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Effect of Biofertilizer in Flax Yield and its components

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Abstract. A field experiment was carried out in the winter season 2020-2021 in Al-Mahaweel (25 km north of babylon Governorate) in order to study the effect of bio fertilizer in flax yield and its components for several varieties of flax. A factorial experiment was applied according to a Randomized Complete Block Design (R.C.B.D) with three replications. The experiment included two factors, the first includes eight varieties of flax (Indian Variety, Giza 11, Giza 10, Sahka 5, Sahka 6, Giza 8, Syrian Variety, Thorshansity 72), The second factor, bio fertilizer includes four levels: (control, bacterial fertilization, fungal fertilization and a bacterial-fungal mixture). The following traits were measured (number of capsules per plant, number of seeds per capsules, 1000 seed weight, total seed yield, biological yield and harvest index). The results showed that Giza 10 Varity significantly superiority on other verities in all studied traits, while Thorshansity 72 Varity gave lowest means in most of the yield traits and its components. The bio fertilization also achieved a significant increase in all traits with the superiority of the fertilization treatment (Bacterial fertilizer + Mycorrhiza). The interaction between the variety and the bio fertilization was The combination (Giza 10 + Bacterial fertilizer + Mycorrhiza) achieved highest means for all studied traits, as number of capsules per plant was (76.22) capsule. plant^{-1}, number of seeds per capsule (9.95) seed. capsule^{-1}, weight of 1000 seeds (13.79) g, total seeds yield (1,681.40) kg.h^{-1}, biological yield (6542.70) kg and harvest index (30.87) %.

Keywords: *Flax, Biofertilizer, Varieties.*

1. INTRODUCTION

Flax, scientific name is (*Linum usitatissimum* L.) belongs to the genus *Linum* and to the Linaceae family. It is one of the oldest industrial crops known to people and has been cultivated since ancient times for the purpose of obtaining oil or fiber or both. [1]. Flax oil is used medicinally in the treatment of various diseases such as heart disease, as well as an anti-inflammatory for the intestines and joints, in addition to the treatment of growth retardation and neurological disorders. [2-3-4]. It is also considered an anti-cancer of the prostate and breast, and is also used in the manufacture of burn ointments and treatment of rheumatic joint diseases. [5]. In addition to its medicinal uses, it is also used for various industrial purposes, such as soap, dyes, printing ink, and others, it is also used as animal feed and its seed residues are used as organic fertilizer. In addition to the use of fibers in industry, such as the manufacture of fabrics, ropes, insulating materials and car tires. [6]. Cultivation and selection of the appropriate varieties is one of the important factors to obtain a high economic return from oil or fiber. To achieve this, the necessary improvements must be made in agricultural technology, which is the application of necessary agricultural operations such as crop service operations such as fertilization and others in order to stimulate the plant to

show its genetic and physiological ability in order for the variety to express himself in his agricultural environment. [7]. The use of bio-fertilizers is one of the modern techniques in the agricultural field to reduce use of mineral fertilizers and environmental pollution, Bio-fertilizers are preparations of micro-organisms that are added to seeds, plants, or the surface of the soil in order to increase the readiness of nutrients for plants and improve soil properties, and this is reflected positively on increased production. These bio-fertilizers are environmentally friendly and contribute to the analysis of organic waste and the secretion of some enzymes, growth regulators and plant hormones, and their importance in biological control. [8]. This study aimed to know the effect of biological fertilization in many varieties of flax yield and its components.

2. MATERIALS AND METHODS

The field experiment was carried in the winter season 2020-2021 in Al-Mahaweel District (25 km north of babylon Governorate). In order to study the effect of biofertilizer on flax yield and its components for many flax varieties. Random soil samples were taken from them at a depth of 30 cm before planting and analyzed to measure some of their physical and chemical properties in the laboratory of the Department of Soil and Water Resources in College of Agricultural Engineering Sciences - University of Baghdad. (Table 1).

