Response of Flax Plant to Foliar Spray by Urea and Some of Micronutrients Mixture under Different Nitrogen Levels

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ABSTRACT

Two field trial were conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt, during 2016/2017 and 2017/2018 winter seasons to study the physiological response of flax (*Linum usitatissimum L.*) Sakha 3, cultivar to three nitrogen fertilizer rates *i.e*; 25, 35 and 45 kg N/fad.. in a combination with foliar spray by urea 2(%) plus some of micronutrients mixture of (Fe + Zn + Mn) using concentration at 200 ppm for each element. The maximum values of plant height, fruiting zone length, technical length, as well as, leaf area/plant and dry matter accumulation (g)/m^2 at 80 and 95 days after sowing (DAS), crop growth rate (CGR) and net assimilation rate (NAR) at (80–95 DAS) period were obtained when plants received 35 kg N/fad. and foliar spray with urea 2(%)plus 200 ppm micronutrients mixture of (Fe + Zn + Mn). In addition, straw and seed yields, its components, fiber (%), fiber yield, total chlorophyll of leaves at 95 DAS, oil (%) and oil yield.

The total saturated fatty acids of flax oil were, gradually, increased with increasing nitrogen fertilizer rate from 25 up to 45 kg N/fad., whereas, the total unsaturated fatty acids were decreased. The minimum value of the total unsaturated fatty acids were obtained from plants received [35 kg N/fad. and a spray with 200 ppm micronutrients mixture of (Fe+ Zn +Mn)].

Key words: Flax plants, nitrogen fertilizers and micronutrients.

INTRODUCTION

Flax (*Linum usitatissimum* L.) is an annual plant grown in many countries all over the world. In Egypt, it is one of the oldest crop planted as a dual purpose typs for seeds and fibers, which is used for manufacture of linen. Oil seed of flax is edible and quick drying, properly, which, is used for the preparation of paints, varnishes, printing ink, oil cloth and soap.

Flax fiber is soft, flexible and stronger than cotton or wool. The growing area decreased in the last three years to 12000, 1445 fad. in 2016/2017 and 2017/2018 seasons, respectively. due to the great competition of other economic winter crops, resulting in a gab between production and consumption Moursi *et al*.(2015). Therefore, it is necessary to increase flax productivity per unit area, which could be achieved by using high yielding cultivars and improving the cultural practices; *i.e.* nitrogen fertilization, foliar spray of urea and some of micronutrients mixture (Fe + Zn + Mn) Hussein, (2007) and Ibrahim (2009). Nitrogen is the most important nutrient which improves growth and seed yield and its components of flax plant. Many researchers have postulated the role of nitrogen, which can be ascribed to the function of N in plant metabolism ; *i.e.* constituent of amino and nucleic acids, many cofactors and cellular compounds. El-Gazzar and Kineber. (2002). found that increasing nitrogen fertilizer from 30 to 60 kg N/fad., significantly, increased flax seed yield / fad. El-Nagdy *et al*. (2010) reported that adding 45kg N/fad. recorded the maximum values of seed and straw yields of flax. Dervisevic and Jogic. (2014), reported that adding 30 kg N/ha to flax plants recorded the maximum yield of fiber.

Foliar application of urea, as a supplementary fertilization, to soil applied nitrogen is very important to reduce costs and environmental pollution. At the same time, it increases flax productivity. Khan *et al.,* (2009) reported that foliar spray of 4(%) urea solution enhanced wheat quantitative and qualitative traits, when sprayed at tillering, stem elongation and booting stages.

Micronutrients play a great role in plant growth as a result of affecting many physiological processes in plant life. Several studies, under alluvial soil conditions of Nile Delta in Egypt, indicated that the application of some micronutrients ,as a foliar application caused an increase in seed yield and quality of flax El-Gazzar and El-Kady.(2000), Moawed, (2001) and Mostafa and El-Deeb (2003). In addition, Mousa *et al.* (2010), Khalifa *et al.* (2011) and Bakry *et al.* (2012) reported that the foliar application of micronutrients increased and improved straw and seed yields of flax.

The objective of the present study was to investigate the effect of nitrogen fertilization rates with foliar application of urea plus a micronutrient mixture (Fe+Zn+Mn) on growth, seed yield and its components, seed oil percentage and fatty acids percentage of flax plant.

