Article

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Effect of Spent Ground Coffee, Vermicompost and Chemical Fertilizers on Organic Red Radish (*Ravanello Cherry Belle*) Plant and Soil Quality

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Abstract: The overuse of chemical fertilisers degrades the soil ecosystem and restricts the natural development of plants. Within the coffee industry, various by-products are produced throughout the process of coffee production and consumption, which are significant in terms of environmental waste. SCG (spent coffee grounds) contain a variety of bioactive compounds that have demonstrated potential applications in various fields. These compounds can enhance soil quality by improving its chemical, physicochemical, physical properties, and biological fertility, ultimately leading to improved plant growth. This study examines the impact of SCG, vermicompost and chemical fertilizers on the growth of Organic Red Radish (*Ravanello Cherry Belle*) and soil quality. The experiment, conducted in a greenhouse, tested various concentrations and applications of SCG. Results showed that the SCGT 0.5 gm treatment yielded the highest mean plant length (18.47 cm) and fresh weight (27.54 grams), while the SCG 10% treatment resulted in the lowest mean plant length (4.54 cm) and fresh weight (0.07 grams). Vermicompost at 50% concentration produced the highest mean leaf surface area (58.32). These findings suggest the potential of SCG as a sustainable fertilizer alternative, contributing to improved plant growth and soil quality, thus supporting sustainable agricultural practices and a circular economy.

Keywords: spent coffee grounds; vermicompost; organic red radish; sustainable; agriculture; soil quality; plant growth

1. Introduction

Spent coffee grounds (SCG) are bio-waste whose annual generation amounts to 15 million tons per year, and it contain tannins, caffeine, and phenols [1]. The addition of SCG to soil will improved the soil chemical and physical fertility, increasing N, P and K content, enhancing structural stability of soil aggregates, water holding capacity, soil hydrophobicity, improved the content of soil organic matter, decreasing soil bulk density and increased soil microbial diversity [1–4]. Which make it a good solution for different types of soil, that often present a large deficit of organic matter, making them highly susceptible to erosion, such as in the United Arab Emirates (UAE) [5–7]. Although a significant amount of organic waste from SCG undergoes recycling, the rates of disposal remain high. Hence, the pursuit of strategies to reduce these rates is considered immensely valuable. The utilization of SCG has experienced a significant increase in popularity in recent years, primarily because it contains a high concentration of organic compounds such as fatty acids, lignin, cellulose, hemicellulose, and other polysaccharides. Studies have been undertaken to explore its potential application in improving soil fertility and increasing agricultural productivity [8].

Simultaneously, The global urban population is expected to reach 8.6 billion by 2030 [9], leading to an increase in both food consumption and food waste that give pressure and emerged as a critical challenge for sustainable management, and this requires innovative solutions that not only mitigate environmental concerns but also contribute to the enhancement of crops production quality and quantity. This issue is identical in the United Arab Emirates [10,11]. This could be solved by the

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promising and encouraging approach, which involves reutilizing various food waste materials, such as SCG for fertilizers [12–17].

An example of utilizing food waste for fertilizer is vermicompost, which is a product of organic matter degradation caused by interactions between earthworms and microorganisms in order to speed up the biodegradation process, which leads to a rapid humification process in which the unstable organic matter is fully oxidized and stabilized. The vermicompost produced from biowaste can be reused as nutrient-rich fertilisers or growing substrates [18]. They are finely divided peat-like materials with a high porosity, aeration, drainage, and water-holding capacity and are rich in bacteria, actinomycetes, fungi and cellulose-degrading bacteria. Studies have shown that amending soils with vermicompost can increase the germination, growth and yields of various vegetables and ornamentals, as well as other crops such as cowpeas, cress, grapes, bananas, strawberries and tomatoes [19–21].

On the other hand, The use of chemical fertilizers is one of the major environmental issues in agricultural production. Global food production widely depends on synthetic chemical fertilizers, and the world has now recognized the importance of sustainable agriculture, which defines production based on minimal resource expenses to maintain environmental resilience [22]. The chemical fertilizers are used to improve plant growth and provide nutrients. In contrast to organic fertilizers, chemical fertilizer overuse can lead to soil degradation, water pollution, and greenhouse gas emissions. It is important to use fertilizers responsibly to maximize their benefits while minimizing their negative impacts on the Environment [23,24].

