Bionatura
Latin American Journal of Biotechnology and Life Sciences

Bionatura Issue 4 Vol 8 No 1 2023

Article

Response of growth and yield of Flax (*Linum usitatissimum* L.) to sowing dates and foliar application with zinc

Alaa Raja Ali Al-Ta'iy[1] *and Waleed Khalid Shahatha Al-Juheishy*[2,*]
[1] *Department of Field Crops, College of Agriculture and Forestry, University of Mosul, Iraq*
[2] *Department of Field Crops, College of Agriculture and Forestry, University of Mosul, Iraq*
* *Correspondence:w.khalid83@uomosul.edu.iq*
Available from: http://dx.doi.org/10.21931/RB/CSS/2023.08.04.78

ABSTRACT

A field experiment was conducted winter agricultural season for the year (2020-2021) in two locations: the first location in the Nineveh Forest Nursery/Desertification Department (Mosul city center) at longitude 43˚ 15′ east and latitude 35˚ 36′ north, and the second location in Abu Maria village (Tal Afar District) is one of the suburbs of Tal Afar District, which is approximately 50 km west of the city of Mosul at longitude 42˚ 35′ east and latitude 36˚ 25′ north .To study the effect of planting dates (11/30, 12/20, 1/10) and zinc concentrations (0, 15, 30, 45, 60 mg/L) on the growth, yield and quality of flax (Sharda) cultivar, the experiment was conducted according to Randomized Complete Block Design (RCBD) system with split plots and with three replicates, where the planting dates occupied the main plots, While zinc concentrations occupied the subplots. The planting dates showed significant differences in all growth and yield traits for both locations of Nineveh Forest Nursery and Abu Maria Village. It was found from the average values of these traits that the early planting date (30/11) excelled in plant height, number of branches/plant, number of capsules/plant, number of seeds/capsule, seed yield and biological yield. The second date (20/12) outperformed the harvest index in both locations, and the late date (10/1) excelled in the 1000-seed weight trait for both experiment locations. Zinc concentrations showed significant differences in all studied traits and for both experimental locations. The zinc concentration (60 mg/L) excelled in plant height, number of branches/plant, number of capsules/plant, seed yield, biological yield and harvest index in both locations. In comparison, the concentration (45 mg/L) was excelled in number of seeds/capsule. Most of the studied traits had a significant interaction between sowing dates and zinc concentrations .The interaction between planting date (30/11) and zinc concentration (60 mg/L) excelled in seed yield for both locations, number of plant branches in the Nineveh Forest Nursery location, and biological yield at the Abu Maria village location. The interaction between planting date (20/12) and zinc concentration (30 mg/L) excelled on the harvest index in the Nineveh forest nursery location, while the interaction between planting date (20/12) excelled on the zinc concentration (60 mg/L) in Harvest index at the location of the village of Abu Maria.

Keywords: flax; planting dates; zinc.

