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EFFECT OF ZINC AND BORON FOLIAR APPLICATION ON GROWTH, YIELD AND QUALITY OF SOME SUNFLOWER GENOTYPES (*Helianthus annuus* L.)

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ABSTRACT

A field experiment was conducted during spring and autumn growing seasons of 2009 to study the effect of foliar application of zinc and boron on growth characters, yield components and quality of some sunflower genotypes *(Helianthus annuus* L.*)*. The experiment was carried out according to the factorial experiment in a randomized completely block design, consisting of three zinc application (0, 6, 12 mg.L^{-1}) and three boron application (0, 4 and 8 mg.L^{-1}) with three sunflower genotypes (Myogen, Isaanka and Ginmus). The main findings could be summarized as follows:- Foliar application of zinc to the leaves with concentration 12 mg.L^{-1} showed a significant increase in plant height, stem diameter, leaf area, head diameter, number of seeds head^{-1}, 1000 seed weight and seed yield.ha^{-1}, oil percentage, oil, protein yield (ton. ha^{-1}), However, protein percent was decreased. Addition of boron sprayed on the plant leaves with concentration 4 mg.L^{-1} lead to a significant increase in plant height, stem diameter, leaf area, head diameter, number of seeds head^{-1}, 1000 seed weight and seed yield.ha^{-1}, oil percentage, oil, protein yield (ton.ha^{-1}), while increasing concentration of boron to 8 mg.L^{-1} caused a significant increase in protein percentage in the two seasons'.

Results showed that the Isaanka genotype gave a high values for characters stem diameter, leaf area, head diameter, number of seeds. head^{-1}, 1000 seed weight and seed yield.ha^{-1}, oil percentage, oil, protein yield (ton.ha^{-1}) in both seasons. The triple interaction among Isaanka genotype × foliar application of 12 mg Zn.L^{-1} × concentration of 4 mg B.L^{-1} sprayed on the plant leaves, achieved the highest mean for the characteristics of: plant height, stem diameter, number of seeds head^{-1}, seed yield.ha^{-1} and oil, protein yield (ton.ha^{-1}) for both seasons. In general, it could be concluded that for maximizing total seed and oil yields per unit area may be achieved by planting Isaanka genotype with adding zinc and boron to the leaves plant with concentration 12 Zn and 4 B mg.L^{-1} under the environmental conditions of this study.

Keywords: zinc and boron application, sunflower genotypes, *Helianthus annuus* L.

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) enjoys in having an important position in the world among the new oilseed crops, because of its quantity and high quality of edible oil. Among the factors responsible for increasing yield, judicious use of micronutrients is of prime importance. Crops require a sufficient, but not excessive, supply of essential mineral elements for optimal productivity. Insufficient supply of mineral elements may lead to limit in plant growth. In some agricultural soils, particularly in clay soil, insufficient micronutrients like zinc (Zn) and boron (B) are often common

(Gitte *et al*, 2005). Hence, these elements can be supplied as fertilizers in both intensive and extensive agricultural systems. However, excess Zn and B may be toxic to plants. Increased fertilizer used efficiency can be achieved agronomically, through improved fertilizer management practices (Milutinoc and Stanojevic ,1988; 1983; Asad *et al*, 2002). Sunflower is one of the most sensitive crops to low zinc and boron supply, developing the characteristic of Zn, B deficiency symptoms on leaves, stems and reproductive parts (Oyinlola, 2007).

Plants growth is significantly influenced by soil Zn, B content. It has been shown that sunflower roots are sensitive to Zn, B deficiency as they stop their growth in less than 6 h after the removal of Zn, B from the growth media (Beyersmann and Haase, 2002). Similarly, a considerable increase in dry weight of sunflower by foliar application of 28 mg boron.L^{-1} has been reported (Iskander, 1993). Boron foliar application, not only increased root growth but also increased shoot dry weight of sunflower (Asad *et al*, 2002). Foliar applications of above mentioned mineral partially overcomes the negative effects of stress and provide plants balanced nutrients. Spray of $ZnSo_4$ and H_3Bo_3 was better in all the vegetative growth characteristics Tahsin and Yankov, (2007) also observed a significant effect of micronutrients in growth including yield in sunflower plants by foliar application of zinc, boron and iron. Such enhancement effect of foliar application might be attributed to the favorable influence of these nutrients on metabolism and biological activity and its stimulating effect on photosynthetic pigments and enzymes activity which in turn encourage vegetative growth of plants (Milutinoc and Stanojevic, 1988). Foliar mineral spray significantly affects biomass production of plants irrespective to their growth under different soil conditions. The foliar application of above mentioned minerals appear to minimize these toxic affects through mitigating the nutrient demands of stressed plants. These minerals increased photosynthetic and enzymatic activities and an effective translocation of assimilate to reproductive parts resulting in higher yield (Lindsay, 1996). Spray of boron as an individual mineral element was found to be better in stimulating the pollen viability and germination as compared to zinc. High boron levels in the stigma and style are required for physiological inactivation of callus which is an important polysaccharide component of the pollen tube wall by the formation of borate callus complexes (Sharma *et al*, 1999). When boron levels are low, callus levels increase and induce the synthesis of phytoalexins including phenols which can cause an injury to membrane structure and cellular functions and bring some alteration in the morphology and structure of pollen tubes (Rani and Reddy, 1993). The aim of this research is to determine the effect of zinc and boron foliar application as well as their interactions on seed yield and its components of three sunflower genotypes under the environmental conditions of AL-Quba district, which locate near Mosul city of Iraq.

MATERIALS AND METHODS

The experiment was conducted during spring and autumn growing seasons of 2009 at AL-Quba in the west north region of Mosul city at Nineveh province, on a sandy loam soil having 33.65 ppm available nitrogen, 10.31ppm available phosphorus and 153 ppm available potassium as an average of both seasons (table 1).

Table (1): The physical and chemical characters of soil filed experiments before planting (0 to 30 cm depth) in both seasons.

