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Intrraction effect of hydrogel and integrated nutrient management on the growth parameters of green gram (*Vigna radiata* L.)

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Abstract

A field experiment was conducted during the kharif season of 2025–26 at the Students' Instructional Farm, Department of Agronomy, Eklavya University, Damoh, Madhya Pradesh, to study the interaction effect of hydrogel and integrated nutrient management (INM) on the growth of green gram (*Vigna radiata* L.) under rainfed conditions. The experiment was laid out in a Split Plot Design with three hydrogel levels and four INM treatments, replicated thrice. Results indicated that the interaction between hydrogel and INM significantly influenced growth parameters. The combined application of hydrogel @ 7.5 kg ha⁻¹ with RDF + Rhizobium + PSB + FYM @ 10 t ha⁻¹ (H₃I₄) recorded the highest plant height, branches per plant, functional leaves, fresh and dry biomass, root nodules, and nodule dry weight. Enhanced soil moisture conservation, improved nutrient availability, and greater microbial activity contributed to vigorous crop growth under rainfed conditions.

Keywords: Green gram, *Vigna radiata* L., hydrogel, Integrated Nutrient Management (INM), rhizobium, PSB, farmyard manure (FYM), rainfed agriculture, growth parameters, soil moisture conservation

1. Introduction

Green gram (*Vigna radiata* L.) is an important pulse crop widely cultivated in India due to its high nutritional value, short duration, and ability to fix atmospheric nitrogen through symbiosis with *Rhizobium*. It is an excellent source of protein, carbohydrates, vitamins, and minerals, and contributes significantly to soil fertility and sustainable cropping systems. However, the productivity of green gram under rainfed conditions remains low because of erratic rainfall, poor soil moisture availability, and nutrient deficiencies. These constraints adversely affect crop growth, nodulation, and yield, highlighting the need for efficient moisture conservation and balanced nutrient management by Abinaya *et al.* (2024) ^[1]. Pulses play a vital role in Indian agriculture as well as in human nutrition due to their high protein content and ability to improve soil fertility through biological nitrogen fixation. In the state, green gram is cultivated over an area of about 5.07 lakh hectares, producing 3.67 lakh metric tonnes of seed with an average productivity of 725 kg ha⁻¹.

Integrated Nutrient Management (INM) is a sustainable approach that integrates inorganic fertilizers, organic manures, and biofertilizers to ensure balanced nutrient supply, improve soil fertility, and enhance nutrient-use efficiency. The combined use of Recommended Dose of Fertilizers (RDF), farmyard manure (FYM), *Rhizobium*, and phosphate-solubilizing bacteria (PSB) improves soil microbial activity, nutrient availability, and root development. Hydrogel, a superabsorbent polymer, further enhances crop performance by increasing the soil water-holding capacity, reducing moisture stress, and maintaining continuous water availability during dry periods. Therefore, the combined application of hydrogel and INM is expected to improve growth parameters, nodulation, and overall crop performance of green gram under rainfed conditions, thereby promoting sustainable and climate-resilient agriculture by Barkha *et al.*, (2020) ^[2].

Hydrogels have emerged as an effective soil amendment for improving crop productivity under moisture-deficit conditions. These superabsorbent polymers can absorb and retain large quantities

of water and gradually release it to plant roots as required, thereby maintaining adequate soil moisture throughout the crop growth period. In green gram (*Vigna radiata* L.), hydrogel application enhances seed germination, root growth, nutrient uptake, and overall plant development by minimizing moisture stress. It also improves water-use efficiency, reduces irrigation frequency, and supports better crop performance during dry spells. Therefore, hydrogel technology offers a promising approach for sustainable pulse production, particularly in rainfed, arid, and semi-arid regions where water availability is limited (Khemshetty *et al.*, 2024) ^[9].

2. Materials and Methods

The field experimentation Damoh is located in the central part of Madhya Pradesh at an elevation of about 595 meters above mean sea level. Geographically, it lies between 23°09' and 24°27' North latitude and 79°06' and 80°12' East longitude. The district falls under the sub-tropical climatic zone and is characterized by a semi-arid climate with distinct summer, monsoon, and winter seasons. The average annual rainfall of the region is approximately 1,100–1,200 mm, most of which is received during the southwest monsoon period extending from late June to September.

