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RESEARCH ARTICLE

Effect of organic and bio-fertilization on cuttings of Ruby Seedless grapes cultivated in clay and sandy soils

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Abstract

The objective of the research was to improve the properties of grape cuttings to obtain strong and healthy plantlets and overcome the problems they encounter during cultivation in clay and sandy soils to become vigorous and healthy trees without using chemical fertilizer. This experiment investigated how to vermicompost tea and Plant Growth-Promoting Rhizobacteria (PGPR), individually or in mixed form, influenced the characteristics of grape cuttings cultivated in clay and sandy soils. Some physical and chemical parameters for cutting were measured such as parameters of vegetative growth and root, chemical parameters of plant, and soil parameters as $CaCo_3$ % content, and total count bacteria CFU/g. The results proved that the type of soil affected the growth of cuttings. All treatments gave significant differences, compared with the control. Sometimes significant differences were found among treatments on parameters, and sometimes not. In general, the best effect on the growth of the cuttings was in a treatment that included the combination of vermicompost tea and PGPR, whether cultivated in sandy or clay soil, in both successive growing seasons.

Keywords: Clay soil; Grape cuttings; Organic fertilizer; Sandy soil; Vermicompost tea.

1. Introduction

Grapes use several vegetative propagation methods such as cuttings, rooting, budding, layering, and grafting, but cuttings are the most prevalent. Since ancient times, grapes have been propagated in this manner (Somkuwar *et al.,* 2011). Cuttings have several advantages, such as being a cheaper method and easily having a high germination percentage (Rao, 2004), needing little space, and allowing for the quick dissemination of selected clones or new varieties resulting from breeding programs. They preserve the characteristics of species that have vegetatively propagated. Commonly, grapes use hardwood cuttings rather than softwood cuttings for propagation (Patil *et al.,* 2001; Smart *et al.,* 2006; Waite *et al.,* 2015).

Grape roots have a high ability to adapt to all soil types. Sandy loam or light loam with soft soil, moderate porosity, and low bulk density are the best soils for grape development. Rooting competency is dependent on the type of soil employed for cultivation. It is well known that suitable growth media functions as a reservoir for plant nutrients, hold plant-accessible water, allows for gas exchange, and provides good plant anchoring (Galavi *et al.,* 2013; Farooq *et al.,* 2018). Plant roots perform a variety of substantial

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functions, such as absorbing water and nutrients, storing and secreting chemicals, producing plant hormones, and transmitting stress signals from the roots to the tops (During *et al.,* 1996). Root growth is affected by several agents, such as temperature, soil components, water relations, crop load, and VA mycorrhizas (Atkinson, 1983). To improve and increase the growth of roots, can use many methods, including hormone application and hot treatment of the cuttings (Singh and Chauhan, 2020).

Unquestionably, using chemical fertilizers increases crop production, and the unbalanced use of these chemicals has deteriorated the physical health of soil throughout the years, resulting in sluggish crop production, severely reduced soil fertility and microbial biodiversity, and increased groundwater pollution, putting human and environmental health at risk. (Bakar *et al.,* 2015; Kumar *et al.,* 2018).

Because of the high cost of chemical fertilizers and the associated environmental health issues, research into alternative low-cost and environmentally friendly sustainable crop production methods is required. The injection of beneficial microbes into soils can lessen the need for chemical fertilizers, which are harmful to the environment (Barea *et al.,* 1997).

Plant growth-promoting rhizobacteria (PGPR) are a group of bacteria that can colonize the rhizosphere of plants and have a good impact on their growth (Glick, 1995). They are found in several genera, including *Acinetobacter, Alcaligenes, Arthrobacter, Azospirillium, Azotobacter, Bacillus, Beijerinckia, Burkholderia, Enterobacter, Erwinia, Flavobacterium, Pseudomonas*, *Rhizobium* and *Serratia* (Rodriguez and Fraga, 1999; Dursun *et al.,* 2008).

The mechanisms of Plant Growth-Promoting Rhizobacteria (PGPR) are a little incomprehensible but thought that have several functions such as solubilization of inorganic phosphate and mineralization of organic phosphate and/or other nutrients, being able to produce plant hormones, like auxins (Jeon *et al.*, 2003), gibberellins (Gutierrez-Manero *et al.*, 2001), and cytokinins (Garcia de Salamone *et al.*, 2001), the ability for symbiotic N_2 fixation (Sahin *et al.*, 2004), the synthesis of antibiotics, enzymes, and/or fungicides, antagonism against phytopathogenic microorganisms by the production of siderophores, and competition with detrimental microorganisms (Dey *et al.*, 2004; Kotan *et al.*, 2009). Pseudomonas is the most abundant genus of Gram-negative soil bacteria in the rhizosphere soil, and the PGPR activities of several of these strains have been documented in various places. Plant growth can be aided by the synthesis of phytohormones, antibiotics, siderophores, and enzymes by these species (Esitken *et al.*, 2010; Kumar *et al.*, 2015).

Vermicompost tea is the liquid state of vermicompost solid and has the same useful microbiological and chemical features. Through the fermentation process, plant growth hormones, useful microorganisms, soluble mineral nutrients, and humic and fulvic acids are extracted. In comparison between vermicompost in solid form and liquid state, vermicompost tea is the more applicable and easy method (Pant *et al*., 2009). Vermicompost tea can also be used for pest control due to the phenolic substances that make the plant tissues unpalatable (Pathma and Sakthivel, 2012). Vermicompost has a high potential for holding water, reducing microbial pathogens, and increasing the concentration of nutrient elements (Pandya *et al.,* 2014; Soobhany *et al.,* 2017).

