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Research Article

The Positive Relationship between Foliar Application of Bio fertilizers and Seeds Yield of Flax Crop

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Abstract

Two field experiments were conducted at the Experimental Station of National Research Centre, Nubaria District, EL-Behira Governorate, Egypt during two successive winter seasons 2020/2021-2021/2022 to study the effect of three bio fertilizers - Algae, CMS as by-product of yeast and Metalosate Multi Minerals as Amino acids on seeds yield of two varieties of flax crop i.e. Giza-12 and Sakha-3. Generally, there was a physiological improvement in the tested varieties as a result of nutritional balance by spraying bio fertilizers which was reflected in the characteristics of seeds yield compared the control in sandy soil. It was observed that Giza-12 is superior to Sakha-3.In majority of characteristics. In addition, Amino acids at rate 1.5 ml/L with Giza-12 flax variety had a great effect in number of fruiting branches/plant, number of capsules/plant, biological yield (ton/fed),number of fruiting branches/plant, seed yield (kg/fed) and oil yield (kg/fed).

Keywords: *Flax- Bio fertilizers- Varieties-Seeds yield- Sandy Soil.*

Introduction

Many economic crops such as oil crops are particular importance for their vital role in food industry where flax contains one of them. The average yield of flax crop is very low in Egypt, where the seeds yield recorded about 5018 ton for season 2020/2021 according to Economic Affairs Sector of Ministry of Agriculture. In this regard, Moursi, *et al*., (2015) indicated that it happened a gap between production and consumption as a decreasing area planted with crop annually due to the great competition of other winter crops .For achieving the productivity and quality of flax, it could be using high yielding cultivars and improving fertilization (EL-Shahawy, *et al*., 2008); Nofal, *et al*., 2011 and Bakry, *et al*., 2012). Foliar fertilization with bio fertilizers i.e. Algae, Yeast and Amino acids as a supplementary fertilization can be reduce the environmental pollution ,decreased the costs and increase productivity as well as quality (Ammar, *et al*., 2022 and Sadak, *et al*., 2023). Hashem, *et al*., (2019) indicated the seaweeds are recognized to be a bioactive compound rich natural resource. Furthermore, Niu, *et al*., (2020) clarified that microalgae and beneficial bacteria can be used alone or in consortiums as an alternative source of chemical fertilizers to enhance plant growth, nutrient cycling, plant protection, productivity and soil fertility. Additionally, Ammar, *et al*., (2022) reported that Algal microflora has been found as a true bio environmentally favorable and pollution free. Also, Algae are responsible for half of all photosynthesis on the global. Concerning yeast, previous studies showed that plant growth can be enhanced by yeast within direct and indirect mechanism. Nutaratat, *et al*., (2016) mentioned that direct mechanisms are the production of organic acids and plant hormones. However, Perez-Montano, *et al*., (2014) clarified that the indirect mechanisms, microbes enhance plant growth through compounds that induce resistance to environmental stress, leading to

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the production of antifungal compounds. As for amino acids, pervious reports showed that when amino acids are utilized as plant fertilizer, they improve respiration, photosynthesis and water cycle activities. Marschner, (2011) mentioned that amino acids have a chelating influence on micronutrients that promote the uptake and transport of these nutrients within plant through their effect on cell membrane permeability. Shokunbi, *et al*., (2012) showed that amino acids are organic nitrogen polymers that are used a building blocks of proteins and enzymes and are known as stronger plant growth bio-regulators (Pessarakli, *et al*., 2015). In respect of varieties, many ventilators reported significant differences among flax varieties (Bakry, *et al*., 2012 and 2015).

The aim of the present study was to investigate the effect of some bio fertilizers foliar application on seed yield of flax varieties.

Materials and Methods

Two field experiments were carried out at the Experimental Station of National Research Centre, Nubaria District, EL-Behira Governoate, Egypt during two successive winter seasons i.e. of 2020/2021 and 2021/2022.

The represented soil sample was taken of both experimental cites (0-30) for physical and chemical analysis where reported in **Table (1).**

Table (1):-Some physical and chemical properties of soil sample under study (2020/2021) and (2021/2022).

