Effect of vermiecompost and bio-chemical fertilizers on yield traits of strawberry plants (*Fragaria x ananassa*) Rubygem cultivar

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Abstract

The experiment was conducted in one of the greenhouses belonging to a farmer's field in Al-Al-Musayyib project / Babylon Governorate during the agricultural season 2022-2023. To study the effect of Vermiecompost fertilizer with three levels (0,400,800) gm and biofertilization with the highest levels (without addition, mycorrhiza fungus, azospirillum bacteria, a mixture of fungal and bacterial inoculum) and chemical at two levels (0.50%) on the characteristics of the quantitative and qualitative yield of strawberry plant Rubygem and below-Covered cultivation system (green house) and RCBD design was used with three replicates. The results showed a significantly excelled of vermicompost (V3) in the quantitative and qualitative characteristics of the plant (number of fruits, weight of fruits, total yield, vitamin C, percentage of TTS), as it amounted to (12.19 plant fruits-1,21.74 gm, fruit^{-1}, 397.32 kg greenhouse^{-1}). , 20.91 mg/100 g fresh weight $^{-1}$, 9.73%), respectively. The mixture of bio-fertilizer (B4) excelled in all studied traits The chemical fertilization (C2) when added was 50% of the fertilizer recommendation in all studied traits..The triple interaction (V3B4C2) gave a significantly excelled in all studied plant traits, which amounted to (17.92 fruit of plant-1, 25.04 g. fruit^{-1}, 603.04 kg . greenhouse^{-1}, 25.53 mg of 100 gm fresh weight^{-1}, 11.70%), respectively.

Keywords: vermiecompost, biofertilization, chemical fertilization, strawberry, yield traits

introduction

Strawberry (*Fragaria ananassa* Duch) belongs to the Rosaceae family, and it is a perennial plant (1), and this genus includes about 45 species, 13 of which can be distinguished, and it is believed that North America is its original home (2), and it is the fourth most consumed fruit after apples, oranges, and bananas (3). Its cultivation is spread in more than 65 countries, and the global production is 8 861 381 tons, and the Asian production is 4 336 603 tons (4) and the average productivity in Iraq is 291.657 kg ha^{-1} (5).Strawberries are very voracious for fertilization, and this is due to the fact that the plant yields a large crop of fruits in relation to its small size, so the deficiency resulting from the depletion of plants of mineral elements must be compensated by adding them at appropriate times and in moderate quantities according to the plant's need and during its different stages of growth (6). Vermicompost is the best and finest organic fertilizer for increasing plant productivity, improving soil properties, creating a safe ecosystem for food processing, and increasing the soil content of organic matter (7). Biofertilizers, including mycorrhizae and bacteria, are a group of microorganisms that are added to the soil or seeds or both for the purpose of supplying the plant with its nutritional needs and helping in increasing the yield. It is considered one of the successful alternatives for increasing the availability of nutrients, and its use has spread in several regions of the Arab world (8). The

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increase in the demand for food requires an increase in agricultural production, which leads to the depletion of available nutrients in the soil solution, which leads to a decrease in its productivity and becomes economically unfeasible, so it is necessary to compensate for the shortfall in available nutrients in the soil, and mineral fertilizers are among the most important sources used to compensate the deficiency in it, As it is characterized by ease of use and a clear increase in production, mineral fertilizers have gained great interest from farmers for their role in increasing agricultural production (9).In view of the lack of research on the strawberry plant (Rubygem) in the conditions of Babylon province and the importance of rationing the quantities of added chemical fertilizers, the research aims to reduce the added chemical fertilizers by going to sustainable farming methods and using integration with earthworm manure and biofertilizers for the purpose of reducing pollution and preserving Human health, environment and soil.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse in Musayyib/Babylon, during the agricultural season (2022-2023) to study the effect of vermicompost and bio and chemical fertilization on the yield of strawberry plant of Rubygem cultivar. An unheated (40x9) m covered cultivation system (greenhouse) was used, and the cultivation method was used on terraces. The land was plowed with two orthogonal plows, using Mold-board plows. The process of fragmenting and smoothing the soil was conducted using a rotary plow, and then adding slurry and animal manure to the experimental land. Then the experimental land was divided into three furrows, each with a length of 35 m, a width of 80 cm, and a height of 25 cm. The furrows were equipped with a drip irrigation system. The furrows were covered with black polyethylene, and the distance between one terrace and another was 1 m, and the distance between one plant and another was 30 cm. The seedlings were planted in the greenhouse designated for the experiment on (3/11/2022). A factorial experiment was used with a randomized complete block design (R.C.B.D), with three factors and three sectors. One replicate included 24 treatments. Seedlings were distributed randomly within each replicate at an average of 6 plants per experimental unit. Thus, the number of plants in one sector is 144 plants, and the number of seedlings in the experiment is 432 plants. The experiment included three factors:

The first factor: is the addition of earthworm compost (Vermiecompost) mixed with the soil at three levels (0,400,800) $g.L^{-1}$, symbol (V1, V2, V3) respectively.