Recently, vermicompost has attracted great interest for its physicochemical and biological characteristics (Huang *et al.,* 2014), and the soils treated with vermicompost have several physical and chemical advantages, such as a high potential for holding water, good aeration, high porosity, and an appropriate structure (Zhu *et al.,* 2017). And organic matter, pH, conductivity, and availability of nutrients, all of these contributed to increased crop growth and yield (Lim *et al.*, 2015). Vermicompost is regarded as a long-term source of macro- and micronutrients that are readily digested by plants (Atiyeh *et al.*, 2000). And also, has bacteria for nitrogen-fixing and phosphorus-solubilizing (Yatoo *et al.*, 2020), growth regulators such as gibberellins, auxins, and cytokinin, and substances like vitamins, humic acids, and several kinds of enzymes (Ravindran *et al.*, 2016; Amooaghaie and Golmohammadi, 2017).

As a result, the current study aims to investigate how vermicomposting tea and PGPR, alone or in combination, have influenced the characteristics of grape cuttings grown in clay and sandy soils.

2. Material and methods

This experiment was conducted 2020 and 2021 seasons in the nursery at the Pomology Department, Faculty of Agriculture, Assiut University. The aim was to study the effect of vermicompost tea and PGPR on the growth of grape cutting (*Vitis vinifera*) cv. King Ruby seedless in clay soil and sandy soil.

2.1. Stem cuttings preparation

During the winter dormancy stage, cuttings were taken from the middle portion of canes of good-growth vines that were 15 years old; they were healthy and disease-free, standardized in thickness and strength, approximately 25 cm in length, and had about 3 or 4 buds. A slanting cut was given on the upper end of the cuttings, 1 to 2 cm above the top bud, and a straight cut in at the lower end, just below the last bud, about 1 cm. They were stored in a hole approximately 30 cm deep until planting time in the spring. From time to time, water was sprayed on the cuttings to preserve them from drought.

2.2. Media preparation

Two kinds of soil, clay, and sand separately, were collected from a depth of 0-60 cm. After the soil samples were collected, the dirty particles, stones, and hard clods were carefully removed. The purpose was to ensure the soil was fine before using it for the experiment. At the beginning of the experiment, the samples of soil were subjected to standard physical and chemical analysis (Baruah and Barthakur, 1997; Jackson, 1973). Tables 1, and 2 show the soil sample's physical and chemical properties.

In the spring before the plantation, all the cuttings were carefully sprayed with water to hold the moisture in the wood and preserve them from drying. After that, the soil was put in perforated black polyethylene bags of half kg, one cutting was planted in each black polythene bag, and left a one-inch space at the top of the cutting. Three replicates of each treatment were in the experiment, and each replicate had one hundred filled polythene bags. The experiment was located in an agricultural greenhouse in natural light, with a day/night temperature average of 24$\pm$ 4°C and 15 $\pm$ 3°C, an average relative humidity of 50-60%, and a photoperiod of 16 hours alternating with 8 hours of darkness. The plants were watered three times per week, using the full amount of water that the pots could contain (predetermined).

2.3. Vermicompost tea preparation

Each kilogram and a half of vermicompost were placed in a water-permeable cotton bag and tightly closed, then put in 10 liters of water. To obtain a pH adequate was mixed 25 grams of molasses, 5 grams of magnesium sulfate, 1 gram of monopotassium phosphate, and citric acids. 6-10 grams of humic acid were added with ventilating for 48 hours. After that, the cotton bag was removed from the solution, which became ready to use. One liter of vermicompost tea was added to every 5 liters of water, and 100 ml was taken and applied to soil samples.

2.4. PGPR preparation

This study used four strains of Plant Growth-Promoting Rhizobacteria (PGPR): *Bacillus circulans* (potassium-solubilizing), *Paenibacillus polymyxa* (nitrogen fixation), and *Bacillus megaterium* (phosphorus-solubilizing bacteria). These strains of bacteria were grown in King's medium B until they reached 10^9 cells /ml^{-1}

(Atlas, 1995). And Pseudomonas fluorescens (which inhibits harmful microbes, generates growth-stimulating plant hormones, and creates higher disease resistance in plants) was grown on specialist media for it, and it can be used as powder or liquid. Was taken 2 ml of each strain to make a combination of them, and then I took 6 ml for inoculation of the soil samples. In the middle of the season, plantlets were re-inoculated with 6 ml of the same cell suspension.

2.5. *The experiment included four treatments as follows:*

1- Control: Water application (T_1).
2- Mix: A combination between vermicompost tea and PGPR (T_2).
3- PGPR (T_3)
4- Vermicompost tea (T_4).

These treatments were repeated twice, once at the beginning of the experiment and the second in the middle of the growing season (on the first of June). After planting, add one spoonful of urea fertilizer with PGPR treatments for bacteria feeding. Parameters were measured in the last week of September of two successive seasons, 2020 and 2021 (at the end of the growing stage).

2.6. Parameters of vegetative growth and root

1. Plant height (cm).
2. Main root length (cm).
3. Dry weight of whole plant (g.).
4. Dry weight of roots/plant(g.).
5. The number of leaves/plants.
6. Leaf area (cm^2).

It was measured in the ten leaves taken from the middle portions of the shoot (5th to 7th leaves from the plant base) according to the following equation reported by Ahmed and Morsy (1999).

$$L.A. = 0.56\ (0.79 \times W^2) + 20.01$$

LA = leaf area (cm^2)
W = the maximum leaf diameter (cm.)

At the end of each growing season, before four days of plant removal, the plants were irrigated to facilitate their removal from the soil and then measured for the following parameters:

2.7. Chemical parameters of plant

2.7.1. NPK content of leaves and roots per plant.

Leaf and root samples were cleaned with tap water first, then with distilled water and non-ionic detergent before being dried at 70°C in an air oven and manually pulverized with a mortar and pestle. In a muffle oven, one gram of powder was burned for 25 minutes at 550°C. The resultant white ash was then dissolved in 10 mL of 2 N HCl and 100 mL of distilled water for macro- and micronutrient analyses (Chapman and Pratt, 1961). A flame photometer was used to determine potassium content, and a spectrophotometer was used to determine phosphorous content. The Kjeldahl technique was used to determine total nitrogen content (Olsen *et al.*,1954; Jackson, 1973).