INTRODUCTION

The flax crop (*Linum usitatissimum* L.) is one of the important industrial crops. It belongs to the flax family (*Linaceae*) and is cultivated either to obtain oil from the seeds, which rank fifth in the world or to benefit from the stems to produce fiber, which is ranked third in the world [1]. The percentage of oil in it ranges between 30-45%, and it is a dry oil. Linseed oil contains important fatty acids, the most important of which are linolenic acid (omega 3) estimated at 48%; linoleic acid (omega 6), estimated at about 20%, and oleic acid at 23% (omega 9) and citric acid at 9% of fatty acids [2]. The areas planted with flax in Iraq are very limited, almost on the scope of research only. The production of flax at the global level is approximately 2.8 million for the year 2017. At the forefront of these countries producing this crop are Russia, China, Kazakhstan and Canada, where these countries are at the forefront in terms of production and area. Determining the appropriate date for planting is very important for oil-producing plants and must be set based on the climate of each region. The best date for planting a group of varieties is determined if all the environmental factors that occurred at that time for the germination, stability and survival of the plant are appropriate. Zinc plays an important role in the formation of hormones, which have a role in the elongation of plant cells, in activating the work of enzymes, and as a co-factor in oxidation and reduction processes. It participates in the synthesis of chlorophyll, enters the synthesis of lipids and glycerol, and forms starch in seeds[3]. [4] concluded through his study of four dates for planting flax crop (20/12, 1/1, 10/1 and 20/1) that there are significant differences between planting dates, where the first planting date (20/12) outperformed in the characteristics of the number of Plant capsules, seed yield and harvest guide compared to other planting dates and [5] noticed through their study of different planting dates (30/4, 10/5, 20/5 and 30/5/2012) that there are significant differences between these dates, where the first planting date (30/4) excelled in several capsules per plant, number of seeds per capsule, and biological yield. The results obtained by [6] in his study, which included three planting dates (1/11, 15/11 and 30/11/2018), showed significant differences between the dates, where the early planting date (1/11) excelled in traits of plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, and seed yield. At the same time, the late planting date (30/11) exceeded 1000 seeds in weight. And [7] through their study of three planting dates (11/14, 11/21 and 28/11/2020) for flax crops, showed significant differences between the dates mentioned previously, where the planting date 11/21 outperformed in plant height and number of plants. Branches per plant, number of capsules per plant, number of seeds per capsule, and seed yield.In a study conducted by [8] to know the effect of several concentrations of zinc (0, 0.5, 1.0, 1.5 and 2.0 g Zn/L) that increasing zinc concentrations (2.0 g Zn/L) led to a significant increase in the traits of the number of capsules in the plant and the number of capsules in the plant. Seeds per capsule, 1000-seed weight and seed yield, while the concentration of zinc (1.0 g Zn/L) excelled in the harvest index. The experiment conducted by [9] when adding zinc sulfate (0 and 3/1000) in flax crop showed that there were significant differences when zinc sulfate was added (3/1000) in the characteristics of the number of capsules per plant, number of seeds per capsule, seed yield and biological yield. [6] indicated in his study of three concentrations of zinc (0, 35 and 70 mg Zn/L) that there were significant differences between zinc concentrations, where the zinc concentration (70 mg Zn/L) was excelled noted in plant height and number of branches. Per plant, number of capsules per plant, number of seeds per capsule, weight of 1000 seeds and seed yield. The results indicated by [10] in his study of three concentrations of zinc (0, 5 and 10 mg Zn/L) showed significant differences between zinc concentrations, as the zinc concentration (5 mg Zn/L) was superior to the plant height traits. The

number of branches per plant, the number of capsules per plant, the number of seeds per capsule, the weight of 1000 seeds and the seed yield.

MATERIALS AND METHODS

A field experiment was conducted during the winter agricultural season of 2020 and 2021 in two locations: the first in the Nineveh Forest Nursery / Desertification Department (Mosul city center), which is located at longitude 15° 43′ east and latitude 35° 36′ north, and the second in Abu Maria village (Tal Afar district). Which is about 50 km west of Mosul, at longitude 42° 35′ east and latitude 36° 25′ north. The experiment was conducted using a randomized complete block design (RCBD) according to the split-plot system and with three replicates, according to [14]. Each replicate contained (15) factor treatments resulting from the combination of three planted dates (30/11, 20/12, 10/1/2020) and five concentrations of zinc (0, 15, 30, 45, and 60 mg Zn/L). The experimental land was plowed using a disc plow in an orthogonal manner, then leveling and smoothing operations were conducted, after which the experimental land was divided into experimental units according to the design used, and cultivation was conducted in both locations on (30/11/2020). Factorial experiments were randomly distributed to the experimental units. The experimental units were separated from each other by a distance of (1 m) and between one repeater and another (1.5 m), and each experimental unit contained (4 lines) with a length of (2.5 m) and the distance between one line and another (30 cm). The hoeing process was conducted whenever needed and harvested when plants had completed growth. Ten plants were randomly taken from the two middle lines to study the following characteristics: plant height (cm), number of branches/plant, number of capsules/plant, number of seeds/capsule, weight of 1000 seeds and seed yield. (kg/ha) and biological yield (kg/ha) harvest index (%).

