Effect of bio-fertilizers and phosphate fertilization on the vegetative and flowering growth of the Fennel fruits (*Foeniculum vulgare* Mill)

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Abstract

A factorial experiment was conducted in Al-Watifiyah region 40 km north of Babylon for the winter agricultural season 2018 with the aim of knowing the effect of bio-fertilizers and phosphate fertilizers in the indicators of vegetative and flowering growth of fennel plant(*Foeniculum vulgare* Mill), where a factorial experiment was applied to Randomized Complete Block Design (R.C.B.D) with three replicates, The first two factors were used that included the use of four levels of bio-fertilizers, (without addition, mycorrhiza, and *Azotobacter spp* , Mycorrhiza + *Azotobacter spp*). The second factor was the use of four levels of phosphate fertilizer P_2O_5 (0, 40, 60 and 80 kg.ha^{-1}). Data were collected, statistically analyzed, and arithmetic averages were arranged according to the LSD test, the probability at the level of 5% . The results showed that the bio-fertilizers had a significant effect on the studied traits, where treatment of Azotobacter bacteria and adding phosphorus the level of 60 kg.ha^{-1} excelled and giving the highest average plant height (159.67 cm), the number of vegetable branches (15.0 branch.plant^{-1}), dry weight of the vegetative growth (12.92 g) . While the interaction of Mycorrrizae and the adding of phosphorous at 60 kg.ha $^{-1}$ achieved a significant increase in the number of inflorescences (12.67 inflorescences.plant^{-1}), the number of florets in the inflorescence (9.67 florets. Inflorescence^{-1}), the 1000 grains weight (10.0 g), total fruit yield (1.83 tons.ha^{-1}) while the control treatment gave the lowest average of all studied traits.

Kay world: *Fenniculum vulgare* Mell, bio-fertilizers , phosphate fertilizers

Introduction

The fennel plant is a medicinal aromatic plant that That propagation with seeds and has a rectangular or oval shape. The Mediterranean region is the original country for it and is grown almost all over the world, especially the regions that have moderate temperatures for commercial purposes and known globally as Fennel as they are called by different names in the countries that produce them, and they are

used since ancient times in traditional folk medicine and it is one of the plants traded in Ancient Egyptian, Greek, Roman and Chinese civilizations (Akbar, 2018), the fennel plant is cultivated in many parts of the world where plants for the purposes of spices and in other parts for the purpose of taking advantage of oil, which is one of the oldest medicinal plants used, and in Iraq its cultivation is limited to a small number of farmers and small areas in the center and north and its level of production remained below the required level due to lack of methods The correct scientific method for performing field operations related to its cultivation (AL-Snafi, 2018). Fertilization processes are among the important means that lead to increasing the yield of fruits and oil and improving its physical properties. For the purpose of avoiding the use of chemical fertilizers and the trend towards clean agriculture, those concerned have now turned towards the use of bio-fertilizers in order to move away from the harmful components of health and the environment and for the purpose of producing a crop free of any chemical pollutant of the ability These organisms increase the growth and development of plants and inhibit the growth of pathogenic microorganisms while contributing to resistance to different stress conditions (Mahanty et al., 2016 and Tomer et al., 2018). in view, the lack of scientific and field studies specialized in studying the effect of biological and phosphate fertilization on plant growth and its medical and economic importance in Iraq, This study has been proposed with the aim of studying the effect of different types of bio-fertilizers by interaction with the adding of different levels of phosphorus in the growth indicators of the fennel plant.

