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EFFECT OF BIOFERTILIZER PHOSPHOREIN, MICRONUTRIENTS AND GA_3 ON YIELD AND PRODUCTIVITY OF FLAX PLANT GROWN UNDER CLAY LOAM AND MODERATELY SALINE SOIL

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ABSTRACT

The present investigation was carried out at Giza Experimental Station, A.R.C. (clay loam soil) and at Tag El-Ezz Research Station (moderately saline soil) during the two growing seasons of 2000/2001 and 2001/2002 to study the effect of biofertilizer (phosphorein, 10 g/kg seeds), micronutrients (cotngein, 15 g/kg seeds and foliafeed C, 0.7 g/l) and gibberellin (GA_3, 0.1 g/l) on yield and productivity as well as vitamin E of oil seeds in flax plant grown under clay loam and moderately saline soil conditions. The obtained results indicated that clay loam soil surpassed moderately saline soil in flax yield (seed, straw, fiber yield and its components). Phosphorein significantly increased seed, straw and fiber yield and its components. Also, phosphorein with recommended dose of phosphorus fertilizer (at the rate of 100 kg P_2O_5/fed.) (P_2O_5) surpassed the increase by adding phosphorein combined with half dose of P_2O_5 (1/2 P_2O_5). There are significant increases in stem diameter and fiber fineness due to the interaction between soil type and phosphorein biofertilizer combined with recommended or half dose of P_2O_5. Moreover, there was significant increase in seed, straw, fiber yield and its components of flax plants grown under clay loam and moderately saline soil by using cotngein or foliafeed C application as micronutrients compounds. Cotngein seed coating application surpassed foliafeed C foliar application in seed, straw, fiber yield/fed. Using GA_3 as foliar application at the rate of 100 ppm increased seed, straw, oil and fiber yield and its components. Vitamin E (α-tocopherol) concentration of the oil seeds increased in the plants grown under moderately saline soil when compared with those grown under clay loam soil. α-tocopherol concentration in linseed oil increase significantly by flax seeds treated with phosphorein, cotngein, foliafeed C or GA_3 application when compared with control-untreated plants.

Keywords: biofertilizer, phosphorein, micronutrients, cotngein, foliafeed, GA_3.

INTRODUCTION

Flax crop (*Linum usitatissimum* L.) is considered as the second fiber crop after cotton in the world. It is grown in Egypt as a dual purpose (seed for oil and stem for fibre). Recently many researches confirmed that nutrition on oil of flax has a lot of benefits for human health like heart diseases, cancer, arthritis, inflammatory diseases and diabetes. These positive effects are due to the alpha linolenic acid and alpha tocopherol in linseed oil.

The major function of the vitamin E was the protection of polyunsaturated fatty acids (PuFAs) from oxidation *in vivo* to hydroperoxides, vitamin E breaks the chain of free radical formation by reacting with the free radicals and converts them to non-harmful form and vitamin E plays a vital part in protecting against free radical injury (Basu and Dickerson, 1996).

Moreover, linseed oil is one of the oldest commercial oils and has been used as a drying oil and used in the paint and varnish industry.

Maximizing the production of flax from the limited agricultural area which didn't enough to setoff the great gab between flax seed production and consumption is a basic target of this study. Therefore, to improvement of flax productivity through the horizontal expansion in the newly reclaimed lands (saline soil) depends on using fertilizers generally.

Much interest is focused on using biofertilizers to minimize consumption of chemical fertilizers to decrease production cost and environmental pollution. Similar suggestion was reported by El-Gazzar (1997), El-Shimy *et al.* (2001) and El-Azzouni and El-Banna (2002) when the authors used phosphorein and biofertan as a biofertilizer in flax.

Furthermore, micronutrients are considered one of the important factors for plant nutrition to protect flax plant against adverse environmental conditions (El-Gazzar and El-Kady, 2000 and El-Sweify *et al.*, 2002). In addition, plant growth promoting substances such as GA_3 has been known to play an important role to increase flax yield and its components (El-Shourbagy *et al.*, 1995 and Ghoniem, 2004) as well as to support the plants against salinity stress (Aldesuquy and Ibrahim, 2002).

Thus, the aim of the present study was to investigate the effect of biofertilizer (phosphorein), micronutrients (cotngein and foliafeed C) as well as gibberellin (GA_3) on the productivity of flax plant grown under clay and saline soil conditions.

MATERIAL AND METHODS

Field experiments were conducted during the two growing seasons 2000/2001 and 2001/2002 at the Agriculture Experimental Station, Agricultural Research Center (A.R.C), Giza Governorate and at Tag El-Ezz Research Station, A.R.C., Dakahlia Governorate. The mechanical and chemical analyses of the soils under study are presented in Table (1).

Table (1): Mechanical and chemical analyses of the soil under study.

Location	Giza		Dakahlia	
Season	2000-2001	2001-2002	2000-2001	2001-2002
Coarse sand%	2.30		1.20	
Fine sand%	35.15		25.50	
Silt%	28.04		26.30	
Clay%	34.51		47.00	
Texture	Clay loam		Clay	
Organic matter%	0.40		1.10	
T.S.S.%	0.07		0.22	
$CaCO_3$%	2.04		2.60	
pH (1:2.5 sup.)	7.91	8.00	8.10	8.50
ECe ds/m 1:5	0.45	0.55	2.50	2.59
$HCO_3 + CO_3$	1.70	1.67	2.13	2.30
Cl^- (meq/l)	4.61	4.17	11.00	10.98
SO_4^{-2} (meq/l)	5.20	5.00	8.07	8.10
Ca^{+2} (meq/l)	2.52	3.00	7.14	7.40
Mg^{+2} (meq/l)	1.83	1.88	5.32	5.21
Na^+ (meq/l)	2.02	1.98	13.54	12.66
K^+ (meq/l)	1.08	1.17	1.58	1.86

Mechanical analyses of the soil samples were performed according to the method of Black (1982). Soil chemical analyses were conducted according to Cottenie *et al.* (1982).

Flax seeds (Sakha 1) were obtained from the Fiber Research Section, Field Crops Research Institute, Agricultural Research Center (A.R.C.), Ministry of Agriculture, Egypt.

