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Growth of tall fescue (*Festuca arundinacea* Schreb.) seedlings sown in soil mixed with nitrogen and natural zeolite

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Key words: Clipping, soil mixture, vegetative variables.

Abstract: To determine the interaction of nitrogen and natural zeolite in culture medium on the vegetative growth of tall fescue (*Festuca arundinacea* Schreb.) 'Starlet' a greenhouse experiment was conducted. A complete randomized design with factorial arrangements including two factors (nitrogen and zeolite) was employed for each treatment with four replications. Treatments of nitrogen were 0, 0.06 and 0.12 g kg^{-1} in the soil mixture and treatments of zeolite were 0, 10, 20 and 30 g kg^{-1} in the soil mixture. Application of zeolite and nitrogen had different effects on seedling height, fresh and dry weights of clippings before first, second and third mowings, chlorophyll and nitrogen content of clippings, and dry weights of roots. Adding zeolite at the rate of 30 g kg^{-1} and nitrogen at the rate of 0.12 g kg^{-1} to culture medium significantly increased the height of turf seedlings. It is concluded that zeolite could absorb and slowly release nitrogen to the culture medium.

1. Introduction

The genus *Festuca* includes more than 360 species that differ widely in appearance. Less than ten species are used as turf, all in cool climates. *Festuca arundinacea* Schreb., tall fescue, is a deep-rooted, cool-season perennial grass. It shows vigorous growth in spring and autumn, and its extensive root system helps it to withstand drought conditions. The species is adapted to a wide range of soil and climatic conditions, but performs best where winter is rather mild. Its requirement for relatively high mowing times limits its use as lawns in parks, golf course roughs and other areas mowed at 40 mm or more (Wiecko, 2006).

Zeolites are crystalline, hydrated alumino silicates of alkali and earth metals that possess infinite, three-dimensional crystal structures. They are further characterized by an ability to lose and gain water reversibly and exchange some of their constituent elements without major changes in structure. Nearly 50 natural species of zeoiltes have been recognized and more than 100 species without natural counterparts have been synthesized in the laboratory (Breck, 1974; Meier and Olsen, 1987; Mumpton, 1999).The great effectiveness of zeolites as natural sources of trace elements supplementing NPK and their high adsorption ability have been reported (Kolyagin and Kucherenko, 2003). Therefore, natural zeolites, due to their structure and properties (inert and non-toxic), can be used as slow-release carriers of fertilizers (Ramesh *et al*., 2011).

A 10% addition of clinoptilolite to sand used in the construction of golf-course greens substantially reduced NO_3^- leaching and increased fertilizer-N uptake by creeping bent-grass without disturbing the drainage, compaction, or playability of greens (Ferguson *et al*., 1986; Nus and Brauen, 1991; Hung, 1992). The addition of NH_4^+ exchanged clinoptilolite in greenhouse experiments resulted in 59 and 53% increase in root weight of radishes in medium with light clay soil (Lewis *et al*., 1984).

The water efficiency of surface irrigation systems in Iran is low and nitrogenous fertilizers should be added to soil at a higher level. Therefore leaching of nitrogen fertilizers occurs resulting in underground water pollution particularly in soils with light texture. Clinoptilolite, a naturally occurring zeolite with high exchange capacity, may be used to absorb ammonium and retard excess leaching of nitrate. These facts dictate improving water and fertilization management to decrease the pollution of underground water resources (Abdi *et al*., 2004).

The object of the present study was to investigate the effects on tall fescue growth of applying different amounts of natural zeolite and nitrogen to growth medium.

2. Materials and Methods

A greenhouse pot trial was conducted in 2009 at the Faculty of Agriculture, Shiraz University, Shiraz, Iran, at Badjgah, 1810 m above mean sea level, 29° 36´N and 52°

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32´E on tall fescue (*Festuca arundinacea* Schreb.) 'Starlet' to evaluate N uptake from soil mixture with different amounts of zeolite. The soil samples were collected for soil nutrition analysis before the seeds were planted (Table 1).

