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Influence of Substitution of Peat with Iranian Zeolite (Clinoptilolite) in Peat Medium on *Ficus benjamina* Growth

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Abstract

This experiment was designed to characterize the effects of size and concentration of an Iranian clinoptilolite zeolite on the growth of *Ficus benjamina* (starlight) in peat base media. *Ficus benjamina* was stock rooted and grown in a peat consisting perlite (2:1 v/v) (P: Pe), zeolite (10, 20, 30 and 40 v/v %, two sizes 0.5-3 mm and 3-8 mm) instead of peat in P: Pe (2:1 v/v) media. *Ficus benjamina* was grown in the substituted media for 10 month under fiberglass cover greenhouse, with 4 pots for each treatment. The control consisted of P: Pe alone without zeolite. The results showed that the substitution of 10-30 v/v % zeolites in control did not result in significant difference ($p \leq 0.05$) in shoot and leaf fresh weight, shoot and leaf dry weight, shoot dry weight, leaf dry weight in comparison to control. Instead, substitution of 10-40 v/v % zeolites instead of peat significantly increased media electrical conductivity (EC). There were no positive correlations between *Ficus benjamina* growth and the amounts of mineral-N in potting mixtures or concentration of nitrogen in leaves of plant. Zeolite particle size significantly increased the pH in comparison with the control. With Regard to the high relative price of peat with respect to natural zeolite, zeolite substitution in an amount of 10-30 vol. % is economically preferred.

Keywords: *Ficus benjamina*, Peat, Perlite, Zeolite.

INTRODUCTION

Zeolites constitute a large class of secondary minerals consisting of aluminosilicate with loosely bonded alkali and/or alkali-earth cations and water molecules (Hey, 1930). They are commonly formed at low temperature and pressure in the presence of water (Armbruster and Gunter, 2001). More than 80 natural zeolite species have been identified (Coombs *et al*., 1998). Of these, chazabite, clinoptilolite, erionite, mordenite, and phillipsite are the most commonly used for agronomic, horticultural, and soil remediation applications (Ming and Allen, 2001). Zeolites have two properties that make them desirable for agronomic and horticultural use: (1) a theoretical CEC of 200 to 300 meq/100 due to the substitution of Al^{3+} for Si^{4+} during formation (Ming and Allen, 2001) and (2) large internal channels created by three dimensional (3D) framework of silica and alumina tetrahedron that gives zeolites low bulk densities and allow for retention of water and exchange of cations (Ming and Allen, 2001). Although adding sphagnum peat to a root zone mix increases the CEC of the mixture, researchers have shown that peat binds divalent cations such as Ca^{2+} and Mg^{2+} are more tightly than monovalent cations such as K^{+} (Salmon, 1964; Kussow, 1987). Zeolites seem to have the greatest potential as an amendment.

Zeolites have physical characteristic similar to sand, thereby retaining rapid drainage and resistance to compaction it increases CEC and water retention capacity. In contrast to peat, zeolites have a preference for bonding K^{+} ions over Ca^{2+} ions (McCoy and Stehouwer, 1998; Li *et al*., 2000). This suggests that inorganic amendments have potential substitutes for peat. In addition to being widely used as molecular sieves in the petrochemical industries, zeolites have been used as materials for supplying plants with potassium and phosphate (Chen and Gabelman, 1990; Williams and Nelson, 1997) and as adsorbents for reducing nitrogen transformation (Huang and Petrovic, 1992).

Reported studies show that addition of clinoptilolite zeolite to pine bark substrate reduced the amount of fertilizer leaching from medium on two dates for Abelia, but not for Ilex. There were no responses in plant growth due to substrate amendment with zeolites (Sloan, 1999). Therefore, zeolites may have a great potential ornamental plant industry for use as components of potting media to reduce nutrient leaching (Cox, 1993) and releasing needed nutrients to support plant growth. Objective of this study is to determine potential of a natural Iranian clinoptilolite to be used as substrate amendment for *Ficus benjamina.* Effect of zeolite size and percent substitution with peat on plant growth characteristics has been investigated.

MATERIALS AND METHODS

The experiments were carried out in fiberglass covered greenhouse in factorial experiment with complete randomize block design in four replication and four plant in every treatment for 10 months. Each rooted Ficus benjamina cuttings were transplanted to 4 liter (10 cm diameter) liter plastic pots. In these trials, we compared the growth of plant in Peat: Perlite (2:1 v/v) with respect to zeolite substituted pots for two sizes of the zeolite (0.5 - 3 mm and 3 - 8 mm) and four zeolite concentrations (0% (control), 10%, 20%, 30% and 40%). Each of these mixures was used as instead of peat to be evaluated in the experiment. The basic chemical properties of peat:perlite and zeolite are summarized in Table1.

