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Response of Some Flax Varieties to Micronutrients Foliar Application under Newly Reclaimed Sandy Soil

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Abstract: Two field experiments were conducted at the experimental farm of the National Research Center, Nobaria, El-Behaira Governorate, Egypt during the two winter seasons of (2008/09) and (2009/10).The aim of this work was to investigate the response of four flax varieties, Lithwania-9 (fiber purpose type), Opal and Amon varieties (oil purpose types) and Giza-8 (Dual purpose type) to foliar application of micronutrients. Two EDTA chelated multi-micronutrient suspension compounds, i.e. High-Zn (4.5% Zn+ 1.5% Fe + 3%Mn + 0.2% B W/V) and Equal (3%Zn + 3%Fe + 3% Mn +0.2% B W/V) were twice foliar sprayed at the rate of 1.5 ml/l (200 L/fed.) at flowering and capsules filling stages. Results indicated that significant differences were observed among the flax varieties in all studied traits, i.e. yield, yield components, oil percentage and seed nutrients content. The imported Lithwania-9 variety gave the highest values of yield and most traits of yield components, while Opal variety recorded the lowest ones. Amon variety ranked first and achieved the highest estimates for oil percentage, followed by Opal variety, whereas Giza-8 cultivar recorded the highest values of all nutrients, except P uptake by seeds. Results indicated that foliar application of both micronutrient compounds significantly increased yield, yield components, oil percentage and seed nutrients content as compared with the control treatment. The Equal micronutrient compound surpassed the High-Zn micronutrient compound, in yield and most of yield components, while High-Zn micronutrient compound surpassing in oil percentage and all seed nutrient content except Mn. There were significant interactions between varieties and micronutrient foliar application for yield, yield components, oil percentage and seed nutrient content.

Key words: Flax varieties, micronutrient, foliar spray, seed composition, sandy soil.

INTRODUCTION

Flax (*linum usitatissimum L.*) is an annual plant grown in many different countries all over the world. In Egypt, it is one of the oldest crops cultivated for its seeds and fibers as double purpose crop since pharaoh age. Hence they processed it in very tine linen fabrics for kings and princesses only. The oil from flaxseed is one of the richest of ∞ linolenic acid and is used mainly as drying oil in, paints, varnishes, other industrial and pharmaceutical applications and the oil extracted from unheated seeds is used for food purposes El-Kady, Eman and Abd El-Fatah, (2009). Flax is an important economic crop which plays a role in our policy through its local fabrication as well as exportation. Although, the cultivated area in Egypt is relatively small and decreased dramatically in last decade, great reduction had happened in flax cultivated area which reached about, 16345 feddan (feddan= 4200m^2) in 2005/2006 winter season AERMAE, (2007). This reduction was due to the strong competition between flax and other winter season crops such as wheat, berseem clover and other crops. Thus there is a great gap between the production and consumption especially in seed yield, this gap could be minimized by increasing the yield per unit area through new varieties characterized by high yielding and improvement of agriculture practices such as fertilization as well as, expanded of its cultivation in the newly reclaimed sandy soil. In this respect many studies indicated that flax can successfully grow under newly reclaimed sandy soil conditions in Egypt, Kandil *et al.*, (2008) and Bakry, (2009). Meanwhile, deficiency of micronutrients in such areas of soils has been shown as yield –limiting factor El–Fouly, (1983). Foliar application of micronutrients was successfully used for correcting deficits in crops Alexander, (1986). 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 microelements as foliar application caused an increase in yield and quality of flax, Kineber *et al.*, (2006), El

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-Gazzar and El-Kady (2000), Moawed (2001), Mostafa and El–Deeb (2003) and Abo-Khadra *et al*., (1982) reported that micronutrients foliar application increased and improved straw and seed yield of flax, Mourad *et al*. (1988) and El-Swify (1993) reported that spraying flax plants with Zn SO_4 significantly increased yield as well as fiber quality, Mostafa *et al*., (1998) stated that Zn application caused maximum increase in seed and straw yield in comparison with Fe and Mn. Thus the objective of the present study was to investigate the effect of some micronutrient foliar application on some flax varieties yield, yield components, oil percentage and seed nutrient content under newly reclaimed sandy soil conditions.

