IMPACT OF MINERAL P, BIO-FERTILIZERS, ZINC SPRAY AND IRRIGATION INTERVALS ON PRODUCTIVITY AND QUALITY OF FLAX CULTIVATED IN SIWA OASIS, EGYPT

M. F. Attia, H. A. Fawy, S. M. Ibrahim and Mona M. El-Shazly
Soil Fertility and Microbiology Dept., Desert Research Center (DRC), Cairo

(Received: Sep. 2 , 2015)

ABSTRACT: *A field study was carried out in Tegzerty region, at Siwa Oasis, Egypt, which located at 29º 10'53" N and 25º 33' 12" E. The experiment was done for two successive seasons 2013-2014. Flax (Linum usitatissimum L.) c.v Sakha3 was the test plant. The aim of this study was to evaluate the effect of fertilization under the conditions of saline water irrigation and high water table in loamy sand soil at Siwa Oasis using the mineral and bio-fertilizers of P and foliar Zn applied during different growth stages of flax plants under different rates of water stress.*

Yield parameters of flax plants, nutrients content and uptake in seeds increased with increasing of the P, Zn and moisture content rates additions during the two studied seasons. Application of Azotobacter chroococcum (AZ), Pseudomonas fluorescens (SD) and Bacillus megatherium (PDB) increased yield parameters, nutrients content and uptake. Combining mineral P with bio-fertilizers increased yields as following; P+(AZ)<P+(AZ)+(SD)<P+(AZ)+(PDB)<P+(AZ)+(SD)+(PDB). The most effective treatment was P_2+ (AZ)+(SD)+(PDB)+ Zn_1 under conditions of the irrigation of every 10 days which gave 2.34, 11.1, 0.99 and 1.82 for weight straw, seeds, oil and fiber (Mg ha^{-1}) respectively in the first season, while in the second season it achieved 2.48, 11.4, 1.09 and 1.89 (Mg ha^{-1}). Foliar application of Zn_1 increased yield components, oil content and seed nutrients content and uptake. Irrigation interval every 10 days increased yield components, nutrients content and uptake by seeds of flax plants than the irrigation interval every 20 days.

Key words: *Mineral, Bio-fertilizers, Foliar Zn, Irrigation intervals Flax production, sandy loam soil in Siwa Oasis.*

INTRODUCTION

Negative impact of salinity for agricultural activities is common in newly reclamation areas of Egypt, especially in soils with high water table of Siwa Oasis, Egypt. Siwa soils are affected by irrigation with water salinity and the soil salinity according to Gary and Delno (2004) reported that the water of EC<0.75 dSm^{-1} has no detrimental, 0.75 - 1.50 dSm^{-1} was detrimental effects on sensitive crops, 1.50 - 3.0 dSm^{-1} required careful management practices, and 3.0-7.5 dSm^{-1} was used only for salt tolerant plants El-Agrodi *et al.* (2005) showed that raising soil salinity level up to 3 dSm^{-1} caused an increase in root dry weight, while soil salinity above this level decreased root dry weight of wheat. Ameer khan *et al.* (2006) concluded that the foliar spray of ascorbic acid protected the photosynthetic machinery from the damaging effects of salt stress. Farouk (2011) reported that under moderate salinity levels, application of antioxidants alleviated the harmful effects of salinity on leaf senescence related parameter, but under high salinity levels (7.5-11.5 dSm^{-1}) yield parameters of wheat and nutrients with antioxidants content decreased.

Nutrients function in plant in photosynthetic processes in leaves and plant growth improved by N fertilization. N contributes greatly in protein synthesis, cell structure and carbohydrate production (Weisany *et al.* 2013). P is involved in photosynthesis, energy and nutrient transport in plant (Ceulemans *et al.,* 2011 and Lambers *et al.,* 2014). K is involved in many processes in plant such as photosynthesis, water uptake and retention and protects plant from forest, it also reduces disease of the plant and improves yield and quality (Wang *et al.* 2013). Zn plays very important role in plant such as carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation, water uptake and transport, reduce the adverse effects of short periods of heat and salt stress, synthesis of growth hormone auxin and integrity of cellular membranes (Hafeez *et al.* 2013).

Handreck (2006) reported that high P reduced accumulation of Fe in leaves of flax. Li *et al.* (2007) reported that high P decreased plant micronutrients. Jiao *et al.* (2007) concluded that combination of P and Zn is necessary to optimize crop yield of flax. Berti *et al.* (2009) stated that N at 200 kg N/ha increased oil content of flaxseeds. El-Nagdy *et al.* (2010) reported that the mineral fertilizers applied signal or in combination with bio-fertilizers increased fibre, seeds and oil yield of flax. Khajani *et al.* (2012) recommended mineral fertilizer application to increase the yield components of seeds and flaxseed oil. Khourang *et al.* (2012) recommended mineral fertilizer treatment combined with manure for good flax yield characters. Yaping *et al.* (2014) stated that 30 kg P/ha increased both dry matter and P content in plant tissues and improved oilseed flax grain yield. Esmail *et al.* (2014) obtained highest values of oil yield , P and protein content as well as Fe increased by application of P and Fe at 100kg P/ha and 8kg Fe-EDDHA/ha. Foliar Zn application is effective for correcting deficiency of Zn in soil. Nofal *et al.* (2011) reported that increasing Zn as foliar application from 0.5 to 2.0 g/L increased flax growth, fibre yield, seed yield and seed oil. Khalifa *et al.* (2011) stated that the foliar application of micronutrient compounds increased yield, yield components, oil and seed nutrient contents. Bakry *et al.* (2012) reported that the foliar application with Zn, Mn or Fe positively affected flax yield characters. Almendros *et al.* (2013) reported that the application of Zn-DTPA-HEDTA-EDTA were associated with high flax yield and Zn content. Homayouni *et al.* (2013) stated that yield of flax increased by N + P + Zn. Tahir *et al.* (2014) reported that foliar spray Zn gave highest seed yield and oil content of flax. Bakry *et al.* (2015) concluded that K at 240 kgha^{-1} with spray of 60kg ZnL^{-1} as foliar chelate gave the highest yield components of flax. Mohamed *et al.* (2014) reported that foliar application of micronutrients combinations increased yield, yield components, oil content in seeds.

Yasin *et al.* (2012) assured the important of bio-fertilizers in plant. Mikhailouskaya (2006) reported that the combination between mineral and bio-fertilizers was the most profitable to flax yield and its quality. Neetu *et al.* (2012) reported that the maximum flax yield can be achieved by inoculating plants with Arbuscular Mycorrhizal Fungi (AMF) and *Pseudomonas fluorescens* with 40kgha^{-1} as superphosphate. Yasin *et al.*(2012) reported that *Azotobactor* and *Azosprillum* was fix atmospheric nitrogen as well as solubilize P in soil. El Mokadem and Sorour (2014) reported that *Azospirillum* sp. + P dissolving bacteria + foliar spray of nutrients produced the highest values of growth and yield parameters.

El-Khateeb *et al.* (2009) stated that the highest flax yield increased with increase water irrigation El Hwary and Yagoub (2011) reported that increase yield components of wheat by irrigation every 10 days when compared with every 21 and 28 days. Mirshekari *et al.* (2012) reported that the moisture stress during flowering and filling decreased yield components, nutrients contents and seed oil content of flax. Gaikwad *et al.* (2014) stated that proline content in flax increased with water stress. The objective of the current work is to assess fertilization of flax plants under the conditions of saline water irrigation and high water table on a sandy loam soil at Siwa Oasis using integration of mineral and bio-fertilizers of P and foliar Zn.

MATERIALS AND METHODS

Field experiment carried out in Tegtherty region at Siwa Oasis, located at 29º 10'53" N and 25º 33' '' E in two seasons of 2013 and 2014. The cultivated crop was irrigated with water of 1.65 dS/m and with soil paste extract of 4.63 dS/m (Table 1). The plot area was $10m^2$ consisting of 18 rows, 5 m long and 11.1 cm apart. Seeds flax were sown 2 cm apart at about 3 cm depth. The average of water table level was 90 cm from soil surface. The final plant density was 450 plants/m^2.

