RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
56 (6) 2577-2584, 2024
http://doi.org/10.54910/sabrao2024.56.6.40
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

SEED RATE AND HERBICIDE EFFECTS ON WEEDS POPULATION AND GROWTH AND YIELD-RELATED TRAITS OF WHEAT (*TRITICUM AESTIVUM* L.)

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SUMMARY

The presented study determined the effects of wheat seed rate and herbicide types on weed population and growth and the grain yield of wheat (*Triticum aestivum* L.). The experiment had a randomized complete block design with a split plot arrangement and two factors. The first factor was three seed rates (100, 150, and 200 kg ha^{-1}), and the second was the use of two herbicides (chemical herbicide 'Chevalier' at 300 g ha^{-1}, and biological herbicide 'Trichozon' 2 g m^{-2}), with the control treatment (with no herbicide). The results showed the significant superiority of the highest seed rate (200 kg ha^{-1}) recording minimal weeds and the lowest weed dry weight per square meter. The said seed rate also gave the highest plant height, number of tillers and spikes, and grain and biological yields. In contrast, the seed rate of 100 kg ha^{-1} emerged with the maximum weeds, weed dry weight per square meter and number of kernels per spike. The chemical herbicide Chevalier showed superiority in recording the least weeds and lowest weed dry weight per square meter, the highest plant height, number of tillers and spikes per meter square, and maximum grain and biological yields.

Keywords: Wheat, seed rate, herbicide types, weeds population, growth and yield traits

Key findings: The study revealed the seed rate of 200 kg ha^{-1} and the use of chemical herbicide 'Chevalier' reduced the weeds population and its dry weight in the wheat crop, which eventually enhanced the crop's growth and yield.

Communicating Editor: Dr. A.N. Farhood

Manuscript received: November 08, 2023; Accepted: April 06, 2024.

Citation: Safi HA, Al-Mothefer AA, Alfaris MA, Shanan HA (2024). Seed rate and herbicide effects on weeds population and growth and yield-related traits of wheat (*Triticum aestivum* L.). *SABRAO J. Breed. Genet.* 56(6): 2577-2584. http://doi.org/10.54910/sabrao2024.56.6.40.

INTRODUCTION

In bread wheat (*Triticum aestivum* L.), weeds are one of the most important agricultural pests and determining factor in wheat growth and productivity and cause large yield losses than other pests. Adopting the principle of competition between the crop and its accompanying weeds by increasing the plant's density via increased seed rate is one of the scientific methods to influence the weed population. An efficient technique to raise production per unit area is to raise the number of plants per unit area, their leafy area, and their shade for weed plants. It will increase the number of crop plants over the weed plants that accompany it and minimize their harm. Raising the bread wheat's seed rate from 100 to 200 kg ha^{-1} significantly reduced the total dry weight of weeds (Shehzad *et al*., 2012). Beres *et al.'s* (2009) findings also enunciated the dry weight of total weeds decreased with an increased seed rate (from 300 to 450 seeds m^{-2}) in wheat.

The higher seed rate (120, 180, and 240 kg ha^{-1}) showed the highest weeds control percentage, and the weeds dry weight decreased by 98.10% using the seed rate of 180 kg ha^{-1} in barley (Ahmed and Saleh, 2013). Antar *et al.'s* (2013) findings showed the number and weight of thin-leaved weeds in the characteristics of weeds associated with the bread wheat crop, decreased with an increase in seed rate (from 80 to 120 kg ha^{-1}) by 45.36% and 2.57 g m^{-2}, respectively. Meanwhile, the broadleaf weeds weight decreased by 9.31 g m^{-2}, which eventually boosted the grain yield. This may be due to the increase in crop plants' density, positively affecting the competition of the accompanying weeds. Goss and Wheeler (2015) reported that increased seed rate (from 100 to 300 kg ha^{-1}) for pasta wheat reduced the number of heads of perennial rye per square meter and enhanced the grain yield.

In wheat (*Triticum aestivum* L.), the enhanced seed rate of 200 kg ha^{-1} showed the lowest average dry weight of the broad and narrow-leaf weeds compared with the 100 kg ha^{-1} seed rate. It owned the tallest plant height and highest number of tillers and spikes per square meter, with supreme grain and biological yields (Salman, 2016). Safi's (2019) findings revealed an increased seed quantity (180 kg ha^{-1}) showed a less density and dry weight of the weeds after 60 and 90 days of sowing. Similarly, it gave the highest plant height, number of tillers and spikes per square meter, 1000-seed weight, and grain and biological yields in both seasons.

