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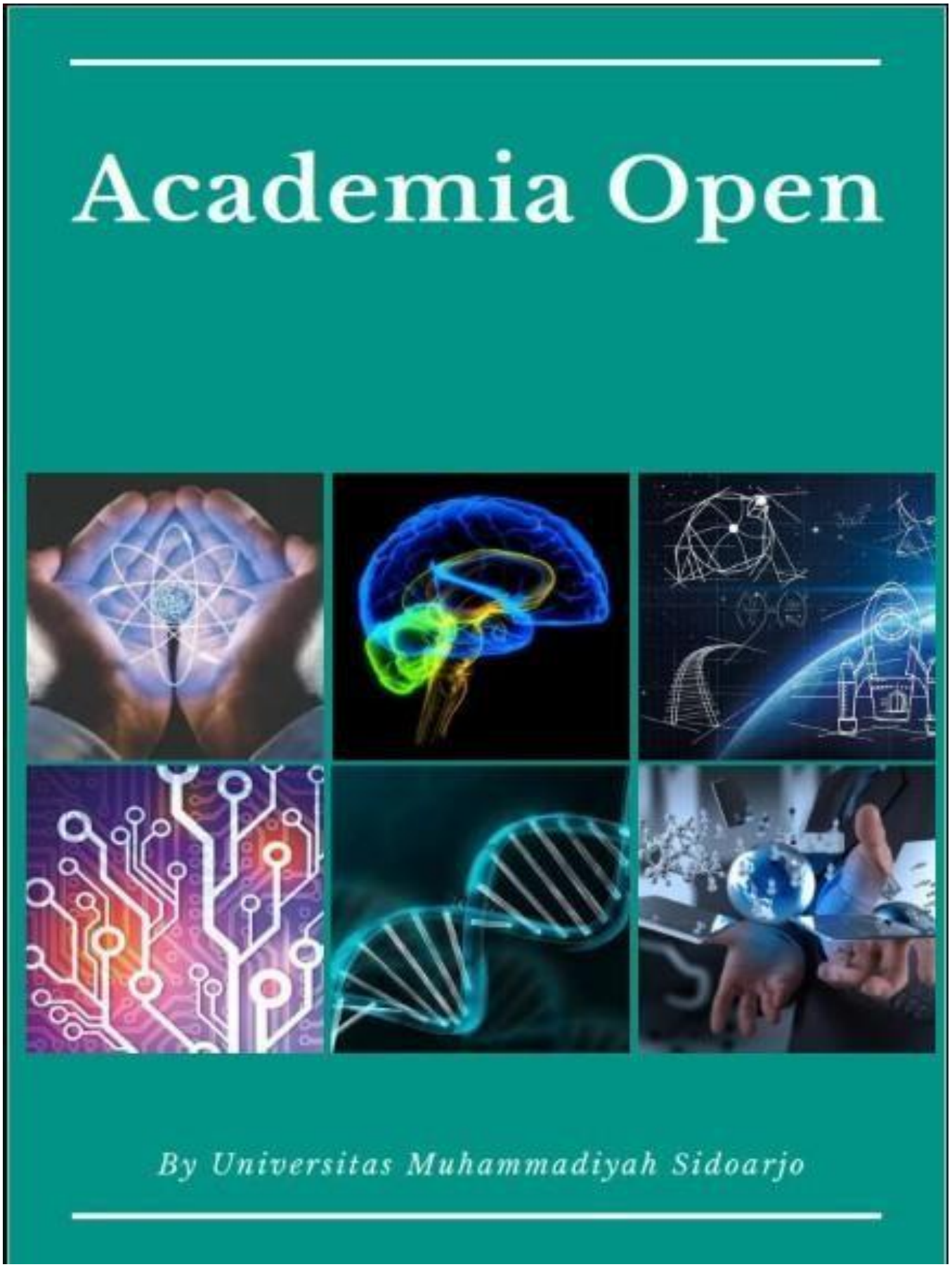

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Optimum Sowing Date And Seeding Rate Determine Wheat Production Under Salinity

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Abstract

General Background: Soil salinity limits wheat growth and productivity in arid and semi-arid regions. **Specific Background:** Appropriate sowing dates and seeding rates are essential for wheat cultivation under saline conditions. **Knowledge Gap:** Their combined effects on wheat yield under saline conditions in southern Iraq remain insufficiently investigated. **Aims:** This study evaluated sowing dates and seeding rates for wheat (*Triticum aestivum* L.) cultivar Sham 6 under saline soil conditions. **Results:** A split-plot randomized complete block design with three replications was conducted during the 2025–2026 winter season, examining three sowing dates and three seeding rates. December 1 sowing at 150 kg/ha produced the highest grain yield (5.120 t/ha) and biological yield (11.127 t/ha), whereas November 15 sowing at 180 kg/ha recorded the lowest grain yield (2.660 t/ha). **Novelty:** The study identifies an optimal sowing date and seeding rate combination for wheat production under local saline conditions. **Implications:** Sowing on December 1 at 150 kg/ha is recommended for wheat cultivation in saline soils of Al-Muthanna Governorate, Iraq.