RESULTS

Plant Height (cm)

It is evident from the results shown in Table (1) that there are significant differences between planting dates in plant height for both locations of Nineveh Forest Nursery and Abu Maria village, where it reached the highest value of this trait (49.74 and 49.45 cm) at the time of planting The first (30/11) which did not differ significantly with the planting date (20/12) by giving it an average of (46.39 cm) in the Nineveh forest nursery location, While the lowest amount of this trait was (42.52 and 43.93 cm) at the third planting date (10/1), with an increased rate of (16.98 and 12.56%) for both location, respectively. The reason may be that delaying the planting date leads to slow growth in addition to the short growing season. This result is in agreement with [7]. It is evident from the results in Table (2) that there are significant differences between zinc concentrations in plant height for the two study locations, where the treatment of adding zinc at a concentration of (60 mg/L excelled by giving it the highest average for this trait that amounted to (49.58 and 49.10 cm), which did not differ significantly with the treatment of The addition of zinc at a concentration of (45 mg/L), which gave an average of (48.08 and 47.36 cm), While treatment without addition (0 mg/L) gave the lowest amount of this trait (42.75 and 43.92 cm), with an increase of (15.97 and 11.79%) for both locations, respectively. The reason may be due to the role of zinc in the formation of tryptophan, from which the hormone auxin (IAA) is formed, which is important for the elongation of plant cells [11]. This result is in agreement with [8, 10]. The results in Tables (3 and 4) for the two locations of Nineveh Forest Nursery and Abu Maria Village indicate no significant interaction between planting dates and zinc concentrations in plant height.

Number of Branches/Plant

It is noticed from the results indicated in Table (1) that there are significant differences between planting dates in the number of branches/plants for both locations of Nineveh Forest Nursery and Abu Maria village, where the highest average for this trait was (4.04 and 4.40 branches/plant) when The first planting date was (30/11), while the lowest average for this trait was (3.56 and 3.64 branches/plant) at the last planting date (1/10), with an increase rate of (13.48 and 20.87%) for both locations, respectively. The reason may be the effect of environmental factors on the growth of the crop. This result is consistent with that indicated by [7]. It is noted from the results in Table (2) that there are significant differences between zinc concentrations in the traits of the number of branches of the plant for both study locations, where the zinc concentration (60 mg/L) excelled by giving the highest amount for this trait amounted to (4.52 and 4.81 branches/plant), which did not differ significantly. On the concentration of zinc (45 mg/L), which gave an average of (4.40 branches/plant) at the location of Abu Maria village, While treatment without addition (0 mg/L) gave the lowest amount of this trait (3.27 and 3.30 branches/plant) with an increased rate of (38.22 and 45.75%) for both locations, respectively. The increase in plant branches may be due to the role of the zinc element, which is necessary in the plant's life. Studies confirm that zinc is involved in the activation of more than 300 enzymes, especially those related to the production of nucleic acids in protein and cell metabolism [12]. This result is in agreement with [6, 10]. It is noted from the results indicated in Table (3) that there is a significant overlap between planting dates and zinc concentrations in the character of the number of branches of the plant for the location of the Nineveh Forest Nursery. The first planting date (30/11) excelled on the last zinc concentration (60 mg/L) by giving the highest value of this trait, amounting to (4.76 branches/plant), which did not differ significantly from the first planting date (30/11) and the fourth zinc concentration (45). mg/L) by giving it an average of (4.56 branches/plant), While the interaction between the last planting date (1/10) and treatment without addition (0 mg/L) gave the lowest value for this trait, amounting to (3.20 branches/plant) with an increased rate of (48.75%). This finding is consistent with what was found by [6]. As for the location of Abu Maria village (Table 4), the interaction between planting dates and zinc concentrations did not reach the statistical significance level in the number of branches/plants.

Number of Capsules/Plant

The data indicated in Table (1) indicate that there is a significant difference between planting dates in the traits of the number of capsules per plant in both locations of Nineveh Forest Nursery and Abu Maria village, where the early planting date (30/11) recorded the highest average for this trait. (13.00 and 14.99 capsules/vegetable), While the late planting date (10/1) recorded the lowest average for this trait of (8.55 and 11.28 capsules/plant), with an increase of (52.04 and 32.89%) for both locations, respectively. The excellence of the early planting date in the number of capsules may be due to its excellence in the number of branches of the plant (Table 10). This result is consistent with what was indicated by [4, 6, 7]. The results presented in Table (2) show significant differences between zinc concentrations in the number of capsules/plants in both study locations. Significantly differs with the addition of zinc at two concentrations (30 and 45 mg/L), which recorded an average of (13.66 and 13.73 capsules/plant) for the Abu Maria location, respectively. The lowest average for this trait was (9.16 and 11.25 capsules/plant) when treated without addition (0 mg/L), with an increased rate of (28.77 and 28.35%) for both locations, respectively. The reason may be due to the role of the necessary zinc element in building cell membranes, stabilizing their work and protecting them from oxidation that may be caused by some types of

oxygen hormone reactions, which affects the flow and transfer of different substances inside the roots, and then the effect appears on the entire growth and reproduction processes in the crop [13]. This result is consistent with the findings of [6, 10]. The results shown in Tables (3 and 4) showed that the interaction between planting dates and zinc concentrations did not reach the statistical significance level in the number of capsules/plants for both Nineveh Forest Nursery and Abu Maria village locations.

