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Optimization of sowing window for late sown *rabi* greengram (*Vigna radiata* L.)

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Abstract

Sowing time is an important agronomic factor that significantly affects plant growth, development and final production. Similarly, suitable variety also plays an appreciable role in final productivity. Therefore, the present study was conducted during late *rabi* season, 2024-25 at dryland farm of S.V. Agricultural College, Tirupati to evaluate the effect of sowing windows and varieties on growth and yield of greengram under dryland conditions under split-plot design with three sowing windows as main plots and four varieties as subplots on sandy loam soils which was low in available nitrogen, medium in available phosphorus and potassium. Results revealed that greengram sown during II Fortnight of December significantly enhanced growth and yield attributes, including number of pods branch⁻¹, number of seeds pod⁻¹, pod length, pod weight plant⁻¹ and thousand seed weight, resulting in the highest seed and haulm yield. Among varieties, LGG 630 recorded the highest seed yield and superior yield attributes, owing to its favourable genetic potential. The interaction between sowing window and varieties were found to be non-significant. The findings suggest that early sowing during II Fortnight of December with the variety LGG 630 can significantly improve productivity in late *rabi* season in Southern Agro-Climatic Zone of Andhra Pradesh.

Keywords: Greengram, fortnight, sowing windows, split-plot, yield attributes and yield

Introduction

Pulses, often called the “poor man’s meat” and “rich man’s vegetable,” are a vital source of protein (20-25%), especially for India’s predominantly vegetarian population. Among them, greengram (*Vigna radiata* L.), also known as mungbean, is an important short-duration pulse crop native to India. It enriches the soil by fixing atmospheric nitrogen (33-37 kg ha⁻¹), reducing fertilizer needs for subsequent crops. As the third most important pulse crop in India, greengram is grown across 55.46 lakh hectares with a total production of 36.76 lakh tonnes and a productivity of 663 kg ha⁻¹ (www.indiastat.com, 2022-23). In Andhra Pradesh alone, it occupies 0.73 lakh hectares with a significantly higher productivity of 1010 kg ha⁻¹ (Season and Crop Report - Andhra Pradesh, 2022-23). Key weather factors such as temperature, solar radiation, soil moisture and relative humidity strongly influence its growth and yield (Makone *et al.*, 2015) [16]. Improved productivity depends on high-yielding varieties, agronomic practices and particularly the selection of superior parents with high heritability and genetic advance for yield traits (Ahmad *et al.*, 2008) [1].

Among agronomic practices, sowing time is a critical, non-monetary factor affecting greengram yield. Optimum sowing time ensures synchronization between the vegetative and reproductive stages, which boosts yield potential (Ahmad *et al.*, 2021) [2]. Both early and late sowings can negatively affect plant establishment and yield due to unfavourable climatic conditions. Since the optimum sowing time varies across varieties and agro-ecological zones, it is essential to identify specific sowing dates for different varieties to ensure maximum productivity (Reddy, 2009 and Ram, 2018) [27, 26]. Varieties respond differently to seasonal variations and their yield potential is influenced by the interaction of genetic makeup and environment (Madhu *et al.*, 2014) [15]. Thus, current research experiments planned to know the effect of sowing windows and varieties of greengram under late *rabi* conditions.

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Materials and Methods

A field experiment was conducted during late *rabi* season, 2024-25 at dryland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Guntur, to study the effect of sowing windows and varieties on growth and yield of greengram. The mean maximum temperature during the crop growth period ranged from 27.7 °C and 39.1 °C while, mean minimum temperature ranged from 12.8 °C to 23.5 °C. A total of 44.6 mm of rainfall was received in 4 rainy days. The soil of the experimental field was sandy loam in texture, neutral in soil reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium. The experiment was laid out in split-plot design with three sowing windows viz., II Fortnight of December (S_1), I Fortnight of January (S_2) and II Fortnight of January (S_3) as main plots, four varieties viz., LGG 607 (V_1), LGG 630 (V_2), LGG 574 (V_3) and IPM-2-14 (V_4) as subplots and replicated thrice. Healthy, well matured and sound seeds of four greengram varieties were sown @ 12 kg ha⁻¹, with a spacing of 30 cm between rows and 5 cm depth. A basal dose of 20 kg nitrogen and 50 kg phosphorus ha⁻¹ was applied through urea and single super phosphate, respectively. Valore-32, a pre-emergence herbicide was applied @ 4 ml litre⁻¹ of water on the next day after sowing followed by manual weeding at 30 DAS. Thinning was carried out at 15 DAS to maintain plant to plant distance of 10 cm. The data on number of pods branch⁻¹, number of seeds pod⁻¹, pod length, pod weight plant⁻¹, thousand seed weight, seed and haulm yields were recorded at harvest, which was tabulated and statistically analyzed and critical difference (CD) was calculated at 5% level of significance for comparing treatments means.