Highlights:

- The best treatment combination produced 5.120 t/ha of grain and 11.127 t/ha of total biomass.
- November 15 planting at 180 kg/ha recorded the lowest productivity of 2.660 t/ha.
- Early November planting recorded the highest harvest index, reaching 45.77% under the medium seed density.

Keywords: Wheat grain yield, Sowing date, Seeding rate, Saline soil, Triticum aestivum

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I. lntroduction

Wheat (Triticum aestivum L.) is one of the most important cereal crops in the world and in Iraq, as it represents the main food for more than one-third of the world's population, and occupies the first place in terms of cultivated area and production among cereal crops [1]. In Iraq, wheat is considered a strategic crop for food security, but its productivity is still below the required level due to deterioration of soil fertility, water scarcity, and exacerbation of the salinity problem, especially in the southern governorates, including Al-Muthanna Governorate [2].Salinity is one of the most dangerous factors limiting wheat production in arid and semi-arid regions, as it affects all stages of plant growth from germination to maturity [3-4] indicated that salinity causes osmotic imbalance, ionic toxicity and oxidative stress, which leads to decreased absorption of water and nutrients, accumulation of sodium and chloride ions in tissues, and decreased chlorophyll content and photosynthetic rate [5] confirmed that salinity reduces germination percentage, delays flowering, and reduces number of productive tillers, number of spikes, number of grains per spike and 1000-grain weight, and consequently reduces final yield [6].also indicated that increasing soil salinity led to a significant decrease in plant height, biomass, photosynthetic rate and chlorophyll content .Sowing date is one of the most important agricultural factors that determine the success of wheat crop, especially under stress conditions [7]. Sowing at the appropriate date allows the plant to benefit from optimum weather conditions, achieve good vegetative growth, and form a sufficient number of tillers and spikes, while late sowing leads to shortening growth duration, reducing dry matter accumulation, and exposing the plant to high temperatures during grain filling[8] proved that sowing at the intermediate date achieved the highest yield, with an increase of 22.92% and 27.28% over very late sowing[5] also proved that late sowing led to a significant decrease in yield compared to sowing at the appropriate date .As for seeding rate, it is another important factor affecting yield components, as it determines number of plants per unit area, and degree of competition among plants for water, light and nutrients[7] In saline soils, germination percentage decreases due to osmotic stress[6], therefore increasing seeding rate may compensate this deficiency and increase number of spikes per unit area. However, excessive increase in seeding rate causes severe competition and reduction in number of productive tillers and grain weight [9].Objectives of the study :To determine the best sowing date for wheat in saline soil in Al-Muthanna Governorate.To determine the best seeding rate that compensates germination deficiency resulting from salinity.To study the effect of interaction between sowing date and seeding rate on yield and its components.To present a practical agricultural recommendation to increase wheat productivity in saline areas.

II. Materials and Methods

2 .1. Location of Experiment

The field experiment was carried out in the winter season 2025-2026 at the Second Research Station of the College of Agriculture - University of Al-Muthanna, located in Al-Bandar area, 2 km north of Al-Muthanna Governorate center. The study area is characterized by a dry and semi-arid climate, where the annual rainfall rate is less than 100 mm, according to data of the Iraqi General Authority for Meteorology and Seismic Monitoring. The site was chosen because its soil is naturally saline, where electrical conductivity (EC) ranges between 6-8 dS/m, which is within the range at which wheat yield begins to decrease significantly [3]

Table 1. Soil chemical and physical properties

Traits		Value	Unit
ECe		6.4	Dms. m^{-1}
PH		7.3	
Available Nitrogen		24.66	mg kg^{-1}
Available Phosphorus		26.12	mg kg^{-1}
Available Potassium		115.76	mg kg^{-1}
Texture	Sand	138	g. kg^{-1}
)(clay loam	Silt	512	
	Clay	350	

2 .2. Soil Analysis

Composite soil samples were taken from the field before sowing from two depths (0-30 cm and 30-60 cm), air-dried, ground and sieved through a 2 mm sieve, then chemical and physical analyses were carried out according to the standard approved methods [10].Table (1): Some physical and chemical properties of the experimental soil

2 .3. Experimental Design

The experiment was carried out according to Randomized Complete Block Design (R.C.B.D) in Split-Plot arrangement with three replications [11]

Main factor: Sowing dates (1/11, 15/11, 1/12) symbolized as D1, D2, D3.

