Effect of Mulching , Bio fertilizer, and Foliar Application with calcium On Some Vegetative Growth Indicators of Strawberry

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Abstract

The experiment was conducted in the agricultural field located in the village of Tunisia / Al-Mahawil District (30 km) north of Babylon province, in a plastic house with an area of 450 m2 and dimensions of 9 x 50 m. to study the effect of the Mulching type, biofertilizer, and calcium spray on the growth and production of the Rubygem cultivar. The experiment was conducted according to the Complete Randomized Blocks Design (CRBD), in a split plot arrangement, with three replicates and with three factors. The first represents the Mulching type namely (Mulching with black polyethylene, white polyethylene, and straw. (wheat and barley waste) and is symbolized by the symbol (A1, A2, A3) respectively and were placed in the main plot . As for the sub-plots , the second factor included biofertilizers at four levels that were added to the soil near the plant roots by injection method (the control, Azotobacter bacteria (10 ml. Plant $^{-1}$). , Mycorrhizas fungi (10 ml. Plant $^{-1}$) and a mixture of (Mycorrhizas fungi with Azotobacter bacteria and symbolized by (B0, B3, B2, B1), respectively. The third factor is spraying with calcium at three concentrations (the first is the control treatment, the second is 2.5 (g. L^{-1}) and the third 5 (g. L^{-1}) and symbolized by (C3, C2, C1). The results showed that the treatment of Mulching with black polyethylene was significantly excelled on traits of plant height, number of leaves, leaf area, number of runners, and fresh and dry weight of vegetative. The root gave the highest values (17.02 cm, 53.470 leaves - 1.91.38 cm^2.Plant^{-1}, 3.98 Plant-1, 71.49 g. Plant^{-1}, 17.52 g. Plant^{-1}) respectively. The bio-fertilization treatment (Mycorrhiza + Azotobacter) also excelled significantly and gave the highest average plant height, number of leaves, leaf area, number of runners, fresh and dry weight of the shoot and root system and gave the highest values (19.39 cm, 57.74 leaves - 1,97.52 cm^2. Plant $^{-1}$, 4.59 runners.plant $^{-1}$, 81.88 g.plant $^{-1}$, 19.53 g plant^{-1}), respectively. The calcium spray treatment with a concentration of (5) g.L^{-1} was also significantly excelled and gave the highest average for plant height, number of leaves, leaf area, number of runners, fresh and dry weight of vegetative and gave the highest values (20.09 cm, 58.39 leaves.plant^{-1}.97.99). cm^2, plant^{-1}, 4.75 g plant^{-1}, 83.17 g. plant^{-1}, respectively. While the triple interaction treatment with black polycarbonate and biofertilizer (AZOTOBACTER at a concentration of 10 ml. plant^{-1} + mycorrhizae at a concentration of 10 ml. plant^{-1}) and calcium spray at a concentration of 5 (g. L^{-1}) excelled and recorded the highest values in most of the studied traits.

Keywords: biofertilizers, calcium, mulching, black polyethylene

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introduction

The strawberry (Fragaria × ananassa Duch.) belongs to the order Rosales, belonging to the Rosaceae family and under the family Rosoideae, and to the genus Fragaria, which includes multiple species of up to 45 species. It is a hybrid between the Virginia strawberry and the Chilean strawberry [9,19] There are factors There are many important factors that affect the growth, flowering, and productivity of Strawberry plant, including mulching, which is one of the important agricultural operations in the development and production of Strawberry because it has many advantages, the most important of which are preserving the quality of the fruits and preventing their rotting, protecting flowers from frost, maintaining soil moisture, and stimulating the growth of superficial roots. To reduce the growth of bushesweeds black and transparent plastic and straw are used for this purpose. The use of the Mulching system also addresses many of the problems that the soil suffers from, as water is one of the most important determinants of production. Therefore, Mulching is one of the technologies widely used by farmers, especially in agriculturally developed countries. organic mulches are a source of supplying elements to the soil when it decomposes after use [6]. In recent decades, those concerned with agriculture have also turned to using alternative methods to chemical fertilizers. To reduce sources of pollution and build a safe and healthy environment free of pollution, one of these means is the use of biofertilizers or biofertilizers instead of chemical fertilization. Biofertilizers are among the types that have received wide attention in modern research because they are cheap and environmentally friendly compared to mineral fertilizers, which play an important role in Fixing some elements, including nitrogen, which in turn leads to increased absorption of phosphorus from the soil. It is believed that the absorption of potassium and other elements present in the soil is improving the nutritional balance for the absorption of the two elements, leading to increased growth and development of the plant. Among these fertilizers are mycorrhizal fungi and osobacter bacteria, which are types of bacteria that fix nitrogen as well. About the production of some amino acids, vitamins, and some growth regulators, which are obtained from isolating microorganisms and propagating them in appropriate farms [23].. Carrying out the spraying process at the appropriate stage improves the qualitative and quantitative traits of strawberry . Calcium is one of the macro elements and has many physiological roles in the growth and development of the plant. It is included in the formation of pectin compounds that bind the cell walls, and it is also involved in the formation of the middle lamella, which leads to increasing the hardness of the fruits. It is also one of the important elements that affects the quality of the fruits and the components of the crop and reduces the phenomenon of cracking of the fruits. Also, increasing the calcium content of the fruits is of great importance. In delaying puberty and maturity in fruits [21]

Materials and methods

The experiment was conducted in the agricultural field located in the village of Tunis / Al-Mahawil District (30 km) north of Babylon province, in a plastic house with an area of 450 m^2 and dimensions of 9*50 m. To study the effect of mulching type ,