This study introduces a comprehensive approach to mitigate waste and the excessive utilization of synthetic agrochemicals. Hence, the aim of this study is to investigate the potential use of SCG as a fertilizer and assess its impact on the biomass of radish plants and the quality of the soil. The study proposes that these waste materials can contribute to the implementation of more sustainable agricultural practices by decreasing reliance on synthetic fertilisers and mitigating the adverse effects of vermicompost and chemical fertilizers. Additionally, the study can promote a circular economy by offering alternative applications for underutilized agri-food byproducts. This study is the first in the UAE to investigate the impact of SCG on radish plants and soil quality.

The current study presented the findings of a recent experiment conducted in controlled greenhouse conditions in which SCG was used as a soil amendment at varying rates and methods. The objective of our study was to examine the changes in plant growth measurements and soil quality resulting from the application of SCG at two specific time intervals (the second and third weeks after seed planting). Plant growth measurements encompass the assessment of the vertical dimension and mass of various plant components. In order to fully assess the effectiveness of SCG as a soil amendment, additional analyses were performed to determine the soil's mineral composition and pH levels.

Organic Red radish (*Ravanello Cherry Belle*) was employed in the present research. Organic Red radish is an annual root vegetable crop belonging to the Brassicaceae family. Roots, leaves and sprouted seeds of the red radish may be ingested raw or in salad. The radish root epidermis has various colours (white, red, pink, purple and yellow), but root flesh is white and has a pungent, crisp flavour. Due to the presence of anthocyanin pigment, root skin is crimson in colour. A sufficient amount of vitamins, glucosinolates, sulforaphane, polyphenolic compounds, sulphur, calcium, potassium and phosphorus are present in the root, and it's associated with many significant health benefits [25] due to the presence of biologically active and potent anti-oxidant substances. Melchini and Traka (2010) and Kumar et al. (2014) [26,27] found that these substances may aid in reducing or preventing the risk of various diseases, including cardiovascular, certain malignancies, hypertension, stroke, and other chronic diseases [26–28].

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2. Materials and Methods

2.1. Experimental site

The current study was carried out at the United Arab Emirates University, college of Science, biology department greenhouse, during the winter seasons from January to April 2023.

2.2. Experimental design

The experiment was set in a split-plot design with three replicates. Spent Coffee Ground, vermicomposting, chemical fertilizer and control (only general media) treatments were randomly distributed within the sub-plots. Each experimental sub-plot consisted of 8 rows, with three replicates and in each pot, there were two seeds.

2.3. Preparation of the different types of fertilizers

In the greenhouse, the evaluation of the different fertilizers was carried out on Organic Red Radish seeds (*Ravanello Cherry Belle*). Our aim was to test the efficacy of these fertilizers on the growth rate and measurement of the radish and soil quality In these experiments, the fertilizers used were as follows:

2.3.1. Control (C):

Control we only use General Media (GM) which was Seed Starter Potting soil product. The Specifications of the soil product were as following:

- Basic material: Decomposed Plant Material
- Density: >200 kg/m3
- Organic matter: 88%
- Moisture content: 47%
- Electrical Conductivity (EC): <1.5mmhos/cm
- Salt Content: <1.5 g/L
- pH: 5.5-6.5

This soil was used for growing Radishes because an EC and pH value matched radish requirements [29].

2.3.2. Spent Coffee Ground (SCG):

SCG collected from the canteen of the United Arab Emirates University was used in two ways:

1. Top dressing method (SCGT):

By Adding the SCG on the top surface layer of the soil on the second and third weeks of planting the seeds in these amounts:

1- SCGT 0.5 g = 0.5 g of SCG on the top surface layer of the soil, and then water the pot by 50 ml water.
2- SCGT 1 g = 1 g of SCG on the top surface layer of the soil, and then water the pot by 50 ml water.
3- SCGT 2.5 g = 2.5 g of SCG on the top surface layer of the soil, and then water the pot by 50 ml water.

2. SCG %: Mixing the SCG in different percentages with the general media (GM) from the first day with as:

1- SCG 5% = 5% (5 parts of SCG and 95 parts GM).
2- SCG 10% = 10% (10 parts of SCG and 90 parts GM).
3- SCG 25% = 25% (25 parts of SCG and 75 parts GM).
4- SCG 50% = 50% (50 parts of SCG and 50 parts GM).