2.7.2. Carbohydrate % content of leaves and roots per plant

The leaves and roots were sampled, rinsed with distilled water, and then baked for 72 hours in a forced-air oven at 65 °C until they attained constant mass. The extracts were then created from 40 mg of macerated leaves using a perchloric acid solution (30% v/v) for starch and an alcohol solution (80% v/v) for soluble sugars. As per McCready *et al.* (1950)-recommended methodology, analyses were performed using the Antron method.

***2.7.3. Total chlorophyll content*:** was determined with a SPAD-502-meter (Minolta Camera Co., Osaka, Japan).

2.8. Soil parameters

2.8.1. $CaCo_3$ % content.

A conical flask containing 5 g of a finely ground soil sample, 10 ml of 1 N HCl, and 50 ml of distilled water was heated for 2 minutes to the boiling point. Three drops of phenolphthalein indicator were added, and 1 N NaOH was used to titrate the mixture after it had been allowed to cool. The percentage of calcium carbonate was then determined using Horvath *et al.* (2005).

2.8.2. Total count bacteria CFU/g.

Microbial counts: A serial decimal dilution using 10 g of moist soil and 95 ml of a sodium pyrophosphate solution at 0.1 percent (w/v) was carried out. These suspensions were then put into Petri dishes with a particular medium for microbial group counts. Using Bunt and Rovira's medium, the total number of bacteria was counted (Bunt, and Rovira, 1955). Following inoculation with diluted solutions heated to 80–85°C in a water bath for 10 minutes, counts of Bacillus spp. Spores were performed on the same medium. Gram-negative bacterial counts were performed using the same medium supplemented with 5 g of crystal violet (Higashida and Takao, 1986).

For actinomycete counts, was used starch-casein agar medium (Kuster and Williams, 1964) with 50 g/ml nystatin, 50 g/ml cycloheximide, 5 g/ml polymyxin-b-sulfate, and 1 g/ml sodium penicillin as supplements (Williams, and Davies, 1965). Afterward, the cultures were incubated at 28 °C for 4 days, and microbial counts (total bacteria, Bacillus spp., and microbial numbers) were calculated using the pour plate method.

2.9. Design of experiment

A combined analysis of the two soil types in each season was used with a randomized complete block design using three replications for each treatment. An analysis of variance (ANOVA) was carried out using Proc Mixed of the SAS package version 9.2 (SAS 2008), and means were compared by the least significant difference test at a 5% level of significance (Steel and Torrie, 1981).

Table 1. The composition of clay soil

Characters		Characters	
Sand (%)	15.43	Total N (%)	0.16
Silt (%)	33.22	Available P (mg/kg)	21.61
Clay (%)	51.35	Available K (mg/kg)	401.33
Texture	Clay	DTPA-extractable (mg/kg)	
pH (1:1 suspension)	8.10	Fe	13.19
E.C (dS/m^{-1})	2.69	Mn	15.16
Organic matter (%)	1.32	Zn	2.35
$CaCo_3$ (%)	3.66	Cu	2.11

Table 2. The composition of sandy soil

Characters		Characters	
Sand %	87.65	Organic Matter %	0.9
Silt %	11.85	Total N %	0.05
Clay	0.50	Available P (according to Olsen, ppm)	30.3
Texture	Sandy	Available K (Ammonium acetate, ppm)	180
pH (1:2.5 extract)	7.15	Field capacity %	8.0
EC (1: 2.5 extract) (dS / m^{-1})	0.01	Wilting point %	2.5
Total $CaCo_3$ %	0.50	Available water %	5.5

3. Result

Data in Tables 3, 4, and 5 illustrated the effect of both vermicompost and PGPR on the vegetative characteristics of cuttings cultivated in clay and sandy soils. They proved that all treatments had a positive impact compared to the control during the two study seasons.

During study seasons in both soils, data showed that the highest value of plant height was found in T_4 (72.83, 73.17 cm), followed by T_2 (67.58, 67.25 cm) and T_3 (68.50, 68.67 cm), respectively, with significant differences, while there was an insignificant difference between T_2 and T_3, and the lowest value was found in the control (55.67, 56.00 cm), respectively.

In addition, the results proved that there were insignificant differences in the effect of soil type on plant height, noticing that the value of sandy soil (67.08, 67.00 cm) was slightly higher than that of clay soil (65.21, 65.54 cm), respectively, in successive seasons. The data explained that the influence of the treatments on main root length followed a consistent pattern throughout two subsequent seasons. The highest value was in T_2 (15.25, 15.42 cm), followed by T_3 (15.00, 15.08 cm), respectively, with trivial differences between them, and then T_4 (14.23 cm). There was an insignificant difference between T_3 and T_4, while there was a significant difference between T_2 and T_4. The control had the lowest value (13.58, 13.50 cm), with significant differences between the treatments and the control.

And the results showed insignificant differences in the effect of soil type on main root length in both study seasons. Whereas sandy soil was recorded at 14.42 and 14.33 cm, and clay soil was recorded at 14.62 and 14.78 cm, respectively.

Table 3. Effect of organic and bio-fertilization on plant height (cm), and main root length (cm) of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

Parameter	Plant height (cm)						Main root length (cm)					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	53.33	58.00	55.67 c	54.00	58.00	56.00 c	13.33	13.83	13.58 c	13.50	13.50	13.50 c
Mix T_2	59.50	75.67	67.58 b	59.17	75.33	67.25 b	15.67	14.83	15.25 a	15.83	15.00	15.42 a
PGPR T_3	72.67	64.33	68.50 b	73.00	64.33	68.67 b	15.33	14.67	15.00 ab	15.50	14.67	15.08 ab
Vermicompost T_4	75.33	70.33	72.83 a	76.00	70.33	73.17a	14.13	14.33	14.23 bc	14.30	14.17	14.23 bc
Mean	65.21 A	67.08 A	66.15	65.54 A	67.00 A	66.27	14.62 A	14.42 A	14.52	14.78 A	14.33 A	14.55