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biofertilizer, and calcium spray on the growth and production of the Rubygem cultivar. The experiment was conducted according to the Complete Randomized Blocks Design (CRBD), in a split plot arrangement, and with three replicates. Each replicate includes two terraces, and each terrace contains 18 experimental units. The number of experimental units in one replicate reached 36 experimental units, with 8 seedlings for each experimental unit, with three factors: The first represents the Mulching type with three levels, which are (Mulching black polyethylene, white polyethylene, and straw. (Wheat and barley waste). It is symbolized by (a3, a2, a1) and placed in the main panels. Main plots. The secondary panels include Sub-plots. The second factor is biofertilizers at four levels that were added near the roots by injection method of 10 ml for each plant, which are (the control, Azotobacter bacteria, ycorrhizas fungi, and a mixture of (Mycorrhizas fungi with Azotobacter bacteria as a ground addition and are symbolized by (b0, b3, b2, b1), and the third factor is Spraying calcium M at three concentrations (the first was the control, the second was 2.5 (g. liter-1), and the third was 5 (g. Then it was left to sterilize in sunlight (solarization), after which it was smoothed and leveled. It planned the terraces in the form of agricultural terraces, the height of the terrace (15 cm), with six terraces along the length of the plastic house, noting that the distance between one terrace and another is (75 cm), and It left a space of (2 m) at the beginning and end of the house without cultivation, then I divided each terrace crosswise into 18 units. Experimental, so that the number of experimental units in one replicate (two terraces containing 36 experimental units), and the area of the experimental unit reached 0.9 m2 (length 2.25 m * width 0.4 m) with a distance of 25 cm between one seedling and another. After that, these terraces were covered with white and black polyethylene covers and straw. (Wheat and barley waste) according to the design of the experiment, and the treatments were then distributed randomly among the experimental units.

Rubygem strawberry seedlings were obtained on 10/31/2022 from Turkey through cooperation with Dabana Company and were placed in the canopy. After the damaged seedlings were sorted and the infected ones were excluded, the seedlings were treated with a systemic fungicide (Asdazim 50wp).to combat the types of fungi that cause crown and leaf rot and root rot. At a concentration of 1 g/L, the seedlings were also sprayed with the acaricide Vertimic, the active ingredient is Abamectin20%, to prevent mites. They were then planted the next day inside the greenhouse designated for the experiment, according to the random distribution of the treatments after preparation. Drip irrigation system and Mulching terraces with black and white polyethylene covers and straw. All recommended agricultural operations were conducted , as (100) kg/ha of NPK complex fertilizer (18:18:18) was added to the soil after the first irrigation (11/1/2022) of the seedlings, and weeding and hoeing operations were conducted manually [1].

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.Table 1. Some chemical, physical and biological traits of the study soil before cultivation

units	values	Adjective	
-	7.3	Soil reaction degree (pH) 1:1	
$DS.m^{-1}$	3.48	The degree of electrical conductivity (EC) in 1:1	
cmolc/kg	18.5	Cation exchange capacity (CEC)	
$g.kg^{-1}$ soil	8.99	Organic matter	
Meq L^{-1}	15.8	Calcium	Dissolved positive ions
	11.81	Magnesium	
	1.76	Potassium	
	5.78	Sodium	
	Nill	Carbonate	Dissolved negative ions
	5.65	Bicarbonate	
	7.26	Sulfates	
	21.9	Chlorine	
$mg.kg^{-1}$ soil	25.17	Nitrogen	available elements
	7.21	Phosphorus	
	174.13	Potassium	
	3.82	Iron	
	0.58	Zinc	
$g.kg^{-1}$ soil	540	Sand	Soil separators
	270	Silt	
	190	Clay	
Sandy Loamy		Textile class	
1.62 $Mg.m^{-3}$		Bulk density	
32 spores/1 g.soil		Mycorrhizal fungus (Glomus mosseae) before adding	
(x10113.6) cells/ml		Azotobacter chroococcum before adding	

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Studied traits:
Vegetative growth indicators:-
Plant height (cm)
Number of leaves (leaf.plant-1):
Leaves area: (cm2)
Number of runners (runners. Plant^{-1}):
Fresh and dry weight of plants (g.plant^{-1}):

Results and discussion

Plant height (cm)

It is clear from the results of Table 2 that there are significant differences in the effect of the studied factors on the plant height, where it was for the triple combination represented by the mulching treatment with white polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant^{-1}) and spraying with calcium at a concentration of 5 (mg L^{-1}) had a significant effect on increasing the rate of height of strawberry plant, and it was significantly excelled and gave the highest average of plant height, reaching (23.32) cm. Plant $^{-1}$ when compared to mulching with straw and the control treatment with biofertilization and calcium, which was (10.12) cm. Plant $^{-1}$. The table shows that the treatment of Mulching with black polyethylene had a significant effect on the studied trait, as it was significantly excelled, as the average plant height reached (17.02) cm. Plant $^{-1}$ compared to control treatment, which amounted to (12.14) cm.Plant^{-1}. The biological fertilization treatment (Mycorrhiza + Azotobacter) was significantly excelled and gave the highest average height of (19.39) cm, while the treatment without addition gave the lowest average of (12.74 cm). It is clear from the result of spraying the seedlings with calcium that there is a significantly excelled over control treatment. When spraying with a concentration of (5) g.l-1, it reached (20.091 cm) compared to control treatment, which recorded the lowest averages.

