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Effect of Varieties and Nutrient Treatments on Physiological and Phenological Parameters of Summer Greengram (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted during the summer season of 2020 at Regional Research Station (Bawal), CCS Haryana Agricultural University, Hisar to study the response of greengran to different varieties and nutrients treatments. The experiment was laid out in split-plot design with four replications. The main plot consisted of varieties (MH-421, MH-318 and SML-668) and sub-plot consisted of nutrient treatments (Control, 100% recommended dose of fertilizer (RDF), 75% RDF + 25% FYM + *Rhizobium* + phosphate solubilizing bacteria (PSB), 50% RDF + 50% FYM + *Rhizobium* + PSB). The findings suggest that variety MH-318 gave significantly higher no. of branches, leaf area, leaf area index (LAI) and leaf area duration (LAD) as well as phenological traits such as days taken to 50% flowering (days) over SML-668 and MH-421. Among the nutrient

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treatments, application of 75% RDF + 25% FYM + *Rhizobium* + PSB demonstrated superior performance across physiological (no. of branches, leaf area, LAI and LAD) and phenological traits (50% flowering) over 100% RDF, 50% RDF + 50% FYM + *Rhizobium* + PSB and control. Thus, a combination of variety MH-318 with 75% RDF + 25% FYM + *Rhizobium* + PSB helps in enhancing the physiological and phenological parameters of greengram without negative influence on plant and the environment.

Keywords: Greengram; nutrient management; physiological; phenological; variety.

1. INTRODUCTION

Greengram (*Vigna radiata* L.), commonly known as "mung bean" or "moong", is a highly valued pulse crop that holds a pivotal position in global agriculture. With origins in the Indian subcontinent, greengram has evolved into a versatile and resilient crop [1]. Greengram cultivation in India spanned across 5.5 million hectares, generating a total output of 3.17 million tones, with an average productivity rate of 570 kg per hectare during 2022 [2]. In Haryana, a region known for its semi-arid climate, greengram was grown on approximately 0.079 million hectares, achieving a production of 0.052 million tonnes, with a productivity rate of 661 kg per hectare (Statistical Abstract of Haryana 2021-22, 2023).

Greengram exhibits exceptional adaptability to various agro-climatic conditions, thriving from the dusty plains of the Indian subcontinent to the lush slopes of south-east Asia, including both rain-fed and irrigated ecosystems. This adaptability, combined with its short duration and ability to fix atmospheric nitrogen, makes it an attractive choice for crop rotation and diversification [3].

However, low productivity of greengram is a major challenge to both farmers and scientists. The key factors contributing to low productivity is the lack of high-yielding varieties, coupled with their suboptimal response to fertilizers. However, addressing these challenges through varietal selection and effective nutrient management can significantly enhance the productivity of greengram. By choosing varieties adapted to specific agro-climatic conditions, farmers can achieve desirable traits such as increased leaf area, improved photosynthetic efficiency, and better root development [4]. Therefore, the current investigation was initiated to examine how varieties and nutrient treatments influence the physiological and phenological parameters of summer greengram.

2. MATERIALS AND METHODS

2.1 Description of Experiment Site

The experiment exploring the combined impact of diverse greengram varieties and nutrient management practices was conducted at RRS (Bawal), CCS Haryana Agricultural University during the summer of 2020. The experiment site is located at 28.07 °N and 76.59 °E in western Haryana. It has an average elevation of 266 m (872 ft) above mean sea level. During summer season, the temperature may go as high as 44°C in June-July while in winters, it may fall as low as -0.5°C in December-January. The average annual rainfall ranges from 250 to 300 mm. A total of 174 mm rainfall occurred during summer, 2020. The experiment field boasts loamy sand soil with well-defined characteristics.