The design of the experiment was using spilt-split technique in randomize complete blocks design with three replications for each treatment. The obtained data were statistically analyzed according to Gomez and Gomez (1984). Treatments were as following; the experiment involved different combination of irrigation intervals, Zn foliar spray and P/bio-fertilization. The irrigation intervals were 10 and 20 days; the Zn treatments were 0 and 300 mg ZnL^{-1} in spray solution. The bio-fertilization was by one or more inoculation of *Azotobacter chroococcum* (AZ), *Pseudomonas fluorescence* (SD) and *Bacillus megatherium* P-dissolving bacteria (PDB). Phosphorus was either 42 or 84 kg P ha^{-1} without or with or more of the bio-fertilizers i.e. (AZ), (AZ+SD), (AZ+PDB), (AZ+SD+PDB). A non-fertilized treatment was added. Thus, the total number of treatment combinations 40 (2 irrigation X 2 Zn X 10 P bio-fertilization). In addition, control treatments were 2 non-fertilized treatments; making the number 42 treatments. The P rates were 70 and 140 kg P_2O_5/ha (as superphosphate 155g P_2O_5 kg^{-1}) applied with seedbed preparation. All treatments received 120 kg N/ha (as urea 460gN kg^{-1}) + 180 kg/ha K_2O (as K-sulphate 500g K_2O kg^{-1}) both given 3 equal splits 40, 80, 120 days after seeding. Foliar Zn spray was repeated 3 times with NK fertilization at 1200L ha^{-1} each time.

The flax plant variety Sakha3 was sown on 20th November 2012 and 2013 while the harvested on 20th April 2013 and 2014. Soil analyses were done according to Page *et al.* (1984) and Klute (1986).

Isolates of bacteria used as bio-fertilizers were purified and identified according to (Bergey's Manual of Determinative Bacteriology, 1994). The selected isolates (*Azotobacter chroococcum* , *Bacillus megatherium* and *Pseudomonas fluorescence*) were subjected to different biochemical tests for screening their hormonal and enzymatic activity (Rizzolo *et al.,* 1993). The selected bacterial isolates are known to produce biochemical and hormonal activities in vitro (Table 1a), that could result in beneficial action in the field (El-Saidy & Abd El-Hai, 2011).

Table (1). Chemical and physical properties of the studied soil.

Depth cm	pH	E.C dS/m	OM %	$CaCO_3$ %	Particle size distributes: Sand %	Silt %	Clay %	C.E.C $emol_c\ kg^{-1}$	Texture
0-30	8.23	4.63	3.82	2.79	84.81	9.54	5.65	5.71	L.S
30-60	8.46	5.84	2.37	2.93	82.54	10.62	6.84	6.96	L.S

Soluble cations and anions in soil ($mmol_c\ L^{-1}$)							
	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}
0-30	22.9	2.9	13.6	6.9	2.0	35	9.3
30-60	27.5	3.8	17.7	9.4	2.7	42	13.7

Available nutrients in soil (mg kg^{-1})							
	N	P	K	Fe	Mn	Zn	Cu
0-30	42.8	0.83	38.5	14.1	6.81	3.45	0.41
30-60	28.4	0.75	49.7	18.7	7.62	3.61	0.56

Soluble cations and anions in water of irrigation ($mmol_c\ L^{-1}$)									
	pH	EC	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}
	7.84	1.65	9.2	0.13	4.4	2.8	0.9	10.9	4.8

Table (1a): Biochemical activities of microbial isolates.

Hormonal activity µg/ml	*A. chroococcum*	*B. megatherium*	*P. fluorescens*
IAA	0.22	0.29	10.2
GA3	2.69	1.81	1.95
Cytokinine	25.3	14.92	18.39
Enzyme Production			
Amylase	+	+	-
Phosphatase	+	+ +	-
Protease	+	+ +	-

Fresh liquid culture of *Azotobacter chroococcum, Bacillus megatherium* and *Pseudomonas fluorescens* were used for soil inoculation at the rate of 108colony forming unit (cfu/ml). Rhizosphere soil samples were collected after the harvest. The samples were analyzed for total counts of microorganisms according to Nautiyal (1999). Counting and growing phosphate dissolving bacteria was by using Pikovskaya's agar medium (PVK) Goenadi *et al.* (2000). Counting and growing azotobacters was by modified Ashby's media (Hill, 2000). *Pseudomonas* counts by kings media, CO_2 evolution according to Anderson (1982). Plant samples were collected at harvest. Plant height, weight seeds/plant, weight straw/plant, weight seeds, weight straw, oil and fiber contents were determined. Flax defoliated plants were collected for retting process as described by Schunke *et al.,* (1995). Plant samples were analyzed for N, P and K according to Cottenie *et al* (1982).

RESULTS AND DISCUSSION

Effect of mineral and bio-fertilizers on yield flax components under water stress conditions

Data in Tables (2a and 3a) showed that straw and seeds yields of flax increased with increasing the P and Zn rates additions and bio-fertilizers application with short irrigation interval during the two studied seasons.

In the first season, P fertilizer gave increases of 57.8, 39.5, 73.4 and 56.3% for w. seeds, w. straw, w. oil and w. fiber of flax plant respectively over control treatment, while in second season were 57.96, 41.8, 73.1 and 58.0%. Zn foliar application increased yield components over without Zn application treatment by 5.58, 5.41, 8.51 and 9.06% for yield of seeds, straw, oil and fibre contents respectively in first season, while it being 6.06, 6.07, 9.32 and 9.29% in the second season. These results agreed with those obtained by Khajani *et al.* (2012), Yaping *et al.* (2014) and Bakry *et al.* (2015).

A. chroococcum (AZ), *P.fluorescens* (SD) and *B. megatherium* (PDB) in the first season recorded increases of yield parameters over control bio-fertilizers application about 11.4, 12.6, 22.5 and 24.5% for yields of weight seeds, weight straw, weight oil and weight fibre respectively, while in the second season it being 11.1, 11.9, 23.7 and 24.4% . The combination of mineral P and all bio-fertilizers under Zn application achieved highest flax yields; ascending as following; P + (AZ) < P + (AZ) + (SD) < P + (AZ) + (PDB) < P+ (AZ) + (SD) + (PDB). The previous results agree with those obtained by Neetu *et al.* (2012), El-Nagdy *et al.* (2010) and Yasin *et al.* (2012).

The yields and components of flax plants decreased with increasing irrigation intervals. The 10 days interval gave values greater than 20 days interval by 25.2, 24.8, 44.4 and 41.6% for weight seeds, weight straw, weight oil and weight fibre respectively in first season, while it being 25.4, 25.1, 44.6 and 41.2 % in second season. This result was due to water quantity in the short irrigation interval being greater than the long irrigation interval. These results agreed with those obtained by El-Khateeb *et al.* (2009), El Hwary and Yagoub (2011) and Mirshekari *et al.* (2012), who reported greater yield components by irrigation every 10 days, in comparison with irrigation every 21 or 28 days.

Table (2a). Effect of the treatments on flax yields, oil and fiber contents (season 2013).

