Research Article

Response of Eight Soft Wheat (*Triticum aestivum* L.) Cultivars to Different Planting Dates

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Abstract | An experiment was conducted in Mosul District, Nineveh Governorate, during the 2024/2025 agricultural season. The experiment aimed to evaluate eight wheat cultivars (Abaa 95, Buhuth 22, Buhuth 10, Adana 99, Baghdad 1, Sham 7, Rashid, Babil 113). The cultivars were planted on three planting dates (November 25, December 10, and December 25). The experiment was conducted using a Randomized Complete Block Design (R.C.B.D.) with three replicates under rain-fed conditions in the northern region of Iraq. The experiment studied the following traits: Number of days to flowering at 50%, plant height, flag leaf area (cm^2), and number of spikes per plant. The Adana 99 variety recorded the shortest number of days to flowering at 50%, at 84.77 days. The Sham 7 variety was the most delayed, recording (101.77) days. As for the plant height and flag leaf area, the Babylon 113 variety outperformed the rest of the varieties, recording (81.66) cm and (43.24) cm^2. The first planting date, 11/25, was superior to the second and third dates. The interaction between the varieties and planting dates was significant, as the Babylon 113 variety, planted on 11/25, gave the highest plant height, reaching (87.66) cm and (46.58) cm^2, followed by the Rashid variety, (84) cm and (43.44) cm^2. The Abu Ghraib 3 and Babil 113 varieties outperformed the rest of the varieties in the number of spikes.

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Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world and is a key ingredient in the manufacture of many ready-to-eat products (Chen *et al.*, 2025). Iraq is one of the countries that relies heavily on wheat for human and animal nutrition (Qasim, 2024). Wheat provides 20% of calories and 23% of protein, in addition to minerals and vitamins that humans need (Shewry and Hey, 2015). Plant breeders face many challenges in dealing with fluctuations in environmental and climatic conditions, such as temperature, light intensity, drought, and salinity, in order to achieve self-sufficiency to meet the needs of an ever-growing population (Okello *et al*., 2021). Iraq's production in 2024 amounted to approximately 5.234 million tons, an increase of 22.17% compared to its production in the previous year (2023), which amounted to 4.248 million tons, and an increase of 19.88% compared to the average for the years 2019-2023 (FAO, 2025). In the Middle East, Iraq is one of the countries most affected by climate change. In recent years, Iraq has experienced significant climatic changes, including sharp increases in temperatures reaching 52°C in some areas, and a decrease in water levels and rainfall rates (Al-Jaf *et al*., 2025). Climate change will lead to significant yield losses compared to previous and historical years, emphasizing the urgent need for climate change adaptation strategies. Wheat yields in all regions are expected to decrease by -18% to -20% by 2040, and by -28% to -27% by 2070 (Tita *et al*., 2025). Planting time is a key input for field crops. Optimal planting dates are affected by climate change, so determining the optimal planting date is essential for achieving optimal plant productivity. The temperature and relative humidity of the atmosphere throughout the growing season have a direct impact on crop production characteristics. Consequently, in order to attain high production, it is imperative to satisfy the temperature needs of wheat cultivars (Paknejad and Ilkaee, 2021). Varieties are an entry point for crop improvement and increased productivity, as they possess genetic diversity that is responsible for the main agronomic traits. The selection of these varieties directly affects vegetative growth and their ability to adapt to environmental conditions. For example, studies conducted in Nineveh Governorate in Iraq showed that the early date of wheat planting was superior to the studied traits. Similarly, there were significant differences between varieties (Abd Al-Dahi and al-Taweel, 2021).

Materials and Methods

Seeds of local wheat (*Triticum aestivum* L.) varieties shown in Table 1 were planted on three dates (November 25, December 10, and December 25), in one of the agricultural fields in Nineveh Governorate, northern Iraq, using a randomized complete block design with three replicates.

Each variety's seeds were planted in two lines, each 2 meters long, with a 20-cm gap between plants and a 30-cm gap between lines. Two batches of 45% urea fertilizer were applied at a rate of 20 kg of nitrogen per dunum, one during planting and the other before ear development. A randomized complete block design was used to evaluate the data (R.C.B.D.) (Antar and Al-Wakaa, 2017). The studies were conducted on five randomly selected plants, and the following traits were studied.

