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THE EFFECT OF ZINC AND MANGANESE APPLIED AS A FOLIAR SPRAY, ON SOME GROWTH PARAMETERS AND YIELD OF FLAXSEED (Linum usitatissimum L.)

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ABSTRACT

This research was conducted in the field of Gerdarasha at college of Agricultural Engineering Sciences/ University of Salahaddin- Erbil during the winter season of 2020-2021. It shows the effect of zinc and manganese applied as foliar spray, on some growth parameters and yield of flaxseed (Linum usitatissimum L.). A factorial experimental design was applied in a randomized complete block design with three replications; the first factor represents three levels of Zinc: (0, 200 and 400) ppm and the second factor was three concentrations of manganese (0, 200 and 400) ppm. The combined effect of foliar application by 400 Zn and 400 ppm of Mn, produced the highest value of a plant height, leaf area, LAI, dry matter, crop growth rate and secondary branches, number No. of capsules plant -1, capsule weight (g), number of seeds capsule-1, weight of 100 seed (g) seed yield (kg. ha-1), oil content% and oil yield (kg. ha-1), while 200 ppm Mn obtained the highest value for fruiting height (cm) and primary branches. The interaction between (Zn 400 with 400) ppm of Mn recorded the highest value of a plant height, leaf area, LAI, dry matter, crop growth rate, secondary branches, number No. of capsules plant -1, capsule weight (g), number of seeds capsule-1, weight of 1000 seed (g), and oil content%. On the other hand, the interaction (400 Zn with 200) ppm of Mn recorded the highest value in fruiting height (cm) and primary branches, secondary branches, seed yield (kg. ha-1) and oil yield (kg.ha -1).

INTRODUCTION

Flaxseed and flaxseed oil are considered as an important and efficient nutrient supply due to their rich nutrients which is beneficial for different health problems (Goyal et al., 2014, Mahmood and Sarkees, 2014). Flaxseed is included in many products and food industries because it contains many nutrients such as proteins, fiber, and fatty acids. Its oil content is (41%), protein (20%), dietary fiber (28%) and fatty acids (50-60) (Oomah, 2001, Tahir and Irfan, 2014). The production of flaxseed has been decreased due to a robust competition between flax and other crops such as wheat, barley … etc. (Goyal et al., 2014). Therefore, there is a great gap between the production and consumption in seed yield which could be reduced by increasing the yield through new improved varieties and utilizing improved agriculture practices as using efficient and sufficient fertilization (Keram et al., 2012). Flax is sensitive to micronutrient deficiencies particularly in calcic soils due to high pH and precipitation of these nutrients which causes low solubility. This leads to reduction of nutrient absorption, and increases the plant requirement to the micronutrients such as Zinc and Manganese (Mousavi, 2011).

Micronutrients play a great role in plant growth as a result of their effects on many physiological processes in plant life. Zn is a cofactor to build enzyme formation and activation, and impacts electron transfer reaction including those of Krebs-cycle; hence affecting in plants energy production (Mahmood and Sarkees, 2014). It is important in carbohydrate metabolism and protein production as well as essential for ribosome composition and plant hormones metabolism (Mousavi, 2011, Keram et al., 2012). There are many factors that affect the availability of Zn including pH, carbonate minerals, organic matter, soil texture and interaction between zinc and other microelements. Its deficiency can be seen in different types of soils and the symptoms appear on the young leaves of plants first, then the yield is more affected than dry matter because of the damage to the pollen fertility (Keram et al., 2012). However, the excessive amount of Zn has adverse effect leads to toxicity in plant. Its high amount reduces absorption of P and Fe (Mousavi, 2011). Nofal et al., (2011) concluded that Zn level from (0.0-to 2.0g/L), increased the highest values of total plant height, and technical stem length, stem diameter and fruiting zone length. The number of fruiting branches/plant was reached the highest increase due to foliar sprayings with the high level of Zn element (2.0g/L). In this connection, it is worthy to note that trace elements were reported to control the hormonal balanced of the plant (Coke and Whittington, 1968) .

