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Influence of Vermicompost Application on the Growth of *Vinca rosea valiant*, *Pelargonium peltatum* L. and *Pegasus patio rose*

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Abstract: Vermicompost (VC) is a nutrient-rich material that is mixed with soil, and it is used in this study. Four different environments were created such as control (Soil:VC:100–0%), mix one (Soil:VC:70–30% *w/w*), mix two (Soil:VC:50–50% *w/w*), and mix three (Soil:VC:40:60% *w/w*), and three well-developed roses (*Vinca rosea valiant*, *Pelargonium peltatum*, *Pegasus patio*) seedlings were transferred to individual pots. Plant growth parameters, i.e., the number of flowers, plant height, stem diameter, chlorophyll reading value, fresh flower weight, and flower dry weight height, were compared with respect to control seedlings. The improvement in the number of flowers, plant height, stem diameter, chlorophyll reading value, fresh flower weight, and flower dry weight height by 264, 71, 58, 255, and 193% for *Vinca rosea valiant rosea*, 138, 12, 160, 13, 55 and 112% for *P. patio rose*, and 50, 14, 23, 8, 61, and 41% for *P. peltatum*, respectively, grown in soil mixed with VC as compared to control. As a result of the research, the optimum growth parameter values and chlorophyll Meter SPAD values were obtained from the mix-three mediums for all three roses species. These results showed that 40% soil and 60% VC application could be proposed as the most effective medium in ornamental plant production.

Keywords: soil amendment; ornamental plants; vermicompost; nutrient

1. Introduction

Due to rapid urbanization, the demand for ornamental plants in urban areas is rapidly increasing; thus, the development of new strategies in professional breeding is required to meet the increasing demand. The input of vermicompost (VC) could be a promising approach to enhance ornamental plant growth as an environmentally friendly fertilizer [1]. Vermicomposting is a nutrient-rich soil amendment produced via passing through the worm guts of any biodegradable materials, i.e., farm, kitchen, market, animal, and bio-wastes, generated from agricultural industries [2]. Since VC is a source of macronutrients such as phosphate, nitrogen, and potassium, as well as micronutrients, some organic and amino acid sources, it meets the nutritional needs of the plant [3]. It has been shown that applying VC in the soil has important effects on the microbial structure, water holding capacity, aeration, porosity, aggregate stability, salinity, and physical properties of the soil, as well as providing plant nutrients to the plant [4]. Preparation based on the VC have high effectiveness in improving the ornamental plant's yield, for example, *Geranium* and *Pegasus patio rose* and peas [5–7].

Earthworm castings are known to be a rich source of plant growth, promoting humic substances, natural hormones, beneficial microorganisms (nitrogen fixing, phosphorous solubilizing), growth hormones, organic acid, amino acid, enzymes, and vitamins [8]. Earthworms have an in-house supply of enzymes such as nitrate reductase, acid phosphatase, and alkaline phosphatase, which are involved in the metabolism of nitrogen and phosphate materials present in the compost [9]. In many studies, the effects of VC application on the growth parameters of different ornamental plants have been investigated. Ascittuto et al. [10] observed significant increases in plant height, leaf area, fresh and dry weights of plant root, as well as stem organs of *Impatiens walleriana* in applications made with 100–75% VC. In another study, 60% VC medium significantly affected flowering and growth parameters, and plant nutrients (N, P, and K) of the *Pegasus patio* rose [11]. The VC application effects at different doses were shown on the growth and yield of velvet plants in two different studies [12,13]. In the study, an increase in flowering, bud formation, plant height, flower diameter, root, and stem biomass was observed with applying 40% VC. The application of 10–30% VC increased the number of flowers, and their growth of *Pelargonium peltatum* and *Pegasus patio rose hybrida* cultivation [14]. The ornamental plants, i.e., *Calendula officinalis*, *Pelargonium peltatum*, and *Pelargonium zonale* showed better growth in VC amended soil than green waste compost applied soil [15].

The rose genus *Pegasus patio* has about 20 species, including annual or perennial species, which originated in South America, and produce pink and purple flowers that bloom from spring to autumn [16,17]. In recent years, *P. patio rose*, *Vinca rosea valiant*, and *P. peltatum* outdoor plants are the most preferred ornamental plants all over the world, and it has become very important to improve the cultivation conditions of these plants. The aim of this study was to investigate the influence of different forms and doses of vermicompost on the number of flowers, duration of flowering, growth parameters, and the plant nutrient content of *P. patio rose*, *V. rosea valiant*, and *P. peltatum*.