Mechanical weed control by available plows is one of the widespread methods of controlling weed, with many advantages, including non-pollution of the environment with herbicide residues. The excessive use of these chemicals greatly affects various aspects of the environment, despite the advantages of the mechanical method in determining the growth of weeds and reducing their competition with crops. However, the herbicides remain the best in this case, as the use of herbicides to control wheat weeds in large areas worldwide has led to an enhanced productivity, sometimes reaching more than 50% (Scursoni *et al.,* 2011). The higher efficiency of the herbicide Chevalier in controlling the broad and thin-leaved weeds correlated with the bread wheat crop compared with the weedy treatment, and the results showing Chevalier's high efficiency in raising wheat yield components (Abadi *et al*., 2009).

The Chevalier herbicide treatment showed the optimum efficiency in controlling the thin and broad-leaved weeds present with the wheat crop, elevating yield components and grain yield (Owen *et al.*, 2023). The study conducted by Khaliq *et al.* (2013) indicated the superiority of the Chevalier herbicide treatment, with a 100% reduction of weeds and inhibiting its dry weight by 91%, 98%, 88%, and 97% after 60 and 90 days of sowing. It could because the superiority of the Chevalier herbicide treatment with a concentration of 100% alone can kill the narrow and broad-leaved bushes, as an effect on photosynthesis. It hindered the formation of amino acids, such as leucine, isoleucine, and valine, resulting in the most number of tillers per square meter and the highest grain yield. The Chevalier herbicide reduced the broad and thin-leaved weeds found with the bread wheat crop compared with the weedy treatment,

which gave the highest broad and thin-leaved weeds dry weight (Safi, 2016).

The results of Safi's (2019) study detailed the use of chemical control with Chevalier herbicide plus traditional plowing with the moldboard plow, raised the efficiency of weed control. The treatment reduced the weed's number and dry weight compared to tillage with the moldboard plow after 60 and 90 days of cultivation. It resulted with the highest number of kernels per spike for the first season and a recognized maximum number of tillers and spikes per square meter and grain yield for the second season. The presented study sought to determine the effects of wheat seed rates and the herbicide types on the weeds population and growth and the grain yield of wheat (*Triticum aestivum* L.).

MATERIALS AND METHODS

The latest wheat field experiment commenced during the winter of 2023 at the Al-Thaghr area, North of Basrah Governorate, Iraq (latitude 31.145288 N and longitude 47.431334 E). The experiment comprised a randomized complete block design with split plot arrangement and two factors. The first factor included three seed rates (100, 150, and 200 kg ha^{-1}), with the second factor was two herbicides (chemical herbicide 'Chevalier' 300 g ha^{-1}, and biological herbicide 'Trichozon' 2 g m^{-2}) and a control treatment (with no herbicide). The seed rates occupied the main plots, while the herbicide types occupied the subplots. After preparing the soil, the planting of the wheat cultivar Abu-Ghraib followed. When the wheat plants reached the tillering stage, herbicide spraying ensued with the dissolved Chevalier (300 g ha^{-1} with 300–400 liters of water) and Trichozon 2 g m^{-2} (dissolved with one liter of water), using the four liters hand sprayer after 75 days of planting (Safi*,* 2019).

Data recorded and statistical analysis

The collected samples came from the weeds found in the wheat crop, with one sample for each experimental unit, and after four weeks of the herbicide application (Ahmed, 2005). It will also diagnose the types of weeds found in the wheat crop (Suwad, Silybum marianum, Raphanus raphanistrum, Lambs quarter, Sweet clover, and Mallow), as well as, the number of weeds and dry weight of weeds per square meter after drying them in an electric oven at 65 °C for 72 h (Al-Chalabi, 1988).

In the wheat crop, calculating the plant height used an average of 10 plants randomly selected from each experimental unit upon completion of the spikes, with the height measured from the base of the plant to the base of the spike (Khan and Splide, 1992). The measurement of the number of tillers and spikes per square meter, and grain and biological yields continued for a group of plants harvested from the mowing square area (50 cm × 50 cm) and randomly selected in each experimental unit's central lines (Mengnan *et al.,* 2016). The number of kernels per spike calculation was an average of 30 spikes randomly selected from the area of the mowing square (50 cm × 50 cm) and averaged in each experimental unit (Mengnan *et al.,* 2016).