The pH was determined by pH meter (Metrohm 691) in a double distilled water suspension of each mixture in the ratio of 1:10 (W/V) that had been agitated mechanically for 30 min and filtered through whatman No.1 filter paper. The same solution was measured for electrical conductivity (Metrohm 644) by a conductance meter that had been standardized with 0.01 and 0.1 M KCl. Total organic carbon was measured by using the method of Nelson and Sommers (1982). Total Kjeldal Nitrogen was determined after digesting the sample with concentrated H_2SO_4 and concentrated $HClO_4$ (9:1, V/V) by Bremner and Mulvaney (1982) procedure. Total P was analyzed using the colorimetric method with molybdenum in sulphuric acid. Total K after digesting the sample in diacid Mixture (concentrated HNO_3: concentrated $HClO_4$, 4:1, V/V), by flame photometer. Total Ca was determined by atomic absorption spectrophotometer (AAS) after digestion of the sample in concentrated HNO_3: concentrated $HClO_4$ (4:1, V/V). The CEC of zeolite was determined by using NaOAc saturation and displacement by NH_4OAc as described by Bower *et al.,* (1952). The CEC of the peat was determined using a Harada and Inoko (1980) method. Plants were cut from surface of pot, leaves wet weight of leaves and shoot, and oven-dried at 75 °C for 2 days to determine their dry weight. Every 10 day 200 cm^3 solution consist of 130 mg/l N; 32 mg/l P and 117 mg/l K (as a KH_2PO_4, KNO_3, Ca $(NO_3)_2$) were used for Each pot (Chen *et al*., 1988; Azizi *et al*., 2008), and irrigation was applied as needed. Each sampling date, were analyzed statically by SAS (SAS Institute,1990). The means data were compared statistically by using Duncan multiple range tests.

RESULTS AND DISCUSSION

The pH of the potting mixtures increased progressively with increasing substitutions of Z_1 and Z_2 instead of peat (fig.1 b and c). Results show that the substitution of peat by 10-30% zeolite had a significant on Ficus benjamina shoot and leaf fresh weight, shoot and leaf dry weight, shoot dry weight and leaf dry weight, but 40% zeolite significantly ($p \leq 0.05$) decreased this growth factor than in the control (Table 2). Such decreases were most likely due to salt concentrations in Z_1 and Z_2 (respectively 1.98 and 2.35 mS/cm). Salinity could be an adverse effect on plant growth in medium when it exceeded 1-3 mS/cm (Gajdos, 1997). The Z_1 and Z_2 had an electrical conductivity of 1.98 and 2.35 mS/cm respectively (Table1). Upon the substitution of 10, 20, 30 and 40% of zeolite instead of peat into Control, the electrical conductivity of the container media increased linearly with the increasing concentrations of zeolite, and were 1.2, 1.4, 1.6 and 1.8 times greater than control (fig.1 a). According to Qian et al (2001), long term application of zeolite caused to increase potentially sodicity and salinity problem. The total amount of mineral-N in the growth mixtures decreased significantly in substitution rates of Z in potting mixtures on all sampling dates (Table 3). However, increases in mineral-N in the mixtures did not correlated with Ficus benjamina plants growth. Similarly, the assimilation of nitrogen into the leave tissues of Ficus benjamina was not correlated with growth of Ficus benjamina plants. It is possible those other enhancing growth factors due to increasing Z to media, caused to improvement of water use efficiency. Huang and petrovic (1996) reported that zeolite increased shoot growth rate of creeping bent grass without influence on evapotranspiration rate during drought stress. However, this conclusion is still speculative and requires further in-depth study specifically addressing the presence and function of that on plant growth. Increasing size and concentration of zeolite in comparison with control significantly ($p \leq 0.05$) decreased media P. The media P increased with 30 and 40% Z_1 and 40% Z_2. The substitution of 30% and 40% Z_1 and 40% Z_2 significantly increased the K of media in comprise to control. The media Ca increased significantly as compared with control by 10%, 20% and 30% Z_1 and 20%, 30% and 40% Z_2. High quality of peat moss can be exceedingly expensive for potting media. For this reasons, interest has arisen in the use of inorganic amendments instead of peat in peat base media. Pay attention to that, substitution of 10-30% Z_1 or Z_2 can be decrease cost of Ficus benjamina growth media with plant mass production, nearly to control.

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Tables

Table 1. Chemical properties of potting medium.

Media component	pH (1:10)	EC (mScm-1)	CEC (meq/100g)	N (%)	P (%)	K (%)	Ca (%)
P: Pe	4.5	0.85	100	0.45	0.23	0.42	0.17
Z1	9.3	1.98	61	0.006	0.002	0.66	0.90
Z2	9.2	2.35	58	0.003	0.001	0.64	0.84

Table 2. Horticultural parameter in various potting mixtures.

Percentage of Z in P:Pe	Shoot and leaf fresh weight (gr)	Shoot and leaf dry weight (gr)	Shoot dry weight (gr)	leaf dry weight (gr)	Leave N (mg/g)
Control	125.80 a	48.10 a	31.68 a	16.42 a	2.1ab
10	128.20 a	48.90a	31.93 a	17.01 a	2.1ab
20	121.10 a	46.20 a	30.37 ab	15.81 a	2.1ab
30	117.70 ab	46.00 a	30.75 ab	15.27 a	2.3a
40	105.10 b	42.50 b	29.32 b	13.16 b	2.3a

P: Pe (2:1), control; Z, Zeolite; Means followed by the same letter do not significantly different (p≤0.05) according to Duncan test.