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

Regarding the dry weight of the whole plant (g.), the data showed that all treatments had a positive effect compared with the control. The biggest value was recorded in T_2 (22.88 and 23.67g), respectively, which combined vermicompost and PGPR and gave significant differences compared to individual treatments. The control had the lowest value (13.97 and 14.3 g), respectively, and the effect was symmetric in two consecutive seasons. In the two successive seasons, there were insignificant differences between the effect of cultivated soils on the dry weight of the whole plant (g.). In contrast, the dry weight of the whole plant in sandy soil was recorded (19.61 and 19.75 g), and in clay soil was recorded (18.78 and 19.69 g), respectively. Data demonstrated the influence of the treatments on the dry weight of cutting roots. In the first season, the best effect was in T_2 (4.60g), compared with the control (3.50g), with significant differences. While the other treatments came after T_2 with significant differences, there was an insignificant difference between T_3 and T_4 (4.03 and 4.07g), respectively, and there was an insignificant difference between T_3 and the control. There was a significant difference between T_4 and the control. This differed from the data indicated in the second season, where there was an insignificant difference between treatments but there were significant differences between both T_2 and T_4

(4.23 and 3.98g), respectively, and the control (3.58 g).

Table 4. Effect of organic and bio-fertilization on the dry weight of whole plant (g), and dry weight of root (g) of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

Parameter	Dry weight of whole plant (g.)						Dry weight of root (g)					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	15.17	12.77	13.97 c	15.50	13.10	14.30 c	3.67	3.33	3.50 c	3.75	3.42	3.58 b
Mix T_2	21.83	23.93	22.88 a	23.17	24.17	23.67 a	4.50	4.70	4.60 a	4.03	4.43	4.23 a
PGPR T_3	18.93	20.67	19.80 b	19.27	20.33	19.80 b	4.08	3.97	4.03 bc	3.85	3.92	3.88 ab
Vermicompost T_4	19.17	21.09	20.13 b	20.83	21.42	21.13 b	4.00	4.13	4.07 b	3.93	4.03	3.98 a
Mean	18.78 A	19.61A	19.20	19.69 A	19.75 A	19.73	4.06 A	4.03 A	4.05	3.89 A	3.95 A	3.92

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

The data explained how the treatments influenced the number of leaves per plant. In both study seasons, optimum effects were found in T_4 (51.00, 51.50) and T_2 (50.50, 51.00), respectively, with negligible differences, followed by T_3 (45.50, 47.00) with significant differences in comparison to the control, which had the lowest value (41.50, 41.00), respectively.

Table 5. Effect of organic and bio-fertilization on the number of leaves/plants, and leaf area (cm^2) of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

Parameter	Number of leaves/ plants						leaf area (cm^2)					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	40.00	43.00	41.50 c	41.00	41.00	41.00 c	25.98	26.97	26.48 c	26.08	26.30	26.19 c
Mix T_2	46.00	55.00	50.50 a	47.00	55.00	51.00 a	29.67	33.95	31.81 a	29.57	32.95	31.26 a
PGPR T_3	45.00	46.00	45.50 b	47.00	47.00	47.00 b	28.34	32.22	30.28 ab	27.78	31.22	29.50 b
Vermicompost T_4	52.00	50.00	51.00 a	52.00	51.00	51.50 a	27.72	31.05	29.38 b	27.32	31.08	29.20 b
Mean	45.75 B	48.50 A	47.13	46.75 A	48.50 A	47.63	27.93 B	31.05 A	29.49	27.69 B	30.39 A	29.04

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

Also, data shows that sandy soil (48.50) had a better effect on the number of leaves per plant compared with clay soil (45.75), with significant differences in the first season whereas in the second season, there were insignificant differences between them, while sandy soil was (48.50) and clay soil was (46.75). Data demonstrated how treatments affected leaf area (cm^2) during the research seasons. The biggest value was in T_2 (31.81, 31.26 cm^2), and the lowest value was in the control (26.48, 26.19 cm^2) in two successive seasons, with significant differences. Regarding other treatments, in the first season, T_3 (30.28 cm^2) values had insignificant differences with both T_4 and T_2 (29.38 and 31.81 cm^2), respectively. It was considered a mediating factor between them. In the second season, there were insignificant differences between T_4 and T_3 (29.20 and 29.50 cm^2), respectively, and both of them had significant differences with T_2 (31.26 cm^2).

Concerning the effect of the cultivated soil, sandy soil (31.05 and 30.39 cm^2) was more effective on leaf area (cm^2) than clay soil (27.93 and 27.69

cm^2) in two successive seasons, with significant differences between them.

Results in Tables 6, 7, and 8 demonstrated the effect of vermicompost and PGPR on chemical parameters of grape cutting leaves that were grown in sandy and clay soils during study seasons and proved that all treatments had a positive effect with significant differences compared with the control in either sandy or clay soil.

Results demonstrated how treatments affected the percentage of nitrogen in leaves, and the two seasons followed the same trend in effect. There were significant differences between all treatments in both successive seasons. The highest rate was in T_2 (1.94, 1.96%), followed by T_4 (1.84, 1.87%), and then T_3 (1.71, 1.74%), and the lowest rate was in the control (1.34, 1.31%), respectively.

Besides, clay soil (1.80 and 1.81%) had the highest effect on the percentage of nitrogen in leaves compared to sandy soil (1.61 and 1.62%) in both seasons, respectively.

