Effect of bio-fertilization on some traits of growth, yield, its components, and oil yield for different cultivars of Flax

Elaf Kh. F. Al-Sudani* M. H. K. Al-Baldawi**
*,**Department of Field Crops, College of Agriculture, University of Baghdad

ABSTRACT

A field experiment was conducted during the winter season 2017 at the Agricultural Research Station, Department of Field Crops, College of Agriculture, Al- Jadriya, in order to determine the effect of bio-fertilization on some traits of growth, yield, its components, and oil yield for different cultivars of Flax. The experiment was applied in the order of split plots, according to the randomized complete block design (RCBD), three replicates. The main plots included three cultivars of flax (Syrian, Egyptian and Iraqi), while the sub- plots represented three treatments for bio-fertilization (*Pseudomonas fluorescens*, *Azospirillum brasilense* and mixture of two fertilizers) as well as treatment of chemical fertilizer NPK with recommended quantities (90 kg N.ha^{-1} and 120 kg P.ha^{-1} and 80 kg K.ha^{-1}) and the control treatment (without bio-fertilization or chemical fertilization). The results showed that the Syrian cultivar achieved the best results for the number of main branches, the number of secondary branches and the number of fruit branches (5.11, 20.00, 111.75 branch.plant^{-1}), respectively, the number of capsules (95.18 seed.capsules^{-1}), the number of seeds in capsule (7.85 seed.capsule^{-1}), the seeds yield (1.192 tons.ha^{-1}) with an increase of (52.6, 17.4%) compared for the seeds yield of the Egyptian and local cultivars, respectively, As well as its superiority by giving it the highest average for oil yield amounted of (0.433 tons.ha-1), While the Egyptian cultivar by giving it the highest average weight of 1000 seeds (7.97 g), and the local cultivar achieved the highest average of the plant height (78.0 cm). The results showed that the bio-mixture treatment achieved the best results for plant height (76.2 cm) and the number of main branches, the number of secondary branches and the number of fruit branches (5.11, 20.01, 111.78 branch.plant-1), respectively, number of capsules (95.21 capsule.plant^{-1}), the number of seeds in the capsule (7.90 seed.capsule-1) and the seed yield (1.112 tons.ha^{-1}), with an increase of 39.0% for the control treatment, As well as its superiority by giving it the highest average of oil yield amounted of (0.406 tons.ha^{-1}), while the bio-fertilizer treatment (P. Fluorescens) has excelled by giving it the highest average weight of 1000 seeds (8.19 g). The effect of the interaction between the two factors of the study was significant in the studied traits. In the bio-mixture treatment, the Syrian cultivar achieved the best results for most traits except the plant height, Where the local cultivar was excelled in it at the bio-mixture treatment and the weight of 1000 seeds, which the Egyptian cultivar has excelled when treating it with bio-fertilizer (P. fluorescens).

Keywords: Flax, *Pseudomonas fluorescens*, *Azospirillum brasilense*.
***Research paper from MSc thesis for first author.**

تأثير التسميد الحيوي في بعض صفات النمو والحاصل ومكوناته وحاصل الزيت لأصناف مختلفة من الكتان

*إيلاف خضر فالح السوداني **محمد هذال كاظم البلداوي
*,**قسم المحاصيل الحقلية – كلية الزراعة – جامعة بغداد

الخلاصة

نفذت تجربة حقلية خلال الموسم الشتوي لعام 2017 في محطة الأبحاث الزراعية التابعة لقسم المحاصيل الحقلية – كلية الزراعة/ الجادرية بهدف معرفة تأثير التسميد الحيوي في بعض صفات النمو والحاصل ومكوناته وحاصل الزيت لأصناف مختلفة من الكتان. طبقت التجربة بترتيب الألواح المنشقة على وفق تصميم القطاعات الكاملة المعشاة وبثلاث مكررات, تضمنت الألواح الرئيسة ثلاثة أصناف من الكتان (السوري والمصري والعراقي) بينما مثلت الألواح الثانوية ثلاثة معاملات للتسميد الحيوي (*Pseudomonas fluorescens* و*Azospirillum brasilense* وخليط بين المخصبين)

