



RESEARCH ARTICLE

Interaction between seeding rates and different wheat varieties in improving yield

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Abstract

An experiment was conducted during the winter season of 2023–2024 on the farm of one of the farmers, using a randomised complete block design (RCBD) with a split-plot arrangement and three replications. The study aimed to investigate the effect of three seeding rates (100, 140 and 180 kg ha⁻¹) as the main treatments on the growth and yield of five wheat varieties (Fayad, Al-Rashid, Tamouz, IPA 99 and Al-Hashimiyya) as the subplots. The results showed that the seeding rate of 100 kg ha⁻¹ resulted in the highest mean values for flag leaf area, 1000-grain weight and harvest index, with values of 15.36 cm², 47.20 g and 26.56 %, respectively. On the other hand, the 180 kg ha⁻¹ seeding rate exhibited superior performance in biological yield and total yield, with values of 21.16 t ha⁻¹ and 5.71 t ha⁻¹, respectively. The 140 kg ha⁻¹ seeding rate was distinguished by producing the highest harvest index, with a mean value of 28.87 %. Significant differences were observed among the varieties for most of the traits studied. The variety Al-Rashid achieved the highest mean values for flag leaf area, total yield and harvest index, with 14.71 cm², 5.92 kg ha⁻¹ and 28.90 %, respectively. Meanwhile, the variety Tamouz recorded the highest mean 1000-grain weight, 52.34 g, while the variety IPA 99 exhibited the highest biological yield, reaching 22.58 t ha⁻¹.

Keywords: biological yield; harvest index; interaction; seeding rates; varieties; wheat

Introduction

Wheat (*Triticum aestivum* L.) is considered one of the worlds' essential and strategic crops in terms of production and cultivated areas. Despite the significant increase in the production of field crops such as wheat, barley and rice per unit area in recent years, achieved through intensive efforts by scientists and researchers in crop improvement yet the gap between global production and the growing demand remains substantial. This challenge is further exacerbated by global population growth, which exceeded seven and a half billion people at the beginning of 2022, with two-thirds of the population increase occurring in developing countries. The estimated wheat production in Iraq for 2022 is 270 thousand tons, a decrease of 84.8 % from last years' production, which amounted to 1765 thousand tons. The cultivated area in Iraq for the wheat crop for the year 2022 was 3096 thousand dunums (1). Iraq still faces a large gap between its production capacity, consumption and increasing demand, as it represents the food backbone (2). The different wheat varieties alone are not sufficient to increase crop productivity, as it is necessary to determine the optimal seeding rate for the cultivated variety, which enables the variety to exploit its latent physiological and genetic capabilities to the highest level to achieve the highest productivity per unit area, as seeding rates are one of the techniques through which the crop growth pattern can

be influenced and thus the yield and its components depending on the field management conditions and genetic composition. Seeding rates significantly impact the main components of the yield, as they are components linked together and an increase in any of these components is accompanied by a decrease in the other components (3, 4). The study aims to know the effect of three seed rates on the growth and yield of five wheat varieties and to know the best seed rate and the best variety to find a selection guide or guides to improve wheat yield, to clarify this information to plant breeders when they wish to improve some of the characteristics of these varieties.

Materials and Methods

In a split-plot arrangement, a field experiment with three replications was conducted on a farmers' farm utilising a randomised complete block design (RCBD). The study aimed to evaluate the effect of three seeding rates (100, 140 and 180 kg ha⁻¹) as the primary treatments on the growth and yield of five wheat cultivars (Fayad, Rashid, Tamuz, IPA 99 and Hashimiyah), which served as the secondary treatments. The experimental area was ploughed, levelled and subsequently divided into experimental units for the study, with an area of 6 m², each with 10 lines and a

