Influence of Zinc Fertilization levels on Growth, Yield and Quality of Some Sunflower Genotypes (*Helianthus annuus L.*)

Dr. Saad A. M. Al-Doori **Dr. Moaid Y. H. Al-Dulaimy**
Department of Science
College of Basic Education / University of Mosul

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Abstract:

The study included two field experiments for (*Helianthus annuus L.*) conducted during spring growing seasons of 2009, 2010 in two locations. The first Sheikh Mohamed 25km west north Mosul city, the second ones Gueer 50 Km east of Mosul city at Nineveh province .The main objective was to find out effect of zinc foliar application on the growth, yield and quality of some Sunflower genotypes. Each experiment was conducted according to factorial experiment in a randomized completely block design with three replications. Each experiment included three levels of zinc foliar application (0, 5 and 10 $mg.L^{-1}$) were sprayed on the leaves one dose during 6 leaves stage, with three genotypes of Sunflower crops (Record, Mlabar and Fodak). The genotype Mlabar gave a high level for characters Plant height (161,152 cm), stem diameter(2.06,2.20cm), leaf area index(1.78,1.74), dry weight of the head, head diameter flower disc (21.90 , 22.20 cm), number of seeds/head, weight of thousand seed, total seed yield (2.49, 2.49 $ton.hectar^{-1}$), oil percentage (43.33 , 44.01 %) and oil yield (1.07, 1.09 ton/ha.) in both locations Sheikh Mohamed and Gueer respectively. The foliar application the zinc to the leaves with concentration 10 $mg.L^{-1}$ lead to a significant increase in plant high (173.55, 163.63cm), while increasing concentration of zinc to 5 $mg.L^{-1}$ cause a significant increase in number of leaves/plant, leaf area index, dry weight for flower disc, disc diameter (22.32, 22.87 cm) , number of seeds/head, weight of thousand seed, seed yield (2.73, 2.72 $ton.hectar^{-1}$) and oil (%), oil yield (1.22,1.24 $ton.hectar^{-1}$) in Sheikh Mohamed and Gueer locations respectively. The interaction between the genotypes and foliar application was significant in some of growth, yield and quality characters, the Mlabar genotype with zinc application to the leaves with concentration 5 $mg.L^{-1}$ was superior for head diameter (22.92 , 23.27 cm), thousand seed weight (82.63 , 81.53 g), oil yield (1.33, 1.30 $ton.hectar^{-1}$) for the Sheikh Mohamed and Gueer locations respectively.

تأثير مستويات التسميد بالزنك في نمو وحاصل ونوعية بعض التراكيب الوراثية من زهرة الشمس (*Helianthus annuus L.*)

د.سعد احمد محمد الدوري   د.مؤيد يونس حسن الدليمي
قسم العلوم
كلية التربية الأساسية/ جامعة الموصل

ملخص البحث:

تضمنت الدراسة تجربتين حقليتين لمحصول زهرة الشمس(*Helianthus annuus L.*) للموسم الربيعي من العام 2009 و2010 في موقعين مختلفين ضمن محافظة نينوى هما الشيخ محمد الذي يبعد حوالي (25كم) شمال غرب مدينة الموصل وموقع الكوير والذي يبعد حوالي (50كم) شرق مدينة الموصل . تهدف الدراسة معرفة تأثير الرش الورقي بعنصر الزنك في نمو وحاصل ونوعيه بعض التراكيب الوراثية من زهرة الشمس.

نفذت كل من التجربتين وفق نظام التجارب العاملية بتصميم القطاعات العشوائية الكاملة بثلاث مكررات لكل تجربة . تضمنت كل تجربة ثلاث تراكيز من الزنك (صفر، 5 و 10 ملغم.لتر$^{-1}$) أضيفت على أوراق النباتات دفعة واحدة عند طور تكوين ستة أوراق وثلاثة تراكيب وراثية من محصول زهرة الشمس (ريكورد، مالبار وفوداك).