Treatments			H. Plant	W. Seeds		W. Straw		Oil		Fiber	
			cm	/plant(g)	Mg ha^{-1}	/plant(g)	Mg ha^{-1}	%	Mg ha^{-1}	%	Mg ha^{-1}
Irrigation every 10 days	Control		33.4	0.16	0.72	1.07	4.82	21.6	0.16	7.46	0.36
	Zn_0	P_1	49.5	0.39	1.76	1.88	8.47	33.4	0.59	11.7	0.99
		P_1+AZ	50.4	0.4	1.80	1.93	8.69	35	0.63	12.6	1.10
		P_1+AZ+SD	50.9	0.41	1.85	1.98	8.92	36.3	0.67	12.7	1.13
		P_1+AZ+PDB	51.6	0.42	1.89	2.06	9.28	36.6	0.69	12.9	1.20
		P_1+AZ+PDB+SD	52.5	0.43	1.94	2.12	9.55	36.9	0.71	13.1	1.25
		P_2	58.6	0.44	1.98	2.09	9.41	35.8	0.71	12.5	1.18
		P_2+AZ	59.8	0.46	2.07	2.14	9.64	37.9	0.79	13.4	1.29
		P_2+AZ+SD	61.8	0.46	2.07	2.22	10.00	39.4	0.82	13.7	1.37
		P_2+AZ+PDB	63.4	0.47	2.12	2.24	10.09	39.9	0.84	13.9	1.40
		P_2+AZ+PDB+SD	63.8	0.49	2.21	2.31	10.41	40.6	0.90	14.2	1.48
	Zn_1	P_1	51.5	0.41	1.85	2.00	9.01	34.0	0.63	11.9	1.07
		P_1+AZ	52.6	0.42	1.89	2.07	9.32	35.6	0.67	12.7	1.18
		P_1+AZ+SD	53.8	0.43	1.94	2.13	9.59	36.2	0.70	12.8	1.23
		P_1+AZ+PDB	54.5	0.44	1.98	2.19	9.86	36.7	0.73	12.9	1.27
		P_1+AZ+PDB+SD	55	0.45	2.03	2.22	10.00	37.4	0.76	13.5	1.35
		P_2	62.7	0.45	2.03	2.13	9.59	37.1	0.75	12.9	1.24
		P_2+AZ	64.1	0.49	2.21	2.28	10.27	39.6	0.87	14	1.44
		P_2+AZ+SD	66.4	0.50	2.25	2.35	10.59	41.2	0.93	14.4	1.52
		P_2+AZ+PDB	67.2	0.51	2.30	2.42	10.90	41.7	0.96	14.9	1.62
		P_2+AZ+PDB+SD	68.6	0.52	2.34	2.47	11.13	42.4	0.99	16.4	1.82
Irrigation every 20 days	Control		22.0	0.15	0.68	1.06	4.77	17.4	0.12	8.7	0.42
	Zn_0	P_1	35.9	0.28	1.26	1.39	6.26	23.5	0.30	9.2	0.58
		P_1+AZ	36	0.30	1.35	1.43	6.44	25.3	0.34	9.3	0.60
		P_1+AZ+SD	36.8	0.31	1.40	1.48	6.67	26.7	0.37	9.5	0.63
		P_1+AZ+PDB	37.2	0.32	1.44	1.55	6.98	27.2	0.39	9.9	0.69
		P_1+AZ+PDB+SD	39.2	0.33	1.49	1.64	7.39	28.1	0.42	11.1	0.82
		P_2	42.2	0.32	1.44	1.54	6.94	26.3	0.38	9.8	0.68
		P_2+AZ	43.5	0.33	1.49	1.59	7.16	27.8	0.41	10	0.72
		P_2+AZ+SD	46.1	0.34	1.53	1.64	7.39	28.8	0.44	10.2	0.75
		P_2+AZ+PDB	46.7	0.35	1.58	1.69	7.61	29.5	0.47	11.0	0.84
		P_2+AZ+PDB+SD	49.1	0.37	1.67	1.79	8.06	31.3	0.52	11.6	0.94
	Zn_1	P_1	37.1	0.30	1.35	1.48	6.67	24.7	0.33	9.4	0.63
		P_1+AZ	38.3	0.31	1.40	1.52	6.85	25.9	0.36	9.5	0.65
		P_1+AZ+SD	39.1	0.32	1.44	1.58	7.12	26.6	0.38	9.9	0.70
		P_1+AZ+PDB	40.3	0.33	1.49	1.59	7.16	27.6	0.41	10.1	0.72
		P_1+AZ+PDB+SD	41.8	0.34	1.53	1.67	7.52	28.8	0.44	9.9	0.74
		P_2	43.1	0.35	1.58	1.57	7.07	27	0.43	10.4	0.74
		P_2+AZ	45.7	0.36	1.62	1.69	7.61	29.4	0.48	10.8	0.82
		P_2+AZ+SD	49.4	0.37	1.67	1.75	7.88	30.6	0.51	10.9	0.86
		P_2+AZ+PDB	49.5	0.38	1.71	1.79	8.06	31.3	0.54	11.5	0.93
		P_2+AZ+PDB+SD	52.7	0.39	1.76	1.91	8.60	32.8	0.58	12.0	1.03

H= high cm, W= weight , Mg ha^{-1}=10^6 gram/hectare

The interactions between four studied factors made the best affective treatment when comparison the treatment of P_2+(AZ)+(SD)+(PDB)+Zn_1 under the short irrigation interval gave highest for yields of seeds, straw, oil and fibre contents. Foliar spray of Zn_1 recorded increases of yield components and seed nutrient contents when compared with the Zn_0 treatment.

Data in Table (3a) showed that the yield components in second season take the same trend of first season and increased with increasing rates of four studied factors (mineral P and bio fertilizers, foliar Zn and irrigation interval). In second season recorded higher increases of yield parameters than obtained first season. This fact was due to bio-fertilizers activity and residual effect of mineral P on yield components of flax. The above results agree with results obtained by Bakry *et al.* (2012), Almendros *et al.* (2013) and Homayouni *et al.* (2013).

These were a number of significant affects and LSD values are given in Tables 2b and 3b.

Effect of the treatments on nutrients content of flax seeds:

The nutrients content in flax seeds during the second season takes the same trend of the first season so we were taking the average values of two seasons for nutrients content and yield components to make the average account nutrients uptake by flax seeds during both seasons.

Data at Table (4a) show that the average values of N, P, K, Zn and Cu contents in flax seeds during two seasons increased with increasing P rates, while contents of Fe and Mn decreased. The P_2 treatment recorded increases of nutrient contents in seeds of 7.1, 30, 2.3, 8.8 and 25.7 % over the P_1 treatment for N, P, K, Zn and Cu respectively, but caused decreased of 9.8 and 3.6 % for Fe and Mn respectively. The previous results agreed with those obtained by Li *et al.* (2007), Yaping *et al.* (2014), and Esmail *et al.* (2014).

Table (2b): LSD 0.05 for table values at 2a.

Variables	H. Plant	W.Seeds		W.Straw		Oil		Fiber	
LSD 0.05	Cm	/plant(g)	Mg ha^{-1}	/plant(g)	Mg ha^{-1}	%	Mg ha^{-1}	%	Mg ha^{-1}
Irrigation	3.01	0.03	0.134	0.142	0.64	2.52	0.089	0.79	0.144
Zn	0.36	0.003	0.012	0.013	0.059	0.12	0.007	0.05	0.013
P	0.51	0.004	0.017	0.018	0.083	0.06	0.009	0.08	0.018
Bio	0.77	0.004	0.018	0.014	0.064	0.26	0.011	0.10	0.017
Irr. x Zn	1.09	0.006	0.025	0.02	0.091	0.37	0.016	0.14	0.023
Irr. x P	1.34	0.007	0.031	0.007	0.032	0.45	0.019	0.17	0.029
Irr. x Bio	0.54	0.003	0.012	0.01	0.045	0.18	0.008	0.07	0.012
Zn x P	1.56	0.008	0.036	0.029	0.13	0.53	0.022	0.19	0.033
Zn x Bio	1.56	0.008	0.036	0.029	0.129	0.52	0.022	0.19	0.033
P x Bio	1.56	0.008	0.036	0.029	0.129	0.52	0.022	0.19	0.033
Irr. x Zn x P	1.56	0.008	0.036	0.029	0.129	0.52	0.022	0.19	0.033
Irr. x Zn x Bio	1.56	0.008	0.036	0.029	0.129	0.52	0.022	0.19	0.033
Irr. x P x Bio	1.56	0.008	0.036	0.029	0.129	0.52	0.022	0.19	0.033
Zn x P x Bio	1.56	0.008	0.036	0.029	0.129	0.52	0.022	0.19	0.033
Irr. x Zn x P x Bio	1.56	0.008	0.036	0.02	0.091	0.52	0.022	0.19	0.033

Table (3a): Effect of the treatments on flax yields, oil and fiber contents (season 2014).

