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# Performance of Three Flax Cultivars (*Linum usitatissimum* L.) with Varient Foliar Spraying of Different Concentrations of Sulfur and Boron in two soil types in Nineveh Governorate

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## Abstract

In order to investigate the effects of micronutrient foliar application in quantitative traits and seed oil content of flax (*Linum usitatissimum* L.), two field experiments were carried out two locations. The first is AL-Rashidia 20 km west north Mosul city, the second ones Gueer 50 Km east of Mosul city at Nineveh province. The experiment was done using randomized complete block design with three replications. The experiment treatments included of three flax cultivars crops (C1: Sakha1, C2: Aryana and C3: Royal-4), three concentration of sulfur (S1: control, S2:10 and S3:20 mg.L$^{-1}$) and three levels of boron foliar application (B1: control, B2: 7 and B3:14 mg.L$^{-1}$). These micronutrient foliar application were sprayed on the leaves one dose during 6 leaves stage. Flax crop cultivars differed for some studied yield and its component in both locations. The highest number of primary branches per plant and total seed yield (ton. ha$^{-1}$) were produced from Aryana cultivar in both seasons. The results revealed that sulfur foliar spraying had a significant effect on some growth traits, yield components and quality. The maximum seed yield obtained from sprayed sulfur with concentration of 10 mg.L$^{-1}$ (S2 treatment). Foliar spraying of boron with concentration of 7 mg.L$^{-1}$ (B2 treatment) had significantly affected on plant height, number of seeds per capsule and oil percentage in both locations, while increasing concentration of boron to 14 mg.L$^{-1}$ (B3 treatment) caused a significant decrease in other traits in in both locations. Overall, we concluded that micronutrient foliar spraying as sulfur and boron on leaves plant, had positive effects on quantitative and qualitative traits of flax cultivars in conditions of the two studied area.

Key words: flax cultivars, *Linum usitatissimum* L., sulfur, boron, foliar application.

## Introduction

Flax (*Linum usitatissimum* L.) belongs to the Linaceae family. Its seeds are grown for the purpose of producing oil, which ranges from 30 to 50%, which is of high economic importance because it contains unsaturated fatty acids that reduce cholesterol in the blood [1]. Its seed also contain protein, some minerals, and omega-3 acids, which treat many heart diseases and arthritis diseases [2]. Because of the calcareous soil with a high pH for most regions of the Iraqi country, the available of microelements, including sulfur and boron, is low for most crops, including flax, which is sensitive to the deficiency of these elements, which makes it necessary for us to add these microelements by spraying on plant leaves [1, 3, and 4]. Given the importance of microelements, including sulfur and boron, in improving the growth and productivity of plants, including flax, and the low cost of production, so it became necessary for researchers to add these elements by spraying on the leaves of plants if the soil has a high pH, the presence of calcium carbonate, organic matter, and the interaction between sulfur or boron and the rest of the elements. Other [5,6,7 and 8] Sulfur is one of the necessary microelements for most crops, including flax. It is a yellow powder, easy to volatilize, and it used to spray on plant leaves, in addition to using it to increase soil fertility. It is always added with fertilization before tillage. The benefits of sulfur are many, including treating saline or alkaline soils. It works to adjust the pH of the soil and increase the availability of many nutrients for the plant, as the process of biological oxidation of different sources of sulfur in calcareous soil has an effect on some soil traits and the availability of some nutrients. Many studies showed that treating the soil with sulfur led to an increase in the electrical conductivity of the soil and an increase in the readiness of each of phosphorous, iron, manganese and boron in the soil, and finally an increase in the height of the flax plant and an increase in the seed yield [9 and 10]. Boron plays an important role in the formation of cell walls, and in the transmission of sugars in the plant. Some have found that the sugars move easily through the cellular membranes after its union with boron. It is necessary for cell division, formation of phloem, transmission of some hormones, germination of pollen grains, and it controls the speed of plant absorption of water. And its presence increases plant resistance to drought and has a great relationship with plant hormones that affect the growth of the developing tops of stems and roots and has a relationship in regulating calcium absorption in the soil [10 and 11]. In this study, two sites were selected in northern Iraq, with different soil conditions, to investigate the effect of foliar spraying with sulfur and boron on the growth, yield and quality of three flax cultivars.