Seeds of tall fescue cultivar of Starlet were planted in 3 kg pots with soil mixture (1:1 v/v field soil and sand). The soil mixture of pots contained 0, 10, 20 and 30 g kg^{-1} zeolite and 0, 0.06 and 0.12 g kg^{-1} Nitrogen (in the form of urea) in different treatments (4 levels of zeolite × 3 levels of Nitrogen × 4 replication= 48 pots). Plants were maintained in a greenhouse under natural light (>850 µ mol m^{-2} s^{-1}) with diurnal temperature 26±3°C and nocturnal temperature 20±3°C, and RH of 56±4%. Turf grasses were irrigated every four days in spring and every two days in summer. One month after seed germination the first mowing was carried out; second and third mowings occurred 2 and 3 months after germination of seeds, respectively. Seedling height before first, second and third mowings, fresh and dry clipping weights after each mowing, chlorophyll and Nitrogen content of clipping, and dry weights of roots were measured. Seedling heights were measured. Chlorophyll content was determined by spectrophotometric method (Saini and Buvalda, 1998). The total amount of nitrogen (N) was measured using the Kjeldahl digestion method. Clippings and roots were weighed for fresh weight and then oven dried at 70°C (Karl Kolb 112SL) for 48 h and weighed for dry weight.

This research was carried out in a complete randomized design with factorial arrangements including two factors (Nitrogen and Zeolite) for each treatment with four replications from April to August 2009. Data were analyzed by MSTATC software and mean values were compared using the LSD test at 5% level.

3. Results

Seedling height before first, second, and third mowings (cm)

Increasing the content of zeolite in the culture medium to 0.12 g kg^{-1}nitrogen, seedling height increased before all mowing times. The effect of zeolite alone on seedling height had shown increase, this increase was significant at 30 g kg^{-1} zeolite in soil mixture before first and second times of mowing. Increasing the nitrogen concentration in the soil mixture had no regular and significant effect on seedling height before the three mowing times when compared to untreated control (Table 2).

Fresh and dry clipping weights after first, second, and third mowings (g)

As indicated in Figures 1, 2, and 3, an increase in zeolite and nitrogen together in the soil mixture let to greater fresh

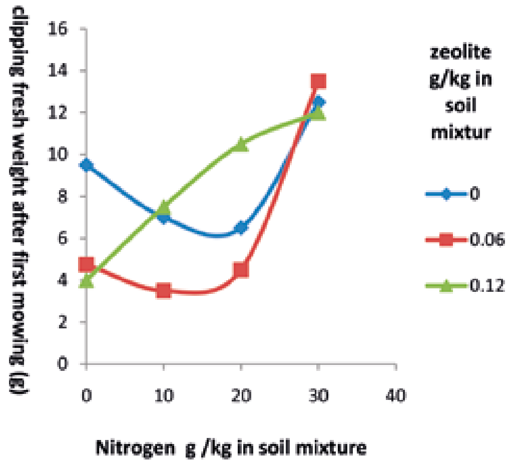

Fig. 1 - Effect of nitrogen and zeolite on clipping fresh weight after first mowing (g) of *Festuca arundinaceae* Schreb'Starlet'..

Table 1 - Some physical, chemical and nutritional characteristics of the soil used in the study

CEC	pH	N %	P (mg kg^{-1})	K (mg kg^{-1})	OC (%)	S.P.	Clay (%)	Silt (%)	Sand (%)
1.3	7.53	0.26	27.5	400	2.72	26	12	34	54

Table 2 - Effect of nitrogen and zeolite on seedling height before first, second and third mowings of *Festuca arundinaceae* Schreb 'Starlet'

