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Effect of tillage systems and boron spraying on some physical properties of the soil and growth and yield of wheat crop (*Triticum aestivum* L.)

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Abstract

A field experiment was carried out during the agricultural season (2021-2022) in Al-Samawah district in the Um Al-Akf region, which is (5 km from the center of Al-Muthanna Governorate). The aim of the study was to investigate the effect of tillage systems and boron spraying on some physical properties of the soil and growth and yield of wheat crop .The experiment was carried out according to the Split Block Design method, using the randomized complete block design (R.C.B.D), and with three replications. The experiment contained (36) experimental units, each area of which was 4.0 m^2.Each experimental unit contained (10) lines, the Distance between one line and another was (20) cm. The experiment included two factors, the first was the tillage systems (no tillage ; reduce tillage at a depth of (10 cm) and conventional tillage at a depth of (20 cm) which occupied the vertical distribution. The second factor was the spraying of boron (0, 50, 100 and 150) mg B L^{-1}, which occupied the horizontal distribution. Boron was sprayed at the stage of 75% flowering, and on 18/11/2021 wheat cultivar (Ibaa 99) was planted. The results of the study indicated that the conventional tillage system was significantly superior in reducing the value of bulk density, as it gave the lowest average of 1.41 mg m^{-3}, and was also superior in increasing porosity by giving it the highest average of 46.64 %. While the no-till system was significantly superior in the characteristics of plant height, number of tillers, number of grains per spike, and grain yield, as it gave the highest averages (79.66 cm, 279.1 tillers m^{-2}, 55.95 grains $spike^{-1}$, and 3.540 ton h^{-1}) respectively. While the Reduce tillage system was significantly superior. in the characteristic of harvest index by giving it the highest average amounted to 43.57%. As for the effect of boron, it was significant in most of the characteristics of the yield and its components, as the concentration of 150 mg B L-^{1} was significantly superior in the characteristic of the number of grains per spike 60.66 grains spike^{-1}, the weight of 1000 grain 36.30 g, and the yield 3.498 ton h^{-1}, the treatment of overlapping (Reduce tillage x 100 mg B L^{-1}) recorded the highest average weight of 1000 grains was 38.03g

Key words: Bulk Density, Harvest Index, Wheat Crop, No Tillage, Boron Spraying

Introduction

Wheat (*Triticum aestivum* L.) is one of the grain crops belonging to the Poaceae family, which represents a basic source of human nutrition as it plays an important economic role in food security because it provides more than 25% of calories and also because it contains carbohydrates, vitamins, proteins and some mineral salts (FAO 2008). The wheat crop ranks first in Iraq in terms of area and production, as wheat production reached (4234) thousand ton for the cultivated area (9464) thousand dunams, and the average yield per dunam was estimated at (447.3) kg per dunam for the agricultural season 2021 (Directorate Agricultural Statistics 2021).

The problem of continuous degradation of agricultural lands and the increasing scarcity of water resources are among the main factors threatening the stability of agricultural production. Therefore, the current situation requires the adoption of an agricultural system that is less depleting of renewable natural resources.

Tillage is one of the most important basic crop service operations, which works to break down and break the surface layer of the soil and it represents one of the important means used in preparing a suitable bed for the seed due to its role in improving soil characteristics (Al-Banna 1990). The presence of different types of agricultural machines due to the different agricultural soils, crops and climatic conditions, the non-optimal use of these machines in the soil preparation operations was the reason for the compaction of the soil, the destruction of its agglomerations, its poor aeration, and the deterioration of its structural character (Smith and Lambert 1990). The Conventional tillage system is still used due to the lack of sufficient information on conservation agriculture or a no-till system or the Reduce works to reduce soil erosion and moisture loss, especially in areas with desert soils and reduces energy requirements, and the yield increases despite the lack of rain, (Neugschwandfer et al 2015). Martinez et al. (2008) showed that the use of an appropriate non- conventional tillage system reduces surface runoff and increases water_logging rates, which causes soil moisture retention. Many scientific references have shown that a no-till system or the Reduce limits thereof has the ability to hold water in the soil greater than in conventional tillage and reduces the energy consumption needed to prepare the soil in the case of conventional tillage such as primary and secondary tillage, smoothing and grading.

The boron element is essential, despite the small amount needed by the crop, but it plays important roles in its life. Boron has an important role in the development of pollen, flowering, seed formation, and increased fertilization. It also has an important role in transforming and transporting sugars from leaves through cellular membranes. And in the formation of the plant cell wall and also has a role in the manufacture of nucleic acids, which are the basis for DNA and RNA, It has a relationship in the manufacture of auxins and the activation of enzymatic reactions (Abu Nuqtah and Al-Shater 2011).