Seasons	spring	autumn
physical characters		
Sand (%)	59.00	57.00
Silt (%)	23.00	32.00
Clay (%)	18.00	11.00
Texture	sandy loom	sandy loom
chemical characters		
Organic matter ($mg.kg^{-1}$)	0.82	0.69
Available N (ppm)	33.20	34.10
Available P (ppm)	11.20	9.42
Available K (ppm)	164.00	142.00
Available Zn (ppm)	4.62	3.46
Available B (ppm)	3.60	3.20
Total $CaCo_3$ ($mg.kg^{-1}$)	2.42	2.20
pH	7.8	6.4
E.C. ($ds.cm^{-1}$)	1.90	2.00

The experiment was laid out according to the factorial experiment in a Randomized Completely Block Design with three replications having a net plot area of 21.6 m^2 (3.6m x 6.0m). Three levels of foliar application [0-0, 6-4 and 12-8 $mg.L^{-1}$ of zinc as zinc sulphate ($ZnSo_4.7H_2o$ 35% Zn) and boron as boric acid (H_3Bo_3 17%B) respectively sprayed on the leaves one dose during budding stage], and three genotypes of sunflower (Myogen, Isaanka and Ginmus). The crop was sown by putting three seeds to hills by hand in 60 cm apart ridges, and six meters long and the distance between hills was 40 cm apart to attain a plant density of 41.666 $plants.hectare^{-1}$ in April 1st, July 6th and harvested in August 7th, October 26th for spring and autumn growing seasons respectively. The plants were thinned to one plant per hill two weeks after sowing. Super phosphate 140 kg per hectare (45 % P_2O_5), and potassium (48% K_2O) were applied (40 kg/hectare) to the soil during the sowing period, Nitrogen fertilizers was applied in the form of urea 80 kg hectare (46%N) in two equal doses, half with sowing and the remaining half after thinning. The first irrigation was applied immediately after sowing and after wards irrigation was scheduled at about three day's intervals. All other agronomic practices were kept normal and uniform for all the treatments. Twenty plants from each plot were selected at random to record plant height (cm), stem diameter (cm), leaf area (cm^2.plant), and head diameter (cm). At harvest, ten guarded plants were taken randomly from the two inner ridges of each experimental plot and left for two weeks until fully air dried, then the following data were measured; number of seeds/head, weight of thousand seed (g.), yield and oil, protein yield ($ton.ha^{-1}$). The seed oil content was determined by the soxholet apparatus (Anonymous, 1980), and seed nitrogen concentration was measured by microkjeldahl method, then, Protein percentage was calculated by multiplying the nitrogen percentage by the converting factor 6.25 (Agrawal *et al*, 1980). Concentration of zinc in soil was measured by atomic absorption spectrophotometer with wave length 213.9 nm. (Anonymous, 1998). Boron in soil was determined by atomic absorption spectrophotometer using curcumin and oxalic acid indicator at 540 nm wave length (Black, 1965, Jackson, 1973, Page *et al*, 1982, and Tandon, 1999). All the data were analyzed by using the SAS statistical software (Anonymous, 2001). Means were compared using Duncan's multiple range test at 1 and 5% probability level (Duncan, 1955).

RESULTS AND DISCUSSION

1- Zinc application effect: Results of statistical analysis showed that foliar application of zinc levels significantly affected all the studied characters (table 10). Plant height, stem diameter, leaf area, head diameter, number of seeds.head^{-1}, weight of thousand seed and seed yield.ha^{-1}, oil percentage, oil, protein yield (ton.ha^{-1}) were significantly increased as zinc application levels increased in the two seasons (table 2). The highest values of previously mentioned characters, except seed protein percentage was obtained with the highest zinc level (12 mg.L^{-1}). Similar results were reported by others (Kathirresan *et al*, 2001; Cui *et al*, 2004; Frey *et al*, 2006; Mirzapour and Khoshgoftar, 2006). The increase in growth characters and yield components with the increase in zinc foliar application from 0 to 12 mg.L^{-1} might be due to the function of zinc at the cellular level of plant is to bind firmly to lamellae of chloroplast, affecting the chloroplast structure and photosynthesis (Meszaros and Simits, 1992). Seed yield ha^{-1} was increased from 1.588, 1.544 to 1.935,1.902 and 2.506, 2.499 ton.ha^{-1} with increasing zinc foliar application from 0 to 6 and 12 mg.L^{-1} in the two growing seasons spring and autumn respectively (table 2). These increases represent 57.80, 61.85% respectively compared to the control. The increase in seed yield with the increase of zinc application might be due to the important role of zinc in activating the growth and yield components (Kathirresan *et al*, 2001). Similar results were reported by (Sharma, 2006; Tahsin and Yankov, 2007). The increase in zinc application to 12 mg.L^{-1} was associated with a decrease in seed protein percentage. Seed protein percentage decreased from 14.94, 14.16 to 12.41, 11.50 with increasing zinc application from 0 to 12 mg.L^{-1} in the two growing seasons spring and autumn respectively. The significant negative relations between seed protein content and high zinc application were also reported by (Kathirresan *et al*, 2001). The decrease in seed protein percentage with the increase in zinc application could be probably attributed to the sugar translocation affecting oil synthesis (table 2). Alternating enzymes imbalance could also contribute in this reduction (Sharma, 2006). Similar results were reported by others (Cui *et al*, 2004; Frey *et al*, 2006). Although the percentage of seed protein percentage decreased with the increase in zinc application to 12 mg.L^{-1}, the total protein yield.ha^{-1} significantly increased as zinc application increased up to 12 mg.L^{-1}. Protein yield.ha^{-1} increased from 0.095, 0.219 to 0.132, 0.289 ton.ha^{-1} with increasing zinc application from 0 to 12 mg.L^{-1}, in spring and autumn seasons respectively. The increase in Protein yield with the increase in zinc application up to 12 mg.L^{-1} despite the decrease of seed protein content might be attributed to the increase in seed yield.ha^{-1}. Similar results were reported by others (Kathirresan *et al*, 2001; Tahsin and Yankov, 2007).

