Response of Three Cultivars of Oats to Spraying Boron and Silicon in Saline Soil

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Abstract

A field experiment was carried out during the winter season 2024-2025 in the field Crops Department - College of Agriculture, Al-Qasim Green University, Babylon / Iraq. to study response of cultivars oat to spraying boron and silicon in saline soil. A randomized complete block design (R.C.B.D) was used with split-plot by three replicates, the main plots included three cultivars; Sheffa, Algouda and Oat11, while the secondary plots included four nutrients treatments; spraying distilled water only (control),spraying boron at a concentration of 1 ml.L^{-1}, spraying silicon at a concentration of 1 ml.L^{-1} and spraying both boron at a concentration of 1 ml. L^{-1} and spray silicone at a concentration of 1 ml L^{-1} together .The results of the statistical analysis indicated a difference between the Cultivars in most of the studied traits, significantly excelled SheffaCultivar by recorded the highest mean for grain yield 6.03 tons. h^{-1} and the biology yield reached 15.09 tons.h^{-1}. In order to spraying silicon at a concentration of 1 ml.L^{-1} indicated a significant increase in the number of panicles (panicle.m^{-2}) by percentage 11.35 %.while to spraying boron at a concentration of 1 ml.L^{-1} indicated a significant increase in the number of grains (grain.panicle^{-1}) by percentage 9.53 %. study that foliar spraying of silicon reduced the effect of salinity on the plant and thus stimulated vegetative growth, which was reflected in the grain yield and its components.

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Keywords: Oats, boron, silicon, grain yield components

1. Introduction

Oats (*Avena sativa* L.) isone of the most important crops in the world, ranking seventh among the world's top producers in terms of production and importance. Their importance is highlighted by their multiple uses, as they are beneficial to humans and animals. In addition to other industrial purposes, the animal feed is used for the high nutritional value of its grains, in terms of protein, vitamins, minerals, water-soluble and easily digestible fiber, and antioxidants that have a beneficial effect on heart disease, diabetes, and blood pressure [1]. The area planted with it globally reached 9.54 million hectares, with a production rate of 23.54 million tons of grain yield [2]. But a result of the major changes in climatic conditions around the world, including Iraq, in terms of declining rainfall rates and the expansion of lands affected by salinity, which was accompanied by the problem of deteriorating agricultural production as a result of hindering the absorption of water and nutrients through the roots.This problem can be reduced by following the foliar feeding method with nutrients necessary for growth [3].such as the element boron is important in stimulating the plant's ability to carry out photosynthesis by maintaining the water

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balance within the cell, stabilizing the components of the cell walls, and activating the cell membranes[4].In addition to the silicon element, which regulates the balance of nutrients and participates in strengthening the structural integrity of cell walls to increase the leg's resistance to lying down[5]. However the process of preparing the plant with these nutrients must be accompanied by the appropriate selection of cultivars characterized by high production efficiency and the ability to adapt to the environmental conditions available to them [6].Therefore this research carried out with the aim of study effect spraying boron and silicon on grain yield components for cultivars of oat crop in saline soils.

2. Materials and methods

2.1. Experiment requirements

The experiment was conducted during the winter season 2024-2025 in the field of the Field Crops Department - College of Agriculture, Al-Qasim Green University in Babil / Iraq, at a latitude of 32.40north and a longitude of 44.39 east.to study effect spraying boron and silicon on grain yield components for cultivars of oat crop in saline soils Table 1 shows some chemical and physical characteristics of fieldsoil .

Table 1: Some chemical and physical properties of field soil.

Traits		Values
PH		7.78
EC		7.11 ds.m^{-1}
OM		0.74 %
Available nitrogen		32.48 mg.kg^{-1}
Available phosphorus		8.16 mg.kg^{-1}
Available potassium		130.49 mg.kg^{-1}
Soil separators	Sand	267
	Clay	395
	Silt	338
The texture		Mixed clay

Soil service operations were carried out, including plowing, smoothing, and leveling. Then the field was divided into three replicates. Each replicate contained 12 experimental units with an area of 4 m^2(2m*2m). Phosphate fertilizer (DAP 46 :18:0%) was added at a rate of 100 kg ha^{-1} [7] mixed with the soil, and the planting process was carried out on lines with a distance between one line and another of 20 cm at a seed rate of 100 kg ha^{-1} [8]. Nitrogen fertilizer (urea 46% N) was added at a rate of 120 kg ha^{-1} In three equal batches, the first after emergence, the second at the beginning of the tillers stage, and the third when 50% of the plants in the experimental unit had flowered [9]. The plants were sprayed during two stages of growth, the first in the tillers stage and the second in the elongation stage. Data were collected and analyzed using the ready-made statistical program GenStat V.20 according to the method. Adopted by [10], the least significant difference test was used at the probability level of 0.05 to compare the arithmetic means.

