



IRAQI
Academic Scientific Journals



العراقية
المجلات الأكاديمية العلمية

TJAS

Tikrit Journal for
Agricultural
Sciences

ISSN:1813-1646 (Print); 2664-0597 (Online)

Tikrit Journal for Agricultural Sciences

Journal Homepage: <http://tujas.tu.edu.iq>

E-mail: tjas@tu.edu.iq

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KEY WORDS:

Wheat, Seed Rates, *Triticum
aestivum* L.

ARTICLE HISTORY:

Received: 05/04/2021

Accepted: 19/06/2021

Available online: 30/09/2021

Tikrit Journal for Agricultural Sciences (TJAS)

Response of Wheat Cultivars to Seed Rates Using Morphological and Yield Characteristics

ABSTRACT

The seed rates are a significant factor influencing the vegetative, reproductive, and yield traits of wheat (*Triticum aestivum* L). Therefore, the response of varieties to different seed rates is constantly studied to find a suitable combination among them. The experiment was performed with three replications using a split-plot design within a randomized complete block design (RCBD). Three seed rates were placed in the main plots (150, 200, 250 kg h⁻¹), and seven wheat cultivars were placed in the sub-main plots (Sham 6, Tammuz2, Latifia, Sally, IPA 99, Rabiaa, and Abu Gharib). The results indicated that the IPA 99 during the average of the three seed rates was given the highest area of a flag leaf (44.25 cm²), grain per spike (78.85), spike per unit area m² (441.81), and the grain yield (5.9) ton h⁻¹. While the Sham6 gave the highest spike length (11.11 cm) and the weight of 1000 grains (35.20 g). The first seed rate (150 kg h⁻¹) during the average of the seven cultivars was surpassed other seed rates for all traits except the plant height. IPA 99 and first seed rates combination was given the highest grain yield with (6.7) tons/hectare. Hence, it would suggest planting IPA 99 with first seed rates (150) kg h⁻¹ in the location of this experiment. More tests can, however, be carried out at various locations in Iraq and with a wide variety of seed rates, to achieve the required combination for growing wheat and achieving high productivity with the cultivated cultivars.

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INTRODUCTION

Wheat is the world's second-largest crop (FAO, IFAD, and WFP 2015), food requirements are projected to be double in 2050, and demand for high-quality foods is rising rapidly (Singh et al. 2015). Wheat breeding programs receive great attention from plant breeders\ producers in Iraq and worldwide in the seed breeding and development centers. Like any other crop, two key factors that affect wheat, the genetic variation and their stability in any agricultural region and the climatic and biological conditions surrounding the crop. Field crop production is mainly dependent on the strength of solar radiation, the rate of total absorption of individual leaves, the rate of respiration, the amount of photosynthesis, the nutritional status of the soil, and the availability of water (Baktash and Naes 2016; Fazily and Habibi 2019). The goal of spacing and intensity of cultivation of crops in general, and wheat in particular, was to meet the specific needs of cultivation methods and to improve productivity (Bektash and Baraihi 2006; Intsar and Wahid 2017). The seed rates are an important factor influencing the wheat growth and yield profile (Hiltbrunner et al., 2007; Grassini et al., 2011; Ermoshkina et al., 2021). Previous experiments have concentrated on determining the optimum density of wheat production, but the findings have varied according to the circumstances of the experiment, traits, and the characteristics being studied. Austin et al. 1980, were found major variations among wheat cultivars in several field characteristics. Al-Aseel 1998 reported increasing seed rates could decrease flag leaf areas and increase plant height. Although,

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Yoshida 1981 stated the dense density increases the flag leaf index, ensuring that plant photosynthesis meets the requirements for high yields. Optimum spacing among plants might lead to the number of plants per plot area is optimum, which leads to the production of growth traits and eventually improves grain yields. Thus, using more solar radiation and soil nutrients, the optimum plant density encourages proper plant growth (Bhowmik et al., 2012; Yadav et al., 2017). Seed ratio at sowing time and planting distances are factors affecting yield and its components (Maric et al., 2008; Lodo et al., 2018)

New wheat cultivars need constant screening and put under different pressures of abiotic stress, including seed rates to know their products and determine their requirements. The high plant density can increase the grain yield and the weight of 1000 grains Nakano et al. 2012. Many variables are influencing the grain yield, so crop management plays a vital role among these variables. Many publications were indicated that as a consequence of the increase in the number of spikes, the grain yield improved with the increase in plant density. The reduction in the seed rate may lead to reducing the number of spikes, and the number of seeds per hectare is more often reduced (Ozturk et al., 2006). On the other hand, the output of some studies has shown the efficacy of this use, which promotes an adequate seed rate for the availability of nutrients, an effective combination of sunlight for photosynthesis, and the efficiency of water use, which is important for the viability of crops, thereby raising the production and yield of crops (Carr et al., 2003; Lloveras et al., 2004; Ozturk et al., 2006; Alemayehu 2015).