2- Boron application effect: Concerning to the effect of boron foliar application levels on some growth characters, seed yield.ha^{-1} and its components, the results in table 3 indicate that growth characters, seed yield and its components were significantly affected by boron fertilizer levels in both seasons. Also, Increasing boron foliar application from 0 to 4 $mg.L^{-1}$ significantly increased plant height, stem diameter, leaf area, head diameter, number of seeds $head^{-1}$, 1000 seed weight in both seasons. In general, increasing boron foliar application from 0 to 4 $mg.L^{-1}$ increased plant height by 4.0% and 3.84%, increased stem diameter by 2.42% and 3.24% and increased leaf area by 6.52% and 6.41% in spring and autumn. In addition, increasing boron foliar application from 0 to 4 $mg.L^{-1}$ increased seed yield per hectare by 15.24% and 14.75%, increased oil yield per hectare by 23.89% and 12.48% and increased protein yield per hectare by 19.00% and 21.19% in the spring and autumn seasons respectively. Increasing boron foliar application from 4 to 8 $mg.L^{-1}$ cased decreased in the previous traits for both seasons. Table 1, also showed that the available boron in the soil is in the average of medium level which is ranged from 3.6, 3.2 ppm, and these results are in agreement with the classification of Maas (1990), although sunflower required a high quantity of boron, this reflected the response of the crop to this element when increasing the concentration from 0 to 4 $mg.L^{-1}$. These results are in agreement with those reported by Rani and Reddy, (1993); Harris and John, (1996); Castro *et al*, (2000); Oyinlola, (2007). The increases in seed yield per hectare with increasing boron application dose may be attributed to the increases in head diameter, number of seeds $head^{-1}$, 1000 seed weight reflected increases of seed yield per hectare. These results are in agreement with those reported by Moore and Hirsch, (1983); Sharma *et al*, (1996); Asad *et al*, (2002). The increases in oil yield per hectare with increasing boron application dose to 4 $mg.L^{-1}$ may be attributed to the increases in yield which reflected increases in seed yield per unit area and hence oil yield per hectare. These results are in agreement with those reported by Korenovska and Polacekova, (2000).

3- Genotypes effect: The results in table 4 indicate that sunflower genotypes significantly differed in growth characters, seed $yield.ha^{-1}$ and its components in both seasons. Issanka genotype exceeded Myogen and Ginmus genotype in stem diameter, leaf area, head diameter, number of seeds. $head^{-1}$, 1000 seed weight and seed yield ha^{-1} oil percentage, protein yield ($ton.ha^{-1}$) in both seasons. Issanka genotype also exceeded Myogen by 15.51% and 15.84% and Ginmus genotype by 19.86 % and 19.81% in seed yield per hectare in the spring and autumn seasons respectively. Myogen genotype exceeded Ginmus by 3.75% and 3.81% in yield per hectare in spring and autumn. The differences between sunflower genotypes in seed yield per hectare might be attributed to their differences in growth traits such as leaf area, head diameter that reflected differences in yield components such as number and weight of seeds $head^{-1}$ as well as 1000 seed weight and hence increased seed yield per plant as well as per unit area. Similar results were obtained by many investigators such as Farah, *et al*, (1981); Baldini and Vear, (1994); Nel *et al*, (2000); Kalarani, *et al*, (2004); Luan, (2006); Mariayesa, *et al*, (2007). The increases of Issanka genotype in oil yield per hectare compared with Myogen and Ginmus genotypes may be attributed to the genetically variation among the tested genotypes in yield components and consequently seed yield as well as oil percentage. Similar results were obtained by many investigators as Dedio, (1985); Baldini and Vannozzi, (1999); Zehra *et al*, (2007).

4- Interaction effect of zinc and boron foliar application: The interaction between zinc and boron foliar application had a significant effect on plant height, stem diameter, leaf area, head diameter, number of seeds $head^{-1}$, 1000 seed weight and seed yield.ha^{-1}, oil, Protein percentage, oil, Protein yield (ton.ha^{-1}) as shown in table 5. The results indicated that addition of the highest zinc application (12mg.L^{-1}) with medium dose of boron (4 mg.L^{-1}) produced the highest plant height (154.5, 152.6 cm), stem diameter (1.9,1.8 cm), leaf area (3396.2, 3384.3 cm^2), head diameter (20.9, 20.8 cm), number of seeds head^{-1} (1003.4, 1002.7), 1000 seed weight (69.0, 68.9gm) and total seed yield (2.78, 2.76 ton.ha^{-1}), oil yield (1.1, 1.2 ton.ha^{-1}), Protein yield (0.14, 0.31 ton.ha^{-1}) in both seasons. Similar conclusions were obtained by Nel *et al*, (2000).

5- Interaction effect of zinc foliar application and genotypes: The interaction between zinc foliar application levels and sunflower genotypes had a significant effect on growth characters, seed yield.ha^{-1} and its components in both seasons as shown in table 6. The results showed that addition of the highest zinc application level i.e. 12 mg.L^{-1} to leaves of Issanka genotype produced maximum stem diameter, head diameter, number of seeds head^{-1}, 1000 seed weight and seed yield ha^{-1} oil percentage, oil, Protein yield (ton.ha^{-1}) in both seasons, which were 2.83 and 2.81 ton.ha^{-1} of seed yield per hectare and 1.26 and 1.27 ton per hectare of oil yield in the spring and autumn seasons respectively. The lowest seed and oil yields per a hectare were produced from sowing Ginmus genotype without adding the zinc (0 mg.L^{-1}) in both seasons. Similar results were reported by Khurana and Chatterjee, (2001); Cui *et al*, (2004); Frey *et al*, (2006); Tahsin and Yankov, (2007).

6- Interaction effect of boron foliar application and genotypes: The interaction between boron foliar application and sunflower genotypes showed significant effects on plant height, stem diameter, leaf area, head diameter, number of seeds head^{-1}, 1000 seed weight and seed yield.ha^{-1}, oil, protein percentage, oil, protein yield (ton.ha^{-1}) in both seasons except protein percentage and protein yield in the autumn season as illustrated in table 7. Data illustrated in table 7 show generally that Issanka, Myogen, and Ginmus genotypes appeared to be clearly affected by increasing rate of boron foliar application up to 4 mg.L^{-1} for plant height, stem diameter, leaf area and head diameter, while they appeared to be little response to 8 mg.L^{-1} for those traits. On the other hand, Issanka genotype reflected the greatest response to boron foliar application up to 4 mg.L^{-1} with this regard , Remussi *et al*, 1972 ; Hilton and Zubriski, 1985; Meszaros and Simits, 1992; Martin *et al* (2007); Chhotu *et al* (2008); Marie and Howarth (2009) found that fertilization with 15 mg.L^{-1} produced maximum 1000 seeds weight (53.71g) and seed yield (4153 kg ha^{-1}). The insignificant effect between genotypes and boron foliar application on other characteristic showed that each of these two factors acted independently on these traits.