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فضلا عن معاملة السماد الكيمياوي NPK بالكميات الموصي بها (90 كغم N ه$^{-1}$ و120 كغم P ه$^{-1}$ و80 كغم K ه$^{-1}$) ومعاملة المقارنة (من دون تسميد حيوي أو كيمياوي). اظهرت النتائج أن الصنف السوري حقق أفضل النتائج لعدد الأفرع الرئيسة والثانوية والثمرية (5.11 و20.00 و111.75) فرع نبات$^{-1}$ بالتتابع وعدد الكبسولات (95.18 كبسولة نبات$^{-1}$) وعدد البذور في الكبسولة (7.85 بذرة كبسولة$^{-1}$) وحاصل البذور (1.192 طن ه$^{-1}$) وبنسبة زيادة بلغت 52.6 و17.4% عن حاصل بذور الصنفين المصري والمحلي بالتتابع, فضلا عن تفوقه بأعلى متوسط لحاصل الزيت بلغ 0.433 طن ه$^{-1}$, بينما تفوق الصنف المصري بأعلى متوسط لوزن 1000 بذرة (7.97 غم), وحقق الصنف المحلي أعلى متوسط لارتفاع النبات (78.0 سم). كما اظهرت النتائج أن معاملة الخليط الحيوي حققت أفضل النتائج لارتفاع النبات (76.2 سم) وعدد الأفرع الرئيسة والثانوية والثمرية (5.11 و20.01 و111.78) فرع نبات$^{-1}$ بالتتابع وعدد الكبسولات (95.21 كبسولة نبات$^{-1}$) وعدد البذور في الكبسولة (7.90 بذرة كبسولة$^{-1}$) وحاصل البذور (1.112 طن ه$^{-1}$) وبنسبة زيادة بلغت 39.0% عن معاملة المقارنة, فضلا عن تفوقها بأعلى متوسط لحاصل الزيت بلغ 0.406 طن ه$^{-1}$, بينما تفوقت معاملة السماد الحيوي *P. fluorescens* بأعلى متوسط لوزن 1000 بذرة (8.19 غم). كان تأثير التداخل بين عاملي الدراسة معنويا في الصفات المدروسة, وحقق الصنف السوري عند معاملة الخليط الحيوي أفضل النتائج لأغلب الصفات باستثناء ارتفاع النبات إذ تفوق فيه الصنف المحلي عند معاملة الخليط الحيوي وزن 1000 بذرة التي تفوق فيها الصنف المصري عند معاملة بالسماد الحيوي *P. fluorescens*.

الكلمات المفتاحية : الكتان, *Pseudomonas fluorescens*, *Azospirillum brasilense* .

*البحث مستل من رسالة ماجستير للباحث الأول

1. INTRODUCTION

The importance of medical plants lies in the fact that they are the basis for the development of the drug industry as a result of its active ingredients of biological effect in the treatment of many diseases as well as having favorable marketing prices, which will stimulate the cultivation of a wide and specialized for these plants, especially if accompanied with the establishment of production lines of pharmaceutical depend on the resulting effective materials from these plants and this requires the finding and placing of agricultural policy related with the cultivation of medical plants and development of its production and such these plant a *Linum usitatissimum* L., which belongs to the Linaceae family, which is cultivated in various parts of the world to obtain its seeds with high content of fixed oils (30-45%), which are used in various industrial fields such as varnishes and paints (1). As well as being used as oils suitable for human consumption because of unsaturated fatty acids such as Omega 3, Omega 6 and Omega 9 (2). The global production of flax seeds is about 2.5 million tons per year. Canada leads the world, followed by China, India, America, Ethiopia and Egypt by about (34, 25.5, 9, 8, 3.5, 2.2 %), respectively from world production. There are other countries producing less (3). In Iraq, the cultivated areas of this crop are almost non-existent. This is due to many reasons, the most important of which is the focus on the production of strategic winter crops, as well as the lack of interest of specialists in the production of this crop and the absence of specialized factories to extract oil from it, Due to its industrial and medical importance, it is necessary to take care of this crop and to make the necessary improvements in its cultivation technology. This is achieved by working on the development of cultivars that are characterized by their high productivity or the development of the available ones or through the use of agricultural applications that will make the plant able to exploit its genetic and physical potential at high required level of production. The availability of plant growth requirements such as fertilizer is important in this regard. Recently, chemical fertilization or part of it has been replaced by bio-fertilizers which play an important role in reducing environmental pollution, maintaining biological balance, improving soil properties, root absorption of water and increasing its content of organic matter, For Its physiological effectiveness in the analysis of plant and animal waste and the availability of a large part of the important nutrient elements for the plant (4). It also secretion some growth hormones such as Gibberellins, Auxins and

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cytokinines that directly contribute to plant growth and development (5). This will be reflected positively on the increase the yields qualitatively and quantitatively and the rising of yields resulting from it, with the low costs of production for medical plants, which should take into account the indicators of environmental management sound that correspond to the trends of the modern world, which aims to return to safe agriculture through the use of what is available in nature and reduce or Minimize the chemical additives as well as work on the production of natural compounds free of pollutants used in various industrial and pharmaceutical fields, Therefore, this experiment aims to determining the effect of bio-fertilization on some traits of growth, yield, its components, and oil yield for different cultivars of Flax.

2. MATERIALS AND METHODS

A field experiment was conducted during winter season 2017 at the Agricultural Research Station, Department of Field Crops, College of Agriculture, Al- Jadriya, located within latitude line 33° N and longitude line 44° E in the silty clay soil, showing their physical and chemical properties in Table (1), in order to determine the effect of bio-fertilization on some traits of growth, yield, its components, and oil yield for different cultivars of Flax. The experiment was applied in the order of split plots according to the randomized complete block design (RCBD), three replicates. The main plots included three cultivars of flax (Syrian, Egyptian and Iraqi), while the sub- plots represented three treatments for bio-fertilization (*Pseudomonas fluorescens*, *Azospirillum brasilense* and mixture of two fertilizers), which were obtained from the Department of Biofertilizers, Department of Plant Protection, Ministry of Agriculture, as well as treatment of chemical fertilizer NPK with recommended quantities, with an average of (90 kg $N.ha^{-1}$) on two batch the first one before cultivating, the second after one and a half months of the first one, (120 kg $P.ha^{-1}$, 80 kg $K.ha^{-1}$) at a same time before cultivating (6) as well as the control treatment (without bio-fertilization or chemical fertilization). The soil service was conducted from plowing, smoothing and settling. The experiment land was divided into experimental units of 45 experimental units. The area of the experimental unit was (4 m2), with dimensions of (2 m × 2 m), Each experimental unit contained 10 lines, the distance between the line and another (20 cm) and the treatments were separated by distance with width of 1 m, Seeds of flax cultivars were cultivated in lines with a seed quantity of (40 kg.ha-1) (7) on 12 November 2017, Crop service operations were conducted from irrigation, Grubbing and weeding whenever necessary, The plants were harvested on April 15, 26 and May 15, 2018 for the Syrian, Egyptian and local cultivars, respectively after the emergence of signs of maturity on the plants, including the fall of leaves and the whole yellowing of the plant and the drying of capsules.

