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EFFECT OF ORGANIC AND BIO-FERTILIZATION ON THE VEGETATIVE YIELD FOR TWO CULTIVARS OF BASIL PLANT

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Abstract

The study was conducted in the nursery and orchards development project belonging to Directorate of Agriculture in Karbala, which located in Al-Husseiniya, Um Grager region, for the period from 2/1/2018 to 2018/1 in order to study the effect of organic fertilizer prepared from palm leaves, bio-fertilizer formed from (*Azotobacter* bacteria and *Mycorrhiza*) and the interaction between them in vegetative and root growth indicators and the production of some medically effective secondary metabolites in the volatile oils for the two cultivars (local and red) of Basil plant (*Ocimum basilicum* L.). Two experiments were conducted according to the Randomized Complete Block Design (RCBD) in the order of the Nested system, and in three replicates, the total number of treatments and their replicate became 72 experimental units. The experiment included two factors, where the organic fertilization factor (palm leaves) represented the main plots which are three levels (S1: without adding fertilizer, S2: adding (30 tons.ha^{-1}), S3: adding (60 tons.ha^{-1}). The sub-plots included the bio-fertilization with four levels (C1: without adding bio-fertilizer, C2: adding of Azotobacter bacteria only, C3: adding of the Mycorrhiza fungus only, C4: adding the mixture of Azotobacter bacteria with the Mycorrhiza fungus. The first experiment was cultivated with the local cultivar T1 and the second experiment with red cultivar T2. The results were statistically analyzed by using the genstat statistical program and the averages for all the study indicators were compared according to the least significant difference of LSD at the 5% probability level. It was compared between the local cultivar and red cultivar according to T-test. The results of the study showed that the organic fertilization treatment (60 tons.ha^{-1}) S3 was excelled in all vegetative and root traits, which included plant height, leaf area, fresh weight for total vegetative, dry weight for total vegetative, the amount of fresh yield vegetative, root length, the weight of fresh root, the weight of dry root for local cultivar (42.29 cm.plant^{-1}, 22.32 cm^2.leaf^{-1}, 103.91 g.plant^{-1}, 11.77 g.plant^{-1}, 138.14 g.plant^{-1}, 16.75 cm.plant^{-1}, 13.50 g.plant^{-1}, 4.50 g.plant^{-1}) and red cultivar (55.55 cm.Plant^{-1}, 26.62 cm.Plant^{-1}, 115.40 g.plant^{-1}, 12.66 g.plant^{-1}, 149.75 g.plant^{-1}, 24.50 cm.plant^{-1}, 33.25 g.plant^{-1}, 11.88 g.plant^{-1}). The results of the study showed that the interaction between Azotobacter bacteria with the Mycorrhiza fungus C4 was excelled in all vegetative and root traits, which included plant height, leaf area, fresh weight for total vegetative, dry weight for total vegetative, the amount of fresh yield vegetative, root length, the weight of fresh root, the weight of dry root for local cultivar (39.00 cm.plant^{-1}, 21.63 cm^2.leaf^{-1}, 96.00 g.plant^{-1},1.17 g.plant^{-1}, 136.80 g.plant^{-1}, 15.67 cm.plant^{-1}, 12.00 g.plant^{-1}, 4.00 g.plant^{-1}) and red cultivar (62.29 cm.plant^{-1}, 24.83 cm^2.plant^{-1},106.70 g.plant^{-1}, 12.00 g.plant^{-1},156.93 g.plant^{-1}, 23.67 cm.Plant^{-1}, 33.11 g.Plant^{-1}, 11.33 g.plant^{-1}). The bi-interaction treatment S3C4 was excelled on the traits of vegetative and root growth, volatile oils, qualitative traits, which included plant height, leaf area, fresh weight for total vegetative, dry weight for total vegetative, the amount of yield vegetative, root length, the weight of fresh root and dry root.