أعطى التركيب الوراثي مالبار أعلى معدل للصفات في ارتفاع النبات(161و152سم)، قطر الساق (2.06 و 2.20سم) ،دليل المساحة الورقية (1.78 و 1.74)، الوزن الجاف للقرص الزهري ،قطر القرص الزهري (21.90 و 22.20 سم)، عدد البذور/قرص ،وزن الألف بذرة، حاصل البذور الكلي (2.49 و 2.49 طن.هكتار$^{-1}$)، نسبة الزيت (44.01 و 43.33٪) وحاصل الزيت (1.07 و 1.09 طن.هكتار$^{-1}$) في موقعي الشيخ محمد والكوير على التوالي. أدى رش الأوراق بالزنك بتركيز 10 ملغم.لتر$^{-1}$ إلى زيادة معنوية في ارتفاع النبات (173.55 و 163.63سم)، في حين سبب زيادة تركيز الزنك إلى 5 ملغم.لتر$^{-1}$ إلى زيادة عدد الأوراق/نبات، دليل المساحة الورقية، الوزن الجاف للقرص الزهري، قطر القرص الزهري (22.32 و 22.87سم)، عدد البذور/قرص، وزن الألف بذرة، حاصل البذور الكلي (2.73 و 2.72 طن.هكتار$^{-1}$) ونسبة وحاصل الزيت (1.24 و 1.24 طن.هكتار$^{-1}$) في موقعي الشيخ محمد والكوير على التوالي. أثر التداخل بين التراكيب الوراثية والرش بعنصر الزنك معنوياً في البعض من صفات النمو والحاصل والنوعية، تفوق التركيب الوراثي مالبار عند رش الزنك بتركيز 5 ملغم.لتر$^{-1}$ بإعطائه أعلى قيمة لكل من قطر القرص الزهري (22.92 و 23.27 سم)، وزن الألف بذرة (82.63 و 81.53غم) وحاصل الزيت (1.30 و 1.33طن.هكتار$^{-1}$) لموقعي الشيخ محمد والكوير على التوالي.

Introduction:

Sunflower oil is described with high nutritive and biological value as well as very good taste quality. These qualities make the oil daily and irreplaceable component from the table of the mankind (Voynar, 1960). Data show that the consumption of sunflower oil in the world increases every year (Sangoi and Kruse,1993). At the same time it is paid great attention to ecologically clean production of sunflower seed (Karimian Teherani *et al*., 1983; Pacyna, 1987; Kastori *et al.*, 1998), oil (Zehra *et al.*, 2007; Gorlach and Gambus, 1992; Korenovska and Polacekova, 2000; Reeves, 2001; Khurana and Chatterjee, 2001) and margarine (Iskander, 1995).

foliar application is an effective way to move nutrients better within the plant and its contribution to the natural growth of the plant also meets the requirements of crop nutrients during the stages of growth (Martin, 2002). The addition of nutrients in a spray on the leaves is an economic process compared to adding nutrients to the soil because the foliar application is useful from the practical side, under conditions where the absorption of these elements from the soil is restricted and which are more often installed by soil particles, causing the reduction of readiness of the plant (Auld, 2001). Foliar application is also important in the operations of leaching, and absorption, and experienced by the nutrients added to the soil (El-fouly *et al.*, 2001).

Micronutrients deficiencies and their impacts on crop yields are widely reported in various parts of the world (Tahsin and Yankov, 2007). As much as 48% of soils in the world are Zn deficient whereas crops showed significant responses to Zn fertilization in nearly 72% field experiments due to widespread hidden hunger. Correction of micronutrient deficiency requires the application of high doses of fertilizer to soils because of low nutrient used efficiency (Cui *et al.*, 2004). Foliar sprays have limitations because they ameliorate deficiencies in crops only at a later growth stage when crops have sufficient foliage to receive the spray. Band placements have similar limitations to soil applications of critical micronutrients at early stages of seedling development (Gitte *et al.*, 2005). However, seed treatment is found to be a better option as it requires micronutrient fertilizer in lesser quantities, it is easy to operate and it provides micronutrients around the vicinity of newly emerging seedlings which support the emergence of a vigorous seedling and better establishment and growth (Singh, 2003). Continuous cropping with high yielding genotypes and improved package of practices depletes the soil nutrients through increased production. Of the various micronutrients, Zn is the most limiting because of its wide spread deficiency. Zinc is essential for synthesis of proteins and auxing in plants and it activates many enzymes such as proteinase and peptidases. In view of the importance of Zn in crop production, it is normally applied to oilseed crops (Chhotu *et al.*, 2008 ; Marie and Howarth , 2009). So, the objective of this trial was to study effect of three zinc foliar application on growth, yield and certain quality trials of three Sunflower genotypes.