7- Interaction effect of zinc, boron foliar application and genotypes: The interaction effect among the three studying factors showed significant effects on plant height, stem diameter, leaf area, head diameter, number of seeds head^{-1}, 1000 seed weight and seed yield.ha^{-1}, oil, protein percentage, oil, protein yield (ton.ha^{-1}) in both seasons except protein percentage in the autumn season as illustrated in tables 8 and 9. The interaction between Issanka genotype with zinc and boron spray in concentration 4,12 mg.L^{-1} gave a high rate for number of seeds head^{-1} (1052.6, 1054.1), total seed yield (3.19,3.17 ton.ha^{-1}), oil percentage (45.1, 45.9%), oil yield (1.44,1.45 ton.ha^{-1}), protein yield (0.171, 0.347 ton.ha^{-1}) in both growing seasons respectively. Similar results were reported by Blamey and Chapman ,(1982); Gimenez and Fereres, (1987);

Table (2): Effect of zinc foliar application on some growth characters, yield components and quality of Sunflower in both seasons.

seasons	Zn Application (mg.L^{-1})	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
spring	0	139.67c	1.37c	3025.31c	19.81c	813.36c	59.40c	1.588c	40.42c	0.642c	14.94a	0.095c
	6	145.28b	1.60b	3294.41b	19.87b	876.70b	63.31b	1.935b	41.41b	0.802b	13.59b	0.108b
	12	147.82a	1.96a	3355.13a	20.75a	969.73a	66.30a	2.506a	42.62a	1.070a	12.41c	0.132a
autumn	0	137.65c	1.27c	3009.88c	19.67b	809.32c	59.19c	1.544c	41.14c	0.635c	14.16a	0.219c
	6	144.21b	1.50b	3271.41b	19.71b	871.84b	62.89b	1.902b	42.13b	0.801b	12.72b	0.242b
	12	146.83a	1.85a	3338.05a	20.67a	968.28a	66.21a	2.499a	43.34a	1.084a	11.50c	0.289a

* The mean values within column followed by the different letter are significant at 5% level.

Table (3): Effect of boron foliar application on some growth characters, yield components and quality of Sunflower in both seasons.

seasons	B Application (mg.L^{-1})	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
spring	0	141.64c	1.65b	3138.31c	19.72c	838.61c	57.43c	1.856c	42.36a	0.791c	12.96c	0.100c
	4	147.40a	1.69a	3342.94a	20.57a	931.64a	67.87a	2.132a	41.39b	0.890a	13.69b	0.119a
	8	143.73b	1.59c	3193.59b	20.14b	889.54b	63.71b	2.040b	40.70c	0.834b	14.29a	0.117b
autumn	0	140.36c	1.54b	3123.46c	19.54c	833.82c	57.15c	1.833c	43.08a	0.793c	12.05c	0.217b
	4	145.73a	1.59a	3323.72a	20.42a	928.71a	67.74a	2.104a	42.11b	0.892a	12.76b	0.263a
	8	142.60b	1.49c	3172.16b	20.09b	886.91b	63.40b	2.007b	41.42c	0.834b	13.56a	0.269a

* The mean values within column followed by the different letters are significant at 5% level.

Table (4): Effect of sunflower genotypes on some growth characters, yield components and quality in both seasons.

seasons	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight (g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
spring	Myogen	131.99c	1.69b	3099.29b	20.23b	892.09b	61.82b	1.933b	40.87b	0.792b	13.75b	0.107b
	Isaanka	144.63b	1.91a	3603.39a	21.14a	936.51a	67.94a	2.233a	42.99a	0.965a	12.70c	0.120a
	Ginmus	156.15a	1.32c	2972.16c	19.06c	831.19c	59.24c	1.863c	40.60c	0.757c	14.49a	0.108c
autumn	Myogen	130.06c	1.59b	3077.85b	20.05b	888.79b	61.62b	1.907b	41.58b	0.794b	12.88b	0.243b
	Isaanka	146.13b	1.81a	3584.46a	21.03a	932.10a	67.63a	2.201a	43.71a	0.967a	11.83a	0.257a
	Ginmus	152.50a	1.21c	2957.03c	18.97c	828.56c	59.04c	1.837c	41.32c	0.759c	13.67c	0.248b

* The mean values within column followed by the different letters are significant at 5% level.

Table (5): Effect of interaction between zinc and boron foliar application on some growth characters, yield components and quality in both seasons.

seasons	foliar Application ($mg.L^{-1}$)		plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
	zinc	boron											
spring	0	0	136.86f	1.39g	2861.37i	19.47g	779.85i	52.13h	1.517g	41.18e	0.625g	14.32c	0.089f
		4	140.90e	1.49f	3299.40f	20.18d	844.02f	66.77c	1.638f	40.21g	0.660f	15.03b	0.098e
		8	141.24e	1.23h	2915.15h	19.78f	816.22g	59.29f	1.610f	39.88h	0.642fg	15.47a	0.098e
	6	0	142.62d	1.65c	3242.08g	18.96h	785.08h	57.75g	1.895e	42.19c	0.800de	13.06e	0.104d
		4	146.79b	1.59d	3333.18c	20.58c	947.46d	67.81b	1.980d	41.33ed	0.819d	13.51d	0.110c