Keywords: organic, bio-fertilization, vegetative yield, Basil plant

Introduction

Medical plants have been used since ancient times in the Therapeutics and treating simple and deadly diseases. This is confirmed by wise men, doctors, and specialists. A number of countries are still relying on different medicinal plants to treat various diseases, depending on the methods of modern medicine. The World Health Organization (WHO) indicated that about 80% of the world's population relies on medicinal herbs as a primary medicine for treating a number of diseases (Mamedov, 2012). Plant drug has long been the main source of drug in developing countries, and in developed countries. Statistics have shown an increase in the number of herbal medicine users in Europe, North America, Australia, and Asia. In Germany, for example, 70% of doctors recommend using herbs for therapeutic purposes, while the rise in sales of herbal medicines is noted in the United Kingdom, Spain and the United States of America (Chevalier, 2001). The reason for increasing the use of herbs in the therapy recently, is the lack of side effects because the few concentrations of active substances contained in the body accepted by the medical form (UNESCO, 1992), and for the large side effects associated with using the chemical drugs and increasing the risk, which led to increasing the aimed scientific research at discovering more medical benefits of pharmaceuticals, on the other hand, we note the increased demand for medicinal plants around the world. Basil (*Ocimum basilicum* L.) belongs to Lamiaceae family. This family includes about 200 species and several cultivars spread in Asia and Africa, which are believed to be the original home of the plant. The cultivated area with the basil plant in the world is estimated at about 5000 ha, and the world oil production is estimated at about 95 metric tons annually (Lawrence, 1992). The use of chemical fertilizer mainly and with high concentrations lead to many problems and negative effects, including environmental pollution, so people resorted to the use of organic fertilizer and vital to maintain the health of humans and animals (Al-Ridiman, 2004). Organic fertilization is considered one of the most important factors influencing the growth and production of plants, especially leafy crops, as well as the addition of these fertilizers lead to improving the traits of the vegetative growth as well as improving the pathways of bio-activities inside plant (Al-Drukzli, 2005). It is also a good source for supplying the plant with nutrient elements and minimization of loss by leaching for its role in the exchange of elements on surfaces of soil particles. It also reduces the pH of the soil solution, Thus affecting the dissolving of metals and making their mineral elements more available (Hartman, 2002). It has been shown through many types of research and scientific experiments that organic fertilizers have a clear effect in increasing the percentage of production of volatile oils (Abu Zeid, 2000). One of the modern technologies used in the agricultural sector is the use of bio-fertilizers, which aim to increase production both qualitatively and qualitatively

(Kloepper et al., 1990). There are different types of bio-fertilizers used in the fertilization of plants, it is bacterial and fungal. The most important biological bacterial fertilizers are the nitrogen-fixing bacterial group, such as *Azotobacter chroococcum*, as well as the Phosphate solubilizing bacteria (PSB) group and the potassium solubilizing bacterial group (Suhail and Fahmi, 2009). Mycorrhiza fungi are considered the most important fertilizers used in supplying the plant with nutrient elements through their symbiotic symbiosis with plant roots (Malusa *et al*., 2016). Several studies have shown that the bio-fertilization works to improve the growth indicators of vegetable crops, especially vegetative growth, by supplying the plant with nutrient elements and increasing its plant availability. Due to the importance of Basil plant (food and medicinal) and due to the lack of studies on this plant in Iraq, this study aims to raise the efficiency of the plant and its ability to produce quantitative and qualitative sub-metabolites through the use of a safe nutrition program for the environment and consumer.

Materials and Methods

Conducting the Experiment

Two field experiments were conducted in the spring season of 2018 in the nursery and orchards development project belonging to Directorate of Agriculture in Karbala, which located in Al-Husseiniya, Um Grager region, in order to studying the response of two cultivars of sweet Basil plant (*Ocimum basilicum* L.) for organic and bio-fertilization and their interaction on vegetative and root growth, Plant yield and some active components in volatile oil. Random samples were taken from the field and from different places, with a depth of 0-30 cm, It was well mixed to obtain homogeneous soil for the purpose of completing the necessary analysis. The analysis was conducted at the Central Laboratory for the College of the Agricultural Engineering Sciences, University of Baghdad. The soil was plowed into two perpendicular plows and was well smoothed with conducting the settling process. The land was divided into terraces with a width of 180 cm and a length of 58 m and with three longitudinal plots. After that, the terraces were divided into plots (experimental units), with dimensions (180 x 180 cm^2), the number of experimental units 72. The drip irrigation system was placed which consisted of the main pipe with a diameter of 3 inches that placed in the middle of the experiment and branching out from it on the two sides a Lateral Pipes, which carries the drippers, with T-tube type from Lebanese origin. The irrigation was conducted by an electric pump installed on the central concrete basin located in the location of the project, which is fed by water from the Um Grager River, which is connected with Al-Husseiniya River. The local basil seeds were obtained from the local markets, while the seeds of the red basil were imported from the Islamic Republic of Iran "Ferdowsi University". The seeds of the two cultivars were examined in the branch of the General Company for the Inspection and Certification of Seeds, Karbala province. The germination rate was 90%. The seeds were cultivated in plastic dishes with the number of their cells (98) cell and using peat moss from German origin on 28/2/2018 in a greenhouse covered with nylon for the purpose of speeding up the germination process. On 4/3/2018 the germination started and the care operations for seedling continued until they reached to the height of 10 cm (Shede *et al*., 1999). The seedlings were transferred to the permanent experiment location on 9/4/2018. The organic fertilizer (palm leaves) was distributed on the terraces according to the required levels and it was mixed with the soil well. The agricultural lines were then determined according to the required distances (30 x 30 cm) between seedlings and others, as well as between one line and another, Light irrigation was given to the location of the experiment by means of a drip irrigation system. After the soil reached the appropriate moisture, the pit for seedlings was identified and dug at a depth of about 5 cm. The fertilizer was placed in it so that it is contacted with the roots of the seedlings, after the cultivating of the seedlings, the irrigation was given to the field with a moderate quantity to conserve the bio-fertilizers. The service operations for the field continued, such as irrigation, Grubbing and weeding, as needed (Matlub et al., 1980). The experimental unit consisted of five lines of each line containing five plants. Thus, the number of plants per experimental unit is 25 plants. Two lines of each plot were allocated for measuring the yield for each plant and for the unit area as a cumulative yield, with a rate of two cutting during the experiment season. Two lines were also allocated from each plot to measure vegetative growth indicators and the yield and quality of the volatile oils and its active components, with leaving a line from each plot as a guard line. Two plants were taken during the growing season, the first cutting on 21/5/2018 and the second one on 18/6/2018 (Abu Zeid, 1992).