2.2 Treatments and Experimental Design

Three varieties (MH-421, MH-318 and SML-668) were tested alongside four different nutrient management treatment (Control, 100% RDF (20:40:0 kg/ha NPK), 75% RDF + 25% FYM + *Rhizobium* + PSB, 50% RDF + 50% FYM + *Rhizobium* + PSB). The experiment followed a split-plot design with four replications, featuring plots of 3m x 5m each.

2.3 Experimental Procedures and Field Management

The seeds were treated with Bavistin (@ 3 g/kg) to safeguard against seed-borne diseases. The field preparation took place on April 23rd, using a tractor-drawn disc harrow and planker. On April 25th, 2020, the crop was sown using the pora method, maintaining a row-to-row spacing of 30 cm and a seeding depth of 5-6 cm using a seed rate of 25 kg/ha. To reduce crop-weed competition, manual hoeing-cum-weeding was performed at 20 days after sowing (DAS). Due to limited rainfall during the crop season, two irrigations were applied after 22 and 45 DAS.

Additionally, to control insect pests, a spray of Rogor 30 EC (dimethoate) @ 250 ml was applied on June 4th, 2020. Finally, the crop was harvested on July 4th, 2020.

2.4 Data Collected and Collecting Procedure

The observations for no of branches per plant were recorded from five randomly selected plants from each treatment at various growth stages. The visual observations were taken to estimate the 50% germination and 50 flowering of the crop. The leaf area was measured using leaf area meter at 30, 60, 90 DAS and at harvest and expressed as cm^2 per plant.

Leaf area index: It is the ratio of leaf area to ground area. It was computed by using following formula:

$$\text{Leaf area index} = \frac{Leaf\ \text{area}}{Groud\ \text{area}} \quad \text{(equation 1)}$$

Leaf Area Duration (days): LAD is the ability of a plant to maintain the green leaves over unit area of land during a period of time. It is expressed in days.

$$\text{Leaf area duration} = \frac{LA_1 + LA_2}{2} \times (t2 - t1) \text{equation 2)}$$

Where,

LA_2 and LA_1 are leaf area of plants at time t_2 and t_1, respectively.

2.5 Data Analysis

The data analysis relied on ANOVA methods with comparisons made at a 5% significance level. The data obtained in this research were subjected to statistical analysis using the analysis of variance (ANOVA) method for the Split-plot design [5]. The F-test at a 5% probability level was employed to ascertain the significance of treatment effects. To assess the notable distinction between the means of two treatments, the critical difference (C.D.) was calculated using the formula below:

$$CD = \sqrt{\frac{2 \times EMS}{n}} \times \text{t value at 5\%} \quad \text{(equation 3)}$$

Where,

CD = Critical difference.
EMS = Error mean sum of square.
n = Number of observations.
t = Value of t-distribution at 5% level of error degree of freedom

3. RESULTS AND DISCUSSION

3.1 No. of Branches per Plant

No of branches plant^{-1} (Table 1) was significantly influenced by variety and nutrient treatments throughout growth (except 30 DAS). Variety MH-318 had significantly higher no. of branches at harvest as compared to SML-668 and MH-421, while the 75% recommended dose of fertilizer (RDF) + 25% FYM + *Rhizobium* + phosphate solubilizing bacteria (PSB) treatment produced the most branches overall. There was no significant difference in no. of branches at 30 DAS in both varieties and nutrient treatments. The higher no. of branches in variety MH-421 might be attributed to its superior genetic composition, which promotes the development of more branches as suggested by Mote et al. [6], Pareek et al. [7] and Singh and Jambukiya [8]. The superiority of 75% RDF + 25% FYM + *Rhizobium* + PSB over other treatment suggests that a combination of adequate nutrients, organic matter and beneficial microbes might have promoted higher growth and branching. Similar results were observed by Ranpariya et al. [9], Ghosh et al. [10] and Mondal and Sengupta [11].

