

Field Evaluation of Late Sowing Dates and Seeding Rates on Growth Traits and Yield of Bread Wheat Cultivars Under Two Different Environments Within Sustainable Agriculture Conditions

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Abstract

A field experiment was conducted during the 2023–2024 winter season in Nineveh Governorate at two locations: the first in Mosul district and the second in Hamidat sub-district, also within Mosul district, to determine the effect of four late sowing dates and three seeding rates (30, 40, and 50 kg donum⁻¹) on growth traits and grain yield of three bread wheat cultivars (Jihan, Rashidiya, and Buhuth 22). The experiment was laid out using a randomized complete block design (RCBD) in a factorial arrangement with three replications. The results showed that the first sowing date was significantly superior in most studied traits at both locations (Mosul and Hamidat), except for plant height and number of spikes m⁻², where the second sowing date was superior at both sites. The cultivar Buhuth 22 significantly outperformed the other cultivars in number of spikes m⁻², 1000-grain weight, and grain yield at Mosul, while at Hamidat the same cultivar was superior in number of spikes m⁻² and 1000-grain weight (g), whereas Jihan recorded the highest plant height (cm). Regarding seeding rates, there was a significant effect, where the second rate (40 kg donum⁻¹) was superior in vegetative traits, number of spikes m⁻², and grain yield (g). In contrast, the first seeding rate (30 kg donum⁻¹) gave the highest 1000-grain weight (g) at Mosul. At the second location, Hamidat, seeding rates also had a significant effect: the second rate (40 kg donum⁻¹) was superior in most studied traits except number of grains spike⁻¹ and grain yield (g), where the third rate (50 kg donum⁻¹) was superior.

Keywords: late sowing dates, seeding rates, bread wheat cultivars, sustainable agriculture.

Introduction

Wheat (*Triticum aestivum* L.) is one of the strategic crops in Iraq and the Middle East, grown over large areas and constituting a main source of food security. Its importance is attributed to its nutritional value as a staple food for humans, in addition to being an important source of energy due to its high carbohydrate

content, which supplies the body with calories [37]. For this reason, it has long been referred to as the "king of cereals" within the Poaceae [38]. More than 35% of the world's population relies on wheat as a primary food, which necessitates intensifying efforts to achieve the highest possible yield per unit area [21].

In Nineveh Governorate, the area planted with wheat in 2023 was 3,744,713 donums, of which 2,032,568 donums were

harvested, with an average yield of 408.9 kg donum⁻¹ based on harvested area and a total production of 773,411 tons [17]. Globally, the wheat area reached about 220 million hectares with a production of 788 million tons [20]. In Iraq, the area planted with bread wheat in 2023 was estimated at 8,419,850 donums, of which 6,672,309 donums were harvested; average yield based on planted area was 504.5 kg donum⁻¹, and based on harvested area 636.6 kg donum⁻¹, with a total production of 4,247,726 tons.

Wheat production in the region faces several environmental challenges, including climate change, water scarcity, and soil salinity. Studies indicate that delaying sowing date reduces productivity and grain quality, as the crop is exposed to higher temperatures during critical growth stages, negatively affecting pollination and grain set [36]. Research has shown that delaying sowing from October to January leads to a marked reduction in wheat yield; for example, in a study conducted by [27] in the Mediterranean region, delaying sowing from 25 October to 5 January reduced yield by 1.56 t ha⁻¹.

Cultivar choice plays a crucial role in improving wheat productivity. Research indicates that selecting cultivars adapted to late sowing dates can enhance both yield and grain quality. For instance, the cultivar "Horyzo" recorded the highest yield when sown in early November in Iraq [14]. Other studies reported that wheat sown on 25 November achieved grain yields of 3.21 t ha⁻¹, representing a 48.61% increase [2], and that sowing date and cultivar had significant effects on grain yield; maximum grain yield (4289.54 kg ha⁻¹)

was obtained when the crop was sown on 22 February [22].

Seeding rate strongly influences crop growth and productivity. Increasing seeding rate to 200 kg ha⁻¹ using large seed size was reported to enhance biological and economic yield [18] evaluated three plant densities (225, 375, and 525 plants m⁻²) and found that 375 and 525 plants m⁻² were significantly superior and produced the highest grain yield.

Given the environmental and economic challenges facing wheat production in Iraq and the Middle East, there is an urgent need for research aimed at improving agronomic practices by identifying optimum sowing dates, selecting suitable cultivars, and determining optimum seeding rates. Such improvements will enhance wheat productivity and quality and thus strengthen food security in the region [14].

The present study aims to:

1. Determine the effect of late sowing dates on wheat production.
2. Identify the most suitable cultivar for late sowing conditions in the study areas.
3. Compare seeding rates commonly used by Iraqi farmers and evaluate their suitability under late sowing.
4. Study the interactions among these factors and their impact on wheat production.

Material and Methods

A field experiment was carried out at two sites in Nineveh Governorate. The first site was located about 5 km from the center of Mosul district (Rashidiya area), and the second in the village of Al-Shuhada within the

administrative boundaries of Hamidat sub-district, about 45 km from Mosul, under supplemental irrigation (as needed). At both sites, three full irrigations were applied for each sowing date: the first at stem elongation, the second at heading, and the third (final irrigation) at physiological maturity.

