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INFLUENCE OF DIFFERENT VARIETIES, SOWING DATES AND THEIR INTERACTION ON GROWTH, YIELD ATTRIBUTES AND YIELD OF CHICKPEA UNDER MIDDLE GUJARAT CONDITIONS"

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ABSTRACT

A field experiment entitled "Performance of chickpea varieties under different dates of sowing" was conducted during the *rabi* season of 2023-24 atAgronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India. The experiment was laid out in a split plot design with three replications comprising 15 treatment combinations. The main plot treatments included three chickpea varieties, viz., GJG 3, GG 5 and JG 14, while the sub-plot treatments consisted of five sowing dates, viz., 20th October, 30th October, 10th November, 20th November and 30th November. The results of the experiment revealed that among the different varieties, GG 5exhibited the highest plant height at 60 DAS (47.81 cm) and at harvest (56.57 cm), highest days to 50% flowering (54.73) anddays to harvest (108.47) and recorded maximum dry matter accumulation per plant (37.24 g). It also produced the highest haulm yield (2871 kg/ha). Similarly, chickpea sown on 20th Octoberresulted in the highest plant height at 30 DAS (22.31 cm), highest days to 50% flowering (57.33) and days to harvest (110.89), maximum pod weight per plant (13.27 g), dry matter accumulation per plant (38.82 g), seed index (23.41 g) and produced the highest seed yield (2291 kg/ha), haulm yield (2949 kg/ha) and protein yield (506.7 kg/ha).

***Key words*:** Chickpea, variety, sowing date, early sowing, late sowing, root nodules, dry matter accumulation, yield, per day productivity, harvest index, protein (%) and protein yield, economics.

Introduction

Chickpea (*Cicer arietinum* L.), also known as gram, Bengal gram or chana, belongs to the *Leguminosae* family and *Papilionaceae* sub-family. Itoriginated in Southeast Turkey and adjoining Syria (Koul *et al*., 2022), it is an ancient, cool-season legume grown as a winter crop in tropics and a summer or spring crop in temperate regions. The crop thrives well in cool, dry and sunny climates (Gaur *et al*., 2010) with ideal temperatures of 21-29°C for day and 18-21°C for night(Maya and Maphosa, 2020). Its seeds are nutritionally dense, containing 18–22% protein, 61–62% carbohydrates and 4–5% fat, along with vitamins, minerals, dietary fiber and bioactive compounds, making chickpea a vital food in combating malnutrition (Begum *et al*., 2023). Chickpea contributes significantly to crop rotations by reducing soil-and stubble-borne diseases in cereals (Ali and Terefe, 2023) and enhancing soil fertility through symbiotic nitrogen fixation. It meets about 80% of its nitrogen requirement via fixation, amounting to up to 140 kg N ha^{-1}, while enriching soil organic matter and leaving substantial residual nitrogen for subsequent crops (Gaur *et al*., 2010). Thus, its inclusion in cropping systems lowers nitrogen input requirements and promotes soil health, long-term fertility and ecosystem sustainability (Jeffrey *et al*., 2021).

Chickpea is the second most produced pulse globally and ranks third in cultivated area. It is grown across all continents, with India, Australia, Turkey, Ethiopia, Myanmar and Russia as leading producers. India dominates, contributing over two-thirds of global output and holding the top spot in both cultivation area and production. During 2024, Worldwide, chickpeas cover about 14.12 million hectares, yielding 16.88 million tons at an average of 1,195 kg/ha. India alone accounts for roughly 67.88% of the area and 65.39% of total production, followed by Australia and Turkey (FAO, 2025). In India, chickpea covers 9.12 million hectares of land, produces about 11.11 million tons at an average of 1,218 kg/ha during 2024-25. Among chickpea producing states, Maharashtra leads the production, contributing nearly 26.65% of the national output with 2.96 million tons production (DA & FW). In Gujarat, chickpea covered 8.49 lakh hectares in 2024-25, producing 15.64 lakh tons with an average yield of 1,840 kg/ha. Back in 2018–19, the crop occupied only 1.73 lakh hectares with 2.35 lakh tons output. Over this period, chickpea area grew by 390% and production by 565%, driven largely by MSP based purchase and irrigated cultivation. This shift led to a nearly fourfold rise in area and a fivefold jump in production (DAG, 2025).