## Material and Methods

Two field experiments for flax (*Linum usitatissimum* L.) conducted during winter growing seasons of 2019-2020 in two locations. The first AL-Rashidia 20 km 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 sulfur and boron foliar application on the growth, yield and quality of three flax cultivars. Each experiment was conducted according to factorial experiment in a randomized completely block design with three replications. Each experiment included three levels of sulfur and boron foliar application (0,0, 10,7 and 20,14 mg.$L^{-1}$) of sulfur as zinc sulphate ($ZnSo_4.7H_2o$) and boron as boric acid ($H_3Bo_3$) respectively, were sprayed on the leaves one dose during 6 leaves stage, with three flax cultivars crops (Sakha1, Aryana and Royal-4). The seeds were sown on the first and fifth of October for AL-Rashidia and Gueer location, respectively. After Fourteen days from sowing the seeds, the process of thinning the plants into one plant took place. Potassium fertilizer was added during cultivation at a rate of 40 kg/ha and superphosphate fertilizer at a rate of 60 kg/ha, and urea fertilizer was added in two batches, after fourteen days of sowing and after 30 days of cultivation at a rate of 100 kg/ha. All field operations were carried out using the scientific methods used in the cultivation of flax crops. Random representative samples of twenty plants were used at full maturity stage from every experimental unit to estimate the following traits:

1- Plant height (cm).
2- No. of branches.$plant^{-1}$.

Twenty plants were randomly at harvested from the two middle lines to study the following traits:

1- Number of capsule per plant.
2- Number of seeds per capsule.
3- Weight of thousand seed (gm).
4- seed yield per plant (gm)
5- Total seed yield (ton. $ha^{-1}$).

The percentage of oil in flaxseeds was estimated using the soxhlet device, according to what was mentioned in [12]. Determine the protein in the ground seeds after nitrogen determination using the micro Kjeldahl using the following equation: Protein% = N% × 6.25 [13]. Before planting, some physical and chemical traits of the soil were measured at a depth of 30 cm [14,15,16,17]. An atomic absorption device was used to measure the concentration of sulfur at a wavelength of 213.9 nanometers [18]. As for the boron content in the soil, it was measured using the same device at a wavelength of 540 nanometers [14].

**Table 1: Some physical and chemical soil traits in the AL-Rashidia and Gueer locations at a depth of 30 cm.**

| locations | AL-Rashidia | Gueer |
|---|---|---|
| physical traits | | |
| Sand (%) | 60.00 | 20.00 |
| Silt (%) | 25.00 | 35.00 |
| Clay (%) | 15.00 | 45.00 |
| Texture | Sandy | Clay Loom |
| Chemical traits | | |
| O.M. ($g.kg^{-1}$) | 9.48 | 10.00 |
| Available N (ppm) | 40.22 | 42.60 |
| Available P (ppm) | 8.88 | 10.44 |
| Available K (ppm) | 148.42 | 144.24 |
| Total $CaCo_3$ ($g.kg^{-1}$) | 10.60 | 11.44 |
| Available S (ppm) | 2.84 | 2.00 |

| | | |
|---|---|---|
| Available B (ppm) | 3.88 | 3.22 |
| pH | 7.60 | 7.22 |
| E.C. mmhos/cm | 0.88 | 0.80 |

SAS software, version 20, was used to analyze the data statistically using Duncan's multiple rang test at probability ($p \leq 0.05$) as mentioned by [19].

