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Response of chickpea to different sowing dates and seed rates under rainfed conditions

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Abstract
In southwestern Ethiopia, chickpea is typically sown with little regard for the optimal thermal window, and seed rates vary widely among smallholders. A farmer in the Jimma zone, for example, may sow anywhere between late September and early December using 60-120 kg seed ha⁻¹, often with disappointing yields. This research tested the interaction between four sowing dates (15 October, 1 November, 15 November, and 1 December) and three seed rates (60, 80, and 100 kg ha⁻¹) on chickpea (*Cicer arietinum* L. cv. Arerti) performance at the Oromia Institute of Agricultural Sciences, Jimma, during the 2023 post-rainy season. A factorial randomized complete block design with three replications was used. The 1 November sowing at 80 kg ha⁻¹ gave the highest grain yield (2.14 t ha⁻¹), significantly above the earliest and latest sowings. Pods per plant peaked at 41.7 under this treatment, and 100-seed weight reached 24.1 g. Delayed sowing to 1 December cut yield by 29.0% due to terminal moisture stress during pod filling. Increasing seed rate from 60 to 80 kg ha⁻¹ improved yield by 14.3%, but the further increase to 100 kg ha⁻¹ didn't provide an additional advantage and instead reduced pods per plant through intra-specific competition. These results indicate that sowing chickpea in early November at 80 kg ha⁻¹ under Jimma's rainfed conditions captures the best combination of moisture availability and thermal time for yield maximisation.

Keywords: Chickpea, sowing dates, seed rates, rainfed agriculture, pulse production, Cicer arietinum, yield components, thermal time, post-rainy season, southwestern Ethiopia

Introduction

A smallholder farmer near Agaro, 45 km west of Jimma, sowed chickpea on 28 November in 2021 and harvested just 0.8 t ha⁻¹; the following year, he sowed on 2 November and got 1.9 t ha⁻¹ from the same field with the same variety and inputs. That twofold difference, repeated across thousands of farms in the Jimma zone, illustrates how strongly sowing date influences chickpea productivity in rainfed systems [1]. Yet recommended sowing windows for the region remain vague—typically stated as "October to November"—without specifying the narrow optimum [2].

Chickpea (*Cicer arietinum* L.) is the second most important pulse crop in Ethiopia after faba bean, with about 473,000 ha planted annually [3]. It is grown almost entirely on residual soil moisture during the post-rainy season (*meher*), and its success depends on matching phenological development to the declining moisture profile. Sow too early, and vegetative growth consumes moisture before the reproductive phase; sow too late, and terminal drought cuts short grain filling [4, 5].

Seed rate interacts with sowing date by altering canopy architecture and the intensity of competition for soil water. Higher plant densities close the canopy faster, reducing evaporative losses but increasing transpirational demand per unit ground area [6]. The optimum seed rate therefore shifts depending on whether moisture is abundant or limited at the critical pod-fill stage.

Despite chickpea's importance in Ethiopian diets and farming systems, factorial trials combining sowing date and seed rate under Jimma's specific altitude (1,780 m), rainfall pattern (1,530 mm, bimodal), and soil conditions are lacking [7]. This research aimed to: (a) identify the sowing date that maximises grain yield and yield components; (b) determine the seed rate that best complements each sowing window; and (c) understand the mechanism through which sowing date and plant density interact to affect chickpea productivity.

Seasonal Rainfall and Temperature Patterns

The post-rainy cropping window at Jimma extends from mid-October through February, during which residual soil moisture from the main rains (June-September) sustains crop growth. Total rainfall during the 2023 trial period (October-February) was 187 mm, concentrated in October (94 mm) and November (52 mm); December through February received only 41 mm combined. Mean daily temperatures ranged from 18.3°C in November to 15.6°C in January. The thermal time accumulated from sowing to maturity was 1,420-1,490°C days across treatments. Late-sown plots (1 December) experienced visible soil moisture stress from mid-January, coinciding with the pod-filling stage [4, 8].

Material and Methods

Material

The trial was conducted at the research farm of the Oromia Institute of Agricultural Sciences, Jimma, Ethiopia (7°40’N, 36°50’E, altitude 1,780 m). The soil is a Nitisol (clay loam, pH 5.8, OC 2.1%, total N 0.16%). Chickpea variety Arerti (desi type, 90-100 days maturity) was used. Seed was treated with *Mesorhizobium ciceri* inoculant at 10 g kg^{-1} seed before sowing. Basal fertiliser was applied at 18:46:0 (DAP) at 100 kg ha^{-1} at sowing. No supplemental irrigation was provided; the crop relied entirely on residual soil moisture and in-season rainfall [9].