Table 2 indicates that the treatment of the bi-interaction between the two factors of the study, Mulching type and biofertilizer, represented by the treatment of coverage with black polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant^{-1} + Mycorrhizae at a concentration of 10 ml. Plant-1) had a significant effect on the studied trait. The highest average height was (20.13) cm2. Plant $^{-1}$ compared to control treatment, which scored lower than that. As for the double interaction between the Mulching type and calcium concentrations, the treatment of Mulching with black polyethylene and spraying calcium at a concentration of 5 (g.L-1) resulted in a significant increase in the rate of height of strawberry plant, as it reached (20.45) cm2. Plant-1 compared to mulching with straw and control treatment for calcium, which recorded (12.14) cm2, and also with regard to the dual combination between biofertilization and calcium spraying, the biofertilization treatment excelled (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) Spraying calcium at a concentration of 5 (gm L-1) achieved the highest height of (22.92 cm2) compared to control treatment, which recorded 10.61 cm2.

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Table (2) Effect of coverage type, biofertilizer, calcium spray, and their interactions on the height of strawberry plants (cm)

mulching type ×Bio-fertilizer	Calcium concentrations (g L-1(			Bio-fertilizer	mulching type
	5	2.5	0		
13.13	16.32	11.99	11.09	Control	Black polyethylene
16.84	19.85	18.85	11.82	*Azotobacter*	
17.96	22.45	17.82	13.62	*Mycorrhizae*	
20.13	23.19	21.89	15.32	*Azot. + Myco.*	
12.80	15.92	11.85	10.62	Control	White polyethylene
17.24	21.79	18.35	11.59	*Azotobacter*	
16.79	19.82	17.22	13.32	*Mycorrhizae*	
18.81	23.32	18.35	14.75	*Azot. + Myco.*	
12.29	15.19	11.55	10.12	Control	Straw
16.89	21.65	17.72	11.29	*Azotobacter*	
16.28	19.29	16.79	12.75	*Mycorrhizae*	
19.23	22.25	21.05	14.39	*Azot. + Myco.*	
1.088	1.853			L.S.D $_{0.05}$	
mulching effect	mulching type × Calcium concentrations				
17.02	20.45	17.64	12.96	Black polyethylene	
16.41	2021	16.44	12.57	White polyethylene	
16.17	19.59	16.78	12.14	.Straw	
0.787	0.983			L.S.D $_{0.05}$	
Bio-fertilizer effect	Bio-fertilizer × Calcium concentrations				
12.74	15.81	11.80	10.61	Control	
16.99	21.10	18.31	11.56	*Azotobacter*	
17.01	20.52	17.28	13.23	*Mycorrhizae*	
19.39	22.92	20.43	14.82	*Azot. + Myco.*	
0.614		1.061		L.S.D 0.05	
	20.091	16.95	12.56	Calcium concentrations effect	
	0.546			L.S.D $_{0.05}$	

number of leaves (leaf plant -1):

The results of Table 3 indicate that there is a significant effect of the studied factors on the number of leaves, as the mulching treatment with black polycarbonate and biofertilization (azotobacter at a concentration of 10 ml. plant-1 + mycorrhizae at a concentration of 10 ml. plant-1) and calcium spraying at a concentration of 5 (mg l-1) showed 1) The significant effect in increasing the average number of leaves of the Strawberry , and it excelled significantly and gave the highest average number of leaves, reaching (65.77) plant leaves-1 when compared to the straw mulching treatment and the comparison of

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biofertilization and calcium, which amounted to (42.10) plant leaves-1. The table showed that The black polyethylene mulching treatment had a significant effect on the studied trait, as it was significantly excelled, and the average number of leaves reached (53.470) leaves per plant, compared to the straw mulching treatment, which recorded the lowest rates, amounting to (51.33) leaves. Plant-1. The biological fertilization treatment (Mycorrhiza + Azotobacter) was significantly excelled and gave the highest average number of leaves, reaching (57.74) leaves. Plant -1, while the treatment without addition recorded the lowest average for the aforementioned trait, amounting to (46.18) leaves. Plant-1, and spraying seedlings with calcium shows that there is a significantly excelled on the rest of the treatments when spraying with a concentration of (5) gm.l-1, as it reached (58.39) leaves. Plant -1 compared to control treatment, which recorded (45.96) leaves. Plant-1. Table 3 shows that the bi-interaction treatment between the study factors, Mulching type and biofertilizer, which is represented by the treatment of coverage with black polyethylene and biofertilization (azotobacter, at a concentration of 10 ml. plant-1 + mycorrhizae, at a concentration of 10 ml. Plant-1) has produced a significantly excelled. On the studied trait, the highest average number of leaves was (59.07) leaves. Plant -1 compared to control treatment, which scored lower than that. As for the bi- interaction between the Mulching type and calcium concentrations, the treatment of Mulching with black polyethylene and spraying calcium at a concentration of 5 (gm l-1) achieved a significant increase in the average number of leaves of the Strawberry , as it reached (59.85) leaves. Plant-1 compared to straw coverage and control treatment for calcium, which recorded (45.30) leaves. Plant-1. As for the dual combination between biofertilization and calcium spraying, the biofertilization treatment (AZOTOBACTER at a concentration of 10 ml. plant-1 + MYCORRHIZAE at a concentration of 10 ml. plant-1) and calcium spraying at a concentration of 5 (gm l-1) excelled in achieving the highest rate of number of leaves reaching (64.4) Leaves. Plant-1 compared to control treatment, which recorded (42.73) leaves. Plant-1.