Table 6. Effect of organic and bio-fertilization on N % and P% in leaves of cuttings of Ruby seedless grapes grown in clay and sandy soils during 2021 and 2022 seasons

Parameter	N % in leaves						P% in leaves					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	1.56	1.11	1.34 d	1.53	1.09	1.31 d	0.26	0.25	0.26 c	0.27	0.27	0.27 c
Mix T_2	1.95	1.93	1.94 a	1.98	1.94	1.96 a	0.41	0.36	0.39 a	0.40	0.39	0.39 a
PGPR T_3	1.85	1.56	1.71 c	1.89	1.59	1.74 c	0.36	0.31	0.34 b	0.37	0.33	0.35 b
Vermicompost T_4	1.83	1.84	1.84 b	1.85	1.88	1.87 b	0.33	0.33	0.33 b	0.34	0.35	0.35 b
Mean	1.80 A	1.61 B	1.70	1.81 A	1.62 B	1.72	0.34 A	0.31 B	0.33	0.34 A	0.33 A	0.34

**Means separation by LSD tests at P ≤ 0.05. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

Concerning the percentage of potassium in leaves, data in Table 7 mentioned that the two successive seasons proved that the treatments had positive results on potassium content when compared with the control. The highest percentage of potassium was in T_2 (2.08, 2.11%), and the minimum was in the control (0.85 %) in both seasons, respectively. In the first season, there was an insignificant difference between T_3 (1.58%) and T_4 (1.62%). In the second season, there was a significant difference between T_3 (1.62%) and T_4 (1.65%). Referring to the cultivated soil, there were significant differences between sandy and clay soil in the effect on potassium percentage in leaves, and sandy soil was recorded (1.69, 1.72%) as the highest value compared with clay soil (1.37, 1.40%) in two successive seasons, respectively. The results in Table 7 showed how the treatments affected the percentage of carbohydrates and how there were significant differences between the treatments and the control. In both subsequent seasons, T_2 had the best effect (0.42, 0.43%), and the control had the worst effect (0.34, 0.33%). Additionally, T_3 and T_4 had little difference while having the same percentage in both of the study seasons (0.38%). Regarding cultivated soil, clay soil had the greatest value (0.42%) on the carbohydrate content of leaves, with a significant effect compared to sandy soil (0.34%) in both seasons, respectively.

The last vertebra of this parameter was talking about total chlorophyll in leaves and included an illustration of how the treatments affected total chlorophyll in leaves during study seasons. In both seasons, the treatments had significant effects compared with the control. The T_2 had the biggest impact (36.32, 36.85) compared to other treatments by significant differences, and the control had the minimum amount of chlorophyll

(27.98, 28.03). In the first season, there was a trivial difference between T_4 and T_3 (33.28 and 32.62), respectively, while in the second season, T_4 (34.18) had a significant value compared to T_4 (33.15).

Table 7. Effect of organic and bio-fertilization on K % and Carbohydrate % in leaves of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

Parameter	K% in leaves						Carbohydrate % in leaves					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	0.92	0.77	0.85 c	0.90	0.79	0.85 d	0.38	0.30	0.34 c	0.37	0.30	0.33 c
Mix T_2	1.63	2.53	2.08 a	1.69	2.54	2.11 a	0.47	0.38	0.42 a	0.47	0.39	0.43 a
PGPR T_3	1.49	1.66	1.58 b	1.53	1.71	1.62 c	0.43	0.32	0.38 b	0.42	0.33	0.38 b
Vermicompost T_4	1.44	1.79	1.62 b	1.48	1.82	1.65 b	0.41	0.35	0.38 b	0.40	0.36	0.38 b
Mean	1.37 B	1.69 A	1.53	1.40 B	1.72 A	1.56	0.42 A	0.34 B	0.38	0.42 A	0.34 B	0.38

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

Regarding cultivated soil, clay soil had the greatest value (34.80, 34.90) effect on total chlorophyll in leaves, with a significant impact compared to sandy soil (30.30, 31.20) in both seasons, respectively.

Table 8. Effect of organic and bio-fertilization on Total chlorophyll in leaves of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

Parameter	Total chlorophyll SPAD					
Season	Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	31.13	24.83	27.98 c	31.07	25.00	28.03 d
Mix T_2	37.97	34.67	36.32 a	38.03	35.67	36.85 a
PGPR T_3	35.73	29.50	32.62 b	35.80	30.50	33.15 c
Vermicompost T_4	34.40	32.17	33.28 b	34.87	33.50	34.18 b
Mean	34.8 A	30.3 B	32.55	34.9 A	31.2 B	33.05

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

The results in Tables 9 and 10 clarified how vermicompost and PGPR affected the characteristics of the roots of the grape cuttings cultivated in sandy and clay soils and proved that all treatments had a favorable effect on these attributes in comparison with the control.

In the two seasons of study, the percentage of nitrogen was influenced by treatments, and the effect was the highest in T_2 (0.99, 1.01%), which had combined vermicompost and PGPR compared with other treatments and with significant differences, followed by T_4 (0.94, 0.95%), and then T_3 (0.86, 0.87%), respectively, with significant differences. And these were compared with the control, which had the lowest percentage of nitrogen (The same value in both seasons 0.75%).

Concerning the cultivated soils, sandy soil (0.92, 0.93%) affected nitrogen percentage in roots more than clay soil (0.85, 0.86%), with significant differences in both successive seasons.

Data explained that the percentage of phosphor was taken the same trend in both seasons. Significant differences were observed between treatments and between treatments and the control. The greatest percentage was in T_2 (0.27, 0.28%), followed by T_4 (0.22, 0.24%), and then

T_3 (0.20, 0.21%), respectively, while the lowest percentage was in the control (0.16, 0.15%), respectively. And noted that the second season had a more favorable impact than the first.

Regarding the cultivated soils, in the first season, there were insignificant differences between sandy and clay soils (0.21, and 0.22%), respectively, whereas, in the second season, clay soil (0.23%) was more influenced by treatments than sandy soil (0.21%), with significant differences.

Table 9. Effect of organic and bio-fertilization N% and P % in roots of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

Parameter	N% in roots						P% in roots					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	0.79	0.70	0.75 d	0.79	0.71	0.75 d	0.17	0.14	0.16 d	0.17	0.14	0.15 d
Mix T_2	0.91	1.08	0.99 a	0.92	1.09	1.01 a	0.27	0.26	0.27 a	0.28	0.27	0.28 a
PGPR T_3	0.87	0.84	0.86 c	0.88	0.86	0.87 c	0.22	0.19	0.20 c	0.24	0.20	0.21 c
Vermicompost T_4	0.84	1.04	0.94 b	0.85	1.05	0.95 b	0.22	0.23	0.22 b	0.23	0.24	0.24 b
Mean	0.85 B	0.92 A	0.89	0.86 B	0.93 A	0.90	0.22 A	0.21 A	0.21	0.23 A	0.21 B	0.22

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

Concerning the potassium percentage, data in both study seasons proved that the treatment, which had a mix of vermicompost and PGPR, gave the highest rate of potassium (0.65, 0.66%) when compared with other treatments by significant differences, and T_3 (0.56, 0.58%) came in second place, and T_4 (0.49, 0.50%) occupied the third place, respectively, with significant differences. Besides, the control gave the lowest rate of potassium (the same value in both seasons 0.38%) when compared with the treatments, with significant differences.