The study aims to evaluate the impact of seed rates on growth and yield and their components of wheat cultivars and to determine the best rate to achieve the full productivity of the wheat cultivar.

MATERIAL AND METHODS

A field experiment was conducted in the Hamra north of Tikrit, located astronomically at the longitude $043^{\circ} 41' 07''$ E degrees east of the Greenwich line, and at $34^{\circ} 36' 14''$ N degrees north of the equator, during 2019-2020 to study the effect of response seed rates on the growth of yield and components of wheat cultivars. In this experiment, seven wheat cultivars were obtained from the Salah El-Din Governorate's Seed Technology Center, as shown in Table (1). All of the cultivars were matured at around the same time from sowing to harvest, about 125 days. The field was prepared using the conventional method of disc plow and cross plowing, and the ground was smoothed and leveled before sowing wheat. Compound fertilizer N: P: K (0, 27, 27) was applied at a rate of 400 kg h⁻¹ in one batch before planting, and urea fertilizer (N 46%) was applied two times with 200 kg ha⁻¹ each during the booting and flowering. Three treatments of (150, 200, and 250 kg h⁻¹) and seven cultivars (Sham 6, Tammuz2, Latifia, Sally, IPA 99, Rabiaa, and Abu Gharib) were used in this experiment. The factorial treatments were spread randomly using a split-plot within a randomized complete block design with four replications, which included seed rates in the main plot and wheat cultivars in the sub-main plot on 11-20-2019. The sowing was performed in lines and at a seeding rate according to the treatment; the number of lines is 5, the length of the line is 5 m, the distance among lines is 15 cm, so the experimental unit is 4.5 m² (0.90 x 5 m), and a distance of 1 m is left among plots. Weeds were manually removed at the beginning of the planting, active tillers, and the heading spikes. Harvest was done manually when wheat plants were reached physiological maturity. The growth and yield characteristics and their components were taken from each plot, where 10 plants were tagged and selected randomly from middle lines. Some growth traits like plant height (cm), spike length (cm), and flag leaf area (cm²) were taken. When the wheat plants were reached ripened, (1 square meter) of the middle lines were harvested from each plot to measure the following characteristics:

The number of grains per spike, the number of spikes per unit area (m²), the weight of 1000 grains (g). Yield (ton h⁻¹) the grain yield was measured by taking the weight of the grains from the harvested plot of (1 m²) and converting it to ton h⁻¹ after correcting the humidity levels to 12.5% (Roberts., 2012). The data were subjected to an analysis of variance using a linear model (GLM) procedure using SAS 9.4 (SAS, 2003). The least significant difference test was used to compare the significant differences among cultivars and seed rates at the level of 5%.

RESULTS AND DISCUSSION

Plant height

The height of the yield is mainly controlled by the genetic variability of the cultivars and may be influenced by the environmental factors surrounding it (Shahzad et al., 2007; Intsar and Wahid 2017). The effect of cultivars on wheat plant height during the mean of the three seed rates was significant in Table (1).

Table (1) The average of the seven cultivars during the mean of the three seed rates for the studied traits

Traits Cultivars	Plant height (cm)	Flag leaf area (cm ²)	spike length (cm)	grain per spike	1000 grain weight (g)	spikes per unit (m ²)	grain yield (ton h ⁻¹)
Sham 6	112.49	42.39	11.11	78.17	29.24	382.47	5.69
Tammuz 2	113.67	43.91	10.76	72.96	29.66	390.9	5.53
Latifia	109.84	41.75	10.21	72.13	28.01	337.95	5.03
Sally	106.41	42.4	11.56	76.82	30.96	382.4	5.5
IPA 99	111.76	44.25	9.94	76.85	35.2	441.81	5.9
Rabiaa	109.54	42.36	10.79	72.1	30.69	382	5.06
Abu Gharib	113.49	40.49	11.03	76.64	30.21	368.33	4.92
L.S.D 0.05	0.73	0.66	0.29	1.67	1.11	44.9	0.66