2.2.Experimental design

A factorial experiment was applied according to a randomized complete block design (R.C.B.D.), in a split-plots arrangement, with three replications. It included a study of the effect of two factors: the first factor: three cultivars of

oats, Shifa, Al-Jouda, and Oats11, and the second factor: Spraying four nutrient treatments: spraying distilled water only (comparison), spraying boron at a concentration of 1 ml L^{-1} (in the form of artificial boron foliage fertilizer - boron 13.20%), spraying silicon at a concentration of 1 ml L^{-1} (in the form of potassium silicate - silicon oxide 35 %, potassium oxide 12%), and spray both boron at a concentration of 1 ml L^{-1} and silicon at a concentration of 1 ml L^{-1} together.

2.3.The studied traits

Some grains yield characteristics were measured when the plants harvested, by taking the mean of a random sample of each experimental unit, for studied traits:

- The number of panicles per mater.
- The the number of grains per panicle.
- weight thousand grains.
- the grain yield is ton per hectare
- the biology yield: is ton per hectare.
- Harvest index (%): Calculated through the following equation: Harvest index% = (grain yield / biological yield) x 100.
-Percentage of infertility (%): Calculated from the following equation: Percentage of infertility = number of empty seeds/number of total seeds x 100 .

3. Results and discussion

3.1. Number of Panicle per Square mater (panicle .m^2)

The results in Table 2 indicated that there are significant differences between the genotpes in number of panicles, as the sheffa cultivar recorded the highest average of 375.30 panicle m^{-2}, compared to the oat11 cultivar, which recorded the lowest average of 342.20 panicle m^{-2}. The reason for this may be due to the role of the genetic factor in determining the cultivar ability to form tillers and transform them into fertile panicles, based on its efficiency in producing the largest amount of the products of the photosynthesis process[11]. It is evident from the same Table that there are significant differences between the nutrients in the number of panicles, there was superiority for the silicon spray treatment at a concentration of 1 ml.L^{-1} recorded the highest average of 375.23 panicle m^{-2}, compared to the control treatment, which recorded the lowest average of 336.96 panicle m^{-2}. The reason for this superiority may be due to the positive effect of the silicon element in reducing the harmful effects of environmental stresses and increasing the plants ability to absorb water and important nutrients to increase the efficiency of the photosynthesis process [12]. The results also indicated there was a significant interaction between the cultivars and nutrients, as the interaction treatment between the sheffa cultivar and spraying silicon at a concentration of 1 ml.L^{-1} excelled in the Number of panicles, by recording the highest average of 390.9 panicle m^{-2} compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded the lowest averages only 308.3 panicle m^{-2}.

Table 2 Effect of boron and silicon on the number of panicles (panicle .m^{-2}) for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	365.4	363.1	390.9	381.90	375.30
Alguda	337.2	355.2	374.9	366.70	358.50
Oat11	308.3	346.3	359.9	354.20	342.20
nutrients averages	336.96	354.86	375.23	367.60	
L.S.D $_{0.05}$	Cultivars = 9.70 ,Nutrients = 9.19 ,Interaction = 15.53				

3.2. Number of Grains per Panicle(grain.$panicle^{-1}$)

According to Table 3 indicated there are significant differences between the cultivars, the nutrients and interaction between the cultivars and nutrients in the number of grains, as the Algouda cultivar recorded the highest average of 56.92 grain $panicle^{-1}$, compared to the oat11 cultivar, which recorded the lowest average of 47.28 grain $panicle^{-1}$.The reason for this may be attributed to the difference between varieties in genetic factors that are positively associated with quantitative traits and the number of grains is one of the most important of these traits[13].that there was superiority for the boron spray treatment at a concentration of 1 $ml.L^{-1}$ recorded the highest average of 55.29 grain $panicle^{-1}$,compared to the control treatment, which recorded the lowest average of 50.48 grain $panicle^{-1}$. The reason for this may be due to the important role of the boron element in controlling the activity of proteins in the pollen tube, in addition to controlling the distribution of synthetic materials, especially proteins, through cellular proliferation practices, including the gaps that lead to the expansion of the pollen tube [14-15].While the interaction treatment between the Algouda cultivar and spraying boron at a concentration of 1 $ml.L^{-1}$ excelled in the trait the number of grain per panicle by recording the highest average of 60.11 grain $panicle^{-1}$, compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded the lowest averages 44.22 grain $panicle^{-1}$.