Table 3. The effect of the Mulching type, biofertilizer, calcium spray, and their interactions on the number of leaves of Strawberry s (plant leaf-1)

mulching type Bio-fertilizer ×	(Calcium concentrations (g L-1			Bio-fertilizer	mulching type
	5	2.5	0		
46.96	51.24	46.27	43.37	Control	Black polyethylene
52.89	58.70	54.70	45.27	Azotobacter	
54.96	63.67	53.50	47.70	Mycorrhizae	
59.07	65.77	61.34	50.10	Azot. + Myco.	
46.33	50.60	45.67	42.70	Control	White polyethylene
53.79	62.34	54.14	44.90	Azotobacter	
51.98	56.64	52.07	47.24	Mycorrhizae	
57.45	64.60	58.70	49.04	Azot. + Myco.	
45.25	49.34	44.30	42.10	Control	Straw
52.26	59.57	53.07	44.14	Azotobacter	

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51.11	55.14	51.80	46.40	Mycorrhizae	
56.70	63.10	58.47	48.54	Azot. + Myco.	
1.997			3.607		L.S.D 0.05
mulching effect	Calcium concentrations × mulching type				
53.47	59.85	53.95	46.61		Black polyethylene
52.39	58.55	52.65	45.79		White polyethylene
51.33	56.79	51.91	45.30		Straw
1.133			1.753		L.S.D 0.05
Bio-fertilizer effect	Calcium concentrations × Bio-fertilizer				
46.18	50.39	45.41	42.73		Control
52.98	60.20	53.97	44.77		Azotobacter
52.68	58.48	52.46	47.11		Mycorrhizae
57.74	64.49	59.50	49.23		Azot. + Myco.
1.222		2.113			L.S.D 0.05
	58.39	52.84	45.96		Calcium concentrations effect
			1.088		L.S.D 0.05

Leaf area (cm2, plant-1):

The results presented in Tables 4 show that there are significant differences in the effect of the three studied factors on the area of one leaf, as was the triple interaction treatment, represented by the treatment of Mulching with white polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. $Plant^{-1}$ + Mycorrhizae at a concentration of 10 ml. Plant-1) and spraying. Calcium at a concentration of 5 (gm L-1) had a significant effect in increasing the average area of one leaf of the Strawberry , and it was significantly excelled and gave the highest average area of one leaf of a plant as it reached (113.22) cm^2. Plant-1 when compared to mulching with straw and the control treatment with biofertilization and calcium, which was (51.90) cm2. $Plant^{-1}$. The two tables above indicate that the treatment of the double interaction between the Mulching type and the biofertilizer, represented by the treatment of the coverage with black polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) had a significant effect on the studied trait and amounted to The highest average lef area was (99.42) cm^2. $Plant^{-1}$ compared to the treatment of Mulching with straw and no addition, which recorded less than that. As for the bi-interaction between the Mulching type and calcium concentrations, the treatment of Mulching with white polyethylene and spraying calcium at a concentration of 5 ($g.L^{-1}$) resulted in a significant increase in the average area of one leaf of the Strawberry , as it reached (99.66) cm^2. $Plant^{-1}$ as measured by Mulching with straw and the control treatment for calcium, which recorded (74.52) cm^2. Plant-1, and also with regard to the dual

combination between biofertilization and calcium spraying, the biofertilization treatment (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) and calcium spraying at a concentration of 5 ($g.L^{-1}$) excelled in achieving the highest rate. The area of one sheet of leaves was (106.68) cm2. Plant-1 compared to control treatment, which recorded (68.65) cm2. Plant-1

The presented results indicate that the treatment of Mulching with black polyethylene had a significant effect on the studied trait, as it was significantly excelled and the highest average area of one leaf per plant reached (91.38) cm2. Plant -1 compared to the straw mulching treatment, which amounted to (86.39) cm2. Plant-1. The biofertilization treatment (Mycorrhiza + Azotobacter) was also significantly excelled and gave the highest average leaf area (97.52) cm2. Plant-1 for the two seasons, while the treatment without addition gave the lowest average amounting to (79.03 cm2. Plant-1). It is also clear from the result of spraying the seedlings with calcium that there is a significantly excelled over the no-spray treatment at the concentration of (5) gm.L-1, as it reached (97.99). cm2 plant-1 compared to the no-spraying treatment, which recorded the lowest averages.

Table (4) Effect of mulching type, biofertiliser, calcium spray and their interactions on the leaf area of Strawberry s (cm2.plant-1)

mulching type Bio-fertilizer ×	Calcium concentrations (g L-1)			Bio-fertilizer	mulching type
	5	2.5	0		
82.72	88.57	81.83	77.77	Control	Black polyethylene
90.17	97.06	93.44	80.02	Azotobacter	
93.94	104.61	92.30	84.90	Mycorrhizae	
98.68	106.28	101.95	87.80	Azot. + Myco.	
81.82	88.24	80.94	76.27	Control	White polyethylene
91.68	102.61	93.091.082	79.40	Azotobacter	
89.82	94.39	98.58	83.98	Mycorrhizae	
99.42	113.39	78.67	86.30	Azot. + Myco.	
72.56	87.11	91.67	51.90	Control	Straw
89.85	99.70	90.02	78.17	Azotobacter	
88.70	93.50	97.58	82.57	Mycorrhizae	
94.46	100.36		85.45	Azot. + Myco.	
2.237			4.508		L.S.D $_{0.05}$
mulching effect	Calcium concentrations × mulching type				
91.38	99.13	92.38	82.62		Black polyethylene
90.68	99.66	90.91	81.49		White polyethylene
86.39	95.17	89.49	74.52		Straw
1.280			2.203		L.S.D $_{0.05}$
Bio-fertilizer effect	Calcium concentrations × Bio-fertilizer				