Based on the foregoing, this study aims to determine the best tillage system and the best concentration of boron, through which it is possible to improve some physical properties of soil, yield and its components.

Material and methods

A field experiment was carried out in the Samawah district in the Um Al-Akf region, which is 5 km from the center of Al-Muthanna Governorate, during the agricultural season (2021-2022), in a silty clay loam soil whose chemical and physical characteristics are shown in (Table 1). The aim of studying the Effect of tillage systems and boron spraying on some physical properties of the soil and growth and yield of wheat crop. The experiment was carried out according the Split Block Design method, using the random complete block design (R.C.B.D), with three replications. The tillage systems (Zero tillage and Reduce tillage at a depth of (10 cm) and Conventional tillage at a depth of (20 cm), coded (T_0, T_1, T_2) were sequentially applied to the vertical distribution, while the boron spray concentrations were (0, 50, 100, 150) mg B L^{-1}, coded (B_0, B_1, B_2, B_3) in sequence, horizontal distribution, boron was sprayed at the stage of 75% flowering, and the spraying process took place after sunset, using a knapsack sprayer (tank capacity was 20 L), use boric acid (17% B) as a boron source. The soil of the field was prepared by conducting the tillage process for each treatment according to the required depths, As it was used for the Conventional tillage treatment (T_2), the Mould board plow was used as a primary plowing at a depth of (20) cm, then the smoothing was done with the hard hoe. As for the Reduce tillage treatment (T_1), the chisel plow was used at a depth of (10 cm), while the third treatment was left no-tillage (T_0), The field was divided into (36) experimental units, the area of the experimental unit was (2×2) m^2, and one experimental unit contained 10 lines, the distance between one line and another was 20 cm, and the distance between one experimental unit and another was (1 m). The seeds of wheat, lbaa99, were sown on 18/ 11/2021, with a seeding rate of 120 kg $h^{-1.}$ The field was fertilized by adding phosphorus in the form of triple superphosphate (46% P) at a rate of 80 kg h^{-1} before planting, while potassium was added in the form of potassium sulfate (42% K) at a rate of 80 kg h^{-1} before planting, while nitrogen was added In the form of urea (46% N) at a rate of 200 kg h^{-1} by three batches in the emergence stage, the stage of overgrowth, and the stage of blanketing (Al-Abedi 2011). The experiment was harvested on the date of 20/4/2022 when reaching the stage of full maturity.

Table (1) Some chemical and physical properties of the soil before tillage

Property	the value	Unit
sand	20	%
Silt	52	%
Clay	28	%
soil texture	Silty Clay Loam	

ph		**7.46**	
EC		**6.04**	Desi Siemens m^{-1}
Bulk Density		**1.48**	Mg m^{-3}
Porosity		**41.7**	%
organic matter		**1.16**	**%**
ready elements	nitrogen	59	ppm
	phosphorous	**10.0**	
	potassium	**143**	
	Boron	**0.58**	

Studied parameters;

1- Bulk Density (mg m^{-3}): They were estimated using the paraffin wax method

2- porosity (%) : It was calculated according to the formula

Porosity = [1 - (bulk density/particle density)] x 100%

3-Plant height (cm): It was calculated from the base of the plant in contact with the soil surface to the apex of the spike without the apex.

4-The number of tillers (m^2): It was calculated after harvesting the two middle lines with an area of (0.8 m^2) and then converted to a square meter.

5-The number of grains per spike (grain $spike^{-1}$) : It was calculated after harvesting, as ten spikes were randomly selected from the two middle lines of each experimental unit, then they were forked and calculated manually.

6-Weight of 1000 grains (g): It was calculated from counting a thousand grains randomly selected from the grain yield for each experimental unit, then weighed with a sensitive scale.

7-Grain yield (ton ha^{-1}): It was calculated after conducting a manual threshing process for the two middle lines of each experimental unit, Separating the straw from the grain, weighing the grain and then converting it into ton ha^{-1}.

8- Harvest Index (%):It was calculated from the following equation**:**

Harvest Index = grain yield / biological yield x 100%

(1962 Donald)

Statistical Analysis

The data were analyzed according to the analysis of variance method using the Genstat.12.1 program, and the averages of the coefficients were tested according to the Least Significant Difference (L.S.D) test, under probability level of 5%.