Bio-Fertilizers

Bio-fertilizers were obtained from the Department of Agricultural Research, Al-Zaafaraniyah belonging to the Ministry of Science and Technology. The bio-fertilizer used in the experiment is:

1- *Azotobacter chrooccum* bacteria

2- *Glomus mosseae* fungi

Bacterial Isolation extracted from Tomato roots and their location Baghdad Al-Tuwaitha (10 × 5.2). Mycorrhiza: Number of spores amounted to (40 spores $.g^{-1}$ soil).

Preparation of Organic Fertilizers (palm leaves):

The organic fertilizer (palm leaves) was prepared at the location of the organic fertilizer and fungus cultivation project belonging to the Directorate of Agriculture in Karbala. Where one ton of palm leaves was prepared after crushing it with an electric hammer mill with length of (2-5 cm), the crushed palm leaves was wetted with water for 8 days until the color becomes light brown and humidity 75% and add to it the Poultry waste with amount of 100 kg and on two meals and adding with it 10 kg of urea and 10 kg Phosphorus pentoxide and mix well and making from it a block with height of 170 cm and 170 cm width, This stage is considered the beginning of the reaction stage, after which seven to nine mixings are conducted each one at the end of the week. The urea is added in three stages and in equal quantities for each of the first, second and third mixings. The second quantity of Poultry waste is added with full and homogenous mixing with the third mixing (With the latest batch of urea fertilizer), The remaining mixings will be conducted only by spraying with water and the spraying continues to the extent that compensates for the loss of evaporation so that we maintain moisture 75%.

Table 1: Chemical analysis for palm leaves fertilizer.

Traits	Values
Electrical conductivity EC	2.66
C	43.7
P	0.650
K	2.80
Ca	2.93
Mg	0.580
Na	0.622
Fe	0.423
Zn	0.055
Mn	0.013
C	0.005

Table 2: Physical, chemical and biochemical traits for the soil of the experiment field before cultivating.

Traits	Units	Values
Ph	-	7.4
Ec	$dS.m^{-1}$	2.8
Mg	%	6.30
Lime	$mg.kg^{-1}$ soil	181.03
N		4.20
P		2.11
K		17.13
Organic matter		6.8
A total number of bacteria	g. Dry soil C F U	1.2 x 10
Total number of fungi		1.5 x 10

Experimental Design

Two experiments were conducted according to the Randomized Complete Block Design (RCBD) in the order of the Nested system, and in three replicates, the total number of treatments and their replicate became 72 experimental units. The area of the experimental unit is (24.3 m^2) (180 x 180 cm). The experimental unit contains 25 plants, the distance between the plant and another is 30 cm, between line and another, is 30 cm. The three longitudinal terraces were isolated by the one-meter distance between them and between the replicates at a distance of half a meter. The incision was dug to a depth of half a meter between the replicators, where nylon was placed vertically in it and buried in the soil for the purpose of isolating the replicates and preventing the mixing of the microorganisms used in the bio-fertilizers. The experiment included three factors:

The first factor: (main plot) organic fertilizer prepared from palm leaves which added in three levels and symbolized by S as follows:

S1 = without adding organic fertilizer.

S2 = Adding organic fertilizer in the amount of (30 $tons.ha^{-1}$)

S3 = Adding organic fertilizer in the amount of (60 $tons.ha^{-1}$)

The second factor: (Subplot) bio-fertilizer and included four additions which symbolized by C as follows:

C1 = without adding Bio-fertilizer.

C2 = adding Azotobacter bacteria (*Azotobacter chroococcum*)

C3 = Adding Mycorrhiza fungus (*Glomus mosseae*)

C4 = Adding a mixture of Azotobacter bacteria + Mycorrhiza fungus

It was compared between the local cultivar and red cultivar by T-test

The studied traits:

Traits of vegetative growth

The following traits were measured as the average for ten plants taken randomly for each experimental unit on 10/6/2018.

(i) Plant height ($cm.plant^{-1}$)

Plant height in each experimental unit was measured from the level of the soil surface to the highest point at the top of the plant and according to its average.

