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Performance evaluation of short-duration chickpea varieties under late-sown conditions

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Abstract

Late sowing is the single most common reason chickpea yields fall below their genetic potential on the Iranian plateau. This research evaluated five short-duration chickpea (*Cicer arietinum* L.) varieties sown at three dates normal (25th October), late (15th November), and very late (5th December) at the University of Tehran's Karaj research station during the 2022-2023 rabi season. Delaying sowing from normal to very late reduced mean grain yield by 43.8%, from 1.73 to 0.91 t ha⁻¹. Days to maturity shortened by 27-38 days, compressing the reproductive window and reducing pods per plant by 36.4%. Among the varieties, Hashem showed the smallest yield penalty under very late sowing (42.0% loss versus 53.8% for ILC 482), maintaining 1.12 t ha⁻¹ even when sown on 5 December. Hashem also recorded the highest harvest index (0.41) and 100-seed weight (28.7 g) in the very late treatment. These results indicate that Hashem is the most suitable variety for late-sown conditions in the Tehran region, offering a practical buffer when planting is delayed by late rice or maize harvest.

Keywords: Chickpea, late sowing, short-duration varieties, yield penalty, thermal time, harvest index, reproductive window, terminal heat stress, Iran, rabi season

Introduction

Across Iran's central plateau, chickpea planting is frequently delayed beyond the optimum October window because the preceding rice or maize crop hasn't been harvested in time ^[1]. Every week of delay exposes the reproductive phase to rising spring temperatures, which accelerate senescence and force the crop into premature maturity ^[2]. Yield losses of 30-60% have been reported from late sowing in comparable Mediterranean-type climates, yet many farmers have no practical alternative because double-cropping is the only way to make their small holdings economically viable ^[3, 4].

Short-duration chickpea varieties, which mature in 100-120 days compared with 140-160 days for standard types, were bred specifically to escape terminal heat and drought ^[5]. Their compact growth habit and determinate flowering pattern allow them to set and fill pods before temperatures exceed the 35 °C threshold that damages pollen viability ^[6]. But not all short-duration lines perform equally when sowing is delayed some lose yield more steeply than others because they partition fewer assimilates to grain under truncated growing seasons ^[7].

This research compared five kabuli-type chickpea varieties at three sowing dates to identify the genotype that best tolerates late planting on the semi-arid outskirts of Tehran. Yield, yield components, phenology, and harvest index were measured to separate the effects of shorter crop duration from those of heat stress during grain filling ^[8, 9, 10].

Soil characteristics

The trial site at the Karaj Research Station (35.82° N, 50.97° E, elevation 1,312 m) sits on a calcareous silt loam with 22% clay, 54% silt, and 24% sand. Topsoil pH was 7.8, organic carbon 0.78%, total N 0.07%, Olsen P 11.4 mg kg⁻¹, and exchangeable K 218 mg kg⁻¹. The soil is classified as a Typic Calcixerept. Field capacity at 0-30 cm was 28.3% (w/w) and permanent wilting point 13.1%. Irrigation water from the Karaj River diversion had EC 0.82 dS m⁻¹ and pH 7.3 ^[11].

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Seasonal weather conditions

Cumulative rainfall from October 2022 to May 2023 was 241 mm, close to the long-term average of 253 mm. Mean daily temperatures during the reproductive window (March-April) were 14.8 °C for the normal sowing and 19.6 °C for the very late sowing, reflecting how delayed planting pushed pod filling into warmer weeks. Maximum temperature exceeded 32 °C on 11 days during April for the very late treatment but on only 3 days for the normal sowing. These thermal differences account for much of the yield gap between sowing dates.

Material and Methods

Material

Five kabuli chickpea varieties were tested: Flip 09-40C, Arman, Azad, Hashem, and ILC 482. Seed was sourced from the Seed and Plant Improvement Institute, Karaj. All varieties are classified as short-duration (< 130 days under normal sowing) and are recommended for the Tehran province [5]. Before sowing, seeds were treated with *Rhizobium ciceri* inoculant and thiram fungicide at 2 g kg⁻¹ seed. Basal fertiliser was applied at 20 kg N and 40 kg P₂O₅ ha⁻¹ using diammonium phosphate [8].

