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Assessing the effects of sowing time and genotype on chickpea dry matter accumulation and yield in the Northern dry zone of Karnataka under changing weather conditions

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Abstract

Chickpea (*Cicer arietinum* L.) is an essential legume in semi-arid regions like the Northern Dry Zone of Karnataka, India, where its productivity is highly sensitive to climatic conditions. This study assessed the effects of different sowing times and genotypes on chickpea dry matter accumulation and yield under changing weather conditions. Conducted at the Regional Agricultural Research Station, Vijayapura, the experiment used a split-plot design with four sowing dates (D₁: early October, D₂: late October, D₃: early November, D₄: late November) and three genotypes (G₁: JG-11, G₂: BGD-111-1, G₃: JG-14). Results showed that early October sowing (D₁) produced the highest dry matter in leaves (1.88 g/plant), stems (5.09 g/plant), and reproductive parts (12.06 g/plant). Genotype JG-11 (G₁) achieved the highest seed yield (1848 kg/ha), while JG-14 (G₃) had the best haulm yield (2273 kg/ha). Seed yield was highest with early sowing (D₁: 1913 kg/ha) and progressively declined with delayed sowing (D₄: 1512 kg/ha). The study highlights the importance of optimizing sowing time, particularly early October, and selecting suitable genotypes like JG-11 and JG-14 to enhance chickpea productivity under changing climatic conditions.

Keywords: Dry matter accumulation, genotype, sowing time, dry weight

Introduction

Chickpea (*Cicer arietinum* L.), a cool-season legume in the Fabaceae family, is a crucial protein source for millions in developing countries, particularly in South Asia. This legume is well-adapted to semi-arid tropical regions and is typically grown in the Indian subcontinent after the rainy season during winter on conserved soil moisture. Nutritionally, chickpea is rich in protein (20-22%), dietary fiber, essential minerals such as phosphorus, calcium, magnesium, iron, and zinc, and vitamins B1 and C (in its green stage) and β -carotene, making it a highly valuable crop often referred to as the “poor man’s meat.” It is consumed in various forms, including raw, roasted, boiled, or processed into flour, and is the foundation of many traditional dishes. Its leaves contain malic and citric acids, which are beneficial for stomach ailments and are considered natural blood purifiers. Furthermore, its grain husks, stems, and leaves serve as livestock feed, contributing to its economic importance. Beyond its nutritional value, chickpea is vital for sustainable agriculture, particularly in enhancing soil fertility through biological nitrogen fixation. The crop can fix atmospheric nitrogen up to 140 kg N ha⁻¹, meeting about 80% of its nitrogen needs through symbiosis and leaving a significant amount of residual nitrogen for subsequent crops. This capability enriches the soil's organic matter, thereby improving soil health and fertility. The deep taproot system of chickpea further enhances soil texture and aeration, benefiting future crop rotations. India, the world’s largest producer of chickpea, accounts for 68% of the global acreage and 66% of its production, with key cultivation areas in Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, and Chhattisgarh. Chickpea production is highly sensitive to climatic factors like temperature, rainfall, light intensity, and sunshine duration. Optimal growth conditions include lower temperatures, shorter photoperiods, and adequate soil moisture, while higher temperatures, longer photoperiods, and moisture stress reduce crop duration and yield.

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Climate change presents a significant challenge to chickpea production, particularly for rainfed crops like winter pulses. Increasing temperatures and altered rainfall patterns have extended rainy seasons and shortened winters, negatively impacting chickpea, which thrives in cooler conditions. This crop is also sensitive to waterlogging, making precise sowing times crucial for maximizing yields and utilizing favourable climatic conditions. Adjusting sowing dates to align with genotypes and agro-climatic conditions can help sustain productivity. Understanding chickpea's phenological responses to changing weather is essential for optimizing sowing times and selecting genotypes better suited to withstand biotic and abiotic stresses. Comprehensive studies on chickpea phenology and crop-weather relationships under different climatic conditions are needed to enhance productivity, especially in regions like the Northern Dry Zone of Karnataka.

Materials and Methods

The experiment was conducted at the Regional Agricultural Research Station (RARS) in Vijayapura, located at a latitude of 16°46'15.16" North, longitude of 75°44'53.78" East, and an altitude of 593.8 meters above mean sea level. The study involved 12 treatments allocated in a split-plot design with three replications to evaluate the effects of different sowing dates and genotypes on chickpea growth and yield. The main plots consisted of four sowing dates represented by Standard Meteorological Weeks (SMW): D₁ (first fortnight of October, 40-41st SMW), D₂ (second fortnight of October, 42-43rd SMW), D₃ (first fortnight of November, 45-46th SMW), and D₄ (second fortnight of November, 47-48th SMW). In the subplots, three chickpea genotypes were tested: G₁ (JG-11), G₂ (BGD-111-1), and G₃ (JG-14). Sowing was done as per the treatments by hand dibbling with 1-2 seeds at each hill.