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2.3.3. Vermicompost fertilizer (VC):

The Vermicompost is the product of the decomposition process using various species of worms. In this study, red wigglers species were used. Mixed food waste from the canteen of the United Arab Emirates University was used to feed the earthworms. And then it was used in this different percentages:

1. VC %: Mixing the SCG in different percentages with the general media (GM) from the first day with as:
   1. VC 10% = 10% (10 parts of VC and 90 parts GM).
   2. VC 25% = 25% (25 parts of VC and 75 parts GM).
   3. VC 50% = 50% (50 parts of VC and 50 parts GM).

2.3.4. Chemical Fertilizer (CF):

The 1 gram (g) of chemical fertilizer was mixed with 1000 millilitres (ml) of water to create a 1.2 Electronic conductivity (EC) solution, which is equivalent to radish EC. Then, the CF was applied in the second and third weeks after planting the seeds. The product details were as follows:

- Composition: 20% N, 20% P2O5, 20% K2O + micro elements
- Formulation: Powder
- Application type: top dressing

2.4. Greenhouse Experiments

In the greenhouse experiments, all the above treatments were used; for each treatment/group, eight separate pots, each containing two seeds, were arranged in a split-split design. Greenhouse experiments were repeated three times. Control and inoculated soil were maintained in the greenhouse (15 h day/ 9h night) for 35 days; temperature of 28 ± 2 ◦C; relative humidity of 42 ± 5%).

Table 1. Lay out of greenhouse experiments.

Replicate	**Treatments**	**SCG%**	**SCGT (Top dressing)**	**Vermicompost**	**CF**	**C**
	Time *	**Day 0**	**Week 2 and 3**	**Day 0**	**Week 2 and 3**	**Day 0**
	Percentage or gram* *	**5%**	**0.5 g**	**10%**	**1 gram**	
		10%	**1.0 g**	**25%**		
		25%	**2.5 g**	**50%**		
		50%				

*The day of application, * *The percentage or gram that were apply, All sub-plots containing vermicompost and SCG as percentages were mixed with GM from day one, while SCG (0.5, 1, 2.5 gm) top-dressing and chemical fertilizer 1 gm was added after two weeks.

2.5. Plant Growth Measurements:

The plant growth measurements include:

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2.5.1. Radish Height

1. Height of the whole fresh radish (including shoot, leaves and roots) by using a tap measure by unit (cm).
2. Height of the shoot of the fresh radish by using a tap measure by unit (cm).
3. Height of the root of the fresh radish by using a tap measure by unit (cm).
4. Diameter: Diameter of the whole fresh radish by using a tap measure in the units (cm).

2.5.2. Radish weight:

Weight of the whole radish fresh and dry radish by using (Analytical Balance Mod. M214Ai) in grams.

2.5.3. Leaf Surface Area (LSA) was done by:

- Digital applications software (Leaf Byte) [30].
- The grid count method [31,32].
- The width and length of the leaf [33].

2.6. Soil quality

To determine the soil quality, these tests were done:

- pH meter and EC: These were done using the HEM Conductivity Meter, Technical Jica by The Government of Japan Cooperation on UAEU laboratory. The pH and EC were done for all soil used.
- Viable cell count for all soil was done according to [34].
- Laboratory analysis of micronutrients and minerals of soil including (Carbon,N, P, K)

2.7. Statistical Analyses

Data were combined and analyzed using SPSS Software version 29 for statistical analyses.

3. Results

3.1. Reliability and normality tests

In research, ensuring the validity and reliability of data is crucial for drawing accurate conclusions. This study on the growth of red radish plants under various fertilizer treatments emphasizes the importance of these aspects through reliability and normality testing. The reliability of the measures was assessed using Cronbach's alpha, a statistic commonly employed to evaluate the internal consistency of a test or scale.

Table 2. Reliability test.

Plant growth dimensions	Number of items	Cronbach alpha
Length	4	.878
Weight	3 (fresh)	.714
	3 (dry weight)	.746
Leaves	3 (leaves measures)	.809
	2 (leave surface area)	.872

The reliability of the measures was assessed using Cronbach's alpha, with all dimensions showing good reliability (> 0.7).

The study conducted normality tests using the Kolmogorov-Smirnov and Shapiro-Wilk tests to assess the distribution of data across various growth parameters of red radish plants under different fertilizer treatments. These tests were crucial for determining the appropriateness of subsequent statistical analyses, as they checked whether the data followed a normal distribution, a key assumption in many parametric tests.