(ii) Leaf area ($cm^2.plant^{-1}$)

The leaf area was calculated by selecting five plants from each experimental unit. The scanner was used by the Digimizer program loaded on a computer type of hp and according to (Sadik et al., 2011). The result is calculated according to the following equation:

$$\text{leaf area } (cm^2.plant^{-1}) = \frac{\text{The average area for one leaf } (cm^2)}{\text{Number of leaves per plant}} \times 100$$

(iii) Fresh weight for total vegetative ($g.plant^{-1}$)

Plants were pulled and cut at the crown area in order to separate the total vegetative from the root system and the total vegetative was then weighed with a sensitive balance (KERN 572, Japanese origin) and ten plants were selected from each experimental unit.

(iv) Dry weight for total vegetative ($g.plant^{-1}$)

The plants dried at room temperature and The plants were placed in perforated paper bags to protect them from dust, direct sunlight and a well-ventilated room. Until the completion of dry, Dry weight was recorded by a sensitive balance type KERN 572.

(v) The amount of fresh vegetative yield ($g.plant^{-1}$)

Plant cut at a height of 10 cm from the level of the soil surface and the remaining part leave to enable the plant to re-grow again (Darhab, 2005). The harvested plants were placed in transparent polyethylene bags and were weighed directly after harvested by a sensitive balance of KERN 572 to extract the fresh weight of each sample, which represents the amount of fresh yield (after extracting the weight of the bag). The plants were harvested by the rate of two cuttings, the period between one cutting and another is 27 days. The first cutting was after 42 days from the date of transfer of the seedlings to the permanent place. The yield of the first cutting was collected with the yield of the second cutting to represent the fresh vegetative yield.

Root traits

The roots were extracted for the selected plants from the experimental units, with a rate of the five plants and the roots were well washed with water from a tap with a small and quiet flow. Then the roots dried up and left in the air in a special room with good ventilation. The following measurements were taken:

(i) Root length (cm.plant^{-1})

It was measured by measuring tape from the crown area to the end of the bottom root.

(ii) Fresh weight of root (g.plant^{-1})

The roots were weighed with a sensitive balance of KERN 572

(iii) The dry weight of root (g.plant^{-1})

After drying the selected roots, they were placed in the perforated paper bags at a room with good ventilation until full drought and weight stability.

Results and Discussion

Traits of vegetative growth

(i) Plant height (cm.plant^{-1})

The results of Table (5) for the local cultivar showed a significant effect of organic fertilization in plant height, where the treatment of organic fertilization ((60 tons.ha^{-1}) S3 was excelled by giving it the highest average amounted to (42.29) while the control treatment (without fertilization) S1 gave the lowest average amounted to (30.72 cm.plant^{-1}). The results showed that the treatment of the bio-fertilization (mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest height amounted to (39.00) and did not differ significantly from the treatment of the bio-fertilization with Mycorrhiza fungus C3, which recorded a height amounted to (38.21 cm.plants^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest height amounted to (34.51 cm.plants^{-1}). The bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 gave the highest height amounted to (44.00) and did not differ significantly from the two treatments of (S3C3, S3C2), which recorded a height amounted to (43.00, 42.15 cm.plants^{-1}), while the S1C1 treatment gave the lowest height amounted to (24.88 cm.plant^{-1}). Table (6) for the red cultivar also showed a significant difference in the same trait, where the treatment of organic fertilization ((60 tons.ha^{-1}) S3 was excelled by giving it the highest average amounted to (55.55 cm.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest average amounted to (47.47 cm.plant^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 was excelled on all other treatments by giving it the highest height amounted to (67.88 cm.plant^{-1}) while the S1C1 treatment gave the lowest height amounted to (26.11 cm.plant^{-1}).

Table 5: Effect of organic fertilizer and bio-fertilizer and their interaction in the Basil plant height (local cultivar) (cm.plant^{-1}).

Organic fertilizer	Bio-fertilizer C1	C2	C3	C4	Average of Organic fertilizer
S1	24.88	32.55	32.44	33.00	30.72
S2	38.66	39.00	39.20	40.00	39.21
S3	40.00	42.15	43.00	44.00	42.29
LSD	2.37				1.73
Average of Bio-fertilizer	34.51	37.90	38.21	39.00	
LSD	1.26				

Table 6: Effect of organic fertilizer and bio-fertilizer and their interaction in the Basil plant height (red cultivar) (cm.plant^{-1}).