Table 1: Details of Layout

S. No.	Particulars	Dimension
1.	Crop	Green gram
2.	Variety	Pusa Vishal
3.	Design	Split plot design
4.	Number of treatments combinations	12
5.	Number of replications	3
6.	Total number of plots	8 x 3 = 24
7.	Plot size	4.5 x 4 = 18.0 m ²
8.	Spacing	30cm x 10cm
9.	Irrigation channel	1 meter
10.	Field border	1 meter
11.	Plot border	50 cm = 0.5 meter
12.	Fertilizers	NPK @ 20:40:40 kg ha ⁻¹ , Hydrogel, Rhizobium, PSB and FYM

The green gram variety Pusa Vishal is a high-yielding variety developed by Eklavya University, Damoh Madhya Pradesh and recommended for Eastern Hill Zone for *Kharif* season cultivation. Some key characteristics are green seed colour, 70-75 days duration, yield potential 11-14 q ha⁻¹ and resistant to yellow mosaic virus. Owing to its disease resistance, synchronous maturity and wider adaptability this variety is suitable for farmers looking for a reliable and high-yielding option for the *Kharif* season.

2.1 Growth Characters

2.1.1 Tagging Operation

Three plants were randomly selected from each plot and tagged for detailed observations and data recording. This was done because it was not practical to study the entire plant population due to time constraints and to minimize experimental strain. The tagged plants represented the overall field condition and were used for recording various growth and yield parameters throughout the study period.

2.1.1.1. Plant Stand (No. m⁻²)

This study was conducted to assess the uniformity of plant

population under different treatments. After the completion of final thinning, the number of plants per square meter was counted to determine the plant stand. The plant population was also recorded at the time of harvest from the net plots. These observations helped in evaluating the effect of different treatments on crop establishment and stand density.

2.1.1.2 Plant Height (cm)

Plant height of green gram was measured at 30, 60 days after sowing and at the harvesting stage. For this purpose, randomly selected plants from each plot were measured in centimeters from the ground level up to the tip of the main shoot. The average height of three tagged plants was calculated and used for statistical analysis. These observations were useful for assessing crop growth response under different treatments.

2.1.1.3 Number of Branches Plant⁻¹

The total number of branches was counted on each of the three tagged plants selected from each plot. Branches arising from the main stem were carefully recorded at the respective growth stages. The average number of branches per plant was then calculated by dividing the total number of branches by the number of sampled plants. This parameter was used to assess the vegetative growth response of green gram under different treatments.

2.1.1.4 Number of Functional Leaves Plant⁻¹

The total number of green and photosynthetically active leaves was counted from each of the three selected tagged plants in each plot. Only fully expanded and healthy leaves were considered for observation. The average number of functional leaves per plant was then calculated. This parameter helped in assessing the photosynthetic efficiency and overall vegetative growth of green gram under different treatments.

3. Results and Discussion

3.1 Effect of Different Treatments on Plant Population (No. m⁻²)

The effect of hydrogel and integrated nutrient management (INM) on initial and final plant population of green gram was found to be statistically non-significant. However, slight numerical differences were observed among treatments. Among the hydrogel levels, H₃ (Hydrogel @ 7.5 kg ha⁻¹) recorded the highest initial and final plant population (27.98 and 26.74 plants m⁻², respectively), followed by H₂ (Hydrogel @ 5 kg ha⁻¹) with 25.95 and 24.72 plants m⁻², whereas the lowest values (22.43 and 21.48 plants m⁻²) were recorded under H₁ (control). The slight increase in plant stand under hydrogel application may be attributed to improved soil moisture retention, which enhanced seed germination and early seedling establishment. Similarly, among the INM treatments, I₄ (RDF + *Rhizobium* + PSB + FYM @ 10 t ha⁻¹) recorded the highest initial and final plant population (23.17 and 23.02 plants m⁻², respectively), while I₁ (RDF alone) recorded the lowest values (22.25 and 21.37 plants m⁻²). The marginal improvement under integrated nutrient management could be attributed to enhanced soil microbial activity, improved nutrient availability, and a more favorable soil environment during early crop establishment. Nevertheless, the observed differences among treatments were statistically non-significant. Buitrago-Arias *et al.* (2000) ^[3] & Choudhary *et al.*, (2019) ^[4].