Mn another essential micronutrient that contributes significantly in photosynthesis and chlorophyll production, as Mn facilitates photolysis of water molecules and provides energy for photosynthesis (Zulfiqar et al., 2021, Hakala et al., 2006). Therefore, the effect of deficient Mn on crops are reduction in crop yield and quality, reduced dry matter production, low structural resistance against pathogens and tolerance to drought and heat stress reduction as well (Marschner, 2011). These negative influences mainly occurred due to the damage in photosynthesis process and synthesis of starch. Despite of the absence of morphological symptoms, the Mn deficiency significantly decreases the sugar concentration in plants which leads to a decline in the dry matter production and yield (Alloway, 2008).

Mn deficiency is a common problem occurring in soils with high pH especially sandy soils, tropical soils, organic soils, poorly aerated soils and heavily weathered areas as well as in cool and wet conditions. Recent studies under alluvium soil conditions have shown that the application of some micronutrients especially Zn and Mn as foliar application significantly increased yield, dry matter production and photosynthesis efficiency, resistance improvement against various diseases which attack crop root (Movahhedy-Dehnavy et al., 2009). Therefore, the most effective method is the use of foliar application (Gul et al., 2011). The aim of this study is investigating the response of some micronutrients applied as foliar spray application, on growth parameters, yield and oil content of flaxseed (Linum usitatissimum L.).

MATERIALS AND METHODS

A field study was conducted at Grdarasha Research Station of the College of Agricultural Engineering Sciences/ Salahaddin University- Erbil (Latitude 36° 4' N and Longitude 44°2' E) 415 meters above sea level having annual rainfall (250-600 mm) during the season of 2021-2022 to study the effect of some micronutrients applied as foliar spray, on some growth parameters and yield of flaxseed (Linum usitatissimum L.). A factorial experiment (3×3) was applied in a randomized complete block design (RCBD) with three replicates. The first factor represents the element (Zn) and the second factor represents (Mn) which are considered micronutrients by foliar use and in three concentrations (0, 200 and 400 ppm). Typical samples were taken from different locations of the field at depths (0-30 cm) after plowing. These samples were air dried and then sieved using a 2 mm sieve size, and then packed for analysis (Table 1) .

The field was plowed for preparing a good seedbed and also to controlling weeds prior of planting, the land was divided manually to plots, and each replicate consists of 9 experimental units (2m×2 m). Nitrogen fertilizer at rate of 100 kg N ha-1 in the form of urea (46%N), and P2O5 at a rate of 80 kg ha-1 in the form of triple super phosphate (46% P2O5) were applied at time of sowing (AL-Dulaimy, 2000). The seeds of flaxseed genotypes (Lider) were obtained from Agricultural Research Center in Erbil - Iraq. Planting was done manually from 1 November at row spacing 10 cm and plant spacing 5 cm, two seeds were planted in each hole at the depth of 3 cm, and then the plants were thinned after emergence stage to (200 plant. m-2). Plants were sprayed by Zinc and Manganese foliar applications after 30 days from sowing and from flowering stage. Furthermore, five plants were selected randomly from each experimental unit to study the plant height (cm), leaf area (LA)(cm2) and leaf area index (LAI): was calculated by viticanopy program application, Dry matter (gm-2): Which represent the dry mass of total green parts of plant after drying at 80°C for (48-52) hours, then weight was converted to g m-2. Crop growth rate (CGR) g m-2 day-1: It was calculated by dividing dry matter yield (gm-2) at flowering stage by number of days from sowing to the flowering stage, Fruiting height cm, number of primary branches plant-1, number of secondary branches plant-1, number No. of capsules plant -1, Capsule weight (g), number of seeds capsule-1, and weight of 100 seed (g). All middle-line of each experimental unit were harvested, to calculate the seed yield (kg. ha-1), oil content% and oil yield (kg. ha-1). The data was analyzed statistically for all of the studied traits according to analyses of variance using the Statistical Analysis System (SAS Institute, 2004). Duncan's multiple range test DMRT at 5% level of significant was used to the compare among means (Steel and Torrie, 1997). Simple correlation coefficient was calculated between the seed yield and other traits, and among the traits themselves and simple regression among some studied traits (Gupta et al., 2016).