Experimental area unit was 6 m^2 consisting of 10 rows of 3 meter in length and 20 cm apart. Seeds of flax "*Linum usitatissimum* L." were sown on November 22nd and 18th in 2000-2001 and 2001-2002 seasons, respectively at Dakahlia (moderately saline soil; 2 < ECe > 4 mmhos/C as reported by Amer and de Ridder, 1989) and on the 23rd of November 2000 in the first season and on 20th November 2001 on the second season at Giza (clay loam soil). Fertilization was carried out according to recommendation of Ministry of Agriculture, nitrogen was added to plots in the form of ammonium nitrate 33.5% at the rate of 70 kg N/fed. Half dose of the nitrogen fertilizer was added before the first irrigation, and the second half 21 days later. Calcium super-phosphate (15.5 P_2O_5) at the rate of 100 kg P_2O_5/fed and potassium sulphate (48% K_2O) at the rate of 50 kg K_2O/fed were added to the soils before planting.

For both soil types the experiment contains 6 treatments as follows: 1) Control (untreated plants), 2) Phosphorien + recommended dose of P_2O_5 fertilizer, 3) Phosphorien + half dose of recommended calcium superphosphate fertilizer (50 kg P_2O_5/fed), 4) Cotngein, 5) GA_3 and 6) Foliafeed C.

- Phosphorien: is a biofertilizer that contains free living bacteria (*Bacillus megatherium*), which converted the unavailable form of $Ca_3(PO_4)_2$ to the available form $Ca(HPO_4)_2$, at the rate of 10 g/kg flax seeds.
- Cotngein: seed coated micronutrients compound fertilizer contains chelated micronutrients (2% Fe, 2% Mn and 1% Zn) which used at the rate of 15 g/kg flax seeds.
- GA_3 (0.1 g/l): spraying was applied twice with thirty days intervals starting from 30 days after planting.
- Foliafeed C, a micronutrient compound fertilizer used at the rate of 0.7 g/l, contain (6% Fe, 4% Zn and 4% Mn all in chelated form on EDTA as well as 0.5% Cu, 0.5% B, 0.5% Mg, 0.02% Mo in inorganic forms), spraying was carried out twice at the same time of GA_3 foliar applications.

At maturity flax plants were harvested at 165 days after sowing (D.A.S). Samples of 10 guarded plants from each plot were taken to determine the following growth and yield characters: 1) Shoot height (cm), 2) Technical length (cm), 3) Main stem diameter (mm) by using bocles, 4) Number of apical branches/plant, 5) Straw yield/plant, 6) Number of capsules/plant, 7) Number of seeds/capsule, 8) Seed yield/plant, 9) Straw and seed yield (kg/fed), 10) Oil yield (kg/fed), 11) Oil percentage (was determined according to the method described by Horwitz *et al.* (1965) using Soxhelt apparatus) and 12)Fiber yield/plant as well as per feddan).

The statistical analysis was carried out according to Sendecor and Cochran (1980) by using factorial experiments, where type of soil was the main factor and treatments (phosphorein, cotngein, GA_3 and foliafeed C) were the sub-factor.

Fiber fineness: in metrical number (Nm) was determined by using Radwan and Momtaz methods (1966) according to the following formula:

$$Nm = \frac{N \times L}{G}$$

Where:Nm =metrical number N=Number of fiber(20 fibers each 10 cm).

L =Length of fiber in(mm) G = weight of fiber in mg.

Vitamin E (α-Tocopherol) in flax seed oil was determined by using high performance liquid chromatographic (HPLC) Beckman according to the method described by Leth and Sndrgard (1983); (HPLC) conditions were as follows: Column: Lichrosorb SI 60, Mobil phase: Isopropanol (15%) in n-heptan (85%), Flow rate: 1 ml/min, wavelength: 292 nm.

RESULTS AND DISCUSSION

Concerning the effect of soil type, generally, it is clear from the results in Tables (2, 3 and 4) that, the maximum mean values of straw and fiber yield and its components (shoot height, technical length, number of apical branches, stem diameter, straw and fiber yield/plant and fiber fineness) as well as seed yield and its components (number of capsules/plant, number of seeds/capsule, seed yield/plant, oil percentage and oil yield/fed.) were obtained when plants were growing under clay loam soil as compared with those growing under moderately saline soil in the two successive seasons, except number of seeds/capsule in the 2^{nd} season and fiber fineness in the two successive seasons which were higher under moderately saline soil than clay loam one. These results are in agreement with those reported by Singh (1980), Rowland *et al.* (1989), Beke and Volkmar (1995), Dubey *et al.* (2001) and Tsakou *et al.* (2002) on flax plants.

The above mentioned results indicating the superiority of clay loam soil than moderately saline one, which might be explained by the hazard effects induced by salinity on plant growth and consequently its productivity.

Furthermore, it is important here to mention that, the reduction in flax yield due to soil type may be attributed to the inhibitor effect of salinity in the growth through its effect on photosynthesis and transpiration. In this respect, Sharma *et al.* (1994) working on wheat, reported that growth, yield parameters, chlorophyll content, photosynthesis and respiration decreased, while membrane permeability increased with increasing salinity levels. Moreover, Keshta *et al.* (1999) working on rapeseed, reported that the reduction in yield characters caused by salinity could be attributed to increasing osmotic pressure of the soil solution to a point which retarded or reduced the intake of water resulting in water stress in the plant and decreasing cell division, cell elongation and cell initiation.

Table (2): Straw yield and its components of flax plant as affected by Phosphorein, Cotngein, GA_3 and Foliafeed C in clay loam and moderately saline soil 2000-2001 and 2001-2002 seasons.