Land preparation included plowing with a disc plow, followed by harrowing and leveling. The land was then divided into experimental units of 2.5 m² (2.5 m length × 1 m width). Each plot contained five rows spaced 20 cm apart, leaving 10 cm as a border at the beginning and end of each plot to ensure uniformity, with 50 cm alleys between plots and 1 m between blocks.

Experimental Factors

1. Sowing dates:

- First date: 15 November 2024
- Second date: 15 December 2024
- Third date: 15 January 2025
- Fourth date: 15 February 2025

2. Cultivars (bread wheat):

- Rashidiya
- Buhuth 22
- Jihan

3. Seeding rates:

- 30 kg donum⁻¹
- 40 kg donum⁻¹
- 50 kg donum⁻¹

The experiment was arranged as a factorial field trial in a randomized complete block design (RCBD) with split plots and three replications. Sowing dates occupied the main plots (four dates), while cultivars and seeding rates were randomly distributed within each main plot. Thus, there were 36 treatment combinations in each replication at each site, with a total of 108 experimental units per site.

Diammonium phosphate (DAP) fertilizer was applied at a rate of 120 kg ha⁻¹ at sowing, and urea was applied at 160 kg ha⁻¹ in two splits: at sowing and at tillering, according to

Ministry of Agriculture recommendations for 2024. Weeds were controlled manually using hoes to remove narrow- and broad-leaf weeds during the vegetative growth stage after their emergence.

Harvest dates at Rashidiya site were: 12 May 2024 for the first sowing date, 24 May 2024 for the second, 12 May 2024 for the third, and 2 June 2024 for the fourth. At Hamidat, the first and second sowing dates were harvested on 2 May 2024, while the third and fourth were harvested on 28 May 2024, using manual sickles.

Studied traits:

The following traits were recorded:

- Plant height (cm)
- Flag leaf area (cm²)
- Number of spikes m⁻²
- Number of grains spike⁻¹
- 1000-grain weight (g)
- Grain yield (g m⁻²)

Data were analyzed using RCBD appropriate for factorial experiments, with SAS statistical software. Means were compared using Duncan's multiple range test at the 5% probability level [10].

Results and Discussion

Effect of Sowing Dates, Cultivars, and Seeding Rates on the Studied Traits

1. Plant Height (cm)

The data in Table 1 indicate significant differences among sowing dates at both locations. The second sowing date was significantly superior to the other dates, achieving the highest mean plant height of 69.62 and 61.70 cm at Mosul and Hamidat, respectively, while the fourth sowing date recorded the lowest means of 45.85 and 49.77 cm at the two locations. These results agree with findings of [25][28] regarding the impact of environmental factors and sowing dates on vegetative growth.

At Mosul, cultivar differences in plant height were not significant, whereas at Hamidat there were significant differences: Jihan recorded the tallest plants (56.47 cm), while Rashidiya and Buhuth 22 recorded 55.25 and 55.22 cm, respectively, without significant differences between them. This agrees with [12][31]. The variation among cultivars in plant height may be attributed to genetic differences and their varying responses to environmental conditions or genotype \times environment interactions, which are reflected in growth traits including plant height. This result is consistent with findings of [5][29].

Seeding rate of 40 kg donum⁻¹ was significantly superior to 30 and 50 kg donum⁻¹ at both locations, recording the highest plant heights of 63.93 and 56.27 cm at Mosul and Hamidat, respectively.

Table 1 also shows significant interactions among sowing dates, cultivars, and seeding rates for plant height at both sites. At Mosul, Rashidiya and Buhuth 22 at the second sowing date with 40 kg donum⁻¹ recorded the highest plant heights (90.07 and 90.67 cm, respectively), whereas Buhuth 22 at the fourth sowing date with 40 kg donum⁻¹ recorded the lowest (42.33 cm). Similar patterns were observed at Hamidat, where Rashidiya and Buhuth 22 at the second sowing date with 40 kg donum⁻¹ showed the highest values (69.66 and 69.33 cm), while Buhuth 22 at the fourth sowing date with 40 kg donum⁻¹ had the lowest height (42.66 cm).

2. Flag Leaf Area (cm²)

Table 2 shows that sowing dates significantly affected flag leaf area at both locations. The first sowing date recorded the highest means (22.29 and 22.92 cm² at Mosul and Hamidat, respectively), consistent with findings of [13][23]. Cultivar differences in flag leaf area were not significant at either site.

Seeding rate significantly affected flag leaf area, with 40 kg donum⁻¹ giving the highest means (16.68 and 17.12 cm² at Mosul and Hamidat, respectively).

The interaction between sowing dates and cultivars was significant; the combination of

the first sowing date with Jihan recorded the highest values (23.66 and 24.11 cm² at Mosul and Hamidat).

The interaction between sowing dates and seeding rates was also significant, with the first sowing date combined with 30 kg donum⁻¹ giving the highest flag leaf area (23.33 and 24.00 cm² at Mosul and Hamidat).