Table. 1. Physical and chemical properties of field soil

Charcter	pH	Ec	N $Mg.kg^{-1}$	P $Mg.kg^{-1}$	K $Mg.kg^{-1}$	Organic Matter (%)	Soil separators			Testure
							Sand $gm.kg^{-1}$ soil	Loamy $gm.kg^{-1}$ soil	Clay $gm.kg^{-1}$ soil	
Value	7.7	2.8	27.9	16.4	109	0.77	120	580	300	Clay loamy

The soil of the field was plowed by two orthogonal plows, then the experimental land for the two sites was plowed by two orthogonal plows using a disc plow, then smoothing and leveling operations were performed on it for the purpose of preparing a suitable bed for the seeds. Then the field was divided according to the field plan of the experiment into experimental units numbering 96 experimental units for each site distributed randomly in three replications with 32 experimental units for one replicate and the area of the experimental unit 4 m^2 (2 m x 2 m), each experimental unit included 10 lines, the distance between lines 20 cm, the treatments were isolated from each other by 1 m wide shoulders. The soil was fertilized by adding 180 kg $.h^{-1}$ nitrogen fertilizer in form of urea fertilizer (46%) in two batches when planting and the second after one month from planting. [9]. and 90 kg $.H^{-1}$ phosphate fertilizer (46% P_2O_5) scattered before planting and 120 kg $.H^{-1}$ potassium fertilizer K_2SO_4 was added in one batch before planting. [10]. The seeds of flax varieties were planted in lines with a seed quantity of 40 kg H^{-1} [11]. in 15 November during the winter season 2020, and crop service operations were carried out by irrigation, hoeing and weeding as needed, and the plants were harvested after the appearance of signs of maturity on the included plants. All leaves fall, yellowing of the entire plant and dryness of the capsules. A factorial experiment was applied according to Randomized Complete Block Design (R.C.B.D) that included two factors:

The first includes eight varieties of flax (Indian Variety, Giza 11, Giza 10, Sahka 5, Sahka 6, Giza 8, Syrian Variety, Thorshansity 72).

The second factor: - Biofertilization (adding ground to the soil immediately before planting) at four levels:

1- Control(without adding).

2- Bacterial biofertilization: A bacterial mixture from three types of bacteria (*Azotobacter chroococcum*, *Pseudomonas fluorescens*and *Bacillus mucilaginosus*).
3- Fungal biofertilization using Mycorrhiza fungi.
4- Mixture (bacterial fertilization + fungal fertilization).
The following traits were studied for a random sample consisting of (ten plants registered as a mean chosen randomly from the two middle lines of each experimental unit):-

1- Number of capsules per plant (capsule. plant $^{-1}$): The number of capsules was averaged in the ten plants taken randomly from the midlines of each experimental unit.
2- Number of seeds in per capsule (seed. capsule^{-1}): was calculated from dividing the number of seeds in plant capsules by the number of capsules in the ten plants randomly taken from the midlines of each experimental unit.
3- Weight of 1000 seeds (gm): After mixing the seeds of plants harvested from each experimental unit, 1000 seeds were taken from them randomly, then weighed and their average was taken.
4- Total seed yield (kg .ha^{-1}): The productivity of one hectare of seeds was estimated according to the following equation:
   Total seed yield (kg .ha^{-1})= individual plant yield*10/ space employed by the plant
5- Biological yield (kg): It represents (dry matter weight) ten randomly dried plants were weighed on the sun and then Calculating the average weight of each plant (gm) and then converting it to a unit (kg).
6- Harvest Index (%): The harvest index for each plant was calculated according to the following equation:
   Harvest Index (%)= (Total seed yield / Biological yield) *100.

The data were statistically analyzed for the studied traits according to the statistical analysis method for Randomized Complete Block Design (R.C.B.D) and the arithmetic means were compared using the least significant difference (LSD) at the 5% probability level. [12].

3. RESULTS AND DISCUSSION

3.1. RESULTS

The results of Table (2) show that the variety had a significant effect on the traits of the number of capsules per plant, as Giza 10 outperformed by giving it the highest mean number of capsules (67.55) capsules. plant $^{-1}$, compared to the Syrian variety, which gave the lowest mean for this trait (49.31) capsules. plant $^{-1}$.
The results of Table (2) indicate that the addition of bio-fertilizer achieved a significant increase in the number of capsules per plant by surpassing the fertilization treatment (Bacterial fertilizer + Mycorrhiza), as it gave the highest mean of (69.27) capsules. plant $^{-1}$, compared to the non-fertilized plants that gave the lowest mean of (40.76) capsules. plant $^{-1}$.
The interaction between the variety and bio-fertilizer showed significant differences in the number of capsules per plant, as the combination (Giza 10 + Bacterial fertilizer + Mycorrhiza) achieved the highest mean (76.22) capsules. plant $^{-1}$, while the combination (Syrian Varity + Control) achieved the lowest mean number of capsules (33.72).) capsules. plant $^{-1}$.