Results and Discussion

Dry matter accumulation in different parts

Leaves: The effect of sowing time on dry matter accumulation in leaves was significant at all the phenological stages. The dry matter was increased up to the beginning seed growth stage after sowing, but it was decreasing at first maturity. The leaf dry weight was maximum under the 1st fortnight of October sowing (D₁) at first flower, first pod, beginning seed growth, first maturity and full maturity (1.39, 3.52, 4.12, 3.60 and 1.88 g/plant, respectively), followed by 2nd fortnight of October (D₂) (1.31, 3.29, 3.87, 3.39 and 1.79 g/plant, respectively), and significantly minimum values recorded under the 2nd fortnight of November (D₄) at all the stages (1.14, 2.97, 3.42, 3.01 and 1.53 g/plant, respectively). The effect of genotypes on dry matter accumulation in leaves was significant at all the phenological stages. Among the genotypes, JG-11 (G₁) has maintained significantly higher leaf dry weight at first flower, first pod, beginning seed growth, first maturity and full maturity phenophases (1.36, 3.39, 4.01, 3.53 and 1.84 g, respectively), followed by BGD-111-1(G₁) (1.19, 3.20, 3.73, 3.24 and 1.74 g, respectively). In comparison, JG-14 (G₃) recorded minimum leaf dry weight at all the phenological stages (1.27, 3.10, 3.59, 3.15 and 1.58 g/plant, respectively).

Stem

A significant change in dry matter accumulation in stem was

observed due to various sowing times at all the growth stages. The stem dry weight was maximum (1.00, 2.39, 3.18, 5.09 and 5.09 g plant⁻¹, respectively) under the 1st fortnight of October (D₁) at first flower, first pod, beginning seed growth, first maturity and full maturity phenophases, followed by the 2nd fortnight of October (D₂, 0.95, 2.21, 3.01, 4.76 and 4.77 g/plant, respectively), and significantly minimum under 2nd fortnight of November (D₄) sowing at first flower, first pod, beginning seed growth, first maturity and full maturity phenophases (0.79, 1.89, 2.57, 4.13 and 4.14 g plant⁻¹, respectively). The effect of genotypes on dry matter accumulation in stem was significant at all the growth stages. Among the genotypes, JG-14 (G₃) has maintained significantly higher stem dry weight at first flower, first pod, beginning seed growth, first maturity and full maturity phenophases (1.03, 2.37, 3.02, 4.96 and 4.96 g/plant, respectively), followed by BGD-111-1 (G₂, 0.88, 2.11, 2.88, 4.50 and 4.50 g plant⁻¹, respectively). At the same time, JG-11 (G₁) recorded minimum stem dry weight at all the stages (0.80, 1.96, 2.78, 4.41 and 4.41 g/plant, respectively).

Reproductive parts

Sowing time varied significantly in dry matter accumulation in reproductive parts at first flower, first pod, beginning seed growth, first maturity, full maturity stages. The reproductive parts dry weight was maximum under the 1st fortnight of October (D₁) at first flower, first pod, beginning seed growth, first maturity and full maturity phenophases (0.52, 4.27, 6.77, 10.43 and 12.06 g/plant, respectively), followed by the 2nd fortnight of October (D₂, 4.06, 6.21 and 9.84 g/plant, respectively) at first pod, beginning seed growth and first maturity but it was statistically at par with the 2nd fortnight of October (D₂, 11.63 g plant⁻¹) and 1st fortnight of November (D₃, 11.28 g plant⁻¹) at full maturity. Significantly minimum weight recorded under 2nd fortnight of November sowing (D₄) at all the phenophases (0.43, 3.52, 4.68, 8.84 and 10.57 g plant⁻¹, respectively). Genotypes varied significantly in dry matter accumulation in reproductive parts at all the phenological stages. Among the genotypes, JG-11 (G₁) has maintained significantly higher reproductive parts dry weight at first flower, first pod, beginning seed growth, first maturity and full maturity phenophases (0.50, 4.04, 6.11, 9.87 and 11.62 g/plant, respectively), followed by JG-14 recorded lower reproductive parts dry weight at all phenological stages (G₃) (0.46, 3.81, 5.39, 9.71 and 11.46 g/plant, respectively). In comparison, BGD-111-1 (G₂, 0.48, 3.91, 5.55, 9.23 and 11.08 g/plant, respectively) but it was on par at first flower stage (0.48 g/plant), but it was on par at first flower stage (0.48 g/plant).