Results and discussion

1- Bulk Density (mg m^{-3})

The results of Table (2) showed that the Conventional tillage system was significantly superior by giving it the lowest value for bulk density of 1.41 mg m^{-3}, while the no-till system recorded the highest value of 1.56 mg m^{-3}. The reason for the decrease in the bulk density when conventional tillage is attributed to the conversion of the cohesive soil body into blocks of different sizes, so the porous spaces increase, which causes an increase in volume compared to the soil mass and thus a decrease in the bulk density. This result agreed with the findings of Ramadhan (2021).

Table (2) Effect of tillage systems and boron spraying and the interaction between them on Bulk Density (mg m^{-3}).

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	1.41	1.48	1.52	1.47
50	1.42	1.47	1.58	1.49
100	1.40	1.49	1.56	1.48
150	1.41	1.48	1.58	1.49
Average tillage systems	1.41	1.48	1.56	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	0.06	NS	NS	

2- porosity (%)

Table (2) showed that the Conventional tillage system was significantly superior in the porosity characteristic by giving it the highest average of 46.64 %, while the no-till system gave the lowest average porosity of 41.01%, The reason for the increase in porosity at conventional tillage is due to the decrease in its bulk density as a result of the increase in the volume of the stirred soil, which leads to an increase in the size of the soil pores.

Table 3. Effect of tillage systems and boron spraying and the interaction between them on porosity (%).

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	46.80	44.16	42.65	44.53

50	46.17	44.41	40.13	43.57
100	47.05	43.54	41.14	43.91
150	46.55	44.16	40.13	43.61
Average tillage systems	46.64	44.06	41.01	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	2.53	NS	NS	

3- Plant height (cm)

The results of Table (4) showed a significant superiority of the no-till system, as it recorded the highest average of 79.66 cm, while the plant height decreased under the Reduce tillage system, as it recorded the lowest average of 77.48 cm. The reason for this may be attributed to the role of the no-till system in providing the necessary moisture for the plant, which It was reflected in its growth. This agreed with (Ziydan et al. 2021) who noticed an increase in the height of the wheat crop under a no-till system.

Table 4. Effect of tillage systems and boron spraying and the interaction between them on plant height (cm).

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	78.60	77.17	79.67	78.48
50	78.13	77.33	80.02	78.49
100	78.47	77.27	79.97	78.57
150	77.07	78.13	79.00	78.07
Average tillage systems	78.07	77.48	79.66	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	1.44	NS	NS	

4- Number of tillers (m^2)

It is noted in the results of Table (5) that the no-till system excelled by giving it the highest average of number of tillers (279.1

tiller m^2), while the Conventional tillage system gave the lowest average number of tillers of 239.9 tiller m^2, and the reason for this may be attributed to the fact that the no-till system improved plant growth by increasing the efficiency of The use of irrigation water and thus providing the appropriate conditions to increase growth and tillers, this result agreed with (Khan et al. 2017).

Table 5. Effect of tillage systems and boron spraying and the interaction between them on number of tillers (m^2).

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	**222.5**	**262.1**	**277.9**	**254.2**
50	**270.0**	**261.7**	**280.4**	**270.7**
100	**222.1**	**255.4**	**272.1**	**249.9**
150	**245.0**	**261.7**	**285.8**	**264.2**
Average tillage systems	**239.9**	**260.2**	**279.1**	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	26.43	NS	NS	

5- Number of grains per spike (grains spike^{-1})

Table (6) showed a significant superiority of the no-till system by giving it the highest average of 55.95 grains spike^{-1}, while the Conventional tillage system gave the lowest average number of grains per spike of 53.10 grains spike^{-1}, the reason may be attributed to the role of the no-till system in increasing the moisture content of the soil, as well as the efficiency of this system in increasing the area of the flag leaf, which is reflected in the increase in the process of photosynthesis that contributes to the formation of grains and the increase in their numbers in the spike. This result agreed with (Nadeem et al. 2019).

Also, the results of table (6) showed that the concentration of 150 mg B L^{-1} was significantly superior by giving it the highest average of 60.66 grains spike^{-1}, while the comparison treatment gave the lowest average of 46.34 grains spike^{-1}. The reason for the increase in the number of grains per spike may be due to the increase in the concentration of the Boron indicates the role of this element in the growth of the pollen tube and germination of pollen grains, as well as the role of boron in accelerating the transfer of photosynthetic products from the source to the downstream, which led to an increase in the number of grains per spike. This result agreed with (Hassan and Khrbeet, 2014).