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79.03	87.97	80.48	68.65	Control
90.57	99.79	92.71	79.20	Azotobacter
90.82	97.50	91.13	83.82	Mycorrhizae
97.52	106.68	99.37	86.52	Azot. + Myco.
1.366		2.631		L.S.D $_{0.05}$
	97.99	90.92	79.54	Calcium concentrations effect
			1.411	L.S.D $_{0.05}$

Number of runners (runners . Plant^{-1}):

The results presented in Tables 5 show that there are significant differences in the effect of the three studied factors on the number of runners as it was for the triple combination represented by the mulching treatment with black polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) and calcium spraying. At a concentration of 5 (gm l-1), it had a significant effect in increasing the average number of runners on the Strawberry . It was significantly excelled and gave the highest average number of runners on the plant, as it reached (5.61) runners. Plant - 1 when compared to mulching with straw and control treatment with biofertilization and calcium, which was (1.45) runners. Plant-1. The two tables above indicate that the treatment of the bi-interaction between the study factors, Mulching type and biofertilizer, which is represented by the treatment of coverage with black polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) had a significant effect on the trait. The highest average number of runners studied was (4.74) runners. Plant -1 compared to control treatment, which scored lower than that. As for the bi- interaction between the Mulching type and calcium concentrations, the treatment of Mulching with black polyethylene and spraying calcium at a concentration of 5 (mg L-1) resulted in a significant increase in the rate of Strawberry height, as it reached (4.89) increments. Plant - 1 compared to straw coverage and control treatment for calcium, which recorded (2.50) runners. Plant-1, and also with regard to the dual combination between biofertilization and calcium spraying, the biofertilization treatment (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) and calcium spraying at a concentration of 5 (gm L-1) excelled in achieving the highest rate. The number of runners reached (5.46) runners. Plant-1 compared to control treatment, which recorded (1.93) runners. Plant-1. The presented results indicate that the treatment of Mulching with black polyethylene had a significant effect on the studied trait, as it was significantly excelled and the highest average number of runners per plant was (3.98) runners. Plant-1 compared to the straw mulching treatment, which amounted to (3.64) increments. Plant-1. The bio fertilization treatment (Mycorrhiza + Azotobacter) also excelled significantly and gave the highest average number of runners (4.59) runners. Plant-1 for the two seasons, while the treatment without addition gave the lowest average of (2.78) runners. Plant-1 It is also clear from the result of spraying seedlings with calcium that there is a significantly excelled over the no-spraying treatment at a concentration of (5) gm.l-1, as it reached

(4.75) runners. Plant-1 compared to control treatment, which recorded the lowest averages .

Table (5) Effect of mulching type , biofertilizer, calcium spray, and their interactions on the number of runners in Strawberry s (runners . Plant-1)

mulching type Bio-fertilizer ×	(Calcium concentrations (g L-1			Bio-fertilizer	mulching type
	5	2.5	0		
2.99	3.84	2.86	2.28	Control	Black polyethylene
3.91	4.71	4.35	2.68	Azotobacter	
4.27	5.41	4.24	3.15	Mycorrhizae	
4.74	5.61	5.01	3.61	Azot. + Myco.	
2.85	3.72	2.76	2.07	Control	White polyethylene
4.11	5.36	2.42	2.56	Azotobacter	
4.01	4.59	4.05	3.38	Mycorrhizae	
4.60	5.52	4.89	3.39	Azot. + Myco.	
2.51	3.54	2.53	1.45	Control	Straw
3.80	4.96	4.09	2.37	Azotobacter	
3.81	4.50	3.96	2.97	Mycorrhizae	
4.42	5.25	4.82	3.20	Azot. + Myco.	
1.543			2.300		L.S.D 0.05
mulching effect	Calcium concentrations × mulching type				
3.98	4.89	4.12	2.93		Black polyethylene
3.89	4.80	4.03	2.85		White polyethylene
3.64	4.56	3.85	2.50		Straw
1.217			1.327		L.S.D 0.05
Bio-fertilizer effect	Calcium concentrations × Bio-fertilizer				
2.78	3.70	2.72	1.93		Control
3.94	5.01	4.29	2.54		Azotobacter
4.03	4.83	4.08	3.17		Mycorrhizae
4.59	5.46	4.91	3.40		Azot. + Myco.
0.827		1.289			L.S.D 0.05
	4.75	4.00	2.76		Calcium concentrations effect
			0.629		L.S.D 0.05

Fresh weight of plants (g. plant-1):

The results of Table 6 indicate that there is a significant effect of the studied factors on the fresh weight of Strawberry s, as it showed Mulching with black polycarbonate and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) and calcium spraying at a concentration of 5 (g). L-1) The