Seasons	Particle size distribution (%)			Texture class	pH (1: 2.5)			EC (dS m^{-1})	Organic Matter (%)	$CaCO_3$ (%)
	Sand	Silt	Clay							
2020/2021	88.6	7.68	3.67	Sandy	7.34			1.8	0.13	2.05
2021/2022	87.9	8.06	3.99	Sandy	7.90			0.93	1.0	4.0
	Macronutrient contents (mg/100g soil)				Micronutrient contents (mg/kg)					
	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
2020/2021	35.0	2.9	11.0	14.0	9.0	24.0	4.43	4.30	1.10	1.60
2021/2022	38.7	2.7	16.7	20.0	12.0	25.0	6.34	3.11	2.45	0.32

The aim of this work was to investigate the effect of three bio fertilizers (Algae (N 8%,P 1.5%,K 1.5%,Ca 0.4 %,Mg 1.4%,Fe 2000 ppm,Zn 80 ppm,Mn 70 ppm,Cu 100 ppm and B 120 ppm),CMS as by-product of yeast production (N 4.62%,P 0.2 %,K 9.8 %,Ca 0.87 %,Mg 0.16%,Fe 71.0 ppm,Zn 485.9 ppm,Mn 11.3 ppm,Cu 5.3 ppm,B 8.5 ppm and Mo 5.3 ppm) and Metalosate multi minerals as Amino acids(Fe 0.5%,Zn 0.5%,Mn 0.5% and Cu 0.5%) on seeds yield of two flax varieties i.e. Giza-12 and Sakha-3.The experiment design was split plot with three replicates, which flax varieties occupied the main plots and foliar application of bio fertilizers engrossed of soil plot (Algae: 0.0,1.0,1.5 and 2.0 ml/L; CMS: 0.0,2.5,5.0 and 7.5 ml/L and Amino acids : 0.0,1.0,1.5 and 2.0 ml/L).

Seeds of flax varieties were sown on 15th Nov. in both seasons in rows 3.5 meters length, the distance between rows was 20 cm apart. Control treatment by addition of recommended dose fertilizers (RDF) of nitrogen, phosphorus and potassium. Irrigation was carried out using the new sprinkler irrigation system where water was added every 5 days. Foliar application of bio fertilizers were carried out twice after 45 and 60 days from sowing.

Flax plants were pulled when signs of fill maturity were appeared, then left on gowned to suitable complete drying capsules were removed carefully. At harvest , the following characters were recorded on random of 10 guarded plants in each plot to estimate the following characters: fruiting zone length (cm);number of fruiting branches /plant ;no. of capsules/plant ;number of seeds/plant ;weight of seeds/plant ;weight of 1000 seed (g);Biological yield (ton/fed);seed yield (kg/fed) and oil yield (kg/fed).

Methods of Analysis: - Soil pH.E.C. O.M. according to (Cottenie, *et al*., 1982), soil texture

with pipette method according to (Piper, 1966), soluble cations (Na, K, Ca and Mg) were determined according to (Black, *et al*., 1965). Nitrogen according to (Jackson, 1973), phosphorus according to (Olsen, *et al*., 1954), Sodium and Potassium were determined by flame photometer as described by (Cottenie, *et al*., 1982). Oil yield (kg/fed) was calculated by seed yield (kg/fed) * seed oil%.

Statistical Analysis:-

The obtained data for the two seasons were computed according to Sendecor and Cochron, (1980). The treatment means were comared by using the test significant different (L.S.D) test according to Waller and Duncon, (1969) at 5% level of significance according to Gomez and Gomey, 1984).

Results and Discussion

- Fruiting zone length, number of fruiting branches/plant and number of capsules/plant:

The obtained data for flax varieties in both seasons are shown in Table (2).

Effect of Algae Extract Rates

Concerning the effect of bio fertilizers application on seed yield of the flax varieties, Table (2) presented the effect of foliar application different rates of Algae on the fruiting zone length (cm), number of fruiting branches/plant and number of capsules/plant in flax varieties in both seasons (2020/2021) and (2021/2022). It was observed that, foliar application of Algae extract at a rate of 1.50 ml/L increased the fruiting zone length by about 30.08, 12.59 % and 14.84, 23.48 % as compared with the control for flax cultivars (Sakha -3 and Giza-12) in both two seasons, respectively. Also, data showed that the effect of bio fertilizers (Algae extract) on number of fruiting branches/plant with application of 1.5 ml/L gave significantly increases on the number of fruiting branches/plant by about 11.56, 26.52% and 24.11, 43.22% in varieties of flax (Sakha -3 and Giza -12) as compared with the control in both seasons, respectively.

For another point, Algae foliar spraying on flax plants incremented significantly number of capsules/plant compared with control plants. Where, maximum improvement in number of capsules/plant was obtained by using of Algae extract, the rate of 1.5 ml/L which significant increase of number of capsules/plant by 17.70, 20.83% and 21.50, 23.12% as compared with the control of the tested two varieties of flax. These results are in agreement with those obtained by EL-umolari and Rengasamy, (2012) and Taraf, *et al*., (2015). They reported that application of seaweed extracts contain macro and micronutrients and amino acids which stimulate the growth and yield plants.