Fertilization of seeds with bio-fertilizer

The sterilization process for flax seeds was conducted by soaking it for 2 minutes in the sodium hypochlorite at 1% concentration. The seeds were then washed with distilled water three times, then dried with blotting paper, and then a 10% gum was added to make the surface sticky to facilitate the adhesion of bio-fertilizers on it. The seeds were then fertilized with liquid bio-fertilizer by adding these fertilizers to the extent that all the seeds in the vessels were covered and left for one hour in the Seed Technology Laboratory, Department of Field Crops, the containers containing the fertilized seeds were then transferred to the field for cultivation (8). The traits of plant height (cm), the number of main branches ($branch.plant^{-1}$), the number of secondary branches ($branch.plant^{-1}$), the number of fruit branches ($branch.plant^{-1}$), the number of

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seeds in capsule (seed.capsule^{-1}), weight of 1000 seeds (g) and yield of seeds and oil (tons.ha^{-1}) were studied. After collecting and tabulating the data, all the studied traits were statistically analyzed according to the order and design used in the experiment using the Gnestat program. A least Significant Difference (LSD) test was used to compare the arithmetic averages at a probability of 0.05 (9).

Table 1: Some chemical and physical properties for soil.

Trait		Value	Unit
Soil texture		silty clay	-
Soil separates	Sand	263	g.kg^{-1} soil
	Silt	345	
	Clay	392	
Electrical conductivity		3.83	ds.m^{-1}
CEC		21.45	dmol.kg^{-1} soil
pH		7.12	-
dissolved ions	CO_3	Nil	Meq.L^{-1}
	$CaCO_3$	23.45	
	Ca	18.70	
	Mg	11.22	
	Na	8.82	
	Cl	23.24	
	HCO_3	5.34	
	SO_4	9.26	
Nitrogen availability		0.005	%
Phosphorus availability		13.38	mg.kg^{-1} soil
Potassium availability		121.26	mg.kg^{-1} soil

3. RESULTS AND DISCUSSION

Plant height

Table (2) shows significant differences between the flax varieties (Syrian, Egyptian and local) in plant height. The local cultivar has excelled by giving it the highest average for this traits amounted of (78.0 cm) compared to the Syrian cultivars (72.5 cm) and the Egyptian cultivar which achieved the lowest average for this trait amounted of (65.2 cm), This difference in plant height is often related to genotype and its ability to express about itself, where the cultivars vary among several vegetative indices. These results agree with (10, 11) who indicated significant differences between flax cultivars in plant height. The results of Table (2) showed a significant effect for the fertilizer treatments (*P. fluoresescens* and *A. Brasilense* and the mixture between them and the adding treatment of NPK) compared to the control treatment in plant height. Plants that their seeds are fertilized with bio-mixture have characterized by giving it the highest average amounted of (76.2 cm) compared to other treatments, in which the control treatment achieved the lowest average amounted of 66.1 cm. The reason of excelling the seeds fertilization treatment with bio-fertilizer in the plant height of the to give it the highest results for traits of the root length and its dry weight (no data exposure), which is reflected in the increase absorption and transfer of nutrient elements necessary for plant growth and its development, thus increase the vegetative growth indicators, including plant height. These results agree with (12, 13) who indicated that there is a significant effect for bio-fertilizer in plant height for flax, as well as Kumar et al., (14) that the addition of mineral fertilizers were significantly affected the height of the flax plant. As for the interaction between the cultivars and the fertilization treatments, its effect was significant in the

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plant height, where the interaction between the local cultivar and the bio-mixture treatment achieved the highest value for the interaction amounted to 84.6 cm, while the Egyptian cultivar with the control treatment achieved the lowest value for interaction amounted of 60.6 cm.