Table (2) The average of seed rates through the mean of the seven cultivars of the studied traits

Traits Seed rates	Plant height (cm)	Flag leaf area (cm ²)	spike length (cm)	grain per spike	1000 grain weight (g)	spikes per unit (m ²)	grain yield (ton h ⁻¹)
150 kg h ⁻¹	109.40	44.68	10.72	75.34	33.18	382.29	5.42
200 kg h ⁻¹	110.70	42.63	11.45	77.18	30.12	402.32	5.62
250 kg h ⁻¹	112.90	40.20	10.13	72.55	28.39	366.46	5.06
L.S.D 0.05	0.55	0.88	0.34	1.33	1.69	21.1	0.37

It is reported that the two cultivars Tammuz 2 and Abu Ghraib, which did not differ significantly between them, achieved the highest average plant height rate with 113.67 and 113.49 (cm) respectively, while Sally was scored the lowest average plant height with 106,41 (cm). The effect of seed rates on plant height of wheat during the average of the seven cultivars was significant in Table (2), where it was observed that increasing the rate of seed from 150 kg h⁻¹ to 200 and 250 kg h⁻¹ led to a significant increase in the rate of plant height. The third seed rate 250 kg h⁻¹ gave the highest plant height with 112.9 (cm) and surpassed the second and first seed rates 200 and 150 kg h⁻¹. The reason for that could be the increase for seeds led to the shading of the plants and this helps to the production of natural plant hormones, especially auxins and gibberellins, which work together to elongate phalanges and increase the growth of the stem of the plant. While Figure (1) shows the effect of cultivars and seed rates interaction in the response of the cultivars to the increase in plant density, as the Rabiaa and Tammuz showed the highest height with the third seed rate 115.6 and 115.2 (cm), respectively. However, the Rabiaa recorded the lowest plant height at the first seed rate (102.8) cm. These results are consistent with Dawood (1991), Baktash and Baraihi (2006), Baloch et al (2010), and Fazily and Habibi (2019) who observed significant differences between wheat cultivars in plant height at different seed rates.

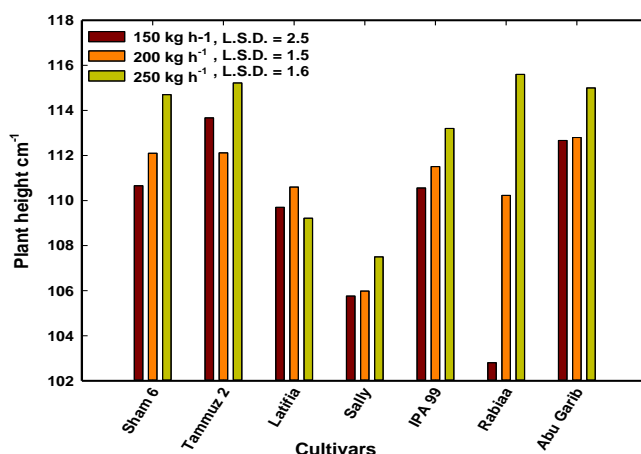


Figure (1) The cultivars and seed rates interaction to plant height

Flag leaf area

The low plant density may increase the leaf area, lengthen the functional leaf phase, and improve its photosynthesis performance, and thus it is suitable for the accumulation of nutrients in grains. There are significant differences between the cultivars in the average flag leaf area during the mean of seed rates, Table (1). The two cultivars IPA 99 and Tammuuz2, who did not differ in a significant way between them, achieved a significant superiority in the area of the flag leaf 44.25 and 43.91 (cm²), respectively over the rest of the wheat cultivars. These results are consistent with the findings of (Baktash and Baraihi (2006), Muhammad (2000) and Fazily and Habibi (2019) who found significant differences among cultivars characteristic in the flag leaf area at different seed rates. From Table (2) it is clear that the seed rates affected significantly the average of the flag leaf area, as it is evident that an increase in the rates of seed led to a significant decrease in the average area of the flag leaf. This can be explained by the intensification of competition over the needs necessary for the growth and development of the cells of the science leaf in terms of food, water, and the intensity of lighting because of the increase in seed rates. Cultivars and seed rates interaction to flag leaf area is shown in Figure (2)