Effect of (CMS):

Regarding the flax varieties as affected by bio fertilizer application, the maximum values of the fruiting zone length (cm) were observed after foliar application of CMS, while the minimum ones were observed at the control of no foliar fertilizer applied. Data appeared that the highest increase of fruiting zone length (cm) found by application of CMS at a rate of 5.0 ml/L were about 22.12, 20.47% and 32.81, 41.66% as compared with the control in flax (Sakha -3 and Giza -12) in both seasons, respectively. Results in Table (2) revealed that, increasing level of CMS application gradually increased the number of fruiting branches/plant of flax at different varieties. Moreover, the data in the same table showed that foliar application of 5.0 ml/L of CMS significantly enhanced the number of fruiting branches/plant by 14.77, 26.35% and 15.09, 43.22% as compared with the control. Improvement in number of capsules/plant was obtained by application of CMS, Data revealed that the effect of CMS on number of capsules/plant with spraying of 5.0 ml/L of CMS significantly increased the number of capsules/plant by (25.47, 20.99% and 43.01, 13.87%) as compared with the control in two tested varieties of flax in both two seasons, respectively. Similar results obtained by Zlotek and Swieca, (2016); El-Nwehy, *et al*., (2021) and EL-Shafey, (2022) where they cleared that yeast has stimulatory effects on

cell division and enlargement. This could be attributed to improving the uptake of nutrients which improved vegetative growth of plants and reflected on yield. In addition, (Bakry, *et al*., 2012) and El-Shafey, (2022) found that Sakha 5 cultivar gave the highest number of fruiting branches per plant, number of capsules per plant, seed yield per plant and total chlorophyll content, results revealed that yeast extract had a superior effect on most studied characters of flax crop.

enhancement effect of yeast

Table (2): Effect of some bio fertilizers on seed yield and its related traits for two varieties of flax cultivated in Nubaria sector in two seasons (2020/2021 and 2021/2022).

Treatments		Fruiting zone length (cm)			No. of fruiting branches/plant			No. of capsules/plant		
		Sakha 3	*Giza 12*	*mean*	*Sakha 3*	*Giza 12*	*mean*	*Sakha 3*	*Giza 12*	*mean*
First season										
Control		11.3	12.7	12.0	4.67	6.07	5.4	12.09	12.67	12.4
Algae 1.0 ml/L		12.7	13.7	13.2	4.96	7.33	6.1	13.00	14.00	13.5
Algae 1.5 ml/L		14.7	14.3	14.5	5.21	7.68	6.4	14.23	15.31	14.8
Algae 2.0 ml/L		14.0	13.4	13.7	5.06	7.00	6.0	12.37	13.34	12.9
CMS 2.5 ml/L		12.3	13.7	13.0	4.87	6.67	5.8	12.67	14.28	13.5
CMS 5.0 ml/L		13.8	15.3	14.6	5.36	7.67	6.5	15.17	15.33	15.3
CMS 7.5 ml/L		13.4	13.7	13.5	5.02	7.33	6.2	14.33	14.67	14.5
Aa 1.0 ml/L		13.5	13.3	13.4	5.18	6.23	5.7	13.25	13.00	13.1
Aa 1.5 ml/L		14.2	15.0	14.6	5.96	6.67	6.3	15.02	14.33	14.7
Aa 2.0 ml/L		13.9	16.3	15.1	5.64	8.08	6.9	14.27	16.00	15.1
mean		13.4	14.1	13.8	5.2	7.1	6.1	13.6	14.3	14.0
LSD 0.05	***Varieties***	**0.52**			**0.35**			**0.53**		
	Treat	**1.16**			**0.78**			**1.18**		
	V*T	**1.64**			**1.11**			**1.66**		
Second season										
Control		12.8	13.2	13.0	5.10	7.45	6.3	9.3	17.3	13.3
Algae 1.0 ml/L		13.0	14.7	13.8	5.67	8.33	7.0	9.7	18.8	14.2
Algae 1.5 ml/L		14.7	16.3	15.5	6.33	10.67	8.5	11.3	21.3	16.3
Algae 2.0 ml/L		13.4	15.7	14.5	5.67	8.67	7.2	10.3	18.5	14.4
CMS 2.5 ml/L		14.3	15.0	14.7	5.67	9.33	7.5	11.7	17.7	14.7
CMS 5.0 ml/L		17.0	18.7	17.8	5.87	10.67	8.3	13.3	19.7	16.5
CMS 7.5 ml/L		13.3	14.3	13.8	6.67	8.67	7.7	12.0	18.7	15.3
Aa 1.0 ml/L		14.9	16.5	15.7	6.32	8.00	7.2	11.7	16.3	14.0
Aa 1.5 ml/L		16.2	17.1	16.6	7.00	8.67	7.8	13.3	22.0	17.7
Aa 2.0 ml/L		15.4	16.9	16.1	6.33	9.60	8.0	12.0	24.2	18.1
mean		14.5	15.8	15.2	6.1	9.0	7.5	11.5	19.4	15.5
LSD 0.05	***Varieties***	**0.87**			**0.568**			**0.707**		
	Treat	**1.95**			**1.269**			**1.580**		
	V*T	**2.76**			**1.795**			**2.234**		