Season	2000– 2001								
Yield component	Shoot height (cm)			Technical length (cm)			No. of apical branches		
Type of soil (A) / Treatment (B)	Clay loam	Moderately saline	Mean (B)	Clay loam	Moderately saline	Mean (B)	Clay loam	Moderately saline	Mean (B)
Control	75.9	67.6	**71.75**	68.5	62.6	**65.55**	4.63	4.17	**4.40**
Phosphorein+P_2O_5	87.6	78.4	**83.00**	73.5	72.4	**72.95**	6.43	5.50	**5.97**
Phosphorein+0.5P_2O_5	85.5	72.8	**79.15**	71.9	63.6	**67.75**	6.30	5.27	**5.79**
Cotngein	91.2	80.1	**85.65**	75.7	69.1	**72.40**	5.99	5.60	**5.80**
GA_3 (0.1g/l)	83.9	79.6	**81.75**	72.2	68.8	**70.50**	4.73	4.90	**4.82**
Foliafeed C (0.7g /l)	88.1	79.4	**83.75**	78.5	70.9	**74.70**	5.42	5.00	**5.21**
Mean (A)	**85.37**	**76.32**		**73.38**	**67.90**		**5.58**	**5.07**	
L. S. D. at 5 %	A=3.005	B=5.204	A*B= N.S	A=3.413	B=N.S	A*B= N.S	A=0.405	B=0.702	A*B= N.S
Yield component	**Stem diameter (mm)**			**Straw yield (g) / plant**			**Straw yield (ton) / fed.**		
Control	1.63	1.29	**1.46**	1.09	0.99	**1.04**	3.22	2.29	**2.76**
Phosphorein +P_2O_5	2.09	1.61	**1.85**	2.08	1.81	**1.95**	3.44	2.78	**3.11**
Phosphorein+0.5P_2O_5	1.96	1.47	**1.72**	2.01	1.68	**1.85**	3.28	2.28	**2.78**
Cotngein	2.41	1.64	**2.03**	2.49	2.18	**2.34**	3.64	2.79	**3.22**
GA_3(0.1g/l)	1.95	1.51	**1.73**	1.93	1.29	**1.61**	3.30	2.33	**2.82**
Foliafeed C (0.7g /l)	2.40	1.44	**1.92**	1.47	1.81	**1.64**	3.49	2.51	**3.00**
Mean (A)	**2.07**	**1.49**		**1.85**	**1.63**		**3.40**	**2.50**	
L. S. D. at 5 %	A=0.161	B=0.279	A*B=0.540	A=0.216	B=0.374	A*B=N.S	A=0.125	B=0.217	A*B=N.S
Season	**2001-2002**								
Yield component	**Shoot height (cm)**			**Technical length (cm)**			**No. of apical branches**		
Control	98.0	70.5	**84.250**	83.2	61.1	**72.15**	5.40	3.97	**4.69**
Phosphorein+P_2O_5	103.2	75.0	**89.10**	89.9	69.1	**79.50**	6.07	5.13	**5.60**
Phosphorein+0.5P_2O_5	98.6	70.2	**84.40**	83.9	64.1	**74.00**	5.67	4.80	**5.24**
Cotngein	100.9	79.5	**90.20**	87.9	71.4	**79.65**	5.60	5.47	**5.54**
GA_3 (0.1g/l)	98.1	76.3	**87.20**	81.2	67.9	**74.55**	5.77	4.87	**5.32**
Foliafeed C (0.7g /l)	101.7	78.7	**90.20**	86.1	69.8	**77.95**	5.44	5.00	**5.22**
Mean (A)	**100.08**	**75.03**		**85.37**	**67.23**		**5.66**	**4.87**	
L. S. D. at 5 %	A=3.322	B=5.301	A*B= N.S	A=3.241	B=N.S	A*B= N.S	A=0.417	B=0.690	A*B= N.S
Yield component	**Stem diameter (mm)**			**Straw yield (g) / plant**			**Straw yield (ton) / fed.**		
Control	1.50	1.25	**1.38**	1.71	1.05	**1.38**	2.91	2.23	**2.57**
Phosphorein +P_2O_5	2.00	1.62	**1.81**	2.22	1.73	**1.98**	3.38	2.75	**3.07**
Phosphorein+0.5P_2O_5	1.90	1.52	**1.71**	2.12	1.48	**1.80**	3.11	2.24	**2.68**
Cotngein	1.70	1.64	**1.67**	1.92	2.03	**1.98**	3.42	2.77	**3.10**
GA_3(0.1g/l)	1.60	1.46	**1.53**	2.14	1.64	**1.89**	3.08	2.29	**2.69**
Foliafeed C (0.7g /l)	2.2	1.61	**1.91**	2.23	1.29	**1.76**	3.36	2.41	**2.89**
Mean (A)	**1.82**	**1.52**		**2.06**	**1.54**		**3.21**	**2.45**	
L. S. D. at 5 %	A=0.121	B=0.210	A*B=0.407	A=0.162	B=0.281	A*B=N.S	A=0.267	B=0.303	A*B=N.S

Furthermore, the decrease in fiber yield/plant and /feddan due to salinity may attributed to the decrease in both technical length and straw yield per plant as well as per feddan (Tables 2 and 4) which might be due to the decrease in the amount of cellulose precipitated in the secondary wall of fiber cells at high salinity levels (Kheir *et al.*, 1991 and Kineber, 1994).

On the other hand, Gaballah and AbouLeilah (2000) working on flax, pointed out that low (1500 ppm) and moderate (3000 ppm) salinity might stimulate the capacity of the plant building metabolites and this might account for the increase in length of fiber cells.

It could be noticed also from Table (4) that, there was a significant difference between both types of soil in fiber fineness. The higher fiber fineness (Nm) was obtained by the plants grown under moderately saline condition; the average increase in fiber fineness was about 1.8 and 1.9% in the 1^{st} and 2^{nd} seasons, respectively when compared with those grown under clay loam soil. This result might be due to much increase in fiber length and the increase in number of fiber per unit weight due to no salinity. These results are in agreement with those obtained by Kheir *et al.* (1991) and Rawya (2001) on flax.

In addition, oil percentage and oil yield/fed were decreased by plants grown under moderately saline condition when compared with those under clay loam soil. Similar results were reported by Gaballah and Abo Leilah (2000). In this respect, Younis *et al.* (1987) reported that, NaCl at 0.5% caused a marked decrease in flax, cotton and castor plants, the decrease was even more at 1.0% NaCl with respiration, glycerol content and lipase activity there was an increase to max. and then a decrease in all controls with time. On the whole, the 2 salt concentrations caused marked decreases in all these parameters except for respiration in flax, where the lower salt concentration caused a significant increase and for lipase activity which showed a significant increase at the lower salt concentration in both cotton and castor.

- Effect of biofertilizer (phosphorein):

It is clear from the results in Tables (2, 3 and 4) that all seeds, straw and fiber yield and its components of flax plants were pronounced increased by inoculation of phosphorein with the recommended or half dose of the recommended P_2O_5 mineral fertilizer in both clay loam and moderately saline soil in the 1^{st} and 2^{nd} seasons. However, the increase by adding phosphorein with the recommended dose of P_2O_5 surpassed the increase by adding phosphorein with half dose of P_2O_5 by about 4.9 and 3.4% of seed yield/fed, and by 11.9 and 14.6% of straw yield/fed as well as by 7.6 and 14.6% of fiber yield/fed in the 1^{st} and 2^{nd} seasons, respectively. These results agreed with those reported by Osman *et al.* (1992), El-Gazzar (1997), El-Gazzar and El-Kady (2000) and El-Azzouni and El-Banna (2002) on flax.