RESULTS AND DISCUSSION

Weeds per square meter

The results showed seed rates had a significant effect on the weed population, and the seed rate of 200 kg ha^{-1} provided the lowest number of weeds (8 plants m^{-2}) (Table 1). The seed rate of 100 kg ha^{-1} appeared with the highest number of weeds (48.7 plants m^{-2}). This may be due to the increasing wheat plants population per unit area causing a considerable reduction in the growth of weeds, enhancing their leafy area and shading the wheat for weed plants. Similarly, an increased wheat plant over the accompanying weed plants reduced their damage to a minimum. These results were consistent with past findings in wheat crop (Antar *et al.,* 2013; Goss and Wheeler, 2015; Safi*,* 2019).

The findings further revealed herbicide types significantly affected the number of weeds per square meter. The chemical herbicide Chevalier achieved the lowest number of weeds per square meter (15 plants

Table 1. Effect of seed rates and herbicide types on the number of weeds per square meter.

Herbicides	Seed rates (kg ha^{-1})			Means (plants m^{-2})
	100	150	200	
Chevalier	28.0	16.0	1.0	15.0
Trichozon	52.0	29.0	10.0	30.3
No herbicide	66.0	37.0	13.0	38.7
Means (plants m^{-2})	48.7	27.3	8.0	
$LSD_{0.05}$ Herbicides = 7.77, Seed rates = 9.59, Seed rates x Herbicide types = N.S.				

Table 2. Effect of seed rates and herbicide types on the weeds' dry weight in square meter.

Herbicides	Seed rates (kg ha^{-1})			Means (g m^{-2})
	100	150	200	
Chevalier	1.980	0.240	0.020	0.747
Trichozon	3.845.	0.435	0.150	1.477
No herbicide	4.860	0.550	0.195	1.868
Means (g m^{-2})	3.562	0.408	0.122	
$LSD_{0.05}$ Herbicides = 0.2007, Seed rates = 0.7155, Seed rates x Herbicide types = 0.5577				

m^{-2}), while the control treatment (no herbicide application) emerged with the highest number of weeds per square meter (38.7 plants m^{-2}). The reason for the Chevalier treatment's superiority could be due to its being a systemic herbicide, killing narrow and broad-leaved weeds. As a result, it influenced photosynthesis by hindering the formation of amino acids, such as leucine, isoleucine, and valine, and these results were analogous to past findings in wheat genotypes sprayed with different herbicides (Abadi *et al.,* 2009; Khaliq *et al.,* 2013; Owen *et al.,* 2023). The interaction effects between the seed rates and the herbicide types revealed nonsignificant differences for the number of weeds per square meter.

Weeds dry weight

For weeds dry weight, the results signified the seed rates, herbicide types, and their interaction had a marked effect on the said trait (Table 2). The seed rate of 200 kg ha^{-1} gave the lowest weeds dry weight per square meter, amounting to 0.122 g m^{-2}, which did not differ significantly from the seed rate of 150 kg ha^{-1}. However, the seed rate of 100 kg ha^{-1} resulted with the highest dry weight of weeds per square meter (3.562 g m^{-2}). This may be because the seed rate of 200 kg ha^{-1} recorded the lowest number of weeds per square meter, while the 100 kg ha^{-1} seed rate occurred with the most number of weeds per square meter. These results aligned with past findings in wheat genotypes grown with different seed rates (Ismail, 2002; Beres *et al.,* 2009; Ahmed and Saleh, 2013).

The chemical herbicide Chevalier also achieved a remarkable superiority in reducing the dry weight of weeds by recording the minimum weed weight (0.747 g m^{-2}), with the control treatment obtaining the maximum dry weight of weeds (1.868 g m^{-2}). These findings agreed with previous findings in wheat genotypes sprayed with different herbicides for the weed management (Abadi *et al.,* 2009; Khaliq *et al.,* 2013; Owen *et al.,* 2023). Moreover, the interaction of seed rate (200 kg ha^{-1}) and the herbicide Chevalier achieved the lowest dry weight of weeds (0.020 g m^{-2}). Meanwhile, the interaction of the seed rate (100 kg ha^{-1}) with the said herbicide and the control treatment achieved the utmost dry weight of weeds amounting to 4.860 g m^{-2}.

Plant height

The outcomes exhibited the seed rates and herbicide types notably influencing the wheat's plant height (Table 3). The seed rate (200 kg ha^{-1}) supplied the highest plant height (81.67 cm). However, it did not significantly differ from the seed rate of 150 kg ha^{-1}. The seed

Table 3. Effect of seed rates and herbicide types on the plant height.