MATERIALS AND METHODS

The present work was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt, during the two winter seasons of 2016/2017 and 2017/2018. The aim was to study the effect of three nitrogen fertilizer rates; *i.e*. 25, 35 and 45 kg N/fad. and a foliar spray with 2(%) urea, as well as some of a micronutrient mixture of (Fe + Zn + Mn) using concentration at 200 ppm for each element on growth, seed yield and its components and flax seed oil content. The micronutrients were used in the form of ethylene diamine tetroacelic acid (EDTA); *i.e.*, EDTA-Fe (10% Fe), EDTA-Zn (14% Zn) and EDTA- Mn (12% Mn). The experiment was laid out in a randomized complete block design, with four replications, in both seasons. The treatments were as follows:

1-25 kg N/fad. 2- 35 kg N/fad. 3- 45 kg N/fad.
4-25 kg N/fad. + spray with urea 2(%).
5-25 kg N/fad. + spray with (Fe + Zn + Mn).
6-25 kg N/fad. + spray with urea 2(%)+ (Fe + Zn + Mn).
7-35 kg N/fad. + spray with urea 2(%).
8-35 kg N/fad. + spray with (Fe + Zn + Mn).
9-35 kg N/fad. + spray with urea 2(%)+ (Fe + Zn + Mn)

Flax seeds (Sakha 3 cultivar) were sown on 2/11 and 6/11 in (2016/2017 and 2017/2018) seasons, respectively. Plot area was 10.5 m^2 (3m × 3.5 m), 20 rows, 15 cm apart and 3.5 m long. Some mechamical and chemical properties of the experimental site are shown in Table (1) and were done, according to Ryan *et al.* (1996).

All plots received the recommended dose of 15.5 kg P_2O_5/fad.(100 kg calcium superphosphate), which incorporated into the soil before sowing. Nitrogen fertilization treatments were applied in the form of urea (46.5% N) ,were added in two equal doses, the first at 21 days after sowing (DAS) and the second at 40 DAS. Foliar application of urea and some of micronutrients mixture were sprayed two times, the first after 45 days from sowing and the second after 60 days from sowing. The volume of water was 200 liter/fad.,(0.5 liter/plot) and 0.5(%) wetting agent of tween 20 was used. Cultural practices were practiced, according to the methods being adopted for growing flax in the locality.

I-Growth analysis and attributes:-

For determining dry matter accumulation (g)/m^2, leaf area / plant (cm^2), crop growth rate (CGR), in (g/ m^2 /week) and net assimilation rate (NAR), in (g/m^2 /week). Plant samples were taken the area (20x20 cm) were randomly taken from the outer rows of each experimental plot at the beginning of flowering (80 DAS) and the beginning of capsules filling (95 DAS). Plants were dried at 105°C in a ventilated oven to a constant weight. Leaf area / plant (cm^2) at 80 and 95 DAS were estimated by using leaf area meter apparatus. Crop growth rate(CGR): The increase of plant dry matter per unit of ground area in unit of time. and Net assimilation rate (NAR) the increase of plant dry matter per unit of assimilatory material per unit of time. were determined, according to Watson (1952), as the following formulae:

$CGR = (W_2 - W_1) / (t_2 - t_1)$ in (g/ m^2 / week).

$NAR = (W_2 - W_1) (\log_e A_2 - \log_e A_1) / (A_2 - A_1) (t_2 - t_1)$ in (g/m^2/week).

Where:- $(A_2 - A_1)$ = Differences in leaf area between two successive samples in m^2.

$(W_2 - W_1)$ = Differences in dry matter accumulation of whole plants between two successive samples in (g).

$(t_2 - t_1)$ = Number of days between two successive samples (in weeks).

Log_e = Natural logarithm.

Table 1: Mechamical and Chemical properties of the experimental site in both seasons.

Soil analysis	2016/2017	2017/2018
Mechanical analysis:		
Clay (%).	42.6	40.9
Silt (%).	31.2	32.1
Sand (%).	26.2	27.0
Texture class	clay	Clay
Chemical analysis:		
pH.	8.19	8.22
EC (ds/m).	1.83	2.30
Organic matter (%).	1.40	1.50
Ca++ (meq. L^{-1}).	4.80	4.43
Mg ++ (meq. L^{-1}).	5.01	5.12
K+ (meq. L^{-1}).	4.70	4.68
Available K (mg kg^{-1}).	350	363
Available P (mg kg^{-1}).	13	16.5
Total nitrogen (mg kg^{-1}).	450	560
Available Zn (mg kg^{-1}).	0.71	0.93
Available Fe (mg kg^{-1}).	4.98	6.12
Available Mn (mg kg^{-1}).	2.29	3.60