## Results and Discussion

### Flax cultivars effect

Analysis of variance results indicated that effect of flax cultivars on all studied traits was significant except protein percentage in both locations and number of capsule per plants, seed yield (gm) number of seeds.capsule$^{-1}$ in Gueer location (table 4). The means of technical length ranged from 137.48 cm to 126.01 cm in AL-Rashidia location and 123.41 cm to 110.51 cm in Gueer location. Aryana cultivar gave the highest technical length in both locations. On the other hand, Sakha-1 produced the shortest technical length compared with other flax cultivars. The mean of number of Primary branches, ranged from 2.51 for Aryana to 2.04 for Sakha 1 cultivar in AL-Rashidia location, whereas Gueer location ranged from 2.18 for Aryana to 1.98 for Sakha 1 cultivar. Aryana cultivar was significantly number of capsule per plants and number of seeds per capsule, whereas the Sakha-1 produced the lowest number of capsule per plants and number of seeds per capsule. The highest of thousand seeds weight was obtained from Aryana cultivar, whereas, the Sakha 1 cultivar gave the lowest in both locations. The differences in seed yield per plant between the three flax cultivars showed that Aryana cultivar and Royal-4 cultivar had the highest seed yield per plant in both locations. On the contrary, Sakha 1 cultivar was significantly the lowest in seed yield per plant. Total seed yield ranged from 1.87 (ton.ha$^{-1}$) for Aryana cultivar to 2.82 (ton.ha$^{-1}$) for Sakha-1 and 1.33 (ton.ha$^{-1}$) for Aryana to 2.29 (ton.ha$^{-1}$) for Sakha 1 in both seasons, respectively. The differences between the tested cultivars could mainly be attributed to the differences in their genetical constitution and their response to the environmental conditions. Such results are in harmony with those obtained by many investigators, [20,21,22,23]. The results showed that oil and protein percentage were always higher for Aryana cultivars than that for Sakha 1 and Royal-4 cultivars.

### Sulfur foliar application effect

Data in table (4) indicates that the levels of applied sulfur not affected significantly on the some studied traits (number of Primary branches, number of capsule per plants and number of seeds per capsule in Gueer location, weight of thousand seeds, oil and protein percentage in both seasons). Data presented in tables (2 and 3) showed that increasing sulfur foliar application from 0 to 10 mg.L$^{-1}$ significantly increased number of primary branches (2.47), number of capsule per plant (18.30) and number of seeds per capsule (24.52) and seed yield per plant (6.77 gm) at the AL-Rashidia location, plant height (135.05, 121.36 cm) and seed yield per plant (6.77, 7.49 gm) at the both locations AL-Rashidia and Gueer, respectively. This refers to the role of sulfur foliar application in nutrients balance of flax under undesirable soil conditions, while they appeared to be negative response to 20 mg.L$^{-1}$ for those traits. This could be attributed to the high available of sulfur in the experimental site in the both locations (table1). The beneficial effect of sulfur 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 sulfur foliar application levels increased plant height as was found by [24,25,26,27]

## Boron foliar application effect

Tables (2 and 3) shows that the increases in boron foliar application from 0 to 7 mg.L$^{-1}$ caused significant increase plant height (140.82, 126.78 cm), number of seeds per capsule (25.02, 21.14) and oil percentage (40.55, 39.76%) at the both locations AL-Rashidia and Gueer, respectively; The reason for the increase in most of the growth and yield traits may be due to the increase in the concentration of boron to a limit of 7 mg / liter, due to the chemical traits of the soil and its low content of organic matter, pH and calcium (table no. 1). In this concern, increasing boron foliar application levels increased plant height as was found by [28,29,30,31,32,33,34,35]

## The interactions effect

The interactions treatments effect cultivars x sulfur concentration, cultivars x boron concentration, sulfur x boron application and cultivars x sulfur concentration x boron concentration for all investigated traits were non-significant for both locations. This showed that each factor acted independently on these traits.

Table 2: Effects of cultivars, sulfur (S), boron (B) and their interactions on the some growth traits, yield components and quality for AL-Rashidia location.