Treatments			H. Plant	W. Seeds		W. Straw		Oil		Fiber	
			cm	/plant(g)	Mg ha^{-1}	/plant(g)	Mg ha^{-1}	%	Mg ha^{-1}	%	Mg ha^{-1}
Irrigation every 10 days	Control		34.8	0.17	0.77	1.11	5.00	22.4	0.17	7.8	0.39
	Zn_0	P_1	50.5	0.41	1.85	1.92	8.65	33.8	0.62	12.0	1.04
		P_1+AZ	52.6	0.43	1.94	2.01	9.05	36.2	0.70	12.8	1.16
		P_1+AZ+SD	53.3	0.44	1.98	2.1	9.46	37.8	0.75	13.2	1.25
		P_1+AZ+PDB	55.2	0.45	2.03	2.12	9.55	38.2	0.77	13.4	1.28
		P_1+AZ+PDB+SD	57.1	0.47	2.12	2.2	9.91	39.3	0.83	13.9	1.38
		P_2	61.3	0.46	2.07	2.13	9.59	36.2	0.75	12.8	1.23
		P_2+AZ	62.2	0.47	2.12	2.18	9.82	38.5	0.82	13.6	1.34
		P_2+AZ+SD	64.4	0.48	2.16	2.26	10.18	40.0	0.86	13.8	1.40
		P_2+AZ+PDB	66.1	0.49	2.21	2.30	10.36	40.5	0.89	14.0	1.45
		P_2+AZ+PDB+SD	67.8	0.52	2.34	2.37	10.68	41.4	0.97	14.5	1.55
	Zn_1	P_1	53.7	0.43	1.94	2.04	9.19	33.8	0.65	12.1	1.11
		P_1+AZ	55.8	0.44	1.98	2.11	9.50	36.2	0.72	13.0	1.24
		P_1+AZ+SD	58.2	0.46	2.07	2.19	9.86	38.1	0.79	13.3	1.31
		P_1+AZ+PDB	60.1	0.47	2.12	2.25	10.14	38.9	0.82	13.6	1.38
		P_1+AZ+PDB+SD	60.8	0.48	2.16	2.28	10.27	39.6	0.86	13.8	1.42
		P_2	64.3	0.51	2.30	2.25	10.14	38.7	0.89	13.4	1.36
		P_2+AZ	66.7	0.52	2.34	2.37	10.68	40.8	0.96	14.2	1.52
		P_2+AZ+SD	69.2	0.53	2.39	2.41	10.86	42.4	1.01	14.6	1.58
		P_2+AZ+PDB	70.3	0.54	2.43	2.48	11.17	42.9	1.04	15.0	1.68
		P_2+AZ+PDB+SD	71.4	0.55	2.48	2.53	11.40	43.8	1.09	16.6	1.89
Irrigation every 20 days	Control		22.8	0.16	0.72	1.01	4.55	18.2	0.13	8.9	0.40
	Zn_0	P_1	36.1	0.3	1.35	1.43	6.44	24.9	0.34	9.6	0.62
		P_1+AZ	39.2	0.31	1.40	1.47	6.62	26.4	0.37	9.9	0.66
		P_1+AZ+SD	40.6	0.33	1.49	1.56	7.03	27.9	0.41	10.1	0.71
		P_1+AZ+PDB	41.2	0.34	1.53	1.57	7.07	28.4	0.43	10.5	0.74
		P_1+AZ+PDB+SD	44.2	0.35	1.58	1.66	7.48	29.9	0.47	11.3	0.84
		P_2	44.1	0.34	1.53	1.56	7.03	26.9	0.41	10.2	0.72
		P_2+AZ	45.3	0.35	1.58	1.61	7.25	28.6	0.45	10.4	0.75
		P_2+AZ+SD	47.9	0.36	1.62	1.66	7.48	29.6	0.48	10.6	0.79
		P_2+AZ+PDB	48.7	0.37	1.67	1.71	7.70	30.3	0.51	11.1	0.86
		P_2+AZ+PDB+SD	52.1	0.39	1.76	1.81	8.15	31.5	0.55	12.0	0.98
	Zn_1	P_1	38.7	0.32	1.44	1.50	6.76	25.3	0.36	9.7	0.66
		P_1+AZ	40.7	0.33	1.49	1.54	6.94	27.1	0.40	10.0	0.69
		P_1+AZ+SD	43.3	0.34	1.53	1.66	7.48	28.4	0.43	10.2	0.76
		P_1+AZ+PDB	44.5	0.35	1.58	1.71	7.70	28.8	0.45	10.4	0.80
		P_1+AZ+PDB+SD	46.2	0.36	1.62	1.73	7.79	29.8	0.48	11.2	0.87
		P_2	48.5	0.37	1.67	1.73	7.79	27.8	0.46	10.6	0.83
		P_2+AZ	49.7	0.38	1.71	1.71	7.70	30.0	0.51	11.1	0.86
		P_2+AZ+SD	51.4	0.39	1.76	1.79	8.06	31.0	0.54	11.0	0.89
		P_2+AZ+PDB	51.5	0.4	1.80	1.83	8.24	31.7	0.57	11.7	0.96
		P_2+AZ+PDB+SD	54.9	0.41	1.85	1.95	8.78	33.4	0.62	12.1	1.06

H= high cm, W= weight

Table (3b): LSD 0.05 for values of table 3a.

Variables	H. Plant	W. Seeds		W. Straw		Oil		Fiber	
LSD 0.05	cm	/plant(g)	Mg ha^{-1}	/plant(g)	Mg ha^{-1}	%	Mg ha^{-1}	%	Mg ha^{-1}
Irrigation	3.05	0.032	0.144	0.147	0.66	2.59	0.098	0.78	0.149
Zn	0.43	0.003	0.014	0.015	0.07	0.14	0.008	0.05	0.014
P	0.6	0.005	0.02	0.008	0.03	0.19	0.012	0.07	0.019
Bio	0.72	0.004	0.018	0.014	0.06	0.23	0.011	0.08	0.016
Irr. x Zn	1.01	0.006	0.026	0.02	0.09	0.33	0.016	0.11	0.022
Irr. x P	0.36	0.007	0.032	0.024	0.11	0.4	0.019	0.14	0.027
Irr. x Bio	0.5	0.01	0.045	0.01	0.04	0.56	0.027	0.20	0.038
Zn x P	1.45	0.008	0.037	0.028	0.13	0.47	0.023	0.16	0.031
Zn x Bio	1.45	0.008	0.037	0.028	0.13	0.46	0.023	0.16	0.031
P x Bio	1.45	0.008	0.037	0.028	0.13	0.46	0.023	0.16	0.031
Irr. x Zn x P	1.45	0.008	0.037	0.028	0.13	0.46	0.023	0.16	0.031
Irr. x Zn x Bio	1.45	0.008	0.037	0.028	0.13	0.46	0.023	0.16	0.031
Irr. x P x Bio	1.45	0.008	0.037	0.028	0.13	0.46	0.023	0.16	0.031
Zn x P x Bio	1.45	0.008	0.037	0.028	0.13	0.46	0.011	0.16	0.031
Irr. x Zn x P x Bio	1.45	0.008	0.037	0.028	0.13	0.46	0.023	0.16	0.031

Foliar application of Zn cause increases in nutrient contents in flax seeds of 5.1, 6.4, 5.8, 46.3 and 8.2% for N, P, K , Zn and Cu respectively over control Zn and decreases of 14.9 and 6.7% for Fe and Mn respectively. The above results agreed with those obtained by Khalifa *et al.* (2011), Almendros *et al.* (2013) and Mohamed *et al.* (2014).

The bio fertilizers secreted the organic acids which dissolved the nutrients in soil, so the nutrients increased in flax seeds by soil application of bio- fertilizers. *A. chroococcum* (AZ) increased N content, while *P.fluorescens* (SD) and *B. megatherium* (PDB) increased P content in flax seeds. The bio-fertilizers increased nutrient contents in flax seeds by 17.6, 36.4, 19.4, 43.7, 23.4, 18.3 and 36.9 % for N, P, K , Fe, Mn, Zn and Cu respectively over control bio-fertilizers treatment. The above results agreed with those results obtained by Neetu *et al.* (2012), Yasin *et al.* (2012) and El Mokadem and Sorour (2014).

The short irrigation interval gave values greater than those of the long interval by average of 24.9, 25.4, 26.2, 50.6, 27.1, 24.2 and 14.5 % for N, P, K, Fe, Mn, Zn and Cu respectively. This result was due to high water at the irrigation interval (every 10 days) led to increase the available nutrients in soil and success all the biological processes. The previous results agreed with those obtained by El-Khateeb *et al.* (2009), El Hwary and Yagoub (2011) and Mirshekari *et al.* (2012),

Comparison between all combined treatments shows that the highest values occurred P_2+(AZ)+(SD)+(PDB)+Zn_1 under the short irrigation. The previous results agree with those obtained by Yasin *et al*. (2012), El-Nagdy *et al.* (2010) and El Mokadem and Sorour (2014).

Table (4a): Effect of the treatments on nutrients content of flax seeds.