Materials and Methods:

Tow filed experiments were carried out during 2009, 2010 season at the experimental farm, first Sheikh Mohamed 25km west north Mosul city, the second Gueer 50 Km east of Mosul city at Nineveh province, to investigate the effect of three levels of zinc foliar application (0, 5 and 10 $mg.L^{-1}$) on the growth, yield and certain quality trials of three Sunflower genotypes (Record, Mlabar and Fodak). Each experiment included twenty seven treatments comprising the combinations of three genotypes and three zinc foliar application with three replications.

Seeds of these genotypes were obtained from the crops industrial company, Baghdad. The experimental design was factorial experiment in a Randomized Completely Block Design with three replications according to Gomez and Gomez (1984).Then Duncan's multiple range test (Duncan, 1955) was used to compare among means (SAS ,2001). A representative soil sample(0-30 and 30-60 cm) was taken before planting, (Table1) to determine some physical, chemical and nutritional properties used. Stones and plant tissues were carefully removed from the soil prior to drying process under laboratory condition. The soil was screened through 2mm stainless steel sieve, and stored in a plastic bag at room temperature until use. Concentration of Zn was measured by atomic absorption spectrophotometer with wave length 213.9nm. (APHA, 1998).Soil texture was determined by the hydrometer method. The pH and electrical conductivity (EC) were measured after 20 min of vigorous mixing samples at 1:2.5 (solid: deionized water) ratio. Available nitrogen, available phosphorus, available K and total $CaCO_3$ were determined according to the standard methods description by Black,1965, Page *et al.*, 1982 and Tandon, 1999. In addition, the organic matter was determined by using Black method (Jackson, 1973).

Seeds were sown in April 5th and 10th 2009, 2010 for two locations respectively, in hills 30 cm apart on ridges 60 cm apart. Super phosphate 150kg/hectar (45%P_2O_5) and potassium (48%K_2O) were applied (50 kg/hectar) in two equal doses, to the soil during the sowing period and the second half was added after one and half month after sowing, Nitrogen fertilizers was applied in the form of Urea 80kg hectar (46%N) in two equal doses, half with sowing and the remaining half after thinning.

Zinc were sprayed on the leaves one dose during 6 leaves stage at a rate of (0, 5 and 10 $mg.L^{-1}$) as zinc sulphate ($ZnSo_4.7H_2o$) (35% Zn). Each plot 18 M^2 included six rows 60cm apart and five meters long. The plant were thinned to one plant/hill 14 days after sowing .The external two rows were left as porder. Two of the remaining rose were devoted for estimating plant growth and some characteristics. The first irrigation was applied after 7 days from sowing and after wards irrigation was scheduled at about five days intervals. Normal cultural practices of growing Sunflower were conducted in the usual manner followed by the farmers of the district. At heading , the heads of the two inner rows were bagged at early seed development to avoid birds damage until maturity.

Table -1-: The physical and chemical characters of soil filed experiments in both locations.

physical characters				
Locations	Sheikh Mohamed		Gueer	
Depth (cm.)	0-30	30-60	0-30	30-60
Sand (%)	60.00	52.00	45.00	41.00
Silt (%)	23.00	29.00	35.00	31.00
Clay (%)	17.00	19.00	20.00	28.00
Texture	Sandy loom	Sandy loom	Silty sandy	Silty sandy loom
chemical characters				
O.M. $mg.kg^{-1}$	1.05	0.86	1.46	0.98
Available N ppm	50.25	35.98	42.56	22.97
Available P ppm	15.45	10.12	13.73	9.51
Available K ppm	178.00	162.00	121.00	112.00
Total $CaCo_3$ $mg.kg^{-1}$	28.50	26.80	18.20	16.10
Available Zn ppm	18.26	12.88	14.62	11.40
pH	7.85	7.63	7.23	7.15
E.C. $mmhos.cm^{-1}$	0.72	0.61	0.96	0.88

The studied characters were:

1- Growth characters:

Sample of ten guarded plants each was taken from each treatment at 105 days after sowing. The following data were record:

plant height (cm), stem diameter (cm), no. of leaves/plant, leaf area index, head dry weight/plant (g.)and head diameter (cm).

