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Improving Hydrophysical Properties Quality of Compost

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Abstract: Soilless culture is in the process of becoming an important part of green houses. Two types of material used as horticultural materials, compost and perlite, were chosen to investigate to somewhat one can improve their hydrophysical properties and hence its quality. Different mixture ratios between two materials were carried out as follows: 100:0, 75:25, 50:50, 25:75 and 0:100 , compost : perlite. The different hydrophysical properties were determined. The obtained results revealed that increasing perlite in mixture could improve total pore space, free air space and easily available water. Increasing perlite has a significant negative effect on water buffering capacity in mixture, while it improves hydraulic conductivity after mixing with compost at all the studied ratios. The highest water retention capacity values were obtained from ratios 75:25 (82.78 %), followed by 50:50 (76.62 %) and 25:75 (48.97 %) compost : perlite ratio , respectively. Improvement of hydrophysical properties of compost through enriching by perlite led to more effective irrigation and fertilization strategies and develop structures that could hold adequate water supply for plant and enough and good aeration.

Key words: Hydrophysical properties, pore size distribution, easily available water, compost, perlite.

INTRODUCTION

Soilless culture is in the process of becoming an important part of world agriculture. There are several advantages of soilless culture where poor structure, poor drainage, disease and salinity problem are dominant. In order to improve quality in horticultural substrates, we need:

i) A better understanding of physical and hydraulic properties
ii) A broader approach to their diagnostics.

The media should also be well drained and yet retain sufficient water to reduce the frequency of watering. Other parameters to consider include cost, availability, consistency between batches and stability in the media over time.

Fonteno[1] stated that the quantity of air and water is a result of physical influences of the medium and extent of root development. A common way to compare substrate is to describe them on the base of hydrophysical properties[2]. They added that within the hydrophysical properties the air – water ratio is most important, which can partly be determined by the granulometery and porosity. Caron and Nkongollo[3] found that volume of air and water retention capacity of substrate is generally considered as the quality determining factors for substrates.

Michcels *et al*[4] stated that for horticulture, the phase distribution (solid material, water and air) of a substrate is important especially at matric potentials between -1 cm and – 100 cm water column as described by many authors.
Knowledge of water dynamics is essential for a better understanding of how the soil-plant system functions, particularly in terms of fertilization – irrigation management and of the pollutant leaching as well[5]. This also and especially true in soilless culture such as container media, due to the specificity of this production system with its extensive use of chemicals. Indeed, plants growing in this media have a limited volume occupied by water, gas and solute availability highly fluctuate over a short period of time involving frequent cycles of watering (fertigation) and drying during growing management. They added that these variations in water content could *lead* to a reorganization of the solid phase due to shrinkage and swelling[6].

The physical environment surrounding roots in through media material consisting of relative volumes of air, water and solid is largely determined by the relationship between water energy status and water content of the medium[1]. He mentioned also that this relationship is a reflection of the pore size distribution of the medium. Drza *et al*[7] stated that pore size have tradionally been divided into macro, meso, micro and ultramicro – pores. The macropores (> 100 um) supply drainage and aeration, the mesopores (100 – 30 um) supply water conduction and the micropores (30 – 3 um) supply water retention. While the water retained in the ultrapores (<3 um) is unavailable for plant use.

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Sahin *et al* [8] stated that media containing the greatest amount of medium sized pores had the potential to hold more readily available water among the organic, inorganic, organic-organic, inorganic-inorganic and organic-inorganic substrates Hydrophysical properties of horticultural substrates have been studied in order to help more effective irrigation and fertilization strategies[9]. He added that the aim was to develop structures that could hold an adequate water supply for plant, but that drained well enough or good aeration and root growth.

The objective of this work was to characterize some hydrophysical properties of compost and perlite and their moisture to improve plant growth.

MATERIALS AND METHODS

Two types of substrate used in horticultural transplanting (compost and perlite) were chosen to carry out this investigation. Plant-based composts was used as final product of compost and its particle size distribution depended on the source material and composting process. Perlite is most commonly used as a component in greenhouse growing media. It is produced by heating igneous rock under high temperatures (1,100 to 1,600°F). It is usually included in a mix to improve the drainage or increase the percent of aeration. Perlite is lightweight, pH neutral, sterile and odorless[10].