The interaction between cultivars and seeding rates was significant as well; Buhuth 22 with 40 kg donum⁻¹ recorded the highest flag leaf area (17.87 and 17.95 cm² at Mosul and Hamidat).

The three-way interaction (sowing date \times cultivar \times seeding rate) was significant, with the combination of first sowing date, Jihan, and 30 kg donum⁻¹ giving the highest values (26 and 27 cm² at Mosul and Hamidat).

3. Number of Spikes (spikes m⁻²)

Table 3 indicates significant differences among sowing dates for number of spikes m⁻². The second sowing date produced the highest means (440.07 and 335.51 spikes m⁻² at Mosul and Hamidat, respectively). These findings are in line with [4][21].

Cultivars differed significantly in number of spikes m⁻² at both sites, with Buhuth 22 recording the highest means (374.19 and 289.86 spikes m⁻² at Mosul and Hamidat). This agrees with [34] and [9].

Seeding rate also had a significant effect; 40 kg donum⁻¹ gave the highest means (383.02 and 309.19 spikes m⁻² at Mosul and Hamidat). This is consistent with results reported by [18].

The sowing date \times cultivar interaction was significant: at Mosul, the second sowing date with Buhuth 22 gave the highest number of spikes (464.12 spikes m⁻²), whereas at Hamidat, the first sowing date with Rashidiya was highest (347.11 spikes m⁻²).

The interaction between sowing dates and seeding rates was also significant, with the second sowing date combined with 40 kg donum⁻¹ producing the highest number of spikes (380.24 and 380.88 spikes m⁻² at Mosul and Hamidat).

The cultivar \times seeding rate interaction was significant; at Mosul, Buhuth 22 with 40 kg donum⁻¹ gave the highest number of spikes (403.33 spikes m⁻²), while at Hamidat, Rashidiya with 40 kg donum⁻¹ recorded the highest value (318 spikes m⁻²).

The three-way interaction showed that at Mosul the combination of first sowing date, Buhuth 22, and 40 kg donum⁻¹ produced the maximum number of spikes (556 spikes m⁻²), whereas at Hamidat the combination of second sowing date, Rashidiya, and 40 kg donum⁻¹ gave the highest value (440.67 spikes m⁻²).

4. Number of Grains per Spike

Table 4 shows that sowing dates significantly affected number of grains spike⁻¹. The first sowing date recorded the highest means (44.85 and 38.92 grains spike⁻¹ at Mosul and Hamidat). These results agree with findings of [4][21].

Cultivars did not differ significantly in this trait.

Seeding rate had no significant effect at Mosul, but at Hamidat the highest mean (30.50 grains spike⁻¹) was recorded at 50 kg donum⁻¹. This agrees with [15][16].

The sowing date \times cultivar interaction was significant, with the first sowing date combined with Buhuth 22 giving the highest number of grains spike⁻¹ (45.24 and 40 at Mosul and Hamidat).

The sowing date \times seeding rate interaction was also significant, with the first sowing date and 50 kg donum⁻¹ producing the highest means (46.31 and 41.88 grains spike⁻¹ at Mosul and Hamidat).

The cultivar \times seeding rate interaction was significant; Rashidiya with 50 kg donum⁻¹ recorded the highest number of grains spike⁻¹ (36.85) at both locations.

The three-way interaction showed that the combination of first sowing date, Rashidiya, and 50 kg donum⁻¹ produced the highest number of grains spike⁻¹ (49.4 and 32.33 at Mosul and Hamidat).

5. 1000-Grain Weight (g)

Table 5 shows a significant effect of sowing dates on 1000-grain weight at both locations, with the first sowing date recording the highest means (34.54 and 28.74 g at Mosul and Hamidat). These results are consistent with findings of [10][34].

Cultivars also differed significantly: Rashidiya recorded the highest 1000-grain weight at Mosul (29.08 g), whereas Buhuth 22 was superior at Hamidat (26.30 g). These findings agree with [7][34]. Seeding rate had a significant effect, with 30 kg donum⁻¹ giving the highest 1000-grain weight (31.16 and 26.91 g at Mosul and Hamidat). These results agree with [16].

The sowing date \times cultivar interaction was significant: at Mosul, the first sowing date with Rashidiya produced the highest 1000-grain weight (35.24 g), while at Hamidat the first sowing date with Buhuth 22 was highest (29.88 g).

The sowing date \times seeding rate interaction was also significant, with the first sowing date at 30 kg donum⁻¹ giving the maximum 1000-grain weight (38.72 and 30.77 g at Mosul and Hamidat).

The cultivar \times seeding rate interaction showed that Rashidiya with 30 kg donum⁻¹ recorded the highest 1000-grain weight (32.13 and 27.08 g at Mosul and Hamidat).

The three-way interaction indicated that at Mosul the highest 1000-grain weight (41 g) was obtained from the combination of first sowing date, Jihan, and 30 kg donum⁻¹, whereas at Hamidat the highest value (31 g) came from the combination of first sowing date, Rashidiya, and 30 kg donum⁻¹.

6. Grain Yield (g m⁻²)

Table 6 shows that sowing dates significantly affected grain yield. The first sowing date produced the highest grain yield (646.22 and 366.18 g m⁻² at Mosul and Hamidat). This agrees with [26] [31].

