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Deepak Kumar Chandrakar
Principal Scientist, Department of
Agronomy, College of Agriculture,
Raipur, Indira Gandhi Krishi,
Vishwavidyalaya, Chhattisgarh,
India

Ankita
M.Sc. (Ag), Department of
Agronomy, College of Agriculture,
Raipur, Indira Gandhi Krishi,
Vishwavidyalaya, Chhattisgarh,
India

Aisha Priyanka Beck
M.Sc. (Ag), Department of
Agronomy, College of Agriculture,
Raipur, Indira Gandhi Krishi,
Vishwavidyalaya, Chhattisgarh,
India

Shatavisha Nayak
Ph.D., Department of Agronomy,
College of Agriculture, Raipur,
Indira Gandhi Krishi,
Vishwavidyalaya, Chhattisgarh,
India

Corresponding Author:
Deepak Kumar Chandrakar
Principal Scientist, Department of
Agronomy, College of Agriculture,
Raipur, Indira Gandhi Krishi,
Vishwavidyalaya, Chhattisgarh,
India

Growth, yield, economics and quality of greengram (*Vigna radiata* L.) as influenced by integrated nutrient management

**Deepak Kumar Chandrakar, Ankita, Aisha Priyanka Beck and Shatavisha
Nayak**

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Abstract

The present investigation was conducted to evaluate the growth, yield, economics and quality of greengram (*Vigna radiata* L.) as influenced by integrated nutrient management at the Instructional-cum-Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during kharif season, 2024. The experiment was laid out in a Randomized Block Design with nine treatments and three replications on clayey loam (Vertisol) “kanhar” soil, which was slightly alkaline in reaction (pH 7.2), low in available nitrogen, medium in phosphorus and high in potassium. The results revealed that integrated nutrient management practices significantly improved growth, physiological parameters, yield attributes, nutrient uptake, quality, and economics of greengram. Among the treatments, T₂ (100% RD of NPK + Zn with 2% urea foliar spray at pre-flowering and pod initiation stages) outperformed all other treatments by recording the highest plant height (63.20 cm), branches per plant (6.27), dry matter accumulation (12.14 g plant⁻¹), leaf area (932.3 cm² at 60 DAS), crop growth rate and relative growth rate. In terms of yield attributes and yield, T₂ produced the maximum pods per plant (24.73), seeds per pod (10.01), seed index (3.41 g), seed yield (881 kg ha⁻¹) and stover yield (1109 kg ha⁻¹). The same treatment also recorded the highest nutrient uptake of N, P and K, nitrogen content (32.18%), protein yield (201.10 kg ha⁻¹) and economic returns with maximum gross return (₹77,568 ha⁻¹), net return (₹55,053 ha⁻¹) and benefit–cost ratio (3.45). Conversely, T₃ (75% RD of NPK + Zn with seed inoculation using NPKZn microbial consortia @ 50 g kg⁻¹) showed the lowest performance across most parameters. Thus, application of 100% recommended dose of NPK and Zn along with 2% urea foliar spray at pre-flowering and pod initiation stages emerged as the most effective and profitable integrated nutrient management strategy for greengram under Chhattisgarh conditions.

Keywords: Greengram, Integrated nutrient management, foliar urea, growth and yield, nutrient uptake

Introduction

Greengram (*Vigna radiata* L.) is one of the most important pulse crops of India and plays a vital role in human nutrition and sustainable agriculture. It is an excellent source of high-quality protein, containing about 24–25% protein, along with essential amino acids such as lysine and tryptophan. Besides protein, greengram grains are rich in carbohydrates, minerals like calcium and phosphorus, and vitamins, and are easily digestible, non-flatulent, and highly palatable. Due to its short duration and early maturing varieties, greengram is grown during kharif, summer and spring seasons and is also used as a green manure crop and fodder after pod picking. Sprouted greengram seeds are valued for their high content of vitamin C. Globally, greengram is cultivated in tropical and subtropical regions including India, China, Pakistan, Bangladesh, Thailand, Indonesia, Malaysia, Africa and the USA. Asia is the major producer, with India contributing more than 50% of the global production followed by China. In India, greengram occupies about 5.5 million hectares with a production of 3.17 million tonnes and an average productivity of 570 kg ha⁻¹. During 2024–25, the area under greengram increased to 55.72 lakh ha, with major producing states being Rajasthan, Madhya Pradesh, Maharashtra, Karnataka, Odisha and Uttar Pradesh. In Chhattisgarh, greengram is grown on about 3.58 lakh ha with a productivity of 419 kg ha⁻¹, which is lower than the national average. Despite its nutritional and agronomic importance. Although greengram is a leguminous crop capable of fixing atmospheric