$$\text{LAI} = \frac{\text{Plant total leaf area per plant}}{\text{Average land area occupied by plant}}\ ,\quad \text{Crop Growth Rate (CGR)} = \frac{1}{\text{GA}} \times \frac{\text{W2} - \text{W1}}{\text{T2} - \text{T1}}$$

Table (1): Some physical and chemical properties of depth (0 - 30 cm) soil:

Soil properties	Particle size distribution			Texture class	pH	EC	O.M	Total (N)	Available (P)	Available (K)	Zn	Mn
	Sand %	Silt%	Clay %			dSm^{-1}	%		ppm		%	
	$g\ kg^{-1}$ soil			Clay laom	7.43							
0-30 cm	28.3	32.5	39.2			0.8	0.09	0.18	9.5	240	0.00529	0.00235

RESULTS & DISCUSSION:

1- Effect of foliar application of zinc and manganese and their interaction on growth parameters of flaxseed crop:

Data in table (2) indicates the great influence of foliar application of Zn on all the studied characteristics, plant height (79.13 cm), leaf area (164.86 cm2), LAI (3.29), dry matter (246.90 gm2), crop growth rate (2.07 g m-2 day-1), fruiting height (18.32 cm), no. of primary and secondary branches (3.80 and 8.61) respectivily, the highest values were obtained from Zn 400 ppm followed by Zn 200 ppm. Table (3) also shows the significant effect of Mn on the studied parameters of flax. Similar to Zn effects, the highest values of plant height (79.89 cm), leaf area (157.82 cm2), LAI (3.15), dry matter (233.97 gm2), crop growth rate (1.94 g m-2 day-1), and secondary branches (7.89) were recorded from Mn 400 ppm followed by Mn 200 ppm, while fruting height (16.68 cm) and no. of primary branches (3.85) showed the highest values when applying foliar application of Mn 200 ppm followed by Mn 400 ppm. Formother the lowest values were recorded for plant height (71.11 cm), leaf area (141.03 cm2), LAI (2.82), dry matter (207.57 gm2), crop growth rate (1.72 g m-2 day-1), fruiting height (13.70 cm), no. of primary and secondary branches (2.97 and 6.18) respectivily when (Zn 0 and Mn 0) ppm applied. Both results from Zn and Mn foliar application suggested that often applying higher concentration of Zn and Mn to some extend significantly improve the growth charecteristics of flax (Movahhedy-Dehnavy et al., 2009, Mahmood and Sarkees, 2014, Zulfiqar et al., 2021). From table (6) there was a positive correlation and highly significant correlation between leaf area with dry matter and crop growth rate (r= 0.987** and r= 0.972**) respectively.

Data presented in table (3) shows that the interaction treatments affected significantlyand the hieghts value of plant height (83.40 cm), leaf area (173.56 cm2), LAI (3.47), dry matter (259.70 gm2), crop growth rate (2.16 g m-2 day-1), and recorded from the combination treatment of (Zn 400 with Mn 400) ppm respectively, but the hieghts value of fruiting height (21.06 cm), no. of primary (4.60) and secondary branches (9.17), was recorded from interaction (Zn 400 with Mn 200) ppm. These results might be due to the action of Zn and Mn as cofactor of many enzymes contributed in improving these charecteristics (Keram et al., 2012, Mousavi, 2011, Mahmood and Sarkees, 2014) while the highest level of Zn in some cases suppress and reduces shoot and root development (Mousavi, 2011). However, the lowest values were recorded for plant height (66.00 cm), leaf area (136.46 cm2), LAI (2.72), dry matter (194.23 gm2), crop growth rate (1.61 g m-2 day-1), when (Zn 0 with Mn 0) ppm applied, and fruiting height (13.10 cm) and primary branches (5.52) when (Zn 0 withe Mn 200) ppm. From figure 1 A the linear component showed a direct proportional relationship between leaf area with dry matter ($\hat{Y} = 1.4737x + 3.943$), hich means an increase of one cm2 will result in increase in dry matter by (1.4737 g cm2).

Table (2): Effect of foliar application of zinc and manganese on growth parameters of flaxseed crop.