Despite its importance, chickpea productivity is highly sensitive to the interaction between genetic potential and sowing time, often summarized as the "Yield Equation" (Richards *et al*., 2022). Sowing date determines the thermal and moisture regime during critical growth stages, while varietal choice provides the genetic capacity to exploit or withstand those conditions (Sekhar *et al*., 2015; Tyagi *et al*., 2021). Early sowing may induce excessive vegetative growth and disease susceptibility (Ali *et al*., 2018; Rocha *et al*., 2023), whereas delayed sowing exposes the crop to terminal drought and heat stress, leading to forced maturity, pollen sterility and yield losses of 30–60% (Neenu *et al*., 2017; Rani *et al*., 2020; Raghavendra *et al*., 2021; Arriagada *et al*., 2022). These stresses account for up to half of global yield losses, underscoring the critical role of sowing date in climate adaptation. Varietal selection is equally decisive. Desi types are generally more resilient to environmental fluctuations, while Kabuli types, though market-preferred, require careful adaptation (Bantilan *et al*., 2014). Traits such as drought tolerance, heat resilience and disease resistance are essential for yield stability under variable environments (Siddique and Krishnamurthy, 2014; Gaur *et al*., 2014; Parankusam *et al*., 2017). For instance, short-duration, heat-tolerant varieties can escape terminal stress under late sowing, while long-duration, high-yielding varieties perform best under timely sowing (Manisha *et al*., 2024; Vignesh *et al*., 2024; Gadde *et al*., 2025). The genotype × environment × management (G × E × M) interaction thus emerges as the farmer's most effective tool for optimizing productivity and resilience (Rutuja *et al*., 2025).

Given increasing climate variability and shifting sowing windows, research on the performance of chickpea varieties under different sowing dates is imperative. Such studies provide evidence-based strategies for aligning genotypic potential with environmental windows, thereby reducing yield gaps, enhancing resource-use efficiency and strengthening climate resilience. This integrated approach transforms sowing date and variety selection from isolated decisions into synergistic strategies for sustainable chickpea production.

Materials and Methods

Description of study area

An experiment was conducted in plot no. 29-A at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India, to evaluate the "Performance of chickpea varieties under different dates of sowing" during the *rabi* season of 2023-24. The experimental site is situated at 22.58° N latitude and 72.92° E longitude, with an elevation of 45.1 meters above mean sea level. The region falls under the Middle Gujarat Agro Climatic Zone (AES III) and experiences a semi arid, sub tropical climate influenced by its proximity to the Arabian Sea. The average annual rainfall is 864.5 mm, received mainly during the monsoon months of July and August. Winters are cool from December to February, while summers are hot and dry, with May being the hottest month when temperatures reach approximately 41°C. The soil of the experimental field was characterized as loamy sand belonging to the Typic Ustipsamments taxonomic class. It exhibited good drainage and moisture retention capacity, with a slightly alkaline reaction (pH 8.11) and low electrical conductivity (0.24 dS/m). Organic carbon content was low (0.40%), while available phosphorus (40.74 kg/ha) and potassium (219.27 kg/ha) were in the medium range.

Experimental design, treatments and procedures

The experiment was laid out in a Split Plot Design with three replications. The main plot treatments consisted of three chickpea varieties, namely Gujarat Junagadh Gram 3 (GJG 3: V_1), Gujarat Gram 5 (GG 5: V_2) and Jawahar Gram 14 (JG 14: V_3). While sub plot treatments comprised five sowing dates: 20th November (D_1), 30th November (D_2), 10th December (D_3), 20th December (D_4) and 30th December (D_5), resulting in a total of fifteen treatment combinations given in Table 1.

The crop was raised following recommended agronomic practices and all necessary plant protection measures were adopted to safeguard against insect pests and diseases. Irrigation was provided as per crop requirements and weed management was ensured

Table 1: Treatment combinations.