3.2 Leaf Area (cm^2/plant)

Leaf area (Table 1. And Fig. 1.) increased significantly between 30 and 45 DAS, followed by a period of slower but continued growth until harvest where a decline in leaf area was observed among both varieties and nutrient treatment. Variety MH-318 (438.2) recorded significantly higher leaf area (cm^2/plant) at harvest as compared to SML-668 (423.3) and MH-421 (409.8). Similarly, nutrient treatments 75% RDF + 25% FYM + *Rhizobium* + PSB (464.4), 100% RDF (449.8) and 50% RDF + 50% FYM + *Rhizobium* + PSB (411.8) demonstrably enhanced leaf area compared to the control (368.8) at harvest. Treatment 75% RDF + 25% FYM + *Rhizobium* + PSB exhibited the highest leaf area at harvest, followed by a statistically significant increase of 25.9% relative to the control. These findings suggest that superior genetic makeup of varieties and strategic nutrient application might have improved no. of branches and leaves on greengram plant which resulted in higher leaf area. Similar findings in leaf area were made by Pandey et al. [12], Nayak et al. [13] and Patil et al. [14].

Table 1. Influence of varieties and nutrient treatments on no. of branches and leaf area of summer greengram

Treatments	No. of Branches plant^{-1}				Leaf Area (cm^2/plant)			
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest
Varieties								
V1	3.03	4.56	5.05	5.42	160.6	321.5	488.5	409.8
V2	3.22	5.14	5.70	6.14	172.1	334.6	517.6	438.2
V3	3.17	5.08	5.42	5.73	167.8	329.1	503.9	423.3
SEm±	0.17	0.13	0.10	0.15	1.3	2.36	2.65	2.84
CD (p≤0.05)	**NS**	**0.47**	**0.35**	**0.52**	**4.5**	**8.16**	**9.16**	**9.82**
Nutrient Treatments								
T1	2.91	4.63	4.83	5.14	144.3	285.0	454.7	368.8
T2	3.25	5.04	5.57	5.95	176.6	349.5	523.7	449.8
T3	3.44	5.25	5.86	6.62	179.9	357.9	539.7	464.4
T4	3.07	4.88	5.30	5.68	166.4	321.2	495.2	411.8
SEm±	0.17	0.16	0.13	0.18	1.2	3.54	4.18	3.71
CD (p≤0.05)	**NS**	**0.47**	**0.38**	**0.54**	**3.45**	**10.26**	**12.12**	**10.8**

**Significant at p≤0.05; DAS: Days after sowing; RDF: Recommended Dose of Fertilizer; V1: MH-421; V2: MH-318; V3: SML-668; T1: Control; T2: 100% RDF; T3: 75% RDF + 25% FYM + Rhizobium + PSB; T4: 50% RDF + 50% FYM + Rhizobium + PSB; NS: Non-Significant*