Cultivars had a significant effect on grain yield at Mosul, where Rashidiya recorded the highest mean (378.23 g m⁻²), which also

agrees with [24][31]. Cultivar effects were not significant at Hamidat.

Seeding rate significantly affected grain yield at both locations: at Mosul, 40 kg donum⁻¹ gave the highest yield (369.16 g m⁻²), while at Hamidat 50 kg donum⁻¹ was superior (244.77 g m⁻²). This is consistent with findings of [7][24].

The sowing date × cultivar interaction was significant: at Mosul, the first sowing date with Rashidiya produced the highest grain yield (707.11 g m⁻²), while at Hamidat the first sowing date with Buhuth 22 gave the highest yield (388.50 g m⁻²).

The sowing date × seeding rate interaction was also significant; at Mosul, the first sowing date with 40 kg donum⁻¹ recorded the highest grain yield (606.78 g m⁻²), whereas at Hamidat the first sowing date with 50 kg donum⁻¹ was highest (419.66 g m⁻²).

The cultivar × seeding rate interaction showed that at Mosul the combination of Buhuth 22 and 40 kg donum⁻¹ gave the highest grain yield (433.58 g m⁻²), while at Hamidat Jihan with 50 kg donum⁻¹ recorded the highest yield (259.66 g m⁻²).

For the three-way interaction, at Mosul the highest grain yield (837 g m⁻²) was obtained from first sowing date with Buhuth 22 and 40 kg donum⁻¹, whereas at Hamidat the highest yield (463.67 g m⁻²) was recorded for first sowing date with Jihan and 50 kg donum⁻¹.

General Discussion

The superiority of the second sowing date in most traits can be attributed to its coincidence with near-optimal environmental conditions for vegetative growth, particularly temperature and day length, which enhanced photosynthetic efficiency, cell division, and cell elongation, and consequently improved vegetative growth and yield components.

Moreover, the moderate climatic conditions during this date helped prolong the vegetative growth period before entering the reproductive stages. In contrast, the decline in traits at the fourth sowing date is likely due to exposure to unfavorable conditions during early growth, shortening the vegetative period and increasing physiological stress, which restricted plant growth. These results are consistent with findings of [25][28] regarding the impact of environmental factors and sowing dates on vegetative and reproductive growth of plants. The superiority of the 40 kg donum⁻¹ seeding rate in vegetative and reproductive traits may be due to achieving an optimal plant density that balanced plant number and available space per plant, improving light interception, nutrient uptake, and physiological activity, which positively affected plant height. Lower density at 30 kg donum⁻¹ or higher density at 50 kg donum⁻¹ may have reduced resource use efficiency or increased intra-specific competition, thus limiting plant height at both locations. This agrees with findings of [16][33][35].

The significant differences observed among cultivars for most traits at both locations are mainly attributed to genetic variation in vegetative and yield traits and to their differential response to environmental factors and management practices. The genotype × environment interaction leads to variation in phenotypic expression under different field conditions [19].

Conversely, similarity among cultivars in some traits may be due to a narrow genetic base and shared ancestry, in addition to high heritability of certain traits, which reduces environmental influence and stabilizes trait expression when agronomic practices such as sowing date and seeding rate are uniform [3][8].

Table 1: Effect of Sowing Dates, Varieties, and Seeding Rates on Plant Height (cm) - Hamidiyat Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	278.00 f g	294.67 e f	463.67 a	345.44 b		
	Rashidiya	380.00 c	336.67 d	392.00 b c	369.55 a		
	bohooth 22	324.67 d e	422.67 b	403.33 b c	383.55 a		
second Sowing Date	Jehan	133.33 n	285.00 f	281.67 f g	233.33 c		
	Rashidiya	172.33 i m	192.33 i	268.67 f g	211.11 d		
	bohooth 22	184.00 i j k	250.33 g h	234.00 g h	222.77 c d		
third Sowing Date	Jehan	178.33 i l	183.67 i j k	158.00 i n	170.00 e		
	Rashidiya	190.33 i j	178.67 i l	132.00 n	167.00 e		
	bohooth 22	139.67 m n	145.00 l m n	183.67 i j k	156.11 e f		
Fourth Sowing Date	Jehan	158.00 i n	132.33 n	143.33 l m n	144.55 f		
	Rashidiya	141.33 m n	158.00 i n	140.00 m n	145.44 f		
	bohooth 22	143.00 l m n	171.67 i m	145.00 l m n	153.22 e f		
Sowing Dates × Varieties	First Sowing Date	327.55 c	351.33 b	419.66 a		366.18 a	
	second Sowing Date	163.22 f g	242.55 e	261.44 d		222.40 b	
	third Sowing Date	169.44 f	169.44 f	155.22 f g h		164.37 c	
	Fourth Sowing Date	147.44 g h	153.00 f g h	142.77 h		147.74 d	
Seeding Rates × Varieties	Jehan	186.91 e	223.41 c d	259.66 a			223.33 a
	Rashidiya	221.00 c d	215.66 d	233.16 b c			223.27 a
	bohooth 22	197.83 e	247.41 a b	241.50 b			228.91 a
Effect of Seeding Rates		201.91 c	228.83 b	244.77 a			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%