The later authors mentioned that, the increment in flax yield might be attributed to the role of biofertilizer (Biofertan and compost) as a source of essential macro and micronutrients which enhancing the growth of flax plants as well as dry matter accumulation. Hanafy Ahmed *et al.* (2002 b) working on lettuce, added that the use of (rhizobactrein, nitrobein, microbein and biogein) may enhance the use of nitrate transformation with the available carbon into plant growth compounds which enhance plant growth by increasing the organic components (total sugars, free amino acids and soluble phenols). Furthermore, Sobh *et al.* (2000) working on wheat, faba bean, cotton and rice, reported that the beneficial effects of inoculation of grains with phosphorus bio-fertilizers is known to be attributed to increase phosphoatase activity, available P and producing growth regulating hormones.

Table (3): Seed yield and its components of flax plant as affected by Phosphorein, Cotngein, GA_3 and Foliafeed in clay and saline soil 2000-2001 and 2001-2002 seasons.

Season	2000–2001									2001-2002								
Yield component	No. of capsules/plant			No. of seed/ capsule			Seed yield (g)/ plant			No. of capsules/plant			No. of seed/ capsule			Seed yield 'g' / plant		
Type of soil (A) / Treatment (B)	Clay loam	Moderately Saline	Mean (B)	Clay loam	Moderately Saline	Mean (B)	Clay loam	Moderately Saline	Mean (B)	Clay loam	Moderately Saline	Mean (B)	Clay loam	Moderately Saline	Mean (B)	Clay loam	Moderately Saline	Mean (B)
Control	7.6	7.1	**7.4**	7.25	6.70	**6.98**	0.30	0.23	**0.27**	10.0	7.0	**8.5**	6.70	6.90	**6.80**	0.50	0.22	**0.36**
Phosphorein $+P_2O_5$	15.5	11.8	**13.7**	8.35	7.32	**7.84**	0.70	0.48	**0.59**	15.7	11.2	**13.5**	7.32	7.60	**7.46**	0.78	0.45	**0.62**
Phosphorein $+0.5P_2O_5$	14.2	10.8	**12.5**	7.80	6.80	**7.30**	0.63	0.47	**0.55**	9.7	10.7	**10.2**	6.80	6.80	**6.80**	0.55	0.44	**0.50**
Cotngein	13.8	13.0	**13.4**	7.98	7.07	**7.53**	0.68	0.48	**0.58**	11.5	12.7	**12.1**	7.07	7.50	**7.29**	0.61	0.48	**0.55**
GA_3 (0.1g/l)	10.3	10.6	**10.5**	7.32	6.81	**7.07**	0.62	0.48	**0.55**	10.3	14.6	**12.5**	6.81	7.60	**7.21**	0.70	0.49	**0.60**
Foliafeed (0.7g /l)	15.5	14.4	**15.0**	7.85	7.33	**7.59**	0.70	0.49	**0.60**	13.2	11.2	**12.2**	7.33	7.20	**7.27**	0.69	0.46	**0.58**
Mean (A)	**12.8**	**11.3**		**7.76**	**7.01**		**0.61**	**0.44**		**11.7**	**11.2**		**7.01**	**7.27**		**0.64**	**0.42**	
L. S. D. at 5 %	A= 0.968	B= 1.677	A*B= N.S	A=0.390	B=N.S	A*B= N.S	A= 0.064	B= 0.111	A*B= N.S	A= 0.011	B=N.S	A*B= N.S	A= 0.389	B=N.S	A*B= N.S	A=0.066	B= 0.114	A*B= N.S
Yield component	**Oil percentage**			**Seed yield (kg)/fed**			**Oil yield (kg) /fed**			**Oil percentage**			**Seed yield (kg)/fed**			**Oil yield (kg) /fed**		
Control	36.3	32.0	**34.2**	398.1	298.7	**348.4**	144.51	95.58	**120.05**	36.2	33.0	**34.6**	395.1	309.0	**352.1**	143.03	101.97	**122.50**
Phosphorein $+P_2O_5$	37.6	35.6	**36.6**	427.4	325.2	**376.3**	160.70	115.77	**138.24**	38.6	35.4	**37.0**	403.0	312.3	**357.7**	155.56	110.55	**133.06**
Phosphorein $+0.5P_2O_5$	36.2	34.7	**35.5**	408.4	309.0	**358.7**	147.84	107.22	**127.53**	38.2	35.3	**36.8**	395.1	295.4	**345.3**	150.93	104.28	**127.61**
Cotngein	37.6	35.6	**36.6**	484.8	384.5	**434.7**	182. 28	136.88	**159.58**	38.6	36.8	**37.7**	444.4	345.6	**395.0**	171.54	127.18	**149.36**
GA_3 (0.1g/l)	40.9	36.9	**38.9**	452.7	354.2	**403.5**	185.15	130.70	**157.93**	38.9	37.2	**38.1**	413.5	338.8	**376.2**	160.85	126.03	**143.44**
Foliafeed (0.7g /l)	38.7	35.8	**37.3**	420.7	321.7	**371.2**	162.81	115.17	**138.99**	37.7	35.6	**36.7**	399.4	306.3	**352.9**	150..57	109.04	**129.81**
Mean (A)	**37.9**	**35.1**		**432.0**	**332.2**		**163.88**	**116.88**		**38.0**	**35.6**		**408.4**	**317.9**		155.41	**113.18**	
L. S. D. at 5 %	A=2.058	B=N.S	A*B= N.S	A=21.57	B=37.36	A*B= N.S	A= 12.46	B=21.58	A*B= N.S	A=1.53	B=N.S	A*B= N.S	A=33.02	B=N.S	A*B= N.S	A=11.56	B=N.S	A*B=N.S

Table (4): Fiber yield and quality of flax plant as affected by phosphorein, cotngein, GA_3 and Foliafeed in clay and saline soil in 2000-2001 and 2001-2002 seasons.