Methods

A 4 × 3 factorial experiment (four sowing dates × three seed rates) was laid out in a randomized complete block design with three replications. Individual plots measured 4 m × 3 m with 30 cm inter-row and continuous within-row sowing. Sowing dates were 15 October (D1), 1 November (D2), 15 November (D3), and 1 December (D4). Seed rates were 60 (S1), 80 (S2), and 100 (S3) kg ha^{-1}. Data on plant height, branches per plant, pods per plant, seeds per pod, 100-seed weight, biological yield, grain yield, and harvest index were collected. Grain yield was measured from a 6 m^2 net plot, adjusted to 10% moisture. Analysis of variance for factorial RCBD was performed in R 4.3.1. Treatment means were compared by Tukey’s HSD at $p \leq 0.05$ [10].

Crop Growth Stage Observations

Phenological stages were recorded following the BBCH scale. Emergence occurred 7-9 days after sowing across all dates. Flower initiation ranged from 42 days (D1) to 38 days (D4), as warmer October temperatures accelerated early development in D1 but cooler December temperatures compressed the vegetative phase in D4. Pod formation began at 58-63 DAS, and physiological maturity was reached at 92-98 DAS. Late-sown plots (D4) matured 4-6 days earlier than D1 and D2 plots, an effect attributed to accelerated senescence under declining moisture rather than true physiological earliness [5].

Results

Table 1: Effect of sowing date on grain yield and yield components of chickpea (averaged across seed rates)

Sowing Date	Grain Yield (t ha^{-1})	Pods per Plant	Seeds per Pod	100-Seed Wt (g)	Plant Ht (cm)	Harvest Index
15 Oct	1.83b	34.2b	1.6ab	22.4b	41.7b	0.38b
1 Nov	2.14a	41.7a	1.8a	24.1a	46.3a	0.43a
15 Nov	1.97ab	38.4ab	1.7ab	23.6ab	44.1ab	0.41ab
1 Dec	1.52c	28.6c	1.4b	21.1c	37.8c	0.34c

Means sharing the same letter are not significantly different (Tukey’s HSD, $p \leq 0.05$).

Sowing date had a highly significant effect on all yield parameters (Table 1). The 1 November sowing (D2) produced the highest grain yield (2.14 t ha^{-1}) and the most favourable yield component profile across the board. Delaying to 1 December slashed yield by 29.0%, primarily through reduced pod number (28.6 vs 41.7) and lighter seed weight (21.1 vs 24.1 g). The 15 October sowing was intermediate; its slightly lower yield compared to D2 may reflect excessive vegetative growth that diverted resources from grain filling [11].

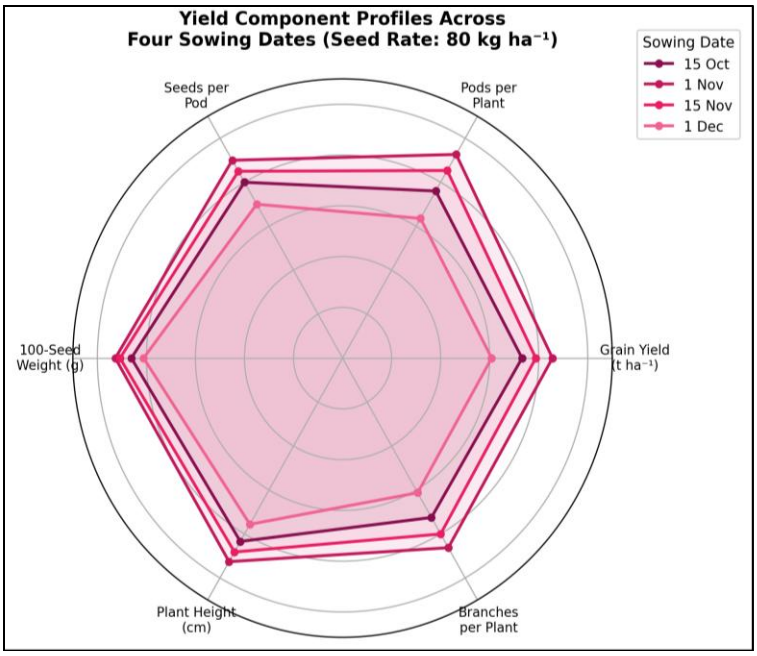

Fig 1: Radar chart comparing normalised yield component profiles of chickpea across four sowing dates at 80 kg ha^{-1} seed rate

Table 2: Effect of seed rate on grain yield and yield components of chickpea (averaged across sowing dates)

Seed Rate (kg ha⁻¹)	Grain Yield (t ha⁻¹)	Pods per Plant	Seeds per Pod	100-Seed Wt (g)	Biological Yield (t ha⁻¹)
60	1.72b	39.8a	1.7a	23.4a	4.31b
80	1.97a	36.4ab	1.7a	22.9a	4.78a
100	1.91a	32.1b	1.6a	22.6a	4.83a

Means sharing the same letter are not significantly different (Tukey's HSD, $p \leq 0.05$).