significant effect of increasing the average fresh weight of the Strawberry , as it was significantly excelled and the average fresh weight of the plant increased, reaching (121.17) g. Plant-1 compared to the straw mulching treatment and the comparison with biofertilization and calcium, which recorded (42.23) g . Plant-1 The two tables showed that the treatment of Mulching with black polyethylene had a significant effect on the studied trait, as it was significantly excelled, and the average fresh weight of the plant reached (71.49) g . Plant -1 compared to the straw mulching treatment, which recorded the lowest rates, amounting to (64.69) g. Plant-1: The biological fertilization treatment (for the mixture of mycorrhizae and azotobacter) was significantly excelled and gave the highest average fresh weight of the plant, amounting to (81.88) g . Plant -1, while the treatment without addition recorded the lowest average for the aforementioned trait, amounting to (53.38) g . Plant-1, and spraying seedlings with calcium showed a significantly excelled over the rest of the spraying treatments at the concentration of (5) gm.l-1, as it reached (83.17) gm. Plant -1 compared to control treatment, which recorded (52.72) g . Plant-1. The table above shows that the double interaction treatment between the two factors of the study, Mulching type and biofertilizer, represented by the treatment of coverage with black polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) has resulted in a significantly excelled in fresh weight. of the plant, which amounted to (89.73) g . Plant -1 compared to the treatment of Mulching with straw and not adding fertilizer, which recorded (51.59) g . Plant-1. Likewise, with regard to the bi-interaction between the Mulching type and calcium concentrations, the treatment of Mulching with black polyethylene and spraying calcium at a concentration of 5 (gm l-1) achieved a significant increase in the average fresh weight of Strawberry s, as it reached (89.57) gm. Plant-1 compared to straw coverage and the control treatment for calcium, which recorded (51.06) g . Plant-1. As for the dual combination between biofertilization and calcium spraying, the biofertilization treatment (Azotobacter at a concentration of 10 ml. plant-1 + Mycorrhizae at a concentration of 10 ml. plant-1) and calcium at a concentration of 5 (gm l-1) excelled in achieving the highest fresh weight of (102.34). Gloom. Plant-1 compared to the control treatment, which recorded (44.10) g. Plant-1.

Table (6) Effect of mulching type , biofertilizer, calcium spray, and their interactions on fresh weight (g. plant-1)

mulching type Bio-fertilizer ×	(Calcium concentrations (g L-1			Bio-fertilizer	mulching type
	5	2.5	0		
54.91	66.03	52.35	46.36	Control	Black polyethylene
67.52	77.93	73.79	50.83	*Azotobacter*	
73.82	93.17	70.65	57.65	*Mycorrhizae*	
89.73	121.17	84.17	63.84	*Azot. + Myco.*	
53.63	65.47	51.72	43.70	Control	White polyethylene
71.68	93.16	72.56	49.33	*Azotobacter*	
66.22	75.65	67.84	55.17	*Mycorrhizae*	

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80.15	98.02	80.90	61.51	*Azot. + Myco.*	
51.59	63.39	49.16	42.23	Control	Straw
66.47	81.83	69.01	48.56	*Azotobacter*	
64.94	74.32	57.39	53.12	*Mycorrhizae*	
75.77	87.84	79.13	60.34	*Azot. + Myco.*	
2.259			4.200	L.S.D $_{0.05}$	
mulching effect	Calcium concentrations × mulching type				
71.49	89.57	70.24	54.67	Black polyethylene	
67.92	83.08	68.26	52.43	White polyethylene	
64.69	76.84	66.17	51.06	Straw	
0.861			1.915	L.S.D $_{0.05}$	
Bio-fertilizer effect	Calcium concentrations × Bio-fertilizer				
53.38	64.96	51.08	44.10	Control	
68.56	84.31	71.79	49.57	*Azotobacter*	
68.33	81.05	68.63	55.31	*Mycorrhizae*	
81.88	102.34	81.40	61.90	*Azot. + Myco.*	
1.456		2.498		L.S.D $_{0.05}$	
	83.17	68.22	52.72	Calcium concentrations effect	
			1.282	L.S.D $_{0.05}$	

dry weight of Plant (g. plant-1):

We note from the results of Table 7 that Mulching with polycarbonate, biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1) and spraying with calcium at a concentration of 5 (gm L-1) had a significant effect on increasing the average dry weight of Strawberry s. It was significantly excelled, and the average dry weight of the plant increased and reached (28.23) g . Plant-1 compared to the straw mulching treatment and the comparison with biofertilization and calcium, which recorded (9.73) g . Plant-1

Also, the bi- interaction coefficients between the study factors had an aspect of this significance, as the bi- interaction treatment between biofertilization and calcium spraying showed superiority that reached the level of significance in the biofertilization treatment (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant - 1) Calcium at a concentration of 5 (gm L-1), achieving the highest dry weight of (24.01) gm. Plant-1 compared to the treatment of no addition and spraying, which recorded (10.24) g . Plant-1. Likewise, with regard to the bi- interaction between the Mulching type and calcium concentrations, the treatment of Mulching with black polyethylene and spraying calcium at a concentration of 5 (gm L-1) achieved a significant increase in the average dry weight of Strawberry s, as it reached (21.24) g . Plant-1 compared to straw coverage and the control treatment for calcium, which recorded (12.82) g . Plant-1. As for the bi- combination between the type of

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mulch and the biofertilizer, which is represented by the mulching treatment with black polyethylene and biofertilization (Azotobacter at a concentration of 10 ml. Plant-1 + Mycorrhizae at a concentration of 10 ml. Plant-1), it resulted in a significant increase in the dry weight of the plant, which amounted to (21.10). g. Plant -1 compared to the treatment of Mulching with straw and not adding fertilizer, which recorded (12.57) g . Plant-1. The significant effect was not limited to the double or triple interaction of the factors only, but rather the individual effect of the factors had a positive effect on this trait, as Table 6 showed that the treatment of Mulching with black polyethylene had a significant effect on the studied trait, as it was significantly excelled, and the average dry weight of the plant reached (17.52) g . Plant -1 compared to the straw mulching treatment, which recorded a slight difference from the other mulching treatments, amounting to (15.82) g . Plant-1

The biofertilization treatment (for the mixture of mycorrhizae and azotobacter 10 + 10) was also significantly excelled and gave the highest average dry weight of the plant, amounting to (19.53) g . Plant-1 for the two seasons, while the treatment without addition recorded the lowest average for the aforementioned trait, amounting to (13.39) g . Plant-1, spraying seedlings with calcium showed significantly excelled on the rest of the spraying treatments at a concentration of 5 gm. Liter-1, as it reached (19.71) g . Plant-1 compared to the no-spraying treatment, which recorded (13.37) g . Plant-1.