| Main effect | plant height (cm) | number of primary branches | no. of capsule.plants$^{-}$ | no. of seeds.capsule$^{-1}$ | 1000 seeds weight (gm) | seed yield (gm) | seed yield (ton.ha$^{-1}$) | oil (%) | protein (%) |
|---|---|---|---|---|---|---|---|---|---|
| Flax cultivars | | | | | | | | | |
| C1: Sakha-1 | 126.012c | 2.0452c | 17.3233c | 23.3630b | 3.2880b | 5.6465b | 1.87930c | 35.5059c | 16.0774 |
| C2: Aryana | 137.484a | 2.5156a | 18.4541a | 24.6874a | 3.4569a | 6.1147a | 2.82859a | 39.0467a | 16.5274 |
| C3: Royal-4 | 131.910b | 2.1922b | 17.9804b | 24.0024a | 3.4228a | 6.6250a | 2.19659b | 38.1989b | 16.1537 |
| Sulfur foliar spraying (mg.L$^{-1}$) | | | | | | | | | |
| S1:0 | 129.930c | 2.0700c | 17.5837b | 23.3996b | 3.3048 | 5.6737b | 2.16904 | 37.7189 | 15.4344 |
| S2:10 | 135.053a | 2.4722a | 18.3052a | 24.5263a | 3.4646 | 6.7750a | 2.43744 | 37.9063 | 16.8804 |
| S3:20 | 130.424b | 2.2107b | 17.8689b | 24.1269a | 3.3982 | 5.9375b | 2.29800 | 37.1263 | 16.4437 |
| Boron foliar spraying (mg.L$^{-1}$) | | | | | | | | | |
| B1:0 | 118.531c | 1.8104 | 17.3433 | 23.4172b | 3.0957 | 5.6025b | 2.15978 | 35.3893c | 15.7204 |
| B2:7 | 140.828a | 2.6089 | 18.8544 | 25.0267a | 3.6526 | 7.0071a | 2.55811 | 40.5563a | 16.7230 |
| B3:14 | 136.048b | 2.3337 | 17.5600 | 23.6089b | 3.4194 | 5.7765b | 2.18659 | 36.8059b | 16.3152 |
| interactions effect | | | | | | | | | |
| C × S | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |
| C × B | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |
| S × B | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |
| C × S × B | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |

*, **: significant at 5 % and 1 % probability levels and N.S.: non-significant and, respectively.

Table 3: Effects of cultivars, sulfur (S), boron (B) and their interactions on the some growth traits, yield components and quality for Gueer location.

| Main effect | plant height (cm) | number of primary branches | no. of capsule.plants$^{-}$ | no. of seeds.capsule$^{-1}$ | 1000 seeds weight (gm) | seed yield (gm) | seed yield (ton.ha$^{-1}$) | oil (%) | protein (%) |
|---|---|---|---|---|---|---|---|---|---|
| Flax cultivars | | | | | | | | | |
| C1: Sakha-1 | 110.519c | 1.9830 | 14.6741 | 19.7711 | 8.7556c | 6.1800 | 1.33326b | 34.7881b | 13.5196 |
| C2: Aryana | 123.417a | 2.1819a | 15.1889 | 20.1674 | 10.2132a | 6.4748 | 2.29919a | 37.7919a | 13.4242 |
| C3: Royal-4 | 117.906b | 2.0911b | 15.4311 | 20.1500 | 9.5719b | 7.0889 | 1.63304b | 37.3600a | 13.2801 |
| Sulfur foliar spraying (mg.L$^{-1}$) | | | | | | | | | |
| S1:0 | 114.861c | 2.0081 | 14.7522 | 19.7033 | 8.9689 | 5.9456c | 1.62041c | 36.1581 | 13.0121 |
| S2:10 | 121.364a | 2.1315 | 15.3274 | 20.7319 | 9.9994 | 7.4659a | 1.90826a | 37.0230 | 13.6705 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S3:20 | 115.617b | 2.1163 | 15.2144 | 19.6533 | 9.5724 | 6.3322b | 1.73681b | 36.7589 | 13.5414 |
| Boron foliar spraying (mg.L$^{-1}$) | | | | | | | | | |
| B1:0 | 100.579c | 1.7104 | 14.4648 | 19.1896c | 8.6052c | 6.1274c | 1.59819b | 34.2733c | 13.1770 |
| B2:7 | 126.482a | 2.3970 | 15.9130 | 21.1478a | 10.4093a | 7.7826a | 2.02367a | 39.7637a | 13.6310 |
| B3:14 | 124.780b | 2.1485 | 14.9163 | 19.7511b | 9.5263b | 5.8337b | 1.64363b | 35.9030b | 13.4160 |
| interactions effect | | | | | | | | | |
| C × S | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |
| C × B | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |
| S × B | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |
| C × S × B | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s | n.s |

*, **: significant at 5 % and 1 % probability levels and N.S.: non-significant and, respectively.