Table 3 Effect of boron and silicon on the Number of grains per panicle (grain.$panicle^{-1}$)for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	54.67	57.33	54.22	54.11	55.08
Alguda	52.56	60.11	56.22	58.78	56.92
Oat11	44.22	48.44	50.00	46.44	47.28
nutrients averages	50.48	55.29	53.48	53.11	

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L.S.D $_{0.05}$	Cultivars=2.72 ,Nutrients=2.07 ,Interaction=3.72

3.3. Weight Thousand Grain (g)

The results presented in Table 4 demonstated that there are significant differences between the cultivars in the weight thousand grain, as the sheffa cultivar recorded the highest average of 29.23 g, compared to the oat11 cultivar, which recorded the lowest average of 27.05 g. The reason for the difference between the varieties may be attributed to the fact that the characteristic of the weight of a thousand grains is one of the components of the yield, which has a high degree of heritability compared to the other quantitative components, in addition to the variation of the varieties in the extent to which they benefit from the products of the photosynthesis process, their accumulation in the grains, and their increased weight [16].As for spraying nutrients, it led to a significant increase in the weight of a thousand grains, that there was superiority for the silicon spray treatment at a concentration of 1 ml.L^{-1} recorded the highest average of 29.39 g, compared to the control treatment which gave the lowest average of 25.97 g. The reason may be to the role of silicon in the production of dry matter, its transfer from the leaves, its accumulation in the grains, and its increase in weight, it is one of the important components leading to an increase in the economic yield and hence the harvest index[17].also indicated that there was a significant interaction between the cultivars and nutrients, as the interaction treatment between the sheffa cultivar and spraying silicon at a concentration of 1 ml.L^{-1} excelled in the weight thousand grain by recording the highest average of 31.63 g, compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded the lowest averages 24.61 g.

Table 4 Effect of boron and silicon on the 1000 grain weight (g) for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	26.87	28.8	31.63	29.60	29.23
Alguda	26.43	27.36	28.12	28.63	27.64
Oat11	24.61	27.07	28.43	28.10	27.05
nutrients averages	25.97	27.74	29.39	29.23	
L.S.D $_{0.05}$	Cultivars = 0.63 ,Nutrients = 0.64 ,Interaction = 1.07				

3.4. Grains Yield (ton.ha^{-1})

The results shown in Table 5 showed there are significant differences between the oat cultivars, the nutrients and interaction between the cultivars and nutrients in the grains yield, as the sheffa cultivar recorded the highest average of 6.05 ton ha^{-1} , compared to the oat11 cultivar which recorded the lowest average of 4.31 ton ha^{-1}. The reason for this may be attributed to the difference in the varieties in their

response to environmental conditions, as well as the difference in the basic yield components of each variety, Perhaps the superiority of the Sheffa cultivar in the two characteristics of the number of panicles and the weight of a thousand grains causes a greater increase in the purity of the other components and thus an increase in the grain yield[18] .that there was superiority for the silicon spray treatment at a concentration of 1 ml.L^{-1}recorded the highest average of 5.88 ton ha^{-1}, compared to the control treatment, which gave the lowest average of 4.40 ton ha^{-1}.The reason for this may be attributed to the role of silicon in enhancing the work of some enzymes important for chemical reactions and reducing the harmful effects of free radicals that negatively affect the work of plant organelles, which improves the characteristics of vegetative and reproductive growth, such as increasing the number of panicles and the weight of a thousand grains, which are among the basic components for increasing grain yield[19]. The interaction treatment between the sheffa cultivar and spraying silicon at a concentration of 1 ml.L^{-1} excelled in the trait of the grains yield by recording the highest average of 6.69 ton ha^{-1}, compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded the lowest averages only 3.29 ton ha^{-1}.

Table 5 Effect Effect of boron and silicon on the grains yield (ton.ha^{-1}) for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	5.41	6.00	6.69	6.12	6.05
Alguda	4.50	5.82	5.85	6.21	5.59
Oat11	3.29	4.40	5.10	4.46	4.31
nutrients averages	4.40	5.40	5.88	5.60	
L.S.D $_{0.05}$	Cultivars = 0.31 ,Nutrients = 0.25 ,Interaction = 0.44				

3.5. Biological Yield (ton.ha^{-1})

The oat cultivars differed significantly in terms of biological yield, as shown in table 6, as the sheffa cultivar recorded the highest average of 15.29 ton ha^{-1}, compared to the oat11 cultivar, which recorded the lowest mean of 13.16 ton ha^{-1}. The reason for this may be attributed to the difference in the characteristics of tillering ability and dry matter production, which represents the effectiveness of the plant in the process of photosynthesis, in addition to the increase achieved by the Sheffa cultivar in the character of grain yield, which comes from a group of components that indicate the extent of improvement in growth characteristics, and this is reflected in the accumulation of dry matter and thus Biological outcome[20]. Spraying nutrients also caused a significant increase in dry matter yield, there was superiority for the silicon spray treatment at a concentration of 1 ml.L^{-1} recorded the highest average of 15.30 ton ha^{-1}, compared to the control treatment, which gave the lowest average of 12.55 ton ha^{-1}.The reason for this may be attributed to the role of silicon in