Table 2: Effect of Sowing Dates, Varieties, and Seeding Rates on Plant Height (cm) - Mosul Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	621.67	537.33	618.33	592.44		
	Rashidiya	764	608	749.33	707.11		
	bohooth 22	512.33	837	568	639.11		
second Sowing Date	Jehan	260	410.67	373	347.89		
	Rashidiya	305.33	354.67	497	385.67		
	bohooth 22	538.33	450.67	323.67	437.56		
third Sowing Date	Jehan	230	190.67	317	245.89		
	Rashidiya	277.33	204.67	208	230		
	bohooth 22	264.67	213.67	110	196.11		
Fourth Sowing Date	Jehan	199.33	208	218	208.44		
	Rashidiya	208	181.67	181.33	190.33		
	bohooth 22	215.67	233	155.67	201.44		
Sowing Dates × Varieties	First Sowing Date	632.67	660.78	645.22		646.22	
	second Sowing Date	367.89	405.33	397.89		390.37	
	third Sowing Date	257.33	203	211.67		224	
	Fourth Sowing Date	207.67	207.56	185		200.07	
Seeding Rates × Varieties	Jehan	327.75	336.67	381.58			348.66
	Rashidiya	388.67	337.25	408.92			378.27
	bohooth 22	382.75	433.58	289.33			368.55
Effect of Seeding Rates		366.38	369.16	359.94			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 3: Effect of Sowing Dates, Varieties, and Seeding Rates on Flag leaf area (cm²)-

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties	Hamidiyat Location
		30	40	50				
First Sowing Date	Jehan	35.00 d e	38.66 b c	42.00 a	38.55 a b			
	Rashidiya	33.66 e f	38.66 b c	42.33 a	38.22 b			
	bohooth 22	37.33 c d	41.33 a b	41.33 a b	40.00 a			
second Sowing Date	Jehan	24.66 i m	31.33 f g	33.33 e f	29.77 c			
	Rashidiya	23.00 l m n	20.66 n	37.00 c d	26.88 d e			
	bohooth 22	26.00 i l	30.00 g h	23.33 k n	26.44 d e f			
third Sowing Date	Jehan	26.00 i l	25.00 i m	25.00 i m	25.33 e f g			
	Rashidiya	30.00 g h	27.66 h i	24.66 i m	27.44 d			
	bohooth 22	22.33 m n	27.33 h i	25.33 i m	25.00 f g			
Fourth Sowing Date	Jehan	26.66 i j k	22.33 m n	22.66 l m n	23.88 g			
	Rashidiya	23.33 k n	24.66 i m	23.66 j n	23.88 g			
	bohooth 22	22.33 m n	27.00 h i j	25.33 i m	24.88 f g			
Sowing Dates × Varieties	First Sowing Date	35.33 c	39.55 b	41.88 a	38.92 a			
	second Sowing Date	24.55 g h	27.33 e	31.22 d	27.70 b			
	third Sowing Date	26.11 e f g	26.66 e f	25.00 f g h	25.92 c			
	Fourth Sowing Date	24.11 h	24.66 g h	23.88 h	24.22 d			
Seeding Rates × Varieties	Jehan	28.08 c d e	29.33 b c	30.75 a b	29.38 a			
	Rashidiya	27.50 d e	27.91 c d e	31.91 a	29.11 a			
	bohooth 22	27.00 e	31.41 a	28.83 c d	29.08 a			
Effect of Seeding Rates		27.52 c	29.55 b	30.50 a				

