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Full Length Research Paper

Effect of soil addition on physical properties of perlite based media and strawberry cv. Camarosa plant growth

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This research was carried out to determine the effect of soil addition to perlite medium on strawberry growth in Erzurum, Turkey. Five different levels of soils (10, 20, 30, 40 and 50% by volume) were added to perlite and 100% perlite was used as a control. The amount of moisture retained at different tensions and distribution of pore size of these growing media were determined. Some vegetative plant properties such as the number of leaves, leaf area, most developed root length and increasing fresh weight of strawberry plants cv. Camarosa grown on these medium were determined. Soil addition caused a decrease of macropores in the growing media while the vegetative parameters of the strawberry plant improved during cultivation period.

Key words: Pore size distribution, soil-perlite mixture media, strawberry plant growth, water retention.

INTRODUCTION

Soilless substrates are used in horticulture for growing seedlings, plant propagation, and ornamental plant production (Sahin et al., 2002). Annual ornamental plants require growing media with adequate water retention and aeration (Erstad and Gislerod, 1994) and a fertilization routine that ensures a continuous nutrient supply (Macz et al., 2001). The basic requirements for plant growing media are excellent chemical resistance properties, light weighted, inexpensive, free of pests and diseases and abundant in source materials (Ercisli et al., 2003). Other than that, it also needs some essential requirements such as permeability and strength to support the plant and maintain crops growth (Chang and Shang, 2007) and the ability of the growing medium to retain water and transport gasses might be of importance for the keeping quality of plants (Dresboll, 2010). The components of soilless substrates must have stable physical and chemical properties during plant cultivation. The bio-stability of alternative substrates varies considerably, which also affects the chemical properties of substrates, their management and the growth of plants. The 'ideal substrate' proposed by Abad et al. (2001) had the following chemical characteristics: pH = 5.2 – 6.3; EC (dS m^{-1}) = 0.75 – 3.49; OM (%) > 80; NO^{-}_{3}-N ($\mu g ml^{-1}$) = 100 – 199; K^{+} ($\mu g ml^{-1}$) = 150–249; Na^{+} ($\mu g ml^{-1}$) = <115; Cl^{-} ($\mu g ml^{-1}$) = <180 and SO^{2-}_{4} –S ($\mu g\ ml^{-1}$) = < 960. In order to satisfy these important requirements, it is necessary to control the growing media structure carefully. Currently, the types of soilless growing media commonly used are wood residues, bark, rice hulls, sand, perlite, vermiculite, calcined clays, peat moss and rockwool. Among them perlite is derived from a siliceous volcanic rock when lava cools very rapidly trapping small quantities (2 - 5% w/w) of water, it is a light weight material of a bulk density of 130 - 180 kg/m^3 and rather inert (low buffering and cation exchange capacities of 0 - 1 mgl^{-1}) (FAO, 1990). In general, it has a closed cellular structure, with the majority of water being retained superficially and released slowly at a relatively low tension, providing excellent drainage of the medium and aeration of rhizosphere. Therefore, it requires frequent irrigation to prevent a fast developing water stress (Maloupa et al., 1992). Perlite also contains 6.9% aluminum which at low pH may be released into the solution and adversely affect the plants such as strawberry. Although commercial strawberry cultivation started towards the end of 1970 in Turkey, the country is currently one of the biggest strawberry producers in the world with 250000 tons production annually (FAO, 2009). Recently some vegetable production areas of the Mediterranean region of Turkey

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Table 1. Some physical and chemical properties of soil and perlite used.

Properties	Soil	Perlite
Clay (%)	18.9	-
Silt (%)	37.2	-
Sand (%)	43.9	-
Bulk density (g cm-3)	1.12	0.38
Particle density (g cm-3)	2.65	2.24
pH	8.21	8.40
Electrical conductivity (dS m-1)	0.29	0.11
Carbonates (%)	0.86	0.80
Organic matter (%)	0.57	-

Table 2. The amount of moisture retained in different tensions (Pv) and pore size distribution (%) of media.

Media	Moisture tension (kpa)				Pore size (µm)			
	0.0 - 0.98	0.98 - 9.81	9.81 - 32.36	32.36 - 1471.0	> 100	100 - 130	30 - 33	< 3
I	51.60a	15.27a	6.80	9.80b	49.61ab	3.41	16.15d	30.82
II	50.64a	16.01a	6.53	9.41b	50.21ab	3.50	16.42cd	30.22
III	50.19a	16.43a	6.24	8.30b	50.14ab	3.48	16.85cd	29.53
IV	51.34a	12.40b	6.86	11.86a	50.97a	3.50	17.47bc	28.06
V	46.67b	14.31ab	6.63	13.20a	49.06b	3.50	18.48b	28.96
VI	44.33c	12.60b	5.57	13.48a	47.31c	3.53	19.76a	29.40

Different letters indicate differences at $p < 0.05$ according to Duncan test.

have been converted to strawberry farms because of increased rentability of the Turkish strawberry production (Esitken et al., 2010).