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seasons	foliar Application (mg.L^{-1}) zinc	boron	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
		8	146.42bc	1.57e	3307.97e	20.07e	897.57e	64.37d	1.930de	40.71f	0.786e	14.20c	0.111c
	12	0	145.44c	1.90b	3311.49d	20.73b	950.90c	62.40e	2.156c	43.71a	0.946c	11.50g	0.108c
		4	154.51a	1.99a	3396.23a	20.95a	1003.45a	69.03a	2.780a	42.64b	1.190a	12.53f	0.148a
		8	143.53d	1.98a	3357.65b	20.57c	954.85b	67.47b	2.582b	41.51d	1.074b	13.19e	0.141b
autumn	0	0	135.23e	1.29g	2860.59g	19.34e	775.81g	51.82h	1.47h	41.90f	0.617i	13.63b	0.201e
		4	138.71de	1.39f	3276.62d	20.03c	841.08e	66.90c	1.59g	40.93h	0.652g	14.29a	0.228d
		8	139.01de	1.13h	2892.43f	19.63d	811.06f	58.86f	1.56g	40.63i	0.635h	14.56a	0.227d
	6	0	140.17d	1.55d	3219.08e	18.80f	779.93g	57.32g	1.86f	42.91c	0.799e	12.04d	0.224d
		4	145.87bc	1.48e	3310.18c	20.43b	942.30c	67.39b	1.95d	42.05e	0.821d	12.49c	0.243c
		8	146.60b	1.47e	3284.97d	19.88cd	893.31d	63.95d	1.89e	41.43g	0.785f	13.63b	0.258b
	12	0	145.70bc	1.80c	3290.72d	20.47b	945.74c	62.31e	2.16c	44.43a	0.965c	10.48f	0.227d
		4	152.61a	1.89a	3384.34a	20.80a	1002.74a	68.94a	2.76a	43.36b	1.204a	11.51e	0.318a
		8	142.19cd	1.87b	3339.10b	20.75a	956.35b	67.38b	2.56b	42.25d	1.083b	12.50c	0.321a

* The mean values within column followed by the different letters are significant at 5% level.

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Table (6): Effect of interaction between zinc foliar application and sunflower genotypes on some growth characters, yield components and quality in both seasons.

seasons	Zn	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight (g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
spring	0	Myogen	129.80i	1.33f	2828.94h	19.65g	815.77h	57.23g	1.548h	39.85h	0.617h	15.04b	0.092f
		Isaanka	138.60f	1.73e	3479.26c	20.73d	857.34f	65.15d	1.715g	41.71d	0.715g	13.69d	0.097e
		Ginmus	150.60d	1.06h	2767.72i	19.05h	766.98i	55.81h	1.502i	39.72i	0.596i	16.08a	0.096e
	6	Myogen	132.40h	1.77d	3132.48f	20.14e	879.69e	61.80e	1.858e	40.83g	0.758e	13.72d	0.104d
		Isaanka	143.70e	1.89c	3788.04a	21.10b	929.27c	67.76b	2.148d	42.55b	0.913d	12.72f	0.116c
		Ginmus	159.70a	1.16g	2962.70g	18.36i	821.15g	60.37f	1.797f	40.87f	0.734f	14.33c	0.105d
	12	Myogen	133.80g	1.98b	3336.46d	20.89c	980.82b	66.44c	2.392b	41.93c	1.000b	12.49g	0.125b
		Isaanka	151.60c	2.13a	3542.87b	21.60a	1022.93a	70.92a	2.836a	44.73a	1.269a	11.68h	0.148a
		Ginmus	158.10b	1.76d	3186.05e	19.77f	905.45d	61.55e	2.290c	41.21e	0.941c	13.05e	0.123b
autumn	0	Myogen	128.01h	1.22g	2806.00h	19.53g	813.00h	57.14h	1.504h	40.57h	0.610h	14.25b	0.215i
		Isaanka	139.94e	1.63f	3467.00c	20.59d	852.00f	64.73d	1.671g	42.43d	0.708g	12.90d	0.216h
		Ginmus	145.00d	0.95i	2756.00i	18.90h	763.00i	55.72i	1.458i	40.44i	0.588i	15.35a	0.225g
	6	Myogen	130.32g	1.66d	3109.00f	20.00e	875.00e	61.38f	1.825e	41.54g	0.758e	12.82e	0.235f
		Isaanka	144.84d	1.78c	3765.00a	20.95b	924.00c	67.35b	2.119d	43.26b	0.915d	11.82g	0.251d
		Ginmus	157.48a	1.05h	2940.00g	18.18i	817.00g	59.95g	1.763f	41.59f	0.733f	13.54c	0.239e
	12	Myogen	131.84f	1.88b	3318.00d	20.63c	979.00b	66.35c	2.392b	42.65c	1.017b	11.58h	0.280c
		Isaanka	153.63c	2.03a	3521.00b	21.56a	1020.00a	70.83a	2.814a	45.45a	1.279a	10.78i	0.305a
		Ginmus	155.03b	1.65e	3175.00e	19.84f	906.00d	61.46e	2.293c	41.94e	0.959c	12.14f	0.281b

* The mean values within column followed by the different letters are significant at 5% level.

Table (7): Effect of interaction between boron foliar application and sunflower genotypes on some growth characters, yield components and quality in both seasons.

seasons	B	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight (g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
spring	0	Myogen	129.15h	1.68e	3042.19f	19.66f	843.44g	56.07g	1.784g	41.58d	0.743f	13.05f	0.096e
		Isaanka	139.26f	1.91b	3443.27c	20.74c	890.79e	61.33e	2.074c	43.97a	0.916c	12.09h	0.108d
		Ginmus	156.50b	1.36f	2929.49i	18.76i	781.60i	54.88h	1.711h	41.53d	0.712g	13.74d	0.096e
	4	Myogen	133.06g	1.72d	3146.75d	20.59d	932.43c	66.48c	2.030cd	40.58e	0.827d	13.74d	0.111cd
		Isaanka	150.35d	2.02a	3872.03a	21.53a	983.71a	74.10a	2.398a	43.10b	1.042a	12.72g	0.130a
		Ginmus	158.79a	1.32g	3010.03g	19.59g	878.79f	63.04d	1.970e	40.50e	0.800e	14.60b	0.114c
	8	Myogen	133.75g	1.68e	3108.94e	20.43e	900.41d	62.91d	1.985de	40.44e	0.805de	14.45c	0.114c
		Isaanka	144.28e	1.81c	3494.87b	21.16b	935.04b	68.41b	2.227b	41.91c	0.938b	13.28e	0.123b
		Ginmus	153.15c	1.29h	2976.96h	18.83h	833.19h	59.81f	1.908f	39.75f	0.759f	15.12a	0.113c
autumn	0	Myogen	127.19f	1.58e	3019.19f	19.43e	838.28f	55.76g	1.76g	42.30d	0.748f	12.15	0.213
		Isaanka	141.74d	1.80b	3432.49c	20.58c	885.64d	61.01e	2.04c	44.69a	0.917c	11.18	0.225
		Ginmus	152.17ab	1.25f	2918.71i	18.61g	777.55h	54.68h	1.68h	42.25e	0.715g	12.83	0.214
	4	Myogen	131.31e	1.61d	3123.97d	20.44cd	929.49b	66.50c	1.99d	41.30f	0.828d	12.83	0.252
		Isaanka	150.53b	1.94a	3849.03a	21.39a	980.77a	73.78a	2.37a	43.81b	1.047a	11.81	0.276
		Ginmus	155.35a	1.21g	2998.14g	19.43e	875.86e	62.95d	1.94e	41.22g	0.803e	13.64	0.261
	8	Myogen	131.67e	1.58e	3090.38e	20.27d	898.58c	62.60d	1.95e	41.15h	0.807e	13.66	0.265
		Isaanka	146.13c	1.71c	3471.87b	21.12b	929.88b	68.10b	2.18b	42.63c	0.936b	12.49	0.271
		Ginmus	150.00bc	1.18h	2954.25h	18.87f	832.26g	59.49f	1.88f	40.49i	0.761f	14.54	0.270