Treatments	V_1 : GJG 3	V_2 : GG 5	V_3 : JG 14
D_1 : 20th October	V_1D_1	V_2D_1	V_3D_1
D_2 : 30th October	V_1D_2	V_2D_2	V_3D_2
D_3 : 10th November	V_1D_3	V_2D_3	V_3D_3
D_4 : 20th November	V_1D_4	V_2D_4	V_3D_4
D_5 : 30th November	V_1D_5	V_2D_5	V_3D_5

through integrated approaches. The crop was harvested manually at physiological maturity and standard post harvest procedures were followed to obtain clean seed samples for further analysis.

Data analysis

Statistical analysis of the experimental data was performed using the analysis of variance (ANOVA) technique through statistical software on computer system, as outlined by Cochran and Cox (1967) at Department of Agricultural Statistics, B. A. College of Agriculture, Anand. The significance of treatment effects was tested using the F test at the 5% probability level and standard error of mean (S.Em.±), critical difference (C.D.) and coefficient of variation (C.V.%) was calculated to interpret treatment differences with precision.

Result and Discussion

Effect of varieties

Plant population:

Plant population per meter row length at both 15 DAS and harvest was not significantly influenced by varietal differences. This uniformity suggests that initial establishment was largely unaffected by genetic variation under the given environmental conditions.

Growth parameters:

Varietal differences were found to be non-significant in plant height at 30 DAS but become evident at 60 DAS and harvest. Variety GG 5 (V_2) recorded the tallest plants (47.81 cm at 60 DAS and 56.57 cm at harvest), statistically on par with JG 14 (V_3). In contrast, variety GJG 3 (V_1) exhibited the shortest plants (38.23 cm at 60 DAS and 45.47 cm at harvest). These differences can be attributed to genetic variation in traits such as cell division, stem elongation and gibberellin activity, which regulate plant height in chickpea. Similar varietal influences were reported by Sikdar *et al*., (2015); Getachew & Abraham (2021).

Root nodulation also varied significantly, among the varieties, JG 14 (V_3) produced the highest number of root nodules (18.08), while GJG 3 (V_1) recorded the lowest root nodules per plant (14.75). This variation reflects genotypic differences in nodulation efficiency and rhizobium symbiosis, corroborating the findings of Kripanidhi *et al*., (2017).

Variety GJG 3 (V_1) required the lowest days to 50% flowering (51.27), whereas the variety GG 5 (V_2) required the highest days to 50% flowering (54.73). Such variation may be linked to genetic regulation of flowering-time genes and sensitivity to photoperiod and temperature. These findings align with those of Gaur *et al*., (2015); Daba *et al*., (2016); Anwar *et al*., (2022). Similarly, variety GJG 3 (V_1) recorded the lowestdays to harvest (101.93), while GG 5 (V_2) recorded the highest (108.47) days to harvest. This variation may reflect differences in growing degree day (GDD) requirements and tolerance to terminal heat stress. These findings are consistent with Singh *et al*., (2022); Ghormare *et al*., (2025); Jha *et al*., (2025).

Yield attributes:

Varietal effects were significant for branching, with variety JG 14 (V_3) produced the highest number of branches per plant (10.87), while GJG 3 (V_1) produced the fewest (7.36). This variation may be linked to differences in apical dominance and lateral meristem activity. Varieties with reduced apical dominance, enhanced lateral meristem activity and greater lateral growth may produce more branches, whereas those with strong apical dominance may produce fewer branches. These findings aligned with those of Getachew and Abraham (2021) and Kumar *et al*., (2022a), who also reported significant varietal effects on branching.

Pods per plant followed a similar trend, with variety JG 14 (V_3) recorded the maximum pods per plant (50.25), statistically at par with GG 5 (V_2), while GJG 3 (V_1) produced the lowest pods per plant (39.64). Similar results were also reported by Sikdar *et al*., (2015); Sethi *et al*., (2016). Varieties with greater branching capacity provide more sites for pod initiation may have resulted in more pods per plant. These findings are in line with those of Rawat *et al*., (2022); Ali & Terefe (2023).

Dry matter accumulation was significantly highest (37.24 g) in GG 5 (V_2), followed closely by JG 14 (V_3), while GJG 3 (V_1) recorded the lowest dry matter accumulation (30.23 g). This variation may reflect genotypic differences in heat utilization, photosynthetic efficiency, assimilate partitioning and physiological efficiency in assimilate accumulation. As reported by Raghavendra *et al*., (2021); Kumar *et al*., (2022a).