The second factor: includes biofertilization with four levels (without inoculum, mycorrhizal fungal inoculum, bacterial inoculum, fungal + bacterial inoculum) and its symbol (B1,B2,B3,B4), respectively. As follows:-

• Mycorrhizal fungus (Glomus mossa) by adding 10 g of fungal inoculum by injection into the soil in contact with the root zone.

• Bacteria (Azospirillum brasilense) by adding 10 ml of the bacteria to each seedling near the roots of the seedlings.

The third factor: Includes mineral fertilization (Fertilization Chemical) with NPK fertilizer at two levels (0,50%) of the fertilizer recommendation, at an average of 5 times in the early morning, and the seedlings were abundantly watered after the addition, and after a period of one month from the last addition, measurements were taken.

studied traits

1- Quantitative traits of the yield

A - Number of fruits ($fruit.plant^{-1}$)

B- Weight of fruits ($g.fruit^{-1}$)

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C- The total yield of the greenhouse (kg greenhouse^{-1})

2- Qualitative traits of the fruits

A- Ascorbic acid content of fruits (mgm 100 gm fresh weight^{-1}) Ascorbic acid was measured according to method (10).

B- Percentage of dissolved solids (TSS) (%) The total soluble solids were measured using the (Hand Rrfractometer).

Results

Number of fruits (fruit.plant^{-1})

The results of the statistical analysis in Table (1) showed that the addition of vermicompost (V3) gave a significant increase in the number of fruits amounting to 12.19 fruits . plant^{-1}, compared to the control (V1), which gave the lowest rate (9.20 fruits . plant^{-1}).The results showed that the mixture of biofertilizer (B4) had an excel of 14.22 fruits plant^{-1}, compared to no addition (B1), which gave the lowest rate of 7.27 fruits plant^{-1}. The addition exceeded 50% of the fertilizer recommendation (C2) to give an average of 10.68 fruits plant^{-1}, compared to no addition (C1), which amounted to 10.35 fruits plant^{-1}. Also, (V3B4) excelled and gave an average of 17.87 fruits plant^{-1}, compared to not adding (V1B1), which gave the lowest rate of 6.19 fruits plant^{-1}. The interference (V3C2) at 50% of the fertilizer recommendation recorded the highest rate of 12.32 plant fruits^{-1}, compared to no addition (V1C1), which gave the lowest rate of 9.01 fruits plant $^{-1}$. The bi-interaction (B4C2) at 50% of the fertilizer recommendation gave the highest rate of 14.31 fruits plant $^{-1}$, compared to no addition (B1C1), which gave the lowest rate of 7.14 fruits plant $^{-1}$. The triple interaction (V3B4C2) at 50% of the fertilizer recommendation gave the highest rate of 17.92 plant-1 fruits without adding (V1B1C1) and gave the lowest rate of 6.11 fruits plant^{-1}. These results agreed with (11) and (12).

Table 1. Effect of vermicompost and bio-chemical fertilizer on the number of fruits .plant^{-1}) of strawberry plant

average V ×B	chemical fertilizers		bio-fertilizers	vermicompost
	C2	C1		
6.19	6.26	6.11	B1	V1 0
8.72	9.08	8.37	B2	
10.41	10.61	10.21	B3	
11.50	11.62	11.37	B4	
7.21	7.35	7.08	B1	V2 400
8.90	9.24	8.56	B2	
11.21	11.35	11.06	B3	
13.28	13.39	13.16	B4	
8.41	8.58	8.22	B1	V3 800
10.21	10.38	10.04	B2	
12.29	12.40	12.19	B3	
17.87	17.92	17.83	B4	
0.037	0.053		L.S.D 0.05	
average V	vermicompost × chemical fertilizers)V×C(			
9.20	9.39	9.01	V1	
10.15	10.33	9.97	V2	
12.19	12.32	12.07	V3	

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0.018	**0.026**		**L.S.D 0.05**
average B	**bio-fertilizers × chemical fertilizers) B×C(**		
7.27	**7.40**	**7.14**	B1 0
9.28	**9.56**	**8.99**	B2 VAM
11.30	**11.45**	**11.15**	B3 Az
14.22	**14.31**	**14.12**	B4 M
0.021	**0.030**		**L.S.D 0.05**
	10.68	**10.35**	**average C**
	0.015		**L.S.D 0.05**