Season	2000– 2001									2001-2002								
Yield component	Fiber yield (g) / plant			Fiber yield (kg) / fed			Fiber fineness (Nm)			Fiber yield (g) / plant			Fiber yield (kg) / fed			Fiber fineness (Nm)		
Type of soil (A) / Treatment (B)	Clay	Saline	Mean (B)	Clay	Saline	Mean (B)	Clay	Saline	Mean (B)	Clay	Saline	Mean (B)	Clay	Saline	Mean (B)	Clay	Saline	Mean (B)
Control	0.230	0.120	**0.175**	419.0	297.7	**358.4**	226.1	229.4	**227.8**	0.190	0.120	**0.155**	377.9	289.3	**333.6**	227.2	228.5	**227.9**
Phosphorein+P_2O_5	0.240	0.140	**0.190**	447.2	360.7	**404.0**	235.8	238.7	**237.3**	0.210	0.140	**0.175**	439.8	357.0	**398.4**	236.5	237.4	**237.0**
Phosphorein+0.5P_2O_5	0.220	0.130	**0.175**	426.4	324.1	**375.3**	233.1	237.3	**235.2**	0.200	0.130	**0.165**	404.7	290.5	**347.6**	234.8	235.9	**235.4**
Cotngein	0.250	0.150	**0.200**	473.2	362.4	**417.8**	239.0	241.8	**240.4**	0.230	0.140	**0.185**	444.6	359.6	**402.1**	235.3	239.8	**237.6**
G A_3 (0.1g/l)	0.230	0.130	**0.180**	429.4	303.0	**366.2**	232.6	236.6	**234.6**	0.190	0.130	**0.160**	400.4	297.4	**348.9**	233.1	240.2	**236.7**
Foliafeed (0.7g /l)	0.230	0.140	**0.185**	454.1	326.4	**390.3**	233.0	240.7	**236.9**	0.190	0.130	**0.160**	436.8	313.6	**375.2**	232.0	243.6	**237.8**
Mean (A)	**0.233**	**0.135**		**441.6**	**329.1**		**233.3**	**237.4**		**0.202**	**0.132**		**417.4**	**317.9**		**233.2**	**237.6**	
L. S. D. at 5 %	A= 0.007 B=0.012 A*B= N.S			A= 17.77 B=30.78 A*B= N.S			A=2.107 B=3.649 A*B=5.160			A= 0.006 B=0.010 A*B= N.S			A= 34.76 B=N.S A*B= N.S			A= 2.878 B=4.984 A*B= 7.660		

In this respect, Fatma (2003) mentioned that, that biofertilizer phosphorein contained phosphate solubilizing bacteria and this play a fundamental role in correcting the solubility problem of phosphate in the soil by converting the fixed form to soluble form ready for plant nutrition. Therefore, it can be suggested that, this increase might be mainly attributed to the phosphorus effect as an important element for cell division activity leading to the increase of plant height and dry weight of plant. Microorganisms have a critical role in the availability of soil immobilized phosphorus through dissolving soil complex inorganic and organic phosphates (El-Dahtory *et al.*, 1989). Hanafy Ahmed *et al.* (2002 a) reported that, the enhancing effect of phosphorein as a biofetilizer on yield and its component might be attributed to many factors such as: a) its ability to release plant promoting substances, mainly IAA, gibberellic and cytokinin like substances which might be stimulated plant growth and yield (Saber *et al.*, 1998), b) synthesis of some vitamins e.g., B_{12} (Sobh *et al.*, 2000), c) increasing amino acid content (Hanafy Ahmed *et al.*, 2002 a), d) increasing the water and mineral uptake from the soil (El-Agrodi *et al.*, 2003), this could be ascribed to increase in root surface area, root hairs and root elongation as affected by biofertilizer as mentioned by Hanafy Ahmed *et al.* (1997), e) enhancing the production of biological active fungistatical substances which may change the microflora in the rhizosphere and effect the balance between harmful and beneficial organisms (Apte abd Shende, 1981).

Furthermore, it might be suggested that, application of phosphorein with full or half recommended dose of P_2O_5 increase oil percentage and oil yield/fed of flax due to increase of available P in plants. In this respect, Harigyansingh *et al.* (1960) pointed out that, application of P and N resulted in comparatively greater accumulation of proteins in flax plants and seeds and thereby hindered satisfactory availability of carbohydrates for polymerization into fatty acids.

As regard to the interaction between soil type and biofertilizer phosphorein with full or half recommended dose of P_2O_5 mineral fertilizer on yield and yield components of flax, it is clear from Tables (2, 3 and 4) that, there was pronounced insignificant difference values between means of most of studied growth characters, except stem diameter and fiber fineness in the 1^{st} and 2^{nd} seasons by using these two different phosphorein treatments.

The maximum values of seed, straw and fiber yield/fed were recorded by using phosphorein with recommended dose of P_2O_5 in clay loam soil with relative increase 7.4 and 2.0% of seed and with 6.8 and 16.2% of straw as well as with 6.7 and 16.4% of fiber yield in the 1^{st} and 2^{nd} seasons, respectively. These results are in harmony with those reported by El-Shimy *et al.* (2001) on flax and El-Sweify *et al.* (2003) on jute.

The enhancing effect of biofertilizer phosphorein on increasing yield and its components in plant grown under moderately saline soil condition might be due to the role played by biofertilizer to reducing soil pH value, which increase as a result of salinity soil addition due to secreting some organic acids such as acetic, propionic, fumaric and succinic, which brought about the dissolution of nutrients bound to organic materials or fixed them in soil on unsoluble forms into soluble forms and consequently tender them available for growing plants (Ibrahim and Abd El-Aziz, 1977). In this respect, El-Fadaly *et al.* (2003) revealed that, the increase in seed and straw yield and its components of faba bean due to inoculation with P-dissolver bacteria may be attributed to the increase in available P in root media. The decreasing in the soil pH due to organic acid may lead to an increase in micronutrient contents.

- Effect of micronutrients:

It is clear from results in Tables (2, 3 and 4) that, there was a significant increase in seed, straw and fiber yield and its component of flax plants grown under clay loam and moderately saline soil in the 1st and 2nd seasons by using cotngein or foliafeed C application, with some exceptions in the number of seeds/capsule, oil percentage and technical length in the two seasons and number of capsules/plant and oil yield/fed in the 2nd season in which the increases did not reach to the level of significant. Cotngein seed coating application surpassed foliafeed C foliar application in seed, straw and fiber yield/fed by about 11.9 and 7.3 and 7.2%, respectively in the 2nd season.

These findings are in agreement with those obtained by El-Sweify (1993), Mostafa *et al.* (1998), El-Gazzar and El-Kady (2000) and El-Azzouni (2003) on flax. These increases might be attributed to the micronutrients influences in enhancing the photosynthesis process and/or the translocation of the photosynthate products to the seeds as a result of increasing enzymatic activity and other biological activities (Amberger, 1974).