Pod weight per plant and seed index were not significantly affected by varietal differences.

Yield:

Haulm yield varied significantly, with variety GG 5 (V_2) produced the highest haulm yield (2871 kg/ha),

Table 2: Plant population and growth of chickpea as influenced by varieties and different dates sowing dates.

Treatments	Plant population (per meter raw length)		Growth parameters				Days to 50% flowering	Days to harvest
			Plant height (cm)			Root nodules		
	At 15 DAS	At harvest	At 30 DAS	At 60 DAS	At harvest	At 40 DAS		
Main plot : Variety (V)								
V_1: GJG 3	10.87	9.67	18.57	38.23	45.47	14.75	51.27	101.93
V_2: GG 5	10.93	9.89	20.52	47.81	56.57	16.43	54.73	108.47
V_3: JG 14	10.69	9.53	19.79	44.91	51.17	18.08	54.07	107.13
S.Em.±	0.28	0.28	0.52	1.14	1.41	0.36	0.04	0.19
C.D. at 5%	NS	NS	NS	4.46	5.54	1.43	0.15	0.76
C.V. (%)	9.87	11.14	10.35	10.07	10.70	8.57	0.28	0.70
Sub plot : Date of sowing (D)								
D_1: 20th Oct.	10.63	9.63	22.31	47.16	53.93	16.22	57.33	112.33
D_2: 30th Oct.	10.67	9.52	22.02	47.22	53.98	17.00	56.11	110.89
D_3: 10th Nov.	10.85	9.59	19.91	45.42	53.58	16.42	54.89	108.33
D_4: 20th Nov.	10.96	9.81	18.38	41.20	48.62	16.80	51.67	103.56
D_5: 30th Nov.	11.04	9.93	15.51	37.24	45.24	15.64	46.78	94.11
S.Em.±	0.31	0.24	0.55	1.29	1.69	0.46	0.12	0.15
C.D. at 5%	NS	NS	1.61	3.75	4.94	NS	0.36	0.45
Interaction (V×D)								
S.Em.±	0.54	0.42	0.96	2.23	2.93	0.80	0.21	0.27
C.D. at 5%	NS	NS	NS	NS	NS	NS	0.62	0.77
C.V. (%)	8.56	7.47	8.43	8.84	9.94	8.48	0.68	0.43

statistically at par with JG 14 (V_3), while GJG 3 (V_1) recorded the lowest haulm yield (2485 kg/ha). This variation can be attributable to differences in plant height, crop duration to accumulate vegetative biomass and dry matter accumulation. These findings are in agreement with Ali *et al*., (2018); Dhote *et al*., (2019). who also reported significant varietal effects on haulm yield.

Harvest index was significantly highest (45.26%) in GJG 3 (V_1), while GG 5 (V_2) recorded the lowest harvest index (43.66%). This may reflect genotypic variation in assimilate partitioning efficiency and efficiency in channelling vegetative biomass into reproductive yield, as also noted by Mallikarjuna *et al*., (2019); Ghormare *et al*., (2025).

Varietal effects on seed yield were found to be non-significant. This indicates that all three varieties (GJG 3, GG 5 and JG 14) showed similar yield performance under the given management conditions, suggesting that their genetic yield potential was expressed comparably under the prevailing agro-climatic conditions.

The per day productivity was also found to be non-significant for varieties. This indicated that the varieties GJG 3 (V_1), GG 5 (V_2) and JG 14 (V_3) produced comparable yield per unit time and their efficiency in yield production remained similar despite differences in days to harvest. The similar per-day productivity suggests that variations in crop duration were offset by proportional differences in yield accumulation. Longer-duration varieties likely accumulated yield more gradually, whereas shorter-duration varieties compensated through a faster rate of biomass and yield formation, resulting in comparable per day productivity.

Quality parameters:

Protein content (%) and protein yield were not significantly influenced by varietal differences, indicating that genetic variation among the tested varieties did not markedly affect seed quality traits and the nutritional quality of chickpea seed was relatively stable across genotypes.