Herbicides	Seed rates (kg ha^{-1})			Means (cm)
	100	150	200	
Chevalier	80.67	83.33	83.00	82.33
Trichozon	77.67	79.67	81.67	79.67
No herbicide	76.67	77.00	80.33	78
Means (cm)	78.33	80.00	81.67	
$LSD_{0.05}$ Herbicides = 1.492, Seed rates = 1.573, Seed rates x Herbicide types = N.S.				

Table 4. Effect of seed rates and herbicide types on the number of tillers per square meter.

Herbicides	Seed rates (kg ha^{-1})			Means (tillers m^{-2})
	100	150	200	
Chevalier	317.67	341.00	385.00	347.89
Trichozon	315.67	334.33	372.00	340.67
No herbicide	297.33	325.67	355.33	326.11
Means (tillers m^{-2})	310.22	333.67	370.78	
$LSD_{0.05}$ Herbicides = 3.278, Seed rates = 4.184, Seed rates x Herbicide types = 5.544				

rate of 100 kg ha^{-1} appeared with the lowest plant height (78.33 cm). This may be due to the increasing seed rate causing a considerable reduction in weed growth by increasing the number of crop plants per unit area. This then encouraged plants to elongate to obtain the light required for the growth. These results were consistent with past findings in wheat grown with different seed rates (Salman, 2016; Safi*,* 2019). Likewise, herbicide types had a significant effect on the plant height. The herbicide Chevalier displayed the tallest plant height (82.33 cm), while the control treatment gave the lowest plant height (78 cm). It may be because the Chevalier herbicide achieved the lowest number and dry weight of weeds per square meter, helping the wheat plants to grow better, and these results agreed with previous findings in wheat sprayed with different herbicides (Safi, 2016, 2019). The interaction between the seed rates and the herbicide types had no significant effect on the plant stature.

Tillers per square meter

The results enunciated the seed rates, herbicide types, and their interaction had a meaningful bearing on the number of tillers (Table 4). The seed rate 200 kg ha^{-1}, the herbicide Chevalier, and their interaction provided the highest number of tillers per square meter (370.78, 347.89, and 385.00 tiller m^{-2}, respectively). The seed rate of 100 kg ha^{-1}, the control treatment, and their interaction emerged with the lowest number of tillers per square meter (310.22, 326.11, and 297.33 tiller m^{-2}, respectively). This may be due to an increased seed rate and the use of Chevalier herbicide causing a considerable reduction in the weeds' growth. These results supported past findings in wheat with the application of different herbicide types (Khaliq *et al.,* 2013; Salman, 2016; Safi*,* 2019).

Spikes per square meter

The findings revealed the seed rates significantly affected the spikes per square meter (Table 5). The seed rate of 150 kg ha^{-1} obtained the supreme number of spikes per square meter (344.4 spike m^{-2}), while the seed rate of 100 kg ha^{-1} reached the lowest number of spikes per square meter (264.9 spike m^{-2}). The herbicide types also substantially influenced the said trait, and on average, the herbicide Chevalier gave the ultimate number of spikes per square meter (309.7 spike m^{-2}), but did not differ significantly from the biological herbicide Trichozon. The control treatment appeared with the lowest number of spikes per square meter (297.7 spike m^{-2}). The

reason for the superiority of the moderate seed rate and the herbicide Chevalier with the highest number of spikes per square meter could be their achievement on the highest number of tillers per square meter. These results were consistent with past findings in wheat genotypes grown with different seed rates and herbicide types (Khaliq *et al.,* 2013; Salman, 2016; Safi*,* 2019).

Grains per spike

The outcomes showed the seed rates had a notable effect on the grains per spike, which is an important yield component in wheat (Table 6). The seed rate of 100 kg ha^{-1} was visible with the highest number of grains per spike (41.22 grains $spike^{-1}$). Meanwhile, the seed rate of 150 kg ha^{-1} was evident with the lowest number of grains per spike (38 grains $spike^{-1}$). The herbicide types also had a remarkable effect on the grains per spike, where the control treatment recognized with the utmost number of grains per spike (40.22 grains $spike^{-1}$). Although, it did not differ significantly from the biological herbicide Trichozon. However, the herbicide Chevalier was distinct with the lowest number of grains per spike (38.89 grains $spike^{-1}$).

The interaction of seed rate (100 kg ha^{-1}) and the control treatment appeared with the highest number of grains per spike, which may be due to the combination achieving the lowest number of spikes per square meter. It may also be because of the phenomenon of compensation in the yield components of small grains, and therefore, the decrease in the number of spikes per square meter led to an increase in the number of grains per spike (Salman, 2016; Safi*,* 2019).