Sub factor: Seeding rates (100, 150, 180 kg/ha) symbolized as K1, K2, K3.Number of treatments: 9 treatments.Number of experimental units: 27 units.Unit area: 4 m^2 (2m × 2m).Cultivar used: Sham 6, a cultivar of the International Center for

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Agricultural Research in the Dry Areas (ICARDA), germination percentage 92%.

2 .4 Agricultural Operations

Soil preparation: Deep plowing 25-30 cm, smoothing and leveling. Fertilization: Urea 200 kg/ha in two doses, Super phosphate 100 kg/ha, Potassium sulphate 60 kg/ha.

Irrigation: Surface irrigation every 12-14 days, 8-10 irrigations.

Weed control manually and chemically as needed [7].

2 .5 Studied Traits

1- Number of Tillers / m² Number of tillers was counted at full tillering stage for all plants harvested from the two middle lines of each experimental unit, then the number was converted to m2

2- Number of Spikes / m² Number of spikes was calculated after reaching full maturity stage for all harvested plants from the two middle lines of each experimental unit.

3- Number of Grains per Spike It was calculated from the average number of grains of ten spikes after threshing these spikes manually and counting their grains.

4- Grain Weight (g-1000) grains were counted randomly from each experimental unit, then weighed using a sensitive balance.

5- Grain Yield (t/ha) Grain yield was estimated for the plants harvested from the two middle lines after manual threshing of plants from each experimental unit. After separating straw from grains, they were weighed and grain yield was calculated (t/ha).

6- Biological Yield It was obtained from the dry matter yield (grains + straw) from an area of 0.45 m² from three guarded middle lines inside each experimental unit under secondary conditions, and the weight was converted to t/ha .

7- Harvest Index %It was calculated from the following equation:HI=Gy/DM×100. [4-12]

2 .6. Statistical Analysis

Data were analyzed using analysis of variance (ANOVA) for split-plot design, using GenStat program, and means were compared using Least Significant Difference (L.S.D) test at 5% significance level [12].

III. Results and Discussion

1- Number of Tillers m2

The results of analysis of variance showed a significant effect of sowing dates and the interaction between sowing date and seeding rate on the number of tillers / m², while the effect of seeding rate was non-significant. The least significant difference (L.S.D) value was 34.80 for sowing date and 23.97 for the interaction, while the effect of seeding rate was non-significant (N.S).The third sowing date (D3) recorded the highest mean number of tillers, reaching 351.5 tillers / m², followed by the first sowing date (D1) with a mean of 332.2 tillers / m², while the second sowing date (D2) recorded the lowest mean of 267.4 tillers / m². The superiority of the third and first sowing dates in number of tillers is attributed to the fact that plants in these two dates had a longer period of vegetative growth before entering the elongation and flowering stages, which allowed the lateral buds to divide and form a larger number of tillers [7]. Whereas the second sowing date shortened the tillering period due to temperature fluctuations and increased salt concentration in the surface layer during germination and tillering, which led to a decrease in tiller survival rate and a lower proportion of them turning into fertile tillers [3-5]. This agrees with what was reported by[13] that the appropriate sowing date increases the number of tillers by 18-25% compared to inappropriate dates, because the plant exploits the optimum weather conditions to form the maximum possible number of tillers before the elongation stage.The interaction between sowing date and seeding rate was significant, where the treatment (D3 × 100 kg/ha) recorded the highest number of tillers, reaching 368.0 tillers / m², followed by the treatment (D3 × 180) with a mean of 343.6 tillers / m², the treatment (D3 × 140) with a mean of 343.0 tillers / m², and the treatment (D1 × 140) with a mean of 339.3 tillers / m². While the treatment (D2 × 140) recorded the lowest number of tillers, reaching 235.0 tillers / m². The superiority of the treatment (D3 × 100) can be explained on the basis that the low seeding rate in the third sowing date reduced competition among plants, and allowed each plant to obtain a larger amount of water, nutrients and light, which encouraged the formation of a larger number of tillers and compensated for salt stress (6). While the combination of the second sowing date and the medium seeding rate (D2 × 140) led to the worst combination, because plants were exposed at the same time to two stresses: the stress of the inappropriate sowing date and the stress of competition for resources, which led to the death of a large proportion of weak tillers [14]. This confirms that the interaction between the two factors is what determines the final number of tillers, and not each factor alone, and that choosing the appropriate combination between sowing date and seeding rate is more important than choosing each factor individually, and this agrees with what was mentioned by [15,8] that the significant interaction indicates that the plant's response to seeding rate changes with changing sowing date. In general, this result confirms that the number of tillers is the first trait

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that determines the number of spikes and the final yield, and that obtaining a high number of tillers in the third sowing date with low seeding rate represents a good basis for obtaining a high yield, provided that these tillers turn into fertile spikes.