Core with 7.5 cm in diameter and 10 cm in height were filled with investigated materials in five treatments with three replicate and were exposed for wet and dry cycle for 3 weeks. Then hydrophysical and chemical characteristics were determined. The design of experiment was complete randomized in three replicates. Chemical properties of the substrates used in this study (EC (1:10), pH (1:10) , $CaCO_3$% , cation exchangeable capacity, CEC and organic matter) were determined after[11]. Hydrophysical characteristics (bulk density and specific gravity) were determined after[12]. Saturated hydraulic conductivity was carried out after[13].

Moisture characteristics cure using sand box apparatus described by[14] were used to estimate the followings:

Total pore space % (TPS) was calculated from the equation:

$$TPS = (100 \times (1 - BD/RD)$$

Where BD is bulk density (g/cm^3) and RD is the real density (g/cm^3).

Water retention capacity %(WRC) is the difference between water content at 0 and 100 cm suction, Free air space % (FAS) is the ratio of water content in the material (dry weight) / bulk density, Water Buffering capacity (WBC) is the difference of water content between suction 50 cm and 100 cm, easily available water % (EAW) is the difference of water content between suction 10 cm and 50 cm and Air capacity % (AC) is the difference between total pore space and water content at suction 10 cm

Particle size distribution of each substrate was determined using three, 100 g oven dry samples. Each sample was placed on a series of 5 sieves (ranging from 4 mm to 0.5 mm) and shaken for 5 min at 160 shakes per min. Portions of substrate samples remaining on each screen were weighed and expressed as the percentage of total sample weight (Table 2). Pore size distribution curves for a particular substrate were derived directly from moisture retention curve data after[15].

Obtained results were statistically analyzed after Snedecor and Coshran[16].

RESULTS AND DISCUSSIONS

Chemical Properties: Some chemical properties of the studied materials, compost and perlite and their mixtures are recorded in Table (1). Values of pH varied from 3.88 to 7.91 for compost and perlite, respectively. Also, one can noticed that increasing ratio of perlite in mixes led to increase pH values from acidic to approximately natural one. Abad *et al* [17] stated that plants require different pH ranges in grown medium, but many horticultural plants grown well close to 6.5 pH degree. They added also, that the chemical composition of media particles, the ratio of media components in the mix used and irrigation and fertilizer practices effect the pH of growing media. The EC of compost was higher than of inorganic one , perlite, (Table 1). On the other hand, among the compost mixes, the highest EC value was obtained from compost alone (0.15 dSm^{-1}) and the lowest one from perlite alone (0.08 dSm^{-1}). Data on hand revealed that, there were no salinity problem either in each material alone and/or with their combination[17]. Cation exchangeable capacity (CEC) values of organic materials used (compost) are higher than the perlite (Table 1). The values were widely affected by the ratio of compost in the mix. The average CEC value of organic matter is 250 meq/100 gm[18]. They also pointed that no CEC values were obtained of perlite because its surface had no electrical charges. Moreover, particle size distribution of perlite affect negatively on its surface area which led to decrease in CEC value. The data shows that increasing ratio of compost increased the OM content in the mixes. The importance of organic material in different studied mixes is a result of their optimum air capacity at water saturation and its ability to buffer pH, nutrients and salts content.

Table 1: Some chemical properties of the studied materials and its mixes.

Compost	Perlite			BD	SG	CEC	$CaCO_3$	OM
Ratio %		pH	EC dS/m	g/cm^3		meq/100g	%	
100	0	3.88	0.15	0.207	0.421	93.80	0.00	86.4
75	25	4.86	0.13	0.182	nd	76.45	0.03	58.6
50	50	5.42	0.11	0.168	nd	68.92	0.08	37.1
25	75	6.33	0.09	0.152	nd	42.12	0.11	15.4
0	100	7.91	0.08	0.128	0.227	71.60	0.15	0.00
LSD 5%		0.23	0.02	0.015		8.25	0.03	12.35

EC (1:10), pH (1:10), $CaCO_3$% CEC:, cation exchangeable capacity, OM: organic matter, BD: bulk density, SG: specific gravity, nd: not determined.