Optimization of pore size distribution in the media is crucial. The amount of pore space and the continuity of pores in container media are the most critical physical characteristics which influence water and nutrient absorption and gas exchange by the root system (Nkongolo and Caron, 1999; Gruda and Schnitzler, 2004). The aim of the present investigation was to determine the effect of soil in the perlite based growing media to get over the disadvantages of material such as low buffering capacity and weak physical support for plants to evaluate whether soil could improve both media properties and strawberry plant growth.

MATERIALS AND METHODS

The day-notr strawberry cv. camarosa cold-stored seedlings were planted directly in 3 liter plastic bags filled with mixture of soil (S) and perlite (P). The characteristics of perlite and soil used are given in Table 1. Different amendment levels (10, 20, 30, 40 and 50 by volume) were applied and 5 different growing media were formulated 100% perlite used as control. The treatments were as follow;

100% P (I) 10% S + 90% P (II) S: Soil 20% S + 80% P (III) P: Perlite 30% S + 70% P (IV) 40% S + 60% P (V) 50% S + 50% P (VI)

The amount of moisture the media retained in different tensions (pF 1, pF 2, pF 2.52, pF 3 and pF 4.18) was determined by a pressure membrane (Klute, 1986). Porosity was estimated by calculation (Danielson and Sutherland, 1986). Plants were planted into plastic bags and plastic bags were kept under greenhouse temperature regime of 25/20°C day/night respectively. The daily nutrient solution prepared according to Day (1991). After 4.5 months growing period, each plant was uprooted and evaluated in terms of the numbers of leaves, leaf area, length of the most developed roots, fresh root weight, dry root weight and increasing fresh weight.

The experiment design was of a completely randomized design with three replicates including ten plants per replicate. Analysis of variance (ANOVA) for the data of pore size distribution, amounts of moisture retain in different tensions and plant growth and Duncan's multiple range tests were used for important treatments.

RESULTS

The amounts of moisture retain in different tensions (Pv) and pore size distribution (%) of the 6 different media are given in Table 2. The control treatment (I) had more pore which were bigger than 100 µm but the media with 50% soil amendment (VI) had more pore size between 30 - 3 µm and results have found statistically significant ($P < 0.05$). An increase in amount of mositure retained in higher tensions have been seen, on the other hand there was a decrease in lower tensions by adding soil to the perlite at increased ratios. No significant differences in pore size between 100 - 30 µm were observed compared with the control media (I) (Table 2).

Table 3. The effect of growing media on some plant properties of strawberry cv. Camarosa.

Media	Leaf number	Leaf area (cm^2)	Length of the most developed roots (cm)	Increase of fresh root weight (%)
I	10.35a	30.93	20.55c	10.02c
II	8.1b	29.68	24.0b	17.61c
III	9.05ab	27.73	24.84b	30.45b
IV	6.50c	30.83	28.4a	39.12b
V	6.95c	25.62	30.25a	54.98a
VI	7.36b	24.98	30.35a	54.80a

Different letters indicate differences at $p < 0.05$ according to Duncan test.

The effect of growing media on some plant properties of strawberry cv. Camarosa were given in the Table 3. There were no significant differences in leaf area of the strawberry cv. Camarosa grown with different soil addition ratios. However, leaf number decreased as the soil amount increased in the media, while increase of fresh root weight was greater than control treatment significantly.

DISCUSSION

Water retention, air-filled porosity and gas diffusion are dependent on particle size distribution of the growing medium and the pores created between these particles (Caron and Nkongolo, 1999; Caron et al., 2005). Therefore, the amount of moisture retained at < 0.98 kPa decreased with increasing soil amount especially 40% and more soil addition ratio decreased water retention capacity as compared to control (100% perlite). Amendments of oversize fragments such as large granules of perlite will increase the air-filled porosity (Caron et al., 2005) and in our results, increased soil addition ratio to the perlite media was also decreased the amount of macropores (> 100 µm diameter) which supply both drainage and aeration (Gemalmaz, 1993). However, micropores (30 - 3 µm diameter) which are important for water retention were increased by 50% soil addition ratio. The water retained in ultramicropores (< 3 µm diameter) which is unavailable for plant use (Drzal et al., 1999) and the mesopores (100 - 30 µm diameter) supply water conductivity (Gemalmaz, 1993) was statistically not significant with all soil addition ratios.

Most developed root length and increase of fresh root weight of strawberry plants were increased by increased soil addition ratio while the number of leaves decreased. The leaf area did not change significantly in the applications. The highest most developed root lengths and increasing fresh weight were obtained from 50% soil addition ratio which prove the positive effect of soil in the rhizosphere.

The relative balance of air and water within a soil's pore space is critical to plant growth (Brückner, 1997). Perlite is generally unsatisfactory for the production of plants in containers. This is primarily because perlite does not provide the aeration, drainage and moisture in good balance at low tensions required. Parallel to increasing soil addition ratio, micropores which provide water retention in the root zone, and development of plant root parameters increased at an important level while good properties of perlite are not corrupted such as superiority on water conductivity and aeration in rhizosphere, thus, this situation affected strawberry plant growth positively as well. Soil addition effects on perlite based growing media could be investigated by using heavy and light textural soils as a recommendation for further researches.

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