Biological yield

The results exhibited the seed rates, herbicide types, and their interaction had a significant effect on the biological yield in wheat crop (Table 7). The seed rate of 150 kg ha^{-1}, the herbicide Chevalier, and their interaction provided the highest biological yield (10,340.00, 10,301.00 and 10,718 kg ha^{-1}, respectively). The seed rate of 100 kg ha^{-1}, the control treatment, and their interaction recorded with the lowest biological yield (9,985.00, 10,023.00, and 9,866 kg ha^{-1}, respectively). The results further revealed that the higher seed rate and the herbicide Chevalier were superior in biological yield. This may be due to the combination attaining the least number of weeds per square meter. This led to a decrease in competition between the weeds and wheat plants. It provided an opportunity for the wheat plants to obtain the largest amount of necessary growth elements with improvement in the process of photosynthesis and eventually the grain yield (Salman, 2016; Safi*,* 2019).

Table 5. Effect of seed rates and herbicide types on the number of spikes per square meter.

Herbicides	Seed rates (kg ha^{-1})			Means (spikes m^{-2})
	100	150	200	
Chevalier	266.3	351.7	311.00	309.7
Trichozon	266.00	344.3	301.00	303.8
No herbicide	262.3	337.00	293.3	297.7
Means (spikes m^{-2})	264.9	344.4	301.8	
$LSD_{0.05}$ Herbicides = 6.65, Seed rates = 7.05, Seed rates x Herbicide types = N.S.				

Table 6. Effect of seed rates and herbicide types on the number of grains per spike.

Herbicides	Seed rates (kg ha^{-1})			Means (grains $spike^{-1}$)
	100	150	200	
Chevalier	41.00	36.67	39.00	38.89
Trichozon	41.00	38.67	39.00	39.56
No herbicide	41.67	38.67	40.33	40.22
Means (grains $spike^{-1}$)	41.22	38.00	39.44	
$LSD_{0.05}$ Herbicides = 0.699, Seed rates = 0.816, Seed rates x Herbicide types = N.S.				

Table 7. Effect of seed rates and herbicide types on the biological yield.

Herbicides	Seed rates (kg ha^{-1})			Means (kg ha^{-1})
	100	150	200	
Chevalier	9920	10718	10267	10301
Trichozon	9980	10435	10103	10173
No herbicide	10055	9866	10149	10023
Means (kg ha^{-1})	9985	10340	10173	
$LSD_{0.05}$ Herbicides = 98.9, Seed rates = 71.7, Seed rates x Herbicide types = 147.4				

Table 8. Effect of seed rates and herbicide types on the grain yield (kg ha^{-1})**.**

Herbicides	Seed rates (kg ha^{-1})			Means (kg ha^{-1})
	100	150	200	
Chevalier	3201	4651	4702	4185
Trichozon	3426	4550	4491	4156
No herbicide	3259	4357	4160	3925
Means (kg ha^{-1})	3296	4519	4451	
$LSD_{0.05}$ Herbicides = N.S., Seed rates = 211.6, Seed rates x Herbicide types = N.S.				

Grain yield

The outcomes demonstrated seed rates remarkably affected grain yield, which is the final product of the wheat crop (Table 8). The seed rate of 150 kg ha^{-1} supplied with the maximum grain yield (4,519 kg ha^{-1}). However, the said yield did not differ significantly from the grain yield obtained through the seed rate of 200 kg ha^{-1}. The seed rate of 100 kg ha^{-1} occurred with the minimum grain yield (3,296 kg ha^{-1}). The herbicide types and the interaction of seed rates and herbicide types had nonsignificant influences on the wheat grain yield. The results further authenticated that the higher seed rates manifested the superior grain yield. This is attributable to the combinations attaining the least number of weeds, which led to a decline in the competition between the weeds and wheat plants. Thus, it provided an opportunity for wheat plants to obtain the largest amount of necessary growth elements with a boost in the process of photosynthesis and an improvement in the growth and yield-related characteristics of wheat (Goss and Wheeler, 2015; Salman, 2016; Safi*,* 2019; Ahmad *et al*., 2023; Khan *et al*., 2023).

CONCLUSIONS

The seed rate of 200 kg ha^{-1} and the chemical herbicide Chevalier showed a considerable reduction in the number of growing weeds and their dry weight in wheat crops, improving the growth and yield characteristics of the plant. Therefore, the study recommends the abovementioned seed rate and herbicide for the farming community in growing the wheat crop.

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