

## Effect of Planting Dates on Growth Traits of Sunflower Genotypes and Their Selected Lines

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**Abstract.** A field experiment was conducted during the spring and autumn seasons of 2025 to cultivate sunflower (*Helianthus annuus* L.) at the fields of Al-Mussaib Technical College, Babil Governorate / Al-Mussaib Project area, located about 40 km north of the governorate (longitude 44.50, latitude 32.50). The study aimed to investigate the effect of planting dates on growth traits of sunflower genotypes and their selected lines. The experiment included two factors: the first factor was six sunflower genotypes, and the second factor was three planting dates. The experiment was laid out according to a Randomized Complete Block Design (RCBD) in a factorial arrangement. The results of statistical analysis showed significant differences among genotypes. The genotype Selected Zahra Al-Iraq recorded the highest mean plant height (176.00 cm), whereas the genotype Shamos recorded the lowest mean (156.33 cm). Planting dates had a significant effect, as the first planting date (20 June) gave the highest mean plant height (170.89 cm) compared with the third planting date (10 July), which gave the lowest mean (159.33 cm). The interaction treatment Selected Zahra Al-Iraq × first planting date recorded the highest value (181.00 cm), while Shamos × third planting date gave the lowest value (148.00 cm). For leaf area, significant differences were observed among genotypes. The genotype Selected Shamos achieved the highest mean leaf area (0.845 m<sup>2</sup>), whereas Zahra Al-Iraq recorded the lowest mean (0.535 m<sup>2</sup>). The first planting date (20 June) produced the highest mean leaf area (0.707 m<sup>2</sup>), while the third planting date (10 July) resulted in the lowest mean (0.671 m<sup>2</sup>). The interaction Selected Shamos × third planting date recorded the highest value (0.856 m<sup>2</sup>), whereas Zahra Al-Iraq × second planting date recorded the lowest value (0.474 m<sup>2</sup>). Significant differences among genotypes were also found for the leaf area index (LAI). The genotype Selected Zahra Al-Iraq recorded the highest mean (6.4842), while Shamos recorded the lowest mean (3.8596). The first planting date (20 June) resulted in the highest mean LAI (4.9384), compared with the third planting date (10 July), which gave the lowest mean (4.7768). The interaction Selected Zahra Al-Iraq × second planting date recorded the highest LAI (7.4600), whereas Shamos × second planting date recorded the lowest value (3.6010). Regarding head area, significant differences among genotypes were observed. The genotype Selected Argensun recorded the highest mean head area (383.57 cm<sup>2</sup>), while Zahra Al-Iraq recorded the lowest mean (323.33 cm<sup>2</sup>). The first planting date (20 June) gave the highest mean head area (389.05 cm<sup>2</sup>), whereas the third planting date (10 July) gave the lowest

mean (328.07 cm<sup>2</sup>). The interaction treatments *Argensun* × first planting date and *Selected Argensun* × first planting date recorded the highest head area (430.00 cm<sup>2</sup>), while *Zahra Al-Iraq* × third planting date recorded the lowest value (280.00 cm<sup>2</sup>).

**Keywords:** *Helianthus annuus* L.; Sowing date; Genetic variation; Morphological traits; Leaf area; Leaf area index; Capitulum diameter; Yield components; Agro-environmental conditions

## 1. INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a member of the family Compositae (Asteraceae) and is considered one of the most important oilseed crops worldwide. It is cultivated for its seeds, which contain up to 50% oil in some improved cultivars, in addition to other desirable quality traits [1]. Sunflower oil is widely used for food purposes because it is among the most suitable edible oils, owing to its content of several vitamins such as E, D, and A, which play an important role in preventing oil oxidation. These characteristics make sunflower oil one of the most widely consumed oils globally [2]. Sunflower is also used in the manufacture of pharmaceuticals, soaps, and paints. The resulting oilseed meal contains 30–35% protein and is used in poultry and livestock feeding. However, sunflower productivity in Iraq still suffers and remains below the desired level. This is mainly due to the inadequate application of proper scientific practices and crop and soil management operations. Crop growth is determined by genotypes, environmental factors, and their interactions, as well as planting dates. Therefore, identifying the optimum planting date that can provide high yields and meet farmers' needs is essential. Selection is considered one of the oldest and most widely used breeding methods for improving deteriorated cultivars, as it contributes to increasing gene frequency for genes controlling the selected trait. Accordingly, improved genotypes can be selected. Tolerance to environmental stresses is a physiological trait associated with genetic improvement of yield. Yield is a complex trait influenced by environmental factors; thus, selection for traits with high heritability is an important process in breeding and improvement programs [3]. Plant height of approximately 150 cm is considered one of the important selection criteria, as it contributes to increased sunflower yield and enhances plant tolerance to stressful environmental conditions. Head diameter is also a trait closely associated with seed yield and can be considered a reliable indicator for increasing productivity [4]. Yield is not controlled by specific genes alone, but rather by multiple genes that contribute to its increase or decrease. Heritability and genetic advance are among the most important factors upon which selection depends, and their estimation helps to determine the expected genetic gain [5]. Improvement of crop populations represents the main objective of plant breeding programs, as progress in these programs depends primarily on the efficiency of the selection method and the degree of genetic divergence. Therefore, the present study aimed to:

1. Improve some field traits related to yield through evaluating the efficiency of selection.
2. Identify the optimum planting date that ensures maximum efficiency and high yield, contributing to increased production and expansion of sunflower cultivation.