The dry matter accumulation in leaf, stem and reproductive parts was significantly more at the 1st fortnight of October sowing (1.88, 5.09 and 12.06 g/plant, respectively) and the lower dry matter under the 2nd fortnight of November (1.53, 4.14 and 10.57 g/plant, respectively). Similar results had earlier been reported by Kumar *et al.* (2006) [4]. The genotype JG-14 is considered thermo-tolerant, which had maintained higher dry matter at all the stages. The differences in dry matter production among varieties could mainly be attributed to differences in the leaf area and their genetic constitutions. Genotypic variations in dry matter accumulation in chickpea genotypes were also reported by Kumar *et al.* (2006) [4] and Patil *et al.* (2020) [5].

Table 1: Dry matter accumulation in leaves, stem and reproductive parts (g/plant) of chickpea genotypes influenced by the growing environments at different phenological stages

Treatments	Dry matter accumulation (g plant ⁻¹)														
	Leaves					Stem					Reproductive parts				
	II	III	IV	V	VI	II	III	IV	V	VI	II	III	IV	V	VI
Date of sowing (D)															
D ₁ : 1 st fortnight October	1.39	3.52	4.12	3.60	1.88	1.00	2.39	3.18	5.09	5.09	0.52	4.27	6.77	10.43	12.06
D ₂ : 2 nd fortnight October	1.31	3.29	3.87	3.39	1.79	0.95	2.21	3.01	4.76	4.77	0.49	4.06	6.21	9.84	11.63
D ₃ : 1 st fortnight November	1.24	3.14	3.69	3.22	1.68	0.87	2.10	2.83	4.50	4.51	0.46	3.83	5.07	9.30	11.28
D ₄ : 2 nd fortnight November	1.14	2.97	3.42	3.01	1.53	0.79	1.89	2.57	4.13	4.14	0.43	3.52	4.68	8.84	10.57
S.Em±	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.08	0.03	0.24
C.D. (p=0.05)	0.02	0.03	0.07	0.03	0.02	0.03	0.08	0.03	0.05	0.06	0.04	0.04	0.28	0.11	0.82
Genotype (G)															
G ₁ : JG-11	1.36	3.39	4.01	3.53	1.84	0.80	1.96	2.78	4.41	4.41	0.50	4.04	6.11	9.87	11.62
G ₂ : BGD-111-1	1.19	3.20	3.73	3.24	1.74	0.88	2.11	2.88	4.50	4.50	0.48	3.91	5.55	9.23	11.08
G ₃ : JG-14	1.27	3.10	3.59	3.15	1.58	1.03	2.37	3.02	4.96	4.96	0.46	3.81	5.39	9.71	11.46
S.Em±	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.07	0.02	0.02
C.D. (p=0.05)	0.01	0.02	0.03	0.02	0.02	0.02	0.06	0.02	0.05	0.05	0.03	0.03	0.20	0.07	0.06

Seed yield

The data on seed yield of chickpea as influenced by sowing dates and genotypes presented in Table 3. The seed yield varied significantly among the different sowing dates. The seed yield was progressively decreased with delay in sowing. A significantly higher seed yield (1913 kg/ha) was recorded under early sowing at the 1st fortnight of October (D₁), which was on par with the 2nd fortnight of October (D₂, 1775 kg/ha). The minimum seed yield (1512 kg/ha) was recorded under delayed sowing on the 2nd fortnight of November (D₄). The genotypes showed variation in the seed yield significantly. Among the genotypes, the JG-11 (G₁) was produced a significantly maximum seed yield (1848 kg ha⁻¹) and which was on par with the genotype BGD-111-1 (G₂) (1748 kg/ha). The minimum seed yield was with genotype JG-14 (G₃) (1521 kg/ha). The higher seed yield produced in the earlier sowing dates than the delayed sowing. 1st fortnight of October (1913 kg/ha) recorded higher seed yield followed by the 2nd fortnight of October (1775 kg ha⁻¹) and we observed that with each consecutive 15 days delay in sowing from 1st fortnight of October cause a reduction in seed yield by 15.2 percent at 1st fortnight of November (1622 kg/ha) and 20.96 percent at 2nd fortnight of November (1512 kg/ha). The results of our investigation were in conformation with Ahmed *et al.* (2011) ^[1], Tiwari and Meena (2014) ^[8] and Ali *et al.* (2018) ^[2]. Heat stress 145 coincides with the reproductive phase of chickpea under delayed sowings. However, chickpea being sensitive to fluctuating temperatures, reduction in reproductive efficiency directly impacts on yield and yield associated traits (Kiran *et al.*, 2017) ^[3]. Among the genotypes, JG-11 recorded a significantly higher seed yield (1848 kg/ha) with an increase of 5.41 percent and 17.7 percent over the genotype BGD-111-1 (1748 kg/ha) and JG-14 (1521 kg/ha). These results were found to be similar to the results of Ahmed *et al.* (2011) ^[1] and Wang *et al.* (2006) ^[9].