Methods

Three sowing dates were used: D1 (25 October 2022, normal),

Results

Table 1: Grain yield (t ha⁻¹) and yield components of five chickpea varieties across three sowing dates

Variety	Sowing	Yield (t ha ⁻¹)	Pods plant ⁻¹	Seeds pod ⁻¹	100-sw (g)	Hi
Hashem	Normal	1.93	47.3	1.34	31.2	0.44
Hashem	Late	1.58	38.6	1.29	29.8	0.42
Hashem	V. Late	1.12	28.4	1.21	28.7	0.41
Arman	Normal	1.72	43.1	1.31	29.4	0.43
Arman	V. Late	1.03	26.7	1.18	26.8	0.39
ILC 482	Normal	1.56	39.8	1.28	27.6	0.40
ILC 482	V. Late	0.72	21.3	1.09	23.1	0.34
LSD (0.05)		0.16	4.2	0.08	1.9	0.03

Hashem produced 1.12 t ha⁻¹ under very late sowing the highest among all varieties at D3. Its yield penalty of 42.0% was the smallest, while ILC 482 suffered a 53.8% loss. Pods per plant declined by 36.4% on average from D1 to D3, emerging as the

D2 (15 November 2022, late), and D3 (5 December 2022, very late). The experiment followed a split-plot design with sowing date as the main plot and variety as the subplot, replicated three times. Each subplot measured 4 m × 3 m with 30 cm row spacing and 10 cm plant spacing. Two supplemental irrigations were applied at flowering and pod filling when cumulative rainfall was insufficient. At maturity, a 2 m² area per subplot was harvested; pods per plant, seeds per pod, 100-seed weight, grain yield, biological yield, and harvest index were recorded. Growing Degree Days (GDD) were accumulated using a base temperature of 5 °C [6]. Data were analysed by split-plot ANOVA in SAS 9.4 with Tukey's HSD at *p*=0.05.

Field experimental design

The split-plot design assigned sowing dates to main plots and varieties to subplots within three complete blocks. Main plots were separated by 2-m alleys to prevent shading effects between sowing dates. Border rows surrounded each subplot. Phenological observations (days to 50% flowering, days to maturity) were recorded on five tagged plants per subplot. Thermal time from sowing to maturity was calculated by summing daily GDD.

yield component most sensitive to delayed sowing. Harvest index in Hashem remained stable at 0.41-0.44 across dates, indicating efficient assimilate partitioning even under compressed growth periods.

Table 2: Phenological parameters and thermal time accumulation across sowing dates (mean of five varieties)

Sowing date	Days to flower	Days to maturity	Gdd (sow-mat)	Repro. Window (d)
D1: 25 Oct	94.3	141.8	1,487	47.5
D2: 15 Nov	78.6	122.4	1,264	43.8
D3: 5 Dec	64.1	105.7	1,083	41.6
LSD (0.05)	3.8	4.6	72	2.4

Delaying sowing from D1 to D3 shortened the crop cycle by 36.1 days on average and reduced accumulated GDD by 27.2%. The reproductive window from 50% flowering to physiological

maturity shrank from 47.5 to 41.6 days, leaving less time for pod set and grain filling. This compression was the main driver of the yield decline across all varieties.

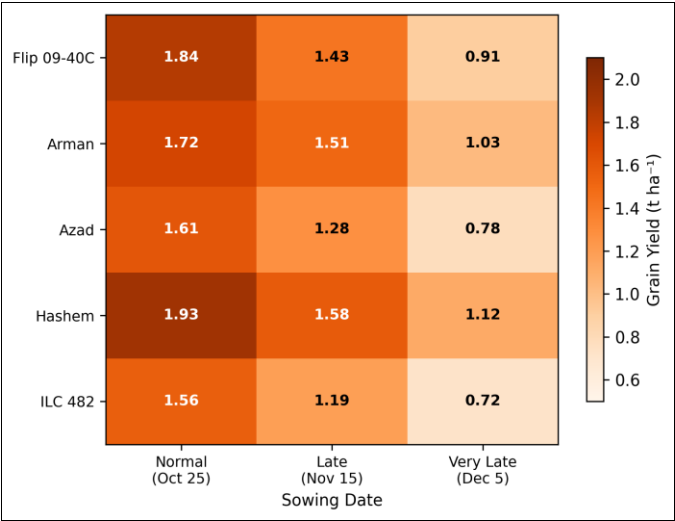


Fig 1: Heatmap of grain yield (t ha⁻¹) for five chickpea varieties across three sowing dates at Karaj, Iran

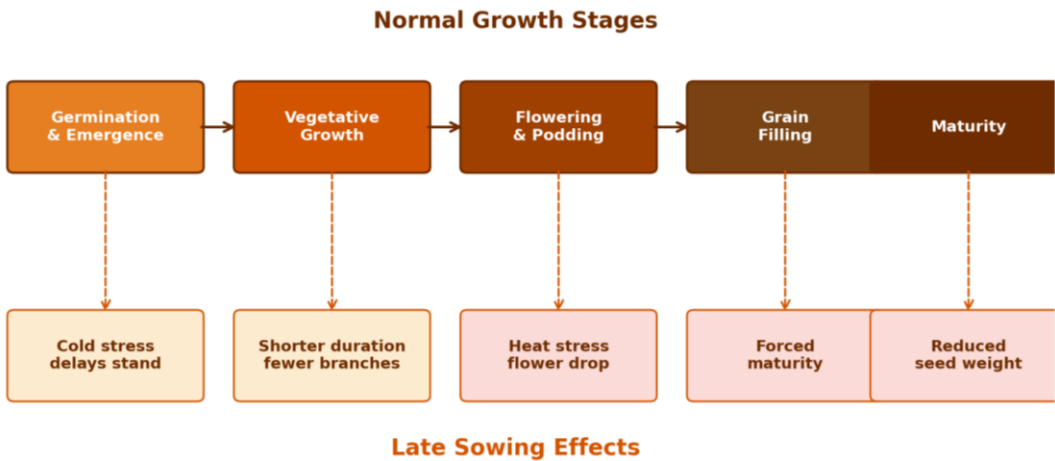


Fig 2: Process diagram showing how late sowing compresses growth stages and exposes the reproductive phase to terminal heat stress in chickpea