3. Estimate broad-sense and narrow-sense heritability and determine some genetic parameters.
4. Determine selection indices for seed yield of the sunflower genotypes used, through studying genetic and phenotypic correlations.

## 2. MATERIALS AND METHODS

A field experiment was conducted during the spring and autumn seasons of 2025 at the fields of Al-Mussaib Technical College. In the spring season, seeds of three sunflower genotypes—Zahra Al-Iraq, Argensun, and Shamos—were sown on 15 March. Planting was carried out on ridges spaced 75 cm apart, with 25 cm between plants within the row. At physiological maturity, five plants from each genotype were selected based on head diameter as a selection criterion. Seeds of each genotype were bulked to form the first selected generation ( $S_1$ ). Thus, three selected lines along with their three parental genotypes were obtained, resulting in six genotypes that were used for planting in the autumn season. In the autumn season, planting was carried out at three planting dates: 20 June, 30 June, and 10 July (2025), with three replications, giving a total of 54 experimental units. Seeds of the genotypes were planted using a Randomized Complete Block Design (RCBD) arranged as a factorial experiment with two factors: the first factor was genotypes, and the second factor was planting dates. Each experimental unit consisted of five ridges, each 3 m long. Observations were recorded from the three central ridges. The experiment in both seasons was fertilized with DAP fertilizer containing 18% N and 46%  $P_2O_5$  at a rate of 150 kg ha<sup>-1</sup> applied before planting [6]. Sowing was done manually by placing three seeds per hill, which were later thinned to one plant per hill at the four-leaf stage. Urea fertilizer (46% N) was applied at a rate of 100 kg ha<sup>-1</sup> [6] in two split doses: the first 2–3 weeks after emergence, and the second at the beginning of floral bud formation. Weeding, pest control, and irrigation were carried out as required. After completion of the flowering stage, ten plants were randomly selected from the three central ridges, and their heads were covered with mesh bags (potato bags) to protect them from bird damage. From these plants, five plants were randomly chosen for trait measurements.

### Field Traits Studied

#### a. Plant height (cm)

Plant height was measured from the soil surface to the base of the head.

#### b. Leaf area (m<sup>2</sup>)

The maximum leaf width of each plant was measured, and leaf area was calculated using the following equation [7]:

$$\text{Leaf Area (L.A.)} = 0.65 \sum L^2$$

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where:

L.A. = leaf area,  
L = leaf width,  
0.65 = constant.

c. Leaf area index (LAI)

Leaf area index was calculated according to the following equation [8]:

$$\text{LAI} = \frac{\text{Leaf area per plant}}{\text{Ground area occupied by the plant}}$$

d. Head area (cm<sup>2</sup>)

Head area was calculated by measuring the diameter of the seed-bearing portion of the head only and determining the area of the corresponding circle [9].

### 3. Results and Discussion

Significant differences were observed among planting dates and genotypes for plant height. The results presented in Table (1) indicate significant effects of genotypes, planting dates, and their interaction on plant height. The genotype (V1S1) recorded the highest plant height, reaching 176.00 cm, whereas genotype (V3) produced the lowest mean plant height (156.33 cm). Regarding planting dates, the first planting date (20 June) resulted in the highest plant height (170.89 cm), while the third planting date (10 July) produced the lowest value (159.33 cm). The interaction between genotypes and planting dates showed that the combination (V1S1 × first planting date) gave the highest plant height (181.00 cm), whereas (V3 × third planting date) recorded the lowest value (148.00 cm). These results are consistent with those reported by [10, 11, 12, 13, 14], who indicated that plant height is a quantitative trait controlled by several genes that vary according to genetic background, and is also influenced by environmental factors such as soil conditions, moisture availability, and planting date. For leaf area, significant differences were detected among genotypes, planting dates, and their interaction, as shown in Table (2). The genotype (V3S3) recorded the highest leaf area (0.845 m<sup>2</sup>), while genotype (V1) recorded the lowest mean leaf area (0.526 m<sup>2</sup>). With respect to planting dates, the first planting date (20 June) resulted in the highest leaf area (0.707 m<sup>2</sup>), whereas the third planting date (10 July) produced the lowest value (0.671 m<sup>2</sup>). The interaction (V3S3 × third planting date) recorded the highest leaf area (0.856 m<sup>2</sup>), while (V1 × second planting date) resulted in the lowest value

(0.474 m<sup>2</sup>). These findings agree with those reported by [15], who found that cultivars with longer growth duration and extended vegetative growth generally possess larger leaf areas, which enhances light interception efficiency and carbohydrate production. In contrast, early-maturing or short-duration cultivars tend to have smaller leaf areas and are characterized by rapid maturity and head formation. In addition, hybrid cultivars usually exhibit greater leaf area compared with open-pollinated varieties [16].