3.2 Effect of Different Treatments on Height of Plant (cm)

Hydrogel application and integrated nutrient management (INM) significantly influenced the plant height of green gram. Among

the hydrogel treatments, H₃ (Hydrogel @ 7.5 kg ha⁻¹) recorded the maximum plant height (42.27 cm) at harvest, followed by H₂, whereas the minimum height (37.10 cm) was observed under H₁ (control). Plant height increased progressively from 30 DAS to harvest, indicating continuous vegetative growth. The superior performance of hydrogel-treated plots may be attributed to improved soil moisture retention, enhanced nutrient availability, and better root growth. Among the INM treatments, I₄ (RDF + *Rhizobium* + PSB + FYM @ 10 t ha⁻¹) produced the tallest plants (42.03 cm), followed by I₃, while the lowest plant height was recorded under I₁ (RDF alone). Improved nutrient availability, enhanced biological nitrogen fixation, greater microbial activity, and better soil physical properties due to FYM application collectively promoted vigorous vegetative growth and significantly increased plant height. Doifode *et al.* (2012) [5] & Gadi *et al.*, (2017) [6].

3.3 Effect of Different Treatments on Number of Branches Plant⁻¹

Hydrogel application and integrated nutrient management (INM) significantly influenced the number of branches per plant in green gram. The number of branches increased progressively from 30 DAS to harvest, indicating enhanced vegetative growth. Among the hydrogel treatments, H₃ (Hydrogel @ 7.5 kg ha⁻¹) recorded the highest number of branches (5.65 plant⁻¹), while the lowest value (3.94 plant⁻¹) was observed under H₁ (control). Improved branching under hydrogel application may be attributed to better soil moisture conservation, enhanced nutrient uptake, and increased cell division. Similarly, among the INM treatments, I₄ (RDF + *Rhizobium* + PSB + FYM @ 10 t ha⁻¹) produced the

maximum number of branches (5.47 plant⁻¹), followed by I₃, whereas I₁ (RDF alone) recorded the minimum. Enhanced nutrient availability, improved microbial activity, biological nitrogen fixation, and better soil physical conditions under integrated nutrient management collectively promoted vigorous vegetative growth and increased branching. Kankarwal *et al.*, (2025) [7] & Khanna *et al.* (2011) [8].

3.4 Effect of Different Treatments on Number of Functional Leaves Plant⁻¹

Hydrogel application and integrated nutrient management (INM) significantly influenced the number of functional leaves per plant in green gram. Among the hydrogel treatments, H₃ (Hydrogel @ 7.5 kg ha⁻¹) recorded the highest number of functional leaves (6.43 plant⁻¹), whereas the lowest value (2.68 plant⁻¹) was observed under H₁ (control). The improved leaf production under hydrogel application may be attributed to enhanced soil moisture retention, which ensured continuous water availability, improved nutrient uptake, and promoted photosynthesis, chlorophyll synthesis, and assimilate production. Similarly, among the INM treatments, I₄ (RDF + *Rhizobium* + PSB + FYM @ 10 t ha⁻¹) produced the maximum number of functional leaves throughout the crop growth period, while I₁ (RDF alone) recorded the minimum. The combined application of inorganic fertilizers, FYM, and biofertilizers improved nutrient availability, biological nitrogen fixation, phosphorus solubilization, soil microbial activity, and root development, resulting in vigorous vegetative growth, enhanced canopy development, and a significantly higher number of functional leaves. Kumar *et al.*, (2017) [10] & Kumar *et al.*, (2025) [11].

Table 2: Effect of Hydrogel and INM on initial and final plant population (no. m⁻²) and Plant height (cm) of green gram (2025-26).