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 4: Effect of Sowing Dates, Varieties, and Seeding Rates on Flag leaf area (cm²)- Mosul Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	40.73 c d	46.46 a b	45.40 a b	44.20 a		
	Rashidiya	42.66 b c d	43.26 b d	49.40 a	45.11 a		
	bohooth 22	44.33 b c	47.06 a b	44.33 b c	45.24 a		
second Sowing Date	Jehan	29.00 i m	33.00 f i	35.33 e f	32.44 b c		
	Rashidiya	27.66 k n	27 l o	43.33 b c d	32.66 b c		
	bohooth 22	39.33 d e	39.00 d e	25.33 m n o	34.55 b		
third Sowing Date	Jehan	34.33 f g	25.33 m n o	32.00 f k	30.55 c		
	Rashidiya	33.66 f g h	32.33 f j	29.00 i m	31.66 c		
	bohooth 22	22.66 o	30.66 g k	23.00 o	25.44 d		
Fourth Sowing Date	Jehan	29.33 h m	24.00 n o	24.33 n o	25.88 d		
	Rashidiya	24.00 n o	26.66 l o	26.66 l o	25.44 d		
	bohooth 22	24.00 n o	28.00 j n	22.66 o	24.88 d		
Sowing Dates × Varieties	First Sowing Date	42.57 b	45.60 a	46.37 a		44.85 a	
	second Sowing Date	32.00 d e	33.00 c d	34.66 c		33.22 b	
	third Sowing Date	30.22 e f	29.44 f	28.00 f g		29.22 c	
	Fourth Sowing Date	25.77 g h	26.22 g h	24.22 h		25.40 d	
Seeding Rates × Varieties	Jehan	33.35 c d	32.20 c d	34.26 b c			33.27 a
	Rashidiya	32.00 d	32.31 c d	36.85 a			33.72 a
	bohooth 22	32.58 c d	36.18 a b	28.83 e			32.53 a
Effect of Seeding Rates		32.64 a	33.56 a	33.31 a			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 5: Effect of Sowing Dates, Varieties, and Seeding Rates on Number of spikes m⁻² - Hamidiyat Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	287.33	304.33	394	328.55		
	Rashidiya	354	335	352.33	347.11		
	bohooth 22	290	361.33	324	325.11		
second Sowing Date	Jehan	247	373.67	351	323.88		
	Rashidiya	294.33	404.67	321	340		
	bohooth 22	271	364.33	392.67	342.66		
third Sowing Date	Jehan	242	313.33	238	264.44		
	Rashidiya	243.33	277.67	211.33	244.11		
	bohooth 22	237	213.33	284	244.77		
Fourth Sowing Date	Jehan	226	254	247.33	242.44		
	Rashidiya	244	254.67	243.33	247.33		
	bohooth 22	244.67	254	242	246.88		
Sowing Dates × Varieties	First Sowing Date	310.44	333.55	356.77		333.59	
	second Sowing Date	270.77	380.88	354.88		335.51	
	third Sowing Date	240.77	268.11	244.44		251.11	
	Fourth Sowing Date	238.22	254.22	244.22		245.55	
Seeding Rates × Varieties	Jehan	250.58	311.333	307.58			289.83
	Rashidiya	283.91	318	282			294.63
	bohooth 22	260.66	298.25	310.66			289.86
Effect of Seeding Rates		265.05	309.19	300.08			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 6: Effect of Sowing Dates, Varieties, and Seeding Rates on Number of spikes m⁻²- Mosul Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	384.33 g h i	375.33 h i	423.67 e f g	394.44 d		
	Rashidiya	447.33 d e f	442.67 d e f	456.33 c d e	448.78 a b		
	bohooth 22	343.33 i j k	556.00 a	397.33 g h	432.22 b c		
second Sowing Date	Jehan	367.33 h i j	460.67 c d e	420.33 e f g	416.11 c d		
	Rashidiya	344.00 i j k	518.33 a b	457.33 c d e	439.89 b		
	bohooth 22	423.33 e f g	470.67 c d	498.67 b c	464.22 a		
third Sowing Date	Jehan	240 o p	324.00 j m	406.67 f g h	323.56 e		
	Rashidiya	290.67 l m n	217.33 p	266.67 n o	257.89 g		
	bohooth 22	408.00 f g h	266.67 n o	205.33 p	292.00 f		
Fourth Sowing Date	Jehan	242.67 o p	382.67 g h i	330.67 j k l	318.67 e		
	Rashidiya	332.67 j k l	266 n o	266.67 n o	287.11 f		
	bohooth 22	319.33 k l m	324.00 j m	281.67 m n o	308.33 e f		
Sowing Dates × Varieties	First Sowing Date	391.67 d	458.00 b	425.78 c		425.14 b	
	second Sowing Date	378.22 d	483.22 a	458.78 b		440.07 a	
	third Sowing Date	312.89 e f	268.00 g	292.56 f		291.14 d	
	Fourth Sowing Date	298.22 f	322.89 e	293.00 f		304.70 c	
Seeding Rates × Varieties	Jehan	308.58 e	385.66 a b	395.33 a		363.19 a b	
	Rashidiya	353.66 c d	360.08 c d	361.50 c d		358.41 b	
	bohooth 22	373.50 b c	403.33 a	345.75 d		374.19 a	
Effect of Seeding Rates		345.25 c	383.02 a	367.52 b			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 7: Effect of Sowing Dates, Varieties, and Seeding Rates on Number of grains spike⁻¹ - Hamidiyat Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	27 a	22 b c d	23.33 b c	24.11 a		
	Rashidiya	22 b c d	19.33 e i	24 b	21.77 b		
	bohooth 22	23 b c	21.66 b e	24 b	22.88 b		
second Sowing Date	Jehan	16.63 k j	18 h k	19.43 e i	18.02 c d		
	Rashidiya	18 h k	20.30 d h	18.83 g j	19.04 c		
	bohooth 22	16 k	20.56 d g	15.80 k	17.45 d		
third Sowing Date	Jehan	12.33 l m	19 f j	10.80 m n	14.04 e		
	Rashidiya	18 h k	17 i j k	17.33 i j k	17.44 d		
	bohooth 22	19.33 e i	21.26 c f	13.33 l	17.97 c d		
Fourth Sowing Date	Jehan	10 n o	9 n o	10.33 m n o	9.77 f		
	Rashidiya	8.33 o	9 n o	9.33 n o	8.88 f		
	bohooth 22	9.66 n o	8.33 o	8.50 n o	8.83 f		
Sowing Dates × Varieties	First Sowing Date	24 a	21 b	23.77 a		22.92 a	
	second Sowing Date	16.87 e f	19.62 c	18.02 d e		18.17 b	
	third Sowing Date	16.55 f	19.08 c d	13.82 g		16.48 c	
	Fourth Sowing Date	9.33 h	8.77 h	9.38 h		9.16 d	
Seeding Rates × Varieties	Jehan	16.49 b c d	17.00 a b c	15.97 c d		16.48 a	
	Rashidiya	16.58 b c	16.40 b c d	17.37 a b		16.78 a	
	bohooth 22	17.00 a b c	17.95 a	15.40 d		16.78 a	
Effect of Seeding Rates		16.69 a b	17.12 a	16.25 b			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5