Moreover, cotngein and foliafeed C increased oil percentage and oil yield of flax due to enhancing effect of micronutrients on lipid. In this respect, Hopkins (1999) reported that, iron appears to catalyze both the initiation and propagation stages of lipid peroxidation. Copper is a potent catalyst of lipid oxidation.

Regarding the interaction between soil type and micronutrients application on yield and its components of flax, the results in Tables 2, 3 and 4 indicate that, there are insignificant differences in seed, straw and fiber yield/plant and per feddan and its components by using cotngein or foliafeed C application in the 1st and 2nd season, except stem diameter and fiber fineness in the two seasons. Also, it is clear from the data in the same Tables that, seed, straw and fiber yield/fed in the first season surpassed it in the second one by using both cotngein and foliafeed C micronutrients fertilizer, this might be due to differences in climatic condition prevailing in both seasons.

These results are in agreement with those obtained by Moawed (2001) on flax and Salama *et al.* (2003) on wheat who mentioned that, the increase of grain and straw yield and its component of wheat plants by using Zn in saline soil may be due to that applying micronutrient delayed the senescence of wheat plants through an increase in the level of IAA, chlorophyll content and net assimilation rate (NAR) in leaves which consequently increased the total dry matter accumulation and yield components.

Generally, in clay loam and moderately saline soil, pH value tend to be alkaline so effect on the solubility of micronutrients on the soils, in this respect, Osman *et al.* (1990) working on faba bean using Fe, Mn and Zn chelates by coating method, found that such method was efficient for correcting the requirements and suitable balance between such nutrients in alluvial slightly alkaline soils for growth, nutrients uptake and high yield production.

Abdel-Aziz and Anton (1999) reported that, the pH of the soil system is an important factor in determining the solubility relationship. Crop yield may evidently be increased by the addition of micronutrient in soil suffer from their deficiencies and/or by its foliar application.

Thus, applying micronutrients, i.e. coating or spraying may be compensation the micronutrients which fixed in the soils. Moreover, this proves that Egyptian soils either old or new suffer from micronutrients deficiencies.

- Effect of GA_3:

It is noticed from the results in Tables 2, 3 and 4 that there was a pronounced increase in seed, straw and fiber yield and its component by using GA_3 foliar application at the rate of 100 ppm in the 1st and 2nd seasons. The relative increase in seed, straw and fiber yield/fed reached 6.8, 4.7 and 4.6%, respectively in the 2nd season when compared with mean values of control untreated plants. The highest mean values of oil percentage were obtained by using GA_3. In this respect, the increases in oil yield/fed due to GA_3 foliar application was attributed to the increases of oil percentage and seed yield/fed. These results agreed with those obtained by Bahia *et al.* (1995), El-Azzouni (2003) and Ghoniem (2004) on flax. In this respect, Bhattacharjee *et al.* (2000) working on Jute, reported that the stimulating effect of GA_3 in increased fruit setting and their subsequent growth and development accounted for promotion of seed yield and its components. Also, the authors added that the degree of improvement of growth promoter GA_3 was found to be related with increase in the size of seed produced. Increase in seed size exerted beneficial effect on seed weight, emergence, seedling dry matter and consequently seed yield. The increase in pod length and seed yield were observed with GA_3 application indicating that more number of seeds with reduced size were produced in case of GA_3 which received application of GA_3 during 50% flowering. This might be attributed to increased cell division within the flower due to localized application of GA_3 on the floral organs.

Regarding the interaction between soil type and GA_3 application on yield of flax and its components, the results in Tables 2, 3 and 4 showed that there was a significant difference in stem diameter and fiber fineness in the 1st and 2nd seasons. However, the differences in seed, straw and fiber yield as well as its components were insignificant increase due to the interaction between soil type and GA_3 foliar application.

The highest stem diameter recorded by using GA_3 was 1.95 and 1.60 mm in clay loam soil in the 1st and 2nd seasons, respectively, with relative increase 19.6 and 6.7% when compared with control. But, the highest fiber fineness recorded by using GA_3 in moderately saline soil with relative increase 3.1 and 5.1% in the 1st and 2nd seasons, respectively when compared with control plants. In this respect, Sing and Singh (1980) reported that, the growth regulators, GA_3, kinetin or IAA significantly mitigated the adverse effect of salinity; each growth regulator had specific effect for different parameters. Moreover, Ebad *et al.* (1992) revealed that, salinity effect on the activity of the endogenous growth regulator in mesophytic plants. The contents of auxins, gibberellins and cytokinins were obviously decreased, while, the activity levels of the growth inhibitors are markedly increased by increasing soil salinity. Therefore, the application of growth promoting substances, among which gibberellins, to plants grown under salinity may compensate the depression in endogenous growth regulators resulting from salinity and the plants can withstand under the saline conditions.

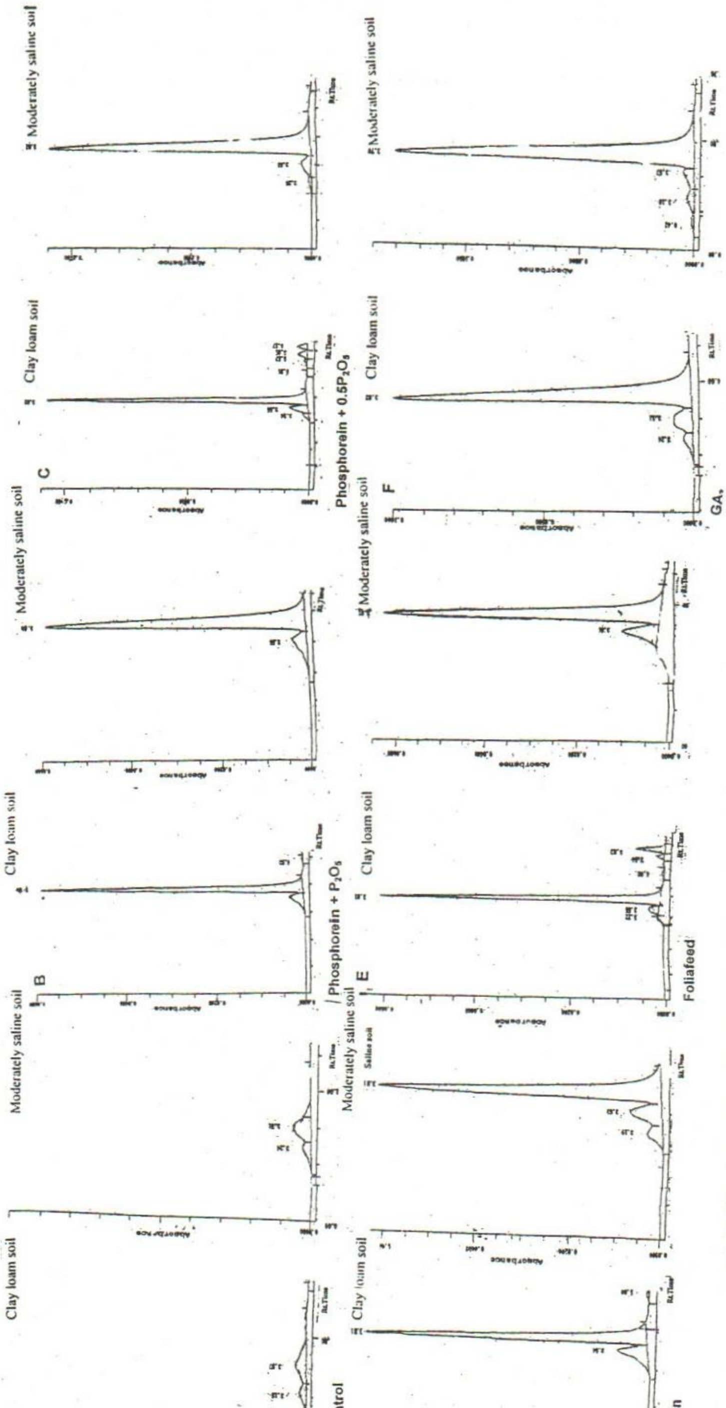
- α-Tocopherol:

Concerning the effect of soil type, generally, the present results in Table 5 and Fig. (1 A) indicate that, α- tocopherol concentration increase in the plants grown under moderately saline soil when compared by those grown under clay loam soil. In this respect, Oomah *et al.* (1997) studied the tocopherol content of oil from 8 flax seed cvs. grown at 4 locations. They found that flax seed contained an average of 9.3 mg/100 g of total tocopherol in the seed, with gamma-tocopherol representing 96-98% of the total tocopherols. The level of tocopherol in flax seed was cv. specific and regulated by environmental conditions as indicated by the storage cv. × location × year interaction. Seasonal differences in total tocopherol content were significant, although the contribution of the delta isomer was constant at 2.5% of the total tocopherol. In flax seed, tocopherol content was weakly but positively associated with oil content. In this connection, Machlin (1991) revealed that, increment in α- tocopherol due to saline conditions may in turn due to that vitamin E functions as *in vivo* antioxidant that protects tissue lipids from free radical attack.

Table (5): Alpha-Tocopherol (mg/kg) of linseed oil as affected by phosphorein, cotngein, GA_3 and foliafeed C of flax plants grown under clay loam and moderately saline soil in the first season.

Soil type / Treatment	Clay loam	Moderately Saline	Mean B
Control	1.5	3.5	**2.5**
Phosphorein+P_2O_5	14.0	20.5	**17.3**
Phosphorein+0.5 P_2O_5	9.5	12.5	**11.0**
Cotngein	18.0	26.5	**22.3**
G A_3 (0.1g/l)	25.5	50.0	**37.8**
Foliafeed C (0.7g /l)	22.0	30.5	**26.3**
Mean (A)	15.4	23.6	
L. S. D. at 5 %	A= 2.96	B= 5.13	A*B= 9.73

In this respect, Meneguzza *et al.* (1999) found that, salt excess can induce conditions of oxidative stress, O_2 and H_2O_2 could play important role in the mechanism of salt injury. Moreover, Erdei *et al.* (1995) revealed that, a variety of antioxidant systems exists in plants which work by eliminating precursors of hydroxyl radicals (i.e. hydrogen peroxide, superoxide radical).



Fig(1):Vitamin E(α-Tocopherol) of linseed oil as affected by phosphorein, cotngein,foliafeed and GA_3 of flax plants grown under clay loam and moderately saline soil in the first season.

These species can lead to the formation of damaging free radicals which process can be catalyzed by metal ions. The reactive radicals cause lipid peroxidation and denaturing of proteins. One general antioxidant category which may be involved in abiotic stress tolerance includes the enzymatic/peptidic scavenging systems. These are catalase and peroxidase converting hydrogen peroxide into water and oxygen, superoxide dismutase that catalyzes the conversion of the superoxide radical to hydrogen peroxide and oxygen (Vianello and Macri, 1991). In this respect, Lovaas and Olsen (1998) mentioned that, environmental factors, such as high light intensities, drought, mineral excess and environmental pollutants, induce oxidation of cellular components of plants. Furthermore, they added that, oxidative stress can induce or enhance superoxide dismutase, glutathione reductase and ascorbate peroxidase. It also leads to an increase in glutathione, ascorbic acid and α- tocopherol (Mehlhorn *et al.*, 1986). Thus, it can be suggested that, under moderately saline soil conditions, flax plants might be increasing α- tocopherol production which acting as antioxidant to protecting plant tissue from increasing free radical produce due to salinity stress.

- Effect of biofertilizer (phosphorein):

It is clear from the results in Table (5) and Figs. (1 B and C) that there was significant increase in α- tocopherol concentration in linseed oil by inoculation flax seeds by phosphorein combined with the recommended or the half recommended dose of P_2O_5 mineral fertilizer. Phosphorein with recommended dose of P_2O_5 surpassed phosphorein with half dose of P_2O_5 by about 47.4% in clay loam soil.

In this respect, Machlin (1991) mentioned that, vitamin E may inhibit lipoxygenase and phospholipase activity. The inhibition of phospholipase activity may be a secondary effect of vitamin E decreasing formation of lipid peroxides which in turn activate phospholipase. Moreover, Jacob and Lux (1968) reported that the benzene ring in vitamin E may trap free radicals such as exist in the presences of hydrogen peroxide and its breakdown products and so prevent the initiation of peroxidation of the polyunsaturated fatty acid component of cellular membranes which synthesize from phosphorus.

As regard to the interaction between type of the soil and phosphorein on α- tocopherol concentration, there was a positive significant difference between using phosphorein combined with recommended dose of P_2O_5 and those treated with phosphorein combined with the half dose of P_2O_5. The highest value of α- tocopherol was obtained by the plants treated with phosphorein combined with recommended dose of P_2O_5 in moderately saline soil (20.5 mg/kg), while, the lowest value was (9.5 mg/kg) obtained by using phosphorein combined with half dose of P_2O_5 under clay loam soil condition.