Table .2. Effect of Bio fertilizer and Variety in number of capsules. plant^{-1}

Varieties	BioFertlizer				Mean
	Control	Bacterial fertilizer	Mycorrhiza	Bacterial fertilizer+ Mycorrhiza	
Indian Varity	40.89	46.72	60.78	64.93	53.33
Giza 8	39.82	50.39	56.63	69.08	53.98
Giza 10	50.15	70.55	73.27	76.22	67.55
Giza 11	44.25	61.34	70.75	72.82	62.29
Sahka 5	42.74	53.08	67.89	70.78	58.62
Sahka 6	37.82	48.75	59.60	69.88	54.01
Syrian Varity	33.72	46.58	53.94	63.01	49.31
Thorshansity 72	36.72	44.54	54.9	67.41	50.89
Mean	40.76	52.74	62.22	69.27	
L.S.D$_{0.05}$	Varieties	BioFertlizer	Varieties*BioFertlizer		
	1.477	1.045	2.955		

The results of Table (3) indicate that there are significant differences between the varieties in the trait of number of seeds in capsule, as the Giza 10 variety plants were characterized by giving highest mean number of seeds (9.03) seed. Capsule^{-1}, compared to plants of the Syrian variety, which gave the lowest mean for this trait (6.82) seed. Capsule^{-1}.

The results of Table (3) show that the addition of bio-fertilizer significantly affected the number of seeds in capsule, as the plants fertilized with the fertilizing treatment (Bacterial fertilizer + Mycorrhiza) achieved the highest mean of (9.04) seed. Capsule^{-1}, while the plants of the comparison treatment gave the lowest mean of (5.70) seed. Capsule^{-1}.

The interaction between the variety and bio-fertilizer showed significant differences in the number of seeds in capsule, as the combination (Giza 10 + Bacterial fertilizer + Mycorrhiza) was significantly superior and gave the highest mean (9.95) seed. Capsule^{-1}, while the combination (Syrian Varity + Control) gave the lowest mean number of seeds reached (5.04) seed. Capsule^{-1}.

Table .3. Effect of Bio fertilizer and Variety in number of seeds. capsule $^{-1}$

Varieties	BioFertlizer				Mean
	Control	Bacterial fertilizer	Mycorrhiza	Bacterial fertilizer+ Mycorrhiza	
Indian Varity	5.84	6.54	7.87	8.52	7.19
Giza 8	5.24	7.30	7.90	8.97	7.35
Giza 10	7.13	9.32	9.75	9.95	9.03
Giza 11	6.01	8.12	9.5	9.62	8.31
Sahka 5	5.97	7.43	8.87	9.21	7.87
Sahka 6	5.23	7.54	8.07	9.10	7.48
Syrian Varity	5.04	6.36	7.54	8.36	6.82

Thorshansity 72	**5.17**	**6.13**	**7.59**	**8.60**	**6.87**
Mean	**5.70**	**7.34**	**8.38**	**9.04**	
L.S.D$_{0.05}$	**Varieties**	**BioFertlizer**	**Varieties*BioFertlizer**		
	0.22	**0.16**	**0.45**		

The results of Table (4) show that the variety had a significant effect in 1000seed weight trait, as Giza 10 superior it by giving the highest mean weight of 1000seeds (11.66) g, compared to the variety Thorshansity 72, which gave the lowest mean for this trait amounted to (7.74) g.
The results of Table (4) show that the addition of bio-fertilizer achieved a significant increase in the weight of 1000 seeds, with the superiority of the fertilizing treatment (Bacterial fertilizer + Mycorrhiza), which gave the highest mean of (11.53) g, compared to the unfertilized plants, which gave the lowest mean of (6.06) g.