Table 8: Effect of Sowing Dates, Varieties, and Seeding Rates on Number of grains spike⁻¹- Mosul Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	26 a	22 b c	16.66 g h i	23.66 a		
	Rashidiya	22 b c	19.33 c g	21.33 b e	20.88 b		
	bohooth	22 b c	21.66 b c d	23.33 b	22.33 a b		
	22						
second Sowing Date	Jehan	16.63 g h i	17.33 g h i	18.76 d h	17.57 d		
	Rashidiya	18 f i	20.34 b f	18.83 d h	19.06 c		
	bohooth	16 h i j	20.56 b f	15.40 i j	17.32 d		
	22						
third Sowing Date	Jehan	11.33 l m	18.66 e h	13.33 j k	14.44 e		
	Rashidiya	17 g h i	23	16.33 g h i	16.66 d		
	bohooth	18 f i	20.93 b f	12 k l	16.97 d		
	22						
Fourth Sowing Date	Jehan	9.33 l m	9 m	10.33 l m	9.55 f		
	Rashidiya	8.33 m	9 m	9.33 l m	8.88 f		
	bohooth	9.33 l m	8.33 m	8.50 m	8.72 f		
	22						
Sowing Dates × Varieties	First Sowing Date	23.33 a	21 b	22.55 a		22.29 a	
	second Sowing Date	16.87 e f	19.41 c	17.66 d e		17.98 b	
	third Sowing Date	15.44 f	18.75 c d	13.88 g		16.02 c	
	Fourth Sowing Date	9 h	8.77 h	9.38 h		9.05 d	
Seeding Rates × Varieties	Jehan	15.82 b c	16.75 a b	16.35 b		16.31 a	
	Rashidiya	16.33 b	16.33 b	16.45 b		16.37 a	
	bohooth	16.33 b	17.87 a	14.80 c		16.33 a	
	22						
Effect of Seeding Rates		16.16 b	16.98 a	15.87 b			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%

**Table
Effect
Sowing**

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	28.66	25.66	28.66	27.66		
	Rashidiya	33	26.00	27.00	28.66		
	bohooth 22	30.66	28.66	30.33	29.88		
second Sowing Date	Jehan	21.00	24.33	24.00	23.11		
	Rashidiya	25.00	23.33	23.66	24		
	bohooth 22	26.00	23.00	26.33	25.11		
third Sowing Date	Jehan	28.00	23.33	25.00	25.44		
	Rashidiya	26.66	23.66	25.00	25.11		
	bohooth 22	26.00	24.33	25.33	25.22		
Fourth Sowing Date	Jehan	26.33	23.00	26.00	25.11		
	Rashidiya	25.66	25.00	25.00	25.22		
	bohooth 22	26.00	25.33	23.66	25		
Sowing Dates × Varieties	First Sowing Date	30.77	26.77	28.66		28.74	
	second Sowing Date	24	23.55	24.66		24.07	
	third Sowing Date	26.88	23.77	25.11		25.25	
	Fourth Sowing Date	26	24.44	24.88		25.11	
Seeding Rates × Varieties	Jehan	26	24.08	25.91			25.33
	Rashidiya	27.58	24	25.16			25.75
	bohooth 22	27.16	25.33	26.41			26.30
Effect of Seeding Rates		26.91	24.63	25.83			

**9:
of
Dates,**

Varieties, and Seeding Rates on 1000-grain weight (g) - Hamidiyat Location

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Table 10: Effect of Sowing Dates, Varieties, and Seeding Rates on 1000-grain weight (g) - Mosul Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	41.00 a	31.60 c	32.66 bc	35.08 a		
	Rashidiya	40.36 a	32.03 c	33.33 bc	35.24 a		
	bohooth 22	34.80 b	31.93 c	33.16 bc	33.30 b		
second Sowing Date	Jehan	24.33 hi	26.26 dh	25.23 ghi	25.27 f		
	Rashidiya	32.03 c	25.30 ghi	25.66 fi	27.66 cd		
	bohooth 22	32.10 c	25.60 fi	26.33 dh	28.01 c		
third Sowing Date	Jehan	28.46 de	23.50 i	27 dg	26.32 def		
	Rashidiya	28.06 def	26.50 dh	25.93 ei	26.83 cde		
	bohooth 22	28 def	26 ei	24.33 hi	26.11 ef		
Fourth Sowing Date	Jehan	28.80 d	23.50 i	27.33 dg	26.54 def		
	Rashidiya	28.06 def	26.16 eh	25.60 fi	26.61 def		
	bohooth 22	28 def	25.66 fi	24.33 hi	26 ef		
Sowing Dates × Varieties	First Sowing Date	38.72 a	31.85 b	33.05 b		34.54 a	
	second Sowing Date	29.48 c	25.72 e	25.74 e		26.98 b	
	third Sowing Date	28.17 d	25.33 e	25.75 e		26.42 c	
	Fourth Sowing Date	28.28 cd	25.11 e	25.75 e		26.38 d	
Seeding Rates × Varieties	Jehan	30.65 b	26.21 d	28.05 c			28.30 b
	Rashidiya	32.13 a	27.50 c	27.63 c			29.08 a
	bohooth 22	30.72 b	27.30 cd	27.04 cd			28.35 b
Effect of Seeding Rates		31.16 a	27.00 b	27.57 b			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5