CMS*: Condeused Molassed Solution.* ***Aa****: Amino acids.*

Effect of Amino Acids

Concerning the effect of foliar application rates of amino acids on seed yield of the flax varieties, data in Table (2) indicated that amino acids application at the levels, 1.0, 1.5 and 2.0 ml/L achieved a positive effect on fruiting zone length (cm) for the flax varieties (Sakha -3 and Giza -12) in both seasons. In addition, data in the same table appeared that the amino acids application at a rate of 1.5 ml/L gave the highest increase in fruiting zone length about 25.66, 18.11% and 26.56, 29.54% as compared with control in varieties of flax (Sakha -3 and Giza -12) in two seasons, respectively. With respect to number of fruiting branches/plant, the results indicated that all amino acids levels (from 1.0 to 2.0 ml/L) have a significant promotive effect on number of fruiting branches/plant of flax

varieties. The highest of number of fruiting branches/plant were obtained with for application of 1.5 ml/L. Which produce the maximum increase in number of fruiting branches/plant (27.62, 9.88% and 37.25, 16.37%). Results presented in Table (2).Indicated that the effect of amino acids on number of capsules/plant, at the rate of 1.5 ml/L significantly increased of number of capsules/plant by 24.23, 13.10% and 43.01, 27.16% as compared with the control. While, application of 2.0 ml/L of amino acids increased number of capsules/plant by 18.03, 26.28% and 29.03, 39.88% as compared with the control in flax (Sakha -3 and Giza -12) in both seasons, respectively. Such results are in agreement with those obtained by Moradi, (2015). He found that foliar spray with amino acid recorded the best results for increasing growth parameters such as fruiting zone length and number of capsules/plant of flax plants.This results indicated by, Meijer, (2003) and Bakry, *et al., (*2018) where they found that amino acids raised ascorbic acid levels accelerated protein biosynthesis, and improved plant growth and productivity. Another explanation may be that the improvement is due to the increase in the concentrations of micronutrients in the compound and their balance, which has a better effect on the physiological condition. These results are in harmony with Moawed, (2001).

Effect of Interaction

Table (2) presented the interaction between the two flax varieties (Sakha-3 and Giza-12) with bio-fertilizers treatments in different levels on seed yield traits as (Fruiting Zone Length, Number of Fruiting branches/plant and Number of capsules/plant). The interaction between Giza-12 flax variety and amino acid at rate of (2.0 ml/L) significantly surpassed all other interactions for fruiting zone length, number of fruiting branches/plant and number of capsules/plant (16.3, 8.08 and 16.0 cm) in the 1st season, while the interaction between Giza-12 flax variety and CMS extract at rate of (5.0 ml/L) for fruiting zone length recorded the highest significant values (15.3 cm) in the 1st season. Furthermore, in the fruiting zone length, number of fruiting branches/plant and number of capsules/plant trait there were non-significant differences between all interactions of the same flax variety (Giza-12) and algae at rates of (1.0, 1.5 and 2.0 ml/L) which gave (13.7, 14.3 and 13.4 cm),(7.33,7.68 and 7.0) and (14.0,15.31 and 13.34) respectively in the 1st season.

Moreover, data in Table (2) confirmed that the interaction between Sakha-3 flax variety and CMS at rate of (5.0 ml/L) surpassed all other interactions for number of capsules/plant (15.3 and 14.33 cm) without significant differences with the interaction between the two flax varieties and amino acid at rate of (1.5 ml/L) (16.2 and 17.1 cm) in the 1nd season and the interaction between Giza-12 flax variety and amino acid at rate of (2.0 ml/L) which recorded (16.0 and 24.2 cm) in the 1st and 2nd season respectively. These results may be due to differences in genetic attribute between varieties in dealing biofertilizers.Homayouni, *et al*., (2013) confirmed these findings.

Number of Seeds/Plant, Weight of Seeds/ Plant and Weight of 1000 Seeds (g):

Effect of Algae Extract Rates

Concerning the effect of bio fertilizers application on seeds yield of the flax varieties. It was observed from Table (3) That, foliar application of Algae extract at a rate of 1.50 ml/L increased the number of seeds/plant by about 3.88, 4.44% and 25.73, 17.15% as compared with the control for flax cultivars (Sakha -3 and Giza -12) in both growing seasons, respectively. According to the above mentioned results in Table (3) data clarified that the application of 1.5 ml/L of algae extract significantly increased the weight of seeds/ plant by about 1.19, 8.22% and 25.0, 20.0 % in varieties of flax (Sakha -3 and Giza -12) as compared with the control in both seasons, respectively.