Table (2): Effect of sowing date, seeding rate and their interaction on number of tillers (tillers/m²)

Sowing date	100	150	180	Mean
D1	332.0	332.7	339.3	324.7
D2	306.7	290.0	235.0	277.2
D3	319.7	368.0	343.0	343.6
Mean	309.4	330.2	305.8	
LSD	D	K	DXK	
	23.97	N.S	34.80	

2- Number of Spikes / m²

The results of analysis of variance showed no significant effect of sowing dates and the interaction between sowing date and seeding rate on the number of spikes / m², while the effect of seeding rate was significant at the 5% level, where the least significant difference (L.S.D) value was 29.53.The seeding rate of 150 kg/ha significantly outperformed, recording the highest mean of 331.8 spikes / m², compared to the seeding rate of 180 kg/ha which recorded 313.4 spikes / m², and the seeding rate of 100 kg/ha which recorded the lowest mean of 308.9 spikes / m². This increase can be explained on the basis that increasing the number of plants per unit area up to a certain limit leads to an increase in the number of fertile tillers producing spikes, especially under saline soil conditions which reduce the germination percentage and seedling survival rate, therefore increasing the seed quantity compensates for this deficiency and ensures obtaining an optimum plant density [6-16]. This agrees with what was mentioned by [13] that the number of spikes / m² increases with increasing seeding rate up to a certain limit, then starts to decrease at high rates as a result of increased competition among plants for water, light and nutrients, which leads to the death of a proportion of weak tillers and their failure to turn into productive spikes.As for the decrease in the number of spikes at the seeding rate of 180 kg/ha compared to 150 kg/ha, it is attributed to the fact that the very high rate led to an increase in severe competition within the plant community, reduced light penetration to the lower leaves, and decreased photosynthetic rate of late tillers, and consequently their failure to form spikes [7-9]. As pointed out by [8], the high seeding rate in saline soils increases osmotic stress, because increasing the number of plants increases water uptake from the soil and increases salt concentration in the root zone, which negatively reflects on tiller growth.In contrast, the non-significance of the effect of sowing date on the number of spikes, despite the existence of numerical differences among dates, can be attributed to the fact that wheat plants possess a high compensatory ability through tillering, as plants sown on different dates were able to compensate for the deficiency in the vegetative growth period by increasing the number of tillers, especially since weather conditions during the experimental season were relatively similar among dates in terms of temperatures, which reduced the effect of delayed sowing on this trait [14]. Also, salinity was the main limiting factor for tiller growth more than sowing date, as salt stress reduces cell division in apical buds and limits tiller formation regardless of sowing date [3-5].

Table (3): Effect of sowing date, seeding rate and their interaction on number of spikes (spikes/m²)

Sowing date	100	140	180	meas
D1	310.0	359.0	343.3	337.4
D2	276.3	260.0	261.7	266.0
D3	240.3	376.3	335.3	350.7
Means	308.9	331.8	313.4	
LSD	K	D	DXK	
	29.53	N.SD	N.S	

3- Number of Grains per Spike

The results of analysis of variance showed a significant effect of sowing date and seeding rate on the number of grains per spike, while the effect of the interaction between them was non-significant.The results showed that the third sowing date (D3) significantly outperformed and recorded the highest mean of 50.96 grains / spike, followed by the first sowing date (D1) with a mean of 48.60 grains / spike, while the second sowing date (D2) recorded the lowest mean of 41.76 grains / spike. The superiority of the third sowing date in number of grains per spike is attributed to the fact that plants in this date were exposed during the period of floral primordia formation and fertilization to more favourable weather conditions, especially moderate temperatures, which led to an increase in the number of fertile florets and a decrease in floret abortion percentage [7]. While the second sowing date led to the coincidence of the flowering stage with high temperatures and increased salt concentration in the soil solution, which led to pollen desiccation, weak fertilization and increased percentage of sterile florets, and consequently a decrease in the number of grains per spike [16,5]. This agrees with what was mentioned by [13] that delaying or advancing the sowing date from the optimum date reduces the number of grains per spike by 12-20%, due to shortening the growth period and shortening the grain filling period, while the appropriate date provides a longer period for spike formation and spikelet differentiation.The seeding rate of 100 kg/ha significantly outperformed and recorded the highest mean of 50.36 grains / spike, followed by the seeding rate of 150 kg/ha with a mean of 47.22 grains / spike, while the seeding rate of 180 kg/ha recorded the lowest mean of 43.38 grains / spike. The differences among all seeding rates were significant. The superiority of the low seeding rate (100 kg/ha) in number of grains per spike