Number of Seeds/Capsules

The data referred to in Table (1) shows that there are significant differences between planting dates in the traits of the number of seeds per capsule in the Nineveh Forest Nursery and Abu Maria locations, where the highest value for this trait was (9.16 and 9.39 seeds/capsule) at the time. The early (30/11) did not differ significantly from the planting date 12/20, which gave an average of (8.86 seeds/capsule) in the location of Abu Maria village. In comparison, the lowest value for this trait was (7.95 and 8.46 seeds/capsule). With an increase rate estimated at (15.22 and 10.99%) for both locations, respectively. The reason may be because planting at a late date (10/1) led to the negative impact of environmental conditions (temperature and humidity) during the flowering period and the fullness of seeds, in addition to the short flowering period, which led to a small number of seeds formed in each capsule. This result is in agreement with [9, 6, 7]. The results shown in Table (2) indicate significant differences between zinc concentrations in the number of seeds per capsule for both experiment locations. The fourth zinc concentration (45 mg/L) excelled by recording the highest amount for this trait (9.07 and 9.31 seeds/capsule), which did not differ significantly from the zinc concentration (60 mg/L), which recorded (8.61 and 9.07 seeds/capsule)) for both locations, respectively, While the treatment without addition (0 mg/L) recorded the lowest amount for this trait (7.18 and 8.52 seeds/capsule) and an increased rate of (26.32 and 9.27 %), respectively. The reason may be that the zinc element has less effect in the plant on the growth and production of reproductive parts and its direct role in increasing the percentage of pollination and fertilization than its clear role on vegetative growth, in addition to the effect of zinc in the production of nutrients necessary for the growth of seeds in the crop [12]. This result is consistent with the findings of [8, 6, 10]. The results in Tables (3 and 4) show no significant interaction between planting dates and zinc concentrations in the characteristics of the number of seeds/capsules in the two locations of Nineveh Forest Nursery and Abu Maria village.

Weight of 1000 Seeds (gm)

It is noticed from the results of Table (1) that there are significant differences between planting dates in the characteristic of the weight of 1000 seeds for both locations of Nineveh Forest Nursery and Abu Maria village. The highest average for this trait was (7.65 and 6.94 gm) at the late planting date (1/10), which did not differ significantly from the second planting date (20/12), which recorded an average of (6.74 gm) at the location of Abu Maria village. The lowest average for this trait was (6.72 and 6.55 g) at the early planting date (30/11), with an increase of (13.83 and 5.95%) for both locations, respectively. The reason may be due to the low number of seeds/capsules at a later date (Table 12). This result is consistent with the findings of [6]. It is evident from the data referred to in Table (2) that there are significant differences between zinc concentrations in the characteristic of the weight of 1000 seeds in both study locations. The highest value for this trait was (7.71 g) when zinc was added at a concentration of (60 mg/L), which did not differ significantly from the addition of zinc at concentrations (30 and 45 mg/L), which recorded an average of (7.21 and 7.22 mg/L), respectively. While treatment

without addition (0 mg/L) gave the lowest value for this trait (6.38 g), with an increased rate of (20.84%). As for the location of Abu Maria village, the results indicate the excelled of adding zinc at a concentration of (60 mg/L) by recording the highest value for the weight of 1000 seeds amounted to (6.95 g), which did not differ significantly from the addition of zinc at a concentration (45 mg/L), which recorded an average of (6.82g), While treatment without addition gave the lowest value for the weight of 1000 seeds (6.53 g), with an increased rate estimated at (6.43%). The reason for the influence of the seed weight by spraying treatments with zinc may be due to the lack of competition between the seeds for the nutrients produced inside the plant, and consequently the lack of chances of aborting the seeds, as well as the lack of competition between capsules for processed foodstuffs, which leads to an increase in the weight of the crop seeds [15]. This finding is consistent with that of [8, 6]. Tables 3 and 4 show that the interaction between planting dates and zinc concentrations did not reach statistical significance in the weight of 1000 seeds for both study locations.