Treatments			N	P	K	Fe	Mn	Zn	Cu
			g kg^{-1}			mg kg^{-1}			
Irrigation every 10 days	Control		11.2	0.90	4.20	56.4	11.5	15.3	4.26
	Zn_0	P_1	19.5	1.90	4.40	92.9	20.8	31.6	11.4
		P_1+AZ	23.2	2.10	4.60	96.0	21.7	34.1	12.5
		P_1+AZ+SD	23.4	2.40	4.80	102.5	23.2	36.9	13.7
		P_1+AZ+PDB	23.6	2.70	5.10	112.7	24	38.3	14.4
		P_1+AZ+PDB+SD	23.9	3.10	5.30	120.5	25.6	41.8	15.7
		P_2	21.2	2.80	4.50	89.9	18.4	35.8	13.9
		P_2+AZ	23.8	3.00	4.70	93.8	19.3	37.4	15.3
		P_2+AZ+SD	24.1	3.40	4.90	98.4	21.0	39.5	16.7
		P_2+AZ+PDB	24.5	3.80	5.30	105.6	21.9	43.9	17.9
		P_2+AZ+PDB+SD	24.8	4.20	5.50	112.8	23.2	45.2	18.5
	Zn_1	P_1	20.8	2.20	4.60	88.5	19.8	63.2	12
		P_1+AZ	24.4	2.30	4.90	91.4	20.6	65.8	13.2
		P_1+AZ+SD	24.6	2.50	5.10	96.7	21.8	69.1	14.6
		P_1+AZ+PDB	24.8	2.80	5.50	105.3	22.4	70.9	15.5
		P_1+AZ+PDB+SD	25.1	3.30	5.70	112.6	23.9	74.7	16.8
		P_2	21.9	2.90	4.70	85.6	17.5	67.6	14.5
		P_2+AZ	25.0	3.20	5.00	89.3	18.4	69.3	16.1
		P_2+AZ+SD	25.3	3.60	5.20	92.8	19.8	71.9	17.7
		P_2+AZ+PDB	25.6	4.10	5.70	98.7	20.5	76.9	19.2
		P_2+AZ+PDB+SD	25.9	4.50	5.90	105.4	21.7	78.3	19.8
Irrigation every 20 days	Control		0.77	7.70	0.50	2.80	36.43	7.74	9.94
	Zn_0	P_1	14.4	1.40	3.30	68.73	15.4	22.44	8.45
		P_1+AZ	17.2	1.50	3.40	70.93	16.02	25.17	9.24
		P_1+AZ+SD	17.5	1.80	3.60	76.65	17.34	27.54	10.3
		P_1+AZ+PDB	17.9	2.00	3.90	85.27	18.13	28.95	10.91
		P_1+AZ+PDB+SD	18.1	2.40	4.00	91.17	19.36	31.68	11.88
		P_2	15.7	2.10	3.30	66.44	13.55	26.49	10.21
		P_2+AZ	17.6	2.20	3.50	69.34	14.26	27.63	11.26
		P_2+AZ+SD	18.0	2.60	3.70	73.57	15.66	29.57	12.5
		P_2+AZ+PDB	18.5	2.90	4.00	79.9	16.63	33.18	13.55
		P_2+AZ+PDB+SD	18.8	3.20	4.10	85.36	17.6	34.14	13.99
	Zn_1	P_1	15.1	1.50	3.40	65.38	14.61	48.05	8.89
		P_1+AZ	18.0	1.70	3.60	67.58	15.22	49.98	9.77
		P_1+AZ+SD	18.5	1.80	3.80	72.34	16.37	52.98	10.91
		P_1+AZ+PDB	19.1	2.10	4.10	79.73	16.98	54.91	11.7
		P_1+AZ+PDB+SD	19.4	2.60	4.30	85.18	18.13	57.82	12.67
		P_2	16.5	2.20	3.50	63.27	12.94	51.39	10.74
		P_2+AZ	18.6	2.40	3.70	66.0	13.64	52.62	11.88
		P_2+AZ+SD	19.1	2.70	3.90	69.43	14.78	55.97	13.29
		P_2+AZ+PDB	19.7	3.10	4.20	74.71	15.49	58.61	14.52
		P_2+AZ+PDB+SD	19.9	3.40	4.50	79.73	16.46	60.46	14.96

Table (4b): LSD 0.05 for values table 4a.

Variables	N	P	K	Fe	Mn	Zn	Cu
LSD 0.05	g/kg			mg/kg			
Irrigation	0.32	0.07	0.11	0.83	0.38	0.71	0.11
Zn	0.08	0.01	0.02	0.4	0.09	0.62	0.06
P	0.05	0.06	0.01	0.26	0.12	0.22	0.15
Bio	0.12	0.14	0.02	0.64	0.3	0.54	0.36
Irr. x Zn	0.05	0.02	0.03	0.57	0.12	0.78	0.08
Irr. x P	0.07	0.08	0.01	0.37	0.17	0.31	0.21
Irr. x Bio	0.12	0.14	0.02	0.64	0.32	0.54	0.36
Zn x P	0.09	0.03	0.01	0.45	0.21	0.12	0.08
Zn x Bio	0.12	0.14	0.02	0.64	0.31	0.54	0.36
P x Bio	0.12	0.14	0.02	0.64	0.33	0.54	0.36
Irr. x Zn x P	0.12	0.04	0.01	0.20	0.09	0.17	0.11
Irr. x Zn x Bio	0.12	0.14	0.02	0.32	0.15	0.54	0.36
Irr. x P x Bio	0.06	0.14	0.02	0.32	0.15	0.54	0.36
Zn x P x Bio	0.12	0.14	0.02	0.32	0.15	0.54	0.18
Irr. x Zn x P x Bio	0.12	0.14	0.02	0.45	0.21	0.54	0.25

Effect of the treatments on nutrients uptake by flax seeds under water stress conditions:

Concerning to the effect of integration between mineral and bio-fertilizers application on nutrients uptake by flax seeds (Table 5); the N, P, K, Fe, Mn, Zn and Cu uptake increased with increasing P applications. The P_2 treatment gave higher increases than P_1 treatment by 18.2, 38.1, 14.1, 3.5, 7.3, 20.1 and 35.7% for N, P, K, Fe, Mn, Zn and Cu respectively. The highest increase was P uptake while the lowest was Fe and Mn uptake.

Zn application increased the uptake of nutrients by seeds except for Fe and Mn which were decreased, by 10.7, 12.2, 11.5, 49.3 and 14.2% for N, P, K, Zn and Cu respectively, while decreases averaged 7.7 and 0.3% for Fe and Mn respectively.

Application of bio-fertilizers increased nutrients uptake by flax seeds to 25.4, 42.4, 27.1, 47.9, 30.1, 26.1 and 44.2% for N, P, K, Fe, Mn, Zn and Cu respectively over control bio-fertilizers treatment.

The greater nutrients uptake was obtained by the short irrigation intervals over the long one amounted to 44.2, 44.4, 44.7, 63.2, 45.5, 43.6 and 36.9% for N, P, K, Fe, Mn, Zn and Cu respectively. This reflects the sufficient moisture of the short interval. The current results agreed with those obtained by El-Khateeb *et al.* (2009), El Hwary and Yagoub (2011) and Mirshekari *et al*.(2012),

Integration between mineral and bio-fertilizers increased nutrients uptake by flax seeds. The most effective treatment was P_2+ (AZ) + (SD) + (PDB) + Zn_1 under irrigation of every10 days. The previous results agreed with those obtained by Yasin *et al.* (2012), El-Nagdy *et al.* (2010) and El Mokadem and Sorour (2014).

Table (5a): Effect of the treatments on nutrients uptake by flax seeds.

Treatments			N	P	K	Fe	Mn	Zn	Cu
			kg ha^{-1}			g ha^{-1}			
Irrigation every 10 days	Control		8.0	0.64	3.00	7.90	4.7	4.6	1.25
	Zn_0	P_1	35.7	3.47	8.07	33.00	16	24.3	3.62
		P_1+AZ	43.1	3.90	8.54	35.90	16.9	26.6	4.52
		P_1+AZ+SD	44.0	4.52	9.02	41.50	18.3	29.2	5.53
		P_1+AZ+PDB	44.9	5.14	9.71	50.20	19.2	30.6	6.16
		P_1+AZ+PDB+SD	47.2	6.12	10.47	58.50	21.2	34.7	7.47
		P_2	43.4	5.74	9.21	34.30	15.8	30.8	6.19
		P_2+AZ	50.4	6.35	9.95	39.00	17.2	33.3	7.65
		P_2+AZ+SD	51.6	7.28	10.50	43.60	18.9	35.6	9
		P_2+AZ+PDB	53.6	8.33	11.61	51.20	20.1	40.4	10.3
		P_2+AZ+PDB+SD	55.5	9.40	12.30	59.00	21.8	42.5	11.09
	Zn_1	P_1	39.6	4.19	8.76	30.80	15.8	50.6	4.24
		P_1+AZ	47.0	4.43	9.45	33.50	16.7	53.3	5.27
		P_1+AZ+SD	48.6	4.95	10.07	38.80	18.1	57.4	6.56
		P_1+AZ+PDB	50.2	5.66	11.14	47.00	19	60.3	7.48
		P_1+AZ+PDB+SD	52.0	6.83	11.80	54.50	20.8	65	8.79
		P_2	48.0	6.35	10.28	32.80	16.1	62.2	7.18
		P_2+AZ	55.9	7.16	11.19	36.90	17.3	65.1	8.84
		P_2+AZ+SD	58.4	8.31	12.00	41.50	19.2	69.7	10.67
		P_2+AZ+PDB	60.3	9.66	13.42	48.20	20.3	76.1	12.38
		P_2+AZ+PDB+SD	62.9	10.92	14.33	56.50	22.1	79.9	13.36
Irrigation every 20 days	Control		1.57	3.70	0.26	0.88	2.50	1.8	2.00
	Zn_0	P_1	19.2	1.88	4.33	10.50	7.5	12.6	3.08
		P_1+AZ	23.3	2.02	4.66	11.90	9.1	14.3	3.42
		P_1+AZ+SD	24.2	2.43	4.97	15.50	10.1	16.0	3.88
		P_1+AZ+PDB	25.5	2.88	5.52	21.20	10.9	17.4	4.26
		P_1+AZ+PDB+SD	26.8	3.50	5.97	25.50	12	19.6	4.79
		P_2	23.1	3.12	4.93	10.20	8.4	16.4	4.11
		P_2+AZ	27.2	3.40	5.45	12.60	9.3	18.0	4.76
		P_2+AZ+SD	28.3	4.00	5.81	15.60	10.3	19.5	5.36
		P_2+AZ+PDB	30.3	4.76	6.64	20.60	11.5	22.9	6.08
		P_2+AZ+PDB+SD	32.3	5.43	7.09	25.50	12.7	24.6	6.55
	Zn_1	P_1	20.9	2.07	4.74	8.90	6.2	27.9	3.35
		P_1+AZ	25.8	2.38	5.14	10.60	9.1	30.0	3.81
		P_1+AZ+SD	27.3	2.74	5.59	13.80	10.1	32.8	4.4
		P_1+AZ+PDB	28.2	3.12	6.09	18.40	10.5	34.0	4.72
		P_1+AZ+PDB+S	30.6	4.00	6.78	23.20	12.0	38.2	5.44