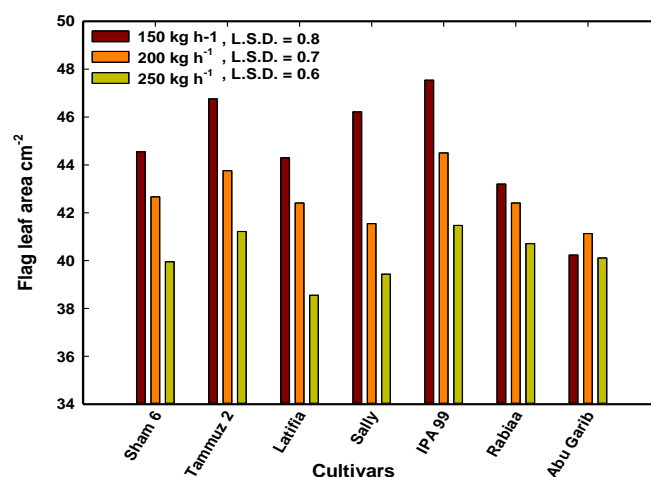


Figure (2) The cultivars and seed rates interaction to flag leaf area

IPA 99 was recorded the highest value in the first seed rate 150 kg h⁻¹ and in the second seed rate 200 kg h⁻¹ with 47 and 43 (cm²), respectively, while Tammuuz2 recorded the highest value third seed rate 250 kg h⁻¹ with 41 (cm²). This result confirms that reducing the amount of suitable seed helps in obtaining a high percentage of leaf area. Although cultivars have recorded a decrease morally for flag leaf area, they had a varied response according to the increase in seed rates. The

higher seeding rates lead to lower rates of photosynthesis from the flag leaf, and that reduced seeding yields, leaf aging and improves the photosynthesis of wheat (Arduini et al., 2006; Ozturk et al., 2006; Ermoshkina et al., 2021). Meanwhile, the photosynthesis of the flag leaf decreased significantly with the increase in seeding rate (Xu et al., 2015).

Spike length

The characteristic of spike length plays a vital role in wheat due to related the number of grains in the spike and finally with the grain yield (Iqbal et al. 2010). Although spike length is hereditary, and the effect of the surrounding conditions is mostly insignificant, significant differences were found in the seed rates and cultivars in this study. Sally scored the highest average value for spike length with 11.56 (cm) and was significantly different from the rest of the cultivars while IPA 99 scored the lowest spike length with 9.94 (cm) according to the mean of three seed rates Table (1). The length of the spike was affected by the increase in seed rates, as the second seed rate gave the highest average with 11.45 (cm), and it significantly exceeded the first and third seed rate Table (2). The decrease in spike length with the increase in seeding rates may be due to the negative role of high competition among plants on nutrient, light, and water. The reduction of spike length also may be due to the effect of increasing the seeding rate on spike growth starting from the booting stage to the heading stage of the spike. Figure (3) shows the effect of the cultivars and seed rates interaction. Rabiaa gave the highest spike length with 12.25 cm at the second seed rate 200 kg h-1 while the lowest value was given to the same cultivar with 9.53 cm at the third seed rate 250 kg h-1. This coincides with the findings of Khan et al. (2001) who stated that the cultivars have different genetic potentials with the seed rates concerning spike length and is inconsistent with Baloch et al. (2010) and Akhtera et al. (2017) who stated that the different seed rates did not show significant differences in the characteristic of spike length. There is variability in the way the cultivars responded to the increase in seed rates, so approximately 85% of the cultivars responded inversely with an increase in the seed rates to the spike length characteristic.