Algae foliar spraying on flax plants incremented significantly weight of 1000 seed compared with control plants. The results indicated that the highest weight of 1000 seed was obtained by using of Algae extract, the

rate of 1.5 ml/L which significant increase of weight of 1000 seed by 10.18, 35.79 % and 24.28, 15.60% as compared with the control. These results may be due to Algae comprise active compounds, such as enzymes ,free and organic amino acids and phytohormones, in addition to secondary bioactive metabolites, vitamin precursors and vitamins Ddinesh Kumar, *et al., (*2018) indicated the same meaning. In addition, Renuka, *et al., (*2018) clarified that Algae affects essential nutrients, and plant hormone like auxin and cytokines which regulate plant growth.

Effect of (CMS):

It is worthily to observe that the flax varieties as affected by bio fertilizer application where the maximum values of the number of seeds/plant were observed after foliar application of CMS, while the minimum ones were observed at the control of no foliar fertilizer applied. Data appeared that the highest increase of number of seeds/plant found by application of CMS at a rate of 5.0 ml/L were about 21.14, 13.66 % and 65.66, 4.38% as compared with the control in flax (Sakha -3 and Giza -12) in both two seasons, respectively. In this manner, **EL-morsy, *et al.*, (2011)** reported that yeast positively affected the yield components by yeast extract application that contained growth improving compounds like cytokine which stimulate cell division, protein synthesis and chlorophyll synthesis and hence resulted in significant increase in yield components.

Table.(3):- Effect of some biofertilizers on number of seeds/plant, weight of seeds/ plant and weight of 1000 seed(g) for two varieties of flax cultivated in Nubaria sector in two seasons (2020/2021 and 2021/2022).

Treatments		Number of Seeds/Plant			Weight of seeds/ plant			Weight of 1000 seed(g)		
		Sakha 3	*Giza 12*	*mean*	*Sakha 3*	*Giza 12*	*mean*	*Sakha 3*	*Giza 12*	*mean*
First season										
Control		92.7	90.0	91.3	0.84	0.73	0.8	7.56	6.37	7.0
Algae 1.0 ml/L		94.0	92.0	93.0	0.83	0.78	0.8	7.93	8.48	8.2
Algae 1.5 ml/L		96.3	94.0	95.2	0.85	0.79	0.8	8.33	8.65	8.5
Algae 2.0 ml/L		102.0	93.7	97.9	0.86	0.79	0.8	8.07	9.01	8.5
CMS 2.5 ml/L		103.7	92.3	98.0	0.84	0.77	0.8	8.46	8.38	8.4
CMS 5.0 ml/L		112.3	102.3	107.3	0.96	0.82	0.9	8.81	8.02	8.4
CMS 7.5 ml/L		105.7	100.0	102.8	0.88	0.79	0.8	8.52	7.87	8.2
Aa 1.0 ml/L		108.3	100.3	104.3	0.86	0.77	0.8	8.87	7.71	8.3
Aa 1.5 ml/L		121.3	106.0	113.7	0.92	0.75	0.8	9.13	7.04	8.1
Aa 2.0 ml/L		105.7	110.0	107.8	0.96	0.80	0.9	9.07	7.31	8.2
mean		104.2	98.1	101.1	0.9	0.8	0.8	8.5	7.9	8.2
LSD 0.05	***Varieties***	**7.26**			**0.02**			**0.204**		
	Treat	**16.23**			**0.05**			**0.457**		
	V*T	**22.95**			**0.07**			**0.646**		
Second season										
Control		112.7	**130.0**	121.3	**0.80**	**0.50**	0.7	5.89	5.96	5.9
Algae 1.0 ml/L		125.3	**142.7**	134.0	**0.94**	**0.45**	0.7	5.86	6.44	6.1
Algae 1.5 ml/L		141.7	**152.3**	147.0	**1.00**	**0.60**	0.8	7.32	6.89	7.1
Algae 2.0 ml/L		135.7	**150.7**	143.2	**0.93**	**0.58**	0.8	6.48	6.09	6.3
CMS 2.5 ml/L		132.0	**133.0**	132.5	**0.94**	**0.60**	0.8	6.08	6.11	6.1
CMS 5.0 ml/L		168.7	**135.7**	152.2	**1.06**	**0.56**	0.8	6.51	6.76	6.6
CMS 7.5 ml/L		121.7	**135.3**	128.5	**0.97**	**0.56**	0.8	7.43	6.60	7.0
Aa 1.0 ml/L		145.7	**146.0**	145.8	**1.01**	**0.55**	0.8	6.70	6.37	6.5
Aa 1.5 ml/L		164.0	**155.0**	159.5	**1.07**	**0.55**	0.8	6.95	6.87	6.9
Aa 2.0 ml/L		149.0	**158.3**	153.7	**1.00**	**0.66**	0.8	6.42	7.29	6.9
mean		139.6	143.9	141.8	1.0	0.6	0.8	6.6	6.5	6.6
LSD 0.05	***Varieties***	**6.06**			**0.022**			**0.302**		
	Treat	**13.55**			**0.048**			**0.676**		
	V*T	**19.17**			**0.068**			**0.956**		