Table 11: Effect of Sowing Dates, Varieties, and Seeding Rates on Grain yield

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates × Varieties	Effect of Sowing Dates	Effect of Varieties	(g m ⁻²) - Hamidiyat Location
		30	40	50				
First Sowing Date	Jehan	66	51.66	63.33	60.33			
	Rashidiya	61.33	54	61.33	58.88			
	bohooth 22	58.33	56	64.33	59.55			
second Sowing Date	Jehan	55	67	62.66	61.55			
	Rashidiya	53	69.33	60	60.77			
	bohooth 22	58	69.66	60.66	62.77			
third Sowing Date	Jehan	55	58.33	55	56.11			
	Rashidiya	59.66	61.33	48.66	56.55			
	bohooth 22	60	54.66	46.33	53.66			
Fourth Sowing Date	Jehan	46.66	47	50	47.88			
	Rashidiya	43.33	43.66	47.33	44.77			
	bohooth 22	46.33	42.66	45.66	44.88			
Sowing Dates × Varieties	First Sowing Date	61.88	53.88	63	59.59			
	second Sowing Date	55.33	68.66	61.11	61.70			
	third Sowing Date	58.22	58.11	50	55.44			
	Fourth Sowing Date	45.44	44.44	47.66	45.85			
Seeding Rates × Varieties	Jehan	55.66	56	57.75	56.47			
	Rashidiya	54.33	57.08	54.33	55.25			
	bohooth 22	55.66	55.75	54.25	55.22			
Effect of Seeding Rates		55.22	56.27	55.44				

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%

Table 12: Effect of Sowing Dates, Varieties, and Seeding Rates on Grain yield (g m^{-2}) - Mosul Location

Sowing Dates	Varieties	Seeding Rates (kg/donum)			Sowing Dates \times Varieties	Effect of Sowing Dates	Effect of Varieties
		30	40	50			
First Sowing Date	Jehan	71.44 b	63.66 e f	71.66 b	68.92 B		
	Rashidiya	70.03 b c	61.90 e h	71.83 b	67.92 B		
	bohooth 22	68.80 b c d	71.73 b	70.63 b c	70.38 a b		
second Sowing Date	Jehan	60.13 f i	73 b	70.40 b c	67.84 B		
	Rashidiya	61.33 g f h	81.46 a	64.80 d e f	69.20 B		
	bohooth 22	62.93 e f g	82.06 a	70.46 b c	71.82 A		
third Sowing Date	Jehan	62.93 e f g	66.53 c d e	60.60 g f h	63.35 c		
	Rashidiya	66.13 c d e	58.86 g h i	57.86 h i	60.95 d		
	bohooth 22	63.06 e f g	60.66 g f h	56 i j	59.91 d		
Fourth Sowing Date	Jehan	53.66 j k	55.66 i j	47 l	52.11 e		
	Rashidiya	48.66 k l	49.33 k l	51.33 k l	49.77 f		
	bohooth 22	49.66 l	42.33 m	50.33 k l	47.44 g		
Sowing Dates \times Varieties	First Sowing Date	70.09 b c	65.76 d	71.37 b	69.07 a		
	second Sowing Date	61.46 f	78.84 a	68.55 c	69.62 a		
	third Sowing Date	64.04 d e	62.02 e f	58.15 g	61.40 b		
	Fourth Sowing Date	50.66 h	49.11 h	49.55 h	49.77 c		
Seeding Rates \times Varieties	Jehan	62.04 b c	64.71 a	62.41 b c		63.05 a	
	Rashidiya	61.54 c	62.89 a b c	61.45 c		61.96 a	
	bohooth 22	61.11 c	64.20 a b	61.85 c		62.39 a	
Effect of Seeding Rates		61.56 b	63.93 a	61.91 b			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5

Conclusion

1. The first sowing date, during the vegetative growth stage, produced the highest values for most vegetative traits and for yield and its components; this was positively reflected in an increased grain yield (economic yield).

2. The two cultivars (Buhouth 22 and Rashidiya) showed a significant superiority in most of the studied traits, including yield and its components.

3. The second seeding rate (40 kg/dunum) showed a significant superiority in most of the studied traits, including yield and its components.

Acknowledgment: Sincere gratitude and appreciation are extended to all individuals who contributed to the completion of this work through their guidance, support, and cooperation.

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