nitrogen through symbiosis, a small starter dose of nitrogen is essential during early growth stages for better establishment and yield. Phosphorus plays a crucial role in root development, nodulation, energy transfer and grain quality, while potassium is important for physiological processes and stress tolerance. Continuous and imbalanced use of chemical fertilizers adversely affects soil health and fertilizer use efficiency, leading to soil degradation and environmental pollution. Therefore, Integrated Nutrient Management (INM) has emerged as a sustainable approach to improve crop productivity while maintaining soil fertility. INM involves the combined use of inorganic fertilizers, biofertilizers and foliar nutrition to ensure balanced nutrient availability. Seed inoculation with microbial consortia enhances nodulation, nitrogen fixation, phosphorus solubilization and soil microbial activity. Foliar application of nutrients such as urea, NPK (19:19:19), nano urea and nano DAP at critical growth stages ensures rapid nutrient absorption, improves photosynthetic efficiency, and enhances flowering, pod formation and seed development.

Materials and Methods

A field experiment was undertaken during kharif season 2024-25 at Instructional-cum-Research Farm, IGKV, Raipur (C.G.). The soil was slightly alkaline with pH (7.2), low available N, medium available phosphorus and high level of potassium. The experiment comprised of nine treatments with three replications of different integrated nutrient management combinations that are T₁: 100% RD of NPK Zn + Water spray at pre-flowering and pod initiation stages, T₂: 100% of RD of NPK Zn + 2% urea spray at pre-flowering and pod initiation stages, T₃: 75%RD of NPK Zn+ Seed inoculation with NPK Zn microbial consortia @50g kg⁻¹, T₄: 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) @ 2% at pre-flowering and pod initiation stages, T₅: 75% RD of N & 100% RD of PK Zn+ Nano urea (4%N) @4ml/l at pre-flowering and pod initiation stages, T₆: 75% RD of NP & 100% RD of K Zn + Nano DAP (8%N+16% P₂O₅) @2ml/l at pre-flowering and pod initiation stages, T₇: 75% RD of NPK Zn+ Seed inoculation with NPK Zn microbial consortia @50 g kg⁻¹ + NPK (19:19:19) @2% at pre-flowering and pod initiation stages, T₈: 75% RD of NPK Zn + Seed inoculation with NPK Zn microbial consortia @50 g kg⁻¹ + Nano Urea (4%N) @4ml/l at pre-flowering and pod initiation stages, T₉: 75% RD of NPK Zn + Seed inoculation with NPK Zn microbial consortia @50 g kg⁻¹ + Nano DAP (8%N+16% P₂O₅) @ 2ml/l at pre-flowering and pod initiation stages. Indira shikha was taken as the test crop. It is a high yielding variety developed by IGKV, Raipur and was officially released in 2010. The variety was subsequently notified by the Central Variety Release Committee (CVRC) for cultivation in Chhattisgarh, particularly suited for the kharif and summer season. It matures in 75-80 days and gives grain yield of 12-14 q ha⁻¹. The Shikha variety typically grows to a plant height of about 60 to 63 centimeters (cm) under normal growing conditions. This variety has proven to be well-suited for the North Eastern Plain Zone (NEPZ), which includes regions like Karnataka, Maharashtra, Odisha and Uttar Pradesh West Bengal, Assam and Chhattisgarh. What makes this variety especially valuable to farmers is its natural resistance to serious diseases like Yellow Mosaic Virus and Powdery Mildew. This not only reduces the need for chemical inputs but also makes it a dependable option for pulse cultivation in these areas. The test crop was sown on 14th July 2024 at a spacing of 30 x 10 cm. Recommended dose of nutrients like N: P₂O₅:K₂O, and Zn as basal application was applied at a time of sowing. Foliar spray of was done at two critical stages specifically at pre flowering