***CMS**: Condeused Molassed Solution.* ***Aa**: Amino acids.*

Results in Table (3) Revealed that, increasing level of CMS application gradually increased the weight of seeds/ plant of flax at different varieties. Foliar application of 5.0 ml/L of CMS significantly increased the weight of seeds/ plant by 14.29, 12.33% and 32.50, 12.0% as compared with the control. While, application of 7.5 ml/L of CMS increased number of fruiting branches by about (4.76, 7.76%) and (20.33, 12.08%) compared to a control treatment in flax (Sakha -3 and Giza -12) in both seasons, respectively. Improvement in weight of 1000 seed was obtained by application of CMS, where data revealed that the effect of CMS on weight of 1000 seed with spraying of 5.0 ml/L of CMS significantly increased the weight of 1000 seed by (16.53, 25.90% and 10.53, 13.42 %) as compared with the control in varieties of flax (Sakha -3 and Giza -12) in both two seasons, respectively. Such results are in harmony with those obtained by Afifi, *et al*, (2014) which they found that application of CMS as bio-fertilizers (yeast) is the best treatment for better growth and high seeds and oil yield of flax plants such as weight of seeds per plant and weight of 1000 seeds per plant as grown in sandy soil. In this connection, Ahmed, *et al,* (2022) found that foliar application with yeast treatments improved weight of seeds/plant and weight of 1000 seeds/plant of flax plants due to increasing flower formation and the reduction of flowers and pod shedding as well as increasing their ability to accumulate more bio constituents. Significantly higher seed yield with yeast (10 g L–1) was compared with control.

Effect of Amino Acids

It is visible from Table (3) indicated that amino acids application at the rates, 1.0, 1.5 and 2.0 ml/L achieved a positive effect on number of seeds/plant for the flax varieties (Sakha -3 and Giza -12) in both two seasons. It can be seen from in Table (3) and Fig. (2) Appeared that the amino acids application at a rate of 1.5 L/fed gave the highest increase in number of seeds/plant about 30.85, 15.22 % and 45.52, 19.23% as compared with control in varieties of flax (Sakha -3 and Giza -12) in two seasons, respectively. While, application of amino acids at a rate 2.0 ml/L gradually stimulate number of seeds/plant of flax varieties by 14.03, 22.22% and 32.25, 21.79% as compared with control in both two seasons(2020/2021 and 2021/2022), respectively.

Data also indicated that all amino acids levels (from 1.0 to 2.0 ml/L) have a significant promotive effect on weight of seeds/ plant of flax varieties. The highest of weight of seeds/ plant were obtained with for application of 1.5 ml/L. Which produce the maximum increase in weight of seeds/ plant (9.52, 2.74% and 33.75, 10.0 %).

Regarding the effect of amino acids on weight of 1000 seed, the results in Table (3) found that foliar application of 1.5 ml/L significantly increased of weight of 1000 seed by 20.77, 10.52 % and 17.99, 15.27 % as compared with the control. These results are in harmony with Gamal El–Din, (2011), Eman, *et al.,* (2011) and Bakry, *et al.,* (2012).

Effect of Interaction

The interaction between the two flax varieties (Sakha-3 and Giza-12) with bio-fertilizers treatments in different levels on growth traits as (fruiting zone length (cm), number of fruiting branches/plant and number of capsules/plant) are presented in Table (3). The interaction between Giza-12 flax variety and amino acid at rate of (2.0 ml/L) significantly surpassed all other interactions for fruiting zone length in cm, number of fruiting branches/plant (16.3 and 8.08 cm) in the 1st season, while the interaction between Giza-12 flax variety and algae extract at rate of (1.5 ml/L) recorded the highest significant values (16.3 and 10.67 cm) in the 2nd season. Furthermore, in the number of capsules/plant trait there were non-significant differences between all interactions of the same flax variety (Giza-12) and amino acid at rates of (1.0, 1.5 and 2.0 ml/L) which gave (13.0, 14.33 and 16.0), respectively in the 1st season.

It is clear from the data pointed out in Table (3) indicated that the interaction between Sakha-3 flax variety and amino acid at rate of (1.5 ml/L) surpassed all other interactions for

number of fruiting branches/plant (14.2 cm) without significant differences with the interaction between the two flax varieties (Sakha-3 and Giza-12) and CMS at rate of (5.0 ml/L) (5.36 and 7.67 cm) in the 1st season and the interaction between Giza-12 flax variety and amino acid at rate of (2.0 ml/L) which recorded (8.08 and 9.69 cm) in the 1st and 2nd season respectively.