**Table 1. Effect of Planting Dates on Growth and Yield of Sunflower Genotypes and Their Interaction on Plant Height (cm)**

Genotype mean	Planting dates			Genotypes
	D3	D2	D1	
161.55	159.00	157.33	168.33	V1
176.00	169.00	178.00	181.00	V1S1
157.33	150.00	155.00	167.00	V2
173.33	168.00	177.00	175.00	V2S2
156.33	148.00	155.00	166.00	V3
168.33	162.00	175.00	168.00	V3S3
1.22**	2.12			Lsd5%
	159.33	166.22	170.89	Mean of planting dates
	0.86**			Lsd5%

**Table 2. Effect of Planting Dates on Growth and Yield of Sunflower Genotypes and Their Interaction on Leaf Area (m<sup>2</sup>)**

Genotype mean	Planting dates			Genotypes
	D3	D2	D1	
0.526	0.535	0.474	0.570	V1
0.724	0.625	0.830	0.718	V1S1
0.598	0.622	0.535	0.637	V2
0.792	0.790	0.833	0.754	V2S2
0.661	0.600	0.650	0.733	V3
0.845	0.856	0.850	0.830	V3S3
0.001**	0.003			Lsd5%
	0.671	0.695	0.707	Mean of planting dates
	0.001**			Lsd5%

Regarding the leaf area index (LAI), significant effects of genotypes, planting dates, and their interaction were observed, as shown in Table (3). The genotype (V1S1) recorded the highest

LAI (6.4842), whereas genotype (V3) recorded the lowest mean LAI (3.8596). Concerning planting dates, the first planting date (20 June) produced the highest LAI (4.9384), while the third planting date produced the lowest value (4.7768). The interaction (V1S1 × second planting date) resulted in the highest LAI (7.4600), whereas (V3 × second planting date) recorded the lowest value (3.6010). These results are in agreement with those reported by [17], who stated that different planting dates have a direct effect on leaf area dynamics and the rate of leaf area accumulation due to variations in temperature and solar radiation during the vegetative growth period, which in turn influence LAI values. As for head area, the statistical analysis presented in Appendix (1) revealed significant differences among genotypes, planting dates, and their interaction, as shown in Table (4). The genotype (V2S2) recorded the highest head area (383.57 cm<sup>2</sup>), whereas genotype (V1) recorded the lowest mean value (323.33 cm<sup>2</sup>). Regarding planting dates, the first planting date (20 June) resulted in the highest head area (389.05 cm<sup>2</sup>), while the third planting date (10 July) produced the lowest value (328.70 cm<sup>2</sup>). The interaction treatments (V2 × first planting date) and (V2S2 × first planting date) recorded the highest head area (430.00 cm<sup>2</sup>) for both combinations, whereas (V1 × third planting date) recorded the lowest value (280.00 cm<sup>2</sup>). These results are consistent with findings reported by [18, 19, 20], who indicated that planting date is one of the most important environmental factors affecting plant growth and development. Delayed planting often leads to reduced growth and negatively affects traits such as head diameter, head weight, and number of seeds. Moreover, there are specific genomic regions influencing head

**Table 3. Effect of Planting Dates on Growth and Yield of Sunflower Genotypes and Their Interaction on Leaf Area Index (LAI)**

Genotype mean	Planting dates			Genotypes
	D3	D2	D1	
4.8832	5.2100	4.2897	5.1500	V1
6.4842	5.6407	7.4600	6.3520	V1S1
3.9690	3.9100	3.6280	4.3690	V2
5.3137	5.3313	5.6100	4.9997	V2S2
3.8596	3.8680	3.6010	4.1097	V3
4.6073	4.7010	4.4710	4.6500	V3S3
0.0017**	0.0030			Lsd5%
	4.7768	4.8433	4.9384	Mean of planting dates

	<b>0.0012**</b>	<b>Lsd5%</b>
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diameter in sunflower, as reported by [21], who indicated that varietal differences are attributed to particular genetic regions. Delayed planting may also shorten the growth period and reduce the availability of resources (water, light, and nutrients), in addition to imposing temperature stress, which limits the full development of the head [22].

**Table 4. Effect of Planting Dates on Growth and Yield of Sunflower Genotypes and Their Interaction on Head Area (cm<sup>2</sup>)**

Genotype mean	Planting dates			Genotypes
	D3	D2	D1	
323.33	280.00	360.00	330.00	V1
343.80	346.70	351.00	333.70	V1S1
370.00	320.00	360.00	430.00	V2
383.57	350.70	370.00	430.00	V2S2
383.43	370.00	380.00	400.30	V3
364.10	301.00	381.00	410.30	V3S3
13.07**	22.63**			Lsd5%
	328.07	367.00	389.05	Mean of planting dates
	9.24**			Lsd5%

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