VAM=Vesiculara Arbuscular endomycorrhizae ,Az= Azospirillum , M=Mix

Fruit weight (g.fruit^{-1})

The results showed in Table 2 that the addition of vermicompost (V3) gave a significant increase in the weight of fruits amounting to 21.74 g.fruit^{-1}compared to the control (V1) which gave the lowest rate of 16.75 g.fruit^{-1}. The results showed that the mixture of biofertilizer (B4) excelled, as it gave the highest rate of 23.16 g.fruit^{-1}, compared to not adding (B1), which gave the lowest rate of 15.72 g.fruit^{-1}. The addition 50% excelled the fertilizer recommendation (C2) to give an average of 19.46 g.fruit^{-1}, compared to no addition (C1), which amounted to 19.04 g.fruit^{-1}. The interaction (V3B4)excelled and gave an average of 24.70 g.fruit^{-1}compared to no addition (V1B1), which gave the lowest rate of 13.41 g.fruit^{-1}. The bi-interaction(V3C2) at 50% of the fertilizer recommendation recorded the highest rate of 21.94 g.fruit^{-1}, compared to no addition (V1C1), which gave the lowest rate of 16.59 g.fruit^{-1}. The bi-interaction(B4C2) at 50% of the fertilizer recommendation gave the highest rate of 23.44 gm fruit-1 compared to no addition (B1C1) which gave the lowest rate of 15.56 g.fruit^{-1}. The triple-interaction (V3B4C2) at 50% of the fertilizer recommendation gave the highest rate of 25.05 gm fruit-1 without adding (V1B1C1) as it gave the lowest rate of 13.23 g.fruit^{-1}. These results agreed with (13), (14) and (15).

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Table 2. Effect of vermicompost and bio-chemical fertilizers on fruit weight (g.fruit^{-1}) of Strawberry plant

average V ×B	chemical fertilizers		bio-fertilizers	vermicompost
	C2	C1		
13.41	13.58	13.23	B1	V1 0
15.44	15.64	15.23	B2	
16.90	16.97	16.84	B3	
21.24	21.42	21.06	B4	
15.54	15.71	15.36	B1	V2 400
17.55	17.87	17.24	B2	
20.46	20.77	20.14	B3	
23.54	23.84	23.24	B4	
18.22	18.36	18.08	B1	V3 800
20.37	20.49	20.25	B2	
23.66	23.87	23.46	B3	
24.70	25.05	24.35	B4	
0.017	0.024		L.S.D 0.05	
average V	vermicompost × chemical fertilizers) V×C(			
16.75	16.90	16.59	V1	
19.27	19.55	18.99	V2	
21.74	21.94	21.54	V3	
0.008	0.012		L.S.D 0.05	
average B	bio-fertilizers × chemical fertilizers) B×C(			
15.72	15.88	15.56	B1 0	
17.79	18.00	17.57	B2 VAM	
20.34	20.54	20.14	B3 AS	
23.16	23.44	22.88	B4 M	
0.010	0.014		L.S.D 0.05	
	19.46	19.04	average C	
	0.007		L.S.D 0.05	

The total yield of the greenhouse (kg greenhouse^{-1})

The results of Table (3) showed that the addition of vermicompost (V3) gave a significant increase in the total yield of the greenhouse amounting to 397.32 kg greenhouse-1 compared to the control (V1) which gave the lowest rate of 375.28 kg greenhouse-1.The results showed the excellence of the mixed bio-fertilizer (B4), as it gave the highest rate of 588.20 kg greenhouse-1, compared to not adding (B1), which gave the lowest rate of 287.73 kg greenhouse-1. The addition 50% excelled on the compost recommendation (C2) to give an average of 388.04 kg greenhouse-1, compared to no addition (C1), which amounted to 385.51 kg greenhouse-1. The interaction(V3B4) was gave an average of 600.40 kg greenhouse-1 compared to no addition (V1B1), which gave the lowest rate of 275.19 kg greenhouse-1.

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The bi-interaction (V3C2) at 50% of the fertilizer recommendation recorded the highest rate of 398.05 kg greenhouse-1, compared to no addition (V1C1), which gave the lowest rate of 374.39 kg greenhouse-1 and the bi-interaction (B4C2) at 50% of the compost recommendation gave the highest rate of 592.65 kg greenhouse-1 compared to no addition (B1C1) which gave the lowest rate of 287.52 kg greenhouse-1.The triple interaction (V3B4C2) at 50% of the compost recommendation gave the highest rate of 603.04 kg greenhouse-1 without adding (V1B1C1), which gave the lowest rate of 275.04 kg greenhouse-1. These results agreed with (13), (15), and (16).