Foliar application ppm	Plant height (cm)	Leave area cm^2	Leave area index (LAI)	Dry matter (gm^{-2})	Crop growth rate g m^{-2} day^{-1}	Fruitin g height cm	No. of Primary branche s plant $^{-1}$	No. of Secondary branches plant $^{-1}$
Zn 0	71.11 c	141.03 c	2.82 b	207.57 c	1.72 c	13.70 c	2.97 b	6.18 c
Zn 200	77.54 b	148.35 b	2.96 b	220.85 b	1.84 b	15.67 b	3.75 a	7.37 b
Zn 400	79.13 a	164.86 a	3.29 a	246.90 a	2.07 a	18.32 a	3.80 a	8.61 a
Mn 0	72.24 c	145.25 c	2.90 c	215.12 c	1.79 c	14.84 b	3.15 b	6.84 c
Mn 200	75.63 b	151.17 b	3.02 b	226.33 b	1.88 b	16.68 a	3.85 a	7.43 b
Mn 400	79.89 a	157.82 a	3.15 a	233.97 a	1.94 a	16.14 a	3.53 b	7.89 a

2- Effect of foliar application of zinc and manganese and their interaction on component of flaxseed crop:

Table (3): Effect of Interaction between foliar applications of zinc with manganese on growth parameters of flaxseed crop.

Foliar application of Zn ppm	Foliar application of Mn ppm	Plant height (cm)	Leave area cm^2	Leave area index (LAI)	Dry matter (gm^{-2})	Crop growth rate g m^{-2} day^{-1}	Fruiting height cm	No. of Primary branche plant $^{-1}$	No. of Seconda ry branche plant $^{-1}$
Zn 0	Mn 0	66.00 g	136.46 h	2.72 h	194.23 h	1.61 h	14.13 d	2.76 f	6.05 fg
	Mn 200	71.65 f	140.90 g	2.81 g	212.46 g	1.77 g	13.10 d	2.90 f	5.52 g
	Mn 400	75.65 de	145.73 e	2.91 f	216.00 f	1.80 f	13.86 d	3.26 e	6.97 de
Zn 200	Mn 0	74.41 e	142.60 f	2.85 g	216.60 f	1.80 f	14.30 d	3.42 de	6.36 ef
	Mn 200	77.58 c	148.30 d	2.96 e	219.76 e	1.83 e	15.89 c	4.05 b	7.61 cd
	Mn 400	80.64 b	154.16 d	3.08 d	226.20 d	1.88 d	16.76 bc	3.80 c	8.13 bc
Zn 400	Mn 0	76.33 cd	156.70 c	3.13 c	234.53 c	1.95 c	16.10 c	3.28 e	8.10 bc
	Mn 200	77.66 c	164.33 b	3.28 b	246.46 b	2.05 b	21.06 a	4.60 a	9.17 a
	Mn 400	83.40 a	173.56 a	3.47 a	259.70 a	2.16 a	17.81 b	3.53 d	8.58 ab

The results of number of capsules plant-1 are displayed in table (4). A wide variation was observed results, the highest number of capsules plant-1 was at 400 ppm of Zn and Mn foliar application (9.69 and 9.00) respectively. While the minimum values (6.36 and 6.67) were obtained from 0 ppm of Zn and Mn respectively. The interaction between seed treatment with zinc foliar application also affected significantly on number of pods plant-1, the highest value (11.27) was recorded from interaction 400 ppm Zn with 400 ppm of Mn, while the lowest value (5.69) was obtained from interaction 0 ppm Zn with 0 ppm of Mn **.**

Table (4) shows the highest Capsule pod weight for foliar application by 400 ppm Zn which was (5.13 g), and (4.60 g) from Mn concentration 400 ppm, while the lowest weight was recorded at 0 ppm in Zn and Mn which was (3.12 and 3.46 g) respectivily. From table (6) shows the highest interaction was recorded at zinc with manganece foliar application 400 ppm (5.70 g), but the lowest was (2.46 g) for interaction 0 ppm of Zn with Mn. Data in table (5) also shows that the highest was recorded for the sample collected from foliar application of both zinc and manganece concentration at 400 ppm which was (6.74 and 6.94) respectivily, whereas the lowest number of seeds capsule-1 was collected at 0 ppm Zn which was (6.02) and 0 ppm of Mn was (5.73). Considering the interaction between zinc with manganece foliar application, the highest was (7.66) for 400 ppm Zn with 400 ppm of Zn, but the lowest value was recorded from 0 ppm Zn with 0 ppm of Mn (5.49) table 4. The data presented in (Table, 5) inducted significant differences between zinc and manganece foliar application and their interactions. It was found that the concentration of 400 ppm Zn recorded the highest 1000-seed weight (7.68 g), The results showed that 400 ppm of Mn concentration was surpassed in 1000-seed weight (7.55 g). The interaction between zinc with manganece foliar application significantly affected on this trait, it was found that 400 ppm Zn with 400 ppm of Mn recorded the highest weight of 1000-seed (8.21 g), compared with other interactions**.**