2. Materials and Methods

2.1. Experimental Setup

A greenhouse experiment was conducted in 2019 to evaluate the effects of different doses of solid VC on growth and yield parameters of 3 different (*V. rosea valiant*, *P. peltatum*, and *P. patio rose*) ornamental plants. These flower seedlings were grown in polyethylene pots in the greenhouse of Atatürk University, Erzurum. Commercial vermicompost was used in this study with the properties; organic matter 65.5%, pH 8.1, humidity 25.5%, total nitrogen 1.1%, water-soluble potassium 1.5% and total phosphorus 0.7% [18–22].

The growing medium was created using a soil and VC mixture; control (Soil:VC:100–0%), mix 1 (Soil:VC:70–30% *w/w*), mix 2 (Soil:VC:50–50% *w/w*), and mix 3 (Soil:VC:40:60% *w/w*) of 1 dm³ pots, respectively. The greenhouse temperature was maintained at an average of 22 ± 2 °C during the day and 17 ± 2 °C at night. The experiment was conducted in 5 replications and in total of 60 pots. The trial started in mid-April and ended in mid-July.

2.2. Growth and Yield Parameters

Harvest was made after 90 days of planting seedlings. Plant growth parameters were measured and evaluated as plant height (mm), stem diameter (mm), number of flowers produced, flower stem length (mm), flower diameter (mm), flower stem thickness (mm), fresh flower weight (g), dry flower weight (g), fresh plant weight (g), plant dry weight (g), and chlorophyll content (SPAD) were examined. The plant samples for dry weight were kept in an oven at 65 °C for 48 h. Leaf greenness was determined with a portable chlorophyll meter (SPAD-502, Konica Minolta Sensing Inc., Osaka, Japan).

2.3. Analysis of Soil Physicochemical and Chemical and Plant Nutrients

Soil samples were air dried, crushed, and passed through a 2-mm sieve before physical and chemical analysis. The method described by Bremner [18] was used to determine organic N, while plant-available P was determined by using the sodium bicarbonate

method of Olsen et al. [19]. Electrical conductivity (EC) was measured in saturation extracts according to Rhoades [20]. Soil pH was determined in 1:2 extracts, and calcium carbonate concentrations were determined according to McLean [21]. Soil organic matter was determined using the Smith–Weldon method according to Nelson and Sommers [22]. Ammonium acetate buffered at pH 7 [23] was used to determine exchangeable cations. Micro-elements in the soils were determined by diethylenetriaminepentaacetic acid (DTPA) extraction methods [24].

Plant samples were ground after being dried at 68 °C for 48 h in an oven for constant dry mass. Determination of the total N was achieved by the Kjeldahl method using a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Königswinter, Germany). An inductively coupled plasma spectrophotometer (Optima 2100 DV, ICP/OES; Perkin-Elmer, Shelton, CT, USA) was used to determine tissue P, K, Ca, Mg, Fe, Cu, Mn, Zn, B, Cl, and Cd [25].

2.4. Statistical Analysis

In the experiment, a randomized pot design was used (3 plants \times 4 medium \times 5 replications and total 60 pots), and the obtained data were analyzed using SPSS20 statistical package program. Data were subjected to variance analysis (ANOVA), and differences in means were determined by Duncan multiple comparison test.

3. Results and Discussion

3.1. Morphological Parameters of *Vinca rosea valiant*, *Pelargonium peltatum* and *Pegasus patio rose* Flowers

VC application in soil considerably increased all measured morphological parameters for *V. rosea valiant rosea*, *P. patio rose*, and *P. peltatum* plant in this study (Table 1). Growth parameters, such as the number of flowers, plant height, stem diameter, flower diameter, flower stem thickness, chlorophyll reading value (SPAD), and fresh and dry weight of flowers were significantly affected by VC ($p \leq 0.001$) and reached the highest values at with input of 60% VC (Soil:VC: 40–60% *w/w*) for *V. rosea valiant rosea*, *P. patio rose* and *P. peltatum*.

Table 1. The effects of VC applications on plant growth parameters of *Vinca rosea valiant*, *Pegasus patio rose* and *Pelargonium peltatum* plants (90 days).