Table 3. The effect of vermicompost and bio-chemical fertilizers on the total yield of one greenhouse (kg greenhouse^{-1}) of Strawberry plant

average V ×B	chemical fertilizers		bio-fertilizers	vermicompost
	C2	C1		
275.19	275.34	275.04	B1	V1 0
320.25	320.45	320.04	B2	
327.60	328.06	327.14	B3	
578.10	580.85	575.35	B4	
287.44	287.74	287.15	B1	V2 400
333.53	333.91	333.15	B2	
343.79	334.83	343.76	B3	
568.11	594.07	578.14	B4	
300.56	300.76	300.36	B1	V3 800
338.20	338.26	338.14	B2	
350.10	350.15	350.05	B3	
600.40	603.04	397.76	B4	
0.414	0.586		L.S.D 0.05	
average V	vermicompost × chemical fertilizers) V×C(			
375.28	377.17	374.39	V1	
387.72	389.89	385.55	V2	
397.32	398.05	396.58	V3	
0.207	0.293		L.S.D 0.05	
average B	bio-fertilizers × chemical fertilizers) B×C(			
287.73	287.95	287.52	B1 0	
330.66	330.87	330.45	B2 VAM	
340.50	340.68	340.32	B3 AS	
588.20	592.65	583.75	B4 M	
0.239	0.338		L.S.D 0.05	
	388.04	385.51	average C	
	0.169		L.S.D 0.05	

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Fruit content of ascorbic acid (mg 100 g fresh weight^{-1})

The results of table ((4) showed that the addition of vermicompost (V3) gave a significant increase in the fruit content of ascorbic acid amounting to 20.91 mg.100 gm fresh weight-1 compared to (V1), which gave the lowest rate of 18.59 mg. 100 gm fresh weight-1.The results showed the mixed biofertilizer (B4) excelled and gave the highest rate of 23.44 mg. 100 gm fresh weight-1 compared to no addition (B1), which gave the lowest rate of 17.23 mg. 100g fresh weight-1.The addition exceeded 50% of the fertilizer recommendation (C2) to give an average of 19.96 mg.100 gm fresh weight-1 compared to no addition (C1) which amounted to 19.44 mg.100 gm fresh weight-1.The interaction (V3B4) also excelled and gave an average of 25.13 mg. 100 gm fresh weight-1 compared to no addition (V1B1), which gave the lowest rate of 16.50 mg.100 gm fresh weight-1. and the interaction record (V3C2) at 50% of the fertilizer recommendation had the highest rate of 21.21 mg. 100 gm fresh weight-1 compared to the non-adding (V1C1) which gave the lowest rate of 18.42 mg.100 gm fresh weight-1.The interaction (B4C2) at 50% of the recommended fertilizer gave the highest rate of 23.83 mg. 100 gm fresh weight-1 compared to no addition (B1C1) which gave the lowest rate of 16.99 mg.100 gm fresh weight-1. The interaction (V3B4C2) at 50% of the recommended fertilizer gave the highest rate of 25.53 mg. 100 gm fresh weight-1, compared to (V1B1C1), which gave the lowest rate of 16.37 mg. 100 g fresh weight-1. These results agreed with (17) and (18).

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Table 4. Effect of vermicompost and bio-chemical fertilizers on ascorbic acid (100 gm fresh weight-1) of Strawberry

average V ×B	chemical fertilizers		bio-fertilizers	vermicompost
	C2	C1		
16.50	16.63	16.37	B1	V1 0
17.52	17.67	17.37	B2	
18.45	18.57	18.33	B3	
21.88	22.17	21.60	B4	
17.28	17.53	17.03	B1	V2 400
18.11	18.50	17.73	B2	
19.65	19.77	19.53	B3	
23.32	23.80	22.83	B4	
17.90	18.23	17.57	B1	V3 800
19.30	19.33	19.27	B2	
21.32	21.73	20.90	B3	
25.13	25.53	24.73	B4	
0.500	0.707		L.S.D 0.05	
average V	vermicompost × chemical fertilizers) V×C(			
18.59	18.76	18.42	V1	
19.59	19.90	19.28	V2	
20.91	21.21	20.62	V3	
0.250	0.353		L.S.D 0.05	
average B	bio-fertilizers × chemical fertilizers) B×C(			
17.23	17.47	16.99	B1 0	
18.31	18.50	18.12	B2 VAM	
19.81	20.02	19.59	B3 AS	
23.44	23.83	23.06	B4 M	
0.289	0.408		L.S.D 0.05	
	19.96	19.44	average C	
	0.204		L.S.D 0.05	