The table (4) displayed seed yield performed the highest was used zinc foliar application by 400 ppm (712.44 kg ha-1), while the lowest was at 0 ppm Zn (576.55 kg ha-1). The highest value was also for manganece foliar application at 400 ppm (661.77 kg ha-1) but the lowest value was recorded (608.22 kg ha-1) at 0 ppm, this variation is due to when planting flaxseed by zinc and manganece foliar application at 400 ppm, leads to increase no. of branch plant-1, no. of capsules plant-1 and 1000 - Seed weight and consequently resulted to increase of yield. These variations in results, in the samples confirm that the interaction between zinc and manganece foliar concentration are different. The optimum value was at zind foliar application by 400 ppm with manganece foliar application at 200 ppm (764.00 kg ha-1), whereas the minimum was at 0 ppm Zn with Mn 0 ppm (552.33 kg ha-1). From table (6) there was a positive correlation and highly significant correlation between number of primery branches with number of capsul plant-1 and seed yield (r= 0.841** and r= 0.875**) respectively**.**

The data presented in (Table, 4) showed significant differences between zinc and manganece foliar application and their interactions. It was found that the concentration by 400 ppm of Zn recorded the highest oil content (40.60 %), while the 0 ppm of Zn recorded the lowest oil content (37.86 %). The results showed that 400 ppm of Mn foliar application was surpassed in oil percentage (39.67 %). The interaction between zinc with manganece foliar significantly affected on this trait table (6), it was found that 400 ppm Zn with 400 ppm of Mn concentration recorded the highest oil percentage (41.47%), compared with other interactions. This might be due to zinc manganece are required for integrity of cellular membranes to preserve the structural orientation of macromolecules and ion transport systems (Kabata et al., 2001 and Disante et al., 2010). The oil yield kg ha-1 are displayed in table (6) shows that the highest level was observed at foliar applicationt by 400 ppm of Zn which was (289.96 kg ha-1), while the lowest level of zinc concentration was at 0 ppm (218.40 kg ha-1), also the maximum was at 400 ppm of Mn foliar application that was (263.33 kg ha-1), but the minimum rate recorded at 0 ppm of manganece concentration (234.73 kg ha-1). The foliar application of zinc with manganece recorded the highest rate of oil yield interaction which was at 400 ppm Zn with 200 ppm of Mn foliar application (312.07 kg ha-1). whereas the lowest at 0 ppm Zn with Mn 0 ppm (206.79 kg ha-1). From figure 1 C and F the linear component showed a direct proportional relationship between number of capsules. plant-1 with seed yield ($\hat{Y}$ = 36.136x + 376.32), and seed yield with oil yield according to the following equation and ($\hat{Y}$ = 0.4995x - 69.247).

Table (4): Effect of foliar applications of zinc with manganese on yield components of flaxseed crop.

Foliar applicatio n of Zn ppm	No. of capsules plant $^{-1}$	Capsule weight (g)	No. of seeds capsule $^{-1}$	1000 Seed weight (g)	Seed yield (kg ha^{-1})	Oil %	Oil yield (kg ha^{-1})
Zn 0	6.36 c	3.12 c	6.02 c	7.07 b	576.55 c	37.86 c	218.40 c
Zn 200	7.54 b	3.72 b	6.42 b	6.89 c	645.11 b	38.96 b	251.36 b
Zn 400	9.69 a	5.13 a	6.74 a	7.68 a	712.44 a	40.60 a	289.96 a
Mn 0	6.67 c	3.46 c	5.73 c	6.74 c	608.22 b	38.53 c	234.73 c
Mn 200	7.92 b	3.91 b	6.52 b	7.35 b	664.11 a	39.21 b	261.38 b
Mn 400	9.00 a	4.60 a	6.94 a	7.55 a	661.77 a	39.67 a	263.33 a

Table (5): Effect of Interaction between foliar applications of zinc with manganese on yield components of flaxseed crop.