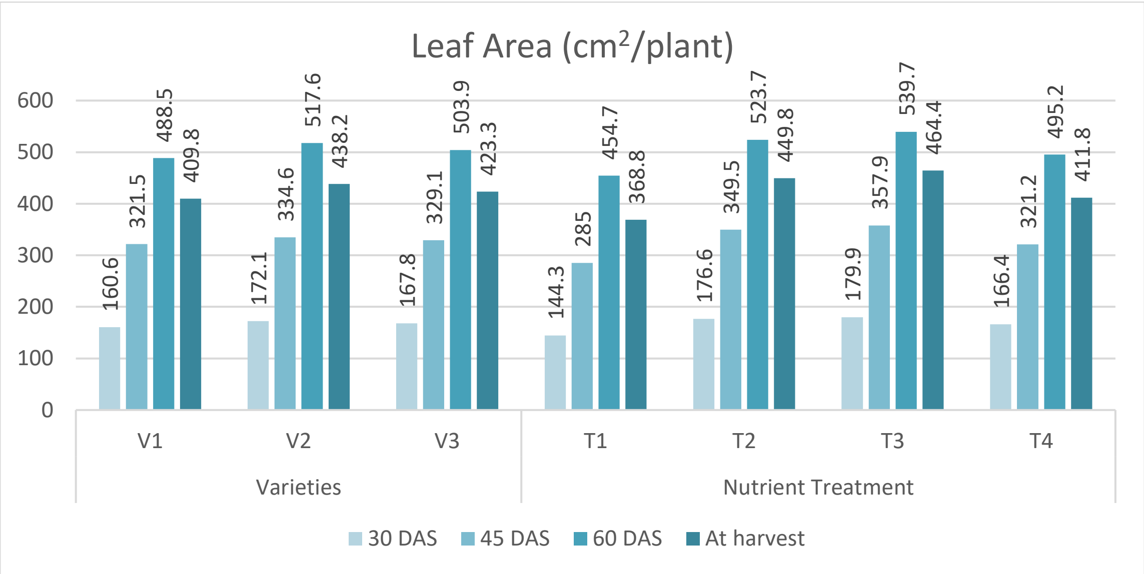

Fig. 1. Effect of varieties and nutrient treatments leaf area of summer greengram at 30, 45, 60 DAS and at harvest

Table 2. Influence of varieties and nutrient treatments on leaf area index and leaf area duration of summer greengram

Treatments	Leaf Area Index				Leaf Area Duration (days)			
	30 DAS	45 DAS	60 DAS	At harvest	0-30 DAS	30-45 DAS	45-60 DAS	60 DAS to harvest
Varieties								
V1	0.535	1.072	1.628	1.366	8.03	12.06	20.25	22.46
V2	0.574	1.115	1.725	1.461	8.60	12.67	21.30	23.89
V3	0.559	1.097	1.680	1.411	8.39	12.42	20.82	23.18
SEm±	0.004	0.008	0.009	0.009	0.065	0.09	0.19	0.24
CD (p≤0.05)	**0.015**	**0.027**	**0.030**	**0.032**	**0.225**	**0.30**	**0.67**	**0.82**

Treatments	Leaf Area Index				Leaf Area Duration (days)			
	30 DAS	45 DAS	60 DAS	At harvest	0-30 DAS	30-45 DAS	45-60 DAS	60 DAS to harvest
Nutrient Treatments								
T1	0.481	0.950	1.516	1.229	7.22	10.73	18.49	20.59
T2	0.589	1.165	1.746	1.499	8.83	13.15	21.83	24.34
T3	0.600	1.193	1.799	1.548	9.00	13.45	22.44	25.10
T4	0.555	1.071	1.651	1.373	8.32	12.19	20.41	22.68
SEm±	0.004	0.118	0.014	0.012	0.06	0.13	0.22	0.30
CD (p≤0.05)	**0.011**	**0.034**	**0.040**	**0.056**	**0.173**	**0.37**	**0.65**	**0.86**

**Significant at p≤0.05; DAS: Days after sowing; RDF: Recommended Dose of Fertilizer; V1: MH-421; V2: MH-318; V3: SML-668; T1: Control; T2: 100% RDF; T3: 75% RDF + 25% FYM + Rhizobium + PSB; T4: 50% RDF + 50% FYM + Rhizobium + PSB; NS: Non-Significant*

3.3 Leaf Area Index

Table 2. revealed leaf area index (LAI) values for greengram varieties and nutrient treatments measured at various growth stages. MH-318 recorded significantly higher LAI at all growth stages over SML-668 and MH-421, except 30 and 45 DAS where it was at par with SML-668. MH-318 observed 3.5 and 6.9% higher LAI over SML-668 and MH-421 at harvest, respectively. Nutrient treatments 75% RDF + 25% FYM + *Rhizobium* + PSB (1.548), 100% RDF (1.499), 50% RDF + 50% FYM + *Rhizobium* + PSB (1.373) resulted in significantly higher LAI compared to the control (1.229) at all growth stages. Treatment 75% RDF + 25% FYM + *Rhizobium* + PSB resulted in the highest LAI at each stage, with statistically significant differences compared to other treatments except 30 and 45 DAS where they were statistically at par. The increase in LAI may be attributed to increased leaf area under increased nutrient concentration as well better micronutrient availability and varietal characters. Similar findings in leaf area index were made by Mote et al*.* [6] and Arutkumaran et al*.* [15].