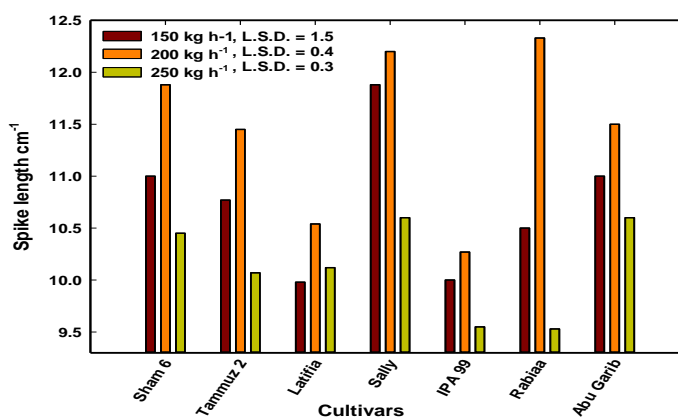


Figure (3) The cultivars and seed rates interaction to spike length

Grain per spike

The effect of seed rate on the wheat yield depends on the genotype of the cultivars and the environment. The potential of wheat yield is determined from several factors; the most important is the number of spike grains, which is an essential and important element in the grain production of wheat. The cultivars showed significant differences for this trait at the average of the three seed rates. The Sham 6 was recorded the highest number of grains per spike, which reached 78.17 grain spike-1, significantly superior to the rest of the cultivars while Rabiaa was scored the lowest average for the trait with 72.10 grain spike-1 Table (1). The second seed rate gave the highest average number of seeds for the seven varieties, which was 77.88 grain spike-1, and was significantly superior to that of the other seed rates, while the third seed quantity gave the lowest rate with 72.55 grain spike-1, and it differed significantly from the average rate of the second seed

rate. The reason may be due to the competition between plants in high seeding rates Table (2). The intensity of competition may cause a decrease in the number of spikelets in the spike. It may cause also an increase in the rates of abortion with florets and a decrease in pollen vitality and pollination rates. While figure (4) shows the effect of the cultivars and seed rates on grain per spike.

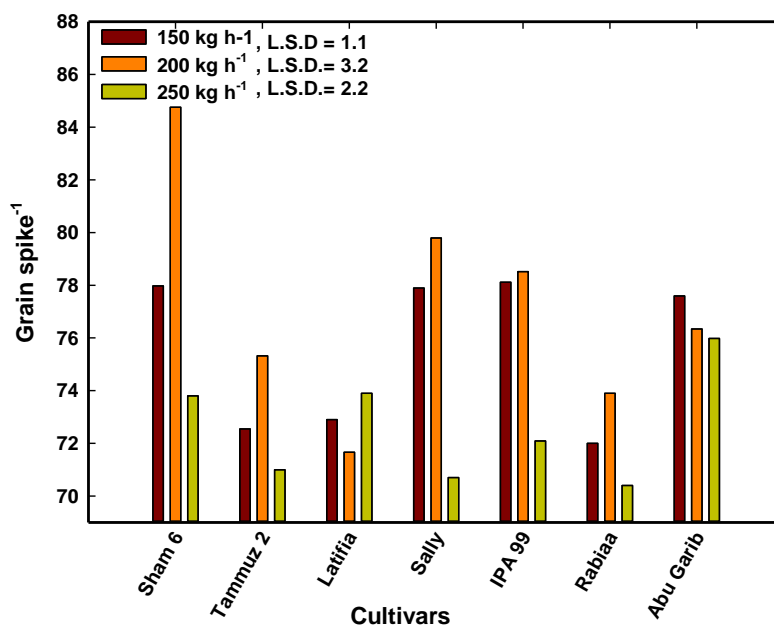


Figure (4) the cultivars and seed rates interaction to grain per spike

The Cultivars IPA 99, Sham 6, and Abu Gharib recorded the highest number of grains per spike at the second, first, and third seed rates with 79.22, 84.12, and 77.66 grain spike⁻¹, respectively. The genetic factor plays a great influence on this trait, as the semi-short cultivars were distinguished by a higher number of grains because of the difference in the percentage of representative and fragmented materials of the spike. The palace genes in modern cultivars affected the increase in the grain per spike due to the improvement in the survival rate of the primates of florets alive and this is consistent with what was found by (Bektash and Naes (2016), Iqbal et al., (2010). The effort variation of the increased seed rate on the number of grain per spike among cultivated cultivars gives us an indication that the abortion of florets has occurred easily for some cultivars due to the different genetic variations of the cultivars. The result of this study agrees with the results of Rahim et al. (2012) who stated that high seed rates produced a reduction in grain per spike. Jemal et al. (2015) indicated that seed rates of 150 kg h⁻¹ gave more grain per spike across cultivars while seed rates of 200 kg h⁻¹ gave fewer grains per spike. Moreover, Gafaar (2007) reported that increasing the seeding density from 200 to 400 grains per square meter resulted in a significant decrease in the grain per spike.