and pod initiation stages. The crop was harvested manually at maturity as per schedule. The data for growth attributes: plant height (cm), no. of branches plant⁻¹, no. of leaves plant⁻¹ were recorded at different stages of growth at 20, 40, 60 DAS and at harvest. The yield is calculated from different yield attributes data at harvest. These parameters were statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized block design.

Results and Discussion

Growth attributes

Growth parameters such as plant height, number of branches plant⁻¹, number of leaves plant⁻¹ and dry matter accumulation were significantly influenced by integrated nutrient management treatments. Among the treatments, T₂ (100% RDF + microbial consortia + 2% urea spray) recorded the maximum plant height and dry matter accumulation, which was statistically at par with T₅ (75% RD of N & 100% RD of PK Zn+ Nano urea (4%N) @4ml/l at pre-flowering and pod initiation stages.) The lowest values were recorded under T₃ (75%RD of NPK Zn+ Seed inoculation with NPK Zn microbial consortia @50g kg⁻¹, T₄: 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) @ 2% at pre-flowering and pod initiation stages) control. The enhanced growth under integrated treatments may be attributed to balanced nutrient supply from chemical fertilizers, improved nitrogen fixation by Rhizobium, enhanced phosphorus availability through PSB and rapid nitrogen absorption through foliar spray. Similar results were also reported by Singh *et al.* Root nodulation number of nodules plant⁻¹ and dry weight of nodules were significantly affected by seed inoculation with microbial consortia. Treatments T₄, T₅, T₆ and T₇ recorded significantly higher nodulation compared to non-inoculated treatments. Maximum nodulation was observed under T₂ (100% of RD of NPK Zn + 2% urea spray at pre-flowering and pod initiation stages) whereas minimum was recorded under control. Improved nodulation may be due to better root development and enhanced Rhizobium activity under integrated nutrient supply. These findings are in conformity with Bahadur and Tiwari.

Yield attributes

Yield attributes such as number of pods plant⁻¹, number of seeds pod⁻¹ and test weight showed significant improvement under integrated nutrient management treatments. Treatment T₂ (100% of RD of NPK Zn + 2% urea spray at pre-flowering and pod initiation stages) recorded the highest values of yield attributes followed by T₉ and T₆, while T₁ recorded the lowest values. The improvement in yield attributes may be due to better assimilate production and translocation under balanced nutrition. Similar findings were reported by Ali *et al.* (2008) ^[1] and Goud and Kale (2010) ^[2]. Seed yield of greengram was significantly influenced by different treatments. The highest seed yield was recorded under T₂ (100% of RD of NPK Zn + 2% urea spray at pre-flowering and pod initiation stages), which was statistically at par with T₉ but significantly superior over sole application of RDF and control. The increase in yield under integrated treatments may be attributed to improved growth, higher nodulation and superior yield attributes. These results are in agreement with the findings of Verma *et al.* (2017) and Mangaraj *et al.* (2023) ^[4]. Quality parameters such as protein content of greengram seed was significantly improved by integrated nutrient management. Treatment T₂ (100% of RD of NPK Zn + 2% urea spray at pre-flowering and pod initiation stages), recorded the highest protein content, followed by T₅ (75% RD of N & 100% RD of PK Zn+ Nano urea (4%N)

@4ml/l at pre-flowering and pod initiation stages.), whereas the lowest protein content T₃ (75%RD of NPK Zn+ Seed inoculation with NPK Zn microbial consortia @50g kg⁻¹, T₄: 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) @ 2% at pre-flowering and pod initiation stages) was recorded under control. Increased nitrogen availability through biological fixation and foliar spray might have enhanced protein synthesis. Economic analysis revealed that T₂ (100% of RD of NPK Zn +