Seed Yield (kg/h)

The data referred to in Table (1) shows that there are significant differences between the planting dates in the trait of seed yield for both locations of Nineveh Forest Nursery and Abu Maria village, where the early planting date (1/11) was significantly excelled by recording the highest amount The seed yield reached (1364.38 and 1385.46 kg/ha), while the lowest amount of seed yield was (1233.00 and 1265.06 kg/ha) at the late planting date (1/10).With an increase of (10.65 and 9.51%) for both locations, respectively. The reason for the excelled of the early sowing date (30/11) may be due to the excelled of the same date in the characteristics of the number of branches per plant, the number of capsules per plant, the number of seeds per capsule, and the weight of 1000 seeds, which positively affected the increase in seed yield. This result is in agreement with [7, 6]. The results shown in Table (2) showed that zinc concentrations significantly affected the seed yield trait in both study locations. The zinc concentration (60 mg/l) excelled with the highest value for this trait being recorded (1501.01 and 1534.11 kg/ha), while the treatment without addition (0 mg/l) recorded the lowest value for this trait amounting to (1114.27 and 1142.66 kg/ha).), with an increase of (34.70 and 34.25%) for both locations, respectively.The reason may be due to the excelled of the early planting date (30/11) in the characteristics of the number of branches/plant (Table 2), the number of capsules/plant (Table 2), and the weight of 1000 seeds (Table 2), which was positively reflected in the increase in plant yield. This result is consistent with what was found by [6, 10]. It is noticed from the data of tables (3 and 4) that there is a significant interaction between planting dates and zinc concentrations in the seed pods for both experiment locations. The interaction between planting date (30/11) and zinc concentration (60 mg/L) recorded the highest value for this trait, which amounted to (1554.47 and 1585.66 kg/ha), while the interaction between planting date (1/10) with treatment without addition was recorded. (0 mg/l) The lowest value for this trait was (1114.27 and 1142.66 kg/ha), With an increase rate estimated at (35.50 and 38.76%) for both locations, respectively. This result is consistent with the findings of [6].

Biological Yield (kg/ha)

The results shown in Table (1) indicate that there are significant differences between the planting dates in the bio yield of both locations of Nineveh Forest Nursery and Abu Maria village, where the first planting date (30/11) was significantly excelled by giving it the highest average of these The characteristic was (3082.60 and 3139.53 kg/ha), While the third planting date (10/1) gave the lowest

average for this trait amounting to (2778.20 and 2845.33 kg/ha) with an increased rate of (10.95 and 10.33%) for both locations, respectively. The reason for the increase in the biological yield when planting at the early date (30/11) may be attributed to the increase in the number of branches of the plant (Table 1) and the seed yield (Table 1). This result is consistent with what was indicated by [5].The results in Table (2) in both study locations show that the zinc concentration (60 mg/L) was significantly excelled by giving it the highest amount of biological yield that reached (3207.11 and 3281.55 kg/ha), Whereas treatment without addition (0 mg/L) gave the lowest amount of biological yield (2581.88 and 2653.89 kg/ha), with an increased rate of (24.21 and 23.65%).The reason may be due to the significant increase in the traits of the number of branches per plant (Table 8), the number of capsules per plant (Table 2), the number of seeds per capsule (Table 2) and the seed yield (Table 2). This result is consistent with what was found by [9]. The results shown in Table (3) showed that there was no significant interaction between planting dates and zinc concentrations in the traits of the number of capsules per plant for the Nineveh Forest Nursery location. In contrast, in the Abu Maria village location (Table 4), The interaction between the first planting date (30/11) and zinc concentration (60 mg/L) excelled in giving it the highest value for this trait, which amounted to (3427.66 kg/ha), while the interaction between the early planting date (30/11) with treatment without addition (0 mg/l) the lowest value for this trait was (2509.00 kg/ha), with an increase of (36.31%).