2- Yield, yield components and quality:

At harvest, ten guarded plants were taken randomly from the two inner rows of each experimental plot and left for two weeks until fully air dried, then the following data were measured; number of seeds/head, 1000 seeds weight (g.), hulls (%), fertility (%), yield and oil yield ($ton.hectar^{-1}$). Oil seed content was determined using Soxhlet method (A.O.A.C.,1980).

Results and Discussion:
1- Effect of genotypes:
A- Growth characters:

In this study, all investigated characteristics were significantly affected by sowing dates (table 10). Data in table (2) revealed that Mlabar genotype had taller (161.65, 152.35 cm) and thicker (2.06, 2.20 cm) plant then those of Record and Fodak in both locations Sheikh Mohamed and Gueer respectively. The result of number of leaves per plant showed that the Fodak genotype significantly exhibited higher number of leaves (21.98, 22.12) than those of Record and Mlabar genotypes in the two locations respectively.

The differences among the three genotypes in the number of leaves may be attributed to the general varietals differences in the Plant height and number of internodes per plant (Blamey *et al.*, 1979; Mohamed *et al.*, 1992; Sangoi and Kruse 1993; Abd EL-Samie *et al.*, 1995). Moreover, the differences in leaf area index may be attributed to the differences in leaf area per plant. In this concern, (Salama, 1996) showed that taller genotypes had more leaves and leaf primordial that the others sunflower cultivars. It can also noted that the head dry weight and head diameter of Mlabar genotype out weighed Record and Fodak in a descending order at both locations.

The superiority of Mlabar genotype in the dry matter production may be attributed to having the tallest and thickest plants, and as well the highest area of photosynthetic leaves and this in turn increased the capacity of dry matter accumulation in the different plant parts. In this report, Prunty, (1981), Awad and Griesh, (1992), Abou-Kresha *et al.*, (1996), and Ibrahim *et al.*, (2003) reported that fodak genotype had highest head dry weight per plant than the euro flower and mlabar genotypes.

Table -2-: Effect of sunflower genotypes on some growth characters in both locations.

locations	genotypes	plant height (cm)	stem diameter (cm)	no. of leaves/plant	leaf area index	head dry weight/plant (g.)	head diameter (cm)
Sheikh Mohamed	Record	157.77c	2.03b	21.79c	1.74c	35.47c	20.84b
	Mlabar	161.65a	2.06a	21.93b	1.78a	37.21a	21.90a
	Fodak	161.08b	2.04b	21.98a	1.76b	36.67b	21.29c
Gueer	Record	149.46b	2.15b	21.82b	1.68b	35.74c	21.13c
	Mlabar	152.35a	2.20a	21.76c	1.74a	37.36a	22.20a
	Fodak	152.77a	2.14b	22.12a	1.73a	36.69b	22.06b

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

B- Yield, yield components and quality:

Mean values of seed yield, yield components and some related traits for the three tested genotypes are presented in table (3). The data revealed that Mlabar genotype surpassed Record and Fodak genotypes in the head characteristic (head dry weight/plant, head diameter, no. of seeds/head, 1000 seeds weight), Moreover, Fodak surpassed Record in those traits in both locations. This means that Mlabar plants were more efficient to accumulate dry mater in their head .

Regarding to the seed characters studied i.e., 1000 seeds weight, hulls, fertility and oil percentage, data show that there were significant variations among the three tested Sunflower genotypes in both locations.

Mlabar genotype surpassed significantly Record and Fodak genotypes in no. of seeds/head(1058.77, 1032.29), 1000 seeds weight, yield and oil yield (2.49, 2.49; 1.07, 1.09 ton.hectar^{-1}) in both locations respectively. However, fertility seeds percentage showed fluctuated direction from tow locations. Where Fodak genotype was the highest in both locations. On the other hand, Mlabar genotype was the medium in both locations.