Growth Medium	Number of Flower (Per Plant)	Plant Height (cm)	Stem Diameter (mm)	Flower Diameter (mm)	Flower Stem Thickness (mm)	Chlorophyll Reading Value (SPAD)	Flower Fresh Weight Per Plant (g)	Flower Dry Weight Per Plant (g)
<i>Vinca rosea valiant</i>								
Control	4.67 \pm 3.05 ^d	11.66 \pm 1.45 ^d	5.19 \pm 0.50 ^c	33.94 \pm 1.15 ^{ns}	0.77 \pm 0.02 ^{ab}	32.63 \pm 0.67 ^b	9.96 \pm 0.88 ^b	1.26 \pm 0.33 ^d
Mix 1	7.00 \pm 0.57 ^c	15.00 \pm 1.52 ^{bc}	5.70 \pm 0.48 ^c	27.61 \pm 1.27	0.97 \pm 0.11 ^a	34.10 \pm 0.56 ^{ab}	21.60 \pm 0.27 ^c	2.62 \pm 0.33 ^c
Mix 2	11.50 \pm 6.68 ^{ab}	16.16 \pm 1.15 ^b	6.64 \pm 0.48 ^{ab}	35.52 \pm 1.35	0.64 \pm 0.10 ^b	35.66 \pm 0.33 ^a	32.38 \pm 0.33 ^{ab}	3.32 \pm 0.66 ^b
Mix 3	17.00 \pm 3.84 ^a	20.76 \pm 0.60 ^a	8.22 \pm 0.15 ^a	32.72 \pm 1.66	0.76 \pm 0.02 ^b	35.86 \pm 0.66 ^a	35.42 \pm 0.28 ^a	3.52 \pm 0.00 ^a
<i>Pegasus patio rose</i>								
Control	12.00 \pm 1.20 ^c	21.83 \pm 1.66 ^{ab}	1.65 \pm 0.28 ^c	53.00 \pm 1.11 ^{ns}	1.10 \pm 0.04 ^{ns}	30.67 \pm 0.58 ^c	25.00 \pm 3.01 ^b	3.00 \pm 0.58 ^c
Mix 1	19.67 \pm 4.80 ^b	22.66 \pm 0.88 ^{ab}	1.92 \pm 0.32 ^c	51.00 \pm 1.25	1.33 \pm 0.03	33.67 \pm 0.33 ^{ab}	39.65 \pm 1.00 ^a	5.67 \pm 0.71 ^{ab}
Mix 2	16.00 \pm 2.60 ^{bc}	20.67 \pm 0.44 ^b	3.09 \pm 0.04 ^b	48.13 \pm 1.12	1.01 \pm 0.04	32.00 \pm 0.58 ^{bc}	33.00 \pm 3.11 ^{ab}	4.57 \pm 0.42 ^{bc}
Mix 3	28.67 \pm 1.70 ^a	24.66 \pm 0.98 ^a	4.30 \pm 0.38 ^a	50.63 \pm 0.97	1.10 \pm 0.02	34.67 \pm 0.20 ^a	38.86 \pm 2.30 ^a	6.36 \pm 0.32 ^a
<i>Pelargonium peltatum</i>								
Control	1.33 \pm 1.33 ^c	24.67 \pm 1.76 ^b	10.56 \pm 1.52 ^c	52.00 \pm 2.77 ^c	2.67 \pm 0.03 ^{ns}	34.67 \pm 1.15 ^b	37.67 \pm 5.23 ^c	4.00 \pm 0.58 ^c
Mix 1	2.33 \pm 0.58 ^b	29.33 \pm 0.91 ^a	11.66 \pm 1.45 ^c	68.00 \pm 5.0 ^b	2.67 \pm 0.02	38.33 \pm 0.67 ^a	50.67 \pm 4.16 ^{bc}	5.33 \pm 0.58 ^{bc}
Mix 2	3.33 \pm 0.58 ^a	30.00 \pm 0.66 ^a	12.00 \pm 1.84 ^b	58.67 \pm 2.85 ^c	2.67 \pm 0.05	38.67 \pm 1.00 ^a	68.00 \pm 2.51 ^a	7.00 \pm 0.71 ^a
Mix 3	2.00 \pm 0.46 ^{bc}	28.33 \pm 0.9 ^a	13.00 \pm 1.45 ^a	79.33 \pm 8.33 ^a	3.00 \pm 0.04	37.67 \pm 1.73 ^a	61.00 \pm 2.51 ^{ab}	5.67 \pm 0.58 ^{ab}

Note: Control (Soil:VC:100–0%), Mix 1 (Soil:VC:70–30% *w/w*), Mix 2 (Soil:VC:50–50% *w/w*), and Mix 3 (Soil:VC:40:60% *w/w*). Means followed by the same letter(s) in a column is not significantly (ns) different at $p < 0.01$ level.