* The mean values within column followed by the different letters are significant at 5% level.

Table (8): Effect of interaction between zinc, boron foliar application and sunflower genotypes on some growth characters, yield components and quality in spring seasons.

Application ($mg.L^{-1}$) zinc	Application ($mg.L^{-1}$) boron	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
0	0	Myogen	125.73n	1.38k	2772.17y	19.37l	769.12w	50.68p	1.526l	40.42hi	0.617l	14.32d	0.088n
		Isaanka	135.06ij	1.77h	3098.75q	20.54g	830.19q	54.66o	1.623l	42.73d	0.693k	13.13h	0.091mn
		Ginmus	149.79e	1.04pq	2713.20yz	18.50p	740.25z	51.06p	1.403m	40.39i	0.567m	15.51b	0.088n
	4	Myogen	130.52m	1.36k	2877.84v	19.90i	853.40p	63.72hi	1.576l	39.51jk	0.623l	15.07c	0.093ln
		Isaanka	139.72h	2.00c	4194.87a	21.15e	885.33n	75.57a	1.770jk	41.65e	0.737ij	13.74e	0.101hj
		Ginmus	152.46d	1.12n	2825.51x	19.50k	793.33u	61.03k	1.570l	39.47jk	0.619l	16.27a	0.100hk
	8	Myogen	133.13jl	1.26m	2836.81w	19.70j	824.80s	57.29m	1.543l	39.62jk	0.611l	15.73b	0.096km
		Isaanka	140.93h	1.42j	3144.16p	20.50g	856.49o	65.23fg	1.753k	40.74gh	0.714jk	14.19d	0.101hk
		Ginmus	149.66e	1.02q	2764.47z	19.16m	767.37x	55.36no	1.533l	39.29k	0.602lm	16.47a	0.099jl
6	0	Myogen	129.93m	1.74i	3072.84r	18.83n	778.13v	56.29n	1.853ik	41.29f	0.765i	13.30gh	0.101gk
		Isaanka	139.26h	1.90e	3723.16d	20.16h	827.20r	61.63k	2.050g	43.72b	0.896g	12.43ij	0.111f
		Ginmus	158.66c	1.33l	2930.23u	17.90q	749.93y	55.32no	1.783jk	41.57ef	0.741ij	13.45fg	0.099jl
	4	Myogen	132.79kl	1.78gh	3178.77m	21.10e	935.51j	66.03f	1.870ij	40.79g	0.762i	13.59ef	0.103gij
		Isaanka	147.00f	1.90e	3834.40b	21.90a	1013.20c	73.03b	2.236f	42.46d	0.949f	12.51ij	0.118e
		Ginmus	160.60bc	1.09o	2986.37s	18.75o	893.67m	64.39gh	1.833jk	40.75gh	0.747ij	14.44d	0.107fh
	8	Myogen	134.46ik	1.80g	3145.83n	20.50g	925.43k	63.09ij	1.853ik	40.38i	0.748ij	14.28d	0.106fi
		Isaanka	144.93g	1.87f	3806.57c	21.26d	947.43i	68.64e	2.160f	41.45ef	0.895g	13.23gh	0.118e
		Ginmus	159.86bc	1.06p	2971.52t	18.44p	819.85t	61.39k	1.776jk	40.29i	0.716jk	15.11c	0.108fg

Application ($mg.L^{-1}$)		genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
zinc	boron												
12	0	Myogen	131.80lm	1.94d	3281.55j	20.80f	983.08f	61.26k	1.973gh	43.04c	0.849h	11.54l	0.098jl
		Isaanka	143.46g	2.06b	3507.90g	21.51c	1015.00b	67.70e	2.550cd	45.46a	1.159c	10.71m	0.124e
		Ginmus	161.06b	1.72i	3145.04o	19.90i	854.62p	58.26l	1.946hi	42.63d	0.829h	12.25j	0.101gk
	4	Myogen	135.86i	2.02c	3383.65h	20.78f	1008.38d	69.70d	2.643c	41.44ef	1.095d	12.57i	0.137cd
		Isaanka	164.33a	2.18a	3586.84e	21.56c	1052.60a	73.70b	3.190a	45.18a	1.441a	11.91k	0.171a
		Ginmus	163.33a	1.77h	3218.22k	20.52g	949.39h	63.69hi	2.506d	41.30ef	1.035e	13.11h	0.135cd
	8	Myogen	133.66jl	2.00c	3344.18i	21.10e	951.00g	68.36e	2.560cd	41.31ef	1.057e	13.35fh	0.141c
		Isaanka	147.00f	2.16a	3533.88f	21.73b	1001.19e	71.36c	2.770b	43.55b	1.206b	12.43ij	0.149b
		Ginmus	149.92e	1.79gh	3194.90l	18.90n	912.35l	62.70j	2.410e	0.959f	0.959f	13.78e	0.132d

* The mean values within column followed by the different letters are significant at 5% level.

Table (9): Effect of interaction between zinc, boron foliar application and sunflower genotypes on some growth characters, yield components and quality in autumn seasons.

