

Effect of Pumice Addition on Available Water Capacity of Different Soil Textural Classes

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Abstract

The objective of this study was to determine if addition of pumice material with two different ratios into various soil textural classes increases available water capacity of the soils. For this purpose, grounded pumice particles smaller than 2 mm diameter were added into loamy sand, sandy loam, loam, clay loam, and clay soil textural classes with a ratio of 1/4 and 1/2 on weight basis.

Results indicated that pumice addition with a ratio of 1/4 increased available water capacity of loamy sand and clay soils while decreased those of sandy loam, clay loam, and loamy clay soil textural classes compared to control samples. When pumice particles were added with a ratio of 1/2 into the same soils, available water content of loamy sand, sandy loam, loamy clay, and clay soil textural classes was significantly increased but those of clay loam was decreased.

Key words: *Pumice, soil textural classes, available water capacity, pumice material-soil mixture, water depletion.*

Introduction

Water conservation has become a vital issue since water, which is one of the basic substances for the life of the living things, is not equally distributed on the earth; therefore, it makes life miserable in some areas. In order to overcome this situation, human being has been trying to various methods to eliminate water inadequacy. For example, to meet water deficiency in plants and to achieve a sufficient growth irrigation methods are applied. On the other hand, unless species of the same plant grow in the same soil conditions they need different amount of irrigation water depending upon soil types. In order to maintain water in the soil as long as possible after an irrigation event some additional materials such as organic matter, polymer and perlite are added into the soil. For instance, Sivapalan (2001) reported that polymer addition to sandy soil increased water use efficiency for plants.

In recent years, pumice is used due to increasing water holding capacity of the soils and causing a better plant growth in agriculture. It has also long been used as an abrasive in cleaning, polishing and lightweight aggregate in precast masonry units. Many scientific articles are available about different characteristics of pumice (Lura et al., 2006; Sterba et al. 2007; Üstün et al. 2005), yet there is very little information about water retention capacity of pure pumice material (Kuşlu et al., 2005). On the other hand, pumice is introduced as a commercial material for increasing soil moisture capacity (Melendizliler, 2007) but we have not met with any scientific evidence about its effect on water holding capacity of the soils.

Turkey has an enormous pumice reserves. It is predicted that there are about 3 billion cubic meters pumice reserve in the studied areas and it is exist in different regions of Turkey (DPT, 2001). Pumice is an igneous rock having acidic or basic character.

As mentioned above, if pumice significantly affects soil moisture, it could be useful in terms of water conservation. Therefore, the effect of pumice addition on available water capacity of different soil textural classes is examined in this study.

Material and Methods

The soils used in this experiment were collected from Belgrad Forest where soils developed from neogen parent material. Pumice material with basic character collected from surrounding of Kayseri city in Central Anatolia. The soil samples were analyzed for texture by using Bouyoucos hydrometer method and textural classes were determined from textural triangle (Hillel, 1998). Five different soil textural classes (loamy sand, sandy loam, loam, clay loam, and clay) were chosen to examine the effect of pumice addition. On the other hand, soil samples were treated with hydrogen peroxide to eliminate the effect of organic matter on water holding capacity of the soils. In order to add pumice into soil, pumice was grounded and dried in an oven at 105 °C. Oven-dried samples were passed through a sieve having circular holes 2 mm in diameter and added into each textural class in a ratio of 1/4 and 1/2 on weight basis. The model 1500 15-bar pressure plate extractor was used to determine moisture content of the samples at field capacity and permanent wilting point (Soil Moisture Equipment Corp., 2002). Available water capacity of the samples were calculated by subtracting water retained at permanent wilting point from water held at field capacity.

Saturation capacities for control and mixed soil samples of different textural classes were also determined and then these samples were weighted on daily basis to calculate moisture loss and to compare water depletion curves.

Experiment was arranged in a completely randomized block design with five replications. Data were analyzed by using ANOVA and means were compared with student's t-tests. Arc-sin transformation was performed on data prior to analysis of variance.

Results and Discussion

Moisture constants and some of their statistical parameters were presented for control and treated (25 % and 50 % pumice additions) samples of loamy sand, sandy loam, loam, clay loam, and clay textural classes in Table 1.

The highest field capacity was found for clay control samples (49.72 %) and it was followed by control samples of clay loam (29.33 %), loam (24.78 %), sandy loam (17.33 %), and loamy sand (11.44 %), respectively. The control samples had also similar order for permanent wilting point. In contrast, the same samples had different order in terms of available water capacities, which were 10.63 % for clay loam, 7.77 % for sandy loam, 6.13 % for loam, 2.17 % for loamy sand, and 1.81% for clay textural classes (Table 1). In other words, clay loam had the maximum and clay soils had the minimum available water capacities (Fig. 1).