The superiority of Mlabar genotype in the most seed characters with excepted hulls percentage may be due to that Mlabar genotype had better vegetative growth and hence photosynthetic area which led to more carbohydrates which was translocated from the source (leaves and stem) to the sink (seeds) (Mengel and Kirkby, 1982: Zehra *et al.*, 2007 and Al-Doori and Al-Dulaimy 2012). The results showed that no. of seeds/head, 1000 seeds weight and yield, oil yield (ton.hectar^{-1}) were always significantly higher for Mlabar than that for Record and Fodak genotypes.

Table -3-: Effect of Sunflower genotypes on yield, yield components and quality in both locations.

locations	genotypes	no. of seeds/head	1000 seeds weight (g.)	hulls (%)	fertility (%)	yield (ton/ha.)	oil (%)	oil yield (ton.ha^{-1})
Sheikh Mohamed	Record	971.14b	65.09c	57.23a	87.09b	2.27c	43.76a	0.99c
	Mlabar	1058.77a	75.99a	55.80b	88.38b	2.49a	43.33a	1.07a
	Fodak	965.08b	71.35b	54.82b	89.83a	2.38b	42.28b	1.00b
Gueer	Record	939.46c	63.83c	58.07a	89.05b	2.23b	44.69a	0.99c
	Mlabar	1032.29a	74.26a	56.50b	90.01a	2.49a	44.01b	1.09a
	Fodak	994.87b	68.68b	55.46b	90.65a	2.41a	42.84c	1.03b

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

2- Effect of zinc foliar application:

A- Growth characters:

Data presented in table (4) showed that increasing zinc foliar application from 0 to 5 $mg.L^{-1}$ significantly increased stem diameter, no. of leaves/plant, leaf area index, head dry weight/plant and head diameter at the both locations, while they appeared to be negative response to 10 $mg.L^{-1}$ for those traits. This could be attributed to the high available of zinc in the experimental site in the both locations (table1). The beneficial effect of zinc on plant height may be due to its essential for synthesis of proteins and auxing in plants and it activates many enzymes such as proteinase and peptidases. In this concern, increasing zinc fertilizer levels increased plant height as was found by Abd Elnaim (1983); Douglas and Beegle (2001); Sankaran *et al.*, (2001); Beyersmann and Haase (2002); Gitte *et al.*, (2005); Martin *et al.*, (2007); Chhotu *et al.*, (2008); Marie and Howarth (2009).

The number of leaves per plant, leaf area index were increased significantly with the addition of zinc foliar application up to 5 $mg.L^{-1}$ compared to the check and the high level of zinc in the both locations. However, increasing zinc foliar application up to 10 $mg.L^{-1}$ had low significant effect on those traits. These results means that zinc application up to 5 $mg.L^{-1}$ was great enough to increase the number of leaves/plant and leaf blade area. These findings confirmed those obtained by Bron and Zhan (1993); Auld (2001); El-fouly *et al.*, (2001); Kathirresan *et al.*, (2001); Cui *et al.*, (2004); Alloway (2004); Sharma (2006); Mirzapour and Khoshgoftar (2006); Chhotu *et al.*, (2008) who found that the application of 15 mg $Zn.L^{-1}$ increased sunflower leaf area/plant and number of leaves per plant.

It can be observed also that the highest head dry weight/plant was found in the plant fertilized with 5 $mg.L^{-1}$ compared to the check and 10 $mg.L^{-1}$ in the both locations.

The stimulatory effect of zinc in sunflower plant may be due to its role in enhancing metabolic process. These results are in harmony with those obtained by Chhotu *et al.*, 2008; Marie and Howarth, 2009.