MATERIAL AND METHODS

Two field experiments were carried out at the newly reclaimed area at the experimental farm of the National Research Center, Nobaria, El-Behaira Governorate, Egypt during the two winter seasons of (2008/09) and (2009/10).The aim of this work was to investigate the response of four flax varieties, Lithwania-9(fiber purpose type), Opal and Amon (oil purpose types) and Giza-8 (Dual purpose type) to foliar application of micronutrients. Two EDETA chelated multi-micronutrient suspension compounds, i.e. High-Zn (4.5% Zn+ 1.5% Fe + 3%Mn 0.2% B W/V) and Equal (3%Zn + 3%Fe + 3% Mn + 0.2% B W/V) prepared by project "Micronutrients and Other Plant Nutrition Problems in Egypt" (NRC / GTZ) were twice foliar sprayed at the rate of 1.5ml / l (200 L /fed.) at flowering and capsules filling stages.

The treatments of this study were as follows:

1- Four flax varieties (Lithwania -9, Opal, Amon, and Giza-8)
2-Three foliar fertilizers:-
(A)Control (sprayed with water).
(B) High- Zn micronutrient compound (4.5% Zn+ 1.5% Fe + 3%Mn + 0.2% B W/V).
(C) Equal micronutrient compound (3%Zn + 3%Fe + 3% Mn +0.2% B W/V).

The treatments were arranged in a split – plot design with four replicates where, flax varieties were assigned in main plots and foliar fertilization were allocated in subplots. Seeds were sowing on mid November (15^{th}) in both seasons and seeds were sown in rows of 3. 5 m long with 15cm apart and were drilled with seeding rate of (2000 seeds/m^2). Plot area was 10.5 m^2 (3.0 m x 3, 5 m) and consisted of fifteen rows.

Each mineral fertilizers of NPK were added at the rates of 100% from that recommended by the Egyptian Ministry of Agriculture. For nitrogen fertilizer, the recommended dose was 200 kg ammonium nitrate (33.5% N) /feddan, whereas, the recommended dose for phosphorus fertilizer was 150 kg calcium superphosphate (15.5% P2O5) /feddan and for all treatments, basic dose of 50 kg potassium sulphate (48% K2O) / feddan was added. Phosphorus and Potassium fertilizer was added as one part before sowing during seed bed preparation. Whereas, nitrogen fertilizer as ammonium nitrate (33.5%) was splited into five equal doses i.e. 15, 30, 45, 60 and 75 days after sowing. Foliar application of micronutrients was applied twice, the first one was applied immediately at the beginning of flowering stage, and the second foliar application was carried out at the beginning of capsules filling stage.

At full maturity stage and appearance of harvesting symptoms in every variety, random representative samples of ten plants were taken from every experimental unit to estimate the following characters:

1- Plant height (cm). 2- Straw yield/plant (g). 3- Seed yield/plant (g).
4- Number of capsules/plant. 5- Number of fruiting branches/plant.
6- Fruiting zone length (cm). 7- 1000- Seed weight (seed index) (g).

Plants were harvested from each plot. These plants were dried under open air for one week and seeds were cleaned after removal from capsules, then the following parameters were calculated:

1-Straw yield (tons/feddan). 2- Seed yield (kg/feddan).

A composite surface soil samples (0-30cm) were taken before sowing from the experimental site, air dried, passed through 2 mm sieve pores for determination of physic-chemical properties Chapman and Pratt, (1978). The data of the analyzing are presented in Table (1).

Table 1: physic-chemical properties of the experimental site (Mean of the two seasons).

Item	Value		Element	Value	
Sand%	90.8		Available macro element (mg/100g)		
Silt%	2.0		P	0.23	VL
Clay%	7.2		K	12.00	L
Texture	Sandy		Mg	18.00	L
PH	8.3	H	Ca	140.00	M
Ec(dS/m)	0.12	L	Na	11.92	VL
CaCO3%	3.2	L	Available microelement (ppm)		
O.M%	0.41	VL	Fe	8.15	L
			Mn	7.50	L
			Zn	0.15	VL
			Cu	0.10	VL

VL= very low, L=low, M = medium H= high, according to Ankerman and Large (1974)

Texture:

Hydrometer method Bouyoucos, (1954).

PH and Ec:

in 1:2.5 soil/water suspension Chapman and Pratt, (1978).

O.M:

Black method Isaac and Johnson, (1984).

CaCO3:

Collin, s Calcimeter Alison and Moodle, (1965).

P:

NaH CO3Extraction at PH 8.5 Olsen *et al*. (1954).

K, Ca, Na and Mg:

NH4-OAc extraction at PH7 Jackson, (1973).

Fe, Mn, Zn and Cu:

DTPA extraction at PH7.3 Lindsay and Norvell, (1978).