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can be explained on the basis that the decrease in the number of plants per unit area reduced competition for light, wat er and nutrients, and allowed each spike to obtain a larger amount of photosynthetic products, which led to an increase in the number of fertile florets and a decrease in floret abortion percentage at the top and base of the spike [9,8]. While the high seeding rate (180 kg/ha) led to increased mutual shading among plants, decreased photosynthetic rate of the flag leaf, and reduced amount of carbohydrates translocated to the spike during flowering, which increased floret abortion percentage and decreased grain number [6]. This agrees with what was reached by [3]that salt stress increases the sensitivity of florets to competition, because salinity reduces the absorption of water and potassium necessary for the fertilization process, therefore increasing seeding rate in saline soils doubles the effect of salinity on grain number.

Table (4): Effect of sowing dates and plant density and their interaction on number of grains per spike

Sowing date	100	150	180	Man
D1	52.00	48.50	45.30	48.60
D2	44.67	42.17	38.17	41.67
D3	54.40	51.00	46.67	50.69
Man	50.36	47.22	43.38	
LSD	D	K	DxK	
	2.266	1.369	N.S	

4- 1000-Grain Weight

The results of analysis of variance showed a significant effect of sowing date and seeding rate on 1000-grain weight, while the effect of the interaction between them was non-significant.The results showed that the first sowing date (D1) significantly outperformed and recorded the highest mean of 42.00 g, followed by the second sowing date (D2) with a mean of 39.90 g, while the third sowing date (D3) recorded the lowest mean of 37.30 g. The superiority of the first sowing date in 1000-grain weight is attributed to the fact that early-sown plants obtained a longer period for the grain filling stage, and were exposed during it to moderate temperatures, which allowed the continuation of photosynthesis in the flag leaf for a longer period and the translocation of a larger amount of carbohydrates to the grains [7]. While delayed sowing in the third sowing date led to shortening the grain filling period and its coincidence with high temperatures and increased salt stress, which led to accelerating leaf senescence and decreasing the rate of nutrient translocation to the grains, and consequently the formation of shriveled grains with light weight [16, 5]. This agrees with what was mentioned by [13] that 1000 -grain weight decreases by 10-15% when sowing is delayed beyond the optimum date, due to shortening the growth period and the effect of high temperature at the maturity stage, and also agrees with what was reached by [14] that early sowing increases grain weight under salinity conditions because it avoids salt accumulation at the end of the season.It was also observed that the seeding rate of 100 kg/ha significantly outperformed and recorded the highest mean of 41.04 g, followed by the seeding rate of 150 kg/ha with a mean of 39.34 g, while the seeding rate of 180 kg/ha recorded the lowest mean of 36.10 g. The differences among all seeding rates were significant. The superiority of the low seeding rate in 1000-grain weight can be explained on the basis that the decrease in the number of plants per unit area reduced competition for water, light and nutrients, and allowed each plant to obtain a larger amount of photosynthetic products during the grain filling period, which led to an increase in grain size and weight [9,8]. While the high seeding rate (180 kg/ha) led to an increase in the number of spikes and grains per unit area, which led to the distribution of photosynthetic products over a larger number of grains, and consequently a decrease in the share of each grain and a decrease in its weight, a phenomenon known as the compensation phenomenon among yield components [6]. This agrees with what was mentioned by [3] that salinity reduces grain weight by reducing the absorption of potassium and water necessary for the grain filling process, and that increasing seeding rate in saline soils doubles this effect because it increases water uptake and Increases salt concentration in the root zone

Table (5): Effect of sowing date, seeding rate and their interaction on 1000-grain weight (g4)

Sowing date	100	150	180	Man
D1	42.00	37.63	43.50	39.73
D2	39.90	36.83	41.30	35.54
D3	37.30	32.17	38.83	41.21
Man	41.04	39.34	36.10	
LSD	D	K	DxK	
	2.923	1.240	N.S	

5- Grain Yield

The results of analysis of variance showed a significant effect of sowing date, seeding rate and their interaction on grain yield.The results showed that the third sowing date (D3) significantly outperformed and recorded the highest mean of 4.573 t / ha, followed by the first sowing date (D1) with a mean of 4.209 t / ha, while the second sowing date (D2) recorded the