Table -4-: Effect of zinc foliar application on some growth characters of sunflower in both locations.

locations	Zn Application (mg.L^{-1})	plant height (cm)	stem diameter (cm)	no. of leaves/plant	leaf area index	head dry weight/plant (g.)	head diameter (cm)
Sheikh Mohamed	0	148.09c	3.49a	21.91b	1.72b	36.34b	21.44b
	5	158.87b	2.35b	22.12a	1.91a	38.03a	22.32a
	10	173.55a	1.73c	21.66b	1.65c	34.99c	20.27c
Gueer	0	142.58c	1.96b	21.72b	1.69b	36.73b	22.15a
	5	148.37b	2.59a	22.24a	1.84a	38.20a	22.87a
	10	163.63a	1.93b	21.75b	1.61b	34.86c	20.37b

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

B- Yield, yield components and quality:

Data reported in table (5) demonstrated that the number of seeds per head significantly increased by increasing zinc application from 0 to 5 (mg.L^{-1}) in the both locations. Many researchers concluded that increasing zinc rates increased number of seeds per head (Bron and Zhan (1993); Auld (2001); Beyersmann and Haase (2002); Cui *et al.*, (2004); Gitte *et al.*, (2005); Mirzapour and Khoshgoftar (2006); Martin *et al.*, (2007); Chhotu *et al.*, (2008); Marie and Howarth (2009).

The obtained data show that 1000 seeds weight, hulls, fertility, total yield and oil yield were increased significantly as the zinc application was increased from 0 to 5 mg.L^{-1} in the two locations. These results are in agreement with those reported by Milutinoc, and Stanojevic (1988) who reported that zinc application increased seed yield to 40 % . Lindsay (1996) found that the increases in yield through zinc application may be duo to the increase in the plant internal translocation capacity and auxing in plants and it activates many enzymes such as proteinase and peptidases. Similar results were obtained by Chhotu *et al.*, (2008) who found that head dry weight/plant, head diameter, no. of seeds/head , 1000 seeds weight and oil yield were increased with increasing zinc application from 0 to 20 mg.L^{-1}. On the contrary, The fertility percentage and seed oil percentage were decreased with increasing zinc application up to 10 mg.L^{-1}. The decrease in the fertility seed may attributed to more photo assimilate translocation to the seeds by increasing zinc concentration. However, The decrease in seed oil contents by zinc application may be duo to the increase in seed protein content at the expense of oil concentration (Bron and Zhan (1993); Cui *et al.*, (2004); Sharma (2006); Mirzapour and Khoshgoftar (2006); Chhotu *et al.*, (2008). In this concern, Many researchers reported that the zinc application to sunflower plant caused a reduction in seed oil percentage (Alloway, 2004; Marie and Howarth (2009).

Table -5-: Effect of zinc foliar application on yield, yield components and quality in both locations.

locations	Zn Application ($mg.L^{-1}$)	no. of seeds/head	1000 seeds weight (g.)	hulls (%)	fertility (%)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)
Sheikh Mohamed	0	1019.97b	69.52b	55.21b	88.11b	2.22b	42.48b	0.94b
	5	1067.26a	75.91a	57.83a	90.40a	2.73a	44.80a	1.22a
	10	968.05c	67.00b	54.80b	86.57c	2.18b	42.09c	0.91c
Gueer	0	994.68b	67.70b	55.88b	89.79b	2.25b	43.08b	0.96b
	5	1036.03a	74.55a	58.62a	91.62a	2.72a	45.88a	1.24a
	10	935.30c	64.52c	55.44b	88.29b	2.15c	42.58c	0.91c

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

3- Effect of interaction between genotypes and zinc foliar application:

A- Growth characters:

The interaction between the studying factors (genotypes and zinc application) showed significant effects on plant height, head dry weight/plant in Sheikh Mohamed location, leaf area index in Gueer location and head diameter in both locations as illustrated in tables (6,7). The interaction between the genotypes and zinc fertilization for the other investigated traits were not statistically significant in both locations, therefore the data were excluded .

Data illustrated in tables (6,7) show generally that Record, Mlabar and Fodak genotypes appeared to be clearly affected by increasing rate of zinc fertilization levels up to 5 $mg.L^{-1}$. for plant height, stem diameter, no. of leaves/plant, leaf area index, head dry weight/plant and head diameter, while they appeared to be little response to 10 $mg.L^{-1}$ for those traits. On the other hand, Mlabar genotype reflected the greatest response to zinc foliar application up to 5 $mg.L^{-1}$ for these traits, with this regard, Auld (2001); Douglas and Beegle (2001); Kathirresan *et al.*, (2001); Sankaran *et al.*, (2001); Beyersmann and Haase (2002); Cui *et al.*, (2004); Alloway (2004); Gitte *et al.*, (2005); Sharma (2006); Mirzapour and Khoshgoftar (2006); Martin *et al.*, (2007); Chhotu *et al.*, (2008); Marie and Howarth (2009) and Al-Doori and Al-Dulaimy (2012), 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 zinc foliar application on other characteristic showed that each of these two factors acted independently on these traits.