1000 grain weight

Table (1) shows that the cultivars differed significantly in the weight of 1000 grains, as IPA 99 scored the highest weight with 35.20 (g) significantly superior to the rest of the cultivars while Latifia scored the lowest average with 28.01 (g). It is noticed that there is a relationship between the characteristics of leaf area and the weight of 1000 grain because the leaves are the main provider of nutrients in the grains during the period of the fullness of the grain, so IPA 99 has the highest area of a flag leaf compared to Abu Gharib, which has a lower leaf area. Table (2) indicates the existence of significant differences for this characteristic at different seed rates, as the first seed rate gave an average with 33.18 (g) while the rate of the third seed rate gave the lowest rate of 28.39 (g), which was significant for the rate of the second seed. The reason why the weight of 1000 grains decreases

with increasing seed rates is that the higher density resulting from the increase in the total number of vegetative loops causes increased competition among plants. There will be little photosynthesis available for the accumulation of nutrients in the seed and thus the weight of the grains will be reduced. Figure (5) shows the cultivars and seed rates interaction to 1000 grain weight, as Sham 6 recorded the highest average weight of 1000 grains at the first, second, and third seed rates with 38, 35, and 32 (g), respectively. Changes in seed rates are of particular importance in cereal crops, especially wheat, as they have a direct effect on the yield of grains and their components (Lithourgidis et al., 2006; Intsar and Wahid 2017). In this study, the weight of 1000 grains decreased with an increase in the seeding rate in all cultivars, which is consistent with the findings of Baloch et al. (2010) and Laghari et al. (2011).

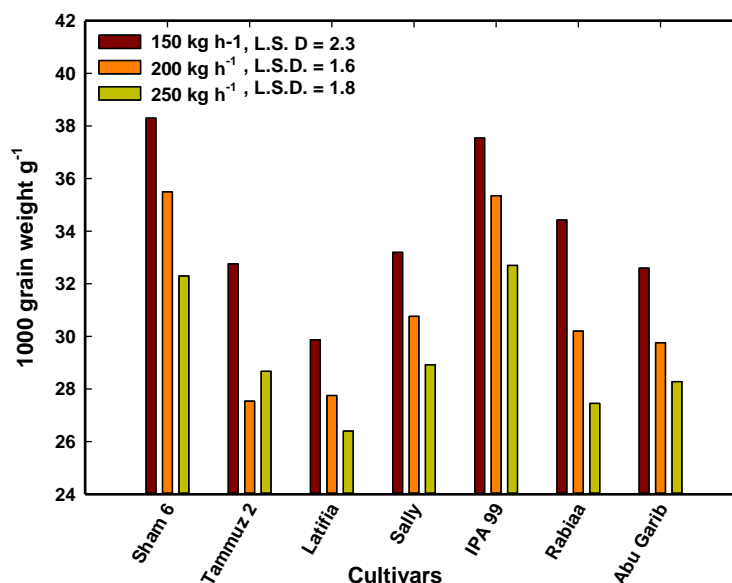


Figure (5) The cultivars and seed rates interaction to 1000 grain weight

Spikes per unit area

Table (1) shows the average of the cultivars during the three seed rates, as it is clear that the IPA 99 achieved the highest average in this characteristic, which amounted to 441.81 spikes (m²) and differed significantly with the rest of the cultivars while Latifia has achieved the lowest average among cultivars with 337.95 spike (m²). The susceptibility of the cultivars to the formation of the tillers and the vegetative branches is due to hereditary reasons and other related to the surrounding conditions, as the cultivars with a high susceptibility to forming tillers are expected to give the highest number of spikes per unit area than those cultivars with low susceptibility. Table (2) shows the average of seed rates during all cultivars, the second seed rate 200 kg h⁻¹ gave the highest average number of spike (m²), followed by an insignificant difference in the first seed rate 150 kg h⁻¹ with 402.32 and 382.29 spike (m²), respectively. While the third seed rate 250 kg h⁻¹ recorded the lowest rate with 366.46 spike (m²). These results are in line with the findings of Mahdi et al. (2002), (Ali (2009), Al-Kubaisi (2010) and Akhtera et al. (2017) who explained that spikes per unit were decreases with increasing seed rate and this trait is controlled by genetic factors specific to the cultivated cultivar. Figure (6) indicates the existence of significant statistical differences to cultivars and seed rate interaction for this characteristic. where the IPA 99 exceeded and gave the highest value at first, second, and third seeds rate respectively, and the superiority was significant over the rest of the cultivars and their combinations. However, Latifia gave the lowest value in the three seed rates. This may be due to the difference in the ability of cultivars to form more fertile tillers than others. This result is consistent with the results of studies for each (Al-Rifai et al., 2007, Abdi et al., 2011; Yadav et al., 2017) who indicated that there are significant differences among the wheat cultivars in the number of spikes per unit area m².