enhancing physiological processes within the plant and increasing the absorption and accumulation of nutrients necessary for the photosynthesis process, which is reflected in the accumulation of dry matter (biological yield)[21]. While a significant interaction was observed between oat cultivars and nutrients in this trait through, the interaction between the sheffa cultivar and spraying silicon at a concentration of 1 ml.L^{-1} excelled in the trait of the biology yield by recording the highest average of 16.03 ton ha^{-1} compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded the lowest averages only 10.92 ton. ha^{-1}.

Table 6 Effect of boron and silicon on the Biology yield (ton.ha^{-1}) for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	14.19	15.05	16.03	15.88	15.29
Alguda	12.54	15.00	15.51	15.56	14.65
Oat11	10.92	13.41	14.38	15.94	13.16
nutrients averages	12.55	14.49	15.30	15.13	
L.S.D $_{0.05}$	Cultivars = 0.56		,Nutrients = 0.38	,Interaction = 0.72	

3.6. Harvest Index (%)

The results of the table 7 showed there are a significant difference between the study factors and the interaction between them in the harvest index, as the sheffa cultivar recorded the highest average of 39.11%, compared to the oat11 cultivar which recorded the lowest average of 32.01 %.The reason for this may be attributed to the Shiffa cultivar possessing a number of characteristics compared to the rest of the varieties, such as the number of tillers producing panicles and the production and accumulation of dry matter in the grains, which caused an increase in grain yield, which was reflected in the harvest index [22].the silicon spray treatment at a concentration of 1 ml.L^{-1} recorded the highest average of 37.76 % , compared to the control treatment, which gave the lowest average of 34.2 %.The reason for the increase in the harvest index may be attributed to the role of the silicon element in suppressing harmful free radicals resulting from the effect of salt stress and thus improving the characteristics of vegetative growth, which led to an increase in the ratio of grain yield to biological yield[23]. The interaction treatment between the sheffa cultivar and spraying silicon at a concentration of 1 ml.L^{-1} excelled in the trait of the harvest index by recording the highest average of 41.43 %, compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded the lowest averages 29.73 %..

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Table 7 Effect of boron and silicon on the harvest index (%) for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	37.96	39.26	41.43	37.81	39.11
Alguda	34.91	38.16	37.25	39.25	37.39
Oat11	29.73	32.21	34.62	31.49	32.01
nutrients averages	34.2	36.54	37.76	36.18	
L.S.D $_{0.05}$	Cultivars = 1.58 ,Nutrients = 1.23 ,Interaction = 2.20				

3.7.Percentage of Infertility (%)

The results in Table 8 explained there are significant differences between the oat cultivars in trait the Percentage of infertility, as the sheffa cultivar recorded average of 4.60 %, compared to the oat11 cultivar which recorded average of 6.49 %. The reason for the discrepancy between varieties may be attributed to differences in genetic factors and the extent of their adaptation to environmental conditions [24]. While the boron spray treatment at a concentration of 1 ml.L^{-1} recorded average of 4.48 %, compared to the control treatment which gave average of 6.52 %.The reason for this may be attributed to the role of the active element boron in the processes of transferring carbohydrates from the source to the downstream, which is necessary to complete the processes of pollination and fertilization, and this is reflected in the increase in the number of grains[25-26].The results also table indicate that there was a significant interaction between the cultivars and nutrients, as the interaction treatment between the sheffa cultivar and spraying boron at a concentration of 1 ml.L^{-1} excelled in the Percentage of infertility by recording average of 4.01 %, compared to the interaction treatment between the Oats11 cultivar and the control treatment that recorded averages only 8.34 %.

Table 8 Effect of boron and silicon on the Percentage of infertility (%) for oat cultivars in saline soil.

Nutrients / Cultivars	Control	Boron	Silicon	Boron + Silicon	Cultivars averages
Shifa	5.59	4.01	4.47	4.32	4.60
Alguda	5.62	4.12	4.6	4.28	4.65
Oat11	8.34	5.29	6.64	5.69	6.49
nutrients averages	6.52	4.48	5.23	4.76	
L.S.D $_{0.05}$	Cultivars = 0.16 ,Nutrients = 0.24 ,Interaction = 0.38				

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Conclusion

conclude from this experiment that the cultivars differ among themselves in the basic grain production components, which distinguishes the Shifa variety from the rest of the cultivars.The silicon spraying process also led to a significant increase in most grain production characteristics of plants grown in saline soil.

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