II-Yield and its components:-

Harvesting took place at 28/3 and 1/4 in (2016/2017and 2017/2018) seasons, respectively. At harvest time, ten individual guarded plants were randomly taken from the central row in each plot to determine the following:-

A - Straw yield and its components:-

- Plant height (cm) by measuring the distance from the cotyledon node to upper capsule.
- Technical length (cm) by mearing the length of the main stem from the cotyledon node to the lower branch.
- Straw yield/ fad. (ton)to estimate straw yield /fad., all plants from each plot were harvested, then the total weight of the air dried straw yield/plot after removing capsules was recorded and converted into fad.(ton).
- Fiber %. It was calculated from the following formula:

fiber percentage = (fiber yield /straw yield) x 100.

- Fiber yield / fad. (kg), It was calculated from plot where straw yield/plot was pulled, then retted to calculated fiber yield/plot after that it transformed per fad.

B-Seed yield and its components:-

- Fruiting zone length (cm) by measuring the distance between the lower branch to the top of plant.
- Capsules number / plant.
- 1000- seed weight (g).was determined and an average of three random samples was recorded .
- Seed yield / fad. (kg).Seed yield of the area of each plot was estimated and transformed to fad.(kg).
- Oil yield /fad.(kg).Estimated by using the following formula:

Oil percentage × Seed yield/fad. (kg)/100

- Harvest index, according to the following formula:

Harvest index = Seed yield /fad.(kg) / biological yield × 100.

Where: biological yield= straw yield with capsules/fad.(ton).

III- Chemical composition:-

At 95 days after sowing (DAS) leaf samples were taken to determine the total chlorophyll content (in mg/g) fresh weight (F.W) by using a spectrophotometer according to Welburn and Lichtenthaler, (1984). Mature seeds were subjected to determine oil content, using Soxhlet apparatus, according to A.O.A.C. (2000) and oil yield /fad. (kg)**.**

Flax oil seed was subjected to determine saturated and unsaturated fatty acids percentages by using Gas Liquid Chromatographic (GLC), according to A.O.A.C. (2000).

IV- Statistical analysis:-

Data were statistically analyzed, according to Snedecor and Cochran (1989) and means were compared by least significant difference test (LSD) at 0.05 level of significance. Bartlett test according to Bartlett, (1937) was done to test the homogeneity of error variance. The test was not significant for all assessed traits, so, the two seasons data were combined. The discussion of the results were carried out on the basis of combined analysis for the two seasons.

RESULTS AND DISCUSSION

I- Growth analysis and attributes:-

A – Growth analysis: -

Results in Table (2) indicated that all growth traits under study; *i.e.*, dry matter accumulation (g)/m^2 and leaf area (cm^2/ plant) at 80 and 95 days after sowing (DAS) were significant as affected by the investigated treatments. Increasing fertilizer from 25 up to 45kg N/fad., gradually, increased all growth traits under study. Mousa *et al.* (2010) reported that treated flax plants by 45 kg N/fad, increased all growth characters, compared to the control and 30 kg N/fad. The results, also, showed that the maximum values of such studied traits were scored from plant received 35 kg N/fad. and foliar sprayed with urea 2(%)plus 200 ppm (Fe + Zn + Mn) followed by adding 45 kg N/fad.,with insignificant differences between such two treatments. This fending may be referred to the role of urea and some of micronutrients mixture (Fe + Zn + Mn), as a foliar application for reduceing soil dressing of nitrogen fertilizers by 10 kg N / fad, which reduced costs and environmental pollution. In this connection, Marschner (1995) stated that micronutrients, especially Fe and Zn acted either as metal components of various enzymes or as functional, structural, or regulatory cofactors. Thus, they were associated with saccharine metabolism, photosynthesis, nucleic acid, lipid metabolism and protein synthesis. He added that zinc was an essential micronutrient for synthesis of auxin, cell division and the maintenance of membrane structure and function. Zinc, also, plays an important role in the production of biomass. Nasiri *et al.* (2010) reported that Mn was regarded as an activator of many different enzymatic reactions and took part in photosynthesis.

B- Growth attributes:-

Table (2) for there shows crop growth rate (CGR) and net assimilation rate (NAR) at (80-90 DAS) period. It was observed that there were significant differences in CGR and NAR values among the three nitrogen levels (25, 35 and 45 kg N/fad.) and their combination with foliar spray with 2(%) urea and some of micronutrients mixture (Fe + Zn +Mn).

Table 2: Growth analysis and attributes of flax, as affected by different levels of nitrogen fertilizer and foliar spray by urea plus of some micronutrients mixture in 2016/2017 and 2017/2018 seasons, (combined.data).