Organic fertilizer	Bio-fertilizer C1	C2	C3	C4	Average of Organic fertilizer
S1	26.11	52.00	54.33	57.44	47.47
S2	34.44	52.66	54.22	61.55	50.72
S3	38.22	57.88	58.22	67.88	55.55
LSD	2.24				1.96
Average of Bio-fertilizer	32.92	54.18	55.59	62.29	
LSD	0.96				

(ii) Leaf Area (cm^2.Plants^{-1})

The results of Table (7) for the local cultivar showed a significant effect of organic fertilization in leaf area (cm^2.Plants^{-1}), where the treatment of organic fertilization ((60 tons.ha^{-1}) S3 was excelled by recording it the highest average amounted to (22.32 cm^2.Plants^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest average amounted to (15.15 cm^2.Plants^{-1}). The results showed that the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest leaf area amounted to (21.63 cm^2.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest leaf area amounted to (17.33 cm^2.plants^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 was excelled by giving it the highest leaf area amounted to (25.52 cm^2.plants^{-1}) while the S1C1 treatment gave the lowest lead area amounted to (13.00 cm^2.plant^{-1}). Table (8) for the red cultivar also showed that the treatment of organic fertilization ((60 tons.ha^{-1}) S3 was excelled by giving it the highest average amounted to (26.62 cm^2.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest average amounted to (20.75 cm^2.plant^{-1}). The treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest leaf area amounted to (24.83 cm^2.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest leaf area amounted to (21.30 cm^2.plants^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 gave the highest leaf area amounted to (30.00 cm^2.plants^{-1}) and did not differ significantly from the S2C3 treatment, which recorded a leaf area amounted to (29.00 cm^2.plants^{-1}), while the S1C1 treatment gave the lowest leaf area amounted to (20.00 cm^2.plant^{-1}).

Table 7: Effect of organic fertilizer and bio-fertilizer and their interaction in the leaf area (cm^2.plant^{-1}) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	13.00	13.50	16.10	18.00	15.15
S2	18.50	19.56	20.00	21.40	19.87
S3	20.50	21.26	22.00	25.50	22.32
LSD	1.98				1.95
Average of Bio-fertilizer	17.33	18.11	19.37	21.63	
LSD	0.41				

Table 8: Effect of organic fertilizer and bio-fertilizer and their interaction in the leaf area (cm^2.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	20.00	20.50	21.00	21.50	20.75
S2	21.90	22.00	22.50	23.00	22.35
S3	22.00	25.50	29.00	30.00	26.62
LSD	1.89				1.79
Average of Bio-fertilizer	21.30	22.67	24.17	24.83	
LSD	0.62				

(iii) Fresh weight for total vegetative (g.plant^{-1})

The results of Table (9) for the local cultivar showed a significant effect between the treatments in fresh weight for total vegetative (g.plant^{-1}), where the treatment of organic fertilization ((60 tons.ha^{-1}) S3 was excelled by recording it the highest average amounted to (103.91 g.Plants^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest average amounted to (46.51 g.Plants^{-1}). The results showed that the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest weight amounted to (95.55 g.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest weight amounted to (64.28 g.plants^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 was excelled by giving it the highest weight amounted to (125.66 g.plants-1) while the S1C1 treatment gave the lowest weight amounted to (30.50.plant^{-1}). Table (10) for the red cultivar also showed a significant difference between the treatments in the same trait, where the treatment of organic fertilization ((60 tons.ha^{-1}) S3 was excelled by giving it the highest average amounted to (115.40 g.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest average amounted to (51.30 g.plant^{-1}). Bio-fertilization treatments were significantly excelled among them, where the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest weight amounted to (106.70 g.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest weight amounted to (70.50 g.plants^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (a mixture of Azotobacter and Mycorrhiza) S3C4 gave the highest weight amounted to (140.00 g.plants^{-1}) while the S1C1 treatment gave the lowest weight amounted to (32.20 g.plant^{-1}).

Table 9: Effect of organic fertilizer and bio-fertilizer and their interaction in the fresh weight for total vegetative (g.plant^{-1}) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	30.50	40.00	45.55	70.00	46.51
S2	76.33	80.00	85.00	94.00	83.83
S3	86.00	99.66	104.33	125.66	103.91
LSD	2.13				1.88
Average of Bio-fertilizer	64.28	73.22	78.29	96.55	
LSD	0.90				

Table 10: Effect of organic fertilizer and bio-fertilizer and their interaction in the fresh weight for total vegetative (g.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	32.20	45.00	48.00	80.00	51.30
S2	83.00	61.30	90.00	100.00	83.60
S3	96.30	110.00	115.20	140.00	115.40
LSD	N.S				13.68
Average of Bio-fertilizer	70.50	72.10	84.40	106.70	
LSD	13.13				

(iv) Dry weight for the total vegetative (g.plant^{-1})