TSS %

Table ((5) showed that the addition of vermicompost (V3) gave a significant increase in the percentage of soluble solids (TSS) %, amounting to 9.73%, compared to control (V1), which gave the lowest rate of 7.48%, and the excelled of bacterial biofertilizer (B3), which gave a rate of 9.96%. % compared to fungal biofertilizer and not adding (B1), which gave the lowest rate of 7.32%, and the results of the same table showed that there were no significant differences between the treatment of not adding chemical fertilizer and adding 50% of the fertilizer recommendation. Compared to not adding (V1B1), which gave the lowest rate of 6.02%, the interaction (V3C2) at 50% of the fertilizer recommendation recorded the highest rate of 10.08%, compared to (V1C2), which gave the lowest rate of 7.21%. (B3C2) at 50% of the fertilizer recommendation had the highest rate

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of 10.13% compared to not adding (B1C1) which gave the lowest rate of 7.30%. The (V3B4C2) at 50% of the fertilizer recommendation gave the highest rate of 11.70% compared to (V1B1C2) as it gave The lowest rate was 5.80%, and these results agreed with (14) and (17).

Table 5. The effect of vermicompost and bio-chemical fertilizers on the percentage of soluble solids (TSS%) in the fruits of the strawberry plant

average V ×B	chemical fertilizers		bio-fertilizers	vermicompost
	C2	C1		
6.02	5.80	6.23	B1	V1 0
6.87	6.37	7.37	B2	
9.05	9.40	8.70	B3	
7.97	7.27	8.67	B4	
7.38	7.63	7.13	B1	V2 400
8.88	8.23	9.53	B2	
10.38	10.50	10.27	B3	
9.13	9.63	8.63	B4	
8.57	8.60	8.53	B1	V3 800
9.08	9.50	8.67	B2	
10.45	10.50	10.40	B3	
10.82	11.70	9.93	B4	
0.44	0.63		L.S.D 0.05	
average V	vermicompost × chemical fertilizers) V×C(			
7.48	7.21	7.74	V1	
8.95	9.00	8.89	V2	
9.73	10.08	9.38	V3	
0.22	0.31		L.S.D 0.05	
average B	bio-fertilizers × chemical fertilizers) B×C(			
7.32	7.34	7.30	B1 0	
8.28	8.03	8.52	B2 VAM	
9.96	10.13	9.79	B3 AS	
9.31	9.53	9.08	B4 M	
0.26	0.36		L.S.D 0.05	
	8.76	8.67	average C	
	N.S		L.S.D 0.05	

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Discussion

From tables (1, 2, 3, 4 and 5) it was noted that there was a significant effect of the experimental factors in most of the studied traits (number of fruits, weight of fruits, total yield, ascorbic acid, TSS percentage) through the possibility of using less amount of chemical fertilizers (50%) From the compost recommendation) in addition to organic fertilizers (vermicompost) and biological (mycorrhiza fungus and Azospirillum bacteria), which contributed to reducing environmental pollution, which was achieved through the triple overlap between the study factors. The vermicompost fertilizer added to the soil played a role in the process of enriching the plant's rhizosphere with nutrients (19) and (20) and its contribution to the permanence of water and not consuming it from the root zone (21) and (22) and the positive interactions between vermicompost and the added organisms (mycorrhizae and bacteria) that contributed to improving The plant by increasing the bioactivity of the microorganisms and thus yields high quality fruits (23). And that combinations of biofertilizers have an effect on the metabolic processes that take place inside the plant and stimulate it to produce many plant growth regulators that positively affect the increase in yield (24). that act as additional root hairs in addition to their positive interaction with the rest of the beneficial organisms in the soil and work to increase the contact of elements between the roots and the soil and then transfer them to the plant through the roots (19). It is one of the important nutrients for flowering and fruiting process, such as phosphorous and potassium, and it agrees with (25), as for the mineral fertilizer NPK, it had a significant effect on the studied characteristics, due to the increase in the readiness of nutrients N.P.K in the soil solution, which increases its absorption by the plant (26).

Recommendations

We recommend the use of vermicompost because it provides half of the fertilizer recommendation, as well as the use of the mixture of biofertilizers (mycorrhiza and azospirillum) and the use of the fertilizer combination consisting of vermicompost 800 gm and the biofertilizer mixed with half of the fertilizer recommendation, due to its effect on improving the characteristics of the yield, the quantity and quality studied, and the possibility of reducing the added chemical fertilizers by going to Sustainable farming methods and the use of integration with earthworm compost and biofertilizers.

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