Table 2: Effect of fertilization treatments and cultivars in plant height (cm)

Fertilization treatments	**Cultivars**			**Average**
	Syrian	**Egyptian**	**local**	
Control	66.3	60.6	71.4	66.1
NPK	72.7	70.3	78.3	73.9
Pseudomonas fluorescens	70.1	65.1	74.5	69.9
Azospirillum brasilense	75.8	63.4	81.3	73.5
P. fluorescens + A. brasilense	77.6	66.5	84.6	76.2
LSD 0.005	**2.0**			**1.1**
Average	**72.5**	**65.2**	**78.0**	
LSD 0.005	**1.4**			

The number of main branches (branch.plant^{-1})

The branching is considered an important morphological component in the evolution of the seeds yield in flax seeds and one of the adaptive mechanisms to maintain balance between sources and sinks, Increasing nutrient elements availability in the soil solution and its transfer within plant tissues and their accumulation in appropriate quantities promotes the division and stimulates the growth of main, secondary and fruit branches in flax seeds. Table (3) indicates a significant difference between the flax cultivars (Syrian, Egyptian and local) in the number of main branches in the plant. The Syrian cultivars achieved the highest average for the trait amounted of (5.11 branches.plant^{-1}) compared to the plant of local cultivar which gave (4.78 branches.plant^{-1}) and the plants of the Egyptian cultivar, Which achieved the lowest averages for this traits amounted of (4.22 branches.plant^{-1}), The reason for this variation in the number of branches is related to the genetic nature of each cultivars. These results agree with (Andruszczak et al., (15) that flax cultivars differ significantly among each other in the number of main branches in the plant. The results of Table 3 indicate that there is a significant effect of the fertilizer treatments (*P. fluoresescens* and *A. Brasilense* and the mixture between them and the adding treatment of NPK) compared to the control treatment in the number of main branches in the plant. The bio-mixture treatment gave the highest average for this traits amounted of (5.11 branch.plant^{-1}) and did not differ significantly from the fertilization treatment with bio-fertilizer (*A. basilense*) which amounted of (4.95 branch.plant^{-1}). While the control treatment gave the lowest average for this trait amounted of (4.08 branches.plant^{-1}). The reason of excelling the seeds fertilization treatment with bio-fertilizer may be due to the complementary role of *A. brasilense* and *P. Fluorescens* in increasing the transferred nutrient elements to the plant through their respective mechanisms to achieve this (16), The first works on secretion or stimulation of signals in a process called Rhizocoenosis. These signals cross the plant cell wall and are organized into cellular membranes, which in turn are sensitive to any alteration, stimulating the surface adsorption for nutrient elements by the cortex cells (17). The second works to dissolve the phosphate by producing organic acids that produce hydrogen ion and then reduce the pH of the soil and convert the Tri-calcium phosphate into a binary or mono, which stimulates dissolving this element from its compounds and increasing its availability for the plant (18). This result will positively affect the encouragement and

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stimulate the growth of dormant buds and then increase the number of branches in the plant. This result agrees with (Kumar et al., (14), who indicated that there is a significant effect of the addition of bio-fertilizers in the number of main branches in flax, also agreed with (Khajani et al., (19) that the addition of mineral fertilizers significantly affected the number of main branches in flax. The effect of the interaction between cultivars and bio-fertilizers was significant in the number of branches of the plant, where the plants of the Syrian cultivar at the bio-mixture treatment achieved the highest value for interaction amounted of (5.61 branches.plant^{-1}) and did not differ significantly from the plants of the same cultivar when treated with the bio-fertilizer (*A. brasilense*) and the local cultivar when treated with the bio-mixture (5.40, 5.30 branches.plant^{-1}), respectively, While the interaction between Egyptian cultivar and the control treatment gave the lowest value for interaction amounted of (3.71 branch.plant^{-1}) as shown in Table (3).

Table 3: Effect of fertilization treatments and cultivars in the number of main branches (branch.plant^{-1})

Fertilization treatments	**Cultivars**			**Average**
	Syrian	**Egyptian**	**local**	
Control	4.42	3.71	4.10	4.08
NPK	5.19	4.67	4.82	4.89
Pseudomonas fluorescens	4.93	3.97	4.53	4.48
Azospirillum brasilense	5.40	4.31	5.15	4.95
P. fluorescens + A. brasilense	5.61	4.42	5.30	5.11
LSD 0.005	**0.33**			**0.19**
Average	**5.11**	**4.22**	**4.78**	
LSD 0.005	**0.17**			

The number of secondary branches in the plant (branch.plant^{-1})

Table (4) shows a significant difference between the flax cultivars (Syrian, Egyptian and local) in the number of secondary branches in the plant. The Syrian cultivar was characterized by giving it the highest average for this traits amounted of (20.00 branches.plant^{-1}) compared to the plants of the local cultivar (18.72 branches.plant^{-1}) and the plants of Egyptian cultivar, which achieved the lowest average for this trait amounted of (16.50 branches.plant^{-1}). These results agree with (Gupta et al., (11) who showed significant differences between flax cultivars in the number of secondary branches. The results of the same table showed a significant effect of fertilizer treatments (*P. fluoresescens* and *A. Brasilense* and the mixture between them and the adding treatment of NPK) compared to the control treatment in the number of secondary branches in the plant. The bio-mixture treatment achieved the highest average for trait amounted of (20.01 branches.plant^{-1}) and did not differ significantly from the seeds fertilization treatment with bio-fertilizer (*A. brasilense)* (19.38 plant branch^{-1}) while the control treatment gave the lowest average for this trait amounted of (15.97 plant branch^{-1}). The reason of excelling the seeds fertilization treatment with bio-fertilizer may be due to its superiority in root length, its dry weight, The leaves content of nitrogen, chlorophyll index (no data exposure) and number of main branches as shown in Table (3), which contributed to an increase in the number of secondary branches in the plant. These results agree with (El-Refaey et al., (20) who indicated that there is a significant effect of the addition of bio-fertilizers in the number of secondary branches of flax. It was also agreed with (Gupta et al., (11) that the addition of mineral fertilizers significantly affected the number of secondary branches