VC increased the number of flowers, plant height, stem diameter, chlorophyll reading value, fresh flower weight, and dry flower weight height by 264, 71, 58, 9, 255, and 193 for *V. rosea valiant rosea*, 138, 12, 160, 13, 55 and 112% for *Pegasus patio rose*, and 50, 14, 23, 8, 61, and 41% for *P. peltatum*, respectively, when compared to (Soil:VC:100–0% *w/w*) control

(Table 1). Many researchers working on studies have shown that substituting peat-based potting medium with VC can improve the growth and flowering of some ornamental plants. Karagöz et al. [26] found in their study that autoclaved vermicompost enriched with PGBR performed well on plant growth parameters in gladiolus cultivation. VC doses as low as 10% of the potting media increases in biomass and flower production of *P. patio roses* [6]. Jaayanta observed that plant-growth parameters such as height, weight, the number of seeds, and shoot number were improved by applying 50:50 soil and VC mixture [27]. It was also documented that *P. peltatum* growth and flowering were significantly greater in a medium containing 50% VC and 50% soil than in a medium containing 100% soil [28]. The significant growth achieved by plants grown in VC-treated mixes was greatly aided by the moisture in the VC and the balance between organic and inorganic nutrients. VC application increased the availability of plant's available forms of nutrients in the soil [29] (Table 2). The growth media enrichment by VC led to the macro-(N, P, K, Ca, Mg, Na) and micro-nutrients (Zn, Fe, Mn, Cu, and B) increasing for *V. rosea valiant*, *P. peltatum*, and *P.s patio rose* plants.

Table 2. Effects of vermicompost applicant on macro- and micronutrient content of *Vinca rosea valiant*, *Pelargonium peltatum* and *Pegasus patio rose* plants (90 days).