Application ($mg.L^{-1}$)		genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
zinc	boron												
0	0	Myogen	124.39l	1.27m	2749.17p	19.31hi	763.96mn	50.25q	1.481l	41.14p	0.609o	13.64	0.203kl
		Isaanka	139.94eh	1.66ij	3109.08j	20.38ef	825.03k	54.23o	1.578k	43.45f	0.685n	12.44	0.197l
		Ginmus	141.34dg	0.93rs	2723.53p	18.34k	738.43o	50.97p	1.358m	41.11q	0.557p	14.82	0.202kl
	4	Myogen	128.96kl	1.25m	2855.51n	19.74gh	854.91j	64.29hi	1.531kl	40.23u	0.615o	14.38	0.221ik
		Isaanka	140.94dg	1.92d	4171.87a	21.02cd	880.17i	75.15a	1.725j	42.37i	0.730km	13.06	0.226hj
		Ginmus	146.23dg	1.01p	2802.51o	19.34hi	788.17l	61.27k	1.525kl	40.19v	0.612o	15.42	0.236fi

Application (mg.L^{-1}) zinc	Application (mg.L^{-1}) boron	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
	8	Myogen	130.68il	1.15o	2813.82o	19.54gh	819.64k	56.87m	1.498l	40.34t	0.603o	14.71	0.221ik
		Isaanka	138.93fi	1.31l	3121.16j	20.34ef	851.34j	64.80h	1.708j	41.46o	0.707mn	13.17	0.226hj
		Ginmus	147.44ce	0.92s	2742.32p	19.00ij	762.21n	54.91o	1.488l	40.01w	0.594o	15.79	0.236fi
6	0	Myogen	127.37kl	1.63k	3049.85k	18.67jk	772.97m	55.87n	1.821i	42.01m	0.764i	12.28	0.224hj
		Isaanka	137.04gj	1.79g	3700.16c	20.00fg	822.04k	61.21k	2.018h	44.44c	0.896g	11.41	0.231gj
		Ginmus	156.10ab	1.22n	2907.23m	17.74l	744.77o	54.90o	1.741j	42.29j	0.736jl	12.43	0.217ik
	4	Myogen	131.01jl	1.67ij	3155.77hi	20.97cd	930.35g	65.60g	1.832i	41.51n	0.759ij	12.57	0.231gj
		Isaanka	148.00cd	1.79g	3811.41b	21.74ab	1008.04b	72.60c	2.211f	43.18h	0.954f	11.49	0.255df
		Ginmus	158.60a	0.97q	2963.37l	18.59jk	888.51i	63.97i	1.808i	41.47o	0.749ik	13.42	0.243eh
	8	Myogen	132.57hk	1.69i	3122.83j	20.34ef	920.27h	62.67j	1.821i	41.10q	0.748ik	13.59	0.249eg
		Isaanka	149.48bc	1.76h	3783.57b	21.10cd	942.27f	68.22f	2.125g	42.17k	0.895g	12.54	0.267d
		Ginmus	157.75a	0.95qr	2948.52l	18.21k	817.38k	60.97k	1.738j	41.01y	0.712lm	14.75	0.257de
12	0	Myogen	129.80jl	1.83f	3258.55g	20.31ef	977.92d	61.17k	1.995h	43.76e	0.872gh	10.52	0.211jl
		Isaanka	148.24cd	1.95c	3488.23e	21.35bc	1009.84b	67.61f	2.538d	46.18a	1.171c	9.69	0.247eg
		Ginmus	159.06a	1.61k	3125.38ij	19.74gh	849.46j	58.17l	1.968h	43.35g	0.852h	11.23	0.222ij
	4	Myogen	133.97gk	1.91de	3360.65f	20.62de	1003.22bc	69.61e	2.631c	42.16k	1.108d	11.55	0.305c
		Isaanka	162.66a	2.10a	3563.84d	21.40bc	1054.11a	73.61b	3.178a	45.90b	1.458a	10.89	0.347a
		Ginmus	161.22a	1.66j	3228.55g	20.36ef	950.90ef	63.60i	2.495d	42.02lm	1.047e	12.09	0.302c
	8	Myogen	131.77il	1.89e	3334.51f	20.94cd	955.84e	68.27f	2.548d	42.03l	1.070e	12.66	0.324b
		Isaanka	150.00bc	2.05b	3510.88e	21.90a	996.03c	71.27d	2.725b	44.27d	1.205b	11.74	0.321bc
		Ginmus	144.81cf	1.68ij	3171.91h	19.41hi	917.19h	62.61j	2.414e	40.45s	0.975f	13.08	0.317bc

* The mean values within column followed by the different letters are significant at 5% level.

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Table (10): Analysis of variance F values for some growth characters, yield and yield components and quality in spring and autumn seasons.