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for flax. The effect of the interaction between the cultivars and the fertilizer treatments was significant in the number of secondary branches in the plant. The Syrian cultivar achieved the highest value when treating it with bio-mixture for interaction amounted of (21.97 branches.plant^{-1}) and did not differ significantly from the treatment of (A. brasilense) (21.13 branches.plant^{-1}) and the local cultivar which its seeds fertilized with its bio-mixture (20.75 branches.plant^{-1}), While the Egyptian cultivar with the control treatment achieved the lowest value for interaction amounted to (14.53 branches.plant^{-1}).

Table 4: Effect of fertilization treatments and cultivars in The number of secondary branches in the plant (branch.plant^{-1})

Fertilization treatments	**Cultivars**			**Average**
	Syrian	**Egyptian**	**local**	
Control	17.30	14.53	16.06	15.97
NPK	20.32	18.27	18.88	19.15
Pseudomonas fluorescens	19.28	15.54	17.74	17.52
Azospirillum brasilense	21.13	16.86	20.16	19.38
P. fluorescens + A. brasilense	21.97	17.30	20.75	20.01
LSD 0.005	**1.27**			**0.33**
Average	**20.00**	**16.50**	**18.72**	
LSD 0.005	**0.66**			

Number of fruit branches in plant

The nature of the fertilization in the seed flax is the emergence of the main branches from the branches node located above the surface of the soil at a height of 5-7 cm, The nature of the fertilization in the seed flax is the emergence of the main branches from the branches node located above the surface of the soil at a height range between 5-7 cm, In the upper third for each branch, the group of secondary branches, which carries the fruit branches, and the latter includes two types of branches either fertile bearing capsules or non-fertile, and thus the increase in the number of main branches in the plant and the number of secondary branches associated with the presence of nutrition materials in the appropriate quantities will result in Increase the number of fruit branches in the plant. The results of the statistical analysis in Table (5) show a significant difference between flax cultivar (Syrian, Egyptian and local) in the number of fruit branches in the plant, The Syrian cultivar was characterized by giving it the highest average amounted of (111.75 branches.plant^{-1}) compared to the plants of the local cultivar (104.59 branches.plant^{-1}) and the plants of the Egyptian cultivar, which achieved the lowest average amounted of (92.19 branches.plant^{-1}), This variation is due to the nature of the genetic material for each cultivars. These results agree with (21, 22) who found a significant difference between flax cultivars in the number of fruits branches plant. The results showed a significant effect of the fertilizer treatments (*P. fluoresescens* and *A. brasilense* and the mixture between them and the adding treatment of NPK) on the control treatment in the number of fruit branches in the plant, Where the bio-mixture treatment achieved the highest average for this trait amounted of (111.78 branches.plant-1), without significant difference from the seed fertilization treatment with bio-fertilizer (A. brasilense) (108.30 plant branch^{-1}), while the control treatment gave the lowest average amounted of (89.20 branches.plant^{-1}) as shown in table (5), The reason of excelling the Seeds fertilization treatment with bio-mixture in number of fruit branches in plant may be due to its excelling in the root length, its dry weight, the leaves content of nitrogen, chlorophyll index (no data presented), number of main branches and

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number of secondary branches in plants as shown in Tables (3, 4). The effect of interaction between cultivars and fertilization treatments was significant in the number of fruit branches in the plant, where the Syrian cultivars achieved the highest value for interaction when treating it with bio-mixture amounted of (122.77 branches.plant^{-1}) and did not differ significantly from the plants of the same cultivar at the treatment of (*A. brasilense*) (118.04 branches.plant^{-1}) and the local cultivars that their seeds fertilized with bio-mixture (115.92 branches.plant^{-1}) while the interaction between Egyptian cultivar and the control treatment achieved the lowest value for the interaction amounted of (81.20 branches.plant^{-1}).

Table 5: Effect of fertilization treatments and cultivars in the number of fruit branches in plant (branches.plant^{-1}).

Fertilization treatments	Cultivars			Average
	Syrian	Egyptian	local	
Control	96.66	81.20	89.75	89.20
NPK	113.52	102.06	105.49	107.02
Pseudomonas fluorescens	107.75	86.83	99.14	97.90
Azospirillum brasilense	118.04	94.21	112.64	108.30
P. fluorescens + A. brasilense	122.77	96.66	115.92	111.78
LSD 0.005	**7.11**			**4.10**
Average	**111.75**	**92.19**	**104.59**	
LSD 0.005	**3.70**			