The results varied across different groups and parameters. For plant length, the Kolmogorov-Smirnov test suggested non-significant deviations from normality for most groups, except for a few, such as SCG 5%, which indicated a lower bound significance. However, the Shapiro-Wilk test showed significant deviations for groups like SCG 10%. In terms of fresh weight, both tests indicated significant deviations from normality in several groups, notably SCG 10%. For dry weight, significant deviations were observed in groups like SCG 10% in both tests. The leave measures and leave surface area parameters also showed significant deviations in some groups, particularly in the SCGT 2.5 gm topdressing on soil group, as indicated by both tests. Both mean and median scores can be used to account for potential differences.

3.2. Data analysis procedures

The study reported mean, median, minimum, maximum, standard error of mean, standard deviation, and variance for each treatment group across different dependent variables. Analysis of variance (ANOVA) was conducted to compare the effects of different fertilizers on plant growth dimensions. Significant effects were found in plant length, fresh weight, dry weight, leave measures, and leave surface area, as indicated by the F values and significance levels ($p < .05$). Eta and Eta squared values were reported, indicating a strong association between the type of fertilizer and plant growth parameters.

3.3. Plant length

Table 3 presents the descriptive statistics for plant length under various fertilizer treatments. The sample size (N), minimum, maximum, median, mean, standard error of the mean, standard deviation, and variance were reported for each treatment group. Notably, the group treated with SCGT 1 gm showed the highest mean plant length (18.47 cm), while the group with SCG 10% showed the lowest mean length (4.54 cm). The control group C (no treatment) displayed the widest range in plant length, with a maximum of 31.67 cm and a minimum of 11.88 cm, indicating substantial variability in plant growth under natural conditions.

Table 3. Plant lenght.

Fertilizers	N	Min	Max	Median	Mean	Std. Error of Mean	Std. Deviation	Variance
SCG 10%	12	2.58	5.33	4.76	4.54	0.22	0.77	0.59
SCG 25%	3	5.23	7.00	6.10	6.10	0.51	0.88	0.78
SCG 5%	17	6.68	10.75	8.26	8.45	0.21	0.88	0.77
SCG 50%	1	6.90	6.90	6.90	6.90	.	.	.
SCGT 1 gm	6	15.25	23.25	18.12	18.47	1.19	2.91	8.51
SCGT 2.5 gm	9	13.25	21.75	17.00	16.97	0.83	2.49	6.24
CF	34	15.75	27.75	20.50	20.82	0.45	2.62	6.89
SCGT 0.5 gm	6	15.25	20.25	17.68	17.58	0.70	1.73	2.99
C	31	11.88	31.67	20.42	20.22	0.95	5.33	28.45
VC 10%	9	16.00	21.38	19.25	18.68	0.69	2.07	4.30
VC 25%	10	13.63	22.33	18.1375	18.3425	.77644	2.45532	6.029
VC 50%	9	19.50	27.25	23.2500	23.3917	.98762	2.96287	8.779
Total	147	2.58	31.67	18.5000	16.9378	.53634	6.50283	42.287

The ANOVA table indicated significant differences in plant length among the different fertilizer treatments ($F(11, 135) = 43.112$, $p < .001$). This result suggests that the type of fertilizer significantly affects the growth of red radish plants in terms of length. The between-groups sum of squares

(4805.79) and the within-groups sum of squares (1368.07) further elucidate the variation attributed to the treatment effects versus individual differences within groups.

Table 3. ANOVA.

			Sum of Squares	df	Mean Square	F	Sig.
Plant lenght * Fertilizers	Between Groups	(Combined)	4805.79	11	436.89	43.11	0.000
	Within Groups		1368.07	135	10.13		
	Total		6173.86	146			

The measures of association, as indicated by Eta (0.882) and Eta Squared (0.778), reveal a strong relationship between the type of fertilizer used and the plant length. An Eta Squared value of 0.778 suggests that approximately 77.8% of the variance in plant length can be explained by the type of fertilizer used, indicating a substantial effect size.

Table 4. Measures of Association.