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lowest mean of 3.120 t / ha. The superiority of the third sowing date in grain yield is attributed to its superiority in number of spikes and number of grains per spike as mentioned in the previous traits, since yield is the resultant of its components, and any increase in number of spikes and number of grains is directly reflected in increasing yield [7]. Also, plants in the third sowing date were able to exploit the suitable weather conditions during the flowering and grain setting stage, which led to a decrease in floret abortion percentage and an increase in the number of filled grains [13]. As for the decrease in yield of the second sowing date, it is attributed to its decrease in all yield components, especially number of tillers, number of grains per spike and 1000-grain weight, as a result of its exposure to unsuitable conditions during critical growth stages, and increased salt concentration in the root zone during germination and tillering [3-5]. This agrees with what was mentioned by [14] that choosing the appropriate sowing date can increase wheat yield in saline soils by 25-35% compared to the inappropriate date.Also, the seeding rate of 150 kg/ha significantly outperformed and recorded the highest mean of 4.417 t / ha, while the seeding rate of 180 kg/ha recorded a mean of 3.743 t / ha, and the seeding rate of 100 kg/ha recorded a mean of 3.742 t / ha. The difference between the rate of 150 and the other two rates was significant, while the difference between 100 and 180 was non-significant. The superiority of the medium seeding rate (150 kg/ha) represents the optimum rate which achieves a balance among yield components, as it gave the highest number of spikes / m² (331.8 spikes) with a suitable number of grains and a good grain weight, while the low seeding rate (100) gave a lower number of spikes despite its superiority in number of grains per spike and grain weight, and the high seeding rate (180) gave a high number of spikes but with a large decrease in number of grains and grain weight due to severe competition [6-9]. This agrees with what was reached by [8-13] that grain yield increases with increasing seeding rate up to a certain limit then decreases, because the increase in number of spikes does not compensate for the decrease in number of grains and their weight at very high rates, especially under salinity conditions which increase the severity of competition for water. Also, the rate of 150 kg/ha was able to compensate for the decrease in germination resulting from salinity and ensure an optimum plant density, without reaching the stage of severe competition which leads to tiller death and grain shriveling [16].The interaction between sowing date and seeding rate was significant, where the treatment (D3 × 150 kg/ha) recorded the highest grain yield of 5.120 t / ha, followed by the treatment (D3 × 180) with a mean of 4.643 t / ha, and the treatment (D1 × 150) with a mean of 4.650 t / ha, while the treatment (D2 × 180) recorded the lowest yield of 2.660 t / ha. The superiority of the treatment (D3 × 150) can be explained on the basis that it combined the best sowing date and the best seeding rate, where the third sowing date provided suitable conditions for flowering and grain setting, and the rate of 150 provided the optimum number of spikes with providing a sufficient amount of photosynthetic products for each spike, which led to obtaining the highest yield [7-15]. As for the decrease in yield of the treatment (D2 × 180), it is attributed to the fact that it combined the worst sowing date and the highest seeding rate, which led to the coincidence of the stress of the inappropriate sowing date with the stress of severe competition and salinity, and consequently the decrease of all yield components at the same time [5-14]. The significance of the interaction indicates that the response of yield to seeding rate changes with changing sowing date, therefore the optimum seeding rate cannot be determined in isolation from sowing date, but the appropriate combination between them must be chosen. In general, this result confirms that the combination (D3 × 150 kg/ha) is the best combination for obtaining the highest grain yield under saline soil conditions in the study area, and that it achieved an increase in yield of 92.5% compared to the lowest combination (D2 × 180), which indicates the great importance of choosing the appropriate sowing date and seeding rate.

Table (6): Effect of sowing dates and plant density and their interaction on grain yield

Sowing date	100	150	180	Man
D1	4.050	4.650	3.927	4.573
D2	3.220	3.480	2.660	3.120
D3	3.957	5.120	4.643	4.209
Man	3.742	4.417	3.743	
LSD	D	K	DxK	
	0.2526	0.2824	0.4344	

6- Biological Yield

The results of analysis of variance showed a significant effect of sowing date, seeding rate and their interaction on biological yield.It was observed that the third sowing date (D3) significantly outperformed and recorded the highest mean of 10.224 t / ha, followed by the first sowing date (D1) with a mean of 9.568 t / ha, while the second sowing date (D2) recorded the lowest mean of 7.024 t / ha. The differences among all sowing dates were significant because they are larger than the L.S.D value of 0.2517. The superiority of the third sowing date in biological yield is attributed to its superiority in vegetative growth, especially number of tillers, which led to a greater accumulation of dry matter in the plant [7]. Plants in the third sowing date obtained a longer growth period before flowering, which allowed them to produce a larger amount of carbohydrates and store them in stems and leaves [13]. As for the decrease in biological yield in the second sowing date, it is attributed to the shortening of the vegetative growth period and the decrease in number of tillers, as a result of plants being exposed to unsuitable conditions and increased salt concentration, which led to a decrease in photosynthetic rate and a decrease in dry matter accumulation [3-5]. This agrees with what was mentioned by [14] that biological yield is greatly affected by sowing date, because any delay or advance from the optimum date reduces the vegetative growth period and consequently reduces total dry matter.The seeding rate of 150 kg/ha significantly outperformed and recorded the highest mean of 9.746 t / ha, while the seeding rate of 180 kg/ha and the seeding rate of 100 kg/ha recorded the same mean of 8.536 t / ha. The difference between the rate of 150 and the other two rates was significant. The superiority of the medium seeding rate (150 kg/ha) in biological yield can be explained on the basis that it achieved the optimum plant density which allows full exploitation of light, water and nutrients, without severe competition occurring [6]. At the low seeding rate (100), the