Growth Medium (w/w)	N (%)	P (mg kg ⁻¹)	K (mg kg ⁻¹)	Ca (mg kg ⁻¹)	Mg (mg kg ⁻¹)	Na (mg kg ⁻¹)
Control	1.79 ± 0.06 ^d	1538.11 ± 77.91 ^d	9010.03 ± 667.96 ^b	14,670.49 ± 655.46 ^d	1443.88 ± 21.78 ^c	75.40 ± 2.32 ^c
Mix 1	4.25 ± 0.02 ^c	4220.26 ± 13.12 ^b	35,025.05 ± 214.65 ^a	24,676.25 ± 203.24 ^c	4567.67 ± 22.84 ^b	115.11 ± 0.85 ^b
Mix 2	4.52 ± 0.03 ^b	2533.45 ± 12.04 ^c	37,166.07 ± 168.16 ^a	26,186.59 ± 81.66 ^b	5305.56 ± 7.89 ^a	119.17 ± 0.60 ^b
Mix 3	4.58 ± 0.02 ^a	4495.11 ± 11.08 ^a	39,485.27 ± 398.08 ^a	33,294.86 ± 41.19 ^a	5312.55 ± 17.79 ^a	125.78 ± 0.65 ^a
	Zn (mg kg⁻¹)	Fe (mg kg⁻¹)	Mn (mg kg⁻¹)	Cu (mg kg⁻¹)	B (mg kg⁻¹)	
Control	45.99 ± 0.11 ^d	33.21 ± 1.05 ^d	17.72 ± 0.24 ^c	22.91 ± 0.28 ^b	16.99 ± 0.11 ^c	
Mix 1	69.56 ± 0.45 ^c	48.72 ± 0.33 ^c	26.23 ± 0.18 ^b	31.46 ± 0.30 ^a	17.28 ± 0.10 ^c	
Mix 2	85.70 ± 0.76 ^b	70.7 ± 0.94 ^b	29.44 ± 0.47 ^b	33.23 ± 0.18 ^a	18.37 ± 0.11 ^b	
Mix 3	88.22 ± 0.25 ^a	80.6 ± 0.52 ^a	47.14 ± 4.06 ^a	34.10 ± 2.34 ^a	24.62 ± 1.66 ^a	
<i>Pegasus patio rose</i>						
	N (%)	P (mg kg⁻¹)	K (mg kg⁻¹)	Ca (mg kg⁻¹)	Mg (mg kg⁻¹)	Na (mg kg⁻¹)
Control	1.95 ± 0.22 ^d	1522.55 ± 40.21 ^d	22,200.62 ± 324.5 ^d	13,976.56 ± 96.55 ^c	1466.87 ± 11.46 ^d	74.63 ± 1.77 ^c
Mix 1	3.13 ± 0.15 ^a	4615.77 ± 15.11 ^a	20,173.59 ± 206.5 ^c	20,391.38 ± 1322.82 ^a	2814.97 ± 169.4 ^c	134.93 ± 5.26 ^a
Mix 2	2.51 ± 0.75 ^c	3356.15 ± 7.00 ^c	39,686.07 ± 347.77 ^b	24,285.32 ± 150.85 ^b	3440.35 ± 9.34 ^b	117.16 ± 1.48 ^b
Mix 3	2.87 ± 0.68 ^b	3667.10 ± 12.92 ^b	40,949.08 ± 474.08 ^a	24,907.47 ± 169.83 ^b	4851.75 ± 17.79 ^a	124.25 ± 1.16 ^b
	Zn (mg kg⁻¹)	Fe (mg kg⁻¹)	Mn (mg kg⁻¹)	Cu (mg kg⁻¹)	B (mg kg⁻¹)	
Control	6.34 ± 0.16 ^d	13.61 ± 0.19 ^a	7.32 ± 0.20 ^d	3.50 ± 0.23 ^c	7.37 ± 0.22 ^d	
Mix 1	10.76 ± 0.10 ^c	1863 ± 0.05 ^b	8.65 ± 0.07 ^c	4.38 ± 0.38 ^c	8.33 ± 0.13 ^c	
Mix 2	19.74 ± 0.34 ^b	26.35 ± 0.27 ^a	17.73 ± 0.32 ^b	10.27 ± 0.25 ^b	11.06 ± 0.12 ^a	
Mix 3	21.65 ± 0.74 ^a	27.14 ± 0.42 ^a	19.02 ± 0.26 ^a	16.76 ± 0.46 ^a	9.97 ± 0.44 ^b	
<i>Pelargonium peltatum</i>						
	N (%)	P (mg kg⁻¹)	K (mg kg⁻¹)	Ca (mg kg⁻¹)	Mg (mg kg⁻¹)	Na (mg kg⁻¹)
Control	1.83 ± 0.04 ^d	1466.55 ± 46.71 ^d	20,639.95 ± 366.14 ^d	13,366.90 ± 335.17 ^d	1402.97 ± 47.26 ^d	76.17 ± 0.92 ^d
Mix 1	2.70 ± 0.02 ^b	3782.61 ± 12.10 ^b	32,385.12 ± 91.19 ^b	31,008.561 ± 272.53 ^a	5471.50 ± 15.20 ^a	185.74 ± 2.43 ^a
Mix 2	2.46 ± 0.01 ^c	2890.05 ± 38.14 ^c	30,842.22 ± 79.81 ^c	18,999.35 ± 111.58 ^c	2777.99 ± 43.81 ^c	125.11 ± 0.13 ^c
Mix 3	4.76 ± 0.33 ^a	4830.85 ± 8.52 ^a	43,441.12 ± 278.83 ^a	22,896.35 ± 132.50 ^b	2934.50 ± 13.19 ^b	168.42 ± 0.52 ^b
	Zn (mg kg⁻¹)	Fe (mg kg⁻¹)	Mn (mg kg⁻¹)	Cu (mg kg⁻¹)	B (mg kg⁻¹)	
Control	6.03 ± 0.06 ^d	12.00 ± 0.96 ^d	7.76 ± 0.22 ^d	3.56 ± 0.11 ^d	7.20 ± 0.20 ^d	
Mix 1	45.20 ± 0.72 ^b	40.78 ± 0.53 ^a	26.61 ± 0.15 ^a	22.53 ± 0.33 ^a	12.04 ± 0.04 ^c	
Mix 2	36.85 ± 0.18 ^c	26.11 ± 0.19 ^c	20.78 ± 0.19 ^b	15.48 ± 0.25 ^c	13.84 ± 0.08 ^b	
Mix 3	51.73 ± 0.24 ^a	30.04 ± 3.01 ^b	19.54 ± 0.25 ^c	21.42 ± 0.56 ^b	15.34 ± 0.08 ^a	

