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Effect of rhizobium consortia and foliar NPK on growth and yield parameters of greengram (*Vigna radiata* L.)

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Abstract

The present study titled “Effect of Rhizobium consortia and foliar NPK on growth and yield parameters of Greengram (*Vigna radiata* L.)” was conducted during the *Kharif* season of 2024 at the Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (C.G.). The experiment was designed using a Randomized Block Design (RBD) with three replications, incorporating seven different nutrient management treatments: Control (T_1), RDF (20:50:25 NPK kg ha⁻¹) (T_2), RDF + Rhizobium consortia (T_3), RDF + NPK foliar spray once @ 40 DAS (T_4), 75% RDF + Rhizobium consortia (T_5), 75% RDF + NPK foliar once @ 40 DAS (T_6) and 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS (T_7). The findings revealed that 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS (T_7) significantly outperformed other treatments in terms of growth parameters such as plant height, number of branches and nodules, as well as yield attributes like pod length, grain count, number of pods and test weight. While 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS (T_7) was statistically superior, it was comparable to RDF + NPK foliar spray once @ 40 DAS (T_4) and RDF + Rhizobium consortia (T_3). In terms of yield, 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS (T_7) recorded the highest grain and straw yields, again showing statistical superiority over other treatments, though similar to RDF + NPK foliar spray once @ 40 DAS (T_4) and RDF + Rhizobium consortia (T_3). Economic analysis also showed that 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS (T_7) achieved the highest gross returns, net returns, and benefit-cost (B:C) ratio among all the treatments.

Keywords: Greengram, rhizobium, consortia, benefit: cost ratio and yield

Introduction

Pulses are the dried seeds of leguminous plants belonging to the Fabaceae (or Leguminosae) family, which encompasses around 19,400 species across 730 genera—making it the third-largest plant family (Bhavya *et al.*, 2024) ^[17]. Often termed the “poor man’s meat,” pulses deliver an affordable source of high-quality protein (Azadi *et al.*, 2013) ^[3] and also supply carbohydrates, vitamins, minerals, Omega-3 fatty acids and dietary fiber (Kumar & Sharma, 2009) ^[18]. India is not only the world’s leading producer of pulses but also one of its largest consumers and importers, meeting domestic demand through imports driven by population growth and rising nutritional awareness (FAO, 2022). According to the Government of India’s Crops Division report on the pulses revolution (2017-2018), green gram (*Vigna radiata* (L.) Wilczek) ranks as the fourth most cultivated pulse in India, with a production of 1.9 million tonnes—behind chickpea (11.1 million tonnes), pigeon pea (4.1 million tonnes) and urd bean (3.2 million tonnes). Dubbed the “green pearl” for its rich nutrient profile (Nayak *et al.*, 2020) ^[12], green gram is also known by various names including mung bean, moong, chickasono pea, chiroko, Oregon pea, Chickasaw pea and golden gram (Dhananjoy *et al.*, 2023) ^[13]. Native to the India-Myanmar region of northeastern Asia (Yang *et al.*, 2011) ^[19], green gram has an aromatized variety called “sona mung” that is exclusively cultivated in West Bengal (Saravanan *et al.*, 2013). Seed coat color ranges from green, yellow, and olive to brown, purplish brown, or black, with variability in testa hue and texture contributing to a glossy or matte appearance (Sharma *et al.*, 2004; Kuttamani & Velayutham, 2011) ^[16, 9]. In India, it is grown during the *Kharif*, *Rabi* and summer seasons (Prusty, 2022) ^[4]. In 2017-2018, green gram occupied 4.1 million hectares, yielding 1.9 million tonnes (467 kg ha⁻¹). Rajasthan led production with 39.06% of the total, followed by Madhya Pradesh (11.57%), Maharashtra (8.57%), Bihar

(5.54%), Karnataka (5.05%), Tamil Nadu (5.02%), Gujarat (4.63%) and Andhra Pradesh (4.31%)—together accounting for 8% of India's overall pulse output (Anonymous, 2023). Mung bean exhibits low tolerance to saline conditions and is particularly vulnerable to iron chlorosis and other micronutrient deficiencies, especially when cultivated in alkaline soils (Muchomba *et al.*, 2023)^[11]. The application of nitrogen (N) and phosphorus (P) fertilizers promotes root growth, which in turn enhances the uptake of water and nutrients, leading to an expanded photosynthetic surface and increased dry matter production. Studies have shown that phosphorus application in mung bean significantly boosts dry matter at harvest, the number of pods plant⁻¹, seeds pod⁻¹, 1000-seed weight, seed yield and total biomass (Mitra *et al.*, 1999)^[10]. Integrated nutrient management (INM) is based on the principle of providing essential nutrients to crops in a manner that sustains productivity while minimizing negative impacts on soil health and the environment. The primary objectives of INM are: to preserve soil fertility, ensure sustainable crop yields, reduce environmental degradation and lower the cost of chemical fertilizer inputs (Sharma *et al.*, 2004)^[16].