Regarding cultivation soils, clay soil influenced potassium percentage (0.54, 0.55%) more positively than sandy soil (The same value in both seasons 0.50%) with significant differences in two successive seasons.

Table 10. Effect of organic and bio-fertilization K% and Carbohydrate % in roots of cuttings of Ruby seedless grapes cultivated in clay and sandy soils in 2021 and 2022 seasons

parameter	K% in Roots						Carbohydrate % in Roots					
Season	Season 1			Season 2			Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	0.36	0.40	0.38 d	0.35	0.41	0.38 d	19.10	9.86	14.48 d	19.33	9.83	14.58 d
Mix T_2	0.66	0.63	0.65 a	0.69	0.62	0.66 a	33.57	18.32	25.95 a	33.67	18.43	26.05 a
PGPR T_3	0.64	0.47	0.56 b	0.67	0.49	0.58 b	30.30	11.48	20.89 b	30.60	11.65	21.12 b
Vermicompost T_4	0.49	0.48	0.49 c	0.50	0.49	0.49 c	28.37	12.09	20.23 c	28.63	12.14	20.38 c
Mean	0.54 A	0.50 B	0.52	0.55 A	0.50 B	0.53	27.83 A	12.94 B	20.39	28.06 A	13.01 B	20.53

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

The data, which described the percentage of carbohydrates in the roots of cuttings, took the same track in both study seasons and proved that the maximum value was in T_2 (25.95, 26.05%), followed by T_3 (20.89, 21.12%), and then T_4 (20.23, 20.38%), respectively, with significant differences compared with the control (14.48, 14.58%), which had the minimum value of carbohydrate %. Concerning cultivated soils, clay soil (27.83, 28.06%) affected carbohydrates % in roots more than sandy soil (12.94, 13.01%), with significant differences in both successive seasons. The percentage of $CaCo_3$ in soil was different according to the treatments and their comparison with the control. In both study seasons, treatments were similar in their direction of effect, and the $CaCo_3$ % values ascending increased from the lowest value found in T_2 (0.15%), next in T_3 (0.21, 0.19%), and then T_4 was the highest (0.25, 0.24%). However, the maximum value of $CaCo_3$ was recorded in the control. There were significant differences between the treatments and the control. As for the cultivated soil, there were significant differences between sandy and clay soil values in $CaCo_3$. Sandy soil had a higher value (0.39, 0.38%) than clay soil (the same value in both seasons 0.09%), respectively, in both successive seasons.

Table 11. Effect of organic and bio-fertilization on $CaCo_3$ in both clay and sandy soils in 2021 and 2022 seasons

Parameter	$CaCo_3$ % of soil					
Season	Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	0.18	0.51	0.34 a	0.19	0.51	0.35 a
Mix T_2	0.04	0.26	0.15 d	0.05	0.25	0.15 d
PGPR T_3	0.05	0.39	0.21 c	0.05	0.33	0.19 c
Vermicompost T_4	0.09	0.42	0.25 b	0.08	0.41	0.24 b
Mean	0.09 B	0.39 A	0.24	0.09 B	0.38 A	0.23

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

Data in Table 12 showed the effect of treatments on the total count of bacteria in soil and explained if there was an effect or not. In the two study seasons, treatments had the same direction of influence on the total count of bacteria in both seasons; T_2 recorded the highest number of bacteria (97×10^8 CFU/g), followed by other treatments and the control, with significant differences between them in both seasons. As was noticed, there were insignificant differences between T_4, T_3, and the control, but the data mentioned that T_3 had a higher amount than T_4, and the control had the lowest amount. Concerning the cultivation soil, data explained that the sandy soil had the biggest recorded total count of bacteria (2700522500, 272552×10^3 CFU/g) compared with the clay soil (2150796250, 2150796250 CFU/g), with significant differences between them, in both successive seasons.

Table 12. Effect of organic and bio-fertilization on Total count of bacteria CFU/g in both clay and sandy soils in 2021 and 2022 seasons

Parameter	Total count of bacteria CFU/g in soil					
Season	Season 1			Season 2		
Soil type / Treatment	Clay	Sandy	Mean	Clay	Sandy	Mean
Control T_1	690000	470000	58×10^4 b	69×10^4	46×10^4	575000 b
Mix T_2	86×10^8	108×10^8	97×10^8 a	86×10^8	109×10^8	975×10^7 a
PGPR T_3	1635000	905000	127×10^4 b	1635×10^3	915000	1275000 b
Vermicompost T_4	86×10^4	715000	787500 b	86×10^4	725000	792500 b
Mean	2150796250 B	2700522500 A	24256594	2150796250 B	272552×10^3 A	243816063

**Means separation by LSD tests at $P \leq 0.05$. The same letters within columns are not significantly different. Ascending order starts from (A or a) which means the highest value until it reaches the letter with the lowest value.*

4. Discussion

Both internal and environmental factors may have an impact on the germination of grape cuttings. The amount of food that has been stored in the cuttings, the age and maturity of the tissue, the development of callus and adventitious roots, and the presence of leaves and buds on the cuttings are all internal factors that affect the rooting of cuttings. Rooting media, chemical and hormone therapies, light, temperature, mechanical treatment, and mist spray are some examples of external influences. One of the most crucial elements for the creation of rooted cuttings, especially in the case of grapes, is the rooting medium. It is one of the elements influencing the germination and development of grape cuttings.

Types of media have significantly influenced the rooting and vegetative growth of cuttings. Because of the difference in organic matter content and water-holding capacity, different planting media have significantly influenced the vegetative growth of cuttings. The suitability of the rooting medium depends on the species, type of cuttings, growing conditions, year's season, and the medium components' cost-effectiveness.