The seed oil percentage was determined according to A.O.A.C. (1980) using a Soxhlet apparatus and petroleum ether (40 – 60 ^{o}C).

The dry aching technique was used to extract macro and micronutrients from dried and ground seeds as described by Chapman and Pratt, (1978). Total N was determined using Kjeldahl method ; total P was photo metrically determined using molybdate-vanadate method and measured by Spectrophotometer apparatus while total K and Ca were determined using Flame Photometer, Genway Micronutriments and magnesium were measured using Atomic Absorption Spectrophotometer, Perkin Elmer, Model 1100B.

Statistical Analysis:

The analysis of variance procedure of split-plot design according to Snedecor and Cochran (1990) was used. The combined analysis was conducted for the data of the two seasons after tested the variances homogeneity of both seasons according to Gomez and Gomez (1984). The least significant difference (LSD) was used to compare between different means.

RESULTS AND DISCUSSION

1- Yield and its Components:

1-1- Varietal Differences:

Data in Table (2) revealed that there were significant differences between flax varieties under study for yield and its components, where Giza – 8 variety gave the tallest plant and highest value of 1000 – seed weight, while lithwania -9 variety gave the highest values of, straw and seed yield / plant, number of capsules and fruiting branches / plant, fruiting zone length as well as straw and seed yield per feddan. In conclusion, the data clearly indicated that Lithwania–9 variety surpassed the other varieties in respect of seed and straw yield per feddan and most yield components, while opal variety recorded the lowest values of seed and straw yield per feddan as well as most yield components. The differences between the tested varieties could mainly be attributed to the differences in their genetical constitution and their response to the environmental conditions. In this connections, many investigators obtained higher levels of varietal differences in yield and its components in many regions of growing flax in the world, Verma and Pathak (1993), El-Nakhlay (1995), Dubey (2001), Kineber and El-Sayed (2004), Kineber *et al*. (2006) and El – kady, Eman and Abd El–Fatah (2009).

Table 2: The effect of varieties and micronutrients foliar spray on yield and yield components (combined analysis of 2008/2009 and 2009/2010 seasons).

Varieties	Plant height (cm)	Straw yield/ plant (g)	Seed yield/ plant (g)	Number of Capsules / plant	Number of Fruiting Branches/plant	Fruiting zone length (cm)	1000-seed weight (g)	Straw yield/fed. (ton)	Seed yield/fed. (kg)
				Effect of varieties					
Lithwania-9	72.11	2.79	1.28	30.57	10.30	27.20	6.55	1.75	642.09
Opal	61.78	1.16	0.70	13.33	6.33	16.10	5.75	0.73	434.00
Amon	68.56	2.05	0.98	23.00	8.80	17.20	5.16	1.28	600.78
Giza-8	76.11	1.55	0.99	15.67	6.10	18.43	8.01	0.98	625.80
LSD 5%	3.92	0.23	0.15	2.21	0.53	1.02	0.16	0.13	23.17
				Effect of micronutrients foliar spray					
Control	59.59	1.30	0.75	14.58	6.5	14.15	5.93	0.82	474.56
High- Zn compound	78.677	2.31	0.95	22.28	8.07	20.65	6.52	1.44	615.40
Equal compound	70.67	2.06	1.26	25.07	9.07	24.40	6.61	1.29	637.04
LSD 5%	1.97	0.15	0.11	1.24	0.97	0.72	0.03	0.09	42.76

1-2- Effect of micronutrients:

The results in Table (2). Indicated that foliar application of micronutrients gave significant effect on yield and its components in comparison with the control treatment. Regarding the effect of Micronutrients ratios in compounds, data clearly indicated that foliar application of the equal ratio of micronutrients in compound (3%Fe + 3%Mn + 3%Zn) significantly increased seed yield per plant and feddan.) number of capsules and fruiting branches per plant, fruiting zone length and 1000-seed weight as compared with the control and high-Zn compound (Fe 1.5% + Mn 3% + Zn 4.5%). While the high–Zn compound gave the highest significant values of plant height and straw yield per plant. The results of increasing in seed yield and most of yield components would find an interpretation through that foliar application the equal ratio of micronutrients compound (3%Fe + 3%Mn + 3%Zn) could cover at least considerable part of genotype nutritive needs and through affecting the metabolic processes of plant growth was enhanced Amberger, (1991). For instance the role of Zn in biosynthesis of natural auxin indole acetic acid. Moreover, Mn activates number of enzymes involved in carbohydrate synthesis and also essential in the photo system II. Fe acts as a catalyst chlorophyll formation Mengel and Kirkby, (1982), and improves the photosynthesis processes, leading to more dry matter production. Many investigators found positive effect of micronutrients on flax plants, among them, Mourad *et al*., (1988), Mostafa *et al*., (1998), El - Gazzar and El – Kady (2000), Moawed (2001) and Mostafa and El – Deeb (2003).