Treatments	Plant population (no. m ⁻²)		Plant height (cm)		
	Initial	Final	30 DAS	60 DAS	At harvest
(A) Hydrogel					
H1: Control (No Hydrogel)	22.43	21.48	15.42	34.71	37.10
H2: Hydrogel (5 kg ha ⁻¹)	25.95	24.72	16.98	37.25	39.95
H3: Hydrogel (7.5 kg ha ⁻¹)	27.98	26.74	18.79	39.41	42.27
SE + (diff)	0.160	0.143	0.57	1.04	0.71
C.D. at 5%	NS	NS	2.05	3.11	2.61
(B) INM					
I1: RDF + (20: 40: 40 kg ha ⁻¹)	22.25	21.37	15.20	34.26	37.38
I2: RDF + <i>Rhizobium</i> inoculation	24.48	22.58	16.92	36.89	38.57
I3: RDF + <i>Rhizobium</i> inoculation + PSB (Soil application)	27.39	26.91	17.27	38.23	41.55
I4: RDF + <i>Rhizobium</i> inoculation + PSB + 10 ton ha ⁻¹ FYM	27.89	26.52	18.58	39.32	42.13
SE + (diff)	0.236	0.248	0.66	1.12	1.13
C.D. at 5%	NS	NS	1.98	3.48	3.51

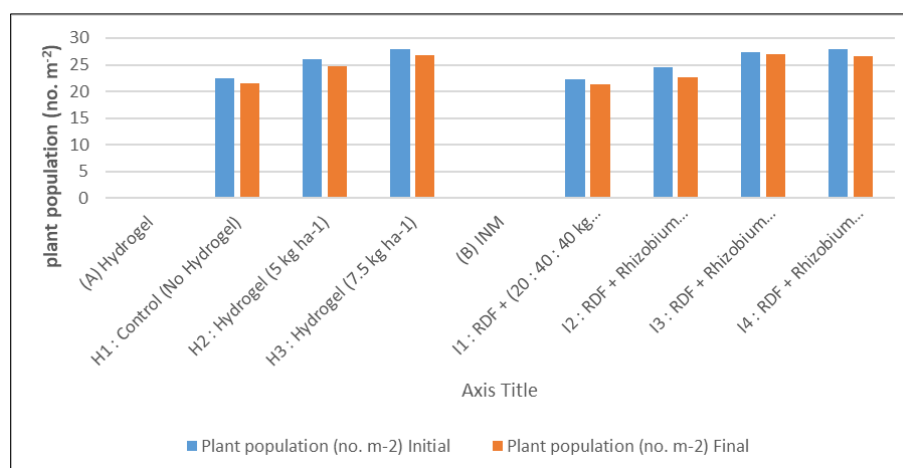


Fig 1: Effect of Hydrogel and INM on initial and final plant population (no. m⁻²) of green gram (2025-26)

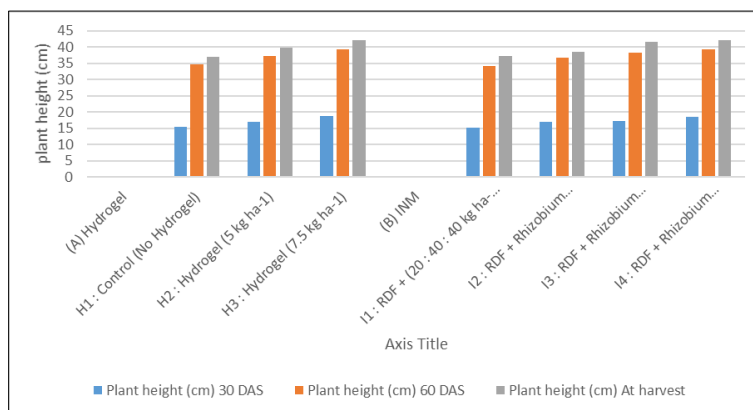


Fig 2: Effect of Hydrogel and INM on plant height (cm) of green gram (2025-26).