Materials and methods

A factorial field experiment was conducted for the agricultural season 2018-2019 in Al-Watifiya region (40 km north of Babylon province), where the seeds of the plant were planted in soil with known characteristics. The experimental land was plowed with a moldboard plow , and then leveling and smoothing were performed .The experiment was conducted on 10/15/2018 and the cultivation was done by placing (3-4) seeds in each pit with a distance of 25 cm between one pit and another. The bio-fertilizers, which was obtained from the Agricultural Research Department of the Ministry of Science and Technology, was added at four levels, namely (without addition, mycorrhiza, and *Azotobacter spp* , Mycorrhiza + *Azotobacter spp*). By 5 g per pit

Table (1) Physical and chemical properties of field soils

Uints	Values	Traits	
———————	7.9	pH	
$ds.m^{-1}$	2.8	EC	
$gm.kg^{-1}$	9.3	Ca	Dissolved positive

$gm.kg^{-1}$	**5.9**	**Na**	**ions**
$gm.kg^{-1}$	**0.31**	**K**	
$gm.kg^{-1}$	**93**	**Total nitrogen**	
$gm.kg^{-1}$	**19.2**	**Organic matter**	
$gm.kg^{-1}$	**238.7**	**sand**	**soil separates**
$gm.kg^{-1}$	**362.1**	**Silt**	
$gm.kg^{-1}$	**399.2**	**Clay**	
	clay loam	**Soil Texture**	
$gm.m^{-3}$	**1.42**	**Bulk density**	

Where the strength of spores for the fungus reached 40 g. spores $^{-1}$and the vaccine strength of bacteria was 2.8×10^{10} per g. Load the fungal vaccine onto the cultivated medium of peat moss (35 g per 1 g of soil), taking into account that it is close to the seed inside the pit, while the bacterial vaccine was liquid. As the seeds were soaked in it for an hour, and the gum Arabic material was applied to fix it on the surface of the seeds to be cultivated. After a month of cultivated, the seeds with the bacterial vaccine were reinforced again. With the process of thinning the plants by leaving one plant in its pit after the height of the plants (10 cm). The woods were controlled by manual hoeing, bearing in mind that the experiment land was almost empty of woods. The plants were harvested on (20/5/2019) after the fruits ripened and were stained with olive color and before complete drying. With the process of thinning the plants by leaving one plant in its pit after the height of the plants (10 cm). The woods were controlled by manual hoeing, bearing in mind that the experiment land was almost empty of woods. The plants were harvested on (20/5/2019) after the fruits ripened and were stained with olive color and before complete drying. All agricultural operations used in this crop were conducted from irrigation, weeding, and the number of plants in pit to 2 or 3 plants. Then the studied traits at the end of the growing season were measured on five plants that were randomly taken in each experimental unit and included the plant height (cm), The number of vegetative branches (branch.plant^{-1}), the dry weight of the vegetative growth(g), the number of inflorescences (inflorescences .plant^{-1}), number of florets in inflorescences (florets . inflorescences $^{-1}$),The 1000 grains weight (g) , total fruit yield (tons.ha^{-1}). After taking, arranging and tabulating the measurements, the statistical analysis was conducted using Excel on the computer To factorial experiment with the Randomized Complete Block Design (RCBD) as reported by Al-Rawi and Khalaf Allah (1980) and using LSD test to compare the mean of the coefficients for each source of variance with significant effect.

Results and discussion

The plant height (cm):

The data in Table (2) shows that there were significant differences between the bio-fertilizer treatments for the plant height, where the treatment of bacterial adding A2 (Azotobacter) significantly excelled on the rest treatments and gave the highest average of (159.75 cm), while treatment A0 (without fertilizer) gave the lowest average this trait 134.42 cm. As for phosphate fertilizer, treatment B2 (60 $kg.ha^{-1}$) was significantly excelled on the rest treatments and gave the highest average (159.17 cm). compared to treatment B0 (without fertilizer) gave the lowest average (137.08 cm). The interaction of the two factors of the experiment had a significant effect in this trait, where the data of the same table showed that the A2B2 treatment was significantly excelled and gave the highest average of (168.00 cm) followed by the A3B2 interaction (167.67 cm) without differing significantly. Where, treatment A0B0 gave the lowest average value (126.33 cm) without having significant differences with the treatment of interaction according to the conditions of the experiment. The cause of significantly excelled may be due to the induction of the bio-fertilizer, the increase in the secretion of activated growth regulators such as Auxin, Cytokinins, gibberellins and kinase that contribute to increased cell division and expansion and elongation of plant tissues, which increases plant height (Abu Saud et al., 2017).