1-3- Effect of the interaction:

Results presented in Table (3) indicated that there were significant effects due to the interaction between flax genotypes and foliar application of micronutrients for all yield components traits and seed yield. From this table, it is clear that the highest values for most studied characteristics of yield and yield components, i.e. straw and seed yield per plant and feddan, number of capsules and fruiting branches and fruiting zone length were obtained from lithwania-9 variety sprayed with both micronutrients compound ratio. On the other hand the foliar spraying of height Zn ratio compound on Giza–8 variety resulted the highest values of plant height and 1000–seed weight. Concerning the comparison of the yield and yield component of the genotypes under the control treatment, it can be seen from Table (3) that Giza–8 variety gave the highest values of seed yield per plant and feddan and 1000–seed weight, while lithwania-9 genotype surpassed other varieties in respect of plant height, straw yield per plant and feedan, number of capsules and fruiting branches per plant and fruiting zone length. From the above mentioned results it could be concluded that lithwania-9 and Giza–8 varieties revealed the higher efficient under unsprayed treatment. In addition the results also clearly indicated that the varieties significantly differed in their responses to the micronutrient ratios.

Table 3: Effect of interaction between flax varieties and micronutrients foliar spray on Yield and yield components (combined analysis of 2008/2009 and 2009/2010 seasons).

Varieties	Micronutrients height (cm) compound foliar spray	Plant height (cm)	Straw yield/ plant (g)	Seed yield/ plant (g)	Number of Capsules / plant	Number of Fruiting Branches/plant	Fruiting zone length (cm)	1000-seed weight (g)	Straw yield/fed. (ton)	Seed yield/fed. (kg)
Lithwania-9	Control	64.33	1.78	0.78	24.30	9.30	16.30	6.14	1.12	493.33
	High- Zn	78.00	4.40	1.10	28.70	11.30	25.30	6.49	2.76	725.77
	Equal	74.00	2.20	1.95	38.70	10.30	40.00	7.02	1.37	707.17
Opal	Control	59.67	0.99	0.64	6.70	4.70	10.00	5.27	0.63	403.20
	High- Zn	65.33	1.31	0.67	21.00	5.00	21.00	5.87	0.81	478.80
	Equal	60.33	1.18	0.80	12.30	9.30	17.30	6.09	0.75	420.00
Amon	Control	53.67	1.20	0.73	15.30	6.70	14.30	4.93	0.75	457.80
	High- Zn	81.00	2.10	1.03	22.70	9.70	16.30	5.18	1.29	635.43
	Equal	71.00	2.84	1.17	31.00	10.00	21.00	5.21	1.79	709.10
Giza-8	Control	60.67	1.21	0.86	12.00	5.30	16.00	7.38	0.76	543.90
	High- Zn	90.33	1.43	0.99	16.70	6.30	20.00	8.54	0.90	621.60
	Equal	77.33	2.01	1.13	18.30	6.70	19.30	8.11	1.26	711.90
LSD 5%		3.95	0.30	0.22	2.48	1.95	1.44	0.29	0.18	85.52

2- Seed oil and nutrients content:

2-1- Varietal differences:

Data in Table (4) indicated that significant differences in seed oil percentage and seed macro and micronutrients content between flax varieties, which exhibited a wide variability in their seed oil and nutrients content. Regarding seed oil percentage, results revealed that Amon variety recorded the highest value of oil seed content (40.97%) followed by opal variety (39.38%), while Lithwania-9 variety recorded the lowest one (37.02%). The differences between varieties in their seed oil content were reported by, Moawed, (2001) and El–Kady, Eman and Abd El–Fatah (2009). Concerning seed nutrients content, it is clear that the highest values of seed content from N, K, Ca, Mg, Fe, Mn, and Zn were obtained from Giza–8 variety while the highest values of seed content from P and Cu were recorded by Opal variety.

Table 4: Effect of varieties and micronutrients foliar spray on seed oil and nutrients content (combined analysis of 2008/2009 and 2009/2010 seasons).