S.O.V	D.f	M.S. for spring season										
		plant height (cm)	stem diameter (cm)	leaf area (cm^2\plant)	head diameter (cm)	no. of seeds/head	1000 seeds weight(g.)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
Replications	2	36.012346	0.00029259	0.001	0.0042259	0.3929	0.3712	0.00199	0.50644	0.00060	0.0238	0.000018
A	2	470.2353**	2.341559**	831976.7**	7.55727	167034.10**	323.53**	5.7947**	32.726**	1.2604**	43.314**	0.00947**
B	2	229.7648**	0.058581**	302543.2**	4.87290**	58595.77**	746.55**	0.5342**	18.708**	0.0667**	11.893**	0.00281**
C	2	3943.471**	2.411433**	3009271.8**	29.4608**	75483.29**	539.36**	1.0453**	46.500**	0.3364**	21.805**	0.00154**
A × B	4	90.6978**	0.064307**	123599.1**	1.38072**	10347.06**	39.78**	0.2155**	0.5950**	0.0365**	0.297**	0.00088**
A × C	4	82.3129**	0.156287**	194304.6**	1.07049**	586.093**	12.38**	0.0723**	2.2315**	0.029**	0.659**	0.00034**
B × C	4	87.7920**	0.027525**	115289.1**	0.32599**	204.252**	12.73**	0.0108**	0.7458**	0.004**	0.0589*	0.000061**
A×B × C	8	24.8668**	0.030140**	107462.3**	0.56971**	1781.679**	7.852**	0.0188**	0.3987**	0.003**	0.124**	0.000052**
Error	52	1.43542	0.0001669	0.01	0.0019605	0.5648	0.31774	0.00294	0.03730	0.00052	0.02295	0.0000122
Total	80											
S.O.V	D.f	M.S. for autumn season										
Replications	2	144.294734	0.94792119	52857.281	2.4386096	3104.9623	23.5968	0.24340	42.0336	0.00878	99.9594	0.0644507
A	2	604.0933**	2.334880**	812396.9**	8.70827**	173154.15**	332.71**	6.2905**	32.875**	1.3940**	47.979**	0.034348**
B	2	196.2529**	0.065017**	294486.7**	5.36763**	61056.07**	765.48**	0.5081**	18.624**	0.0668**	15.379**	0.021457**
C	2	3612.997**	2.473979**	2992165.4**	28.6054**	73005.13**	524.92**	1.0053**	46.371**	0.3330**	23.041**	0.001412**
A × B	4	104.2184**	0.067798**	113856.8**	1.09871**	9626.48**	45.490**	0.1931**	0.5735**	0.0340**	0.9015**	0.004499**
A × C	4	127.9765**	0.159171**	203746.2**	1.18666**	503.34**	11.270**	0.0612**	2.1936**	0.0266**	0.7011**	0.000650**
B × C	4	49.440590*	0.035110**	110751.7**	0.2046*	272.07**	12.044**	0.0139**	0.7403**	0.0050**	0.095 ns	0.000213ns
A×B × C	8	41.130801*	0.031339**	107302.7**	0.44575**	1878.96**	7.2241**	0.0200**	0.3851**	0.0036**	0.152 ns	0.0002520*
Error	52	16.71689	0.00025303	345.32	0.0756278	31.6701	0.188265	0.001155	0.000075	0.000201	0.108740	0.00011201
Total	80											

*,** Significant at the 0.05 and 0.01 probability levels, respectively. and n.s. not significant.

Vannozzi, *et al.* (1988); Faizani *et al.* (1990); Prasad, (1991); Villalobos *et al.* (1994); Herdem, (1999); Castro *et al*, (2000) and Nel, (2001). It could be concluded that maximizing seed and oil yields per unit area could be achieved by sowing sunflower Issanka genotype with adding zinc dose of 12 mg.L^{-1} and boron with concentration of 4 mg.L^{-1} under the environmental conditions of the west north region of Mosul city at Nineveh Governorate.

تأثير الرش الورقي بالزنك والبورون في نمو وحاصل ونوعية بعض التراكيب الوراثية من زهرة الشمس

(*Helianthus annuus* L.)

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الخلاصة

أجريت تجربة حقلية أثناء فصلي النمو الربيعي والخريفي من العام 2009 لدراسة تأثير الرش الورقي بعنصري الزنك والبورون في صفات النمو ومكونات الحاصل والنوعية لبعض التراكيب الوراثية من زهرة الشمس (*Helianthus annuus* L.). تضمنت التجربة ثلاثة إضافات لعنصري الزنك (صفر و 6 و12 ملغم زنك.لتر$^{-1}$) والبورون (صفر و4 و8 ملغم بورون.لتر$^{-1}$) وثلاثة تراكيب وراثية من زهرة الشمس (ميوجين، اسنكا وجنمس) نفذت وفق نظام التجارب العاملية بتصميم القطاعات العشوائية الكاملة.

ويمكن تلخيص النتائج الرئيسة بالاتي: أدى الرش الورقي بعنصر الزنك بتركيز 12 ملغم زنك.لتر$^{-1}$ إلى زيادة معنوية في ارتفاع النبات، قطر الساق، المساحة الورقية، قطر القرص الزهري، عدد البذور.قرص$^{-1}$، وزن الألف بذرة، حاصل البذور الكلي (طن.هكتار$^{-1}$)، نسبة الزيت وحاصلي الزيت والبروتين (طن.هكتار$^{-1}$)، بينما سبب زيادة تركيز الزنك إلى 12 ملغم زنك.لتر$^{-1}$ انخفاض معنوي في نسبة البروتين في البذور في الموسمين الربيعي والخريفي. أدى إضافة عنصر البورون رشا على أوراق النبات بتركيز 4 ملغم بورون.لتر$^{-1}$ إلى زيادة معنوية في ارتفاع النبات، قطر الساق، المساحة الورقية، قطر القرص الزهري، عدد البذور.قرص$^{-1}$، وزن الألف بذرة، حاصل البذور الكلي (طن.هكتار$^{-1}$)، نسبة الزيت وحاصلي الزيت والبروتين (طن.هكتار$^{-1}$)، بينما زيادة تركيز البورون إلى 8 ملغم بورون.لتر$^{-1}$ سبب زيادة معنوية في نسبة البروتين في البذور في كلا الموسمين الربيعي والخريفي. تشير النتائج بأن التركيب الوراثي اسنكا أعطى أعلى قيم لصفات قطر الساق، المساحة الورقية، قطر القرص الزهري، عدد البذور.قرص$^{-1}$، وزن الألف بذرة، حاصل البذور الكلي (طن.هكتار$^{-1}$)، نسبة الزيت وحاصلي الزيت والبروتين (طن.هكتار$^{-1}$) في كلا الموسمين الربيعي والخريفي. حقق التداخل الثلاثي بين التركيب الوراثي اسنكا × الرش الورقي بالزنك بتركيز 12 ملغم زنك.لتر$^{-1}$ × رش البورون على أوراق النبات بتركيز 4 ملغم بورون.لتر$^{-1}$، أعلى متوسط للصفات: ارتفاع النبات وقطر الساق وعدد البذور في القرص وحاصل البذور الكلي (طن.هكتار$^{-1}$) وحاصلي الزيت والبروتين لكلا الموسمين. عموماً، يمكن الاستنتاج بان أعلى حاصل كلي من البذور وحاصل الزيت في وحدة المساحة يمكن أن يتحقق بزراعة التركيب الوراثي اسنكا وإضافة الزنك على أوراق النبات بتركيز 12 ملغم.لتر$^{-1}$ والبورون بتركيز 4 ملغم.لتر$^{-1}$ تحت الظروف البيئية لهذه الدراسة.

الكلمات الدالة: الرش بالزنك والبورون، تراكيب وراثية من زهرة الشمس *Helianthus annuus* L..

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