Effect of sowing date

Plant population:

Plant population per meter row length at 15 DAS and harvest was not affected significantly by sowing date, suggesting that germination and establishment were uniform across treatments.

Growth parameters:

Sowing date exerted a significant influence on plant height. At 30 DAS, the tallest plants (22.31 cm) were recorded in the 20th October sowing (D_1), statistically at par with the 30th October sowing (D_2). At 60 DAS and harvest, maximum plant height (47.22 cm and 53.98 cm, respectively) was observed in the 30th October sowing (D_2), at par with 20th October (D_1) and 10th November (D_3). The shortest plants across all stages were consistently recorded in the 30th November sowing (D_5).

Table 3: Yield attributes, yield and quality parameters of chickpea as influenced by varieties and different dates sowing dates.

Treatments	Yield attributes					Yield				Quality parameters	
	Branches per plant	Pods per plant	Pod weight (g)	DMA	Seed index (g)	Yield (kg/ha)		HI	PDD	Protein (%) in seed	Protein yield (kg/ha)
	AH	AH	AH			Seed	Haulm				
Main plot : Variety (V)											
V_1: GJG 3	7.36	39.64	12.34	30.23	22.46	2049	2485	45.26	20.01	22.43	459.03
V_2: GG 5	9.71	48.81	12.61	37.24	21.48	2223	2871	43.66	20.49	22.24	494.40
V_3: JG 14	10.87	50.25	12.53	36.63	22.64	2025	2596	43.82	18.96	22.05	446.02
S.Em.±	0.25	1.27	0.34	0.96	0.44	63	75	0.08	0.54	0.18	13.56
C.D. at 5%	1.00	4.99	NS	3.77	NS	NS	293	0.32	NS	NS	NS
C.V. (%)	10.55	10.64	10.65	10.71	7.75	11.64	10.92	0.72	10.54	3.20	11.26
Sub plot : Date of sowing (D)											
D_1: 20th Oct.	9.47	49.11	13.27	38.82	23.41	2291	2949	43.73	20.40	22.14	506.73
D_2: 30th Oct.	9.87	49.69	13.08	38.43	22.70	2230	2825	44.06	20.18	22.24	495.87
D_3: 10th Nov.	9.87	47.76	13.14	35.13	22.12	2164	2752	44.03	19.97	22.28	481.94
D_4: 20th Nov.	9.38	44.53	11.89	31.98	21.61	1956	2439	44.57	18.86	22.25	434.61
D_5: 30th Nov.	7.98	40.09	11.09	29.14	21.11	1856	2288	44.84	19.70	22.30	413.28
S.Em.±	0.29	1.26	0.36	1.06	0.49	75	93	0.05	0.71	0.17	15.37
C.D. at 5%	0.84	3.67	1.04	3.11	1.44	219	271	0.13	NS	NS	44.86
Interaction (V×D)											
S.Em.±	0.50	2.18	0.62	1.84	0.85	130	161	0.08	1.23	0.30	26.62
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	3.59	NS	77.71
C.V. (%)	9.30	8.16	8.60	9.20	6.66	10.72	10.52	0.31	10.76	2.30	9.88

AH: At harvest; DMA: Dry matter accumulation per plant (g); PDD: Per day productivity; HI: Harvest Index

Delayed sowing (30th November) reduced plant height by 43.84% at 30 DAS, 26.78% at 60 DAS and 19.32% at harvest compared to early sowing (20th October). Similar reduction in plant height with delayed sowing were reported by Kripanidhi *et al*., (2017). The variation might be due to shortened vegetative growth phase under late sowing due to exposure to high temperature and accelerated transition from vegetative to reproductive phases. These findings are comparable to those of Sikdar *et al*., (2015); Thombre *et al*., (2019)

Days to 50% flowering were minimum (46.78 days) in 30th November sowing (D_5) and maximum (57.33 days) in 20th October sowing (D_1). Delayed sowing markedly reduced the days taken to 50% flowering, as also reported by Ali *et al*., (2018). Late sowing may have accelerated flowering might be due to higher temperature during the early vegetative phase, which may have accelerated physiological processes and hasten the shift to reproduction to escape terminal heat stress. These findings aligned with those of Krishnamurthy *et al*., (2011); Gaur *et al*., (2015). Richard *et al*., (2020) further noted that rapid GDD and thermal time accumulation for flowering also shorten the vegetative phase, thereby reduces the days to 50% flowering.