Table 4: Analysis of variance F values for some growth traits, yield components and quality for AL-Rashidia and Gueer locations.

| S.O.V | D.f | M.S. for AL-Rashidia location. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | plant height (cm) | number of primary branches | no. of capsule.plants$^{-1}$ | no. of seeds.capsule$^{-1}$ | 1000 seeds weight (gm) | seed yield (gm) | seed yield (ton.ha$^{-1}$) | oil (%) | protein (%) |
| Replications | 2 | 22992.2726 | 17.01016 | 1338.7821 | 909.95908 | 222.524348 | 34.5986 | 12.4022 | 1396.6 | 24.76 |
| C | 2 | 888.61651 ** | 1.563356 * | 8.706004 * | 11.845203 ** | 0.2154716 * | 6.46702 ** | 6.30568* * | 92.28* | 1.565 n.s |
| S | 2 | 215.57333* | 1.124834 * | 3.564993 ** | 8.810036* | 0.174 N.S. | 8.92679 ** | 0.4865N.S | 4.47 n.s | 14.849 n.s |
| B | 2 | 3720.97053 * | 4.442564 n.s | 18.026944 n.s | 20.867136 * | 2.1119175 n.s | 15.82959 * | 1.3383652 n.s | 192.467 * | 6.8637 n.s |
| C × S | 4 | 49.04008 n.s | 0.59225 n.s | 4.72141 n.s | 0.535932 n.s | 0.0322084 n.s | 0.6164 n.s | 0.206061 n.s | 0.639 n.s | 1.985 n.s |
| C × B | 4 | 14.78119 n.s | 0.23990 n.s | 0.74655 n.s | 1.597135 n.s | 0.0958591 n.s | 1.4952 n.s | 0.075505 n.s | 0.387 n.s | 4.447 n.s |
| S × B | 4 | 22.52258 n.s | 0.04279 n.s | 0.19805 n.s | 0.100903 n.s | 0.0103099 n.s | 1.1772 n.s | 0.018832 n.s | 0.846 n.s | 0.5902 n.s |
| C × S× B | 8 | 3.3239 n.s | 0.03797 n.s | 0.37737 n.s | 0.29943 n.s | 0.008041 n.s | 0.7390 n.s | 0.00757 n.s | 0.83 n.s | 0.186 n.s |
| Error | 52 | | | | | | | | | |
| Total | 80 | | | | | | | | | |
| S.O.V | D.f | M.S. for Gueer location. | | | | | | | | |
| Replications | 2 | 19839.1975 | 1.34917 | 929.55586 | 53.10926 | 508.2549 | 17.2879 | 1.272916 | 497.772 | 162.39 |
| C | 2 | 1130.93687 ** | 0.267690 * | 4.035649 n.s | 1.3540975 n.s | 14.411690 * | 5.80536 n.s | 6.5998483 ** | 71.2041 * | 0.392 n.s |
| S | 2 | 341.51438* | 0.122119 n.s | 2.507616 n.s | 10.005986 n.s | 7.23888 n.s | 16.85844 * | 0.5661115 * | 5.3033 n.s | 3.2866 n.s |
| B | 2 | 5667.99106 * | 3.263608 n,s | 14.824409 n.s | 27.4512753 * | 21.972386 * | 29.80830 * | 1.4738752 * | 214.673 * | 1.3920 n.s |
| C × S | 4 | 72.11532 n.s | 0.01553 n.s | 0.14329 n.s | 2.433342 n.s | 0.15403 n.s | 1.87975 n.s | 0.177918 n.s | 0.3397 n.s | 0.031 n.s |
| C × B | 4 | 19.97473 n.s | 0.17159 n.s | 0.40029 n.s | 0.664447 n.s | 0.90934 n.s | 3.46256 n.s | 0.089099 n.s | 0.5447 n.s | 0.314 n.s |
| S × B | 4 | 57.83750 n.s | 0.01816 n.s | 0.14117 n.s | 0.228958 n.s | 0.08758 n.s | 2.49472 n.s | 0.028429 n.s | 0.6073 n.s | 0.053 n.s |
| C × S× B | 8 | 12.23716 n.s | 0.0362 n.s | 0.03903 n.s | 0.42623 n.s | 0.0876 n.s | 1.5227 n.s | 0.01280 n.s | 0.449 n.s | 0.04 n.s |
| Error | 52 | | | | | | | | | |
| Total | 80 | | | | | | | | | |

*, **: significant at 5 % and 1 % probability levels and N.S.: non-significant and, respectively.