		D							
		P_2	26.6	3.57	5.69	9.00	8.8	34.9	4.75
		P_2+AZ	30.9	3.95	6.16	11.20	9.5	36.8	5.41
		P_2+AZ+SD	32.7	4.66	6.64	14.00	10.6	40.3	6.22
		P_2+AZ+PDB	34.7	5.43	7.45	18.30	11.5	43.4	6.98
		P_2+AZ+PDB+SD	36.4	6.28	8.23	22.90	12.7	46.6	7.49

Table (5b): LSD 0.05 for values of table 5a.

Variables	N	P	K	Fe	Mn	Zn	Cu
LSD 0.05	kg ha^{-1}			g ha^{-1}			
Irrigation	1.18	0.262	0.428	0.78	0.74	0.97	0.32
Zn	0.33	0.048	0.071	0.40	0.33	1.02	0.10
P	0.45	0.167	0.095	0.21	0.10	0.29	0.22
Bio	1.12	0.381	0.214	0.50	0.21	0.71	0.55
Irr. x Zn	0.48	0.071	0.119	0.57	0.48	1.44	0.14
Irr. x P	0.64	0.214	0.119	0.29	0.12	0.41	0.32
Irr. x Bio	1.12	0.381	0.214	0.50	0.21	0.71	0.55
Zn x P	0.79	0.262	0.167	0.36	0.17	0.50	0.39
Zn x Bio	1.12	0.381	0.214	0.50	0.21	0.71	0.55
P x Bio	1.12	0.381	0.214	0.50	0.21	0.71	0.55
Irr. x Zn x P	0.36	0.119	0.214	0.50	0.21	0.71	0.17
Irr. x Zn x Bio	0.55	0.381	0.214	0.26	0.21	0.71	0.55
Irr. x P x Bio	0.55	0.381	0.214	0.26	0.21	0.71	0.55
Zn x P x Bio	0.55	0.381	0.214	0.26	0.12	0.71	0.55
Irr. x Zn x P x Bio	1.12	0.381	0.167	0.36	0.17	0.49	0.55

Effect of the treatments on microbial activities in flax rhizosphere:

Initial total microbial counts in Tegtherty soil of Siwa Oasis were 30×10^5 cfu/g dry soil. Data in Table (6a) show that the total microbial counts in flax rhizosphere tended to increase in all treatments receiving fertilizers. Highest total microbial counts was obtained with second level of P , Zinc foliar application and with mixed bio-fertilizers treatments. Microbial respiration (CO_2 evolution) increased after long term P addition, the microbial activity increases in the presence of P and allows more rapid transformation of organic matter. The carbon dioxide (CO_2) is an indication of the biological activity in the rhizosphere. Results in Table (6a) assure that the mixed treatment of mineral and bio-fertilizer gave highest rate of CO_2 evolution than the other treatments. Data of CO_2 evolution were in harmony with those of total microbial counts. These results agreed with those obtained by Visser and Dennis (1992), Gilliam *et al.* (2011) and Liu *et al.* (2012).

Concerning to effect of integration between mineral and bio-fertilizers on phosphate dissolving bacterial (PDB) counts, *Azotobacter* and *Pseudomonas* (Ps) counts; the results show that the initial treatment or the non-treated treatment was lowest (Table 6a), but the increasing achieved with bio-fertilizers and mineral fertilizers application. Highest counts occurred with second level of P and zinc foliar applications under irrigation intervals of 10 days. The previous results agree with those obtained by Yasin *et al.,* (2012), Neetu *et al.,* (2012) and El Mokadem and Sorour (2014).

Table (6a): Effect of studied the treatments on microbial activities in rhiosphere of flax plants .

Treatments			Total microbial counts ($\times10^2$cfu/g dry soil)	PDB counts ($\times10^2$cfu/g dry soil)	Azotobacter densities ($\times10^3$cells/g dry soil)	Ps counts ($\times10^2$cfu/g dry soil)	CO_2 mg/100g dry soil /24hr
Irrigation every 10 days	Control		28	3.7	6.2	1.6	5.3
	Zn_0	P_1	34	4.3	7.4	2.1	6.2
		P_1+AZ	69	6.2	9.3	2.6	6.9
		P_1+AZ+SD	96	6.5	9.8	3.9	7.1
		P_1+AZ+PDB	109	7.3	9.8	2.8	7.4
		P_1+AZ+PDB+SD	138	8.0	10.3	4.1	7.5
		P_2	31	4.9	6.2	2.3	6.2
		P_2+AZ	70	7.0	7.6	2.8	7.0
		P_2+AZ+SD	103	8.2	7.9	4.0	7.3
		P_2+AZ+PDB	112	8.9	8.0	3.1	8
		P_2+AZ+PDB+SD	145	8.9	8.1	4.6	8.2
	Zn_1	P_1	37	4.7	6.1	2.3	6.7
		P_1+AZ	78	6.9	7.4	2.9	7
		P_1+AZ+SD	110	7.1	9.7	4.0	7.5
		P_1+AZ+PDB	126	7.5	9.5	3.0	7.9
		P_1+AZ+PDB+SD	158	8.6	10.6	4.5	8.1
		P_2	38	5.2	6.5	2.3	6.8
		P_2+AZ	82	7.3	7.7	3	7.1
		P_2+AZ+SD	118	8.0	8.4	4.5	7.8
		P_2+AZ+PDB	134	8.9	8.4	3.3	8
		P_2+AZ+PDB+SD	165	9.3	8.9	4.8	8.3
Irrigation every 20 days	Control		24	3.2	5.9	1.2	4.8
	Zn_0	P_1	31	4	6.3	2	6
		P_1+AZ	45	5.9	8	2.4	6.2
		P_1+AZ+SD	63	5.9	8.2	3.5	6.6
		P_1+AZ+PDB	80	6.4	8	2.6	6.9
		P_1+AZ+PDB+SD	98	6.8	8.6	4	7.2
		P_2	30	4.3	6.4	2.1	6.1
		P_2+AZ	49	6.3	8.3	2.5	6.8
		P_2+AZ+SD	70	6.9	8.5	3.7	7
		P_2+AZ+PDB	89	7	8.6	2.9	7.1
		P_2+AZ+PDB+SD	108	7.5	8.9	4.1	7.4
	Zn_1	P_1	32	4.3	6.5	2	6.1
		P_1+AZ	56	6.5	8.2	2.7	6.9
		P_1+AZ+SD	79	7.2	8.8	3.9	7

		P_1+AZ+PDB	83	7.8	8.7	2.8	7.3
		P_1+AZ+PDB+SD	119	8	9	4	7.3
		P_2	32	4.4	6.6	2.4	6.4
		P_2+AZ	61	6.6	8.7	2.7	7.1
		P_2+AZ+SD	85	7.2	8.9	4	7.5
		P_2+AZ+PDB	97	7.9	9.1	2.9	7.8
		P_2+AZ+PDB+SD	128	8.2	9.7	4.2	7.9

Combining bio-fertilizers with mineral chemical fertilizers may be useful to obtain increases of flax yield components and reduce environmental pollution. Application of *P.flouresence* increased plant growth, soil fertility and counts of microbial communities. Microbial activity however decreased with increasing irrigation rates. These results agreed with those obtained by Yadav *et al.,* (2007) and Nasrin *et al.,* (2012).