The number of capsules in plant

Table (6) shows significant differences between the flax cultivar (Syrian, Egyptian and local) in the number of capsules in the plant, where the Syrian cultivar was characterized by giving it the highest average for this trait amounted of (95.18 capsules. plant^{-1}) compared to the plants of the local cultivar, which gave (89.08 capsules.plant^{-1}) and plants of the Egyptian cultivar, which achieved the lowest average for this trait amounted of (78.53 capsules.plant^{-1}), These depend on the genetic traits for each cultivar. These results agree with (22, 23) who indicated a significant difference between flax cultivars in the number of capsules in flax. The results showed a significant effect for the fertilizer treatments (*P. fluoresescens* and *A. brasilense* and the mixture between them and the adding treatment of NPK) compared to the control treatment in the number of capsules in the plant as shown in Table (6). where the bio-mixture treatment achieved the highest average for this trait amounted of (95.21 capsules.plant^{-1}) and did not differ significantly from the fertilization treatment with bio-fertilizer (*A. basilense*) which amounted of (92.24 capsules.plant^{-1}) while the control treatment gave the lowest average for the traits amounted of (75.98 capsules.plant^{-1}), and that the increase achieved in the conditions of this study can be attributed to the indicators of good vegetative growth in most of the studied traits, which means increasing the efficiency of carbon representation and the transport of metabolic compounds resulting from it from sources to the members of the reproductive development and the positive effect in the increase in the number of capsules in the plant. These results agree with (13, 14, 24) who indicated that there is a significant effect of the addition of bio-fertilizers in the number of capsules for flax. It is also agreed with (Gupta et al., (11); Khajani et al., (19) that The addition of mineral fertilizers significantly affected the number of capsules for flax. As for the interaction between the cultivars and the fertilizer treatments, the effect was significant in the number of capsules in the plant, In the treatment, the Syrian cultivar gave the highest value for interaction when treating

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it with bio-mixture amounted of (104.57 capsules.plant^{-1}) and did not differ significantly from the treatment of *A. brasilense* (100.54 capsules.plant^{-1}) and the local cultivars that their seeds fertilized with the bio-mixture (98.74 capsules.plant^{-1}), While the interaction between the Egyptian cultivar and the control treatment gave the lowest value for the interaction amounted of (69.17 capsules.plant^{-1}).

Table 6: Effect of fertilization treatments and cultivars in the number of capsules in plant

Fertilization treatments	Cultivars			Average
	Syrian	**Egyptian**	**local**	
Control	82.33	69.17	76.44	75.98
NPK	96.69	86.93	89.85	91.16
Pseudomonas fluorescens	91.77	73.96	84.45	83.39
Azospirillum brasilense	100.54	80.24	95.94	92.24
P. fluorescens + A. brasilense	104.57	81.13	98.74	95.21
LSD 0.005	**6.05**			**3.49**
Average	**95.18**	**78.53**	**89.08**	

The number of seeds in the capsule

Table (7) shows significant differences between flax cultivars (Syrian, Egyptian and local) in the number of seeds in the capsule. The Syrian cultivar achieved the highest average for trait amounted of (7.85 seed.capsule^{-1}) compared to the local cultivar (7.35 seed.capsule^{-1}) the Egyptian cultivar which achieved the lowest average for trait amounted of (6.46 seed.capsule^{-1}). This difference is due to the number of seeds in the capsule to the genetic variance between the cultivars. These results agree with (10, 21) who indicated that flax cultivars differ significantly between them in the number of seeds in the capsule. The results showed that there was a significant effect for the fertilizer treatments (P. fluoresescens and A. Brasilense and the mixture between them and the adding treatment of NPK) compared to the control treatment in the number of seeds in the capsule, The bio-mixture treatment was excelled by giving it the highest average for trait amounted of (7.90 seed.capsule^{-1}) compared with other fertilizer treatments and the control treatment, which gave the lowest average for trait amounted of (6.25 seed.capsule^{-1}) as shown in Table (7), The reason for excelling the bio-mixture treatment by giving it the highest average for number of seeds in the capsule may be due to the biological role of microorganisms in increasing the availability of nutrient elements in the soil solution and their absorption and transfer within the plant tissue and in appropriate concentrations. Which means increasing the efficiency of C4 Carbon fixation on the one hand and the transfer of metabolic compounds to the new locations of primordia in the reproductive stage of the plant on the other side (25). This will lead to an increase in the number of fertilized eggs and thus increase the number of seeds in the capsule. These results agree with (El-Refaey et al., (20) who indicated that there is a significant effect for the adding of bio-fertilizers in the number of seeds in the capsule for flax, it also agrees with (14, 19) who mentioned that the addition of mineral fertilizers significantly affected the number of seeds in the capsule for flax. The effect of the interaction between cultivars and fertilizer treatments was significant in the number of seeds in the capsule. The plants of the Syrian cultivar gave the highest value for interaction when treating it with bio-mixture amounted of (8.70 seed.capsule^{-1}) and did not differ significantly from the plants of the same cultivar at the treatment of A. brasilense (8.27 seed.capsule^{-1}) and the local cultivars that their seeds fertilized with bio-mixture (8.22 seed.capsule^{-1}), while the interaction between the Egyptian cultivar and the

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control treatment gave the lowest value for interaction amounted of (5.69 seed.capsule[1]).