Harvest Index (%)

The data shown in Table (1) show that there are significant differences between planting dates in the trait of harvest index for both locations of Nineveh Forest Nursery and Abu Maria village, as it is noted that the second planting date (20/12) excelled the second planting date (20/12) by recording the data shown in Table (1). The highest amount for this trait (46.02%), While the first and third planting dates (11/30 and 10/1) gave the lowest amount of this trait, amounted to (44.17 and 44.26%) respectively, and an increase rate of (4.18%) for both location, respectively. This finding is consistent with [4]. The results shown in Tables (3 and 4) indicate that there are significant differences between zinc concentrations in the harvest index and for both experiment locations. The fifth zinc concentration (60 mg/L) achieved the highest value for this trait, which amounted to (46.81 and 46.74%). While the first and second zinc concentrations (0 and 15 mg/L) achieved the lowest value for this trait (43.15, 43.06 and 43.11, 43.39%) for both locations, respectively. This finding is consistent with that reported by [8]. The results shown in Table (3) in both study locations showed that there was a significant interaction between planting dates and zinc concentrations in the harvest index, as it was noticed in the Nineveh Forest Nursery location that the interaction between the second planting date (20/12) and zinc concentration (30 mg/L) was significant.) by recording the highest amount of this trait amounted to (48.80%), While the interaction between the third sowing date (1/10) with treatment without addition (0 mg/L) recorded the lowest amount for this trait amounted to (42.64%), with an increase of (14.44%). As for the location of Abu Maria village, it is noted that the interaction between the second planting date (20/12) and the fifth zinc concentration (60 mg/L) was excellent, giving the highest value for this trait (47.51%). While the interaction between the first planting date and treatment without addition (0 mg/L) gave the lowest value for this trait (42.30%), with an increase of (12.31%).

Traits planting dates	plant height (cm)	Number of fruiting branches/plant	Number of capsules/plant	Number of seeds/capsule	Weight of 1000 seeds	Seed yield (kg/ha)	Biological yield (%)	Harvest Index (%)
Nineveh Forest Nursery location								
11/30	49.74 a	4.04 a	13.00a	9.16a	6.72b	1364.38 a	3082.60a	44.17 b
12/20	46.39 a b	3.78 b	10.01b	8.18b	6.82b	1333.64b	2891.60b	46.02 a
1/10	42.52 b	3.56 c	8.55c	7.95b	7.65a	1233.00 c	2778.20c	44.26 b
Abu Maria village location								
11/30	49.45 a	4.40a	14.99a	9.36a	6.55b	1385.46 a	3082.60a	44.17 b
12/20	46.51 b	4.01b	13.10b	8.86a b	6.74a b	1353.20b	2891.60b	46.02 a
1/10	43.93 c	3.64c	11.28c	8.46b	6.94a	1265.06 c	2778.20c	44.26 b

Table 1. Effect of planting dates on growth and yield traits.[1] The values followed by different letters within the same column differ significantly.

Traits Zinc concentrations (mg/L(	plant height (cm)	Number of fruiting branches/plant	Number of capsules/plant	Number of seeds/capsule	Weight of 1000 seeds	Seed yield (kg/ha)	Biological yield (%)	Harvest Index (%)
Nineveh Forest Nursery location								
0	42.75d	3.27e	9.16c	7.18c	6.38c	1114.27e	2581.8e	43.15c
15	44.59 c d	3.46d	9.60bc	8.20bc	6.80bc	1199.74d	2783.00d	43.11c
30	46.09 bc	3.65c	10.34bc	8.46a-c	7.21ab	1319.80c	2887.00c	45.72b
45	48.08 ab	4.04b	10.63b	9.07a	7.22ab	1416.86b	3128.33b	45.29b
60	49.58a	4.52a	12.86a	8.61a b	7.71a	1501.01a	3207.11a	46.81a
Abu Maria village location								
0	43.92 c	3.30d	11.25c	8.52c	6.53c	1142.66e	2653.89e	43.06d
15	45.77 bc	3.64c d	12.55bc	8.73bc	6.67bc	1235.44 d	2848.11d	43.39d
30	46.99 a-c	3.94bc	13.66a b	8.84a-c	6.73a-c	1337.66c	2955.88c	45.26b
45	47.36 ab	4.40a b	13.73a b	9.31a	6.82ab	1423.00b	3206.11b	44.36c
60	49.10 a	4.81a	14.44a	9.07a b	6.95a	1534.11a	3281.55a	46.74a

Table 2. Effect of zinc concentrations on growth and yield traits [1] The values followed by different letters within the same column differ significantly.