Results and Discussion

Number of pods branch⁻¹

Number of pods branch⁻¹ of greengram varied significantly due to sowing window and varieties, while the interaction effect of sowing windows and varieties was not statistically measurable (Table 1).

With respect to varied sowing windows, greengram sown during II Fortnight of December (S_1) resulted in higher number of pods branch⁻¹. This was followed by the crop sown during I Fortnight of January (S_2) and II Fortnight of January (S_3). The difference between the latter two varieties were non-significant. The crop sown during II Fortnight of January (S_3) recorded lower number of pods branch⁻¹. The highest number of pods branch⁻¹ with early sown crop might be due to the fact that early seeding enjoyed congenial climatic conditions, better harmony of photosynthates between growth and pod formation. Subsequently delayed sowing recorded significantly lower number of pods branch⁻¹. Results obtained during the course of investigation were similar to the findings of Rabbani *et al.* (2012) [25] and Gurjar *et al.* (2018) [10].

Among the varieties tested, LGG 630 (V_2) recorded higher number of pods branch⁻¹. This was followed by LGG 607 (V_1) and IPM-2-14 (V_4) with significant disparity between them. Significantly lower number of pods branch⁻¹ was recorded with the variety LGG 574 (V_3). This might be due to genetic makeup of cultivar and prolific branching, which leads to more number of pods branch⁻¹. Similar findings were reported by Kumar *et al.* (2012) [14] and Prasad *et al.* (2012) [24].

Number of seeds pod⁻¹

Different sowing windows and varieties of greengram exerted significant difference on number of seeds pod⁻¹ (Table1), while the interaction effect between sowing window and varieties was

not statistically conspicuous.

Number of seeds pod⁻¹ of greengram was significantly higher with the crop sown during II Fortnight of December (S_1). Lower number of seeds pod⁻¹ were recorded with II Fortnight of January (S_3) which was statistically at par with I Fortnight of January (S_2) sown crop. The probable reason for increased number of seeds pod⁻¹ with early sown crop i.e., II Fortnight of December (S_1) depends on genotype and it is independent on environmental factors. These results were in conformity with Samanth and Mohanty (2017) [28] and Mule *et al.* (2020) [20].

Among different greengram varieties tested, maximum number of seeds pod⁻¹ was recorded with the variety LGG 630 (V_2) which was significantly superior over other varieties tried. This was followed by LGG 607 (V_1) and IPM-2-14 (V_4) in producing more number of seeds with significant disparity between them. Lower number of seeds pod⁻¹ was observed with the variety LGG 574 (V_3). The greengram variety LGG 630 (V_2) produced more number of seeds pod⁻¹ which might be due to a combination of factors, including genetic variability and the variety's specific traits, shows high pollen viability, efficient source sink relationship which resulted in the plants efficiently channels nutrients from photosynthesis (source) to the developing seeds (sink), supporting the development of a higher number of seeds pod⁻¹. Similar findings were reported by Gangwar *et al.* (2013) [7] and Ahmed *et al.* (2023) [3].

Pod length

The pod length of greengram was significantly influenced by sowing window and varieties, while the interaction effect between sowing window and varieties was found to be non-significant (Table 1).

Among the different sowing windows tried, greengram sown during II Fortnight of December (S_1) recorded higher pod length. The next best sowing window was I Fortnight of January (S_2) sown crop which was however on par with II Fortnight of January (S_3) sown crop, which recorded significantly lower pod length. The maximum pod length was recorded with early sown crop i.e., II Fortnight of December (S_1) sown crop might be due to the fact that moderate temperatures during flowering and pod setting reduced the stress and encouraged elongation of pods. Higher vegetative growth especially more number of branches helped in synthesis of greater amount of food material which might have increased yield attributes. These results were in accordance with the findings of Mondal and Sengupta (2019) [19] and Gavali *et al.* (2023) [8].