	Seedling height before first mowing (cm)			Means of zeolite	Seedling height before second mowing (cm)			Means of zeolite	Seedling height before third mowing (cm)			Means of zeolite
	Zeolite g·kg^{-1} soil mixture				Zeolite g·kg^{-1} soil mixture				Zeolite g·kg^{-1} soil mixture			
	0	0.06	0.12		0	0.06	0.12		0	0.06	0.12	
Nitrogen g kg^{-1} in soil mixture												
0	20.50 ab*	18.25 abc	13.75 cd	17.50 B	17.50 bcd	18.00 bcd	13.50 d	16.33 B	15.25 a	13.50 abc	11.25 bc	13.33 AB
10	22.50 ab	13.25 d	22.75 ab	19.50 AB	19.00 abc	13.50 d	18.75 abcd	17.08 B	14.25 abc	11.00 c	13.75 abc	13.00 B
20	16.50 bcd	20.0 abcd	22.00 ab	19.50 AB	16.00 cd	17.75 bd	22.00 ab	18.58 B	13.50 abc	14.00 abc	13.50 abc	13.67 AB
30	21.50 ab	23.00 ab	24.25 a	22.92 A	20.25 abc	22.00 ab	24.00 a	22.08 A	15.00 ab	15.25 a	15.50 a	15.25 A
Mean of Nitrogen	20.25 A	18.63 A	20.69 A		18.19 A	17.81 A	19.56 A		14.50 A	13.44 A	13.50 A	

* In each column and row means followed by the same letter(s) (small letters for means and capital letters for means of rows and columns) are not significantly different using LSD test at 5% level.

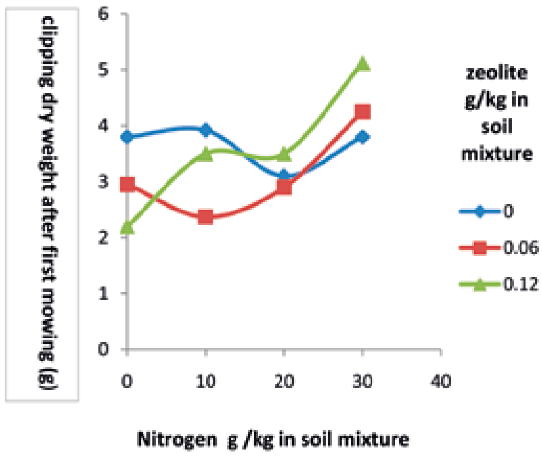

Fig. 2 - Effect of nitrogen and zeolite on clipping dry weight after first mowing (g) of *Festuca arundinaceae* Schreb'Starlet'.

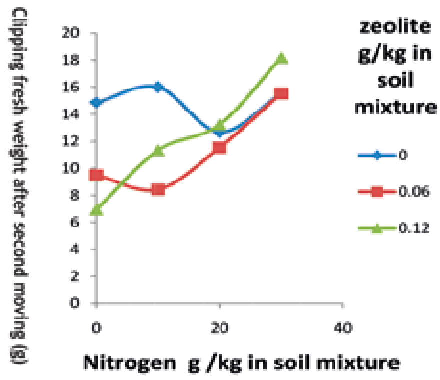

Fig. 3 - Effect of nitrogen and zeolite on clipping fresh weight after second mowing (g) of *Festuca arundinaceae* Schreb'Starlet'.

and dry weights of the clippings from the first, second, and third mowings. The means of zeolite had shown increase with increasing in zeolite content of soil mixture and this increase was significant only at 30 g kg^{-1} zeolite in soil mixture at fresh weight of clipping after all times of mowings. Also 30 g kg^{-1} zeolite in soil mixture had shown significant increase at dry weight of clipping after first and second times of mowings. The mean nitrogen content in the soil mixture had no significant effect on the fresh and dry weights of clippings for all mowing times (Figs. 1, 2, 3, 4, 5 and 6).