planting dates	Zinc con-cen-tra-tions (mg/L)	plant height (cm)	Number of fruiting branches/plant	Number of cap-sules/plant	Number of seeds/capsule	Weight of 1000 seeds	Seed yield (kg/ha)	Biolog-ical yield (%)	Har-vest Index (%)
30/11	0	44.10	3.33f g	12.38	8.77	6.00	1178.20 h	2749.67	42.84 d
	15	44.80	3.66de	10.88	8.57	6.56	1258.57 f	2943.67	42.76 d
	30	51.34	3.86c d	12.77	9.25	6.90	1366.67 d	3068.67	44.53c
	45	53.81	4.56a b	13.03	9.82	6.76	1464.00 c	3282.33	44.59 c
	60	54.65	4.76a	15.93	9.42	7.36	1554.47 a	3368.67	46.14 b
20/12	0	44.55	3.30f g	7.99	7.17	6.16	1125.90 i	2560.67	43.96 c d
	15	47.21	3.36f g	9.48	8.56	6.40	1203.23 gh	2764.67	43.52 c d
	30	44.21	3.73de	9.58	8.04	7.06	1382.23 d	2832.00	48.80a
	45	46.22	4.06c	9.44	8.71	7.03	1452.00 c	3111.00	46.67 b
	60	49.77	4.43b	13.55	8.42	7.46	1504.83 b	3189.67	47.17 b
10/1	0	39.60	3.20g	7.11	7.48	7.00	1038.73 L	2435.33	42.64 d
	15	41.77	3.36f g	8.44	7.47	7.43	1137.43 i	2640.67	43.07 d
	30	42.72	3.36f g	8.66	8.09	7.66	1210.50 g	2760.33	43.85c d
	45	44.22	3.50e f	9.44	8.70	7.86	1334.60 e	2991.67	44.60 c
	60	44.55	4.36b	9.10	8.01	8.30	1443.73 c	3063.00	47.13 b

Table 3. The effect of the interaction between planting dates and zinc concentrations on growth traits and yield for Nineveh Forest Nursery location.[1] The values followed by different letters within the same column differ significantly.

planting dates	Zinc concentrations (mg/L)	plant height (cm)	Number of fruiting branches/plant	Number of capsules/plant	Number of seeds/capsule	Weight of 1000 seeds	Seed yield (kg/ha)	Biological yield (%)	Harvest Index (%)
30/11	0	46.99	3.50	12.55	8.90	6.30	1193.33 i	2820.66 j	42.30i
	15	49.44	3.88	15.21	9.36	6.63	1280.66 g	3016.00 h	42.45h i
	30	48.33	4.66	15.55	9.61	6.60	1386.33 e	3105.66 f	44.63c d
	45	50.88	4.77	14.99	9.73	6.53	1481.33 c	3327.66 b	44.51d e
	60	51.61	5.21	16.66	9.66	6.70	1585.66 a	3427.66 a	46.25b
20/12	0	44.33	3.23	12.77	8.60	6.56	1155.33 k	L2632.00	43.89e f
	15	46.44	3.62	12.66	8.66	6.70	1253.33 h	2819.33 j	44.45d e
	30	48.10	3.94	13.33	8.73	6.76	1349.33 f	2939.66 i	45.89b
	45	45.77	4.56	12.66	9.20	6.73	1453.33 d	3250.00 d	44.71c d
	60	47.94	4.73	14.10	9.13	6.93	1554.66 c	3271.33 c	47.51a
10/1	0	40.44	3.16	8.44	8.06	6.73	1079.33 L	2509.00 m	43.01g h
	15	41.44	3.43	9.77	8.16	6.70	1172.33 j	2709.00 k	43.26f g
	30	44.55	3.23	12.10	8.64	6.83	1277.33 g	2822.33	45.25c
	45	45.44	3.86	13.55	9.00	7.20	1334.33 f	3040.66 g	43.87e f
	60	47.77	4.50	12.55	8.43	7.23	1462.00 d	3145.66 e	46.47b

Table 4. The effect of the interaction between planting dates and zinc concentrations on the growth traits and yield of the location of Abu Maria village.[1] The values followed by different letters within the same column differ significantly.

DISCUSSION

This study showed that planting flax at an early date (30/11) and adding zinc at a concentration of (60 mg Zn/L) led to an increase in the productivity of the flax crop.