Treatments	Dry matter accumulation / m^2 (g)						Leaf area / plant (cm^2)						CGR (g/m^2/week)			NAR (g/m^2/week)		
	(80 DAS)			(95 DAS)			(80 DAS)			(95 DAS)			(80 – 95 DAS)			(80 – 95 DAS)		
	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.
25 kg N/fad.	102.00	102.78	102.39	153.09	154.65	153.87	102.8	106.2	104.5	137.7	140.7	139.2	23.87	24.24	24.06	64.0	64.6	64.3
35 kg N/fad.	108.30	109.41	108.87	162.75	164.49	163.62	114.1	117.7	115.9	153.6	157.6	155.6	24.44	25.74	25.58	67.8	68.6	68.2
45 kg N/fad.	112.92	113.88	113.40	169.41	170.85	170.13	119.8	123.8	121.8	160.5	163.9	162.2	26.40	26.62	26.51	70.8	71.4	71.1
25 kg N/fad. + spray urea 2(%)	108.21	109.23	108.72	162.39	163.95	163.17	114.8	118.6	116.7	154.4	158.4	156.4	25.32	25.57	25.44	67.9	68.5	68.2
25 kg N/fad. + spray (Fe +Zn+Mn)*	107.43	108.72	108.09	161.19	162.60	161.91	113.3	117.1	115.2	151.6	154.6	153.1	25.12	25.18	25.15	67.3	67.5	67.4
25 kg N/fad. + spray urea 2(%) + (Fe + Zn+Mn)*	109.77	110.88	110.34	164.49	165.99	165.24	115.6	119.4	117.5	155.8	158.2	157.0	25.57	25.75	25.65	68.8	69.4	69.1
35 kg N/fad. + spray urea 2(%)	112.38	113,16	112.77	168.63	169.80	169.23	120.0	124.0	122.0	160.8	164.6	162.7	26.29	26.47	26.38	70.4	70.8	70.6
35 kg N/fad. + spray (Fe + Zn+Mn)*	111.72	112.29	112.08	167.58	168.60	168.09	118.2	122.6	120.6	158.9	162.3	160.6	26.10	26.31	26.17	70.0	70.4	70.2
35 kg N/fad. + spray urea 2(%) + (Fe + Zn+Mn)*	113.61	114.69	114.15	167.49	172.14	171.33	121.9	125.7	123.8	163.3	166.9	165.1	25.18	26.85	26.72	71.2	72.0	71.6
L.S.D. (0.05)	2.25	2.34	1.59	3.36	3.45	2.37	9.8	10.4	7.07	13.2	13.6	9.4	0.84	0.96	0.63	2.3	2.5	1.7

* (Fe + Zn + Mn) = Spraying micronutrients mixture, 200 ppm for each element.
(DAS) = days after sowing

It was, also, noticed that CGR and NAR gradually values increased with increasing nitrogen level from 25 up to 45 kg N/fad. Such finding could be attributed to the accumulation of dry matter or photosynthesiate compounds with increasing nitrogen fertilizer level Abdo, Fatma *et al.* (2002). In addition, the maximum values of CGR and NAR at (80-95 DAS), were obtained from plants treated with 35 kg N/fad and a foliar spray with 2% urea plus 200 ppm (Fe + Zn +Mn), followed by plants received 45 kg N/fad with insignificant differences between such two treatments. Such finding may due to the positive effect of urea and micronutrients mixture (Fe+ Zn +Mn) as a foliar spray. In this connection, Mohamed *et al.* (2014) reported that micronutrients played a great role in plant growth as a result of affecting many physiological processes in plant life. With respects foliar spray of urea, Khan *et al*. (2009) found similar results.

ll-Yield and its components :-

A - Straw yield and its components:-

Table (3) shows that plant height(cm), technical length(cm) ,straw yield /fad.(t), fiber % and fiber yield /fad.(kg) were significantly affected by nitrogen fertilizers levels and foliar spray with urea 2(%) and 200 ppm some of micronutrients mixture (Fe + Zn + Mn).

Increasing nitrogen fertilizer level from 25 up to 45 kg N/fad significantly increased straw yield and its components traits. It can be noticed that applying 45 kg N/fad. increased plant height, technical length ,straw yield/fad., fiber % and fiber yield/fad. with 9.77, 9.82, 14.72, 12.19 and 25.12(%) respectively. Mousa *et al.* (2010) stated that fertilizing flax plants with 45 kg N/fad. increased straw yield and technological characters compared to control and 30 kg N/fad.. They added that, nitrogen is an essential element for flax growth to build up protoplasm and protein which is important for cell division and meristematic activity, such effect resulted in an increase in cell number, cell size and plant growth.