In conclusion, yield parameters of flax plants, nutrients content and uptake by seeds increased with increasing the P and Zn rates. Application of *A. chroococcum* (AZ), *P.fluorescens* (SD) and *B. megatherium* (PDB) increased the yield parameters of flax plants, nutrients contents and uptake by seeds of flax plants. Combining mineral P with bio-fertilizers increased flax yields as following; P+(AZ) <P+(AZ)+(SD)<P+(AZ)+(PDB)<P+(AZ)+(SD)+(PDB). The most effective treatment was P_2+ (AZ)+ (SD)+(PDB)+ Zn_1 under conditions of the irrigation of every 10 days which gave 2.34, 11.1, 0.99 and 1.82 for weight straw, seeds, oil and fiber (Mg ha^{-1}) respectively in the first season, while in the second season it achieved 2.48, 11.4, 1.09 and 1.89 (Mg ha^{-1}).The foliar application of Zn_1 significantly increased yield, yield components, oil percentage and seed nutrients content as compared with the Zn_0 treatment. Irrigation every 10 days increased yield components of flax plants, nutrients content and uptake by seeds of flax plants than irrigation every 20 days.

Table (6b). LSD 0.05 for values of table 6a.

Treatment	Total microbial counts(×10^2cfu/g dry soil)	PDB counts (×10^2cfu/g dry soil)	Azotobacter densities (×10^3cells/g dry soil)	Ps counts (×10^2cfu/g dry soil)	CO_2 mg/100g dry soil /24hr
Irrigation	2.30	0.07	0.02	0.024	0.037
Zn	0.96	0.04	0.02	0.016	0.029
P	0.34	0.05	0.06	0.013	0.020
Bio	0.84	0.11	0.15	0.032	0.048
Irr. x Zn	1.36	0.06	0.04	0.022	0.040
Irr. x P	0.49	0.07	0.09	0.019	0.028
Irr. x Bio	0.84	0.11	0.15	0.032	0.048
Zn x P	0.60	0.08	0.11	0.007	0.034
Zn x Bio	0.84	0.11	0.15	0.032	0.048
P x Bio	0.84	0.11	0.15	0.032	0.048
Irr. x Zn x P	0.84	0.11	0.15	0.010	0.048

Irr. x Zn x Bio	0.84	0.11	0.15	0.032	0.048
Irr. x P x Bio	0.42	0.11	0.15	0.032	0.048
Zn x P x Bio	0.42	0.11	0.15	0.032	0.048
Irr. x Zn x P x Bio	0.59	0.11	0.15	0.032	0.048

REFERENCES

Almendros, P., D. Gonzalez and J.M. Alvarez (2013). Long-term bioavailability effects of synthesized zinc chelates fertilizers on the yield and quality of a flax (*Linum usitatissimum* L.) crop. Plant and Soil, 368 (1-2):251-265.

Ameer khan, Muhammad Sajid, Aqeel Ahmad, Habib-Urrehman Athar and Muhammad Ashraf (2006). Interactive effect of foliarly applied ascorbic acid and salt stress on wheat (*Triticum aestivumi* L.) at the seedling stage. Pak. J. Bot., 38(5): 1407-1414.

Anderson, J. P. E. (1982). Soil Respiration. In page, A.L. Methods of soil analysis, part 2, 2nd ed., Madison, Wisc.:ASA and SSSA. P: 837–871.

Bakry, B.A., O.A. Nofal, M.S. Zeidan and M. Hozayn (2015). Potassium and zinc in relation to improve flax varieties yield and yield components as grown under sandy soil conditions. Agricultural Sciences, 6:152-158.

Bakry, B.A., M.M. Tawfik, B.B. Mekki and M.S. Zeidan (2012). Yield and yield components of three flax cultivars (Linum usitatissimum L.) in response to foliar application with Zn, Mn and Fe under newly reclaimed sandy soil conditions. American-Eurasian J. Agric. & Environ. Sci., 12 (8): 1075-1080.

Bergey's Manual of Determinative Bacteriology (1994). John G Hol, Noel R. Kriey, Peter H.A. Sneath, James T. Staley T.Williams (Ed.) (9th ed.) Williams and Wilkins, Baltimore, London.

Berti, M., S. Fischer, R. Wilckens and F. Hevia (2009). Flax seed response to N, P, and K fertilization in south central chile. Chilean Journal of Agricultural Research.69(2):145-153.

Ceulemans, T., R. Merckx, M. Hens and O. Honnay (2011). A trait-based analysis of the role of phosphorus vs. nitrogen enrichment in plant species loss across North-west European grasslands. Journal of Applied Ecology,48(5):1155–1163.

Cottenie, A., M. Verlso, L. Kilkens, G. Velghe and R. Camerlynck (1982). Chemical Analysis of Plants and Soils. Lab. Agroch. State Univ. Gent, Belgium.

El-Khateeb, H., M. Khodeir and M. Meleha (2009). Utilization of seed drill machine for planting flax crop and irrigation water management. Misr J. Ag. Eng., 26(3): 1120 – 1137.

El Hwary, E.T.B.A. and S.O. Yagoub (2011). Effect of different irrigation intervals on wheat (triticum aestivum l) in semi-arid regions of Sudan. Journal of Science and Technology 12 (3):75-83.

El Mokadem, E.H. and M. Sorour (2014). Effect of bio and chemical fertilizers on growth and flowering of Petunia hybrid plants. American Journal of Plant Phvsiology 9(2):68-77.

El-Agrodi, M.W.M., Labeeb G. Abd El-Hadi and T.A.M. Abdou (2005). Influence of soil salinity on CEC, growth and NPK content of wheat roots. J. Agric.Sci. Mansoura Univ., 30 (9): 5675-5687.

El-Nagdy, G.A., D.M.A. Nassar, E. A. El-Kady and G.S.A. El-Yamanee (2010). Response of flax plant (*Linum usitatissimum* L.) to treatments with mineral and bio-fertilizers from nitrogen and phosphorus. Journal of American Science, 6(10):207-217.

El-Saidy, Aml E.A. and K.M. Abd El-Hai (2011). Alleviation of peanut seed deterioration during storage using biotic and abiotic agents. Res. J. Seed Sci. ISSN 1819-3552/DoI: 10.3923/rjss, p: 1-13.

Esmail, A.O., H. S. Yasin and B.J. Mahmood (2014). Effect of levels of phosphorus and iron on growth, yield and quality of flax. IOSR Journal of Agriculture and Veterinary Science, 7(5):7-11.

Farouk, S. (2011). Ascorbic Acid and α-Tocopherol Minimize Salt-Induced Wheat Leaf Senescence. Journal of Stress Physiology & Biochemistry Vol. 7 No. 3.

Gaikwad, S. A., D. K. Gaikwad and P. D. Chavan (2014). Influence of water stress on free proline content in three different *Linum Usitatissimum* varieties. World Journal of Pharmacy and Pharmaceutical Sciences, 3(5):1528-1533.

Gary, W. Hergert and Delno Knudsen (2004). Irrigation Water Quality Criteria. Nebraska, Institute of Agriculture and Natural Resources.

Gilliam, F.S., R.L. McCulley and J.A. Nelson (2011). Spatial Variability in Soil Microbial Communities in a Nitrogen-Saturated Hardwood Forest Watershed. Soil Science Society of America Journal 75: 280–286.

Goenadi, D.H., Y. Siswanto and Y. Sugiarto (2000). Soil science society of America journal, 64:927-932 .

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research. 2nd ed., Wiley, New York.

Hafeez, B., Y. M. Khanif and M. Saleem (2013). Role of Zinc in Plant Nutrition- A Review. American Journal of Experimental Agriculture, 3(2): 374-391.

Handreck, K.A. (2006). Interactions Between Iron and Phosphorus in the Nutrition of Banksia ericifolia L.f var ericifolia (Proteaceae) in Soil-Less Potting Media. Australian Journal of Botany 39(4): 373 - 384 .

Hill, G. Sawers (2000). *Azotobacter*. In Encyclopedia of microbiology 3rd ED, Academic Press, New York, 2000, pp.359-371

Homayouni, G., M. Souri and M. Zarein (2013). Effects of Zinc and Nitrogen on Yield Components of Five Flax Genotypes. Global Journal of Science Frontier Research Chemistry.13 (5).(1):20-24.