CONCLUSIONS

The research concludes the response of the growth and yield of flax to planting dates and different concentrations of zinc.

Acknowledgment: The authors are very grateful to the University of Mosul/ College of Agriculture and Forestry for their provided facilities, which helped improve this work's quality.

References

1. Abdelfarag, B. A.; Ali, A. M. Effect of Sowing Date and SeedRate on Growth and Seed Yield of Linseed (Linum usitatissimum L.). *U. of KJ Agric. Sci*, **2016**, 24.2: 158-172.
2. El-Nagdy, G. A.; Nassar, D. M.; El-Kady, E. A.; El-Yamanee, G. S. Response of flax plant (Linum usitatissimum L.) to treatments with mineral and bio-fertilizers from nitrogen and phosphorus. *Journal of American Science*, **2010**, 6.10: 207-217.
3. Brain, A. J. Zinc in soils and crop nutrition. *J. of Plant and Soil*, **2007**, 1: 120 – 128.
4. Rahimi, M. M. Effect of sowing date and nitrogen on yield and yield components of medicinal flax. *Inter. J. of Biosciences (IJB)*, **2014**, 5.12: 160-165.
5. Ghanbari-Odivi, A.; Safari, A.; Tahmasebi, B. K.; Farrokhi, M.; Bahrampour, B. Effect of delaying in sowing date on growth, yield, yield components and oil content of two genotypes of flaxseed (Linum usitatissimum). *Advances in Environmental Biology*, **2013**, 7.6: 1014-1018.
6. Al-Juheishy, W. K. S. Effect of Sowing Dates and Zinc Spraying on Growth and Yield of Flax (Linum usitatissimum L.). *Int. J. Agricult. Stat. Sci.*, **2020**, 16.1: 1875-1882.
7. Abhishek, N.; Singh, S.; Sumanth, M. S. Influence of dates of sowing and varieties on growth and yield of linseed (Linum Usitatissimum L.). *The Pharma Innovation Journal*, **2021**, 10.11: 1905-1908.
8. Nofal, O. A.; Zedian, M. S.; Bakry, B. A. Flax yield and quality traits as affected by zinc foliar application under newly reclaimed sandy soils. *Journal of Applied Sciences Research*, **2011**, September: 1361-1367.
9. Homayouni, G.; Souri, M.; Zarein, M. Effects of zinc and nitrogen on yield components of five flax genotypes. *Global Journal of Science Frontier Research Chemistry*, **2013**, 13.5: 20-24
10. Al-Doori, S. A. M. A. Response of Three Flax Genotypes (Linum usitatissimum L.) to Foliar Spraying with Different Concentration of Zinc and Boron under the Dryland Conditions of Nineveh Governorate. *College Of Basic Education Researches Journal*, **2021**, 17.3: 1680-1700.
11. Cakmak, I.; Marschner, H. Effect of zinc nutritional status on activities of superoxide radical and hydrogen peroxide scavenging enzymes in bean leaves. In: *Plant Nutrition—from Genetic Engineering to Field Practice*. Springer, Dordrecht, **1993**. p. 133-136.
12. Kastrup, V.; Steiger, S.; Lüttge, U.; Fischer-Schliebs, E. L. K. E. Regulatory effects of zinc on corn root plasma membrane H+-ATPase. *New phytologist*, **1996**, 134.1: 61-73.
13. Rashid, A.; Wafique M. Boron and zinc fertilizer use in (*Vicia Faba* L.): importance and recommendation. *Pakistan Agricultural Research Counsel Publication*, **2000**.
14. Al-Rawi, K. M.; Khalaf-Allah, A. M. Design and Analysis of Agricultural Experiments. Foundation of Dar AL-Ktob University of Mosul. Ministry of Higher Education and Science Research, Iraq. **2000**.
15. Graham, R. D.; Rengel, Z. Genotypic variation in zinc uptake and utilization by plants. In: *Zinc in soils and plants*. Springer, Dordrecht, **1993**. p. 107-118.

Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023
Citation: Al-Ta'iy, A.R.A.; Al-Juheishy, W.K.S. Response of growth and yield of Flax (Linum usitatissimum L.) to sowing dates and foliar application with zinc. Revista Bionatura 2023;8 (2) 63. http://dx.doi.org/10.21931/RB/CSS/2023.08.04.78