Results in Table(3) indicated that the highest values of fiber (%) and fiber yield were gained from plants received 35 kg N/fad. and sprayed with urea 2(%) plus 200 ppm (Fe + Zn + Mn), compared to adding 45 kg N/fad. with insignificant difference between such two treatments. In this respect Kadry (1981) found that the maximum fiber yield/fad. was achieved by spraying flax plants with 300 ppm Zn under adding 45 kg N/fad. It can observed that the effect between plants treated with 35 kg N/fad. and foliar spray with urea 2(%)plus 200 ppm (Fe + Zn + Mn), compared to plants received 35 kg N/fad. plus foliar spray with urea 2(%) of respect fiber (%) and fiber yield/fad. were insignificant. Meanwhile whereas, a significant effect was observed between such first treatment and adding 35 kg N/fad. plus foliar spray with 200 ppm (Fe + Zn + Mn). These results role in tryptophan synthesis which is a precursor of IAA which reflected on yield and its components. It can be noticed that treated flax plants by [35 kg N/fad+ foliar spray with urea 2(%)plus 200 ppm (Fe + Zn + Mn)] increased straw yield and its components compared with plants received 35 kg N/fad only. proved that foliar spray of urea plays on important role more than micronutrients mixture in fiber formation.

B-Seed yield and its components:-

Results in Table(4) revealed that the maximum values of fruiting zone length**,** capsules number/ plant, 1000-seed weight, seed yield/fad(kg), oil yield /fad.(kg) as well as harvest index(%) were obtained when flax plants treated with 35 kg N/fad. and foliar sprayed with 2(%) urea plus 200 ppm (Fe + Zn + Mn) followed by adding 45 kg N/fad. with significant differences between such two treatments. fruiting zone length**,** capsules number,1000-seed weight, seed yield, oil yield and harvest index more than adding 25 kg N/fad. by 1.05, 15.47, 15.46, 22.87,30.05 and 7.56 (%) respectively. Soethe *et al.* (2013) reported that nitrogen level influenced capsules number / plant, 1000-seed weight and seed yield / ha of flax plant Such finding proved that the micronutrients mixture (Fe +Zn +Mn) and urea as foliar application reduce nitrogen fertilizers which reduce costs and environmental pollution. These results could be explained on the basis that micronutrients must be presented during the vegetative stage to get the normal growth. Where, Mn regulates the oxidation reduction system of Fe. Also, Zn played an important role than micronutrients mixture in seed formation.

lll-Chemical composition:-

A-Total chlorophyll of leaves:

Results in Table (5) indicated that the total chlorophyll of leaves,at 95 DAS, was significantly increased with increasing nitrogen rates from 25 up to 45 kg N/fad. In this respect, Ibrahim *et al.* (2016), on flax plant, reported that the increase of chlorophyll formation, with increasing nitrogen levels, might be due to the role of mineral nitrogen. The maximum value of total chlorophyll of leaves at 95 DAS, was gained, when plants treated with 35 kg N/fad. and urea 2(%)plus 200 ppm (Fe + Zn + Mn), followed by plants treated with 45 kg N/fad, with insignificant differences between such two treatments. These results may be attributed to the role some of micronutrients mixture (Fe + Zn + Mn) and urea, as a foliar application. In this regard, Nasiri *et al*. (2010) reported that, micronutrients, especially Fe and Zn were associated with saccharide metabolism, photosynthesis and chlorophyll formation.

B-Oil percentage:-

Table (5) shows that oil percentage was significantly increased with raising nitrogen rates from 25 up to 45 kg N/fad., gradually.

Table 3: Straw yield and its components of flax, as affected by different levels of nitrogen fertilizer and foliar spray by urea plus of some micronutrients mixture in 2016/2017 and 20172018 seasons (combined data).