Table 3: Effect of Hydrogel and INM on number of branches plant⁻¹ and Number of functional leaves plant⁻¹ of green gram (2025-26)

Treatments	Number of branches plant ⁻¹			Number of functional leaves plant ⁻¹		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
(A) Hydrogel						
H1: Control (No Hydrogel)	1.99	3.82	3.94	2.68	4.18	2.62
H2: Hydrogel (5 kg ha ⁻¹)	2.85	4.56	4.89	3.69	5.78	3.83
H3: Hydrogel (7.5 kg ha ⁻¹)	3.32	5.41	5.65	4.32	6.43	3.98
SE + (diff)	0.37	0.43	0.49	0.79	1.13	0.74
C.D. at 5%	1.61	1.82	2.15	2.24	3.14	2.05
(B) INM						
I1: RDF + (20: 40: 40 kg ha ⁻¹)	1.79	3.63	3.88	2.62	4.19	2.72
I2: RDF + Rhizobium inoculation	2.72	4.67	4.94	3.24	5.42	3.29
I3: RDF + Rhizobium inoculation + PSB (Soil application)	2.90	4.73	4.98	3.73	5.81	3.79
I4: RDF + Rhizobium inoculation + PSB + 10 ton ha ⁻¹ FYM	3.25	5.24	5.47	4.35	6.43	4.14
SE + (diff)	0.37	0.42	0.39	0.90	0.82	1.05
C.D. at 5%	1.20	1.35	1.26	2.77	2.46	3.16

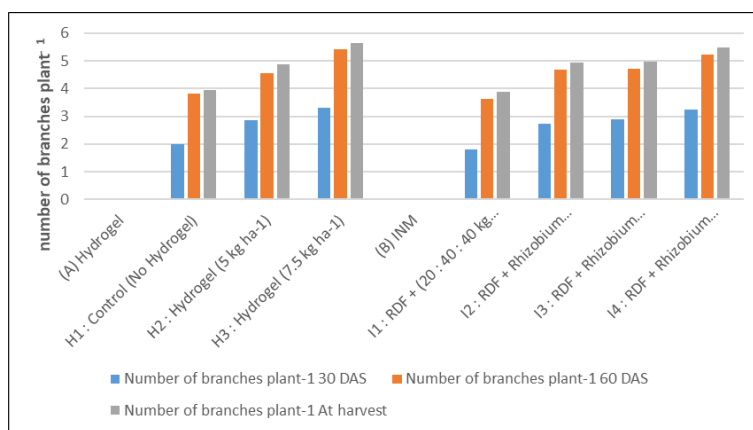


Fig 3: Effect of Hydrogel and INM on number of branches plant⁻¹ of greengram (2025-26).

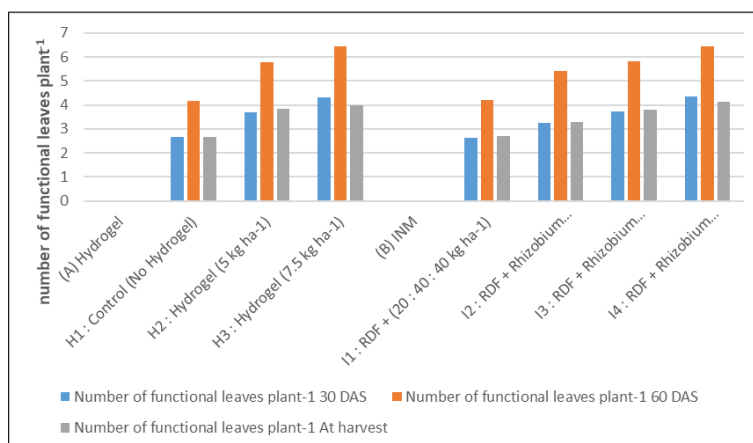


Fig 4: Effect of Hydrogel and INM on number of functional leaves plant⁻¹ of green gram (2025-26)

Conclusion

The present study demonstrated that the combined application of hydrogel and integrated nutrient management (INM) positively influenced the growth parameters of green gram under rainfed conditions. Although plant population was not significantly affected, hydrogel application at 7.5 kg ha⁻¹ (H₃) and RDF + *Rhizobium* + PSB + FYM @ 10 t ha⁻¹ (I₄) consistently recorded superior growth in terms of plant height, number of branches, and functional leaves. Improved soil moisture conservation by hydrogel, together with balanced nutrient supply and enhanced microbial activity under INM, promoted better nutrient uptake and vigorous vegetative growth. Therefore, the integration of hydrogel @ 7.5 kg ha⁻¹ with RDF + *Rhizobium* + PSB + FYM can be recommended as an effective and sustainable practice for enhancing the growth performance of green gram under rainfed agroecosystems.

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