Results showed that the available water capacity increased for all soil textural classes except for clay loam with pumice addition in a ratio of 1/2 whereas increases only occurred for loamy sand and clay soil textural classes when addition was 0.25 % at the weight basis. These increase were statistically significant except for sand loam soils ($P < 0.05$). In contrast, although non-significant decrease was found for clay loam soils after 50 percent addition statistically significant decreases were found for available water holding capacity of sand loam, clay loam, and loam soils after 25 percent pumice addition.

Increases in the available water holding capacity for some textural classes can be explained with higher available water holding capacity of the pumice material compared to the soils used in this study. As seen from Table 1, available water content of grounded pumice was found to be about 21 percent. This is the main factor for the increase of available water content of the soils having less than 10 percent moisture content. Available water capacity for some soil textural classes reported was below 14 percent (Çepel, 1985). Available water content for different textural classes were generally found less than 15 percent in various studies conducted in Turkey (Özhan, 1977; Özhan, 1982; Özyuvacı, 1976; Özyuvacı, 1978; Hızal, 1984; Balcı, 1973). According to the results of this study, grounded pumice could have an effect on increasing available water content of loamy sand, sandy loam, loam, and clay soil textural classes.

Table 1. Moisture constants of different soil textural classes and pumice-soil mixtures.

Soil textural classes ¹⁾	Moisture constants					
	Field capacity		Permanent wilting point		Available water	
	Mean \pm Sd ²⁾	Cv ³⁾	Mean \pm Sd	Cv	Mean ⁴⁾ \pm Sd	Cv
LS (control)	11.44 \pm 0.36	3.13	9.27 \pm 0.78	8.40	2.17 ^a \pm 0.43	20.00
LS + % 25 P	20.80 \pm 0.65	3.10	12.57 \pm 0.65	5.19	8.23 ^b \pm 0.38	4.63
LS + % 50 P	26.59 \pm 0.77	2.91	12.11 \pm 0.56	4.64	14.48 ^c \pm 0.99	6.87
SL (control)	17.33 \pm 1.36	7.85	9.56 \pm 0.59	6.17	7.77 ^a \pm 1.47	18.86
SL + % 25 P	26.11 \pm 0.96	3.66	21.92 \pm 0.66	3.01	4.19 ^b \pm 0.83	19.82
SL + % 50 P	27.95 \pm 0.57	2.06	18.92 \pm 0.78	4.13	9.03 ^a \pm 0.42	4.67
CL (control)	29.33 \pm 1.85	6.32	18.70 \pm 0.90	4.80	10.63 ^a \pm 2.55	23.99
CL + % 25 P	36.07 \pm 0.51	1.40	29.53 \pm 0.35	1.18	6.54 ^b \pm 0.52	7.92
CL + % 50 P	34.50 \pm 0.96	2.78	25.13 \pm 0.83	3.30	9.37 ^a \pm 1.21	12.89
L (control)	24.78 \pm 0.95	3.82	18.65 \pm 0.82	4.40	6.13 ^a \pm 0.71	11.62
L + % 25 P	31.97 \pm 0.99	3.09	28.69 \pm 0.57	1.98	3.28 ^b \pm 1.20	36.40
L + % 50 P	30.74 \pm 0.68	2.20	21.44 \pm 1.03	4.83	9.30 ^c \pm 0.69	7.42
C (control)	49.72 \pm 0.77	1.56	47.90 \pm 0.30	0.63	1.81 ^a \pm 1.03	56.87
C + % 25 P	48.39 \pm 0.70	1.44	44.65 \pm 0.60	1.35	3.74 ^b \pm 0.77	20.69
C + % 50 P	42.20 \pm 1.39	3.29	35.48 \pm 1.19	3.37	6.72 ^c \pm 0.61	9.03
P	32.38 \pm 0.79	2.45	11.36 \pm 1.46	12.83	21.02 \pm 0.78	3.70

¹⁾ LS: Loamy sand, SL: Sandy loam, CL: Clay loam, L: Loam, C: Clay, P: Pumice

²⁾ Sd: Standard deviation

³⁾ Cv: Coefficient of variation

⁴⁾ Means available water content with different superscript letters differ significantly for the same soil textural class (P<0.05).

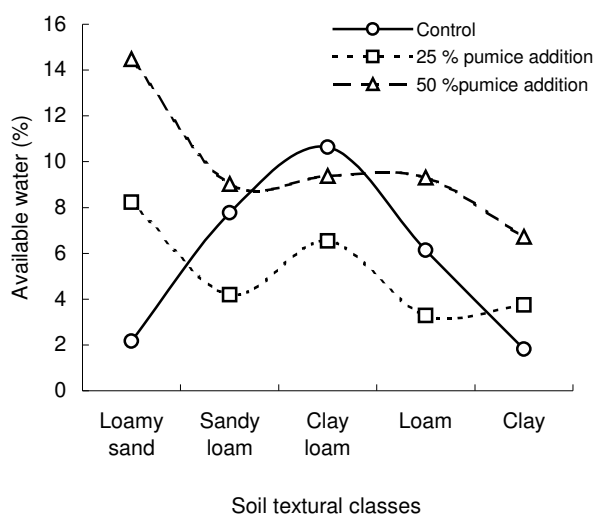


Figure 1. Variations of available water capacity of soil textural classes with respect to different pumice additions.