Treatments	Plant height (cm)			Technical length (cm)			Straw yield /fad.(ton)			Fiber (%)			Fiber yield/fad. (kg)		
	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.
25 kg N/fad.	98.7	100.7	99.7	86.3	88.1	87.2	3.538	3.508	3.523	19.05	19.13	19.09	674.0	671.1	672.5
35 kg N/fad.	104.7	106.9	105.8	91.6	93.6	92.6	3.894	3.862	3.878	20.78	20.88	20.83	809.2	806.4	807.8
45 kg N/fad.	109.3	111.7	110.5	95.6	97.8	96.7	4.148	4.114	4.131	21.68	21.80	21.74	899.3	896.9	898.1
25 kg N/fad.+ spray urea 2(%)	104.8	106.8	105.8	91.7	93.5	92.6	3.684	3.653	3.669	20.70	20.78	20.74	762.6	759.1	760.8
25 kg N/fad. + spray (Fe +Zn+Mn)*	103.8	105.0	104.4	90.7	91.9	91.3	3.577	3.547	3.562	20.65	20.71	20.68	738.6	734.6	736.6
25 kg N/fad. + spray urea 2(%) + (Fe + Zn+Mn)*	105.7	108.1	106.9	92.4	94.6	93.5	3.748	3.717	3.733	20.80	20.90	20.85	779.6	776.9	778.3
35 kg N/fad. + spray urea 2(%)	109.7	111.1	110.4	96.0	97.2	96.6	4.090	4.056	4.073	21.98	22.08	22.03	899.0	895.6	897.3
35 kg N/fad. + spray (Fe + Zn+ Mn)*	108.1	109.5	108.8	94.5	95.9	95.2	3.971	3.939	3.955	21.85	21.95	21.90	867.7	864.6	866.1
35 kg N/fad. + spray urea 2(%) + (Fe + Zn+Mn)*	110.9	113.3	112.1	97.0	99.2	98.1	4.187	4.152	4.170	22.00	22.10	22.05	921.1	917.6	919.4
L.S.D. (0.05)	3.2	3.4	2.3	2.8	2.9	2.0	0.183	0.172	0.124	1.35	1.45	0.90	75.0	73.3	51.91

* (Fe + Zn + Mn) = Spraying micronutrients mixture, 200 ppm for each element.

Table 4: Seed yield and its components of flax as affected by different levels of nitrogen fertilizer and foliar spray by urea plus of some micronutrients mixture in 2016/2017 and 2017/2018 seasons (combined data).

Treatments	Fruiting zone length (cm)			Capsules number / plant			1000-seed weight (g)			Seed yield /fad (kg)			Oil yield /fad (kg)			Harvest index (%)		
	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.	2016/17	2017/18	Comb.
25 kg N/fad.	12.38	12.58	12.48	7.25	7.07	7.16	7.768	7.746	7.757	511.9	502.5	507.2	170.3	167.6	169.0	12.64	12.53	12.59
35 kg N/fad.	13.13	13.35	13.24	7.98	7.78	7.88	8.551	8.521	8.536	588.2	574.2	581.2	206.0	201.4	203.7	13.12	12.94	13.03
45 kg N/fad.	13.71	13.95	13.83	8.50	8.28	8.39	9.108	9.072	9.090	648.4	635.6	642.0	235.8	231.7	233.8	13.52	13.38	13.45
25 kg N/fad. + spray urea 2(%)	13.10	13.34	13.22	7.55	7.37	7.46	8.090	8.064	8.077	550.3	540.1	545.2	194.2	191.0	192.6	13.00	12.88	12.94
25 kg N/fad. + spray (Fe +Zn+Mn)*	13.05	13.13	13.09	7.33	7.15	7.24	7.855	7.831	7.843	527.5	518.5	523.0	185.7	182.9	184.3	12.85	12.75	12.80
25 kg N/fad. + spray urea 2(%)+ (Fe + Zn+Mn)*	13.26	13.50	13.38	7.68	7.48	7.58	8.230	8.202	8.216	587.9	579.5	583.7	208.6	206.1	207.4	13.56	13.49	13.53
35 kg N/fad. + spray urea 2%	13.68	13.88	13.78	8.38	8.16	8.27	8.980	8.946	8.963	648.7	634.7	641.7	237.1	232.7	234.9	13.69	13.53	13.61
35 kg N/fad. + spray (Fe + Zn+Mn)*	13.55	13.63	13.59	8.13	7.93	8.03	8.712	8.680	8.696	622.1	609.7	615.9	226.1	221.0	223.6	13.54	13.40	13.47
35 kg N/fad. + spray urea 2(%)+ (Fe + Zn+Mn)*	13.91	14.15	14.03	8.58	8.36	8.47	9.194	9.158	9.176	660.4	654.8	657.6	242.2	241.0	241.6	13.62	13.62	13.62
L.S.D. (0.05)	0.64	0.67	0.48	0.52	0.48	0.35	0.420	0.400	0.290	29.3	28.3	20.1	25.8	23.9	17.4	0.41	0.40	0.28

* (Fe + Zn+Mn) = Spraying micronutrients mixture, 200 ppm for each element.