Table (2) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on plant height trait(cm)

phosphate fertilizers					bio fertilizers
average	**B3**	**B2**	**B1**	**B0**	
134.75	135.67	139.67	137.33	126.33	**A0**
150.67	153.00	161.33	158.33	130.00	**A1**
159.75	159.33	168.00	159.67	152.00	**A2**
155.42	154.67	167.67	159.33	140.00	**A3**
	150.67	159.17	153.67	137.08	**average**
5.99 AB 2.995 A , B					**L.S.D.**

The number of vegetative branches (branch.plant $^{-1}$):

Table (3) shows that the bio-fertilizer achieved significant differences in the number of vegetative branches, where treatment A2 significantly excelled on the rest treatments and gave the highest average of (14.58 branch.plant $^{-1}$) compared to the control treatment 9.08 (branch.plant $^{-1}$) .As for phosphate fertilizer, treatment B2 was significantly excelled on the rest treatments and gave the highest average of (13.50 branch.plant $^{-1}$) compared to the control treatment that gave the lowest average of (9.92

branch.plant $^{-1}$).As for the interaction of the experiment factors, the interaction (A2B2 and A2B3) excelled and given (15,33,15. branch.plant $^{-1}$) Respectively for each of them without significant difference with (A2B1 and A3B2) which registered (15.00 branch.plant $^{-1}$). Where the interaction treatments A0B1 gave the lowest average value of (8.33 branch.plant $^{-1}$) without significantly differing with the control treatment and the interaction A1B0. The two records a revised average of (8.67 branch.plant $^{-1}$) for each of them. The reason for the significantly excelled can be due to that this species is one of the stimulating species for the growth of many plants and for various plant families where it has a positive effect on growth and this may explain the role of this type of bacteria in the secretion of many compounds that improve physiological processes, It also increases the susceptibility of the roots to the absorption of water, Micro and Macronutrients, and this, in turn, has a positive effect on plant growth and development (Kamil et al., 2008).

Table (3) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on The number of vegetative branches (branch.plant^{-1})

phosphate fertilizers					bio fertilizers
average	**B3**	**B2**	**B1**	**B0**	
9.08	9.00	10.33	8.33	8.67	**A0**
11.25	11.67	13.33	11.33	8.67	**A1**
14.58	15.33	15.33	15.00	12.67	**A2**
12.67	13.67	15.00	12.33	9.67	**A3**
	12.42	13.50	11.75	9.92	**average**
1.141 AB 0.571 A , B					**L.S.D.**

The dry weight of Vegetable growth (g):

Table (4) indicates the treatment A2 significantly excelled, where it gave the highest average dry weight of Vegetable growth amounted to (12.92 g), without significant difference with the treatment A3 that was recorded (11.08 g), while treatment A0 gave the lowest average value (7.83 g). As for phosphate fertilizer, treatment B2 was significantly excelled and gave the highest average of (12.17 g), where treatment B0 gave the lowest average of (9.01 g) without significantly differing with treatment B1 which gave (9.47 g). The interaction of the two study factors significantly increased the A2B2 interaction significantly and gave the highest average of (15.33 g) compared to the control treatment that recorded the lowest average of (6.03 g). The influence of the metabolic and physiological

processes of the plant is due to the activity of the bacteria that caused a significant response in the vegetative indicators and this effect was reflected in the vegetative growth of the plant. Perhaps this response may be due to the processing of plants with atmospherically proven nitrogen, as these bacteria have a high ability to Nitrogen fixation freely, which meets the need of the plant for this. The necessary element that is included in many activities in addition to its entry into the composition of many important organelles such as chlorophyll, proteins, amino acids, organic and nuclear DNA, and its effect is beneficial in increasing the growth of the vegetative system, In addition to compensating for the rapid loss of the nitrogen component where a result of the rapid melting of some easily soluble nitrogenous compounds, this positively increases the fertility of the soil and preserves its fertile components, which benefits the growth and development of the plants growing there (Al Abbasi and Al-Zuhairi, 2018).