distance of 25 cm between each line. The number of experimental units in each replicate was 15 experimental units. The seed rates were distributed randomly on the main plots within each replicate, as was the distribution of varieties on the secondary plots. The experiment was fertilised with phosphate fertiliser at a rate of 120 kg ha⁻¹ DAP, which was added in a single application at planting, while nitrogen fertiliser was added at a rate of 180 kg ha⁻¹ N in two batches. Half the quantity was added 20 days after planting and the remaining was added 45 days after the first batch (5). The experiment was planted on 18 November 2023 by hand within the lines and at a depth not exceeding 3 cm, then covered with soil and given the first irrigation immediately after planting, then repeated after that depending on the soil moisture and the condition of the plant, where the number of irrigations reached five during the growing season. Harvesting was done upon reaching the stage of full maturity. Random samples were selected from the middle lines of each experimental unit to study the characteristics of flag leaf area, weight of 1000 grains, biological yield, grain yield per unit area and harvest index.

Results and Discussion

Flag leaf area

Table 1 reveals that the Rashid variety was superior in terms of the highest mean flag leaf area, which reached 14.71 cm². This value did not differ significantly from that of the Hashimiyah variety, which had a mean of 14.52 cm². In contrast, the Fayyad variety exhibited the lowest mean for this trait, with a value of 13.43 cm². The superior performance of the Rashid and Hashimiyah varieties can be attributed to differences in their genetic composition, as well as variations in the growth period leading up to spike emergence, during which the growth rate and expansion of the flag leaf are enhanced (6). This finding is consistent with previous studies, which reported significant differences between wheat varieties in terms of flag leaf area (7–10). The same table also indicates significant differences in seed rates for this trait. A seed rate of 100 kg ha⁻¹ resulted in the highest mean flag leaf area of 15.36 cm², while a seed rate of 180 kg ha⁻¹ produced the lowest mean at 13.11 cm². The percentage increase over the 180 kg ha⁻¹ seed rate was 16.17 %. This result aligns with findings from other researchers, although some studies have shown variations

between varieties when seed rates are increased, specifically in flag leaf area (11–18). Additionally, the interaction between varieties and seed rates was significant, as evidenced by the Rashid variety outperforming at a seed rate of 100 kg ha⁻¹, with the highest mean flag leaf area of 16.40 cm². This result significantly differed from the Hashimiyah variety at a seed rate of 180 kg ha⁻¹, which had the lowest mean flag leaf area of 10.28 cm². Furthermore, the Tamouz variety at a seed rate of 140 kg ha⁻¹ recorded the lowest mean of 11.76 cm². These data highlight the variation in flag leaf area responses to different varieties and seed rates.

The results of Table 2 show that there were significant differences in seed rates for the 1000-grain weight trait, as the 1000 grain weight decreased with increasing seed rate, where the 100 kg ha⁻¹ seed rate gave the highest Mean 1000-grain weight, reaching 47.20 g, which gave a Mean 1000-grain weight of 46.76 g, while the opposite situation was with the 180 kg ha⁻¹ seed rate, which gave the lowest mean 1000-grain weight, reaching 45.13 g. This result was consistent with other researchers who showed significant differences between rates for the 1000-grain weight trait (19–23). The results presented in the same table indicate that the interaction between the study factors was significant. The Tamouz variety, at a seed rate of 140 kg ha⁻¹, recorded the highest mean 1000-grain weight, reaching 52.88 g and this value did not differ significantly from the same variety at a seed rate of 100 kg ha⁻¹. The variety IPA 99, with a seed rate of 180 kg ha⁻¹, recorded the lowest Mean, reaching 39.12 g, with a decrease of 35.17 % over the variety Tamouz with a seed rate of 140 kg ha⁻¹. A significant difference in the response of the varieties to the seed rates was noted. This result is consistent with other researchers who showed significant differences between seed rates for the 1000-grain weight trait.