The results of Table (11) for the local cultivar showed that the treatment of organic fertilization (60 tons.ha^{-1}) S3 was excelled by recording it the highest dry weight amounted to (11.77 g.Plants^{-1}) and did not differ significantly from the fertilizer treatment (30 tons.ha^{-1}) S2, which gave a dry weight amounted to (10.60 g.Plants^{-1}) while the control treatment (without fertilization) S1 gave the lowest average amounted to (7.94 g.Plants^{-1}). The results showed that the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest dry weight amounted to (11.17 g.plant^{-1}) compared the control treatment (without bio-fertilizer) C1 which gave the lowest dry weight amounted to (9.05 g.plants^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C) did not significantly differ between them, The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 was excelled by giving it the highest dry weight amounted to (12.50 g.plants^{-1}) while the S1C1 treatment gave the lowest dry weight amounted to (6.25 g.plant^{-1}). Table (12) for the red cultivar also showed that the treatment of organic fertilization (60 tons.ha^{-1}) S3 was excelled by giving it the highest dry weight amounted to (12.66 g.plant^{-1}) and did not differ significantly from the S2 treatment, which gave (11.10 g.plant^{-1}) while the control treatment (without fertilization) S1 gave the lowest dry weight amounted to (8.00 g.plant^{-1}). Bio-fertilization treatments recorded a significant differing among them, where the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest dry weight amounted to (12.00 g.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest dry weight amounted to (9.84 g.plants^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C) did not differ significantly among them, The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (a mixture of Azotobacter and Mycorrhiza) S3C4 gave the highest dry weight amounted to (140.00 g.plants^{-1}) while the S1C1 treatment gave the lowest weight amounted to (7.00 g.plant^{-1}).

Table 11: Effect of organic fertilizer and bio-fertilizer and their interaction in the dry weight for total vegetative (g.plant^{-1}) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	6.25	8.00	8.00	9.50	7.94
S2	9.90	10.00	11.00	11.50	10.60
S3	11.00	11.60	12.00	12.50	11.77
LSD	N.S				1.59
Average of Bio-fertilizer	9.05	9.87	10.33	11.17	
LSD	0.85				

Table 12: Effect of organic fertilizer and bio-fertilizer and their interaction in the dry weight for total vegetative (g.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	7.00	7.50	7.50	10.00	8.00
S2	10.50	10.90	11.00	12.00	11.10
S3	12.03	12.10	12.50	14.00	12.66
LSD	N.S				1.93
Average of Bio-fertilizer	9.84	10.17	10.33	12.00	
LSD	0.56				

(v) The amount of fresh vegetative yield (g.plant^{-1})

The results of Table (13) for the local cultivar showed there were significant differences between the study factors, where the treatment of organic fertilization (60 tons.ha^{-1}) S3 was excelled by recording it the highest yield amounted to (138.14 g.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest yield amounted to (108.52 g.plant^{-1}). The results showed that the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 recorded the highest yield amounted to (136.80 g.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest weight amounted to (105.00 g.plant^{-1}). The bi-interaction treatments between organic fertilizer and bio-fertilizer (S x C) have significantly differed among them, The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 recorded the highest yield amounted to (147.25 g.plant^{-1}) while the S1C1 treatment gave the lowest yield amounted to (88.88 g.plant^{-1}). Table (14) for the red cultivar also showed a significant difference between the treatments in the same trait, where the treatment of organic fertilization (60 tons.ha^{-1}) S3 was excelled by giving it the highest yield amounted to (149.75 g.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest yield amounted to (138.79 g.plant^{-1}). Bio-fertilization treatments were significantly differed among them, where the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest yield amounted to (156.93 g.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest yield amounted to (121.62 g.plant^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (a mixture of Azotobacter and Mycorrhiza) S3C4 gave the highest yield amounted to (163.00 g.plant^{-1}) while the S1C1 treatment gave the lowest yield amounted to (116.46 g.plant^{-1}).

Table 13: Effect of organic fertilizer and bio-fertilizer and their interaction in the amount of fresh vegetative yield (g.plant-1) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	88.88	123.78	94.08	127.33	108.52
S2	103.13	134.11	129.16	135.83	125.56
S3	123.00	142.69	139.63	147.25	138.14
LSD	2.22				1.90
Average of Bio-fertilizer	105.00	133.53	120.96	136.80	
LSD	0.98				

Table 14: Effect of organic fertilizer and bio-fertilizer and their interaction in the amount of fresh vegetative yield (g.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	116.46	147.66	139.53	151.50	138.79
S2	115.40	124.33	124.00	156.30	130.01
S3	133.00	147.85	155.13	163.00	149.75
LSD	2.47				2.39
Average of Bio-fertilizer	121.62	139.95	139.55	156.93	
LSD	0.69				

Root traits

(i) The length of root (cm.plant^{-1})