Table 5: chemical composition and its components of flax, as affected by different levels of nitrogen fertilizer and foliar spray by urea plus of some micronutrients mixture in 2016/2017 and 2017/2018 seasons(combined data).

Treatments	Total chlorophyll of leaves (mg/g F.W.) at 95 DAS			Oil (%)			Total Saturated acids (%)			Total unsaturated acids (%)			Unsaturated / saturated acids ratio		
	2016/17	2017/18	Comb.	2016/17	2017/18	Comb	2016/17	2017/18	Mean	2016/17	2017/18	Mean	2016/17	2017/18	Mean
25 kg N/fad.	3.253	3.275	3.264	33.27	33.35	33.31	10.07	10.44	10.26	89.93	89.56	89.75	8.93	8.58	8.76
35 kg N/fad.	3.455	3.481	3.468	35.02	35.08	35.05	10.30	10.68	10.49	89.70	89.32	89.51	8.71	8.36	8.54
45 kg N/fad.	3.602	3.630	3.616	36.36	36.46	36.41	11.18	11.60	11.39	88.82	88.40	88.61	7.94	7.62	7.78
25 kg N/fad. + spray urea 2(%)	3.460	3.484	3.472	35.29	35.37	35.33	12.55	12.93	12.74	87.45	87.07	87.26	6.97	6.73	6.85
25 kg N/fad. + spray (Fe +Zn+Mn)*	3.445	3.463	3.454	35.20	35.28	35.24	12.61	12.98	12.80	87.39	87.02	87.21	6.93	6.70	6.82
25 kg N/fad. + spray urea 2(%)+ (Fe + Zn+Mn)*	3.480	3.516	3.498	35.49	35.57	35.53	12.69	13.08	12.89	87.31	86.92	87.12	6.88	6.65	6.77
35 kg N/fad. + spray urea (2%)	3.593	3.615	3.604	36.55	36.65	36.60	12.75	13.14	12.95	87.25	86.86	87.06	6.84	6.61	6.73
35 kg N/fad. + spray (Fe + Zn+Mn)*	3.582	3.602	3.592	36.34	36.42	36.38	12.85	13.30	13.08	87.15	86.70	86.93	6.78	6.52	6.65
35 kg N/fad. + spray urea 2(%)+ (Fe + Zn+Mn)*	3.612	3.638	3.625	36.68	36.80	36.74	12.82	13.21	13.02	87.18	86.79	86.99	6.80	6.57	6.69
L.S.D. (0.05)	0.058	0.062	0.043	0.88	0.95	0.64	-	-	-	-	-	-	-	-	-

(Fe+Zn+Mn)*=Spraying micronutrients mixture, 200 ppm for each elements.
(F. w) =fresh weight

Mousa *et al* (2010) found that adding 45 kg N/fad significantly increased oil percentage compared to control or 30 kg N/fad. The maximum values of oil (%) (36.74%) of flax seeds were gained when plants received 35 kg N/fad and urea 2(%) plus 200 ppm (Fe + Zn + Mn), with insignificant differences between such treatment and adding 45 kg N/fad. Such finding could be attributed to the role some of micronutrients mixture (Fe + Zn + Mn) in oil percentage formation. In this respect, Bakry *et al*. (2012) reported that foliar spray of Zn, Mn or Fe and combined application of (Fe + Zn + Mn), on flax plants obtained a positive effect on oil percentage of flax seeds, with superiority to Zn over the other micronutrients. It can be observed that oil percentage recorded a significant increase when plants treated with [35 kg N/fad and foliar spray with 2(%) urea plus 200 ppm (Fe + Zn + Mn)], compared to plants received [35 kg N/fad and foliar spray by 200 ppm (Fe + Zn + Mn)] or [35 kg N/fad], whereas, insignificant differences were observed between the province first treatment and adding [35 kg N/fad + spray with urea (2%)]. Such results may due to the role of micronutrients, which affected positively oil percentage formation more than foliar spray of urea. Similar results were obtained by Mousa *et al.* (2010).

C- Total saturated and unsaturated fatty acids:

Table (5),also, shows that total saturated fatty acids of flax oil were gradually increased with raising nitrogen fertilizer rate from 25 up to 45 kg N/fad., whereas the total unsaturated fatty acids were decreased. Such finding, consequently, leads to a decrease of unsaturated / saturated fatty acids ratio with increasing nitrogen fertilizer rate. In this connection Grant *et al*. (2016) reported that seed quality for flax oil tended to decline with increasing N application due to lower iodine number which revel the increase of saturated fatty acids was in account of unsaturated fatty acids.