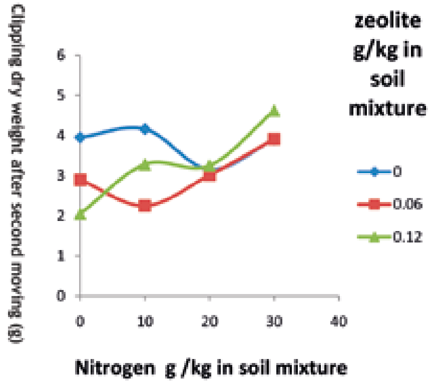

Fig. 4 - Effect of nitrogen and zeolite on clipping dry weight after second mowing (g) of *Festuca arundinaceae* Schreb'Starlet'.

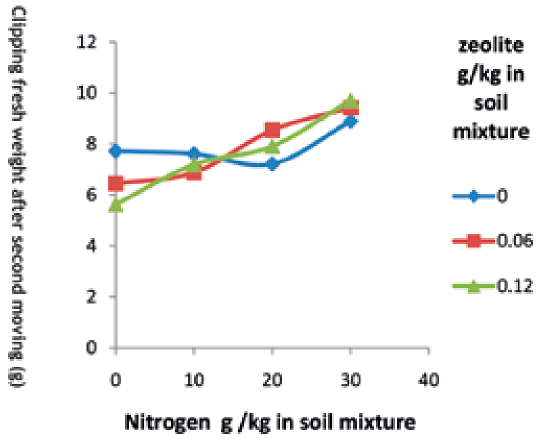

Fig. 5 - Effect of nitrogen and zeolite on clipping fresh weight after third mowing (g) of *Festuca arundinaceae* Schreb'Starlet'.

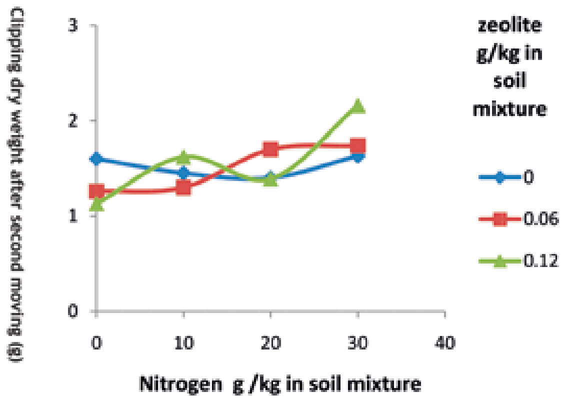

Fig. 6 - Effect of nitrogen and zeolite on clipping dry weight after third mowing (g) of *Festuca arundinaceae* Schreb'Starlet'

Chlorophyll and nitrogen content of clippings

With increasing nitrogen and zeolite in the soil mixture, the chlorophyll content of clippings decreased in most treatments but it was not significant when compared with control. Maximum chlorophyll content of clippings was found at 10 g/kg zeolite with 0.12 g/kg nitrogen in the soil mixture. The nitrogen content of clippings increased when zeolite and nitrogen increased in most treatments but this increase was not significant compared to control. Maximum nitrogen content of clippings was noted at 0 g/kg of zeolite and 0.12 g/kg of nitrogen in the soil mixture (Table 3).

Dry weight of roots

Results of this study indicate that by increasing the zeolite content alone in culture medium, the mean dry weight of roots (compared with control) increased but not significantly. An increase in the culture medium of nitrogen alone did not significantly effect the mean of root dry weight; with increasing nitrogen only, dry weight of roots decreased. However, adding nitrogen and zeolite together to the culture medium increased the dry weight of roots (Fig. 7).