The results of Table (15) for the local cultivar showed there were significant differences between the study factors, where the treatment of organic fertilization (60 tons.ha^{-1}) S3 recorded the highest root length amounted to (16.75 cm.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest yield amounted to (11.50 cm.plant^{-1}). The results showed that the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 recorded the highest root length amounted to (15.67 cm.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest weight amounted to (13.00 g). The bi-interaction treatments between organic fertilizer and bio-fertilizer (S x C) have significantly differed among them, The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 recorded the highest root length amounted to (19.00 g) while the S1C1 treatment gave the lowest root length amounted to (10.00 cm.plant^{-1}). Bio-fertilization treatments were significantly differed among them, where the treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 was excelled by giving it the highest root length amounted to (23.67 cm.plant^{-1}) while the control treatment (without bio-fertilizer) C1 gave the lowest yield amounted to (17.33 cm.plant^{-1}). As for the bi-interaction treatment between organic fertilizer and bio-fertilizer (S x C), The interaction treatment between organic fertilization (60 tons.ha^{-1}) and bio-fertilizer (a mixture of Azotobacter and Mycorrhiza) S3C4 gave the highest root length amounted to (27.00 cm.plant^{-1}) while the S1C1 treatment gave the lowest root length amounted to (12.00 cm.plant^{-1}).

Table 15: Effect of organic fertilizer and bio-fertilizer and their interaction in the length of root (cm.plant^{-1}) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	10.00	11.00	12.00	13.00	11.50
S2	14.00	14.00	14.00	15.00	14.25
S3	15.00	16.00	17.00	19.00	16.75
LSD	1.81				1.73
Average of Bio-fertilizer	13.00	13.67	14.33	15.67	
LSD	0.57				

Table 16: Effect of organic fertilizer and bio-fertilizer and their interaction in the length of root (cm.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	12.00	16.00	20.00	21.00	138.79
S2	20.00	21.00	22.00	23.00	130.01
S3	20.00	25.00	26.00	27.00	149.75
LSD	1.71				1.41
Average of Bio-fertilizer	17.33	20.67	22.67	23.67	
LSD	0.81				

(ii) Fresh root weight (g.plant^{-1})

The results of Table (17) for the local cultivar showed there were significant differences between the treatment, where the treatment of organic fertilization (60 tons.ha^{-1}) S3 recorded the highest root weight amounted to (13.50 g.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest root weight amounted to (8.00 g.plant^{-1}). The bio-fertilization treatments were characterized between them. The treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 recorded the highest root weight amounted to (12.00 g.plant^{-1}), While the treatment of Azotobacter C2 and treatment of the Mycorrhiza C3 gave the lowest root weight amounted to (10.00 g.plant^{-1}). The bi-interaction treatments between organic fertilizer and bio-fertilizer (S x C) have significantly differed among them, The interaction treatment between organic fertilization (60 tons.ha-1) and bio-fertilizer (mixture of Azotobacter and Mycorrhiza) S3C4 recorded the highest roots weight amounted to (15.00 g.plant^{-1}) and did not differ significantly from the treatment of S3C3, which gave (15.00 g.plant^{-1}) while the S1C1 treatment gave the lowest roots weight amounted to (9.00 g.plant^{-1}). Table (18) for the red cultivar showed that the treatment of organic fertilization (60 tons. ha^{-1}) S3 was excelled by giving it the highest root weight amounted to (33.25 g.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest root weight amounted to (21.58 g.plant^{-1}). As for the bio-fertilization treatments, The treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 recorded the highest root weight amounted to (33.11 g.plant^{-1}), While the treatment of Azotobacter C2 and treatment of the Mycorrhiza C3 gave the lowest root weight amounted to (23.33 g.plant^{-1}). The bi-interaction treatments between organic fertilizer and bio-fertilizer (S x C) have significantly differed among them, The two interaction treatments (S3C4, S3C3) recorded the highest roots weight amounted to (35.33 g.plant^{-1}) for both of them while the S1C1 treatment gave the lowest roots weight amounted to (10.33 g.plant^{-1}).

Table 17: Effect of organic fertilizer and bio-fertilizer and their interaction in the fresh root weight (g.plant^{-1}) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	9.00	7.00	8.00	8.00	8.00
S2	10.00	11.00	11.00	12.00	11.00
S3	11.00	12.00	15.00	16.00	13.50
LSD	1.85				1.80
Average of Bio-fertilizer	10.00	10.00	11.33	12.00	
LSD	0.50				

Table 18: Effect of organic fertilizer and bio-fertilizer and their interaction in the fresh root weight (g.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	10.33	14.33	30.33	31.33	21.58
S2	30.33	31.33	31.33	32.67	31.42
S3	29.33	33.00	35.33	35.33	33.25
LSD	1.11				1.02
Average of Bio-fertilizer	23.33	26.22	32.33	33.11	
LSD	0.40				

(iii) Dry root weight (g.plant^{-1})