Biological yield

The results of Table 3 show that there were significant differences in seed rates in the biological yield trait, as the biological yield increased initially but may plateau or decline at excessive seed rates, where the seed rate of 180 kg gave the highest Mean biological yield of 21.16 t ha⁻¹. The results show that the seed rate of 100 kg ha⁻¹ produced the lowest mean for the biological yield trait, reaching 18.68 t ha⁻¹. The superior performance of the 180 kg ha⁻¹ seed rate in terms of biological yield can likely be attributed to

Table 1. Response of flag leaf area (cm²) to seeding rates and wheat varieties

Seeding rates (kg ha ⁻¹)	Variety					
	Fayadh	Rashid	Tamouz	IPA 99	Hashimiyah	Mean
100	14.80	16.40	14.80	14.60	16.20	15.36
140	12.61	14.37	14.24	14.14	15.61	14.19
180	12.88	13.36	13.62	13.91	11.76	13.11
LSD 5 %				0.27		
Mean	13.43	14.71	14.22	14.22	14.52	0.25
LSD 5 %				0.13		

LSD: Least significant difference.

Table 2. Response of 1000-grain weight (g) to seeding rates and wheat varieties

Seeding rates (kg ha ⁻¹)	Variety					
	Fayadh	Rashid	Tamouz	IPA 99	Hashimiyah	Mean
100	47.72	45.27	52.77	41.04	49.22	47.20
140	47.26	44.31	52.88	40.67	48.68	46.76
180	44.41	43.29	51.37	39.12	47.48	45.13
LSD 5 %				1.76		
Mean	46.46	44.29	52.34	40.28	48.46	1.10
LSD 5 %				0.94		

LSD: Least significant difference.

Table 3. Response of biological yield ($t\ ha^{-1}$) to seeding rates and wheat varieties

Seeding rates ($kg\ ha^{-1}$)	Variety					
	Fayadh	Rashid	Tamouz	IPA 99	Hashimiyah	Mean
100	17.51	18.47	20.61	20.94	15.87	18.68
140	18.14	20.99	21.08	22.85	17.93	20.20
180	19.12	22.03	22.13	23.94	18.58	21.16
LSD 5 %				0.27		
Mean	18.26	20.50	21.27	22.58	17.46	0.65
LSD 5 %				0.34		

LSD: Least significant difference.

its higher performance in traits such as plant height and flag leaf area. This finding aligns with the results of previous studies (22–26). Additionally, the interaction between the study factors was significant. The IPA 99 variety, at a seed rate of $180\ kg\ ha^{-1}$, yielded the highest mean biological yield of $23.94\ t\ ha^{-1}$, which represented a 50.85 % increase compared to the Hashimiyah variety at a seed rate of $100\ kg\ ha^{-1}$. Furthermore, there was a significant difference in the response of the varieties to increasing seed rates, a result consistent with the findings of other researchers, who reported significant differences between seed rates.

Grain yield

Table 4 shows that the Rashid variety was superior in producing the highest mean grain yield of $5.92\ t\ ha^{-1}$. However, it did not differ significantly from the Hashimiyah variety, which produced $5.63\ t\ ha^{-1}$, representing an increase of 15.17 %, 8.62 %, 29.54 % and 5.15 % for the Fayyad, Tamuz, IPA 99 and Hashimiyah varieties, respectively. The superior performance of the Rashid and Hashimiyah varieties in terms of grain yield may be attributed to their favourable characteristics, such as the number of tillers and the number of spikes. These results were consistent with other researchers who showed the existence of a significant difference between the studied varieties in grain yield per unit area (26). The results showed significant differences in seeding rates in the grain yield trait, as grain yield increased significantly with each increase in seeding rate, where a seeding rate of $180\ kg$ gave the highest mean grain yield of $5.71\ t\ ha^{-1}$, while a seeding rate of $140\ kg\ ha^{-1}$ gave a yield of $5.42\ t\ ha^{-1}$. The lowest mean seed yield was at a seeding rate of $100\ kg\ ha^{-1}$, reaching $4.90\ t\ ha^{-1}$, as increasing seeding rates lead to an increase in accumulated dry matter and the large number of plants leads to an increase in both the photosynthetic area and the root volume per unit soil surface area, which allows the crop to improve the utilisation of

environmental resources. This result is consistent with other studies that demonstrated significant differences between seeding rates. The interaction between the study factors was significant, as the Rashid variety at a seed rate of $180\ kg\ ha^{-1}$ produced the highest mean grain yield of $6.27\ t\ ha^{-1}$. However, this value did not differ significantly from that of the Hashimiyah variety at the same seed rate. Furthermore, the Rashid variety showed an increase of 48.58 % over the Tamouz variety, which had a seed rate of $100\ kg\ ha^{-1}$. It was also observed that there was a significant difference in the response of the varieties as seed rates increased.