	Eta	Eta Squared
Plant lenght * Fertilizers	0.882	0.778

3.4. Fresh weight

The descriptive statistics for fresh weight, as detailed in the study, show variations across different fertilizer treatments. The sample size (N), minimum, maximum, median, mean, standard error of the mean, standard deviation, and variance were reported for each group. Notably, the SCGT 1 gm group exhibited the highest mean fresh weight (27.54 grams), while the lowest was observed in the SCG 10% group (0.07 grams).

Table 5. Fresh weight .

Fertilizers	N	Min	Max	Median	Mean	Std. Error of Mean	Std. Deviation	Variance
SCG 10%	12	0.01	.24	0.06	0.07	0.017	0.06	0.00
SCG 25%	3	0.05	.35	0.10	0.16	0.09	0.16	0.02
SCG 5%	17	0.19	.70	0.32	0.32	0.03	0.14	0.02
SCG 50%	1	0.12	.12	0.12	0.12	.	.	.
SCGT 1 gm	6	14.57	42.02	26.09	27.54	4.04	9.89	97.93
SCGT 2.5 gm	9	14.56	38.14	22.58	24.56	2.93	8.80	77.48
CF	34	12.20	28.75	20.80	21.05	0.69	4.07	16.61
SCGT 0.5 gm	6	24.09	24.65	24.33	24.34	0.08	0.20	0.04
C	31	1.34	46.84	16.72	19.25	2.30	12.82	164.40
VC 10%	8	4.64	46.16	23.28	24.83	4.74	13.42	180.35
VC 25%	10	13.03	36.33	18.79	21.42	2.48	7.84	61.51
VC 50%	9	30.04	35.55	33.29	33.08	0.59	1.78	3.17
Total	146	0.01	46.84	18.79	17.55	1.04	12.57	158.08

The control group (no treatment) demonstrated a wide range in fresh weight, suggesting significant variability under natural growth conditions.

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Table 6. ANOVA Table.

			Sum of Squares	df	Mean Square	F	Sig.
Fresh weight * Fertilizers	Between Groups	(Combined)	14489.64	11	1317.24	20.93	0.00
	Within Groups		8432.26	134	62.92		
	Total		22921.91	145			

The ANOVA results indicated significant differences in fresh weight among the fertilizer treatments ($F(11, 134) = 20.93$, $p < .001$). This significant finding highlights that the type of fertilizer notably affects the fresh weight of red radish plants. The substantial difference in sum of squares between groups (14489.64) and within groups (8432.26) emphasizes the impact of fertilizer type on fresh weight variation.

Table 7. Measures of Association.

	Eta	Eta Squared
Fresh weight * Fertilizers	0.795	0.632

The measures of association, indicated by Eta (0.795) and Eta Squared (0.632), reveal a strong correlation between the type of fertilizer and the fresh weight of the plants. The Eta Squared value of .632 suggests that approximately 63.2% of the variance in fresh weight is explained by the fertilizer type, indicating a significant effect size.

3.5. Dry weight

The study presented descriptive statistics for the dry weight of red radish plants under various fertilizer treatments. The analysis included the number of observations (N), minimum and maximum values, median, mean, standard error of the mean, standard deviation, and variance for each treatment group.

Table 8. Dry weight .

Fertilizers	N	Min	Max	Median	Mean	Std. Error of Mean	Std. Deviation	Variance
SCG 10%	12	0.00	0.02	0.00	0.00	0.00	0.00	0.00
SCG 25%	3	0.01	0.02	0.01	0.01	0.00	0.00	0.00
SCG 5%	17	0.09	0.10	0.09	0.09	0.00	0.00	0.00
SCG 50%	1	0.05	0.05	0.05	0.05	.	.	.
SCGT 1 gm	6	3.54	5.85	4.10	4.3	0.35	0.87	0.76
SCGT 2.5 gm	9	3.63	6.52	5.15	5.15	0.33	0.99	0.99
CF	34	0.69	4.55	2.10	2.55	0.20	1.17	1.38
SCGT 0.5 gm	6	4.06	5.87	5.18	5.09	0.30	0.73	0.545
C	31	0.19	5.45	2.02	2.23	0.26	1.50	2.25
VC 10%	9	4.41	7.24	5.84	5.77	0.30	0.92	0.84
VC 25%	10	2.68	7.07	5.36	5.19	0.38	1.20	1.46
VC 50%	9	0.71	6.11	4.10	3.73	.70042	2.10	4.41
Total	147	0.00	7.24	2.60	2.70	.17848	2.16	4.68

Notably, the SCGT 1 gm group showed the highest mean dry weight (4.34 grams), while the SCG 10% group had the lowest mean dry weight (0.00 grams). The control group (no treatment) displayed a wide range of dry weight, indicating significant variability in plant dry weight under natural conditions.