Similarly, days to harvest were lowest (94.11days) in 30th November sowing (D_5) and highest (112.33 days) in 20th October sowing (D_1). Delayed sowing curtailed vegetative and reproductive phases might be due to terminal heat stress and longer daylight, which may accelerated phenology, GDD accumulation and force earlier maturity. Similar trends were reported by Krishnamurthy *et al*., (2011); Ali *et al*., (2018).

Root nodules per plant at 40 DAS were not affected significantly by effect of sowing dates.

Yield attributes:

Branching was significantly influenced by sowing date. Maximum branches per plant (9.87) were recorded both in 30th October (D_2) and 10th November (D_3), statistically at par with 20th October (D_1) and 20th November (D_4). The lowest branches per plant (7.98) was observed in 30th November (D_5). Similar results were also reported by Sikdar *et al*., (2015). These differences can be attributed to favourable thermal conditions and longer vegetative phase under optimum sowing, which enhance growth and branching. These findings are similar to those of Husnain *et al*., (2015); Vyshnavi *et al*., (2024).

Pods per plant recorded significantly highest (49.69) in 30th October (D_2), which was statistically on par with 20th October (D_1) and 10th November (D_3). In contrast, the lowest number of pods per plant (40.09) was recorded in 30th November (D_5). Such results were also obtained

Table 4: Days to 50% flowering of chickpea as influenced by interaction between verities and different sowing dates.

Varieties / Date of sowing	V1	V2	V3
D1	56.00	58.00	58.00
D2	54.33	57.00	57.00
D3	54.00	55.67	55.00
D4	49.00	54.00	52.00
D5	43.00	49.00	48.33
S.Em.±	0.21		
C.D. at 5%	0.62		

by Kripanidhi *et al.*, (2017); Rathod *et al.*, (2024). The reduction in pod numbers under delayed sowing is likely due to heat-induced pollen sterility and poor fertilization as highlighted by Ali *et al.*, (2018).

20th October sowing (D_1) recorded significantly highest Pod weight per plant (13.27 g), statistically on par with 30th October (D_2) and 10th November (D_3). The lowest pod weight per plant (11.09 g) was recorded in 30th November (D_5). Optimum sowing enhanced pod weight can be attributed to prolonged reproductive phase, which may have favoured efficient as similate partitioning and translocation, supported the better pod filling. These findings are consistent with those of Raghavendra *et al.*, (2021).

The highest seed index (23.41 g) was recorded in 20th October sowing, which was at par with 30th October and 10th November sowing and the lowest seed index (21.11 g) was recorded in 30th November sowing. The decrease in seed index may be due to shortened crop growth period and exposes the crop to higher temperature and moisture stress during seed filling, which may reduce the dry matter accumulation and assimilate translocation to seeds, resulting in smaller and lighter grains. These findings are in line with findings of Vysnavi *et al.*, (2024).

Sowing date significantly affected dry matter accumulation in chickpea. The highest dry matter accumulation (38.82 g) was recorded in 20th October (D_1), which was at par with 30th October (D_2). While the lowest dry matter accumulation (29.14 g) was observed in 30th November (D_5), representing a 24.94% decline from early (20th October) to late (30th November) sowing. Similar patterns were reported by Thombre *et al.*, (2019); Kumar *et al.*, (2022a). Greater dry matter accumulation under early sowing can be attributed to attributed to extended growth duration, enhanced radiation interception and greater GDD accumulation during flowering and seed filling. These findings are in lined with those of Neenu *et al.*, (2017); Raghavendra *et al.*, (2021).

Table 5: Days to harvest of chickpea as influenced by interaction between verities and different sowing dates.