Pertaining to varieties, LGG 630 (V_2) produced lengthier pods followed by LGG 607 (V_1) and IPM-2-14 (V_4) in the order of descent with significant difference between any two of the four varieties tested. Lower pod length was recorded with LGG 574 (V_3). Significantly higher pod length of greengram was recorded with the variety LGG 630 (V_2) can be attributed to increased cell division and elongation in the pod wall, better photosynthate partitioning to reproductive parts, inherent capacity to produce more number of seeds pod⁻¹ and greater pod cavity space, allowing for more seed development which results in longer pods. Similar results were reported by the findings of Gogoi and Kant (2020) [9].

Pod weight plant⁻¹

Significant difference in pod weight plant⁻¹ of greengram was observed among varied sowing windows and varieties, while their interaction effect was not traceable (Table1).

Among the varied sowing windows, significantly higher pod weight plant⁻¹ was registered with the crop sown during the II

Fortnight of December (S_1), which was significantly superior to I Fortnight of January (S_2) sown crop. However, lower pod weight plant⁻¹ was recorded with the crop sown during II Fortnight of January (S_3). Early sowing of greengram i.e., II Fortnight of December (S_1) recorded more pod weight plant⁻¹ might be due to the favourable environmental conditions during early sowing, such as optimal temperature, which supported better flowering, pod development and seed filling. The results were in agreement with the findings of Thimmegowda *et al.* (2024)^[31].

As regards to varieties tested, significantly higher pod weight plant⁻¹ was registered with variety LGG 630 (V_2) followed by LGG 607 (V_1) and IPM-2-14 (V_4) the latter two varieties were statistically significant with respect to pod weight plant⁻¹. The lower pod weight plant⁻¹ was registered with LGG 574 (V_3). The probable reason for higher pod weight plant⁻¹ with LGG 630 (V_2), might be due to increase in number of pods plant⁻¹ and seeds pod⁻¹, resulting in higher pod weight plant⁻¹. This can also be linked to the inherent capacity of the cultivar. These findings were in support of Singh *et al.* (2011)^[30].

Thousand seed weight

Thousand seed weight of greengram was significantly influenced by sowing window and varieties, while their interaction effect between sowing window and varieties was

found to be non-significant (Table 1).

The higher seed weight was recorded with the crop sown during II Fortnight of December (S_1) which was significantly superior to the crop sown during I Fortnight of January (S_2) and it was statistically comparable with II Fortnight of January (S_3) sown crop and the latter sowing window recorded lower seed weight. Higher seed weight with the crop sown during II Fortnight of December (S_1) might be due to cumulative effect of improvement in growth parameters and yield attributes viz., number of pods branch⁻¹, number of seeds pod⁻¹, pod length and pod weight plant⁻¹ resulted in significantly higher seed weight with the earliest sown crop. Decrease in seed weight due to delayed sowing from December to January was also reported by Aslam *et al.* (2000)^[4] and Nagamani *et al.* (2020)^[21].

The variety, LGG 630 (V_2) recorded higher thousand seed weight which was significantly superior over LGG 607 (V_1). The difference between IPM-2-14 (V_4) and LGG 574 (V_3) was statistically comparable with each other. The difference in seed weight among the varieties might be due to longer grain filling period which allows for greater assimilate accumulation in the seeds, resulting in increased seed size and seed weight, along with the genetic characteristics of that particular variety under specific climatic conditions. The results of the present investigation were in agreement with the findings of Kazi *et al.* (2002)^[12] and Joshi and Rahevar (2015)^[11].

Table 1: Yield attributes of greengram as influenced by sowing windows and varieties

Treatments	Number of pods branch ⁻¹	Number of seeds pod ⁻¹	Pod length (cm)	Pod weight plant ⁻¹ (g)	Thousand seed weight (g)
Main plots: Sowing window (3)					
S_1 : II Fortnight of December	5.0	11.0	7.0	6.2	34.2
S_2 : I Fortnight of January	4.7	10.5	6.7	5.6	33.0
S_3 : II Fortnight of January	4.6	10.3	6.5	5.1	32.9
S.Em±	0.06	0.05	0.04	0.12	0.27
CD (P=0.05)	0.2	0.2	0.2	0.5	1.1
Sub plots: Varieties (4)					
V_1 : LGG 607	4.9	10.9	6.8	5.8	33.8
V_2 : LGG 630	5.2	11.7	7.0	7.0	36.0
V_3 : LGG 574	4.3	9.5	6.5	4.6	31.6
V_4 : IPM-2-14	4.6	10.5	6.6	5.1	31.8
S.Em±	0.06	0.11	0.04	0.14	0.66
CD (P=0.05)	0.2	0.3	0.1	0.4	1.9
Sowing window (S) × Varieties (V)					
S at V					
S.Em±	0.01	0.17	0.07	0.25	1.05
CD (P=0.05)	NS	NS	NS	NS	NS
V at S					
S.Em±	0.10	0.18	0.07	0.25	0.99
CD (P=0.05)	NS	NS	NS	NS	NS