Biological Yield (ton/fed), Seed Yield (kg/fed) and Oil Yield (kg/fed):

Effect of Algae Extract Rates:

Results in Table (4) cleared that foliar application of Algae extract at the level of 1.50 ml/L increased the biological yield (ton/fed) by about 25.0, 28.0% and 9.09, 18.18% as compared with the control for flax cultivars (Sakha 3 and Giza 12) in both two seasons, respectively. For another point, data in Table (4) Showed that application of 1.5 ml/L of algae extract significantly increased the seed yield (kg/fed) by about 26.69, 22.47% and 20.88, 7.73% in both varieties of flax as compared with the control in the two seasons, respectively.

It is clear from Table (4) that maximum improvement in oil yield (kg/fed) was accompanied by using of algae extract, with the rate of 1.5 ml/L which significant increase of oil yield (kg/fed) by 47.71, 29.63 % and 33.71, 29.55 % as compared with the control. Such results are in harmony with those obtained by Hassanzade Ghorttapeh and Motalebizadeh, (2013); Paritosh Patra, *et al.*, (2013); Elewa, *et al.*, (2014) and Mahajan, (2014).

Effect of (CMS):

With respect to the flax varieties as affected by bio fertilizer application. It could be noted that the maximum values of the biological yield (ton/fed) were observed after foliar application of CMS, while the minimum ones were observed at the control of no foliar fertilizer applied. Data appeared that the highest increase of biological yield (ton/fed) found by application of CMS at a rate of 5.0 ml/L were about 37.50, 32.0 % and 40.90, 22.73 % as compared with the control in flax (Sakha-3 and Giza -12) in both two seasons, respectively.

Results in Table (4) Revealed that, increasing level of CMS application gradually increased the seed yield (kg/fed) of flax at different varieties. Where foliar application of 5.0 ml/L of CMS significantly increased of seed yield (kg/fed) by 21.47, 35.92% and 20.65, 6.25% as compared with the control.

Enhancement in oil yield (kg/fed) was obtained by application of CMS, in this connection data revealed that the influence of CMS on oil yield (kg/fed) with spraying of 5.0 and 7.5 ml/L of CMS significantly increased the oil yield (kg/fed) by (48.93, 54.66% and 43.0, 27.65 %) and (24.60, 22.85% and 20.70, 6.26%) as compared with the control of the tested varieties of flax in both seasons, respectively. Where, the rate of 5.0 ml/L was the best one. Similar results were obtained by Al-Sudani, *et al.*, (2018) and El-Shafey, (2022). In addition, Nutaratat, *et al.*, (2014) clarified that the plant growth can be enhanced by the production of organic acids and plant hormones.

Effect of Amino Acids:

Concerning the effect of foliar application rates of amino acids on yield of the flax varieties, It is worthily to observe that amino acids application at the rates, 1.0, 1.5 and 2.0 ml/L achieved a positive effect on biological yield (ton/fed) for the flax varieties (Sakha -3 and Giza -12) in both two seasons. Data in Table (4) appeared that the amino acids application at a rate of 1.5 ml/L gave the highest increased in biological yield (ton/fed) about 41.66, 20.0% and 54.55, 45.45 % as compared with control in the two varieties of flax in both seasons, respectively.

Data also supported that all amino acids levels (from 1.5 to 2.0 ml/L) have a significant promotive effect on seed yield (kg/fed) of flax varieties. The highest of seed yield (kg/fed) were obtained with for application of 1.5 ml/L, which produce the maximum increase in seed yield (kg/fed) (18.61, 35.50 % and 32.31, 20.09%).

Regarding the effect of amino acids on oil yield (kg/fed), foliar application of 1.5 ml/L significantly stimulated of oil yield (kg/fed) by 40.72, 50.56% and 37.45, 6.54 % as compared with the control. These results are in agreement with those obtained by Nasser, *et al*., (2013); Bakry, *et al*., (2018), Dawood, *et al*., (2019). and Sadakal, *et al*., (2023).

Table (4):- Effect of some biofertilizers on biological yield (ton/fed), seeds yield (kg/fed) and oil yield (kg/fed) for two varieties of flax cultivated in Nubaria region in two seasons (2020/2021 and 2021/2022).