Varieties / Date of sowing	V1	V2	V3
D1	109.00	115.00	113.00
D2	106.33	114.33	112.00
D3	103.33	111.67	110.00
D4	99.00	105.67	106.00
D5	92.00	95.67	94.67
S.Em.±	0.27		
C.D. at 5%	0.77		

Yield:

Seed yield in chickpea was significantly influenced by sowing dates. The highest seed yield (2291 kg/ha) was obtained from the 20th October sowing (D_1), statistically at par with 30th October (D_2) and 10th November (D_3), while the lowest seed yield (1856 kg/ha) was recorded under 30th November (D_5). Relative to 20th October (D_1), seed yield declined by 2.74%, 5.87%, 17.13% and 23.44% in 30th October (D_2), 10th November (D_3), 20th November and 30th November (D_5), respectively. Similar seed yield reductions under delayed sowing have been reported by Kripanidhi *et al.*, (2017); Dhote *et al.*, (2019); Bhor *et al.*, (2025). The decline can be attributed to terminal heat stress, shortened growth phases, poor flower and pod set and restricted assimilate translocation. These findings are corroborating with those of Sethi *et al.*, (2016); Neenu *et al.*, (2017).

Haulm yield followed a similar trend, with the maximum haulm yield (2949 kg/ha) was recorded in 20th October sowing (D_1) and the minimum haulm yield (2288 kg/ha) was recorded in 30th November (D_5), representing a 22.41% decline from early to late sowing. The reduction is might be due to reduced vegetative growth, plant height, branching and leaf area under delayed sowing, coupled with accelerated phenology and terminal heat stress during the reproductive phase which may have diverted assimilates towards seed formation rather than vegetative biomass. These findings are consistent with Sethi *et al.*, (2016).

Harvest index was also significantly affected by sowing date. The highest harvest index (44.84%) was observed in 30th November (D_5), while the lowest harvest index (43.73%) was recorded in 20th October (D_1). The increased harvest index under delayed sowing might be due to a sharper decline in biomass relative to seed yield, resulting in greater assimilate partitioning into seeds. Conversely, early sowing produced taller plants and higher biomass, but weaker source-sink relationships lowered proportional seed yield may have resulted in lowered

Table 6: Per day productivity of chickpea as influenced by interaction between verities and different sowing dates.

Date of sowing \ Varieties	V1	V2	V3
D1	109.00	115.00	113.00
D2	106.33	114.33	112.00
D3	103.33	111.67	110.00
D4	99.00	105.67	106.00
D5	92.00	95.67	94.67
S.Em.±	0.27		
C.D. at 5%	0.77		

harvest index. These findings align with Richard *et al*., (2022); Mallikarjuna *et al*., (2019).

Effect of sowing dates on per day productivity was found to be non-significant. This indicates that variations in sowing time did not affect the efficiency of daily yield production. Although delayed sowing reduced total seed yield and crop duration, the average daily productivity remained statistically comparable across sowing dates. This response may be attributed to the proportional decline in seed yield with the shortened crop duration under delayed sowing, resulting in a relatively stable rate of daily yield accumulation and yield efficiency per unit time. Similar findings were reported by Richards *et al*., (2022)

Quality parameters:

The protein (%) in seed was not affected significantly by sowing dates, but sowing dates significantly influenced protein yield. The highest protein yield (506.7 kg/ha) was recorded in the 20th October sowing (D_1), followed by 30th October and 10th November. Delayed sowing markedly reduced protein yield, with the lowest protein yield (413.3 kg/ha) was observed in the 30th November sowing (D_5). This decline can be attributed to reduced seed yield under late sowing, as protein yield is a direct function of seed yield and protein concentration. These findings are consistent with earlier reports of Krishnamurthy *et al*., (2011); Ali *et al*., (2018).

Interaction effect (V×D)

Plant population:

Influence of the interaction between varieties and sowing dates (V×D) was found to be non-significant for plant population at both 15 DAS and harvest

Growth parameters:

A significant varietal × sowing date (V×D) interaction was observed for days to 50% flowering in chickpea. The lowest days to 50% flowering (43.00) was recorded in GJG 3 sown on 30th November (V_1D_5), whereas the highest days to 50% flowering (58.00) was recorded both

Table 7: Protein yield of chickpea as influenced by interaction between verities and different sowing dates.