The results of Table (19) for the local cultivar showed there were no significant differences between the treatment, where the treatment of organic fertilization (60 tons.ha^{-1}) S3 recorded the highest root weight amounted to (4.50 g.plant^{-1}) compared to the control treatment (without fertilization) S1 which gave the lowest root weight amounted to (2.78 g.plant^{-1}). The bio-fertilization treatments did not significantly differ between them. The treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 recorded the highest root weight amounted to (4.00 g.plant^{-1}), While the control treatment (without fertilization) C1 which gave the lowest root weight amounted to (3.67 g.plant^{-1}). The bi-interaction treatments between organic fertilizer and bio-fertilizer (S x C) have not significantly differed among them, The interaction treatments (S3C4, S3C3) recorded the highest roots weight amounted to

(5.00 g.plant^{-1}) for each them while the S1C1 treatment gave the lowest roots weight amounted to (2.10 g.plant^{-1}). Table (20) for the red cultivar showed that the treatment of organic fertilization (60 tons.ha^{-1}) S3 was excelled by giving it the highest dry root weight amounted to (11.88 g.plant^{-1}) and did not significantly differ from the treatment of organic fertilization at the amount of (30 tons.ha^{-1}), which gave a dry root weight amounted to (10.25 g.plant^{-1}). The bio-fertilization treatments also varied significantly among them, The treatment of the bio-fertilization (a mixture of Azotobacter bacteria and Mycorrhiza fungus) C4 recorded the highest root weight amounted to (11.33 g.plant^{-1}) and did not significantly differ from the treatment of Mycorrhiza C3 which gave a dry roots weight amounted to (10.83 g.plant^{-1}) compared to the control treatment (without fertilization) C1 which gave the lowest dry root weight amounted to (8.00 g.plant^{-1}). As for the bi-interaction treatments between organic fertilizer and bio-fertilizer (S x C) have significantly differed among them, The interaction treatment S3C4 was excelled by giving the highest average weight amounted to (13.00 g.plant^{-1}) and did not significantly differ from the two interaction treatments (S3C3, S3C2) which gave a dry root weight amounted to (12.00, 12.50 g.plant^{-1}), respectively while the S1C1 treatment gave the lowest roots weight amounted to (4.00 g.plant^{-1}).

Table 19: Effect of organic fertilizer and bio-fertilizer and their interaction in the dry root weight (g.plant^{-1}) for Basil plant (local cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	3.00	2.10	3.00	3.00	2.78
S2	4.00	4.00	4.00	4.00	4.00
S3	4.00	4.00	5.00	5.00	4.50
LSD	N.S				N.S
Average of Bio-fertilizer	3.67	3.37	4.00	4.00	
LSD	N.S				

Table 20: Effect of organic fertilizer and bio-fertilizer and their interaction in the dry root weight (g.plant^{-1}) for Basil plant (red cultivar).

Organic fertilizer	Bio-fertilizer				Average of Organic fertilizer
	C1	C2	C3	C4	
S1	4.00	5.00	10.00	10.00	7.25
S2	10.00	10.00	10.00	11.00	10.25
S3	10.00	12.00	12.50	13.00	11.88
LSD	1.78				1.69
Average of Bio-fertilizer	8.00	9.00	10.83	11.33	
LSD	0.59				

The results of the study showed the effect of the vegetative and root growth indicators for the basil plant (*Ocimum basilicum* L.) in this study as shown in Table (5-20), where the adding treatment of organic fertilizer (60 tons.ha^{-1}) S3 was excelled on the other treatments in all vegetative and root traits. The reason may be due to the role of bio-fertilizer in the supplying of the plant with sufficient amount of nutrient elements, especially the main elements such as nitrogen, phosphorus, and potassium. due to these elements have a significant impact on many biological and physiological processes, supplying the plant with nutrient elements, activation, stimulation and activation of the action of enzymes associated with the production of nutrient within the plant, as well as stimulating cell division and elongation. These results agree with (Steward David, 1986; Abu Zeid, 1992; Kahlid *et al*., 2006; Jasim *et al*., 2009). It was observed that the treatment of mixed bio-fertilizer from Azotobacter and Mycorrhiza fungus C4 was observed in all vegetative and root traits. This may be due to the role of the *Azotobacter chroacocum* bacteria in increasing plant nutrient elements, especially the nitrogen element, which plays a major role in the building of amino acids and nuclear acids, (Larimi, 2008; Soliman *et al*., 2014), and the production of plant hormones, It also helps to secrete stimulants materials that help grow the roots (Govedarica *et al*., 1997). The use of Mycorrhiza fungus (*Glomus mosseae*) may also lead to enhance the root system of the plant and increase the absorption of water and nutrient elements for growth (Kumari, 2003; Waller *et al*., 2005). These results agree with (Hosseini, 2015 and Al-Salman 2016).

Conclusions

Based on the results of this study we can conclude the following:

1. The excelling of the red cultivar in most the traits of the study
2. Successful use of palm leaves as organic fertilizer and gave positive results in all traits of the study.
3. The successful use of bio-blended fertilizers from Azotobacter and Mycorrhiza bacteria and their use as compound fertilizer, which gave positive results in all the traits of the study.

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