Materials and Methods

An experiment was conducted during the *Kharif* season of 2024 at the Agriculture Research cum Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research, Bilaspur (Chhattisgarh). The experimental site is located in Bilaspur district at 22.09°N latitude and 82.15°E longitude. This region falls under the Eastern Plateau and Hill Region of India (Agro-climatic Zone VII). Chhattisgarh is divided into three agro-climatic zones, and Bilaspur lies within the plains zone of the state. The experiment followed a Randomized Block Design (RBD) with three replications and included seven nutrient management treatments: Control (T₁), RDF (20:50:25 NPK kg ha⁻¹) (T₂), RDF + Rhizobium consortia (T₃), RDF + NPK foliar spray once @ 40 DAS (T₄), 75% RDF + Rhizobium consortia (T₅), 75% RDF + NPK foliar once @ 40 DAS (T₆) and 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS (T₇). Data were recorded on plant population, plant height, number of branches, dry matter accumulation, number of nodules at different growth stages and yield components including number of pods, pod length, number of grains pod⁻¹, test weight, grain yield and stover yield at harvest. Post-harvest plant analysis was also performed to assess nitrogen, phosphorus and potassium content and uptake in both grain and straw. Additionally, the economic performance of greengram was evaluated in terms of gross returns, net returns and benefit-cost ratio. The collected data were statistically analyzed using the Analysis of Variance (ANOVA) method.

Results and Discussion

Tables 4.1 and 4.2 present the data on plant height (cm) of

greengram as influenced by different nutrient management treatments at 30 and 60 DAS, as well as at harvest. The findings reveal that plant height, number of branches, nodulation and dry matter accumulation were significantly affected by the various treatments throughout all observation stages. At 30 DAS, the tallest plants were observed under treatment T₃ - RDF + Rhizobium consortia, statistically significantly superior with T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS. At 60 DAS and at harvest the data varies in plant height were found significant superior treatment T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS statistically being at par with T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia and significantly superior over all the other treatments and T₃ - RDF + Rhizobium consortia which observed smaller plant than T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS and T₄ - RDF + NPK foliar spray once @ 40 DAS. The shortest plants were consistently recorded under the T₁ (Control). In terms of yield attributes, the highest number of pods and grains plant⁻¹ was recorded in treatment T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS, but was statistically comparable to T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia, but it was also significantly better than all other treatments. T₃ - RDF + Rhizobium consortia produced the fewest pods and grains compared to T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS and T₄ - RDF + NPK foliar spray once @ 40 DAS. The bare minimum of pods and grains were recorded for treatment T₁ - Control. The greatest pod length and test weight of greengram was recorded under T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS, which was statistically equivalent to T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia and significantly greater than all other treatments. The T₁ (Control) consistently recorded the shortest pods and the lowest test weight.

Among the different nutrient management treatments, the highest grain and stover yields were recorded under treatment T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS. This treatment was statistically on par with T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia and significantly superior to all other treatments. However, T₃ - RDF + Rhizobium consortia yielded less grain and stover than T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS and T₄ - RDF + NPK foliar spray once @ 40 DAS. The lowest grain and stover yields were observed in the control plot (T₁). The highest harvest index (40.31%) was also noted in T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS, surpassing all other treatments, while the control plot (T₁) recorded the lowest harvest index at 38.26%.

Table 1: Effect of Rhizobium consortia and foliar NPK on plant height, number of branches, plant dry matter and number of nodules of Greengram (*Vigna radiata* L.).