The media which differentiate as light, rich, porous, well-drained, and free from pathogens are considered ideal for growing grapes. Choosing the most suitable growing media for successful plant production is very important.

Soil texture impacts moisture content and chemical qualities such as cation exchange capacity (CEC), or its ability to store positively charged ions. For example, sandy soil has poor moisture retention and a low CEC, allowing plant nutrients and water to leak out of the rooting zone rapidly. Physical qualities of the soil, such as structure, texture, and tilth, are important in determining the land's agronomic potential. These qualities influence root penetrability, potential rooting volume, nutrient uptake and mobility, soil aeration, and water availability. (Adhikary, 2012; Delgado and Gómez, 2016).

Sandy soil faces several impediments that make it an inadequate media for high agricultural productivity. As importantly, it contains a low percentage of organic matter and the ability of cation exchange is weak (CEC). As a result, its holding capability for water and nutrient elements is low. Secondly, with the high soil temperature, organic carbon is rapidly lost from the soil (Jabbagy and Jackson, 2000). In addition, the ability of sandy soil to preserve carbon that results from a microbial activity is weak, it usually has a storage capacity of carbon lower than 1% due to, the reduction of plant productivity, thus reducing carbon input rates (Six *et al.,* 2006). Sandy soils necessitate a precise management system to conserve water and nutrients while increasing productivity and mitigating the negative effects of soil acidity and groundwater. To increase and improve the production of sandy soil, we can use helpful methods such as vermicompost and bio-fertilization (PGPR) (Venda Oliveira *et al.,* 2015; Nweke *et al.,* 2019).

Clay soil has advantages and disadvantages, and it is easy to treat the disadvantages and overcome its problems. Clay soil is the heaviest and densest type of soil; as the percentage of clay in the soil increases, so does the density and heaviness of the texture. Heavy clay is soil that contains more than 50% clay particles. It retains water, is not well-drained, and does not save space for the forking and growth of the plant roots. Clay soils are very fertile because they have a high percentage of nutrients. Their cohesive texture can be fragmented into separate crumbs by the addition of organic matter, which makes the water and nutrients within the clay more easily available for plant roots.

Growing plants in clay-rich soil frequently necessitate alterations. It does not add organic matter. Clay-heavy soil usually has deficiencies in nutrients and micronutrients essential for plant growth and photosynthesis. Mineral-rich clay soils tend to be alkaline, necessitating additional amendments to bring the pH level back to neutral before planting anything that requires a neutral pH (Kodikara *et al.,* 1999).

Vermicompost contains a variety of important plant nutrients, with high rates of N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, and B, all of which help to boost the nutrient content of different plant components like roots, shoots, and fruits (Theunissen *et al.,* 2010). Because of its humus content, vermicompost can keep nutrients for a long time and has a higher water-holding capacity and porosity than traditional compost (Rajiv *et al.,* 2010). Wherefore, vermicompost is considered one of the most important fertilizers which can improve soil validity, increase agricultural productivity, and improve the physical and chemical characteristics of the soil. As a result, adding vermicompost to the soil (especially sandy soil) is helpful because it helps raise the soil organic matter (SOM) composition, which helps improve soil aeration, maintain excellent soil aggregation, prevent soil erosion, and boost nutrient availability (Baligar *et al.,* 2001; Roy *et al.,* 2006).

Vermicomposting is a well-known and well-established method added to soils to increase growth-vegetative and yield, which reached 30-40% more than chemical fertilizers by converting organic wastes into beneficial nutrients for soil and plants and immediate bio-accessibility of nutrients to plants. In addition, 40 percent of irrigation water requirements were less as compared to chemical fertilizer application (Ibrahim *et al.,* 2008; Ganeshnauth *et al.,* 2018).

Vermicomposting, a biochemical method involving the consortia of earthworms and microorganisms for the degradation of organic materials, has been identified as a viable solution for increasing crop yields, maintaining, or improving soil fertility, and doing so without posing any environmental risks. Earthworms, famous as "nature's plowman," are good indicators of soil fertility, improving the physical, chemical, and biological makeup of the host soil at the same time. Most of the earthworm-digested soil is discharged into the soil environment as fine, mucus-covered granular aggregates, which are high in NPK, micronutrients, and beneficial microorganisms. These microorganisms' dwell near plant roots and provide a variety of direct and indirect benefits by forming a symbiotic connection with them, as well as assisting plants in nutrient uptake and coping with harmful situations (Belimov *et al.,* 2005; Asad *et al.,* 2019).

The excreta of earthworms, called "vermicast," has important advantages, such as highly controlling soil salinity, and it is antipathogenic, which decreases the need for pesticides on crops. Research proved that the total count of bacteria was exceed 10^{10}/gm of vermicompost, including Azotobacter, Actinomycetes, Nitrobacter & Phosphate Solubilizing Bacteria, Rhizobium, ranging from 10^{2}-10^{6} per gm of vermicompost (Sinha *et al.,* 2008, 2010, 2014).

Canellas *et al.* (2002) illustrated that vermicompost contained a sufficient percentage of humic acids, which promoted the elongation of roots and the formation of lateral roots; additionally, it removed poisons, dangerous fungi, and bacteria from the soil, and safeguarded plants. Increased moisture content (MC) in vermicompost-amended sandy soil probably can be attributed to the aggregation of the soil particles by the actions of microorganisms in the vermicompost, which provide cementing action between the soil particles (Nweke *et al.,* 2019).

Earthworms are important drivers of vermicomposting because they increase the area of aerobic microbial activity, speed up enzyme activities, and break down complex organic compounds into simpler ones that can be degraded further by microbes (Fu *et al.,* 2014).