Table 2 Table 1: Particle size distribution of the studied materials and its mixes.

	Particle size distribution (%)wb				
Material	> 8 mm	8 – 4 mm	4 – 2 mm	2 – 1 mm	< 1 mm
Compost	23.31	15.26	37.15	18.22	6.05
Perlite	24.82	36.17	21.15	9.11	8.75

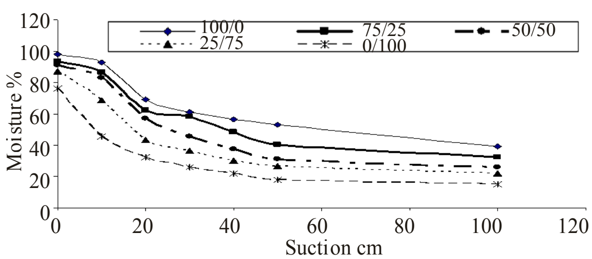

Fig. 1: Moisture characteristics curve for different mixes between compost and perlite.

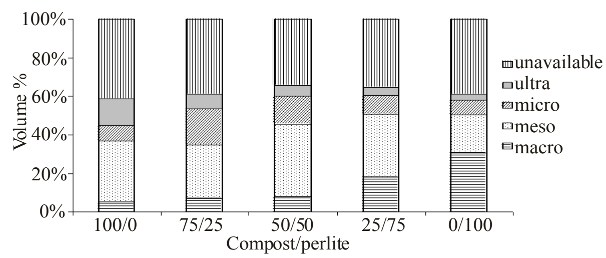

Fig. 2: Pore size distribution in different mixes between compost and perlite.

Hydrophysical Properties: According to the particle size distribution of the studied materials (Table2), results showed that compost had lower percentage of macro particles (>2mm) 38.57 % , while perlite had higher one 61.09%. Consequently, compost had a larger surface area which is reflected on increasing water retention due to highly pore space. The opposite is true in case of perlite due to its larger fraction (60.99 % > 2mm). One can notice that perlite had higher percentage of meso-pores.

Pore size distribution after different combination between compost: perlite is illustrated in Fig. (2). Data on hand revealed that there is significant difference between any two treatment in pore size distributing values of the studied materials.

Perlite showed highly percent of macro and unavailable pores, while the opposite was true in case of compost. Mixed ratio 50:50 , compost: perlite, had a favorable , reasonable, pore size distribution, highl percentage of macro and micro pores, while ultra pores is still slightly high. The obtained results showed that increasing perlite in mixture decrease both of macro and unavailable pores, which is good for growth and root distribution.

Caron and Nkongolo[3] stated that the amount of pore space of media is a critical physical property which directly affect water and nutrients absorption by the root system. They mentioned also, that for sufficient gas exchange, drainage and water retained capacity, the proper proportion of macro-pores to micro-pores is necessary. The Results of the water retention analysis (Fig.2) showed that the highest saturation percentage was obtained from 75% compost : 25% perlite (82.78%), while the lowest was perlite (41.13%). Most of the water was retained at the lower tensions in mixes. The larger amount of macro-pores increased amount of water retained at low tensions (Figure 2).

Among the pure substrates used in this study, the highest water retention capacity (WRC) at the low tensions was obtained from perlite (41.13 %). The highest water retention capacity values for different

Table 3: Hydrophysical properties of the studied materials and its mixes.