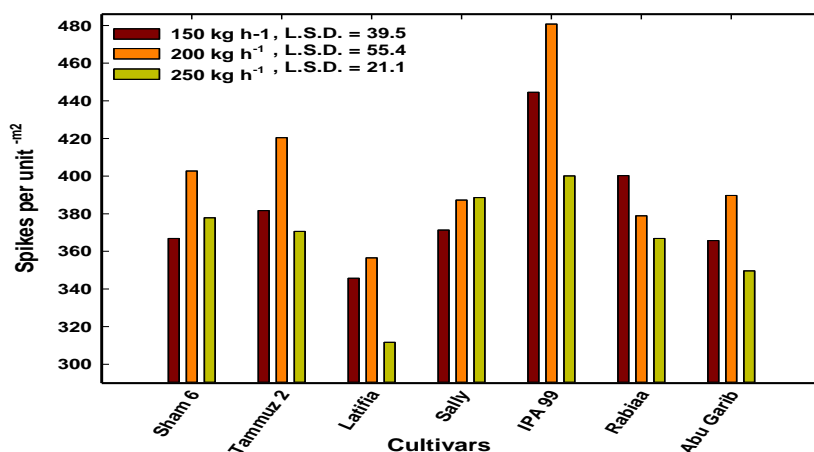


Figure (6) The cultivars and seed rates interaction to spike per unit

Grain yield

The use of low seed rates does not produce a sufficient number of plants in the field and the use of high seeding rates gives a high plant density, which is negatively reflected on the growth and development of the crop (Tanveer et al., 2009). Table (1) showed significant differences among cultivars during a mean of seed rate, as IPA 99 recorded the highest yield 5.90 tons h⁻¹, but it did not differ significantly from Sham 6, which recorded 5.69 tons h⁻¹, but Abu Gharib recorded the lowest grain yield among the cultivars with 4.92 tons h⁻¹. The results of Table (2) indicate that there are significant differences among seed rates, as the second seed rate 200 kg h⁻¹ gave the highest seed yield with 5.62 tons h⁻¹, and it did not differ significantly from the first seed rate, but it significantly differed to the third seed rate 250 kg h⁻¹. The present result is in line with Alemayehu (2015) who reported that the maximum grain yield recorded from seed rate was at seed rate 200 kg h⁻¹. The reason that the second seed rate gave the highest value in grain yield may be due to its record of the highest value in the number of spikes per unit area and the number of grains per spike. The use of high seed rates gives a high plant density, which negatively affects the growth and development of the crop, while the use of low seed rates does not produce the appropriate number of plants in the field and thus the efficiency of light and nutrient utilization decreases (Mahdi et al., 2002; Yadav et al., 2017). Figure (7) shows the cultivars and seed rate interaction.