Table 3. Amount of nutrient elements N, P, K and Ca in various potting mixtures.

Percentage of Z in P:Pe	N (%)	P (%)	K (%)	Ca (%)
Control	0.45 a	0.22 a	0.42 de	0.16 e
10 Z1	0.35 b	0.04 d	0.31 f	0.19 d
20 Z1	0.25 d	0.03 de	0.45 d	0.21 c
30 Z1	0.15 f	0.01 e	0.48 c	0.23 b
40 Z1	0.14 f	0.01 e	0.58 b	0.14 f
10 Z2	0.32 c	0.19 b	0.30 f	0.12 g
20 Z2	0.17 e	0.13 c	0.41 e	0.21 c
30 Z2	0.31 c	0.02 e	0.41 e	0.31 a
40 Z2	0.35 b	0.04 d	0.67 a	0.32 a

P: Pe (2:1), control; Z, Zeolite; Means followed by the same letter do not significantly different (p≤ 0.05) according to Duncan test

Figures

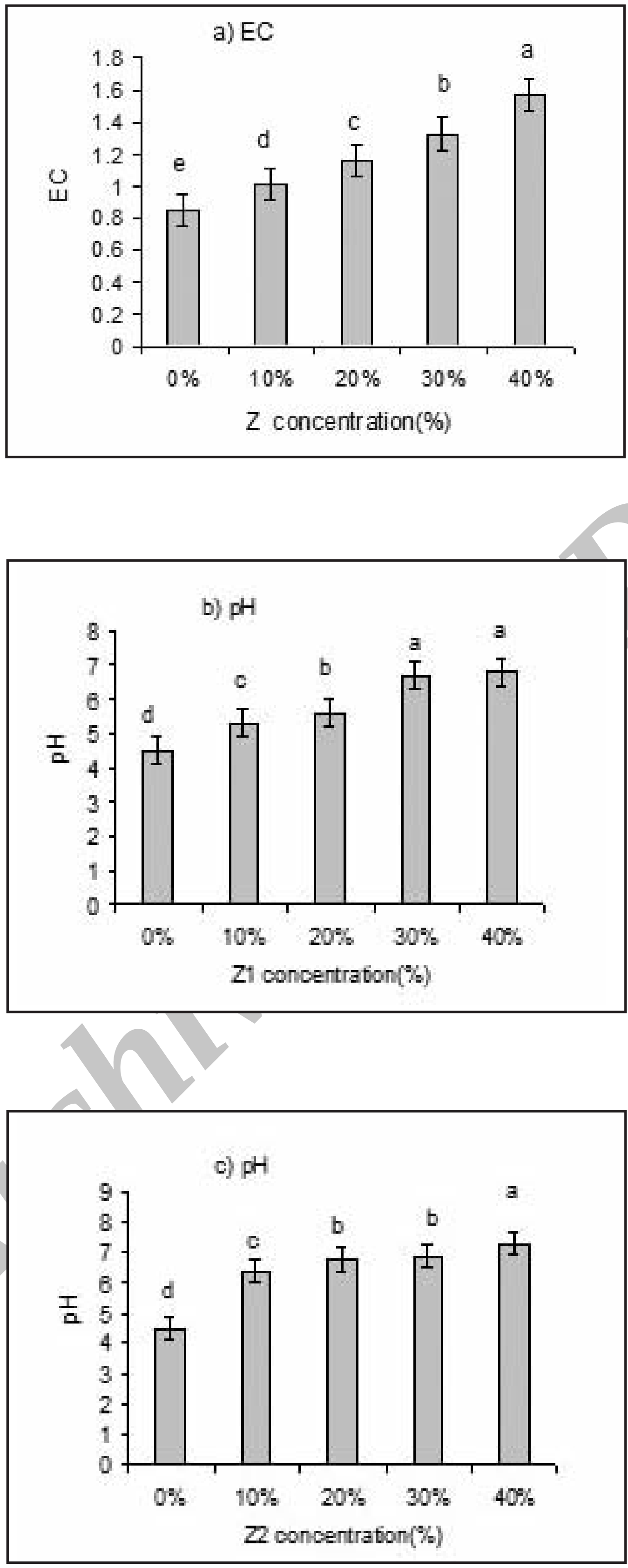

Fig. 1. PH and EC of potting medium. P: Pe (2:1) with substitutions of different concentrations of Z. Columns followed by the same letter do not differ significantly ($P \leq 0.05$); (a) mean Ficus benjamina medium EC. (b) Mean Ficus benjamina medium pH with substitutions of different concentrations of Z_1. (c) Mean Ficus benjamina medium pH with substitutions of different concentrations of Z_2.