Treatments	Plant height (cm)			Number of branches plant ⁻¹			Plant dry matter (g plant ⁻¹)			Number of nodules plant ⁻¹	
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS
T ₁ - Control	38.02	53.73	58.02	1.23	5.76	8.61	4.32	6.86	7.69	17.08	19.37
T ₂ - RDF (20:50:25 NPK kg ha ⁻¹)	45.09	60.53	65.98	3.73	8.38	9.30	6.62	10.12	10.98	33.54	34.94
T ₃ - RDF + Rhizobium consortia	46.95	63.87	69.62	4.61	9.68	10.74	7.42	12.76	14.16	44.25	49.60
T ₄ - RDF + NPK foliar spray once @ 40 DAS	45.16	63.92	69.67	3.84	9.82	10.90	6.71	12.91	14.82	34.87	46.29
T ₅ - 75% RDF + Rhizobium consortia	45.32	62.18	67.78	3.91	8.94	9.92	6.79	11.35	12.24	35.65	39.28
T ₆ - 75% RDF + NPK foliar once @ 40 DAS	43.53	62.25	67.85	3.05	9.13	10.13	6.04	11.62	12.78	25.23	40.84
T ₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS	45.39	64.54	70.44	3.98	10.16	11.25	6.85	13.54	15.94	36.11	50.66
S.Em (±)	0.48	0.51	0.52	0.19	0.17	0.18	0.15	0.35	0.37	2.55	1.37
CD (5%)	1.47	1.59	1.61	0.58	0.52	0.55	0.45	1.07	1.15	7.88	4.23

Table 2: Effect of Rhizobium consortia and foliar NPK on number of pods, pod length, number of seeds, test weight, grain yield, stover yield and harvest index of Greengram (*Vigna radiata* L.)

Treatments	Number of pods plant ⁻¹	Pod length (cm)	Number of seeds pod ⁻¹	Test weight (gm)	Grain yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)	Harvest index (%)
T ₁ - Control	11.73	6.12	11.04	41.07	6.13	16.04	27.99
T ₂ - RDF (20:50:25 NPK kg ha ⁻¹)	17.03	8.02	13.62	44.49	9.32	18.32	33.73
T ₃ - RDF + Rhizobium consortia	19.82	9.87	14.82	45.63	12.58	22.85	35.52
T ₄ - RDF + NPK foliar spray once @ 40 DAS	20.05	9.98	14.91	45.74	12.74	22.96	35.62
T ₅ - 75% RDF + Rhizobium consortia	18.21	8.83	14.17	45.47	10.93	20.43	34.89
T ₆ - 75% RDF + NPK foliar once @ 40 DAS	18.45	8.96	14.25	45.59	11.05	20.78	34.72
T ₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS	20.56	10.43	15.16	45.91	13.29	23.99	35.65
S.Em (±)	0.34	0.23	0.16	0.42	0.47	0.62	0.49
CD (5%)	1.07	0.72	0.48	1.26	1.46	1.94	1.51

Table 3: Effect of Rhizobium consortia and foliar NPK on economics of Greengram cultivation.

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
T ₁ - Control	20698.00	63506.73	42808.73	2.06
T ₂ - RDF (20:50:25 NPK kg ha ⁻¹)	25523.05	82748.33	57225.28	2.24
T ₃ - RDF + Rhizobium consortia	26365.05	111504.69	85139.64	3.23
T ₄ - RDF + NPK foliar spray once @ 40 DAS	27149.05	112904.77	85755.72	3.16
T ₅ - 75% RDF + Rhizobium consortia	25415.28	96937.37	71522.09	2.81
T ₆ - 75% RDF + NPK foliar once @ 40 DAS	26199.28	98014.20	71814.92	2.74
T ₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS	27041.28	117782.90	90741.62	3.36

Conclusion

The findings revealed that growth parameters such as plant height, number of branches, and nodules, along with yield attributes like pod length, number of grains pod⁻¹, number of pods plant⁻¹ and test weight, were highest under treatment T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS. This treatment was statistically comparable to T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia and significantly superior to all other treatments. In terms of yield, the maximum grain and straw yields were also recorded under T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS, which was statistically at par with T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia but significantly better than the remaining treatments. Economically, T₇ - 75% RDF + Rhizobium consortia + NPK foliar spray once @ 40 DAS outperformed all other treatments, recording the highest gross return (117782.90 ₹ ha⁻¹) and net return (90741.62 ₹ ha⁻¹) and benefit-cost (B:C) ratio (3.36). These economic indicators were followed by T₄ - RDF + NPK foliar spray once @ 40 DAS and T₃ - RDF + Rhizobium consortia. On the other hand, the lowest gross return, net return and B:C ratio were observed in the control treatment (T₁).

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