Varieties	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	Oil (%)
			(%)				(ppm)			
				Effect of varieties						
Lithwania-9	3.10	0.26	0.86	0.41	0.55	158.00	16.33	40.67	12.67	37.02
Opal	3.25	0.29	0.87	0.20	0.47	160.33	16.67	46.00	12.67	38.58
Amon	2.56	0.28	0.95	0.34	0.69	162.00	18.00	35.33	12.00	39.93
Giza-8	3.52	0.27	1.22	0.61	0.70	173.67	20.67	53.00	12.33	38.47
LSD 5%	0.12	0.01	0.04	0.02	0.02	6.91	0.70	1.71	0.48	0.04
				Effect of micronutrients foliar spray						
Control	2.79	0.25	0.86	0.23	0.56	136.00	15.50	34.50	10.25	37.97
High- Zn compound	3.63	0.29	1.10	0.58	0.64	183.00	17.75	55.50	13.50	39.07
Equal compound	2.91	0.28	0.97	0.37	0.61	171.50	20.50	41.25	13.50	38.46
LSD 5%	0.22	0.02	0.07	0.03	0.04	12.75	1.29	3.15	0.89	0.09

2-2- Effect of micronutrients:

Data presented in Table (4) indicated that seed oil and nutrient content were significantly increased by micronutrients foliar application, as compared with the control treatment. Results clearly indicated that foliar spraying of micronutrients compound containing high ratio of Zn significantly increased seed oil content as compared with the micronutrients compound containing the equal ratios of micronutrients. With regard to seeds macro and micronutrients content, data in the same table revealed that foliar application of micronutrients in both ratios significantly increased all macro and micronutrients content of flax seeds, as compared with the control treatment. It is clear that the highest values of seeds N, P, K, Ca, Mg, Fe and Zn and oil content were obtained by micronutrients foliar spraying combination. Compound contained high-Zn ratio, which significantly surpassed the micronutrients compound containing the same equal ratio of micronutrients. However, the later combination compound significantly surpassed in respect only Mn seed content. These results of increasing oil content by micronutrients foliar spray are supported by the finding of Moawed, (2001) and Mostafa and El – Deeb (2003) on flax and Rifaat *et al.,* (2004) and Khalifa, (2005) on peanut.

2-3- Effect of the interaction:

Data in Table (5) show that the interaction between flax varieties and micronutrients foliar spraying had significant effects on seed oil and nutrient content. The highest value of seed oil percentage was achieved at foliar application of high-Zn micronutrients compound ratio on Amon genotype. It is clear also that foliar spraying of the high – Zn micronutrients compound ratio increased seed oil content of all varieties, as compared with the micronutrients compound contained equal ratios. Regarding the interaction effects on seed nutrients content, it is evident that there were significant effect on all seed nutrients content, i.e., N, P, K, Ca, Mg, Fe, Mn, Zn and Cu. Moreover, the highest seed content from N, K, Ca, Mg, and Zn were obtained from Giza–8 genotype at foliar spraying with high–Zn micronutrients compound, while the highest seed P content and both Fe and Mn were resulted from Amon genotype sprayed with the high–Zn micronutrient compound, and from Giza–8 variety when sprayed with the micronutrient compound contained equal ratios, respectively.

Table 5: Effect of interaction between flax varieties and micronutrients foliar spray on seed oil and nutrients content (combined analysis 2008/2009 and 2009/2010 seasons).

Varieties	Micronutrients compound foliar spray	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	Oil (%)
			(%)				(ppm)				
Lithwania-9	Control	2.74	0.25	0.80	0.35	0.49	124	15	33	10	36.30
	High- Zn	3.65	0.25	0.84	0.60	0.60	203	18	50	14	37.97
	Equal	2.90	0.27	0.93	0.29	0.55	147	16	39	14	36.80
Opal	Control	2.95	0.26	0.84	0.14	0.47	125	14	37	11	37.74
	High- Zn	3.78	0.29	0.88	0.22	0.47	216	18	55	14	40.58
	Equal	3.03	0.31	0.88	0.25	0.47	140	18	46	13	39.82
Amon	Control	2.48	0.25	0.87	0.22	0.61	154	17	31	9	38.41
	High- Zn	2.71	0.32	1.03	0.51	0.70	173	19	40	13	42.68
	Equal	2.50	0.28	0.96	0.28	0.75	159	18	35	14	41.82
Giza-8	Control	2.98	0.25	0.92	0.20	0.65	141	16	37	11	37.92
	High- Zn	4.38	0.31	1.65	0.99	0.80	140	16	77	13	39.20
	Equal	3.21	0.26	1.10	0.65	0.65	240	30	45	13	38.81
LSD 5%		0.45	0.04	0.14	0.06	0.09	25.51	2.58	6.30	1.79	0.10

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