Date of sowing \ Varieties	V1	V2	V3
D1	506.4	531.4	482.4
D2	555.6	484.5	447.5
D3	471.6	534.2	440.0
D4	390.7	497.8	415.4
D5	370.9	424.1	444.9
S.Em.±	26.6		
C.D. at 5%	77.7		

in GG 5 sown on 20th November (V_2D_1) and JG 14 sown on 20th October (V_3D_1). The variation in days to 50% flowering due to interaction of varieties and sowing dates might be due to differences in GDD requirements and photoperiod sensitivity among genotypes across the different sowing windows. Early maturing types accumulate the required GDD more rapidly, leading to earlier flowering under late sowing, while late maturing types demand additional heat units and thus flower later during early sowing. These findings are comparable to those of Daba *et al*., (2016) and Anwar *et al*., (2022). As noted by Vyshnavi *et al*., (2024), the magnitude of variation depends on the genotypic adaptability to prevailing environmental conditions under different sowing windows.

The minimum days to harvest (92.00) was observed in GJG 3 sown on 30th November (V_1D_5), whereas the maximum days to harvest (115.00) was recorded in GG 5 sown on 20th October (V_2D_1). This interaction highlights that maturity duration is strongly influenced by environmental conditions. The variation in days to harvest can be attributed to cultivar specific responses to temperature, photoperiod and stress, with early maturing types completing their growth cycle more rapidly under delayed sowing, while late maturing types require additional heat units and extend their phenological phases under early sowing. Similar genotype × environment interactions affecting maturity duration have been reported by Narayan *et al*., (2024), Bhor *et al*., (2025) and Jha *et al*., (2025).

Plant height at 30 DAS, 60 DAS and at harvest and root nodules per plant at 40 DAS was not affected significantly due to interaction effect (V×D).

Yield attributes:

All yield attributing characters including branches per plant, pods per plant, pod weight per plant, dry matter accumulation per plant and seed index were found to be non-significant due to the effect of interaction between varieties and sowing dates (V×D).

Yield:

Per day productivity was significantly affected by interaction (V×D) in chickpea. GJG 3 sown on 30th October (V_1D_2) recorded highest per day productivity (22.33 kg/ha/day), which was at par with GJG 3 sown on 20th October (V_1D_1), GJG 3 sown on 10th November (V_1D_3), GG 5 sown on 20th October (V_2D_1), GG 5 sown on 10th November (V_2D_3), GG 5 sown on 20th November (V_2D_4) and GG 5 sown on 30th November (V_2D_5). The lowest per day productivity was observed in GJG 3 sown on 20th November (V_1D_4). Variation in per day productivity may reflects the combined effect of seed yield and maturity duration, with differences arising from genotypic adaptability and growth duration across sowing windows. Thus, any change in yield or crop duration was directly manifested in per day productivity of chickpea.

The effect of interaction between varieties and sowing dates (V×D) was non-significant on seed yield, haulm yield and harvest index.

Quality parameters:

The difference in protein (%) in seed was found non-significant but become significant for protein yield. The highest protein yield (555.62 kg/ha) was recorded in GJG 3 sown on 30th October (V_1D_2) and it was statistically on par with GJG 3 sown on 20th October (V_1D_1), GG 5 sown on 20th October (V_2D_1), GG 5 sown on 30th October (V_2D_2), GG 5 sown on 10th November (V_2D_3), GG 5 sown on 20th November (V_2D_4) and JG 14 sown on 20th October (V_3D_1). The lowest protein yield (370.89 kg/ha) was recorded in GJG 3 sown on 30th November (V_1D_5). This variation in protein yield may be due to combined effects of seed yield and protein concentration, as protein yield is a product of both. While neither component showed significant interaction individually, their combined influence resulted in significant variation.

Conclusion

The present investigation clearly demonstrated that both varietal choice and sowing date exerted significant influence on the growth, yield attributes and yield. Variety GG 5 consistently exhibited superior performance. Optimum sowing on 20th October consistently produced the highest seed yield, haulm yield, protein yield, while delayed sowing beyond 20th November led to substantial reductions due to shortened crop duration, terminal heat stress and poor assimilate partitioning. Overall, the findings emphasize that timely sowing, particularly around 20th October, coupled with varietal choice, is critical for achieving higher productivity and profitability in chickpea cultivation.

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