Table -6-: Effect of interaction between genotypes and zinc foliar application levels on some growth characters in Sheikh Mohamed location.

genotypes	Zn Application (mg.L^{-1})	plant height (cm)	stem diameter (cm)	no. of leaves/plant	leaf area index	head dry weight/plant (g.)	head diameter (cm)
Record	0	144.92e	2.03	21.83	1.68	35.22f	20.76e
	5	155.67c	2.32	22.03	1.89	37.00c	21.82cd
	10	172.73a	1.74	21.52	1.65	34.21g	19.94f
Mlabar	0	149.54d	2.05	21.92	1.75	37.14c	22.02bc
	5	160.72a	2.41	22.14	1.93	38.77a	22.92a
	10	174.71a	1.72	21.75	1.68	35.72e	20.77e
Fodak	0	149.82d	2.05	22.00	1.73	36.67d	21.55d
	5	160.22b	2.32	22.21	1.91	38.32b	22.23b
	10	173.21a	1.75	21.73	1.64	35.04f	20.11f

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

Table -7-: Effect of interaction between genotypes and zinc foliar application on some growth characters in Gueer location.

genotypes	Zn Application (mg.L^{-1})	plant height (cm)	stem diameter (cm)	no. of leaves/plant	leaf area index	head dry weight/plant (g.)	head diameter (cm)
Record	0	140.00	1.94	21.65	1.63d	35.48	21.16e
	5	146.60	2.62	21.89	1.84b	37.32	22.37c
	10	161.78	1.89	21.94	1.58e	34.42	19.88h
Mlabar	0	143.12	1.98	21.83	1.73c	37.47	22.48c
	5	149.30	2.53	21.98	1.86a	38.86	23.27a
	10	164.65	1.92	21.48	1.63d	35.76	20.86f
Fodak	0	144.62	1.98	21.69	1.72c	37.24	22.82d
	5	149.23	2.63	22.86	1.84b	38.43	22.98b
	10	164.48	1.99	21.83	1.63d	34.42	20.38g

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

B- Yield, yield components and quality:

The interaction between genotypes and zinc foliar application was significant for hulls, yield (ton.hectar^{-1}) and oil (%) in Sheikh Mohamed location, fertility (%) in Gueer location and1000 seeds weight (g.), oil yield (ton.hectar^{-1}) in both locations. Data illustrated in tables (8,9) indicated that1000 seeds weight, yield (ton.hectar^{-1}) and oil content of Mlabar genotype clearly responded to the zinc foliar application up to 5 mg.L^{-1}. On the other hand, the response rate of Record and Fodak genotypes to zinc application was low with increasing zinc fertilization levels more than 5 mg.L^{-1} for the most of these traits. It could be concluded that the tallest genotypes i.e. Mlabar responded positively to high concentration of zinc application compared the shorter genotypes i.e. Record and Fodak (Ibrahim *et al.*, 2003).

Table -8-: Effect of interaction between genotypes and zinc fertilization levels on the yield, yield components and quality in Sheikh Mohamed location.

genotypes	Zn Application ($mg.L^{-1}$)	no. of seeds/head	1000 seeds weight (g.)	hulls (%)	fertility (%)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)
Record	0	968.87	63.64g	56.18d	87.02	2.16h	43.22d	0.93d
	5	1026.32	69.22e	59.08a	89.15	2.56c	44.89b	1.14c
	10	919.12	62.43h	56.43d	85.10	2.09i	43.17d	0.90e
Mlabar	0	1058.23	74.26c	55.27e	87.99	2.38d	42.26e	1.00c
	5	1109.23	82.63a	57.66b	90.38	2.84a	45.86a	1.30a
	10	1008.85	71.09d	54.47f	86.78	2.26g	41.88e	0.94cd
Fodak	0	1032.82	70.68d	54.18g	89.34	2.14e	41.98e	0.89f
	5	1066.24	75.88b	56.77c	91.68	2.79b	43.66c	1.21b
	10	976.18	67.49f	53.51h	87.83	2.21g	41.22f	0.91e