Table (4) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on the dry weight of the vegetative growth(g)

phosphate fertilizers					bio fertilizers
average	**B3**	**B2**	**B1**	**B0**	
7.83	8.33	10.00	6.97	6.03	**A0**
9.67	10.00	9.67	9.67	9.33	**A1**
12.92	13.67	15.33	12.00	10.67	**A2**
11.08	10.90	13.67	10.33	10.00	**A3**
	10.58	12.17	9.47	9.01	**average**
1.693 AB 0.846 A , B					**L.S.D.**

The number of inflorescences (inflorescences.plant $^{-1}$):

Table (5) indicates the excelled of treatment A1 significantly and gave the highest average number of inflorescences (14.00 inflorescences . plant $^{-1}$), where treatment A0 gave the lowest average of 10.58 inflorescences . plant $^{-1}$. As for phosphate fertilizer, treatment B2 excelled significantly and gave the highest average for this trait amounted to (13.33 inflorescences . plant $^{-1}$) without having significant differences with treatment B3 recorded (12.42 inflorescences . plant $^{-1}$), while treatment B0 gave the lowest average of (11.58 inflorescences . plant $^{-1}$). As for the interaction between the levels of biological and phosphate fertilizer, the A1B2 interaction excelled and gave the highest average of (15.33 inflorescences . plant $^{-1}$), while the control treatment A0B1 gave the lowest average of (10.33

inflorescences . plant $^{-1}$). The above results indicate the significant effect of bio-fertilizer on the indicators of flowering growth when pollinated with mycorrhiza fungi, which can be due to its role in increasing the absorption of macronutrients, which leads to increased cell division and elongation and an increase in the surface area of the leaves, which in turn leads to increased food and carbohydrate production and thus increases Of the size of the vegetative and flowering growth resulting in increased flower diameter (Tsavkelov et al., 2006 and Shaheen et al., 2007).

Table (5) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on the number of inflorescences (inflorescences .plant^{-1})

phosphate fertilizers					bio fertilizers
average	B3	B2	B1	B0	
10.58	10.33	11.33	10.33	10.33	**A0**
14.00	14.33	15.33	12.67	13.67	**A1**
11.67	11.00	13.00	12.33	10.33	**A2**
13.08	14.00	13.67	12.67	12.00	**A3**
	12.42	13.33	12.00	11.58	**average**
		1.225 AB	**0.613 A , B**		**L.S.D.**

The number of florets in the inflorescence (florets. inflorescence $^{-1}$)

Table (6) shows the treatment significantly excelled and gave the highest average number of florets in the inflorescence reached (10.17 florets. inflorescence $^{-1}$), where treatment A0 gave the lowest average of (7.25 florets. inflorescence $^{-1}$) without significantly differing with treatment A2 that was recorded (7.83 florets. inflorescence $^{-1}$).Concerning phosphate fertilizer, treatment B2 was significantly excelled and gave the highest average number of florets in the inflorescence (9.67 florets. inflorescence $^{-1}$), while treatment B0 gave the lowest average (7.42 florets. inflorescence $^{-1}$).With regard to the interaction between the levels of biological and phosphate fertilizer, the two interaction treatments A1B2 and A3B2 were excelled and gave the highest average of (10.67 florets.inflorescence $^{-1}$), while the treatment A2B0 gave the lowest average number of florets in inflorescence reached (6.00 florets. inflorescence $^{-1}$).