It can be noticed that the minimum value of unsaturated fatty acids (86.93%),were obtained from plants received 35 kg N/fad .+ spray 200 ppm Fe + Zn + Mn) followed by adding 35 kg N/fad and a foliar spray with urea 2(%)plus 200 ppm (Fe + Zn + Mn), (86.99%). On the other hand, the maximum value of saturated fatty acids (13.8%) were gained from plants treated with 35 kg N/fad. + spray 200 ppm (Fe + Zn + Mn), followed by plants received 35 kg N/fad. and foliar spray with urea 2(%)plus 200 ppm (Fe + Zn + Mn), (13.02%). The same trend of total unsaturated fatty(acids were observed, with respect to the unsaturated/saturated acids ratio, which recorded 6.65 and 6.69, respectively. Such results improved that micronutrients mixture played an important role for increasing total saturated fatty acids and decreased total unsaturated fatty acids, whereas, urea gave the reverse effect.

CONCLUSIONS

In the light of the present results, the maximum values of straw, seed, fiber and oil yields were obtained from treated flax plants with 35 kg N/fad. and a foliar spray with urea 2(%)plus 200 ppm (Fe + Zn + Mn), with insignificant differences compared to adding 45 kg N/fad. So, a foliar spray of 200 ppm micronutrients mixture (Fe + Zn + Mn) and urea 2(%) reduced soil dressing of nitrogen fertilizers from 45 to 35 kg N/fad., which reduced costs and environmental pollution.

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الملخص العربي

استجابة نبات الكتان للرش الورقى باليوريا ومخلوط بعض العناصر الصغرى تحت مستويات مختلفة من السماد النيتروجينى

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا - محافظة كفر الشيخ – مصر خلال الموسمين ٢٠١٦/ ٢٠١٧، ٢٠١٧/ ٢٠١٨م. لدراسة تأثير ثلاث مستويات من السماد النيتروجينى(٢٥، ٣٥، ٤٥ كجم نيتروجين /فدان) والرش الورقى بـــ ٢% يوريا بالإضافة إلى مخلوط بعض العناصر الصغرى (حديد + زنك + منجنيز) بتركيز ٢٠٠ جزء فى المليون لكل عنصر.

كانت أعلى قيمة لكل من ارتفاع النبات وارتفاع المنطقة الثمرية والطول الفعال وكذلك مساحة الأوراق بالنبات والوزن الجاف /م٢ عند ٨٠ و٩٥ يوماً من الزراعة ومعدل نمو المحصول(CGR) وصافى معدل التمثيل الضوئى (NAR) (عند فترة٨٠–٩٥يوماً من الزراعة) وذلك بالتسميد بمعدل [٣٥ كجم نيتروجين / فدان والرش الورقى بـــ ٢% يوريا + ٢٠٠ جزء فى المليون (حديد + زنك + منجنيز)] يلى ذلك التسميد بمعدل ٤٥ كجم نيتروجين / فدان بدون فرق معنوى بين المعاملتين.

كما سجلت أعلى القيم لمحصولى القش والبذور ومكوناتهما والنسبة المئوية للألياف ومحصول الألياف والكلوروفيل الكلى للأوراق عند ٩٥ يوماً من الزراعة والنسبة المئوية للزيت ومحصول الزيت للفدان عند إضافة [٣٥ كجم نيتروجين / فدان والرش الورقى بـــ ٢% يوريا + ٢٠٠ جزء فى المليون (حديد + زنك + منجنيز)] بدون فرق معنوى مع إضافة ٤٥ كجم نيتروجين / فدان وهذا يقلل التكاليف والتلوث البيئى.

وأرتفعت نسبة الأحماض الدهنية المشبعة الكلية بزيادة معدلات التسميد النيتروجينى من ٢٥ إلى ٤٥ كجم للفدان وكانت أقل القيم للأحماض الدهنية غير المشبعة عند التسميد بـــمعدل [٣٥ كجم نيتروجين/ فدان + رش ٢٠٠ جزء فى المليون (حديد + زنك + منجنيز)] يلى ذلك التسميد بمعدل بمعاملة النباتات بـــ [٣٥ كجم نيتروجين / فدان والرش الورقى بـــ ٢% يوريا + ٢٠٠ جزء فى المليون (حديد + زنك + منجنيز)].