Foliar application of Zn ppm	Foliar application of Mn ppm	No. of capsules plant $^{-1}$	Capsule weight (g)	No. of seeds capsule $^{-1}$	1000 Seed weight (g)	Seed yield (kg ha^{-1})	Oil %	Oil yield (kg ha^{-1})

Zn 0	Mn 0	5.69 g	2.46 g	5.49 e	6.30 e	552.33 g	37.44 i	206.79 g
	Mn 200	6.20 f	2.80 f	6.12 d	7.26 c	575.00 f	37.83 h	217.54 f
	Mn 400	7.19 e	4.10 d	6.46 c	7.66 b	602.33 e	38.33 g	230.87 e
Zn 200	Mn 0	6.54 f	3.46 e	6.10 d	6.89 d	625.66 d	38.70 f	242.13 d
	Mn 200	7.52 de	3.70 e	6.50 c	6.99 d	653.33 c	38.96 e	254.54 c
	Mn 400	8.55 c	4.01 d	6.70 bc	6.78 d	656.33 c	39.22 d	257.42 c
Zn 400	Mn 0	7.73 d	4.46 c	5.61 e	7.03 cd	646.66 c	39.47 c	255.28 c
	Mn 200	10.07 b	5.24 b	6.94 b	7.18 b	764.00 a	40.84 b	312.07 a
	Mn 400	11.27 a	5.70 a	7.66 a	8.21 a	726.66 b	41.47 a	301.40 b

CONCLUSIONS

It is concluded that the highest plant height, leaf area, LAI, dry matter, crop growth rate and secondary branches, number No. of capsules plant-1, capsule weight (g), number of seeds capsule-1, weight of 100 seed (g) seed yield (kg.ha-1), oil content% and oil yield (kg.ha-1), while 200 ppm Mn obtained the hiehts value for fruiting height (cm) and primary branches. The interaction between Zn 400 ppm with 400 ppm of Mn foliar application recorded the highest value of a plant height, leaf area, LAI, dry matter, crop growth rate, secondary branches, numberof capsules plant-1, capsule weight (g), number of seeds capsules-1, weight of 1000 seed (g), and oil content%. On the other hand, the interaction 400 ppm Zn with 200 ppm of Mn recorded the highest value in fruiting height (cm) and primary branches, secondary branches, seed yield (kg.ha-1) and oil yield (kg.ha -1).

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CONFLICT OF INTEREST

The researcher supports the idea that this work does not conflict with the interests of others.

Table (6): Correlation coefficient analysis among the traits of flaxseed crop characteristics.