Vermicompost application enhanced plant height and dry weight and increased potassium (K), calcium (Ca), magnesium (Mg), and manganese (Mn) concentrations to acceptable levels for the plant (Ali *et al.,* 2007; Hernandez *et al.,* 2010). Vermicompost is currently widely utilized in agriculture, and its potential to produce high crop yields is well documented, as evidenced by reports for peppermint (Ayyobi *et al.*, 2014), maize (Kmet'ová and Kovácik, 2014), wheat (Yousefi and Sadeghi, 2014), and tomatoes (Zucco *et al.*, 2015).

Plants have responded positively to microbial inoculation such as PGPR and have all increased in the germination of seeds, root growth, crop production, leaf area, chlorophyll content and protein, nutrients uptake, hydraulic activity, biotic stress tolerance, shoot, and root weights, biocontrol, and delayed senescence. (Raaijmakers *et al.*, 1997; Bashan *et al.*, 2004; Mantelin and Touraine, 2004; Bakker *et al.*, 2007; Berg, 2009; Yang *et al.*, 2009).

The effect of PGPR is useful for root formation on stem cuttings, and this is due to auxin production by bacteria, or maybe the PGPR can stimulate the cuttings to produce auxin by themselves. Regretfully, we did not measure auxin levels in cuttings during the experiment. PGPR had an obvious and useful effect on increment in root growth and weight (Philippot *et al.*, 2013). Inoculated cuttings by PGPR of different plant species showed genotype-dependent rooting and increment of root growth (Mafia *et al.*, 2007).

Pseudomonas is producing IAA, which causes an increment in the length of seedling roots by about 35–50%(Patten and Glick, 2002). Bae *et al.* (2007) proved that PGPR stimulated the initial development of adventitious roots in rose and cucumber cuttings by using various isolates. Kaymak *et al.* (2008) also explained that mint cuttings treated with PGPR gave a good result in rooting percentage and root dry weight.

PGPR is used especially in sand soil to enhance urea hydrolysis via the enzyme urease (Chou *et al.*, 2011), resulting in increases in soil strength and stiffness (Mortensen *et al.*, 2011; Venda Oliveira *et al.*, 2015).

Plant Growth Promoting (PGPR) bacteria can increase plant growth in two ways: directly by giving nutrients to the roots, or indirectly by contributing to plant hormone balance and disease resistance (Berg, 2009; Lugtenberg and Kamilova, 2009; Philippot *et al.*, 2013; Panke-Buisse *et al.*, 2015).

PGPR can affect the expression of root characteristics, like average root diameter and root branching intensity, and many studies have been performed to illustrate the influences of PGPR on plant growth, graft success, and vegetative growth. Many studies illustrated that using PGPR gave several advantages for plant growth in the nursery, in addition, the forbidden use of any formulations of plant growth regulators synthetic such as indole-3-butyric acid (IBA) in organic agriculture worldwide so, future studies will focus on improving nursery methods to increase rooting percentage. PGPR may influence initiating the rooting of rootstock plants easily (Isci *et al.*, 2019).

Farzana and Radziah (2005) discovered that inoculating sweet potato cultivars with rhizobacterial isolates greatly improved plant growth and nutrient uptake (N, P, K, Ca, and Mg). In several horticultural crops, PGPR has been found to increase the growth and production of pepper and cucumber (Han *et al.*, 2006), apple (Karlidag *et al.*, 2007), lettuce (Chamangasht *et al.*, 2012), tomato (Almaghrabi *et al.*, 2013), cabbage (Turan *et al.*, 2014), and strawberry (Seema *et al.*, 2018).

Oil palm seedlings showed a significant increase in nitrogen and phosphorus uptake (Amir *et al.*, 2005). The inoculation of a mixture of microbial strains was more effective than the inoculation of a single strain (Adesemoye *et al.*, 2008).

Caesar and Burr (1987) found that inoculating apple rootstock (M226 and M7) with PGPR strains in the field under greenhouse conditions resulted in a 65 % increase in seedling growth and a 179 % increase in rootstock growth.

Recent research proved that treating cuttings or seeds with non-pathogenic bacteria, like Alcaligenes, Bacillus, Pseudomonas, Agrobacterium, Streptomyces, etc., stimulated the root formation in several plants due to the production of the natural auxin by the bacteria. Despite that the mechanisms are not fully understood, root formation by PGPR is logical and acceptable for phytohormones, like the production of auxin, ethylene synthesis inhibition, and nutrient elements mineralization by PGPR. It is difficult to determine which of the multiple interactions between the several hormonal signaling ways in plants is the major objective of PGPR. More likely, PGPR modifies several hormonal pathways. This could explain the various morphological alterations seen, such as root hair growth and lateral root elongation. An enhanced rate of lateral root extension and possibly initiation, leading to a more branching root system architecture, is one of the more distinctive impacts of PGPR. One of the most characteristic influences of PGPR is an increase in the elongation rate, and maybe the initiation rate, of lateral roots, resulting in a root system architecture with more branches (Erturk *et al.*, 2010).

Increased pH is caused by higher levels of calcium carbonate in soils, which make several nutrients available in an unfacilitated form to plants. Most plants flourish in soils with a pH between 5.5 and 6.5 (but not all of them!). As lime dissolves in the soil, calcium (Ca) moves to the surface of soil particles, replacing the acidity. The acidity reacts with the carbonate (CO_3) to form carbon dioxide (CO_2) and water (H_2O). The result is less acidic soil. Calcium is considered a basic macronutrient for plants, whereas the concentrations in the shoots range from 0.1 to over 5% of their dry weight. Thus, it has a double action, as a structural component of cell walls and membranes and as an intracellular second messenger (White and Broadley, 2003; Scagel *et al.*, 2011).

5. Conclusion

The aim of this research was to discuss how vermicompost tea and PGPR, as organic and bio-fertilizers, affected the growth of grape cuttings cultivated in different types of soil, such as clay and sandy soil, and if they can be used as a viable alternative to chemical fertilizer application or not. The results proved that treated with, both vermicompost tea and PGPR had a positive effect on the growth of grape cuttings cultivated in clay or sandy soil compared with the control. and the best treatment, which combined vermicompost tea and PGPR in both types of soil.

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Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

Not applicable

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Not applicable.

Conflicts of Interest

The authors disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

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