Table 1: *Database of wheat varieties used in the study (Iraq Ministry of Agriculture, 2024).*

Wheat variety	Committee decision	Decision date	The deduced institution	Variety protection
Abaa 95	Registration and accreditation	17/10/1995	Abaa Center for Agricultural Research	Free
Buhuth 22	Registration and accreditation	26/10/2011	General Authority for Agricultural Research / Ministry of Agriculture	Free
Buhuth 10	Registration and accreditation	31/12/2013	Agricultural Research Department / Ministry of Agriculture	Free
Adana 99	Registration and accreditation	8/10/2012	Ministry of Agriculture and Water Resources / Kurdistan Region	Free
Baghdad 1	Registration and accreditation	8/10/2012	Ministry of Science and Technology / Department of Agricultural Research	Free
Sham 7	Registration and accreditation	11/7/2013	Nineveh Agriculture Directorate / Conservation Agriculture Project	Free
Rashid	Registration and accreditation	4/8/2021	Iraqi Atomic Energy Organization	Free
Babil 113	Registration and accreditation	11/11/2000	Iraqi Atomic Energy Organization	Free

- The number of days before 50% of the spikes appear from the flag leaf after planting and flowering.
- Plant height (cm): The height of the plant was measured in centimeters from the soil's surface to the top of the spike.
- Flag leaf area (cm^2): Flag leaf area (the last leaf at the top of the plant) was estimated using the equation (leaf length × leaf width from its midpoint × 0.95). Flag leaf area was measured at the end of the spike-out stage.
- Number of spikes in one plant.

Results and Discussion

Number of days to 50% flowering (days)

Results showed highly significant differences between the studied wheat varieties in the number of days required to reach 50% flowering. Table 2 shows that the variety "Sham 7" was the most delayed in flowering, recording the highest average number of days at 101.778 days. In contrast, the variety " Adana 99" was the earliest in flowering, recording the lowest average at 84.778 days. These results are consistent with those of (Kumar *et al*., 2013) and differences are mainly attributed to genetic variations between the varieties, which determine their response to environmental conditions and the length of their vegetative growth period before transitioning to the flowering stage.

Planting dates had a clear effect on the number of days to 50% flowering. Delaying the planting date gradually shortened this period. The first planting date on November 25 achieved the longest period to reach flowering, with an average of 94.833 days, followed by the second date on December 10, with an average of 92.083 days. The third and last date, December 25, recorded the shortest period to reach flowering, with an average of 85.291 days. which were reflected in the varieties' response to environmental conditions, especially temperature (Hossain and Da Silva, 2012) and rainfall rate (Ahmed, 2015).

There was a significant interaction between the effect of each variety and planting date on the number of days to 50% flowering, meaning that the response of varieties to different planting dates was not uniform. For example, the variety "Baghdad 1" recorded the longest period to reach flowering, which was 105.667 days when it was planted on the first date (November 25), while the variety "Abaa 95" recorded the shortest period, which was 78.333 days when it was planted on the last date (December 25). In general, it can be observed that early varieties such as "Adana 99" and "Abaa 95" benefited greatly from late planting to shorten the growth period, while late varieties such as "Sham 7" and "Baghdad 1" still required a relatively longer period even with late planting dates. The results were consistent with (Sarhadi *et al*., 2024; Albarwary and Alrijabo, 2022).

Table 2: *Number of days from planting to 50% flowering for the studied cultivars.*

Number of days to 50% flowering (days)				
Planting dates/ wheat varieties	**November 25**	**December 10**	**December 25**	**Varieties**
Abaa 95	92.000 de	90.667 def	78.333 h	87.000 de
Buhuth 22	90.333 def	87.667 f	81.000 gh	86.333 e
Buhuth 10	94.000 cd	89.667 ef	82.333 gh	88.667 d
Adana 99	87.667 f	87.000 f	79.667 gh	84.778 e
Baghdad 1	105.667 a	98.667 b	92.667 de	99.000 b
Sham 7	103.000 a	104.333 a	98.000 b	101.778 a
Rashid	89.000 ef	87.667 f	83.000 g	86.556 de
Babil 113	97.000 bc	91.000 def	87.333 f	91.778 c
Planting dates	94.833 a	92.083 b	85.291 c	

Plant height (cm)

The results of the statistical analysis shown in Table 3 revealed significant differences between the wheat varieties studied in terms of plant height. The variety (Babil 113) was the tallest with an average height of 81.666 cm, significantly surpassing the other varieties. In contrast, the variety (Buhuth 10) recorded the shortest height with an average of 62.688 cm. These differences indicate that the genetic characteristics of varieties play an important role in determining plant height, and the results were consistent with (Al-Sadoon *et al*., 2023).