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

Table -9-: Effect of interaction between genotypes and zinc fertilization levels on yield, yield components and quality in Gueer location.

genotypes	Zn Application ($mg.L^{-1}$)	no. of seeds/head	1000 seeds weight (g.)	hulls (%)	fertility (%)	yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)
Record	0	942.86	62.97e	57.08	88.73g	2.12	43.93	0.93d
	5	996.21	67.75d	60.11	91.02c	2.53	46.58	1.14c
	10	879.32	60.78f	57.04	87.42i	2.04	43.56	0.90e
Mlabar	0	1038.39	72.35c	55.69	90.08e	2.36	42.93	1.00c
	5	1074.78	81.53a	58.33	91.72b	2.87	46.68	1.30a
	10	983.72	68.92d	55.21	88.23h	2.25	42.44	0.94cd
Fodak	0	1002.81	67.78d	54.87	90.58d	2.29	42.38	0.89f
	5	1037.12	74.38b	57.43	92.13a	2.78	44.38	1.21b
	10	942.87	63.88e	54.08	89.24f	2.16	41.76	0.91e

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

Table -10-: Analysis of variance F values for some growth characters, yield and yield components and quality in Sheikh Mohamed and Gueer locations.

S.O.V	D.f	plant height (cm)	stem diameter (cm)	no. of leaves\ plant	leaf area index	head dry weight \ plant (g.)	head diameter (cm)	no. of seeds\ head	1000 seeds weight (g.)	hulls (%)	Fertility (%)	yield (ton\ha.)	oil (%)	oil yield (ton.ha^{-1})
		M.S. for Sheikh Mohamed location												
Replications	2	4.719478	0.008725	0.1709592	0.004	3.8887	2.503181	7157862.3	0.1373	0.436137	0.028611	5.337625	0.3609	6896.2395
A	2	55.9176**	1.0196**	2.012937*	0.21*	17.68*	12.4898*	8125450.9 *	1.06**	1.32538*	0.03423*	32.233**	2.390**	29680.99*
B	2	1637.81**	1.3432**	2.052114*	0.27**	18.096*	21.4668**	8131786.4**	1.38**	1.01379*	0.1319**	43.575**	15.29**	54389.1**
A × B	4	17.96777*	0.0332 n.s	0.26552 n.s	0.039 n.s	17.3117*	12.761081*	5204241.3 n.s	1.066*	1.23149*	0.0162 n.s	36.465**	3.19**	26614.67*
Error	16	4.486111	0.044334	0.3425925	0.039	4.6203	3.231481	2007933.8	0.0441	0.260503	0.007661	5.092592	0.2592	5888.3611
Total	26													
S.O.V	D.f	**M.S. for Gueer location**												
Replications	2	10.792811	52.32651	2.4620703	0.011	0.1798	0.005700	186.04651	0.3750	0.319300	745.2608	282.3245	82.138	80.463369
A	2	187.210**	1112.3**	16.5771**	0.112 **	4.9072 **	0.1822*	20278.188**	229.64 **	15.44653 **	3696.826 *	1270.507 *	1072.2*	1092.110*
B	2	132.48207 **	219.48917*	37.8169**	0.825 **	20.757 **	0.377633 **	23655.125**	249.891**	23.40423 **	5681.173 **	1303.954 *	1203.0*	1287.493*
A × B	4	34.419288 n.s	71.39514 n.s	3.05548 n.s	0.015 **	0.0286 n.s	1.026333 **	441.7098 n.s	8.64783**	0.453883 n.s	3790.754 **	319.1767 n.s	154.31 n.s	1178.705*
Error	16	15.81944	60.64814	2.370	0.005	0.1481	0.0300	180.9814	0.3333	0.332950	795.0405	299.0453	282.42	302.46904
Total	26													

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

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