Table 7: Effect of fertilization treatments and cultivars in the number of seeds in the capsule

Fertilization treatments	**Cultivars**			**Average**
	Syrian	**Egyptian**	**local**	
Control	6.77	5.69	6.29	6.25
NPK	7.95	7.15	7.25	7.50
Pseudomonas fluorescens	7.55	6.08	6.94	6.86
Azospirillum brasilense	8.27	6.60	7.89	7.58
P. fluorescens + A. brasilense	8.70	6.77	8.22	7.90
LSD 0.005	**0.50**			**0.29**
Average	**7.85**	**6.46**	**7.35**	
LSD 0.005	**0.26**			

Weight 1000 seeds

Table (8) indicates that there is a significant difference between flax cultivars (Syrian, Egyptian and local) in the weight of 1000 seeds. The Egyptian cultivar is characterized by the highest average for weight of 1000 seeds amounted of (7.97 g) compared to the Syrian cultivar which gave (7.52 g) and the local cultivar which gave the lowest average for trait amounted of (6.62 g), The reason for increasing weight of 1000 seeds in the Egyptian cultivar is due to the low number of capsules in the plant as shown in Table (6) and the number of seeds in the capsule as shown in Table (7), leading to the seed gets a greater amount of metabolic material and then increase its weight, These results agree with (Bakry et al., (26) who indicated a significant difference between flax cultivars in the weight of 1000 seeds. The results of the same table show a significant difference between the fertilizer treatments (*P. fluoresescens* and *A. brasilense*, the mixture between them and the adding treatment of NPK) compared to the control treatment in the weight of 1000 seeds, where the flax plants that their seeds fertilized with *P. fluoresescens* achieved the highest average for the trait amounted of 8.19 g and differed significantly from the other treatments, especially the control treatment, which gave the lowest average for the trait amounted of 6.68 g. The reason for excelling the bio-fertilizer treatment (*P. fluorescens*) compared to other fertilizer treatment (except for the control treatment) to give it the lowest number for capsules per plant as shown in Table (6), the number of seeds in the capsule as shown Table (7) indicating that plants treated with the bio-fertilizer treatment (*P. fluorescens*) have invested their potential in increasing the weight of the seeds at the expense of the number of nutrient elements available within the plant's cellular tissues, The weight of the seed depends on the amount of what processed for it from nutrient materials from the source as well as the downstream capacity and ability to withdraw the largest amount of metabolic compounds from the source and associated with the ability of the plant to perform the process of carbon metabolic efficiently, The opposite was achieved in flax plants that their seeds fertilized with bio-mixture, Which is due to the low weight of 1000 seeds compared to other fertilizer treatments (Excluding control treatment) is due to its superiority in the number of capsules in the plant as shown in Table (6) and the number of seeds in the capsule as shown in Table (7), This corresponds to the principle of compensation in plants and confirms the inverse relationship between the number of seeds and their weight. The more seeds in the capsule, the more competition between them on the metabolic compounds resulting in the distribution of these products on a larger number of seeds and

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then lower weight, As for the plants control of control treatment, the lowest results were obtained for the components of three yield as shown in Tables (6, 7, 8). The reason for decline was due to the weak root and vegetable growth of the plants, which reflected negatively on the decreasing all components of the yield. These results agree with (13, 24) who indicated that there is a significant effect of the adding of bio-fertilizers in the weight of 1000 seed for flax, it is agreed with (Kumar et al., (14); Khajani et al., (19) that the addition of mineral fertilizers significantly affected the weight of 1000 seed for flax. The effect of the interaction between cultivars and fertilizer treatments was significant in the weight of 1000 seeds as shown in Table (8). The plants of the Egyptian cultivar that their seeds fertilized with the bio-fertilizers treatments *(P. pollorescens*) by giving it the highest value for interaction amounted of (8.72 g) and did not differ significantly from the plants of the Syrian cultivars that their seeds fertilized with treatments (*P. fluoresescens*) amounted of (8.35 g), while the Egyptian cultivars gave the lowest value for interaction amounted of (5.86 g).

Table 8: Effect of fertilization treatments and cultivars in the weight 1000 seeds

Fertilization treatments	**Cultivars**			**Average**
	Syrian	**Egyptian**	**local**	
Control	6.82	7.37	5.86	6.68
NPK	7.96	7.71	7.05	7.57
Pseudomonas fluorescens	8.35	8.72	7.49	8.19
Azospirillum brasilense	7.52	8.25	6.63	7.47
P. fluorescens + A. brasilense	6.97	7.80	6.10	6.96
LSD 0.005	**0.44**			**0.26**
Average	**7.52**	**7.97**	**6.62**	
LSD 0.005	**0.37**			

Seed yield

The seed yield is the product of several components: the number of capsules in the plant, the number of seeds in the capsule and the weight of the seed. These components are the final outcome of the plant's bio-chemical activities during its life cycle, which are influenced by different genetic and environmental factors. The results of Table (9) indicate that there is a significant difference between flax cultivars (Syrian, Egyptian and local) in seed yield. The Syrian cultivar achieved the highest average for trait amounted of (1.192 $tons.ha^{-1}$), with an increase of 52.6% for the Egyptian cultivar, which achieved the lowest average for this trait amounted of (0.781 $tons.ha^{-1}$), The results showed that the Syrian cultivar was more responsive to environmental factors as well as to its genetic nature, which led to the superiority of its plants in seed yield as a result of increasing root length, dry weight, chlorophyll index (no data presented), number of branches main, secondary and fruit as shown in Tables (3, 4, 5) as well as an increase in two components of the yield component: the number of capsules in the plant as shown in Table (6) and the number of seeds in the capsule as shown in Table (7). These results agree with (11, 27) who indicated a significant difference between flax cultivars in seed yield. These results agree with (11, 27) who indicated a significant difference between flax cultivars in seed yield. The results of the same table showed a significant effect of fertilizer treatments (*P. fluoresescens* and *A. brasilense* and the mixture between them and the adding treatment of NPK) compared to the control treatment in the seed yield, the bio-mixture treatment has excelled by giving it the highest average for this trait amounted of (1.112 $tons.ha^{-1}$)

