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A Study on Effects of Different Mixtures of Zeolite with Soil Rates on Some Yield Parameters of Alfalfa (*Medicago sativa* L.)

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Abstract: The effects of six zeolite and soil rates (20% zeolite+80% soil, 40% zeolite 60% soil, 60% zeolite+40% soil, 80% zeolite+20% soil and 100% zeolite, 100% soil) on plant height, green herbage yield, hay yield and dry root weight of alfalafa (*Medicago sativa* L.) were evaluated under the greenhouse conditions in Bursa, Turkey in 2001 and 2002. The highest plant height (68.56 cm), green herbage yield (74.10 g/pot) and dry root weight (9.13 g/pot) were obtained from the pots in which 20% zeolite+80% soil was used. There was no significant differences between treatment and control for the hay yield. The lowest values for all components were determined from the pots with 100% zeolite.

Key words: Zeolite, green herbage yield, hay yield, dry root weight

INTRODUCTION

Zeolites are hydrated aluminosilicates of the alkaline and alkaline-earth metals. Natural and synthetic zeolites are used commercially because of their unique adsorption, ion-exchange, molecular sieve and catalytic properties (Robert, 2001). Zeolite products have many uses such as animal feed, soil conditioner, oil absorbent, desiccant, fungicide or pesticide carrier, gas absorbent and catalyst (Mumpton, 1999; Goldfield Corp, 2002).

In agriculture zeolite is mainly used to improve soil conditions thus improving yield. Incorporation of zeolite into soil improves nitrogen assimilation, increases soil absorption, reduces nitrogen nitrification and reduces fertilizer wash off from soils. In addition to improving soil conditions zeolite increases yield of agricultural crops. Zeolite has been used on variety of soil types and on a number of crops, such as potato, maize, rice, tomato, eggplant, carrot and in all applications, a yield increase was observed, in some cases yield increase reached to 60%. It also increased vitamin content up to 70% (Burriesci *et al*., 1984; Yapparov *et al*., 1988) in some crops.

Different ratios (5, 10, 15 and 20%) of zeolite were applied in tomato seedling mediums to evaluate effects of zeolite and to find the most effective zeolite dose on some growth characteristics, plant height, stem diameter and dry weight. The most effective medium was the one containing 20 % zeolite and it increased significantly all parameters measured (Ünlü *et al.,* 2004). The results of Ünlü *et al.* (2004) are supported the results of Markovic *et al.* (1995), who found also that 20% zeolite mix was the best growth medium for tomato plants. In another study (Olczyk, 2005) incorporation of zeolite in to soil increased tomato yield, but had no positive effects on sweet corn. The results from other field studies clearly demonstrated beneficial effects of zeolites as soil amendments for crop production and to improve available water to growing plants (Olczyk, 2005; Savidov, 2002).

In addition to have many useful benefits as soil additive, suitability of zeolite use in combination with different fertilizer systems in soilless cultures were examined using tomato plants. Fruit yield, quality and different growth parameters were examined. Perlit based systems were the best suited for liquid feeding systems, while zeolite containing mixtures were the most suited for slow releasing fertilizers (Traka-Mavrona *et al.,* 2001). However there were some adverse effects as well namely, deterioration of internal color, but it was not clear whether those effects caused by zeolite or the fertilizing system used.

With its proven benefits zeolite has been gaining attention. There are plans to develop fertilizer products consisting of ammoniated and phosphated zeolite for use in potting soils, fruit and vegetable growing (Mining Engineering, 2001; United States Antimony Corp, 2002; Anonymous, 2004).

In spite of considerable attention given to zeolite use in horticultural crops, there has been much less interest in it for improving forage crop yields. Since zeolite has many

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useful benefits as soil amendment, it should also have beneficial effects on forage crops, such as alfalfa. The objective of the present study was to determine the most effective dose of zeolite to incorporate into soil to use in alfalfa production and to determine the effects of zeolite on some yield parameters of alfalfa.

MATERIALS AND METHODS

This research was carried out in greenhouses of Field Crops Department, Faculty of Agriculture, at Uludag University in 2001 and 2002. In the experiments seeds were sown in 20 cm plastic pods in March 2001 and 2002. Alfalfa (*Medicago sativa* L.) cultivar "Kayseri" was used as plant material.

Six different treatments 100% soil (control), 20% zeolite+80% soil (T_1), 40% zeolite+60% soil (T_2), 60% zeolite+40% soil (T_3), 80% zeolite+20% soil (T_4) and 100% zeolite (T_5) were used in this research. The experiment was set up as a randomized complete block design with four replications. The experiment had total of 24 pots. Plants were watered when required.

Data was collected on plant height, green herbage yield, dry matter yield and dry root weight in this experiment. Individual plant heights were recorded before cuttings and cuttings were performed at the 10% flowering stage of alfalfa plants. After washing off soil and zeolite, plants were weighted to determine green herbage yield. Roots samples were separated and were dried in an oven at 70°C to a constant weight to determine hay yield and dry root weight.

Statistical analyses were carried out using Minitab and Mstat Programs. The differences between treatments and control were separated by LSD methods (Turan, 1995).

RESULTS AND DISCUSSION

The ANOVA analysis showed that the effects of year, treatments and treatments×year interactions on plant height were significant. Treatment×Year interaction averaged over 2 years did not show significant interaction for hay yield, green herbage yield and dry root weight (Table 1).