Seed yield

Seed yield of greengram was significantly influenced by sowing window and varieties tried, but their interaction effect was found to be non-significant (Table 2).

Significantly higher seed yield of greengram was recorded with the crop sown during II Fortnight of December (S_1). The next best sowing window was I Fortnight of January (S_2) sown crop for obtaining higher seed yield which was significantly superior to the crop sown during II Fortnight of January (S_3), which recorded significantly lower seed yield. Higher seed yield of greengram sown during II Fortnight of December (S_1) can be attributed to favourable environmental conditions. Sowing of crop during early winter provides cooler climate during vegetative phase promoted healthy crop growth and reduced pest and disease pressure. Furthermore, flowering and pod setting occurred during late January to February where the temperatures

were optimal for reproductive development. In addition, the clear weather at maturity helped to reduced flower and pod drop, minimized seed damage and ensured uniform pod development, all these factors collectively contributed to the significantly higher seed yield with December sowings. The reduction in yield attributes in delayed sowing might be due to decrease in cell-division, cell expansion and owing to their genetic variability. These results were in conformity with the findings of Dhaka *et al.* (2018)^[6] and Banker *et al.* (2020).

Among the varieties, significantly higher seed yield of greengram was recorded with LGG 630 (V_2), which was significantly superior over other varieties tried. The next best variety was LGG 607 (V_1) and IPM-02-14 (V_4) with significant disparity between them. Significantly lower seed yield was obtained with LGG 574 (V_3). The superior performance of greengram variety LGG 630 (V_2) can be attributed to a

combination of genetic traits (such as higher seed and biomass yield), disease resistance, agronomic advantages and better photosynthetic efficiency. This variety may possess growth traits viz., greater number of leaves and improved canopy architecture, all of which enhance photosynthesis and nutrient allocation to the seeds. In addition, key yield-attributing characters such as higher number of pods branch⁻¹, more number of seeds pod⁻¹, longer pods and greater pod weight have positively correlated with the seed yield of greengram. Similar results were reported by Sadeghipour (2008) and Singh *et al.* (2011)^[30]. The decrease in seed yield with delayed sowings was mainly due to the lower biomass build-up, less translocation of photosynthates towards reproductive parts and the overall shorter life span and reduced seed filling time and sink strength which was supported by Khan and Malik (2001)^[13] and Niveditha *et al.* (2022)^[22].

Haulm yield

Sowing window and varieties exerted significant influence on

the haulm yield of greengram, while their interaction effect was found to be non-significant (Table 2).

Among the varied sowing windows, significantly higher haulm yield was with greengram sown during II Fortnight of December (S₁) and I Fortnight of January (S₂) and II Fortnight of January (S₃) in the order of descent with significant disparity between them for obtaining higher haulm yield. Lesser haulm yield was with the crop sown during II Fortnight of January (S₃). The probable reason for increased haulm yield under early sown crop i.e., II Fortnight of December (S₁) might be attributed to agronomic factors in terms of plant height, number of functional leaves, leaf area index, number of branches plant⁻¹, dry matter accumulation and environmental factors such as cooler temperatures and shorter day length which have directly reflected in increased haulm yield. Similar findings were reported from the studies of Palsaniya *et al.* (2017)^[23] and Niveditha *et al.* (2022)^[22].