Note: Control (Soil:VC:100–0%), Mix 1 (Soil:VC:70–30% w/w), Mix 2 (Soil:VC:50–50% w/w), and Mix 3 (Soil:VC:40:60% w/w). Means followed by the same letter(s) in a column is not significantly (ns) different at $p < 0.01$ level.

3.2. Chemical Parameters of *Vinca rosea valiant*, *Pelargonium peltatum* and *Pegasus patio rose* Flowers

In the study, VC application in growing media increased the plant's available forms of macro- (N, P, K, Ca, Mg, Na) and micro-nutrients (Zn, Fe, Mn, Cu, and B) of *V. rosea valiant*, *P. peltatum*, and *P.s patio rose* plants at varying rates (Table 2). As a result of the analysis of macro- and micro-nutrient nutrient content of *V. rosea valiant*, *P. patio rose*, and *P. peltatum* plants grown in different mixture media, the highest values were reached with mix-three (Soil:VC:40–60%) application. VC application increased the N, P, K, Ca, Mg, Na, Zn, Fe, Mn, Cu and B by 155, 37, 97, 126, 267, 66, 91, 142, 166 48, and 44% for *V. rosea valiant rosea*, 47, 140, 84, 77, 230, 66, 241, 99, 159, 378 and 35% for *P. patio rose*, and 160, 229, 110, 71, 109, 121,

43, 150, 151, 501, and 113% for *P. peltatum*, respectively, when compare with control group (Table 2).

VC is an important source of macro- and micro-nutrients and has great potential to improve plant growth [30] and could promote plant development by increasing soil microbial activity, porosity, permeability, nutrient uptake, and nutrient release gradually. An advantage of VC is that it contains high levels of NPK compared to other fertilizers and provides nutrients when needed by the plant [31,32]. The available form of N taken up by plants is high in VC. The presence of VC in the growth medium increases plant growth and leaf area index, providing more dry matter, a higher yield, and increasing light absorption [33,34]. Our results are compatible with the findings of other researchers. VC application increases the number of flowers/plants, flower diameter, stem length, and flower yield of *Chrysanthemum morifolium* and *Matricaria* plants [35,36]. Moghamad et al. [37] reported that 30% of VC applications showed positive results in the growth and development of the *Lilium asiatic* hybrid variety. The addition of VC in appropriate amounts to the growth medium had synergistic effects on marigold growth and yield [38]. Similarly, VC was applied to African marigolds (*Tagetes*) at a rate of 5 and 2.5 t/ha, and maximum plant fresh weight and dry weight were found at a rate of 5 t/ha in VC treatment [39].

3.3. Effects of Vermicompost Application on Chemical Parameters of Growth Medium

Some chemical properties of growth medium were statistically affected by VC application; electrical conductivity (EC), organic matter, macro- and micro-nutrient of growth medium were significantly increased by applying VC. All applications of VC affected the nutrient value of the growth medium; however, more effective ratio was 40–60% *w/w* (Soil:VC) compared to the soil without VC input (Table 3).

Table 3. Effects of vermicompost application on growth medium chemical properties.