Haulm yield

A significant difference in the haulm yield ha⁻¹ was observed due to the effect of various sowing dates. 1st fortnight of October (D₁) sown crop resulted into significantly higher haulm yield (2304 kg/ha), which was on par with 2nd fortnight of October (D₂) sown crop (2249 kg/ha). The significantly lower haulm yield (2067 kg/ha) was recorded under the 2nd fortnight of November (D₄) sowing. Significant differences in the haulm yield kg/ha was observed due to various genotypes. Among different genotypes, JG-14 (G₃) exhibited significantly higher haulm yield (2273 kg/ha), followed by genotype BGD-111-1 (G₂, 2206 kg ha⁻¹) and JG-11 (G₁, 2129 kg/ha). The haulm yield (kg/ha) was also significantly higher with early sowing in the 1st fortnight of October and the reduction in haulm yield with delay in sowing in the 2nd fortnight of November occurred mainly due to the decreased in growth attributes in terms of plant height, leaf area and lower biomass build-up per plant. The decrease in the haulm yield was a tune of 10.1 percent and 4.9 percent in delayed sowings on the 2nd fortnight of November, the 1st fortnight of November respectively, over the 1st fortnight of October sowing. The slower growth on account of lower temperature during the early vegetative growth phase and the overall shorter life span of the crop caused a reduction in biomass of a plant. The earlier findings of Ahmed *et al.* (2011) ^[1] corroborate these results. The haulm yield (kg/ha) showed significant variation due to the variety where significantly the higher haulm yield (2273 kg/ha) was found in JG-14 while JG 11 gave a lower haulm yield (2129 kg/ha). This result indicated that JG-14 produced a higher TDMP than JG-11, which ultimately resulted in higher production of haulm yield. These results were in accordance with the findings of Sikdar *et al.* (2009) ^[7] and Patil *et al.* (2021) ^[6].

Table 2: Seed yield, stalk yield and harvest index of chickpea genotypes influenced by the growing environments

Treatments	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Date of sowing (D)		
D ₁ : 1 st fortnight October	1913	2304
D ₂ : 2 nd fortnight October	1775	2249
D ₃ : 1 st fortnight November	1622	2190
D ₄ : 2 nd fortnight November	1512	2067
S.Em±	65	26
C.D. (p=0.05)	227	90
Genotype (G)		
G ₁ : JG-11	1848	2129
G ₂ : BGD-111-1	1748	2206
G ₃ : JG-14	1521	2273
S.Em±	39	18
C.D. (p=0.05)	118	53

Conclusion

The study highlights the significant impact of sowing dates and genotypic variation on dry matter accumulation and yield of chickpea under changing weather conditions in the Northern Dry Zone of Karnataka. Early sowing during the first fortnight of October (D₁) resulted in higher dry matter accumulation in leaves, stems, and reproductive parts, and ultimately higher seed and haulm yields, compared to delayed sowing. The data indicated that delaying sowing by 15 days led to a reduction in seed yield by 15.2% at the first fortnight of November (D₃) and 20.96% at the second fortnight of November (D₄). The genotype JG-11 (G₁) performed best in terms of seed yield, while JG-14 (G₃) showed higher dry matter accumulation in stems and haulm yield, demonstrating genotypic variations in response to sowing time. These findings suggest that early sowing aligns well with optimal climatic conditions, minimizing heat stress during the reproductive phase and enhancing overall yield. The results also emphasize the importance of selecting suitable genotypes like JG-11 for early sowing to maximize seed yield, while thermo-tolerant varieties like JG-14 can be considered to optimize haulm yield. Therefore, adjusting sowing dates and choosing appropriate genotypes are crucial strategies for enhancing chickpea productivity in semi-arid regions. These insights can guide farmers and policymakers in adopting sustainable agricultural practices that improve chickpea yield under the increasingly unpredictable climate conditions.

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