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number of plants was not sufficient for full exploitation of the unit area, which led to a decrease in total dry matter despite the superiority of the individual plant. As for the high seeding rate (180), severe competition led to a decrease in the growth of the individual plant, a decrease in leaf area per plant, and a decrease in photosynthetic rate, and consequently a decrease in dry matter [9,8]. This agrees with what was reached by [16] that biological yield increases with increasing seeding rate up to a certain limit then decreases, because the increase in number of plants does not compensate for the decrease in the growth of the individual plant at very high rates, especially under salinity conditions which increase osmotic stress.The interaction between sowing date and seeding rate was significant, where the treatment (D3 × 150 kg/ha) recorded the highest biological yield of 11.127 t / ha, followed by the treatment (D3 × 180) with a mean of 10.107 t / ha, and the treatment (D1 × 150) with a mean of 10.413 t / ha, while the treatment (D2 × 180) recorded the lowest biological yield of 6.150 t / ha. The superiority of the treatment (D3 × 150) can be explained on the basis that it combined the best sowing date which provided a long growth period, and the best seeding rate which provided the optimum number of plants, which led to obtaining the highest leaf area, highest crop growth rate and highest dry matter accumulation [7-15]. As for the decrease in yield of the treatment (D2 × 180), it is attributed to the fact that it combined the worst sowing date and the highest seeding rate, which led to the coincidence of shortening the growth period with severe competition and salinity, and consequently a sharp decrease in vegetative growth and dry matter [5-14]. The significance of the interaction indicates that the response of biological yield to seeding rate changes with changing sowing date, therefore the appropriate combination between them must be chosen to obtain the highest biological yield. In general, this result confirms that biological yield is directly related to grain yield, and that the combination (D3 × 150) which gave the highest biological yield is the same which gave the highest grain yield, which indicates that the increase in total dry matter was positively reflected in increasing grain yield, and this is the main objective of improving agricultural practices in saline soils..

Table (7): Effect of sowing date, seeding rate and their interaction on biological yield (t/ha)

Sowing date	100	150	180	Mean
D1	8.940	10.413	9.350	9.568
D2	7.227	7.697	6.150	7.024
D3	9.440	11.127	10.107	10.224
Mean	8.536	9.746	8.536	
	D	K	DxK	
LSD	0.1841	0.1513	0.2517	