Growth Medium (<i>w/w</i>)	pH	EC (dS m ⁻¹)	OM (%)	N *	P	K	Ca
				(%)	(mg kg ⁻¹)	(mg kg ⁻¹)	(mg kg ⁻¹)
Control	7.33 ± 0.11 ^{ns}	42.00 ± 19.38 ^c	0.33 ± 0.07 ^d	0.001 ± 0.02 ^d	3.67 ± 0.01 ^d	245.33 ± 1.15 ^d	1552.67 ± 2.88 ^d
Mix 1	7.88 ± 0.15	64.67 ± 21.85 ^b	0.83 ± 0.06 ^c	0.008 ± 0.25 ^c	5.00 ± 0.06 ^c	330.67 ± 0.05 ^c	2459.67 ± 2.76 ^c
Mix 2	7.95 ± 0.12	74.67 ± 22.62 ^b	1.85 ± 0.05 ^b	0.023 ± 0.20 ^b	6.00 ± 0.06 ^b	419.33 ± 0.06 ^b	3542.00 ± 2.83 ^b
Mix 3	7.90 ± 0.11	85.67 ± 23.51 ^a	2.88 ± 0.05 ^a	0.088 ± 0.13 ^a	12.00 ± 0.06 ^a	815.33 ± 0.02 ^a	4016.00 ± 3.10 ^a
	Mg	Zn	Fe	Mn	Cu	B	Na
	(mg kg ⁻¹)	(mg kg ⁻¹)	(mg kg ⁻¹)	(mg kg ⁻¹)	(mg kg ⁻¹)	(mg kg ⁻¹)	(mg kg ⁻¹)
Control	44.33 ± 0.56 ^d	0.33 ± 0.04 ^d	1.67 ± 0.01 ^d	1.45 ± 0.01 ^d	1.22 ± 0.06 ^d	0.20 ± 0.04 ^d	10.40 ± 0.28 ^c
Mix 1	88.67 ± 0.57 ^c	0.55 ± 0.07 ^c	2.21 ± 0.05 ^c	2.44 ± 0.03 ^c	2.56 ± 0.03 ^c	0.33 ± 0.01 ^c	12.05 ± 0.23 ^b
Mix 2	95.67 ± 0.58 ^b	0.78 ± 0.01 ^b	3.55 ± 0.06 ^b	3.78 ± 0.01 ^b	3.55 ± 0.01 ^b	0.55 ± 0.02 ^b	14.10 ± 0.32 ^a
Mix 3	104.33 ± 0.76 ^a	1.23 ± 0.06 ^a	4.82 ± 0.03 ^a	4.66 ± 0.02 ^a	3.95 ± 0.02 ^a	0.62 ± 0.02 ^a	14.53 ± 0.27 ^d

Note: *: N, P, K, Ca, Mg are plant available form of macronutrient, Fe, Mn, Zn, Cu, B and Na are plant available form micronutrient. Control (Soil:VC:100–0%), Mix 1 (Soil:VC: 70–30% *w/w*), Mix 2 (Soil:VC:50–50% *w/w*), and Mix 3 (Soil:VC:40:60% *w/w*). Means followed by the same letter(s) in a column is not significantly (ns) different at *p* < 0.01 level.

Electrical conductivity (EC), organic matter, N, P, K, Ca, Mg, Na, Zn, Fe, Mn, Cu, and B content of the growth medium were significantly affected by VC (*p* ≤ 0.001) application. These values increased with VC application and reached the highest at 60% (Soil:VC; 40–60% *w/w*) for *V. rosea* valiat, *P. patio* rose, and *P. peltatum* plants. VC application increased the EC, N, P, K, Ca, Mg, Na, Zn, Fe, Mn, Cu, and B by 103, 772, 8700, 226, 232, 158, 135, 272, 188, 221, 223, 210 and 39%, respectively, when compared to control (Table 3). High salt concentration in the growth medium causes phytotoxicity problems, and, therefore, the use of VC can be a good indicator [40]. It also improves the soil with its macro- and micro-nutrient content, organic acids that promote plant growth, large particle surface, porosity, aeration, drainage, and microbial activity [41], and contains nutrients in forms that are readily taken up by plants, such as nitrates, exchangeable phosphorus and soluble potassium, calcium and magnesium [40]. A study has clearly shown that VC

application is an effective way to improve the soil's physical properties. It can be used as an alternative soil conditioning agent [42].

4. Conclusions

VC applications to the plant growing medium increased both nutrient content and yield. The increases in the parameters of the growth of roses, which is very important, especially for the nutrition of landscape plants, which serves to increase the flowering status, healthy appearance of the plants, and their marketable values, were noted. According to the results obtained in the study, VC added to the growing medium strengthened the physical and chemical of the soil and increased the plant growth parameters. VC application at different rates showed a significant positive correlation between macro- and micro-nutrient values. The optimum growth, especially for *Vinca rosea valiant*, *Pegasus patio rose*, and *Pelargonium peltatum*, can be cultivated by considering the ratio of soil:VC:40–60% *w/w*. However, a large number of field studies are required for cultivating improved growth and quality of produce using VC mixture with the various types of soil and environmental conditions.

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