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Table 9. ANOVA Table.

			Sum of Squares	df	Mean Square	F	Sig.
Dry weight * Fertilizers	Between Groups	(Combined)	500.55	11	45.50	33.54	0.00
	Within Groups		183.12	135	1.35		
	Total		683.68	146			

The ANOVA results demonstrated significant differences in dry weight among the different fertilizer treatments (F(11, 135) = 33.546, p < .001). This finding suggests that the type of fertilizer has a substantial impact on the dry weight of red radish plants. The between-groups sum of squares (500.55) compared to the within-groups sum of squares (183.126) highlights the variation in dry weight attributable to the fertilizer treatments.

Table 10. Measures of Association.

	Eta	Eta Squared
Dry weight * Fertilizers	0.856	0.732

The measures of association, Eta (0.856) and Eta Squared 0(.732), indicate a strong relationship between the type of fertilizer and the dry weight of the plants. An Eta Squared value of 0.732 suggests that approximately 73.2% of the variance in dry weight can be explained by the type of fertilizer used, signifying a significant effect size.

3.6. Leave measures

The study's descriptive statistics provide a detailed look at leaf measures for red radish plants under various fertilizer treatments.

Table 11. Leave measures .

Fertilizers	N	Minimum	Maximum	Median	Mean	Std. Error of Mean	Std. Deviation	Variance
SCG 10%	12	0.80	2.17	1.58	1.51	0.11	0.40	0.16
SCG 25%	3	1.33	2.10	1.76	1.73	0.22	0.38	0.14
SCG 5%	17	2.13	4.50	3.40	3.56	0.16	0.68	0.47
SCG 50%	1	2.10	2.10	2.10	2.10	.	.	.
SCGT 1 gm	6	6.33	9.67	7.66	7.69	0.50	1.23	1.51
SCGT 2.5 gm	9	6.67	7.67	7.66	7.40	0.13	0.40	0.16
CF	34	5.00	8.67	6.41	6.64	0.17	0.99	0.99
SCGT 0.5 gm	6	7.00	8.67	8.00	7.88	0.22	0.54	0.29
C	31	4.23	9.70	7.16	7.29	0.28	1.60	2.58
VC 10%	9	4.67	9.33	7.33	7.14	0.55	1.66	2.78
VC 25%	10	5.60	12.42	7.80	8.07	0.59	1.88	3.56
VC 50%	9	7.50	9.67	8.66	8.60	0.26	0.80	0.64
Total	147	0.80	12.42	6.66	6.26	0.19	2.38	5.68

The analysis included the number of observations (N), minimum, maximum, median, mean, standard error of the mean, standard deviation, and variance for each group. Notably, the group treated with Vermicompost 50% and Soil 50% showed the highest mean leaf measure (8.60), while the SCG 10% group had the lowest mean (1.51). The range of leaf measures was quite broad in some groups, especially in those treated with Vermicompost 25% and soil 75% and the control group, indicating significant variability in leaf growth under different conditions.

Table 12. ANOVA Table.

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			Sum of Squares	df	Mean Square	F	Sig.
Leave measures * Fertilizers	Between Groups	(Combined)	640.46	11	58.22	41.43	0.00
	Within Groups		189.70	135	1.40		
	Total		830.17	146			

The ANOVA results showed significant differences in leaf measures among the various fertilizer treatments ($F(11, 135) = 41.434$, $p < .001$). This finding indicates that the type of fertilizer significantly influences leaf development in red radish plants. The substantial difference in sum of squares between groups (640.46) and within groups (189.70) further underscores the impact of fertilizer type on the variability of leaf measures.

Table 13. Measures of Association.

	Eta	Eta Squared
Leave measures * Fertilizers	0.878	0.771

The measures of association, as indicated by Eta (.878) and Eta Squared (0.771), demonstrate a strong relationship between the type of fertilizer and the leaf measures of the plants. An Eta Squared value of 0.771 suggests that approximately 77.1% of the variance in leaf measures is attributable to the type of fertilizer, signifying a significant effect size.

3.7. Leave surface area

The study's descriptive statistics provide insights into the leaf surface area of red radish plants under various fertilizer treatments.

