close agreement with the findings reported by Philip *et al.* (2021).

CONCLUSION

Based on the results of present study, it may be concluded that to realize the higher yield of green gram in Nagaland the seeds should be inoculated with *Rhizobium* @ 20g kg^{-1} seed + Phosphotika @ 20g kg^{-1} seed prior to sowing with application of 75% of recommended dose of fertilizers (T_5). Thus, integrated use of organic, inorganic and biological sources of nutrients may be suggested for achieving higher productivity along with overall betterment of green gram crop.

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