Table .4. Effect of Bio fertilizer and Variety in 1000 seed weight(gm)

Varieties	**BioFertlizer**				**Mean**
	Control	**Bacterial fertilizer**	**Mycorrhiza**	**Bacterial fertilizer+ Mycorrhiza**	
Indian Varity	**6.07**	**6.87**	**8.77**	**10.33**	**8.01**
Giza 8	**5.89**	**8.06**	**9.01**	**11.24**	**8.55**
Giza 10	**7.76**	**12.14**	**12.97**	**13.79**	**11.66**
Giza 11	**6.32**	**9.58**	**12.43**	**12.68**	**10.25**
Sahka 5	**6.10**	**8.11**	**11.03**	**11.88**	**9.28**
Sahka 6	**5.62**	**7.44**	**9.18**	**11.58**	**8.45**
Syrian Varity	**5.48**	**7.11**	**8.43**	**10.08**	**7.77**
Thorshansity 72	**5.29**	**6.33**	**8.63**	**10.72**	**7.74**
Mean	**6.06**	**8.21**	**10.05**	**11.53**	
L.S.D$_{0.05}$	**Varieties**	**BioFertlizer**	**Varieties*BioFertlizer**		
	0.16	**0.11**	**0.32**		

The results of Table (5) showed that there were significant differences between the variety in the trait of the total yield of seeds, Giza 10 variety plants were characterized by giving the highest mean total seed yield of (1485.23) kg. ha^{-1}, compared to Thorshansity 72 variety plants, which gave the lowest mean for this trait (1139.18) kg. ha^{-1}.
The results of Table (5) showed that the addition of bio-fertilizer significantly affected the characteristics of the total yield of seeds, as the plants fertilized with the mixture (Bacterial fertilizer + Mycorrhiza) achieved the highest mean of (149.53) kg. ha^{-1}, while the comparison treatment plants gave the mean of (1001.891) kg. ha^{-1}.
As for interaction between the variety and the bio fertilizer, significant differences were found in the trait of the total seed yield, as the combination (Giza 10 + Bacterial fertilizer + Mycorrhiza) was significantly superior and gave the highest mean (1,681.40) kg. ha^{-1}, while the combination (Thorshansity 72 Varity + Control) gave the lowest mean of the seed yield. The seeds reached (877.74) kg. ha^{-1}.

Table .5. Effect of Bio fertilizer and Variety in total seed yield (kg. ha $^{-1}$)

Varieties	BioFertlizer				Mean
	Control	Bacterial fertilizer	Mycorrhiza	Bacterial fertilizer+ Mycorrhiza	
Indian Varity	893.1767	1102.06	1213.2	1406.97	1153.85
Giza 8	1037.4	1185.3	1332.04	1459.37	1253.52
Giza 10	1143.21	1522.07	1594.27	1,681.40	1485.23
Giza 11	1071.317	1373.10	1551.73	1,639.33	1408.86
Sahka 5	1045.16	1188.083	1444.03	1503.34	1295.15
Sahka 6	983.903	1126.317	1356.37	1487.3	1238.47
Syrian Varity	963.223	1119.5	1228.27	1426.127	1184.28
Thorshansity 72	877.74	1085.567	1201.07	1392.367	1139.18
Mean	1001.891	1212.75	1365.12	1499.53	
L.S.D$_{0.05}$	Varieties	BioFertlizer	Varieties*BioFertlizer		
	8.82	6.23	17.36		

The results of Table (6) indicate that there are significant differences between the variety in the trait of biological yield, as Giza 10 variety plants were characterized by giving the highest mean of (6454.95) kg. ha^{-1}, compared to plants of the variety Thorshansity 72, which gave the lowest mean for this trait amounted to (6107.55) kg. ha^{-1}.

The addition of bio-fertilizer significantly affected the biological yield, as the plants fertilized with the Bacterial fertilizer + Mycorrhiza treatment achieved the highest mean of (6465.04) kg. ha^{-1}, while the plants of the control treatment gave the lowest mean of (5643.74) kg. ha^{-1}.

The interactions between variety and bio-fertilizer achieved significant differences in the biological yield, as the combination (Giza 10 + Bacterial fertilizer + Mycorrhiza) was significantly superior and gave the highest mean of (6542.70) kg. ha^{-1}, while the combination (Thorshansity 72Varity + Control) gave the lowest mean of biological yield of (5744) kg. ha^{-1}.