Planting dates had a significant effect on average plant height. The first planting date (November 25) was the best, with an average height of 75.691 cm, surpassing the second date (December 10) with an average of 70.716 cm, and the third date (December 25) with an average of 66.100 cm. This superiority of the first date is consistent with what was mentioned by Hussain *et al*. (2002), that the first planting date surpassed the second and third dates in terms of plant height, indicating that the environmental conditions associated with early planting were more suitable for plant growth and increased height.

The interaction between variety and planting date had a significant effect on plant height. The strongest and highest interaction was between variety (Babil 113) and the first planting date (November 25), with this interaction recording the highest value of 87.667 cm. This was consistent with (Sarhadi *et al*., 2024), indicating that varieties with high genetic potential for height growth respond better to the environmental conditions provided by early planting dates. This was consistent with (Kumar *et al*., 2024; Al-Falahi *et al*., 2021; Altai *et al*., 2024).

Table 3: *Plant height in cm for the studied varieties.*

Plant height (cm)				
Planting dates/ wheat varieties	**November 25**	**December 10**	**December 25**	**Varieties**
Abaa 95	69.000 ij	65.333 klm	58.733 q	64.355de
Buhuth 22	68.733 ij	65.800jklm	62.867mno	65.800 d
Buhuth 10	67.000jkl	62.000 nop	59.067 pq	62.688 e
Adana 99	72.533gh	64.667 lmn	61.067 opq	66.088 d
Baghdad 1	76.733de	72.733 fgh	70.267 hi	73.244 c
Sham 7	79.867 c	75.067 efg	68.133 ijk	74.355 c
Rashid	84.000 b	78.600 cd	72.867 fgh	78.488 b
Babil 113	87.667 a	81.533 bc	75.800 def	81.666 a
Planting dates	75.691 a	70.716 b	66.100 c	

Flag leaf area (cm^2)

The results in Table 4 show clear significant differences between the wheat varieties studied in terms of flag leaf area, with the Babil 113 variety significantly outperforming the others, recording the highest average of 43,241 cm^2, followed by the Rashid variety with an average of 40,993 cm^2. In contrast, the variety Buhuth 10 recorded the lowest average of 23,425 cm^2, indicating genetic variation between varieties in their ability to form a larger flag leaf area. This is consistent with what (Kumar *et al*., 2013) pointed out in their studies on genetic diversity in the vegetative growth traits of wheat.

The results showed that planting dates had a significant effect on flag leaf area, with the first date (November 25) recording the largest average flag leaf area of 34.444 cm^2, while the area gradually decreased with delayed planting, reaching 30.475 cm^2 on the second date (December 10) and 28.147 cm^2 on the third date (December 25). This decline is attributed to the fact that plants planted at later dates are exposed to less favorable environmental conditions, such as lower temperatures or shorter growth periods, which reduce vegetative growth and flag leaf size. These results are consistent with the findings of (Sarhadi *et al*., 2024; Altai *et al*., 2024), who confirmed that early planting contributes to improved vegetative growth and larger flag leaf area.

The interaction between varieties and planting dates had a significant effect on flag leaf area, with the interaction between the Babel 113 variety and the first date achieving the highest value of 46.587 cm^2, while the interaction between the Bahoth 10 variety and the third date recorded the lowest leaf area of 20.797 cm^2 (Al-Sadoon *et al*., 2023; Al-Falahi *et al*., 2021). This indicates a clear interaction between genetic and environmental factors in determining flag leaf growth efficiency. These results point to the importance of selecting the appropriate variety with the optimal planting date to achieve the best flag leaf area performance.

Table 4: *Flag leaf area (cm^2) for the studied varieties.*

Flag leaf area (cm^2)				
Planting dates/ wheat varieties	**November 25**	**December 10**	**December 25**	**Varieties**
Abaa 95	33.963 f	27.737 hi	25.177 jk	28.959 d
Buhuth 22	25.91 ij	23.377 klm	21.737lmn	23.674 e
Buhuth 10	25.457 ijk	23.843 kl	20.797 n	23.365 e
Adana 99	26.073 ij	22.947klmn	21.257mn	23.425 e
Baghdad 1	36.35 e	30.86 g	28.527 gh	31.912 c
Sham 7	37.773 de	30.95 g	29.1 gh	32.607 c
Rashid	43.44 b	40.903 c	38.637cde	40.993 b
Babil 113	46.587 a	43.183 b	39.953 cd	43.241a
Planting Dates	34.444 a	30.475 b	28.147 c	

Number of spikes per plant

Results in Table 5 show a significant variation in the average number of spikes per plant among the varieties studied. The varieties “Babil 113” and “Sham 7” produced the highest number of ears, with averages of 5.094 and 5.063 spikes/plant, respectively, significantly outperforming the other varieties. In contrast, the “Adana 99” variety recorded the lowest number of ears (2.46 spikes/plant). This is consistent with (Al-Sadoon *et al*., 2023), that these results indicate fundamental differences in the genetic ability of varieties to produce ears, highlighting the importance of selecting the right varieties to achieve maximum productivity.