Table (6) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on number of florets in inflorescences (florets . inflorescences $^{-1}$)

phosphate fertilizers					bio fertilizers
average	**B3**	**B2**	**B1**	**B0**	
7.25	7.33	7.67	7.00	7.00	**A0**
10.17	10.33	10.67	9.67	10.00	**A1**
7.83	8.33	9.67	7.33	6.00	**A2**
8.75	9.33	10.67	8.33	6.67	**A3**
	8.83	9.67	8.08	7.42	**average**
		1.26 AB	**0.630 A , B**		**L.S.D.**

The 1000 grains weight (g.plant^{-1}):

Table (7) indicates the treatment A1significantly excelled and gave the highest average of (10.33 g.plant^{-1}), while the treatment A0 gave the lowest average value (7.00 g.plant^{-1}). As for phosphate fertilizer, treatment B2 was significantly excelled to the control treatment only, without having significant differences with the rest of the treatments, where it gave the highest average The 1000 grains weight amounted to (9.25 g.plant^{-1}), Where, treatment B0 gave the lowest average of(8.08 g.plant^{-1}). As for the interaction between the levels of bio-fertilizer and phosphate, the interaction treatment A1B2 excelled and gave the highest amount (11.67 g.plant^{-1}), while the control treatment gave the lowest average of (6.67 g.plant^{-1}), The reason may be due to the ability of mycorrhiza fungi to produce plant hormones, such as gibberellins and Auxin, which have a role in regulating and improving plant growth and then increasing synthetic carbohydrates. Cytokinin also plays an important role in improving yield and flowering traits (Jassim et al., 2014).

Table (7) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on The 1000 grains weight (g)

phosphate fertilizers					bio fertilizers
average	**B3**	**B2**	**B1**	**B0**	
7.00	7.33	7.00	7.00	6.67	**A0**
10.33	10.00	11.67	10.00	9.67	**A1**
8.25	8.33	8.00	9.33	7.33	**A2**
9.50	9.67	10.33	9.33	8.67	**A3**

	8.83	9.25	8.92	8.08	**average**
		1.141	**AB**	**0.57** **A , B**	**L.S.D.**

Total fruit yield (tons. ha^{-1}):

Table (8) shows the treatment A1 significantly excelled on the rest of treatments and gave the highest average of (1.46 tons. ha^{-1}), while treatment A0 gave the lowest average of (0.71 tons. ha^{-1}). As for phosphate fertilizer, treatment B2 was significantly excelled and gave the highest average total fruit yield of (1.27 tons. ha^{-1}). While treatment B0 achieved the lowest average value for this trait of (0.91 tons. ha^{-1}). As for the interaction of the two study factors, the results of the same table showed the excelled of the A1B2 interaction and gave the highest average of (1.83 tons. ha^{-1}), while the control treatment gave the lowest average of (0.61 tons. ha^{-1}) . The increase in yield indicators may be due to bio-fertilizer containing PGPR, which led to the promotion of growth through the strategies that the biology system operates, especially the provision of nutrients, increased plant resistance to biotic and abiotic stresses, and the production of different growth regulators and chelating compounds (Allawi, 2013). The increase in the traits of growth, the number of vegetative branches, and the number of inflorescences were clearly reflected in the indicators of the plant's yield, which led to a significant increase, Moreover, the increase in the materials manufactured in leaves represented by proteins and carbohydrates where a result of the effectiveness of soil microorganisms, was clearly reflected in the construction of plant tissues, which consequently improved the level of vegetative and flowering growth by providing balanced nutrients that improved their growth impact (Al-Nuaimi, 2008).

Table (8) Effect of Bio fertilizers and Phosphate fertilizers and their interaction on total fruit yield (tons.ha^{-1}).

phosphate fertilizers					**bio fertilizers**
average	**B3**	**B2**	**B1**	**B0**	
0.71	0.75	0.78	0.69	0.61	**A0**
1.46	1.42	1.83	1.28	1.30	**A1**
0.96	0.91	1.03	1.14	0.74	**A2**
1.23	1.33	1.43	1.18	1.00	**A3**
	1.10	1.27	1.07	0.91	**average**
		0.207	**AB**	**0.104** **A , B**	**L.S.D.**

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