Treatments		Biological yield (ton/fed)			Seed Yield (kg/fed)			Oil Yield (kg/fed)		
		Sakha 3	*Giza 12*	*mean*	*Sakha 3*	*Giza 12*	*mean*	*Sakha 3*	*Giza 12*	*mean*
First season										
Control		2.4	2.5	2.5	436.9	452.7	444.8	164.3	161.0	162.6
Algae 1.0 ml/L		2.7	2.9	2.8	484.2	506.5	495.3	189.9	176.4	183.1
Algae 1.5 ml/L		3.0	3.2	3.1	553.5	554.4	554.0	242.7	208.7	225.7
Algae 2.0 ml/L		2.8	2.8	2.8	531.7	519.0	525.4	223.0	189.4	206.2
CMS 2.5 ml/L		3.1	3.0	3.0	447.3	542.8	495.1	186.2	187.0	186.6
CMS 5.0 ml/L		3.3	3.3	3.3	530.7	615.3	573.0	244.7	249.0	246.8
CMS 7.5 ml/L		3.2	3.2	3.2	477.4	563.8	520.6	204.7	197.8	201.2
Aa 1.0 ml/L		3.1	3.0	3.0	475.6	585.9	530.7	191.5	224.3	207.9
Aa 1.5 ml/L		3.4	3.0	3.2	518.2	613.4	565.8	231.2	242.4	236.8
Aa 2.0 ml/L		3.1	3.1	3.1	522.7	642.2	582.4	227.1	250.4	238.8
mean		3.0	3.0	3.0	497.8	559.6	528.7	210.5	208.6	209.6
LSD 0.05	*Varieties*	**0.07**			**31.66**			**6.45**		
	Treat	**0.15**			**70.79**			**14.42**		
	*V*T*	**0.21**			**100.12**			**20.40**		
Second season										
Control		2.2	2.2	2.2	510.0	528.1	519.1	160.2	179.0	169.6
Algae 1.0 ml/L		2.3	2.3	2.3	575.6	549.5	562.5	180.3	206.2	193.3
Algae 1.5 ml/L		2.4	2.6	2.5	616.5	568.9	592.7	214.2	231.9	223.0
Algae 2.0 ml/L		2.4	2.2	2.3	572.0	543.7	557.8	183.3	199.6	191.4
CMS 2.5 ml/L		2.5	2.5	2.5	559.7	551.7	555.7	187.4	215.6	201.5
CMS 5.0 ml/L		3.1	2.7	2.9	615.3	561.1	588.2	229.1	228.5	228.8
CMS 7.5 ml/L		3.0	2.7	2.8	551.4	543.0	547.2	193.4	190.2	191.8
Aa 1.0 ml/L		2.6	2.9	2.8	602.7	605.0	603.9	197.1	197.2	197.2
Aa 1.5 ml/L		3.4	3.2	3.3	674.8	634.2	654.5	220.2	190.7	205.5
Aa 2.0 ml/L		2.8	3.3	3.1	637.5	698.7	668.1	199.8	217.3	208.6
mean		2.7	2.7	2.7	591.6	578.4	585.0	196.5	205.6	201.1
LSD 0.05	*Varieties*	**0.09**			**10.940**			**4.630**		
	Treat	**0.21**			**24.470**			**10.340**		
	*V*T*	**0.29**			**34.610**			**14.630**		

CMS*: Condeused Molassed Solution.* ***Aa****: Amino acids.*

Effect of Interaction:

The interaction between the two flax varieties (Sakha-3 and Giza-12) with bio-fertilizers treatments in different levels on yield traits as Biological yield (ton/fed), seed yield (kg/fed) and oil yield (kg/fed) are presented in Table (4). The interaction between Sakha-3 flax variety and amino acid at rate of (1.5 ml/L) significantly surpassed all other interactions for biological yield (3.4 ton/fed) in the 1st season, while the interaction between Sakha-3 flax variety and Amino acids extract at rate of (1.5 ml/L) recorded the highest significant values (3.4 ton/fed) in the 2nd season. Furthermore, in seed yield trait there were high-significant differences between all interactions of the same flax variety (Sakha-3) and Algae extract at rates of (1.0, 1.5 and 2.0 ml/L) which gave (484.2, 553.5 and 531.7), respectively in the 1st season.

In addition, data in Table (4) indicated that the interaction between Giza-12 flax variety and Amino acid at the level of (2.0 ml/L) surpassed all other interactions for oil yield

(250.4 kg/fed) with high significant differences with the interaction between the two flax varieties (Sakha-3 and Giza-12) and CMS at the level of (5.0 ml/L) which recorded (229.1 and 228.5) in the 2nd season and the interaction between Giza-12 flax variety and Amino acid at the level of (2.0 ml/L) which recorded (642.16 and 698.72) in the 1st and 2nd season respectively for seed yield. In this connection, these results may be attributed to the effect of micronutrient i.e., zinc on dry matter or due to the great deficiency of enzyme activities which affected plant pigments and rate of photosynthesis. The same findings has occurred by Bakry, *et al.*, (2015).

Conclusion

Generally, it can be concluded that the best bio fertilizer was Metalosate Multi Minerals (Amino acids) followed by Algae then CMS (by-product of yeast production). In addition, the Amino acid compound at the rate 1.5 ml/L recorded the best results with Giza-12.

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