Soil water depletions were also examined for all textural classes at three mixture levels (control, 25 %, and 50 % pumice additions) (Fig. 2a-d).

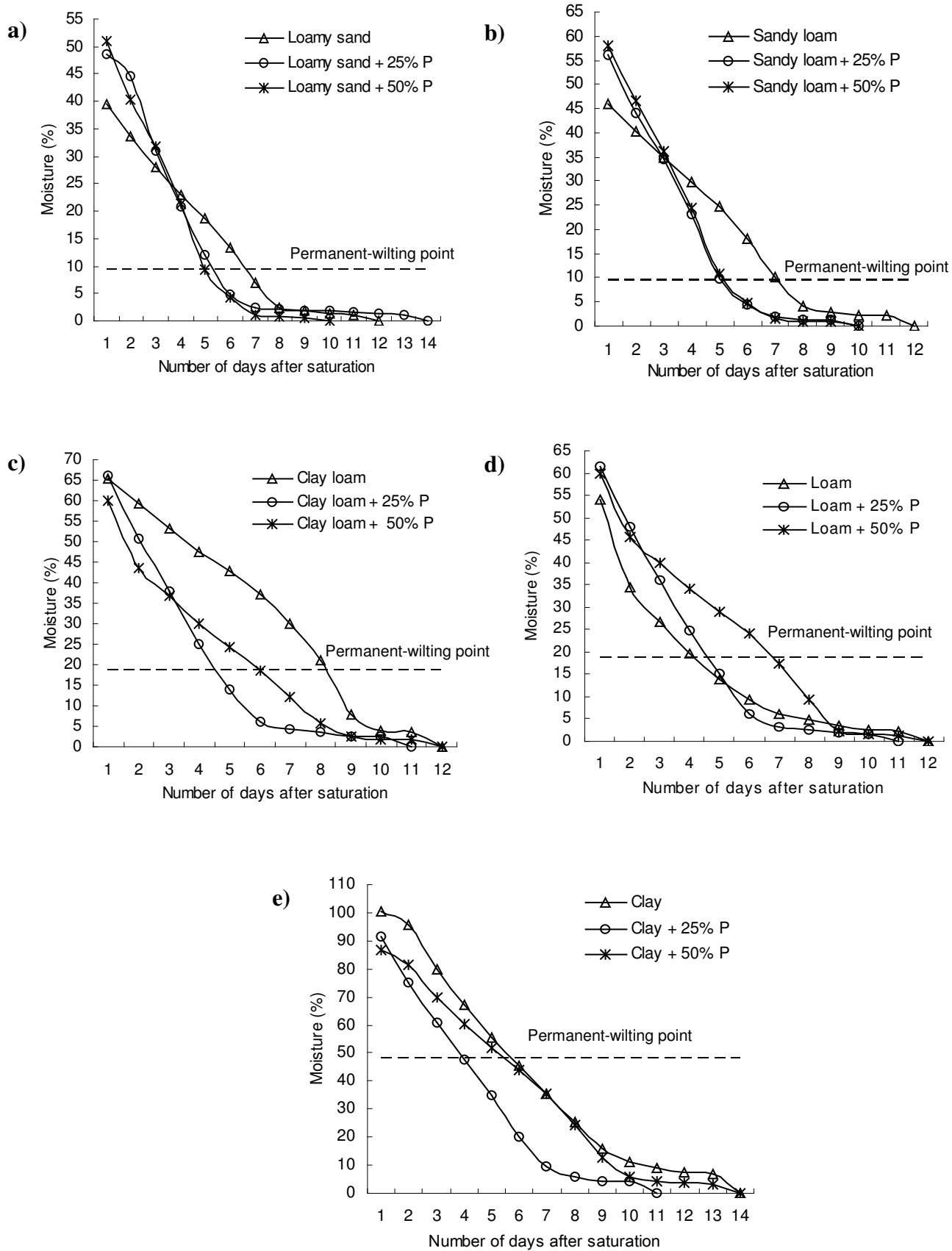


Figure 1. Soil moisture depletion curves for different textural classes

Soil water depletion was retarded about two days for only loam soils with 50 percent pumice addition. In other words, water content of loam soil reached permanent wilting point two days later than control soil sample (Fig. 2d) but this trend was not observed for other textural classes for both 25 % and 50 % pumice additions.

Conclusion

By adding of grounded pumice material to soils, available water capacity could be increased. However, it depends on proportion of pumice within the mixture. In this study, it was found that when proportion of pumice addition within the mixture increased, most of the soil textural classes had greater available water content. It was concluded that when grounded pumice material was added into the soil with a proportion of 1/2 (by weight), available water content for loamy sand, sandy loam, loam, and clay textural classes significantly increased. This is a very important point for water conservation since by adding pumice, much more water would be retained in the soil and plant could use more available water.

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