Table 3 - Effect of nitrogen and zeolite on chlorophyll and nitrogen content of clippings of *Festuca arundinaceae* Schreb 'Starlet'

	Chlorophyll content of clipping			Means of zeolite	Nitrogen content of clipping			Means of zeolite
	Zeolite g·kg^{-1} soil mixture				Zeolite g·kg^{-1} soil mixture			
	0	0.06	0.12		0	0.06	0.12	
Nitrogen g kg^{-1} in soil mixture								
0	20.40 a*	17.47 a	19.60 a	19.16 A	01.12 ab	01.22 ab	03.36 a	01.90 A
10	13.85 a	14.78 a	20.86 a	16.50 A	01.49 ab	01.37 ab	01.45 ab	01.43 A
20	19.98 a	15.04 a	17.25 a	17.42 A	01.01 b	01.40 ab	00.925 b	01.11 A
30	14.89 a	16.55 a	13.22 a	14.89 A	01.12 ab	01.41 ab	01.79 ab	01.44 A
Means of Nitrogen	17.28 A	15.96 A	17.73 A		01.18 A	01.35 A	01.88 A	

* In each column and row means followed by the same letter(s) (small letters for means and capital letters for means of rows and columns) are not significantly different using LSD test at 5% level.

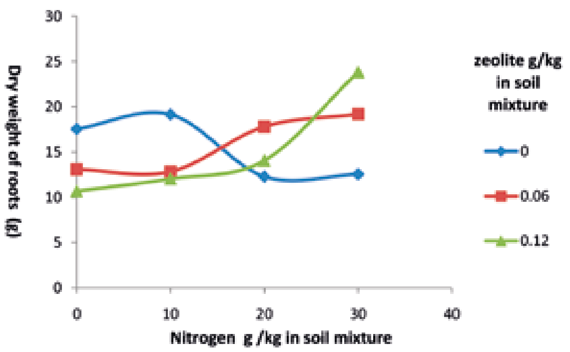

Fig. 7 - Effect of nitrogen and zeolite on clipping dry weight of roots (g) of *Festuca arundinaceae* Schreb'Starlet

4. Discussion and Conclusions

Application of zeolite and nitrogen to the culture medium increased the seedling height before all mowing times. Zeolite absorbs available N (NH_4^+) and releases it gradually to the medium for use by plants. Results of our study indicate that nitrogen alone did not increase seedling height but combined treatment with zeolite and nitrogen increased seedling height at most levels. The findings of the present study are in agreement with those of Hung and Petrovic (1995) who reported that the application of zeolite improved nitrogen efficiency in soil about 16 to 22%. Furthermore, zeolite reduced the leaching of ammonium and nitrate 86 to 99% from the soil. Zeolite, with a high cation exchange capacity (CEC), causes easy storage and release of nitrogen. Omar *et al.* (2011) reported that the application of peat soil water and zeolite with urea significantly increased dry matter, N, P, K uptake and use efficiency in maize plants compared with urea without additives. Our results are in accordance with those of Sepaskhah and Barzegar (2010) who showed that nitrogen and zeolite application resulted in higher grain protein contents in rice and nitrogen recovery efficiency. Also Aghaalikhani *et al.*, (2011) reported that amending soil with zeolite, reduced nitrogen leaching, increased canola yield and nitrogen use-efficiency by avoiding nitrogen leaching and improving soil physical properties so it may be a beneficial approach to decrease chemical fertilizer application rates and develop sustainable agriculture.

In the present study, where zeolite and nitrogen were applied to the soil mixture, the chlorophyll content of clippings decreased while the nitrogen content increased. Perhaps increased nitrogen resulted in a decrease of some elements and the amount of chlorophyll. Our results are in disagreement with Abdi *et al.* (2004) and Nazari *et al.* (2007) who reported that zeolite increases the chlorophyll content of strawberry and African marigold.

Since the application of zeolite and nitrogen, compared to nitrogen application alone, increased the fresh and dry weights of clippings, it can be concluded that natural zeolite with its high exchange capacity may absorb ammonium and release it slowly. These results are in agreement with Abdi *et al.* (2004) who reported that zeolite application increased shoot dry weight in strawberry. Therefore, zeolite balances the amount of nitrogen availability for plants and retards excess leaching of nitrate. In conclusion, natural zeolite as a slow-release compound may be recommended along with nitrogen for use in growth media to improve growth of tall fescue.

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