3.4 Leaf Area Duration (days)

MH-318 consistently exhibited significantly higher leaf area duration (Table 2) compared to SML-668 and MH-421, except at 30 and 45 DAS where it was statistically similar to SML-668. At harvest, MH-318 showed 3.0 and 6.3% higher LAD than SML-668 and MH-421, respectively. Among nutrient treatments, LAD was observed maximum under 75% RDF + 25% FYM + *Rhizobium* + PSB at all stages as compared to other treatments. Application of 75% RDF + 25% FYM + *Rhizobium* + PSB exhibited the highest LAD at each growth stage, showing statistically significant differences compared to other treatments, except at 30 and 45 DAS where they were similar. The enhanced LAD may be attributed to improved leaf area index, better varietal characteristics as well as better nutrient availability. Similar findings in leaf area index were made by Biswas et al*.* [16] and Chaudhary et al*.* [17].

3.5 Phenological Studies

The data presented in Table 3 revealed that the number of days taken to 50% germination was significantly affected by varieties and nutrient treatment. However, MH-318 (5.8) took least no. of days to germinate followed by SML-668 (5.6) and MH-421 (5.9). Among the nutrient treatments, application of 75% RDF + 25% FYM + *Rhizobium* + PSB (5.6) took least number of days to achieve 50% germination followed by 100% RDF (5.7) while control (6.0) took maximum no. of days. Similar findings have also been reported by Singh et al*.* [18] and Patel et al*.* [19].

Days taken to 50% flowering differ significantly with varieties as well nutrient treatment, MH-318 (38.6) recorded significantly lowest number of days to 50% flowering as compared to SML-668 (40.2) and MH-421 (41.0). Among different nutrient treatment application of 75% RDF + 25% FYM + *Rhizobium* + PSB (38.1) recorded significantly less of no. of days to 50% flowering as compared to control which took highest no. of days (41.4) while being at par with 100% RDF (39.6). Similar findings in phenological studies were also made by Phule and Raundal [20], Pareek et al*.* [21],[22] and Patel et al*.* [19].

Table 3. Influence of varieties and nutrient treatments on phenological characters of summer greengram

Treatments	Days taken to	
	50% Germination	50% Flowering
Variety		
V1	5.9	41.0
V2	5.6	38.6
V3	5.8	40.2
SEm±	0.2	0.37
CD (p≤0.05)	**NS**	**1.28**
Nutrient Treatments		
T1	6.0	41.4
T2	5.7	39.6
T3	5.6	38.1
T4	5.8	40.7
SEm±	0.2	0.36
CD (p≤0.05)	**NS**	**1.05**

**Significant at p≤0.05; DAS: Days after sowing; RDF: Recommended Dose of Fertilizer; V1: MH-421; V2: MH-318; V3: SML-668; T1: Control; T2: 100% RDF; T3: 75% RDF + 25% FYM + Rhizobium + PSB; T4: 50% RDF + 50% FYM + Rhizobium + PSB; NS: Non-Significant*

4. CONCLUSION

On the basis of above study, it can be concluded that, variety MH-318 and 75% RDF + 25% FYM + *Rhizobium* + PSB was superior to SML-668 and MH-421 in respect of no. of branches, leaf area, leaf area index and leaf area duration. Similarly, in phenological characters such as 50% flowering MH-318 and 75% RDF + 25% FYM + *Rhizobium* + PSB demonstrated superior performance over other varieties and nutrient treatments, respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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