	Plant height (cm)	Leave area cm^2	Leave area index (LAI)	Dry matter (gm^{-2})	Crop growth rate g m^{-2} day^{-1}	Fruiting height cm	No. of Primary branches $plant^{-1}$	No. of Secondary branches $plant^{-1}$	No. of capsules $plant^{-1}$	Capsule weight (g)	No. of seeds $capsule^{-1}$	1000 Seed weight (g)	Seed yield (kg ha^{-1})	Oil %	Oil yield (kg ha^{-1})
Plant height (cm)	1.000														
Leave area cm^2	0.831 **	1.000													
Leave area index (LAI)	0.831 **	1.000 **	1.000												
Dry matter (gm^{-2})	0.844 **	0.987 **	0.978 **	1.000											
Crop growth rate g m^{-2} day^{-1}	0.844 **	0.972 **	0.978 **	1.000 **	1.000										
Fruiting height cm	0.537 **	0.792 **	0.763 **	0.759 **	0.760 **	1.000									
No. of Primary branches $plant^{-1}$	0.610 **	0.579 **	0.587 **	0.586 **	0.586 **	0.794 **	1.000								
No. of Secondary branches $plant^{-1}$	0.741 **	0.862 **	0.834 **	0.811 **	0.811 **	0.850 **	0.750 **	1.000							
No. of capsules $plant^{-1}$	0.831 **	0.972 **	0.965 **	0.947 **	0.573 **	0.806 **	0.627 **	0.841 **	1.000						
Capsule weight (g)	0.832 **	0.952 **	0.932 **	0.952 **	0.947 **	0.778 **	0.613 **	0.862 **	0.931 **	1.000					
No. of seeds $capsule^{-1}$	0.790 **	0.761 **	0.745 **	0.761 **	0.952 **	0.582 **	0.576 **	0.599 **	0.844 **	0.743 **	1.000				
1000 Seed weight (g)	0.608 **	0.718 **	0.732 **	0.718 **	0.764 **	0.472 **	0.360	0.469 *	0.743 **	0.782 **	0.743 **	1.000			
Seed yield (kg ha^{-1})	0.762 **	0.899 **	0.861 **	0.899 **	0.768 **	0.903 **	0.822 **	0.875 **	0.914 **	0.735 **	0.872 **	0.669 **	1.000		
Oil %	0.807 **	0.975 **	0.935 **	0.975 **	0.930 **	0.832 **	0.652 **	0.850 **	0.962 **	0.763 **	0.886 **	0.719 **	0.949 **	1.000	
Oil yield (kg/ha)	0.771 **	0.926 **	0.921 **	0.926 **	0.971 **	0.897 **	0.783 **	0.874 **	0.936 **	0.751 **	0.945 **	0.767 **	0.997 **	0.971 **	1.000