Generally, it can be suggested that, using biofertilizer (phosphorein) might be released more phosphorus, which may effect on synthesis and/or activity of some enzymes responsible directly or indirectly on production of α-tocopherol.

- Effect of micronutrients:

Significant increase in vitamin E concentration was recorded by the plants treated with cotngein or foliafeed C micronutrients application as compared with control untreated plants (Table 5) and Figs. (D and E).

Foliafeed C foliar application surpassed cotngein coated seed by about 22.2 and 15.1%, respectively in clay loam and moderately saline soil. In this respect, it has been proposed that the vitamin E may serve as a repressor for the synthesis of certain enzymes (Olson, 1974). There is considerable evidence that, in addition to its role as component of many enzymes, zinc can function as a stabilizer of bio-membranes (El-Shamaa and Abd El-Momin, 2002). The authors suggested that poor zinc status could result in reduced absorption of vitamin E. Moreover, Machlin (1991) suggested that, vitamin E prevents iron-induced lipid peroxidation *in vivo* presumably due to its antioxidant properties. In addition, Pond *et al.* (1995) reported that, Zn plays a role similar to that of vitamin E in reducing peroxidative damage on cellular membranes.

Concerning the interaction between soil type and micronutrients application, it is clear from the results that, in both clay loam and moderately saline soils, there was positive significant differences due to using cotngein or foliafeed C on α- tocopherol concentration of linseed oil (Table 5). The highest concentration of α- tocopherol was obtained by using foliafeed C foliar application in moderately saline soil (30.5 mg/kg), while, the lowest concentration of α- tocopherol was obtained by using cotngein seed coated in clay loam soil (18.0 mg/kg).

- Effect of GA_3:

Data represented in Table (5) and Fig. (F) reveal that, GA_3 foliar application (100 ppm) significantly increased vitamin E concentration in linseed oil. It is important here to mention that, biosynthesis of gibberellin occurs through Mevalonic acid cycle from isoprenoid units. Also, isoprenoid is included in the side chain structure of vitamin E, thus, foliar application of GA_3 may be increase directly or indirectly biosynthesis of isopreniod which contained in Vitamin E. Therefore, isoprenoid was the precursor for both GA_3 and vitamin E biosynthesis. In this respect, Lucy (1972) suggested that, the isoprenoid side chain of vitamin E, in addition to being responsible for the fat solubility, may cause stabilization of cellular membranes through physiochemical interaction with fatty acyl chains of polyunsaturated phospholipids. Tocopherols are preferentially oxidized thus protecting the fats.

Concerning the interaction between type of soil and GA_3 foliar application on α- tocopherol concentration, the obtained results show positive significant differences. The highest value of α- tocopherol was obtained by using GA_3 in moderately saline soil (50 mg/kg).

In this respect, Satvir *et al.* (2001) reported that, GA_3 counteracts the effect of salt stress primarily by increasing starch degradation in cotyledons by increasing the activities of enzymes of sucrose metabolism in shoots of chickpea.

Generally, it is clear from the results that, the high value of α-tocopherol of both clay loam and moderately saline soil can be arrangement in the following order, GA_3 > foliafeed C > cotngein > phosphorein + recommended dose of P_2O_5, while, the lowest value was recorded by the plants treated with phosphorein + 1/2 P_2O_5. Moreover, it can generally be suggested that, cotngein was the best treatment for increasing seed, straw, fiber and oil yield of flax, while using GA_3 treatment was the best for α-tocopherol production.

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تأثير المخصب الحيوي الفوسفورين و العناصر الصغري و الجبريللين علي محصول و انتاجية الكتان النامي تحت ظروف الاراضي الطينية الطميية و الملحية الخفيفة

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* المعمل المركزي للأغذية و الاعلاف - مركز البحوث الزراعية - الجيزة - مصر

أجري هذا البحث بمحطة البحوث الزراعية بالجيزة (أراضي طينية طميية) و محطة تاج العز بمحافظة الدقهلية (أراضي ملحية خفيفة) خلال موسمي ٢٠٠٠ - ٢٠٠١ و ٢٠٠١ -٢٠٠٢ لدراسة تأثير المخصب الحيوي الفوسفورين (١٠ جم / كجم بذرة) و العناصر الصغري (الكوتنجين ١٠ جم / كجم بذرة، الفوليافيد ج ٠,٧ جم / لتر) و الجبريللين (٠,١ جم / لتر) علي انتاجية محصول الكتان و كذلك فيتامين هـ تحت ظروف الاراضي الطينية الطميية و الملحية الخفيفة. و قد أظهرت النتائج تفوق نباتات التربة الطينية علي الملحية في محصول البذور و القش و الالياف و كذلك الصفات المرتبطة بهم. و قد ادت المعاملة بالفوسفورين الي زيادة معنوية في محصول البذور و القش و الالياف و الصفات المرتبطة بهم و تفوقت النباتات المعاملة بالفوسفورين مع التسميد الفوسفاتي الموصي به (١٠٠ كجم فو٢ ا٥ من سماد سوبر فوسفات الكالسيوم ١٥,٥%) عن تلك المعاملة بالفوسفورين مع نصف التسميد الفوسفاتي. كذلك فقد ادت المعاملة بالكوتنجين او الفوليافيد ج كمغذيات نباتية بالعناصر الصغري الي زيادة معنوية في محصول البذور و القش و الاليـاف و مكوناتهم. و كانت المعاملة بالكوتنجين كمغلف للتقاوي تفوقت علي مركب الفوليافيد ج رشا علي المحصول و مكوناته. كما ادت المعاملة بالجبريللين بتركيز ١٠٠ جزء في المليون الي زيادة معنوية في محصول البذور و القش و الالياف و الزيت للكتان. و قد اوضحت النتائج ايضا زيادة تركيز فيتامين هـ (ألفا- توكوفيرول) في زيت بذور الكتان في الارض الملحية الخفيفة عن الارض الطينية الطميية. كما زاد تركيز فيتامين هـ زيادة معنوية بمعاملة الكتان بالفوسفورين و الكوتنجين و الفوليافيد ج و الجبريللين. و كانت معاملة الكوتنجين افضل المعاملات للحصول علي اعلي محصول للبذور و القش و الالياف و الزيت للكتان ، بينما كانت المعاملة بالجبريللين افضل المعاملات للحصول علي اعلي تركيز لفيتامين هـ تحت ظروف الارض الطينية الطميية و الملحية الخفيفة.