Table .6. Effect of Bio fertilizer and Variety in Biological yield (kg. ha $^{-1}$)

Varieties	BioFertlizer				Mean
	Control	Bacterial fertilizer	Mycorrhiza	Bacterial fertilizer+ Mycorrhiza	
Indian Varity	4234.57	6052.443	6309.83	6397.26	5748.52
Giza 8	5845.53	6246.533	6314.61	6471.30	6219.49
Giza 10	6235.44	6508.967	6532.73	6542.70	6454.95
Giza 11	6013.67	6341.67	6514.45	6521.21	6347.75
Sahka 5	5867.00	6215.70	6483.26	6501.63	6266.89
Sahka 6	5826.67	6078.41	6328.73	6493.51	6181.83
Syrian Varity	5804.73	6066.45	6301.66	6430.06	6150.72
Thorshansity 72	5744.53	6031.87	6291.10	6362.72	6107.55
Mean	5643.74	6192.75	6384.54	6465.04	
L.S.D$_{0.05}$	Varieties	BioFertlizer	Varieties*BioFertlizer		
	4.34	3.06	8.68		

The results of Table (3) indicate that there are significant differences between the varieties in the trait of harvest index, as the Giza 10 variety plants were characterized by giving the highest mean of the harvest index amounted to (28.81)%, compared to the plants of the variety Thorshansity 72, which gave the lowest mean for this trait amounted to (6.82)%.

The results of Table (3) show that the addition of bio-fertilizer significantly affected the trait of the harvest index, as the plants fertilized with the fertilizing treatment (Bacterial fertilizer + Mycorrhiza) achieved the highest mean of (28.8) %, while the plants of the comparison treatment gave the lowest mean of (21.35)%.

The interactions between the varieties and the bio-fertilizer achieved significant differences in the trait of harvest index, as the combination (Giza 10 + Bacterial fertilizer + Mycorrhiza) was significantly superior and gave the highest mean of (30.87) %, while the combination (Thorshansity 72Varity + Control) gave the lowest mean of (20.06)% .

Table .7. Effect of Bio fertilizer and Variety in harvest index (%)

Varieties	BioFertlizer				Mean
	Control	Bacterial fertilizer	Mycorrhiza	Bacterial fertilizer+ Mycorrhiza	
Indian Varity	20.20	22.96	24.26	27.18	23.65
Giza 8	22.15	23.51	26.46	30.26	25.60
Giza 10	23.66	29.96	30.76	30.87	28.81
Giza 11	22.78	27.09	31.03	30.30	27.80
Sahka 5	21.44	23.83	25.85	29.86	25.25
Sahka 6	20.98	23.06	24.186	28.77	24.25
Syrian Varity	19.57	22.72	23.81	27.12	23.31
Thorshansity 72	20.06	21.93	24.06	26.04	23.02
Mean	21.35	24.38	26.30	28.8	
$L.S.D_{0.05}$	Varieties	BioFertlizer	Varieties*BioFertlizer		
	0.18	0.13	0.37		

3.2. DISCUSSION

The difference between flax varieties in yield trait and components may be due to genetic differences between varieties and their genetic ability to express themselves in place of cultivation, in addition to the difference in their response to weather and soil conditions (Table 1) in place of cultivation. These results agreed with they found [13-14] in their study of flax varieties and that there are significant differences between the cultivated flax varieties.

As for the bio-fertilizer, the reason for the superiority of the biological mixture(Bacterial fertilizer + Mycorrhiza) may be due to the biological role of micro-organisms in increasing the availability of elements in the soil solution and the readiness of their absorption and transfer within the plant tissue and in the appropriate concentrations, which led to an increase in the efficiency of the carbon metabolism process, adding one side and the transfer of metabolic compounds to the sites of Primordia. On the other hand, in the reproductive stage of the plant; As a result, this will lead to an increase in the number of fertilized eggs, and then an increase in the number of seeds in the capsule, which is positively reflected in the yield trait and components. [15].

The reason for the increase in yield may be due to the importance of microorganisms used as bio fertilizer in improving the traits of vegetative growth and their positive impact on the traits of the yield and its components. These results are similar to what was reached. [16]. These results also agreed with [17] was reached in their study on the effect of bio fertilizer on flax yield, that bio fertilizer had a significant effect in increasing yield and its components.

4. CONCLUSIONS

In light of the obtained results, it can be concluded that the Giza 10 variety was the best in the in yield trait and components, and that the biofertilizer(Bacterial fertilizer + Mycorrhiza) gave the best results for all yield trait.

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