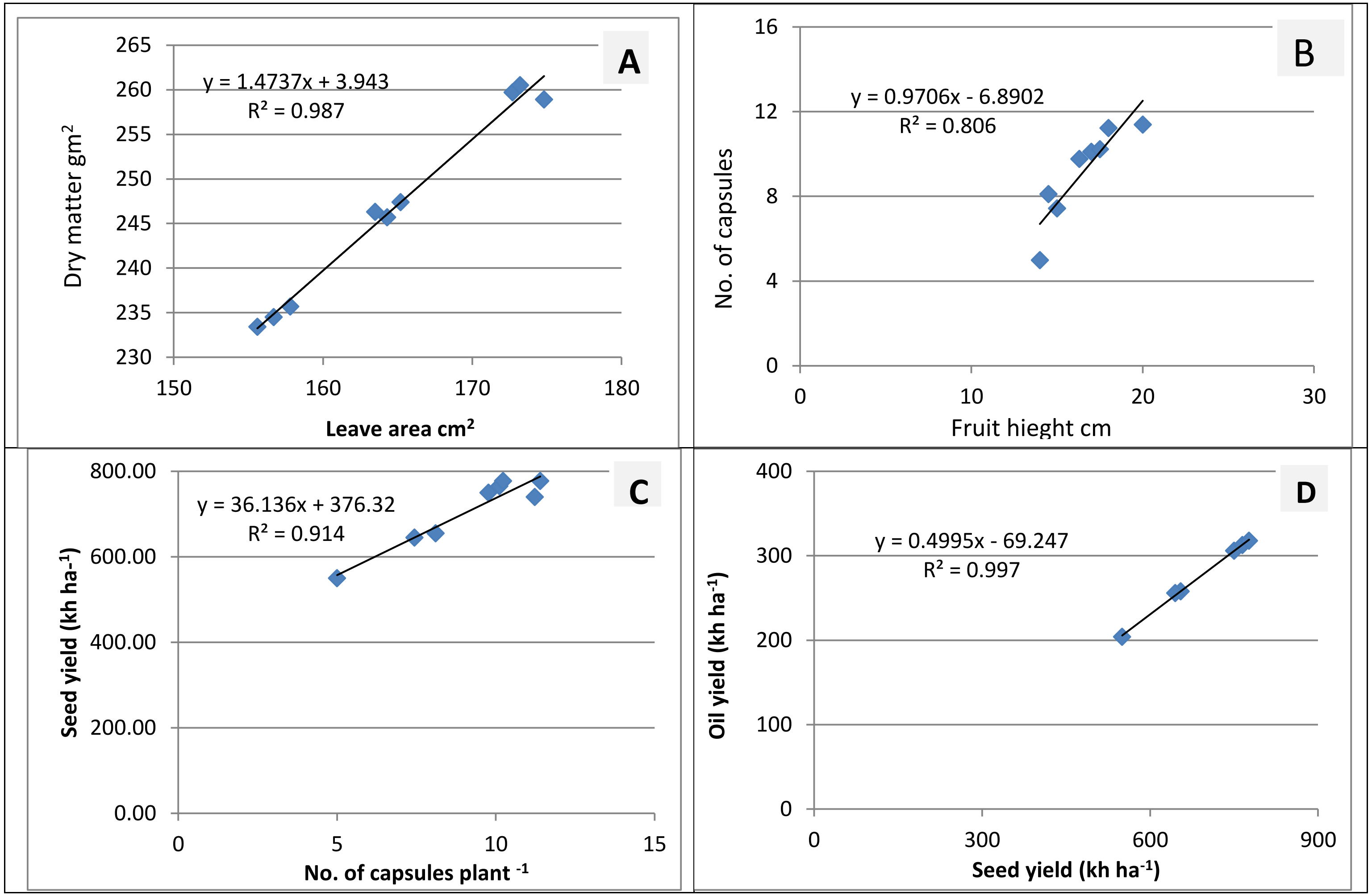

Figure (1): Regression among some studied characters.

تأثير الزنك والمنغنيز المطبقين كرذاذ ورقي على بعض صفات النمو وحاصل بذور الكتان (*Linum usitatissimum* L.)

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الخلاصة

أجري البحث في حقل كردرشة التابعة لكلية هندسة العلوم الزراعية / جامعة صلاح الدين – أربيل خلال فصل الشتاء ٢٠٢٠ – ٢٠٢١. يظهر تأثير العناصر الزنك والمنغنيز بطريقة الرش الورقي على بعض قياسات النمو والحاصل لبذور الكتان. تم تطبيق تصميم تجريبي عاملي في تصميم القطاعات الكاملة العشوائية بثلاث مكررات، يمثل العامل الأول ثلاثة مستويات من عنصرالزنك: (٠،٢٠٠،٤٠٠) جزء في المليون والعامل الثاني هو الرش الورقي بثلاثة تراكيز من المنغنيز (٠،٢٠٠،٤٠٠) جزء في المليون. أنتج عن التأثير المركب للتطبيق الورقي بمقدار ٤٠٠ جزء في المليون من الزنك و ٤٠٠ جزء في المليون من المنغنيز أعلى قيمة لارتفاع النبات، ومساحة الورقية، ودليل المساحة الورقية، المواد الجافة، معدل نمو المحصول، الأفرع الثانوية، عدد الكبسولات النباتية –1، وزن الكبسولة (غم)، عدد كبسولة البذور–1، وزن ١٠٠ بذرة (غم)، محصول البذور (كغم هكتار–1)، محتوى الزيت٪ ومحصول الزيت (كغم هكتار–1)، بينما عند استخدام تركيز ٢٠٠ جزء فى المليون من المنغنيزحصلت على اعلى قيمة لارتفاع الثمار(سم) والافرع الاوليه. سجلت التداخلات بين ٤٠٠ جزء فى المليون من الزنك و ٤٠٠ جزء فى المليون من المنغنيز أعلى قيمة لارتفاع النبات، مساحة الورقية، دليل مساحة الورقية، المادة الجافة، معدل نمو المحصول، الأفرع الثانوية، عدد الكبسولات النباتية –1، وزن الكبسولة (غم)، وعدد كبسولات البذور–1، وزن ١٠٠٠ بذرة (غم)، ومحتوى الزيت٪. من ناحية أخرى، سجل التداخل بين٤٠٠ جزء في المليون من الزنك مع ٢٠٠ جزء في المليون من المنغنيز أعلى قيمة في ارتفاع الاثمار (سم) والأفرع الأولية والثانوية وحاصل البذور (كغم هكتار–1) وحاصل الزيت (كغم هكتار–1).

الكلمات المفتاحية: بذور الكتان، الرش الورقي للزنك والمنغنيز، النمو والحاصل.

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