Increasing seed rate from 60 to 80 kg ha⁻¹ raised grain yield by 14.3% (Table 2), mainly through greater plant stand density that improved light capture and ground cover. But the jump from 80 to 100 kg ha⁻¹ gave no further yield gain and reduced pods per plant from 36.4 to 32.1, indicating that intra-plant competition at high density outweighed the benefit of additional plants [12].

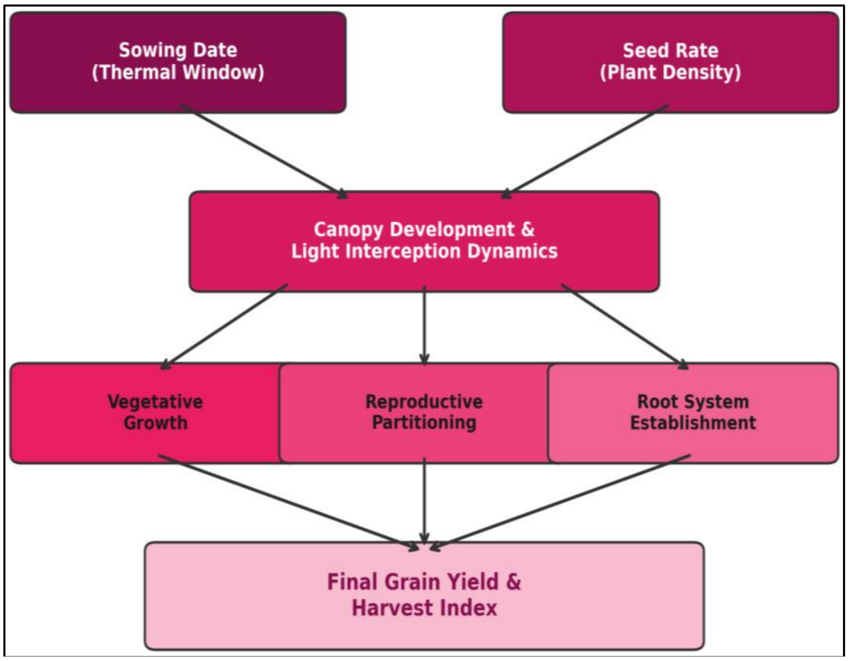

Fig 2: Conceptual mechanism diagram showing how sowing date and seed rate interact through canopy development and resource partitioning to determine final chickpea grain yield

Discussion

The superiority of the 1 November sowing aligns with findings from chickpea trials in central Ethiopia, where Yadeta and co-workers identified late October to early November as the peak sowing window for post-rainy chickpea on Vertisols [2]. The mechanism is straightforward: at this date, adequate residual moisture supports vegetative establishment, and the declining temperature through December and January favours reproductive development without triggering excessive biomass accumulation [13].

The 1 December sowing suffered primarily from terminal moisture stress. By mid-January, soil moisture at 30 cm had fallen below the permanent wilting point in D4 plots, truncating the grain-filling period by roughly 8-10 days compared to D2. This explains both the lower seed weight (21.1 vs 24.1 g) and the reduced pod retention (28.6 vs 41.7 pods per plant) [14]. The 15 October sowing, while not moisture-limited, appears to have overinvested in vegetative growth during the warm October weeks, leading to a lower harvest index (0.38 vs 0.43 for D2).

The seed rate response confirms a well-documented pattern in chickpea agronomy: yield increases with density up to a threshold, beyond which individual plant productivity declines faster than population gains compensate [15]. At 100 kg ha⁻¹, the canopy closed quickly but mutual shading reduced branch number and pod-bearing nodes. For rainfed systems where soil moisture is the limiting resource, the 80 kg ha⁻¹ rate appears to strike the best balance between ground cover and per-plant water consumption [16].

Conclusion

This research identified 1 November as the optimal sowing date and 80 kg ha⁻¹ as the optimal seed rate for rainfed chickpea production at Jimma, Ethiopia. This combination yielded 2.14 t ha⁻¹, which was 29% higher than the latest sowing and 14% higher than the lowest seed rate tested.

Late sowing (1 December) was clearly penalised by terminal moisture stress, while the earliest sowing (15 October) invested too heavily in vegetative biomass. Seed rates above 80 kg ha⁻¹ offered no yield advantage and reduced individual plant productivity. For smallholder farmers in the Jimma zone relying on residual moisture, sowing chickpea in the first week of November at 80 kg ha⁻¹ with rhizobial inoculation is a practical, low-cost recommendation. Future work should validate these findings across multiple seasons and test promising early-maturing varieties that might extend the viable sowing window.

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