## References

1- Oomah, B. D. (2001). Flaxseed as a functional food source, Journal of the Science of Food and Agriculture, vol. 81, no. 9, pp. 889–894. View at: Publisher Site. Google Scholar

2- Acosta, P. P. (1980). Enciclopedia Argentina de Agricultura y

Jardinería, Lino para Semilla y Fibra. Ed. ACME S.A.C.I. Bs As.

3- Ganorkar p.m., jain r.k. (2013). Flaxseed – a nutritional punch. Int. Food Res. J., 20(2): 519-525.

4- Bhatty R.S., cherdkiatgumchai P. (1990). Compositional analysis of laboratory-prepared and commercial samples of linseed meal and of hull isolated from flax. J. Am. Oil Chem. Soc., 67: 79-84.

5- Nofal, O. A; M. S. Zedian and B. A. Bakry (2011). Flax yield and quality traits as affected by sulfur foliar application under newly reclaimed sandy soil. Journal of Applied Science Research, 7(9): 1361-1367.

6- Mousavi, S. R. (2011). Sulfur in Crop Production and Interaction with Phosphorus. Australian Journal of Basic and Applied Sciences 5(9): 1503-1509. ISSN 1991-8178. Aligoudarz Branch, Islamic Azad University, Aligoudarz, Iran.

7- Hasina, G; Ahmad S.; Beena S.; Fida M. and Ijaz A. A. (2011). Effect of foliar application of nitrogen, potassium and sulfur on wheat growth. Journal of Agricultural and Biological Science. Vol. 6, No. 4, April 2011 ISSN 1990-6145. 2006-2011 Asian Research Publishing Network (ARPN).

8- Menge, L. K. and Frnest A. K. (2010). Principles of plant nutrition International Potash Institute. P.O. Box, CH-3048 Worblanfen-Bern/ Switzerland.

9- Bakry, B. A; M. M. Tawfik; B. B. Mekki and M. S. Zeidan (2012). Yield and Yield Components of Three Flax Cultivars (*Linum usitatissimum* L.) In Response to Foliar Application with Zn, Mn and Fe under Newly Reclaimed Sandy Soil Conditions. American-Eurasian J. Agric. & Envboron. Sci., 12 (8): 1075-1080, ISSN 1818-6769.

10- Keram, K. S.; B. L. Sharma and S. D. Sawarkar (2012). Impact of S application on yield, quality, nutrients uptake and soil fertility in a medium deep black soil (Vertisol). International Journal of Science, Envboronment and Technology, 1(5): 563 - 571.

11- Abbas, G. M. Q.; Khan M.; Khan J.; Hussain F. and Hussain I. (2009). Effect of boron on the growth and yield contributing parameters of Flax (*Linum usitatissimum* L.) The Journal of Animal and Plant Science 19(3): 135-139.

12- A.O.A.C. (1980). Official methods of analysis of the Association of Official Analytical Chemists.12th Ed.Washington, D.C.

13- Stahl, E. E. (1967). Thin Layer Chromatography. A Laboratory Handbook. E. D. Springer Verlong, Berline, 359 Heidel, New York.

14- Black, C.A. 1965. Methods of soil analysis. Part 2. Chemical and microbiological properties. Amer. Soc. of Agronomy. Inc. publisher Madison. USA.

15- Jackson, M.L. (1973). Soil chemical Analysis . Prentice Hall of India Pvt., New Delhi.

16- Page, A.L.; R.H., Miller and D.R., Kenney (1982). Methods of soil analysis . Part (2) Agronomy number 9 Madison . USA.

17- Tandon, H. (1999). Methods of analysis of soil, plants, water and fertilizers. Fertilizer

Development and Consultation Organization, New Delhi, India, pp : 144.

18- APHA, (1998). Standard methods for the examination of water and waste water, American Public Health Association (20th Eds.), Washington D.C., U.S.A.

19- Cochran, W. G.; and G. M. Cox (1957).Experimental designs.2nd ed,, John Wiley and Sons Inc, New York, USA. pp. 593

20- Al-Doori, S.A.M. (2012). Influence of Sowing Dates on Growth, Yield and Quality of Some Flax Genotypes (*Linum usitatissimum* L.) Research Journal 12 (1):733-746.