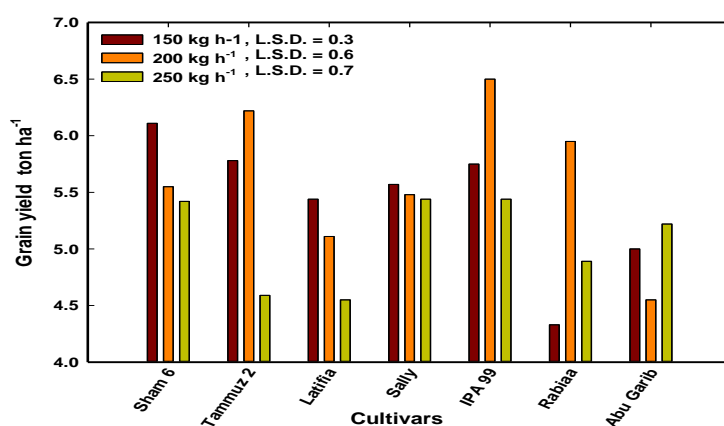


Figure (7) The cultivars and seed rates interaction to grain yield

The combination of IPA 99 and the second seed rate gave the highest yield 6.7 tons h⁻¹ maybe because the same cultivar was having the highest number of spikes per unit area and the weight of 1000 grain. Sham 6 in combination with the first seed rate gave the highest yield of 6.2 tons h⁻¹, and this may be due to the same cultivar was having the highest average in the grain per spike. Sally at the third seed yield recorded the highest seed yield with 5.4 tons h⁻¹. The low seed rate showed higher grain yield, which is an indication that the percentage of aborted wheat florets was relatively low and thus gave higher grain yield than those obtained from a high seeding rate. Chaudhary et al. (2000) and Ali (2009) showed that lower seeding rates resulted in a significant increase in the number of kernels and vice versa.

CONCLUSIONS

Wheat is the main crop produced by farmers and planters in almost all provinces In Iraq. However, its yield and productivity are low due to the use of inappropriate seed rates and low-yielding local cultivars in the study area. Therefore, this experiment was conducted to verify the response of seven cultivars of wheat to different seed rates on some of the characteristics of growth, yield, and components. It is concluded from the results of the study that during the average of the three seed rates, the IPA 99 had been superior in the characteristics of the flag leaf area, 1000 seed weight, spikes per unit area, and the grain yield. The Sham 6 gave the highest values in spike length and grain per spike over the rest cultivars. Besides, during the average of the seven cultivars, the second seed rate exceeded 200 kg h⁻¹ in all traits except the plant height characteristic. The combination of IPA 99 and the second seed rate gave the highest grain yield among the rest of the combinations. Therefore, it can be recommended to use this cultivar with this seed rate for seed cultivation under the conditions of the study location.

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استجابة أصناف القمح لمعدلات البذور باستخدام الخصائص المورفولوجية والمحصولية

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الخلاصة

تعد معدلات البذور عاملاً مهماً يؤثر على الصفات الخضرية، التكاثرية والحاصل للحنطة *Triticum aestivum L* لذلك، تمت دراسة استجابة الأصناف لمعدلات البذور المختلفة لإيجاد توليفة مناسبة فيما بينها. تم إجراء التجربة بثلاثة مكررات باستخدام تصميم القطع المنشقة ضمن تصميم القطاعات العشوائية الكاملة RCBD تم وضع ثلاث معدلات كميات بذار في قطع الألواح الرئيسية (150 ، 200 ، 250 كجم / هكتار) ، وتم وضع سبعة أصناف من القمح في قطع الألواح الثانوية (شام 6 ، تموز 2 ، لطيفة ، سالي ، اباء 99 ، ربيع ، أبو غريب). أشارت النتائج إلى أن اباء 99 خلال متوسط معدلات كميات البذار الثلاث أعطيت أعلى مساحة من ورقة العلم (44.25 سم²)، عدد الحبوب في السنبل (78.85)، وعدد السنابل في وحدة المساحة (441.81) 2م، وحاصل الحبوب (5.9) طن\هكتار. بينما أعطى الصنف شام 6 أعلى طول للسنبل (11.11 سم) ووزن 1000 حبة (35.20 جم). تفوقت كمية البذار الأولى (150 كجم / هكتار) خلال متوسط الأصناف السبعة على معدلات البذور الأخرى لجميع الصفات باستثناء ارتفاع النبات. أعطت التوليفة بين اباء99 وكمية البذار الأولى أعلى محصول حبوب (6.7) طن / هكتار. ومن ثم يقترح زراعة الصنف اباء99 مع كميات البذار الأول (150) كجم / ساعة في هذه المنطقة والمناطق المجاورة لها ذات الطابع البيئي المماثل. ومع ذلك، يمكن إجراء المزيد من الاختبارات في مواقع مختلفة في العراق وبتنوع كبير من معدلات البذور، لتحقيق التركيبة المطلوبة لزراعة القمح وتحقيق إنتاجية عالية مع الأصناف المزروعة.

الكلمات المفتاحية:
القمح ، معدلات البذور ، مورفولوجية النبات