Jiao, Y., C. A. Grant and L. D. Bailey (2007). Growth and nutrient response of flax and durum wheat to phosphorus and zinc fertilizers. Can. J. Plant Sci. 87: 461–470.

Khajani, F.P., H. Irannezhad, M. Majidian and H. Oraki (2012). Influence of different levels of nitrogen, phosphorus and potassium on yield and yield components of flaxseed oil (*Linum usitatissimum* L.) variety Lirina. Journal of Medicinal Plants Research, 6(6):1050-1054.

Khalifa, R. Kh. M, Manal, F.M., A.B. Bakry and M.S. Zeidan (2011). Response of some flax varieties to micronutrients foliar application under newly reclaimed sandy soil. Australian Journal of Basic and Applied Sciences, 5(8): 1328-1334.

Khourang, M., P. Brumand and R. Omidbaigi (2012). Effect of some chemical and biological fertilizers on productivity of a medicinal flax (*Linum usitatissimum*) plant. International journal of Agronomy and Plant Production, 3 (3):78-83.

Klute, A.A. (1986). Methods of Soil Analysis. Part 1 2nd ed. American Society of Agronomy .Inc. Publishes, Madison, Wisconsin, USA.

Lambers, H., P.E. Hayes, E. Laliberte, R.S. Oliveira and G. Zemunik (2014). The role of phosphorus in explaining plant biodiversity patterns and processes in a global biodiversity hotspot. In: Mucina, L., Price, J.N. & Kalwij, J.M. (eds.), Biodiversity and vegetation: patterns, processes, conservation, pp. 41-42. Kwongan Foundation, Perth, AU.

Li, B.Y., D.M. Zhou, L. Cang, H.L. Zhang, X.H. Fan and S.W. Qin (2007). Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. Soil and Tillage Research, 96, (1–2):166–173.

Liu, L., P. Gundersen, T. Zhang and J. Mo (2012). Effects of phosphorus addition on soil microbial biomass and community composition in three forest types in tropical China. Soil Biology & Biochemistry 44: 31–38.

Mikhailouskaya, N. (2006). The effect of flax seed inoculation by *Azospirillum brasilense* on flax yield and its quality. Plant Soil Environ., 52(9): 402–406.

Mirshekari, M., R. Amiri, H.I. Nezhad, S.A.S. Noori and O.R. Zandvakili (2012). Effect of planting date and low irrigation on quantitative and qualitative traits of flax seed. Research Journal of Agronomy 6(1): 20-31.

Mohamed, M..F., R. Kh. M. Khalifa, A.G. Ahmed and M.E. Eleiwa (2014). Effect of micronutrients combinations as foliar application on flax grown under newly reclaimed sandy soil. Middle East Journal of Agriculture Research, 3(2): 378-382.

Nasrin, G. Daneshmandi, B. Abdolmahdi and R. R. Mohammad (2012). International J of Agriculture Research and Review. 2 (6): 699-704.

Nautiyal, C. S. (1999). An efficient microbiological growth medium for screening phosphate solubilizing microorganisms. FEMS Microbiology Letters, 170: 265- 270.

Neetu, N., A. Aggarwal, A. Tanwar and A. Alpa (2012). Influence of arbuscular mycorrhizal fungi and Pseudomonas fluorescens at different superphosphate levels on linseed (*Linum usitatissimum* L.) growth response. Chilean Journal of Agricultural Research 72(2): 237-243.

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

Page, A.L., R.H. Miller and D.R. Keeney (1984). Methods of soil analysis. Part 2: Chemical and Microbiological Properties. Second edition. Agronomy J. 9: 2, Am. Soc. Agron. Inc., Soil Sci. Soc. Am. Inc. Pub. Madison, Wisconsin, USA.

Rizzolo, A.C., J. Baldo and A. Polesello (1993) Application of high performance liquid chromatography to the analysis of niacin and biotin in Italian almond cultivars, J. of Chromatoghraphy, 553(1-2).

Schunke, H., C. Sanio, H. Pape, U. Schunke and C. Matz. (1995). Reduction of time required for dew retting of flax: Influence of agricultural, mechanical and microbiological techniques on fibre processing. Melliand 76:E101–E104.

Tahir, M., M. Irfan and A.U. Rehman (2014). Effect of foliar application of zinc on yield and oil contents of flax. Pakistan J. Agric. Res., 27(4): 287- 295.

Visser, S. and P. Dennis (1992). Soil biological criteria as indications of soil quiantity:Soil microorganisms. American J. of Alternative Agriculture, 7: 33-37.

Wang, M., Q. Zheng, Q. Shen and S. Guo (2013). The critical role of potassium in plant stress response. Int. J. Mol. Sci.,14: 7370-7390.

Weisany, W., Y. Raei and K.H. Allahverdipoor (2013). Role of Some of Mineral Nutrients in Biological Nitrogen Fixation. Bull. Env. Pharmacol. Life Sci., 2 (4):77-84.

Yadav, E., D. V. Pathak, S. K. Sharma, M. Kumar and P. K. Sharma (2007). Isolation and characterization of mutants of Pseudomonas maltophila PM-4 altered in chitinolytic activity and antagonistic activity against root rot pathogens of clusterbean (Cyamopsis tetragonoloba). Indian J. of Microbiology, 47: 64–71.

Yaping, X., N. Junyi, G. Yantai, G. Yuhong and L. Airong (2014). Optimizing phosphorus fertilization promotes dry matter accumulation and P remobilization in oilseed flax. Crop Sci. 54:1729–1736.

Yasin, M., W. Mussarat, K. Ahmad, A. Ali, S. Waseem and H. Shah (2012). Role of biofertilizers in flax for ecofriendly agriculture. Sci.Int.(Lahore),24(1):95-99.

تأثير الفوسفور المعدنى ، الاسمدة الحيوية، الزنك رشا وفترات الرى على انتاجية وجودة الكتان المنزرع فى واحة سيوة، مصر

محرم فؤاد عطية وحسن عبد العاطى فاوى وشريف محمود ابراهيم ومنى مرسى عبد الرحمن

قسم خصوبة والميكروبولوجيا الاراضى , مركز بحوث الصحراء , القاهرة

الملخص العربي

اقيمت دراسة حقلية لنباتات الكتان بمنطقة تجزرتى بواحة سيوة، مصر. والواقعة عند الاحداثيات "29º 10'53 N and 25º 33' 12" E . تمت التجربة الحقلية خلال موسمين متتاليين٢٠١٣-٢٠١٤. نبات الكتان صنف سخا ٣ كان هو النبات المختبر. الهدف من الدراسة هو تقييم التاثير التسميد تحت ظروف الرى بمياة مالحة وارتفاع مستوى الماء الارضى فى ارض طميية رملية فى واحة سيوة بأستخدام الاسمدة المعدنية والحيوية للفسفور واضافة لزنك رشا خلال مراحل النمو المختلفة تحت ظروف معدلات من الاجهاد المائى.

قياسات المحصول لنبات الكتان ، محتوى العناصر الغذائية والممتص منها تزداد مع زيادة معدلات اضافة الفوسفور والزنك ومحتوى الرطوبة خلال موسمى الدراسة. ان اضافة ,Azotobacter (AZ) و Pseudomonas و Bacillus (PDB) زادت المحصول وكذلك محتوى العناصر الغذائية والممتص منها فى بذور الكتان.

اتحاد اسمدة الفوسفور المعدنية والحيوية مع اضافة الزنك رشا قد زادت من قياسات المحصول كالاتى : P+(AZ)<P+(AZ)+ (SD)<P+(AZ)+(PDB)<P+(AZ)+(SD)+(PDB). وكانت المعاملة الاكثر تأثيرا هى P2+(AZ)+(SD)+(PDB)+Zn1 تحت ظروف الرى كل ١٠ ايام والتى اعطت ٢.٣٤ و١١.١ و٠.٩٩ و ١.٨٢ من وزن البذور والقش والزيت والالياف (مليون جرام /هتكار) على التوالى فى الموسم الاول ، بينما فى الموسم الثانى هى احرزت ٢.٤٨ و ١١.٤ و ١.٠٩ و ١.٨٩ (مليون جرام /هتكار). الاضافة الورقية للزنك زادت من قياسات المحصول، ومحتوى الزيت و العناصر الغذائية والممتص منها فى البذور مقارنة بمعاملة عدم الاضافة (كنترول). فترة الرى كل ١٠ ايام زادت من قياسات المحصول ومحتوى البذور من الزيت وكذلك العناصر الغذائية والممتص منها بواسطة بذور الكتان بالمقارنة بفترة الرى كل ٢٠ يوم.