The two-year average plant heights from the 100% soil, 20% zeolite+80% soil, 40% zeolite+60% soil, 60% zeolite+40% soil, 80% zeolite+20% soil and 100% zeolite treatments were 60.88, 68.56, 64.75, 58.50, 56.39 and 40.67 cm, respectively (Table 2). While the highest plant height was obtained from 20% zeolite+80% soil treatment (68.56 cm), the lowest plant height was obtained from 100% zeolite treatment (40.67 cm).

Zeolite+soil treatments had significant effects on green herbage yield (Table 2). Averaged over two years, the highest green herbage yield was obtained from 20% zeolite+80% soil treatment (74.10 g/pot). Whereas, the lowest green herbage yield was obtained from 100% soil treatment (47.67 g/plot).

Although there were no statistically significant differences observed between treatments on hay yield (Table 2), 20% zeolite+80% soil treatment gave the highest hay yield (16.33 g/plot).

The results of variance analysis showed that the effects of treatments on dry root weight were significant while year and treatments x year interaction were not significant (Table 1). Averaged over two years, the highest dry root weight was obtained from 20% zeolite+80% soil treatment (9.12 g/plot) and the lowest dry root weight was obtained from 100% soil treatment (3.69 g/plot).

No T×Y interactions were observed for green herbage yield, hay yield and dry root weight, but T×Y interaction was significant for plant height (Table 1). The average temperature in March 2001 was 14.1°C and it was 10.3°C in March 2002 in greenhouses. The temperature differences might have affected plant height as temperature affects seed germination and initial seedling development. Later when temperature differences reach equilibrium the other recorded parameters would not have been affected adversely. The best results were obtained from T_1 for plant height, green herbage yield and dry root weight. Treatment 1 did not significantly affect hay yield when it was averaged over years (Table 2).

In order to determine hay yield samples were dried in an oven as mentioned above. Even though green herbage yield was significantly affected by treatments, water loss from samples might have rendered treatment effects and as a result, water retention and loss from forage crops

Table 1: Results of variance analysis belonging to plant height, green herbage yields, hay yields and dry root weight which determined different mixtures of zeolite and soil in alfalfa (MS)

Source of variation	DF		Plant height			Green herbage yield			Hay yield			Dry root weight		
	(1)	(2)	2001	2002	Means	2001	2002	Means	2001	2002	Means	2001	2002	Means
Years	-	1	-	-	114.52*	-	-	1035.6	-	-	8.21	-	-	3.40
Treatments	5	5	343.84**	494.59**	748.93**	174.44**	702.5	661.7*	7.69	37.16**	33.21	11.91*	14.50*	26.31**
Treatments×Year	-	5	-	-	89.50**	-	-	215.3	-	-	11.64	-	-	0.10
Error	18	36	8.46	37.99	23.22	10.89	507.8	259.3	0.48	26.86	13.67	3.37	4.06	3.72

(1): Values belonging to 2001 and 2002 years, (2): Values belonging to averages of two years, *, **: statistically significant and highly significant, respectively

Table 2: Averages of two years belonging to plant height, green herbage yields, hay yields and dry root weight which determined different mixtures of zeolite and soil in alfalfa

Mixtures of zeolite with soil	Plant height (cm)	Green herbage yield (g/pot)	Hay yield (g/pot)	Dry root weight (g/pot)
100% Soil (Control)	60.88bc	65.03ab	14.31a	5.71b
20% Zeolite + 80% Soil (T_1)	68.56a	74.10a	16.33a	9.13a
40% Zeolite + 60% Soil (T_2)	64.75ab	64.70ab	14.19a	6.74b
60% Zeolite + 40% Soil (T_3)	58.50c	57.06bc	12.44a	6.52b
80% Zeolite + 20% Soil (T_4)	56.39c	56.65bc	12.38a	5.23bc
100% Zeolit (T_5)	40.67d	47.67c	10.44a	3.69c
LSD (5 %)	5,84.00	13,28.00	6,12.00	1,98.00

might be an important parameter, which should be investigated further in later studies. Green herbage yield is also an important parameter when forage crops are used to make silage for animal consumption. Although some water loss from green herbage could be necessary to increase dry matter content and carbohydrates in plant materials, it is not always necessary. Therefore, the more green herbage yield is better for silage production and incorporation of zeolite to soil might increase green herbage yield on alfalfa production, but more rigorous field and greenhouse investigations would be necessary. Our results are in agreement with the results of Torii (1978), Van Bo (1988) and Mazur *et al.* (1984) who found significant yield increases for barley, carrot, eggplant, wheat, potatoes and clover when these crops were grown zeolite-soil mixes.

Dry root weight was investigated in the present study as it measures development and health of root system underground. Under field conditions, it is desired to have an actively growing, well developed root system for crops since water and nutrient uptake will be significantly affected by the health of the root system, which would affect plant development. Zeolite positively affects soil water and nutrient holding capacity and reduces N and P leaching from soils and improves soil quality, thus; improving nutrient availability (Olczyk, 2005). In the present study, the highest root growth was obtained from T_1. Subsequent increases of zeolite amount did not improve root weight in greenhouse grown alfalfa plants. Therefore the best ratio to use was the 20% zeolite. Positive effects of zeolite on root development also have been observed on radishes. The addition of NH_4-exchanged zeolite in greenhouse experiments resulted in 59 and 53% increase in root weight of radishes in medium-and light-clay soils, respectively (Lewis *et al.*, 1984).

The results from this preliminary research showed some beneficial effects of zeolite as soil amendment for crop production. The best results obtained from the T_1. Increasing zeolite rate did not significantly change yield parameters. The lowest results obtained from T_5 that 100% zeolite was used. Further investigations would be necessary to examine the effects of zeolite on alfalfa plants in field and with different soil types.

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