-1).

Table 6. Effect of tillage systems and boron spraying and the interaction between them on -number of grains per spike (grains spike

Boron (mg B L^{-1})	tillage systems			Average Boron
	Conventional tillage	Reduce tillage	No- tillage	
0	44.47	46.10	48.47	46.34
50	52.67	51.07	54.37	52.70
100	54.97	58.90	59.37	57.74
150	60.30	60.07	61.60	60.66
Average tillage systems	53.10	54.03	55.95	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	1.96	1.61	NS	

6-Weight of 1000 Grains (g)

Table (7) showed that the concentration of 150 mg B L^{-1} was superior, giving it the highest mean of 36.30 g. While the comparison treatment recorded the lowest average of 34.11 g. The reason for the increase in the weight of a thousand grains may be due to the increase in the concentration of the boron element, due to the important role of boron in accelerating the transfer of the products of photosynthesis from their places of manufacture, especially the flag paper (source) to the grain (downstream), leading to this Pill weight gain.

From Table (7), the results of the overlap showed that the overlap treatment (Reduce tillage x 100 mg L^{-1}) was significantly superior by giving it the highest mean of 38.03 g, while the overlap treatment (Conventional tillage x 100 mg L^{-1}) recorded the lowest average of 33.30 g.

)

Table 7. Effect of tillage systems and boron spraying and the interaction between them on Weight of 1000 Grains (g

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	**33.64**	**33.57**	**35.11**	**34.11**
50	**36.87**	**34.13**	**36.17**	**35.72**
100	**33.30**	**38.03**	**36.75**	**36.03**
150	**35.20**	**37.60**	**36.11**	**36.30**
Average tillage systems	**34.75**	**35.83**	**36.03**	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	NS	1.51	**2.08**	

7 -Grain Yield (ton ha^{-1})

Table (8) showed that the no-till system was significantly superior by giving it the highest average of 3.540 ton ha^{-1}, while the Conventional tillage system gave the lowest average of 3.126 ton ha^{-1}. This is due to the efficiency of the no-till system in increasing the components of the yield represented by The number of spikes (m^2) and the number of grains per spike**.**

Also, the results of table (8) showed that there were significant differences between the concentrations of boron spraying, as the concentration exceeded 150 mg B L^{-1}, giving it the highest average of 3.498 ton ha^{-1}, compared to the comparison treatment that gave the lowest average of 3.229 ton ha^{-1}, and the reason is attributed to The role of boron in increasing the yield components, the number of grains per spike and the weight of 1000 grains**.**

Table 8. Effect of tillage systems and boron spraying and the interaction between them on Grain Yield (ton ha^{-1})

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	2.897	3.350	3.440	3.229
50	3.325	3.412	3.468	3.402
100	3.087	3.329	3.498	3.305
150	3.196	3.546	3.752	3.498
Average	3.126	3.409	3.540	

tillage systems				
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	0.225	0.145	NS	

8- Harvest Index (%)

Table (9) indicate the superiority of the Reduce tillage system by giving it the highest average of 43.57%, without a significant difference from the no-till system as it gave an average of 42.78%, while the Reduce tillage and no-tillage system differed significantly from the Conventional tillage system, which recorded the lowest average of 38.59 %, the reason for the increase in the harvest index at the Reduce tillage system may be attributed to the role of this system in increasing the grains yield by a higher rate than the increase in the biological yield, and thus the harvest index increased.

Table9. Effect of tillage systems and boron spraying and the interaction between them on Harvest Index (%)

Boron (mg B L^{-1})	**tillage systems**			**Average Boron**
	Conventional tillage	**Reduce tillage**	**No- tillage**	
0	39.75	44.52	44.16	42.81
50	40.54	45.06	40.41	42.01
100	38.08	44.68	41.76	41.51
150	35.97	40.02	44.78	40.26
Average tillage systems	38.59	43.57	42.78	
L.S.D (0.05)	tillage systems	boron	Boron x tillage systems	
	3.42	NS	NS	

Conclusion

Depending on the research conditions, we can conclude the following:

1) The no-till system excelled in most growth characteristics and achieved an increase in yield and its components. It is worth to mention that this finding is depending on one season field trial results.

2) tillage affected the physical properties of the soil, as the Conventional tillage system was superior in bulk density and porosity.

3) Boron spraying with a concentration of (150) mg L^{-1} was superior in terms of yield and its components.

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