2% urea spray at pre-flowering and pod initiation stages) recorded the highest gross return, net return and benefit-cost ratio, followed by T₅(75% RD of N & 100% RD of PK Zn+ Nano urea (4%N) @4ml/l at pre-flowering and pod initiation stages.). Although the cost of cultivation was higher under integrated treatments, higher yield resulted in better profitability. Similar economic advantages of INM were also reported by Vedpathak and Chavan (2018) [7].

Table 1: Plant height (cm) and Number of branches plant⁻¹ of greengram as influenced by integrated nutrient management practices at various stages of the crop

Treatment	Plant height (cm)				No. of branches plant ⁻¹		
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS
T ₁ : 100% RD of NPK Zn+ water spray at PF and PI stage.	17.7	45.4	55.2	56.5	1.73	5.00	5.53
T ₂ : 100% RD of NPK Zn + 2% urea spray at PF and PI stage.	18.7	48.7	61.9	63.2	1.90	5.80	6.27
T ₃ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortia @50 g kg ⁻¹	16.6	43.9	50.0	52.6	1.27	3.80	4.07
T ₄ : 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) 2% at PF and PI stage.	17.6	45.4	54.8	56.1	1.93	4.87	5.33
T ₅ : 75% RD of N & 100% RD of PK Zn + Nano urea (4% N) @4ml/l at PF and PI stage.	16.6	47.0	56.6	58.3	1.93	5.20	5.60
T ₆ : 75% RD of NP & 100% RD of K Zn + Nano DAP (8% N+16% P ₂ O ₅)@2ml /l at PF and PI stage.	17.4	44.1	52.7	53.9	1.77	4.67	5.13
T ₇ : 75% RD of NPK Zn+ seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ +NPK (19:19:19) @ 2% at PF and PI stage.	17.5	43.9	52.4	53.7	1.73	4.33	5.00
T ₈ : 75% RD of NPK Zn +seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ + Nano Urea (4%N) @4ml/l at PF and PI stage.	16.1	44.4	51.6	53.5	1.73	4.27	4.93
T ₉ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortial @50g kg ⁻¹ .	16.1	44.2	50.4	52.9	1.60	4.00	4.67
S.Em±	0.64	1.05	1.35	1.18	0.35	0.16	0.22
CD(p=0.05)	NS	3.17	4.05	3.54	NS	0.51	0.66

Table 2: No. of root nodule plant⁻¹ and dry matter accumulation g plant⁻¹ of greengram as influenced by integrated nutrient management practices at various stages of the crop

Treatment	No. of root nodule plant ⁻¹			Dry matter accumulation g plant ⁻¹			
	30 DAS	45 DAS	60 DAS	20 DAS	40 DAS	60 DAS	At harvest
T ₁ : 100% RD of NPK Zn+ water spray at PF and PI stage.	11.27	30.45	19.55	0.49	2.56	9.40	11.54
T ₂ : 100% RD of NPK Zn + 2% urea spray at PF and PI stage.	11.73	33.77	21.80	0.54	3.00	10.03	12.14
T ₃ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortia @50 g kg ⁻¹	10.77	25.00	17.23	0.30	2.20	8.31	8.72
T ₄ : 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) 2% at PF and PI stage.	12.10	30.27	19.40	0.49	2.46	9.34	11.48
T ₅ : 75% RD of N & 100% RD of PK Zn + Nano urea (4% N) @4ml/l at PF and PI stage.	11.07	30.50	19.55	0.49	2.81	9.42	11.83
T ₆ : 75% RD of NP & 100% RD of K Zn + Nano DAP (8% N+16% P ₂ O ₅)@2ml /l at PF and PI stage.	10.97	30.23	19.23	0.48	2.46	9.34	11.29
T ₇ : 75% RD of NPK Zn+ seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ +NPK (19:19:19) @ 2% at PF and PI stage.	11.03	30.05	19.20	0.48	2.45	9.34	11.21
T ₈ : 75% RD of NPK Zn +seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ + Nano Urea (4%N) @4ml/l at PF and PI stage.	11.83	30.02	19.13	0.48	2.45	9.33	11.14
T ₉ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortial @50g kg ⁻¹ .	11.50	30.00	19.03	0.48	2.45	9.33	11.11
S.Em±	0.48	1.34	0.86	0.04	0.33	0.34	0.98
CD(p=0.05)	NS	4.04	2.59	NS	1.00	1.04	2.95