Harvest index

Table 5 showed that the Hashimiyah variety was superior by giving the highest Mean harvest index of 31.75 % and it differed significantly from the rest of the varieties, as the Tamouz variety gave the lowest Mean of 21.45 %, as the harvest index in the Tamouz variety was low due to the low total yield. The superiority of the Hashimiyah variety in the harvest index is due to its superiority in the grain yield trait and the low value of the biological yield because the genetic structures vary in their efficiency in distributing the products of photosynthesis from the leaves to the estuary (17). These results agreed with other researchers who showed a significant difference between the studied varieties in the harvest index per unit area (1, 7, 10).

Significant differences were observed for seed rates in the harvest index trait, as grain yield improved with higher seed rates up to a certain level. The seed rates of $140\ kg\ ha^{-1}$ resulted in the highest mean for the harvest index, reaching 27.12 %, though it did not differ significantly from the seed rate of $180\ kg\ ha^{-1}$, which produced a mean of 26.96 %. In contrast, the seed rate of $100\ kg\ ha^{-1}$ produced the lowest mean for this trait, at 26.56 %. This finding is consistent with other studies, which also showed

Table 4. Response of grain yield ($t\ ha^{-1}$) to seeding rates and wheat varieties

Seeding rates ($kg\ ha^{-1}$)	Variety					
	Fayadh	Rashid	Tamouz	IPA 99	Hashimiyah	Mean
100	4.68	5.47	4.22	5.11	5.01	4.90
140	5.37	6.01	4.39	5.52	5.81	5.42
180	5.38	6.27	5.10	5.72	6.08	5.71
LSD 5 %				0.23		
Mean	5.14	5.92	4.57	5.45	5.63	0.19
LSD 5 %				0.12		

LSD: Least significant difference.

Table 5. Response of harvest index (%) to seeding rates and wheat varieties

Seeding rates ($kg\ ha^{-1}$)	Variety					
	Fayadh	Rashid	Tamouz	IPA 99	Hashimiyah	Mean
100	26.73	29.62	20.48	24.40	31.57	26.56
140	29.60	28.63	20.83	24.16	32.40	27.12
180	28.14	28.46	23.05	23.89	31.27	26.96
LSD 5 %				1.23		
Mean	28.16	28.90	21.45	24.15	31.75	0.32
LSD 5 %				0.61		

LSD: Least significant difference.

significant differences between seed rates (23, 26, 27). The interaction between the study factors was significant. The Hashimiyah variety at a seed rate of 140 kg ha⁻¹ recorded the highest mean harvest index of 32.40 %, while the Tamouz variety at a seed rate of 100 kg ha⁻¹ yielded the lowest mean of 20.48 %.

Conclusion

Based on the study's results, using the Rashid variety with a seeding rate of 180 kg ha⁻¹ is recommended to achieve the highest grain yield, which reached 6.27 t ha⁻¹. The Hashimiyah variety also demonstrated potential, particularly at the same seeding rate, which showed good performance at the same seeding rate with an increase in yield by 48.58 % compared to the Tamouz variety at a seeding rate of 100 kg ha⁻¹. In addition, the study shows that increasing seeding rates improves grain yield due to increasing plant density, which contributes to improving the utilisation of environmental resources.

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Authors' contributions

HMO, ZAA, HJH, ASAR, AMO and AMA designed the study, performed the statistical analysis and participated in drafting the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

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