Table 14. Leave surface area .

Fertilizers	**N**	**Minimum**	**Maximum**	**Median**	**Mean**	**Std. Error of Mean**	**Std. Deviation**	**Variance**
SCG 10%	12	0.16	1.90	1.50	1.38	0.13	0.48	0.23
SCG 25%	3	1.09	1.57	1.56	1.40	0.16	0.27	0.07
SCG 5%	17	1.91	8.63	5.58	4.87	0.51	2.10	4.44
SCG 50%	1	1.80	1.80	1.79	1.79	.	.	.
SCGT 1 gm	6	55.47	73.43	62.09	63.30	2.44	5.98	35.79
SCGT 2.5 gm	9	45.50	52.20	50.78	49.27	0.79	2.39	5.74
CF	34	30.02	50.58	39.95	40.07	0.87	5.10	26.03
SCGT 0.5 gm	6	39.77	57.13	50.64	50.06	2.84	6.96	48.49
C	31	52.17	52.17	52.16	52.16	0.00	0.00	0.00
VC 10%	9	12.87	70.07	48.85	42.65	5.56	16.69	278.59
VC 25%	10	22.97	53.49	34.51	36.79	3.22	10.20	104.13
VC 50%	9	35.22	71.81	58.88	58.32	3.84	11.53	133.05
Total	147	0.16	73.43	44.41	37.31	1.69	20.57	423.22

The analysis included the number of observations (N), minimum, maximum, median, mean, standard error of the mean, standard deviation, and variance for each group. The SCGT 1 gm group showed the highest mean leaf surface area (63.30), while the SCG 10% group had the lowest mean (1.38). The control group (no treatment) demonstrated a consistent leaf surface area with no variability. The range of leaf surface area varied significantly across groups, indicating the impact of different fertilizers on leaf growth.

Table 14. ANOVA Table.

			Sum of Squares	df	Mean Square	F	Sig.
Leave surface area * Fertilizers	Between Groups	(Combined)	56160.67	11	5105.51	122.40	0.00
	Within Groups		5630.80	135	41.71		
	Total		61791.47	146			

The ANOVA results indicated significant differences in leaf surface area among the fertilizer treatments ($F(11, 135) = 122.406$, $p < .001$). This significant finding suggests that the type of fertilizer has a substantial effect on the leaf surface area of red radish plants. The large between-groups sum of squares (56160.67) compared to the within-groups sum of squares (5630.80) highlights the variation in leaf surface area attributable to the type of fertilizer.

Table 15. Measures of Association.

	Eta	Eta Squared
Leave surface area * Fertilizers	0.953	0.909

The measures of association, Eta (0.953) and Eta Squared (0.909), demonstrate a very strong relationship between the type of fertilizer and the leaf surface area of the plants. An Eta Squared value of .909 indicates that approximately 90.9% of the variance in leaf surface area can be explained by the type of fertilizer used, signifying an extremely significant effect size.

3.8. Characterization of Soil Properties

Tables 16 and 17 show the effect of different fertilizers on soil properties. The addition of fertilizers to the soil modified pH availability and EC conductivity. The pH varied from 5.4 to 6.8 within the different treatments, and the number of actinobacteria colonies in the different fertilizers is present in Table 16; the results indicate variations in microbial growth depending on the type of fertilizer used. Among the tested fertilizers, SCG at different concentrations (5%, 10%, 25%, and 50%) exhibited noticeable effects on microbial colony counts. The SCG 25% and SCG 50% dilutions resulted in a higher number of colonies compared to the SCG 5% and SCG 10% dilutions. This suggests that higher concentrations of SCG fertilizer created a more favourable environment for microbial proliferation.

Table 16. Characterization of soil pH, EC and Number of Actinobacteria cells.

Treatments	pH	EC	PPM	Number of cells 10^{-4}
SCG 5%	5.58	2.54	1625.60	46
SCG 10%	5.79	3.04	1945.60	12
SCG 25%	5.42	2.60	1664.00	116
SCG 50%	5.50	2.29	1465.60	169
SCGT 0.5 gm	5.56	2.54	1625.60	4
SCGT 1 gm	5.75	3.04	1945.60	4
SCGT 2.5 gm	5.40	2.60	1664.00	15
VC 10%	6.47	2.04	1305.60	10
VC 25%	6.73	1.20	768.00	38
VC 50%	6.83	2.70	1785.60	35
CF	6.70	1.12	716.80	5
C	6.40	0.538	344.30	9

Table 17. Characterization of soil minerals contents.