7-Harvest Index%

The results of analysis of variance showed a significant effect of sowing date, seeding rate and their interaction on harvest index.It was observed that the first sowing date (D1) significantly outperformed and recorded the highest mean of 45.54%, followed by the third sowing date (D3) with a mean of 42.65%, while the second sowing date (D2) recorded the lowest mean of 38.86%. The differences among all sowing dates were significant because they are larger than the L.S.D value of 2.074. The superiority of the first sowing date in harvest index is attributed to the fact that plants in this date achieved a better balance between vegetative growth and reproductive growth, where they were able to convert a larger proportion of total dry matter into grains, compared to other dates which directed a larger proportion of dry matter to stems and leaves [7]. The first sowing date provided a longer grain filling period and more favourable conditions for carbohydrate translocation from leaves and stems to grains [13]. As for the decrease in harvest index in the second sowing date, it is attributed to the decrease in grain yield to a greater extent than the decrease in biological yield, where stress during the flowering and grain setting stage led to a decrease in number of grains and their weight, and consequently a decrease in the proportion of grains to total dry matter [3-5]. This agrees with what was mentioned by [14] that harvest index decreases clearly when the plant is exposed to salt and heat stress during the flowering stage, because stress affects grains more than its effect on vegetative growth.The seeding rate of 100 kg/ha significantly outperformed and recorded the highest mean of 43.08%, followed by the seeding rate of 150 kg/ha with a mean of 42.43%, while the seeding rate of 180 kg/ha recorded the lowest mean of 41.53%. The difference between the rate of 100 and the rate of 180 was significant, and between the rate of 150 and the rate of 180 was significant, while the difference between the rate of 100 and the rate of 150 was non-significant. The superiority of the low seeding rate in harvest index can be explained on the basis that the decrease in number of plants reduced competition, and allowed each plant to direct a larger proportion of photosynthetic products to spikes and grains, while the high seeding rate led to an increase in vegetative growth and competition for light, which led to an increase in stem length and vegetative dry matter at the expense of grains, and consequently a decrease in harvest index [6-9]. This agrees with what was reached by [8] that increasing seeding rate increases biological yield by a larger percentage than its increase in grain yield, which leads to a decrease in harvest index, and also agrees with what was mentioned by [16] that salinity reduces harvest index because it affects the grain filling stage more than its effect on vegetative growth.The interaction between sowing date and seeding rate was significant, where the treatment (D1 × 150 kg/ha) recorded the highest harvest index of 45.77%, followed by the treatment (D1 × 180) with a mean of 45.53%, and the treatment (D3 × 100) with a mean of 45.20%, and the treatment (D1 × 100) with a mean of 45.33%, while the treatment (D2 × 180) recorded the lowest harvest index of 38.52%. The superiority of the treatment (D1 × 150) can be explained on the basis that it combined the first sowing date which provided a long filling period, and the medium seeding rate which provided a balance between number of spikes and grain weight, which led to converting the largest proportion of dry matter into grains [7-15]. As for the decrease in harvest index in the treatment (D2 × 180), it is attributed to the fact that it combined the worst sowing date and the highest seeding rate, which led to an increase in vegetative growth and severe competition, and a decrease in number of grains and their weight, and consequently a decrease in the proportion of grains to total dry matter [5-14]. The significance of the interaction

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indicates that the response of harvest index to seeding rate changes with changing sowing date, and that choosing the appropriate combination is what determines the efficiency of converting dry matter into grains. In general, although the highest grain yield was recorded in the treatment (D3 × 150), the highest harvest index was recorded in the treatment (D1 × 150), which indicates that the first sowing date was more efficient in converting dry matter into grains, while the third sowing date was superior in producing total dry matter and grain yield. This confirms that harvest index alone is not sufficient to judge the superiority of treatments, but it must be considered together with grain yield and biological yield.

Table (8): Effect of sowing dates and plant density and their interaction on harvest index

Mans	100	150	180	Man
D1	45.33	45.77	45.53	45.54
D2	38.72	39.34	38.52	38.86
D3	45.20	42.20	40.54	42.65
Man	43.08	42.43	41.53	
LSD	D	K	DXK	
	2.020	0.861	2.074	

IV. Conclusion

1- Sowing date had a significant effect on all yield and yield components traits. Sowing on 1/12 (D3) was superior in number of tillers, number of spikes, number of grains per spike, grain yield and biological yield, while sowing on 1/11 (D1) was superior in spike length, 1000-grain weight and harvest index. Sowing on 15/11 (D2) recorded the lowest values for all traits.

2- Seeding rate had a significant effect on all studied traits. Seeding rate of 140 kg/ha was the optimum rate for grain yield and biological yield, as it achieved the best balance among yield components. Seeding rate of 100 kg/ha was superior in spike length, number of grains per spike, 1000-grain weight and harvest index, while seeding rate of 180 kg/ha caused severe competition among plants and decreased all yield components.

3- The interaction between sowing date and seeding rate was significant for grain yield, biological yield and harvest index. The combination (D3 × 150 kg/ha) achieved the highest grain yield and biological yield, with an increase of 92.5% in grain yield compared to the lowest combination (D2 × 180 kg/ha).

4- The results proved that increasing seeding rate does not always increase yield under saline conditions, but the medium rate (150 kg/ha) is the best to compensate germination deficiency caused by salinity, without causing severe competition

5- Harvest index was highest in early sowing (D1) and low seeding rate (100 kg/ha), which indicates higher efficiency in converting dry matter into grains, although grain yield was highest in late sowing (D3)

V. Recommendations

1- It is recommended to sow wheat cultivar Sham 6 on 1/12 in saline soils in Al-Muthanna Governorate, to obtain the highest grain yield.It

2- It is recommended to use a seeding rate of 150 kg/ha, as it is the optimum rate under saline soil conditions, and to avoid using high rate (180 kg/ha) because it causes severe competition and decreases yield

3- It is recommended to avoid sowing on 15/11 under saline conditions, because it recorded the lowest yield in this study

4- It is recommended to repeat the experiment for more than one season and in different locations with different salinity levels, to confirm the results.

5- It is recommended to study the effect of adding organic matter and gypsum with sowing date and seeding rate, to improve soil properties and reduce salinity effect.

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