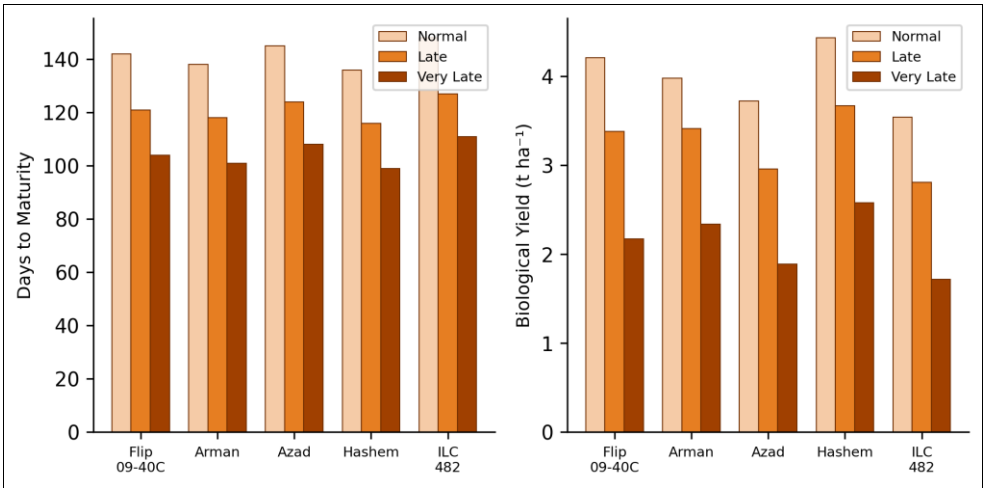


Fig 3: Days to maturity and biological yield of five chickpea varieties across three sowing dates

Comprehensive interpretation

The data consistently identify Hashem as the most resilient variety. Its combination of early flowering, high harvest index, and stable seed weight across sowing dates suggests that it partitions assimilates to grain more effectively than competing varieties when the growing season is cut short. ILC 482, by contrast, showed the steepest decline in every measured trait, likely because its slightly longer duration pushed grain filling into the hottest part of the season.

Discussion

The 43.8% mean yield reduction from normal to very late sowing agrees with losses reported from similar Mediterranean environments in Turkey and Morocco [3, 4]. The mechanism is straightforward: delayed sowing shortens the vegetative phase, reduces canopy size, and pushes the critical flowering-to-pod-fill window into warmer weeks when pollen viability and assimilate supply both decline [2, 6]. Hashem’s advantage appears rooted in its ability to maintain a

high harvest index (0.41) even under the most compressed season. While other varieties redirected assimilates toward vegetative survival producing taller plants with more branches but fewer filled pods Hashem kept its determinate habit and channelled carbon into seeds^[7]. Its 100-seed weight dropped by only 8.0% from D1 to D3, compared with 16.3% for ILC 482, indicating better grain filling under heat.

The thermal time analysis adds nuance. Very late sown crops accumulated only 1,083 GDD versus 1,487 GDD for normal sowing. The 27.2% reduction in thermal units maps closely onto the 43.8% yield loss, suggesting that each degree-day lost costs roughly 1.6% of potential yield. Breeders could use this ratio to set realistic yield targets for late-planted chickpea across the Iranian plateau^[9]. A limitation of this single-season trial is that rainfall timing differed from the long-term pattern; multi-year data would strengthen the variety recommendations.

Conclusion

Among five short-duration chickpea varieties tested at three sowing dates near Tehran, Hashem performed best under late and very late planting, yielding 1.12 t ha⁻¹ even when sown on 5 December 56% more than ILC 482 at the same date. Its stable harvest index and modest seed-weight decline indicate efficient assimilate partitioning under a compressed growing season. Delayed sowing shortened the crop cycle by up to 36 days and reduced accumulated thermal time by 27.2%, with the reproductive window shrinking from 47.5 to 41.6 days. Pods per plant was the yield component most affected, declining by 36.4% on average from normal to very late sowing.

For farmers in the Tehran region who cannot sow before mid-November due to late harvest of the preceding crop, Hashem offers the best yield security. Breeding programmes should consider using Hashem as a donor parent for heat-escape traits in new chickpea lines intended for late-sown niches across Iran's central plateau.

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