Treatments	C*	N	P	K
SCG 5%	41.5	1.32	1168.2	2258.0
SCG 10%	43.7	1.50	1281.2	2795.1
SCG 25%	43.8	1.63	1443.0	3752.7
SCG 50%	45.6	1.99	1749.6	4440.1
SCGT 0.5 gm	41.2	1.11	420.6	167.2
SCGT 1 gm	42.8	1.15	462.2	184.3
SCGT 2.5 gm	41.9	1.21	469.9	200.0
VC 10%	39.1	1.15	730.4	1986.9
VC 25%	20.3	0.68	508.8	2243.4
VC 50%	40.8	1.18	915.5	5157.1
CF	42.4	1.08	549.0	322.0
C	30.5	1.11	809.2	2784.2

C*= carbon, N= Nitrogen, K = Potassium, P= phosphorus.

4. Discussion

The organic Red Radish was planted and treated with different fertilizers. The VC 50% gave the highest plant growth in most parameters. It may be possible that the large microbial populations in vermicomposts and the very considerable buildup of microbial populations and activity in the soils treated with vermicomposts may have influenced plant growth directly or indirectly. Our results were in line with This aligns with a study that assessed the alterations in pH, EC, and carbon content in the rhizosphere of lettuce plants subjected to varying levels of vermicompost. The results demonstrated that the application of vermicompost led to a significant enhancement in plant height and fresh and dry weight, thereby indicating the beneficial influence of vermicompost on plant growth. Furthermore, the utilisation of vermicompost resulted in an augmentation of plant biomass and enhanced soil characteristics, including pH, organic matter content, and microbial activity. The results indicated that the application of vermicompost led to an augmentation in both the quantity and activity of microorganisms in the rhizosphere. This enhancement can have advantageous effects on plant development and the prevention of diseases. Microbial activity in soils has been suggested by many authors as probably responsible for improving soil structure and influencing the root environment and plant growth indirectly, especially in 25 and 50% of vermicompost [35,36].

This study suggests that the type of fertilizer significantly impacts the growth of organic red radish plants. The high eta squared values indicate a strong effect size. Specific treatments, like the application of certain proportions of coffee grounds or vermicompost, showed distinct effects on plant growth dimensions. These findings can inform agricultural practices for organic farming and contribute to sustainable agriculture methods.

The results demonstrate a significant impact of fertilizer type on the length of red radish plants. The large effect size and the significant differences across groups underscore the importance of selecting appropriate fertilizer treatments to optimize plant growth. These findings contribute valuable insights for agricultural practices, particularly in the context of optimizing growth conditions for red radish plants and for countries that need an exact amount of fertilizer, like desert countries such as the UAE.

The results from fresh weight underscore the critical impact of fertilizer type on the fresh weight of red radish plants. The marked differences in fresh weight across treatments reflect the importance of choosing appropriate fertilizers for optimal plant growth. This study offers valuable insights into agricultural practices, particularly for enhancing the fresh weight of red radish plants through strategic fertilizer use. The strong association between fertilizer types and fresh and dry weight outcomes suggests potential avenues for manipulating plant growth characteristics through targeted fertilization strategies.

The results from the dry weight analysis clearly show that fertilizer type significantly influences the dry weight of red radish plants. Much research proved the effect of SCG and vermicompost on plant measurements such as weight, length, leaf development and surface area as well as soil properties field [6,8,35–42].

On this research SCG were showing lowest effect than SCGT, primarily impede the growth of plants This may be attributed to two factors. Firstly, the stimulation of microbial growth and subsequent competition for soil nitrogen between soil microorganisms and plant roots. Secondly, the presence of phytotoxic compounds in SCG, such as polyphenols. Vermicomposting and pyrolysis at 400 °C have been demonstrated as effective SCG transformation methods for the removal of these compounds. Nevertheless, certain studies have indicated that these compounds are accountable for the chelating characteristics of SCG, thereby rendering their removal inadvisable. Research has also investigated the utilisation of SCG as biochelates, resulting in a combination of waste material and micronutrients that can be used to enhance the nutritional value of edible plants through biofortification[6,8,38,42].

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