Table 3: Pods plant⁻¹ (no.), seeds pods⁻¹ (no.) and seed index of greengram as influenced by integrated nutrient management

Treatment	Pods plant ⁻¹ (no.)	Seeds pods ⁻¹ (no.)	Seed index
T ₁ : 100% RD of NPK Zn+ water spray at PF and PI stage.	19.97	8.95	3.33
T ₂ : 100% RD of NPK Zn + 2% urea spray at PF and PI stage.	23.03	10.01	3.41
T ₃ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortia @50 g kg ⁻¹	16.24	7.99	3.29
T ₄ : 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) 2% at PF and PI stage.	19.23	8.77	3.33
T ₅ : 75% RD of N & 100% RD of PK Zn + Nano urea (4% N) @4ml/l at PF and PI stage.	20.06	9.51	3.36
T ₆ : 75% RD of NP & 100% RD of K Zn + Nano DAP (8% N+16% P ₂ O ₅)@2ml /l at PF and PI stage.	19.63	8.53	3.33
T ₇ : 75% RD of NPK Zn+ seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ +NPK (19:19:19) @ 2% at PF and PI stage.	19.53	8.66	3.32
T ₈ : 75% RD of NPK Zn +seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ + Nano Urea (4%N) @4ml/l at PF and PI stage.	19.20	0.46	3.32
T ₉ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortial @50g kg ⁻¹ .	18.80	8.16	3.30
S.Em±	1.13	0.42	0.06
CD(p=0.05)	3.13	NS	NS

Table 4: Protein content (%) and protein yield kg ha⁻¹ of greengram as influenced by integrated nutrient management

Treatment	Protein content (%)	Protein yield (kg ha ⁻¹)
T ₁ : 100% RD of NPK Zn+ water spray at PF and PI stage.	21.33	155.54
T ₂ : 100% RD of NPK Zn + 2% urea spray at PF and PI stage.	22.85	201.10
T ₃ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortia @50 g kg ⁻¹	19.06	125.39
T ₄ : 75% RD of NPK & 100% RD of Zn+ NPK (19:19:19) 2% at PF and PI stage.	20.73	149.20
T ₅ : 75% RD of N & 100% RD of PK Zn + Nano urea (4% N) @4ml/l at PF and PI stage.	21.38	157.09
T ₆ : 75% RD of NP & 100% RD of K Zn + Nano DAP (8% N+16% P ₂ O ₅)@2ml /l at PF and PI stage.	20.25	143.16
T ₇ : 75% RD of NPK Zn+ seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ +NPK (19:19:19) @ 2% at PF and PI stage.	19.79	137.11
T ₈ : 75% RD of NPK Zn +seed inoculation with NPK Zn microbial consortia @50g kg ⁻¹ + Nano Urea (4%N) @4ml/l at PF and PI stage.	19.42	133.81
T ₉ : 75% RD of NPK Zn + seed inoculation with NPK Zn microbial consortial @50g kg ⁻¹ .	19.17	131.25
S.Em±	0.45	7.64
CD(p=0.05)	1.37	22.91

Conclusion

Integrated nutrient management involving T₂: 100% RDF of NPK Zn + 2% urea spray at pre-flowering and pod initiation stage, proved to be the most effective treatment for improving growth, yield, quality and economics of greengram under Vertisol conditions. Hence, this treatment can be recommended for sustainable and profitable greengram production.

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