Table 2: Seed yield, haulm yield and harvest index of greengram as influenced by sowing windows and varieties

Treatments	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Harvest index (%)
Main plots: Sowing window (3)			
S ₁ : II Fortnight of December	874	2083	29.8
S ₂ : I Fortnight of January	641	1517	26.5
S ₃ : II Fortnight of January	454	1179	25.6
S.E.m±	21.9	53.8	1.49
CD (P=0.05)	86	211	NS
Sub plots: Varieties (4)			
V ₁ : LGG 607	720	1666	28.2
V ₂ : LGG 630	819	1887	28.3
V ₃ : LGG 574	475	1357	24.8
V ₄ : IPM-2-14	610	1462	28.0
S.E.m±	30.0	67.4	1.54
CD (P=0.05)	89	200	NS
Sowing window (S) × Varieties (V)			
S at V			
S.E.m±	51.2	116.7	2.67
CD (P=0.05)	NS	NS	NS
V at S			
S.E.m±	50.0	114.4	2.75
CD (P=0.05)	NS	NS	NS

Among the varieties tested, higher haulm yield was registered with the variety LGG 630 (V₂) which was significantly superior over other varieties tried. The difference between LGG 607 (V₁) and IPM-2-14 (V₄) were statistically significant in terms of haulm yield. Significantly lower haulm yield was observed with LGG 574 (V₃). The higher haulm yield with LGG 630 (V₂) variety of greengram might be due to the combination of genetic potential for higher biomass production and growth characteristics viz., vigorous growth habit, more number of branches and higher leaf area index, efficient use of available resources and better photosynthetic efficiency of photosynthates. These results were in conformity with the findings of Miah *et al.* (2009)^[18] and Mathew *et al.* (2017)^[17].

Harvest Index (%)

The harvest index of greengram was not significantly influenced by sowing window and varieties, while the interaction effect was also not statistically traceable (Table 2).

Correlation studies

The correlation analysis revealed strong and significant associations among most of the yield and yield-contributing traits studied (Table 3). Notably, pods branch⁻¹ showed highly significant positive correlations with all other traits except test weight, with which it still maintained a strong significant correlation ($r = 0.909^{**}$). This indicates that an increase in pods branch⁻¹ tends to result in increased pod length, pod weight, seeds pod⁻¹, test weight and ultimately, seed yield. The high correlation of pods branch⁻¹ with seed yield ($r = 0.893^{**}$) suggests its potential as a reliable selection criterion for yield improvement.

Pod weight also exhibited a strong positive and significant correlation with seed yield ($r = 0.878^{**}$), suggesting that heavier pods tend to contribute positively to the overall seed output. Similarly, pod length and seeds pod⁻¹ were positively correlated with seed yield ($r = 0.800^{*}$ and $r = 0.843^{*}$, respectively), though the correlation of pod length with test weight was not significant ($r = 0.655^{NS}$), indicating that longer pods may not necessarily translate to heavier seeds (Table 3).

Table 3: Correlation matrix among yield and yield-contributing traits in greengram

	Pods branch ⁻¹	Pod length	Pod weight	Seeds pod ⁻¹	Test weight	Seed yield
Pods branch ⁻¹	1.000					
Pod length	0.882**	1.000				
Pod weight	0.979**	0.841*	1.000			
Seeds pod ⁻¹	0.982**	0.830*	0.958**	1.000		
Test weight	0.909**	0.655 ^{NS}	0.943**	0.905**	1.000	
Seed yield	0.893**	0.800*	0.878**	0.843*	0.893**	1.000

Interestingly, test weight showed highly significant correlations with pod weight ($r = 0.943^{**}$), seeds pod⁻¹ ($r = 0.905^{**}$), and seed yield ($r = 0.893^{**}$) (Table 3), underlining its importance as an indirect indicator of seed productivity. The strong positive relationship between test weight and seed yield suggests that test weight could serve as an effective secondary trait in selection programs.

Overall, the strong inter-relationships among pods branch⁻¹, pod weight, seeds pod⁻¹, test weight and seed yield point to their collective contribution toward productivity. Traits such as pods branch⁻¹ and pod weight, due to their consistently high correlations with both yield and other yield-contributing traits, can be considered as key selection parameters in breeding programs aimed at enhancing seed yield.

Conclusion

The study showed that the growth and yield of greengram were greatly influenced by sowing windows and varieties. Sowing of greengram variety, LGG 630 should be done on II Fortnight of December resulted in higher yield attributes and yield indicating its suitability for late sowing. Correlation analysis highlighted that traits like pods branch⁻¹, seeds pod⁻¹, and test weight were strongly linked to seed yield. Therefore, early sowing with LGG 630 variety of greengram is the most effective strategy for maximizing greengram productivity during late *rabi* season on sandy loam soils of Southern Agro-Climatic Zone of Andhra Pradesh.

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