Table (7) Effect of mulching type, biofertiliser, calcium spray and their interactions on the dry weight of Strawberry s (g. plant -1)

mulching type Bio-fertilizer ×	(Calcium concentrations (g L-1			Bio-fertilizer	mulching type
	5	2.5	0		
14.11	16.71	14.88	10.75	Control	Black polyethylene
16.65	18.27	17.81	13.88	*Azotobacter*	
18.22	21.76	17.46	15.43	*Mycorrhizae*	
21.10	28.23	19.25	15.82	*Azot. + Myco.*	
13.48	16.15	14.05	10.25	Control	White polyethylene
16.92	20.85	17.48	12.42	*Azotobacter*	
16.71	17.99	17.08	15.06	*Mycorrhizae*	
19.17	23.10	18.85	15.57	*Azot. + Myco.*	
12.57	15.65	12.33	9.73	Control	Straw
15.79	19.18	17.20	10.99	*Azotobacter*	
16.60	17.91	16.88	15.01	*Mycorrhizae*	
18.33	20.69	18.76	15.54	*Azot. + Myco.*	
2.183			4.008		L.S.D $_{0.05}$
mulching effect	Calcium concentrations × mulching type				
17.52	21.24	17.35	13.97	Black polyethylene	
16.57	19.52	16.87	13.33	White polyethylene	
15.82	18.36	16.29	12.82	Straw	

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1.774			2.206	L.S.D $_{0.05}$
Bio-fertilizer effect	Calcium concentrations × Bio-fertilizer			
13.39	16.17	13.75	10.24	Control
16.45	19.43	17.50	12.43	*Azotobacter*
17.18	19.22	17.14	15.17	*Mycorrhizae*
19.53	24.01	18.95	15.64	*Azot. + Myco.*
1.143		2.260		L.S.D $_{0.05}$
	19.71	16.84	13.37	Calcium concentrations effect
			1.222	L.S.D $_{0.05}$

It is clear from the results of the tables of vegetative indicators of the Strawberry (2-7), which showed the superiority of the black plastic mulching treatments along with calcium spraying and biofertilization with a specific fertilizer combination, which led to an increase in the readiness of the nutrients and essential elements for the plant and morphological changes in the growth of the plant, especially the roots, which in turn works on Increasing the efficiency of absorption of nutrients important for plant growth because it contains biologically active substances such as macro- and micro-nutrients and other compounds that stimulate growth and plant development, which was reflected positively on most vegetative indicators and thus led to a significant increase in the characteristics mentioned above. This in turn increases the efficiency of the photosynthesis process and Manufacturing important materials for plant growth and development and transferring them from the source to the rest of the plant parts to carry out their vital functions. High levels of the types of fertilizers included in the combination (biofertilizer and calcium spraying) in addition to Mulching with black and white polyethylene and straw have led to a significant increase in the aforementioned vegetative indicators. .

(The increase in most of the above-mentioned vegetative indicators can be attributed to mulching treatments, especially mulching with black plastic, as it reduces the growth of harmful weeds, and this leads to reducing competition for nutrients and water needed for the growth of the main crop [6] This is consistent with what was found by [15] who emphasized the importance of black plastic in obtaining a greater number of formed purls, number of leaves, and leaf area compared to other covers) on plants [17] in their study on Strawberry s, and also the superiority of some vegetative characteristics when covered with white plastic, as it allows the passage of Through it, solar rays reach the various parts of the plant body, including vegetative growth, which increases the effectiveness of the photosynthesis process and the surface parts of the soil, which increases the activity and effectiveness of the roots, and these results were in agreement with the results reached by[1,20] in their study on the Strawberry . Mulching works to prevent evaporated water from the soil from reaching the atmosphere due to the presence of a plastic barrier, as water condenses on the bottom surface of the plastic and bounces source. Thus, the soil covered with polyethylene maintains a uniform moisture content throughout the soil and its depths, and the soil temperature rises

up to 30 degrees Celsius with a decrease. Variation in temperature day and night, and this helps in better growth of plants [22] or the reason for this increase may be due to the fact that the covered soil has less loss of phosphorus and nitrogen in the form of NH4+ and NO3-, as this element is involved in most processes. Important vital elements in plants, such as building proteins, nucleic acids (RNA and DNA), and chlorophyll, which causes rapid cell division and elongation [10] Providing nitrogen has a major impact on building auxins, which have an effective effect in the process of cell activation, division, and elongation, and that plants covered in soil The leaf content of magnesium, calcium, and nitrogen increases (which in turn leads to strong plant growth and an increase in shoots, and this is consistent with what [18] found) on Strawberry s.