Links Researchers

Planting dates played an important role in determining the average number of spikes per plant. The first (November 25) and second (December 10) planting dates significantly outperformed the third planting date (December 25), which resulted in the lowest average number of spikes (3.431 spikes/plant). This is consistent with (Sarhadi *et al*., 2024), and indicates that environmental conditions during the early planting periods, such as temperature and humidity, were more favorable for ear growth and production than the conditions prevailing during the late planting date.

Analysis of the interaction between varieties and planting dates revealed a significant interaction, with the best interaction observed between the "Babel 113" variety and the first planting date (November 25), resulting in 5.526 spikes/plant. This positive interaction indicates that this particular variety responds better to early planting conditions, enhancing its ability to produce a greater number of spikes. These results are consistent with (Altai *et al*., 2024), confirming the importance of considering both variety selection and optimal planting date to obtain the best results.

Table 5: *Number of spikes per plant for the studied varieties.*

Number of spikes per plant				
Planting dates/ wheat varieties	**Novem-ber 25**	**December 10**	**December 25**	**Varieties**
Abaa 95	3.1433 hi	3.5167defgh	3.8967cde	3.2844 d
Buhuth 22	3.8967cde	3.6333cdefgh	3.15 hi	3.56 c
Buhuth 10	3.36 efghi	3.4133defgh	2.8367 ji	3.2033 d
Adana 99	2.5767 jk	2.52 jk	2.2833 k	2.46 e
Baghdad 1	4.0867 c	3.9133cd	3.5467cdefgh	3.8489 b
Sham 7	5.3367 a	5.2467 a	4.6067 b	5.0633 a
Rashid	3.77 cdef	3.7067cdefg	3.2567fghi	3.5778bc
Babil 113	5.5267 a	5.18 a	4.5767 b	5.0944 a
Planting sates	3.962 a	3.8912 a	3.4312 b	

Table 6 shows the correlation analysis between the studied traits. The positive correlations were divided into three types: the strong correlation was between plant height and flag leaf area (r=0.845), the medium positive correlation was between plant height and spike count (r=0.627), and between flag leaf area and spike count (r=0.593). The weak to medium positive correlation was between the number of days to 50% flowering and plant height (r=0.483). The results were consistent with what (Prakash *et al*., 2023), who studied the linkage of traits in the genetic makeup of wheat (*Triticum aestivum* L.): implications for breeding programs.

Table 6: *Correlation between the studied traits.*

	50% flowering (days)	**Plant height (cm)**	**Flag leaf area (cm^2)**	**Number of spikes per plant**
50% flowering (days)	1			
Plant height (cm)	+ 0.483	1		
Flag leaf area (cm^2)	+ 0.401	+0.845	1	
Number of spikes per plant	+ 0.511	+0.627	+0.593	1

Conclusions

In light of the obtained results, the study offers the following recommendations:

1. Varieties varied in their response to planting dates, and the Babylon 113 variety can be used in agricultural production programs, particularly in the northern regions of Iraq, due to its superior performance in key agronomic traits and proven genetic stability across different planting dates.
2. Early planting is an effective agricultural practice, given its positive impact on improving the number of days to 50% flowering, plant height, flag leaf area, and the number of spikes per plant. This effect has contributed to improved resource use efficiency.
3. Focus on the interaction between variety and planting date in applied research and crop improvement programs. Different results may be obtained when studying other dates or studying the same dates over multiple seasons.

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Novelty Statement

Nineveh Governorate, one of the governorates of Iraq, is characterized by its high production of wheat and is considered the highest in Iraq. Therefore, this article aimed to study the effect of different planting dates on different types of wheat in order to increase production.

Author's Contribution

Yarub Samer Ahmed Alnuimy: Essay Idea Formulation and Supervision.
Omar Ahmed Fathi Al-Rubaie: Field supervision with some practical experiments.
Azhar Idrees Thanoun Khattab: Field supervision with some practical experiments.
Sarah Mohammed Ali Al-Jubouri: Data Collection
Wadhah Thabit Abed Al-Dahi: Data Analysis with Feedback.
Ali M. Saadi: Article Writing, Formatting, and General Supervision.

Generative AI and AI assisted technology statement
The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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