21- El-Beltagi1, H. S., Z. A. Salama and D. M. El-Hariri, (2007). Evaluation of Fatty Acids Profile and the Content of some Secondary Metabolites in Seeds of Different Flax Cultivars (*Linum Usitatissimum* L.). Journal of Plant Physiology, 2007, 33 (3-4), 187-202.

22- Shaker, A.T. and AL-Doori, S. A. (2011). Effect of Different Levels and Timing of Boron Foliar Application on Growth, Yield and Quality of Sunflower Genotypes (*Helianthus annuus* L.). Mesopotamia Journal of Agriculture 39 (3):16-24.

23- Andruszczak, S. , U. GawlikDziki, P. Kraska, E. Kwiecinska-Poppe, K. Rozylo and E. Pałys (2015). Yield and quality traits of two linseed (*Linum usitatissimum* L.) cultivars as affected by some agronomic factors. Plant Soil and Environment, 61(6): 247–252.

24- Al-Doori, S.A.M. and M.Y.H., Al-Dulaimy (2012). Influence of Zn, S and B fertilization levels on Growth, Yield and Quality of Some Sunflower Genotypes (*Helianthus annuus* L., Compositae) Research Journal 11 (4): 714-730.

25- Alloway, B.J. (2008). Zinc in soils and crop nutrition (2thed), Brussels. International zinc association (IZA). 136p.

26- Bakry B.A., Tawfik MM, Mekki B.B., Zeidan MS, (2012). Yield and Yield Components of Three Flax Cultivars (*Linum usitatissimum* L.) In Response to Foliar Application with Zn, Mn and Fe under Newly Reclaimed Sandy Soil Conditions. American Eurasian J. Agric. & Environ. Sci. 12 (8): 1075-1080.

27- Bybordi A., and Malakouti MJ, (2007). Effects of zinc fertilizer on the yield and quality of two winter varieties of canola. Zinc crops. International Congress of Improving Crop Production and Human Health, 24 – 26 May. Istanbul. Turkey.

28- Al-Doori, S.A. and A.T., Shaker. (2012). Effect of Leaves Defoliation and Boron fertilization on Growth, Yield and Quality of Sunflower (*Helianthus annuus* L., Compositae). Nutrient Management for Soil Sustainability Food Security and Human Health. 8th International Soil Science Congress on "Land Degradation and Challenges in Sustainable Soil Management" May 15-17, (2012) Cesme - İzmir, TURKEY PROCEEDINGS BOOK: 63-71

29- Coke, L. and Whittington, W.J. (1968) The Role of Boron in Plant Growth: IV. Interrelationships between Boron and Indol-3YL-Acetic Acid in the Metabolism of Boron

Radicals. Journal of Experimental Botany, 19, 295-308.

30- Shaker, A.T. and S. A., AL-Doori (2009). Effect of Boron Fertilization on Growth, yield and Quality of Sum Sunflower Cultivars (*Helianthus annuus* L.). DIRASAT Journal of Agriculture 36 (1):9-17.

31- Nofal, O.A., Zedian, M.S. and Bakry, B.A. (2011) Flax Yield and Quality Traits as Affected by Boron Foliar Applica. Journal of Applied Sciences Research, 7, 1361-1367.

32- Siavashi K, Soleimani R, Malakouti M. J., (2004). Effect of Boron application times and methods on grain yield and protein content of chickpea in rainfed conditions. Iran Journal of Soil Water, 18: 42- 49.

33- Esmail, A. O. (2012) Effect of soil phosphorus equilibrium on p-availability for wheat using solubility diagram and DRIS-chart methods. Journal of University of Kirkuk for Agriculture Sciences. 3(2): 45-54

34- Saleh, M. M. S. (2000). Cytogenetic and Histological Study of induced polyploid of Crepic capillaries, PhD. Thesis, Faculty of Biology. Cited from Chnar thesis.

35- Bakry, A. B.; Elewa T. A. and Ali O. A. M. (2012). Effect of Fe Foliar Application on Yield and Quality Traits of Some Flax Varieties Grown Under Newly Reclaimed Sandy Soil. Australian Journal of Basic and Applied Sciences, 6(7): 532-536, 2012. ISSN 1991-8178.