The significant increase in the aforementioned vegetative indicators can be due to the role of biological fertilization, represented by mycorrhizae and azotobacter, either individually or in combination, in improving the physical and chemical traits of the seedling soil as a result of the important roles played by these fertilizers, which leads to an increase in the readiness of the nutrients present in the soil and their absorption by the root hairs of the plant as well. On the role of mycorrhizal fungi in improving the symbiotic relationship between plants and fungi and the role of these fungi in absorbing phosphorus from the soil [9]. These fungi extend for several centimeters from the surface of the roots and work to withdraw nutrients from the outer area of the affected roots [5]. These fungi work to increase the absorption area due to their hygroscopicity as a result of increasing the surface area of the roots. They also work to secrete a good amount of growth regulators released in the growth medium (gibberellin, auxin, and cytokinin) [7]. These secretions play an important role in the elongation of plant cells. As a result of increased plant cell division, it also works to stimulate root hairs, which reflects positively on the process of nutrient absorption and then an increase in vegetative characteristics represented by plant height, number of leaves, leaf area, and fresh and dry weight of the plant and runners, Table (2-7), as the mycorrhizal fungus works. It increases the available of phosphorus through its ability to secrete the enzyme phosphatase, which works to convert phosphorus from its organic form that is not ready for absorption to its ready mineral form [13]. This is reflected in an increase in atmospheric nitrogen fixation, as the presence of the phosphorus element increases the efficiency of nitrogen-fixing organisms. [4]Inoculation with mycorrhiza can also provide the plant with some of its nutrient needs, as it can provide the plant with about 80% of its phosphorus needs, 25% of N, 10% of K, 25% of Zn, and 60% of Cu [14]. It also improves water consumption and improves soil construction [7] through the compound Glomalin it secretes, which works to trap soil particles and increase its ability to retain water, and this reflects positively on plant growth by increasing the efficient absorption of elements [24] which is subsequently reflected in vegetative growth indicators.

The ability of mycorrhizal fungi to reach places where the root hairs cannot reach helps increase the area of absorption resulting from the effectiveness of the root hairs and what is absorbed by the mycelium, which may extend to several meters per gram of soil and reach long distances outside the depletion zone [12]. The colonization of the host roots by mycorrhizal fungi stimulates the host's physiological response, which is clearly

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reflected in the increase in root branching, which increases the root's vital mass, thereby increasing absorption, in addition to the secretion of the phosphatase enzyme, which indirectly stimulates the absorption of phosphorus [11] Increasing absorption of nutrients due to the activity of mycelium as well as root hairs and increasing the absorption area resulting from increasing the vital root mass will increase metabolic activities and increase the products of these activities, in addition to the mycorrhizal secretion of the compound Siderophores (Wrunnerselmann, 2017), which works to chelate microelements, which contributes to increasing Absorption, which is reflected in an increase in the relative growth rate, the results of which appeared in an increase in the plant's content of chlorophyll, and this was reflected positively in an increase in the number of plant leaves and thus an increase in the leaf area. The increase in the leaf area led to an increase in the activities of photosynthesis and the accumulation of its products, which was reflected in an increase in the height of the plant and an increase in the number of leaves. The branches and then the dry weight of the shoots increased. This is consistent with the findings of [20] on Strawberrys and [25] on lemon seedlings and Al-Akaishi (2018) on orange seedlings.

Inoculation with azotobacter bacteria may have contributed to improving vegetative growth characteristics directly or indirectly [26] by fixing atmospheric nitrogen, which was reflected in an increase in its content in the leaves, Table 3, and thus an increase in the formation of total chlorophyll, Table 2, and an increase in the number of plant leaves. Table 1, which increased the leaf area Table 2 and was reflected in the increase in the dry weight of the shoots Table 2, which is due to increasing the efficiency of the carbon synthesis process, which leads to an increase in the net CO2 represented in the leaves, which represents the basic unit for building carbohydrates (Mahgoub et al., 2006), in addition to reducing Soil pH, which causes an increase in the availability of phosphorus and most microelements except molybdenum [3] The significant increase in the aforementioned vegetative indicators can be due to the result of spraying seedlings with calcium at both concentrations (2.5 and 5) $g.L^{-1}$. The reason for this is that calcium is necessary for the process of cell division and cell elongation, and calcium is also necessary in maintaining the permeability of cellular membranes [2]. Al-Qutb et al. (2011) stated that calcium is found in large quantities in leaves, and is involved in the structure of the tissues of various parts. This element contributes to regulating respiration processes. Calcium is important for the continuation of indirect growth and division processes in the plant. Calcium is also indirectly involved in starch conversions. To sugar and vice versa, it is also included in the nutritional conversion of nitrogen compounds, and it also encourages phosphorylation enzymes and some other enzymes to perform their functions. For this reason, calcium encourages the growth of roots [16] and thus increases the absorption of nutrients and the rate of their assimilation, and this in turn increases the rate of vegetative growth in characteristics. Vegetative yield, which is represented by the height of the plant, the number of leaves, crowns, and runners, the fresh and dry weight of the plant, and the leaf area. These results are consistent with what [8] and Kazemi (2014) found in their study on the strawberry cultivar Pajaro.

Or this may be due to the increased chlorophyll content of the leaves in Tables (16

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and 17), which in turn leads to increased photosynthesis and increased dry matter, as was caused by spraying at a concentration of 5 g . L-1 of calcium significantly increases the percentage of dry matter in the plant. These results are consistent with [13] in his study on strawberry cultivar Pajaro, who stated that the concentration of calcium leads to an increase in the percentage of dry weight of the plant. The reason for this is that calcium is involved indirectly in the conversion of starch into sugar and vice versa, and is also involved in the food conversion of nitrogen compounds. Also, calcium encourages phosphorylation enzymes and some other enzymes to perform their functions, and for this reason calcium encourages root growth, because calcium is important in root growth [16]

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