Peat moss	Perlite	HC	WRC	Total pore space	Free air space	Easily available water	Water Buffering Capacity
Ratio %		cm/h	%				
100	0	10.23	58.67	91.03	1.73	39.91	13.79
75	25	12.36	61.00	92.41	1.82	46.16	7.70
50	50	18.27	65.55	93.79	2.10	51.78	5.76
25	75	23.07	64.86	94.48	2.53	42.15	4.60
0	100	26.15	61.13	95.12	6.40	27.70	2.89
LSD 5%		1.87	2.45	0.32	0.16	3.24	1.21

WRC: water retention capacity, HC: Hydraulic conductivity

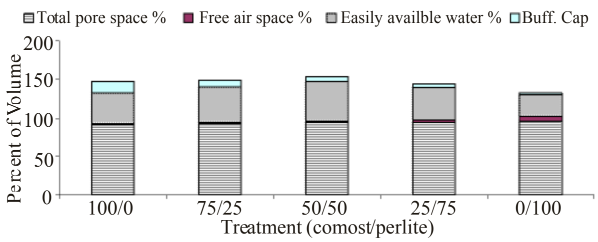

Fig. 3: Hydrophysical characteristics of different mixes between compost and perlite.

mixtured ratio between 0 to 100 cm suction were obtained from ratios 75:25 (82.78 %), followed by 50:50 (76.62 %) and 25:75 (48.97 %) compost : perlite ratio , respectively. Organic matter had increased water retention capacity. The expandable structure of perlite had also increased water retention capacity. Higher water retention capacity at the low tensions is very important for optimal plant growth[19].

Table (3) illustrates that the hydraulic conductivity values as affected by the combination ratio of compost : perlite. Significant positive correlation, at 5% level, between increasing perilt and increasing saturated hydraulic conductivity was observed. Data revealed that saturated hydraulic conductivity of perlite (26.15 cm/h) is more than compost (10.23 cm/h). Results showed that the perlite material has a pronounced effect on increasing hydraulic conductivity values which ranged between 12.36 to 23.07 cm/h at perlite ratios 25 and 75 % in media mixture, respectively. This result agrees with those obtained by[9] and [20] who stated that conductivity of a substrate depends mainly not only the geometry of the pores but also on the properties of the fluid in them. They mentioned also that in saturated conditions, water movements is predominantly through large pores. As waster content decreases, the large pores drain, so tortuosity of the flow path increases and water movement is mainly through smaller ones.

Total pore space (TPS) values were dramatically affected by increasing perlite ratio in mixes. Data on hand revealed that perlite was higher TPS than compost. The results showed significant differences between the studied mixes. The highest and the lowest values were observed in perlit (95.12 %) and compost (91.03 %), respectively.

Perlite had a promotive effect on estimated free air space (FAS) as shown in Table (2). The data indicate that increasing rate of perlite in media mixture increased FAS. There were significant differences at 5% level between any to treatment of mixed materials except between compost alone or compost enriched by 25% of perlite. This finding agrees with[3] who found that make combination between two or more of the media used in horticultural planting could increase FAS to be better media for plant growth.

The most important parameter in any substrate, is the easily available water (EAW). The obtained results revealed that increasing perlite ratio in media mixture could increase EAW to extent that content decrease again. The ratio 50:50 compost: perlite gave a better reasonable value of EAW (51.78 %). The EAW values of pure compost and perlit were 39.91 and 24.70 %, respectively, while the maximum and minimum EAW values for mixtures were 51.78 and 42.15 % for ratios 50:50 and 25:75 (compost :perlite).

Water Buffering Capacity values of the studied materials and their combinations are illustrated in Table (3). Results showed that increasing perlite ratio in mixes decreased buffering capacity for the materials. Buffering capacity values of the compost and perlite were 13.79 and 2.89 %, respectively. The values of water buffering capacity for different mixture ratios could be arranged in ascending order as follows; 75:25 > 50:50 > 25:75 compost : perlite ratio.

Conclusion: The hydrophysical properties of peat mixes is in part related to the capacity of the substrate to store and supply air and water to plant roots. During manufacturing, mixing of various substrate components modifies the substrate characteristics to improve compost quality. Perlite addition to compost increase significantly both of macro and meso-pores which play an important role in drain and conducting water through media. The objective of this study was to assess the changes in air storage and supply properties caused by varying the particle size of the substrate components. The substrate was composed of 60% composted plant residues, 40% of peat (volume basis) mixed with perlite. Finally increased perlite in compost mixtures, used for horticulture, retain more water hence to save water and plant nutrients from leaching.

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