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with an increase of 39.0% compared to the control treatment that achieved the lowest average for trait amounted of (0.800 $tons.ha^{-1}$), The reason for excelling the bio-mixture treatment by giving it the highest average for seed yield may be to its excelling in the number of capsules in the plant as shown in Table (6) and the number of seeds in the capsule as shown in Table (7). These results agree with (13, 14, 20) who indicated that there is a significant effect for the adding of bio-fertilizers in the seed yield for flax. It is also agreed with (Gupta et al., (11); Khajani et al., (19) seed yield for flax. As for the interaction between the cultivars and the fertilizer treatments, its effect was significant in the seed yield. The Syrian cultivar plants, when their seeds fertilized with the bio-mixture, achieved the highest value for interaction amounted of (1.365 $tons.ha^{-1}$) and did not differ significantly from the plants of the same cultivars at the treatment *A. brasilense* (1.322 $tons.ha^{-1}$), While the interaction between Egyptian cultivar and the control treatment gave the lowest value for interaction amounted of (0.587 $tons.ha^{-1}$).

Table 9: Effect of fertilization treatments and cultivars in the Seed yield

Fertilization treatments	**Cultivars**			**Average**
	Syrian	**Egyptian**	**local**	
Control	0.929	0.587	0.882	0.800
NPK	1.186	0.897	1.086	1.057
Pseudomonas fluorescens	1.155	0.769	0.947	0.957
Azospirillum brasilense	1.322	0.804	1.033	1.053
P. fluorescens + A. brasilense	1.365	0.847	1.125	1.112
LSD 0.005	**0.068**			**0.039**
Average	**1.192**	**0.781**	**1.015**	
LSD 0.005	**0.031**			

Oil yield

The results of Table (10) show significant differences between flax cultivars (Syrian, Egyptian and local) where the Syrian cultivar has excelled by giving it the highest oil yield amounted of (0.433 $tons.ha^{-1}$) compared to the local cultivar (0.343 $tons.ha^{-1}$) and the Egyptian cultivar, which achieved the lowest yield amounted of (0.232 $tons.ha^{-1}$), The reason for the superiority of the Syrian cultivars in this trait to its excelling in the seed yield as shown in Table (9) and the percentage of oil in the seeds (data not presented). These results agree with (10, 22, 27) have stated that there is a significant difference between flax cultivars in the oil yield for the flax. The results also showed a significant effect of the fertilizer treatments (*P. fluoresescens* and *A. brasilense* and the mixture between them and the adding treatment of NPK) compared to the control treatment in the oil yield as shown in Table (10), The bio-mixture treatment gave the highest oil yield amounted of (0.406 $tons.ha^{-1}$) compared to other fertilizer treatments and the control treatment which achieved the lowest oil yield amounted (0.234 $tons.ha^{-1}$), The reason for excelling the bio-mixture treatment in this trait is due to its excelling in the seed yield as shown in Table (9) and the percentage of seed oil (data not presented). These results agree with (El-Refaey et al., (20) who indicated that there is a significant effect of adding of bio-fertilizers in the oil yield for the flax, It is also agreed with (Kumar et al., (14) The addition of mineral fertilizers significantly affected the oil yield for the flax. As for the interaction between the cultivars and the fertilizer treatments, its effect was significant in the oil yield. The Syrian cultivar plants, when their seeds fertilized with the bio-mixture, achieved the highest value for interaction amounted of (0.540 $tons.ha^{-1}$) compared to the plants of Egyptian cultivars at the control treatment which achieved the lowest value

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for interaction amounted of (0.152ton.ha^{-1}).

Table 10: Effect of fertilization treatments and cultivars in the oil yield

Fertilization treatments	Cultivars			Average
	Syrian	Egyptian	local	
Control	0.291	0.152	0.260	0.234
NPK	0.427	0.294	0.368	0.363
Pseudomonas fluorescens	0.405	0.214	0.302	0.307
Azospirillum brasilense	0.502	0.243	0.364	0.370
P. fluorescens + A. brasilense	0.540	0.259	0.420	0.406
LSD 0.005	**0.035**			**0.020**
Average	**0.433**	**0.232**	**0.343**	
LSD 0.005	**0.025**			

The summary of study

Pseudomonas fluorescens + *Azospirillum brasilense* improved the most vegetative traits for the flax, which was reflected in the increase of seed yield due to the increase of two components of the plant, namely the number of capsules in the plant and the number of seeds in the capsule as well as its role in increasing the percentage and yield of the oil and its content of acid Linoleic (omega 3) so that the bio-mixture can be an alternative to chemical fertilizers.

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