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Different Growth Responses of Native Turfgrass Accessions to Regulated Deficit Irrigation

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Abstract

Regulated deficit irrigation (RDI) is water-saving strategy under which crops are exposed to a certain level of water stress during a particular period. The objective of this study was to assess the response of native turfgrass accessions to different levels of RDI applied. This research project was conducted in a split-plot based on completely randomized experimental design with three replications. Water treatments (25, 50, 75, 100 % of RDI) were considered as main plot and turf grass types as subplot. We used native monoculture accessions, perennial ryegrass (*Lolium perenne* L. 'Shadegan') (LPS), Native low- variety Mixture (NM1): consisting 50% *Lolium multiflorum* 'Shadegan', 50% *Festuca* spp. 'Shadegan', Native high-variety Mixture (NM2): consisting 55% *Lolium perenne* L. 'Yarand', 35% *Lolium perenne* L. 'Shadegan', 5% *Lolium multiflorum* 'Shadegan' and 5% *Festuca* spp. 'Shadegan' in compared to one commercial turf mixture that commonly used in landscape. Results indicated LPS showed better response than other native and commercial mixture in all traits. LPS and NM2 could preserve more relative water content (RWC) or lower relative saturation deficit (RSD) than NM1 and CM. The values of RWC were lower in commercial mixture (CM) than native species. In the present work, deficit irrigation reduced growth parameter approximately to the imposed drought levels. There was no significant difference between levels of 50 and 75% RDI in all traits. These study results in more efficient use of native species to reduce costs of irrigation in urban landscape.

Keywords: native plants, drought, mixture, grass.

Introduction

Many research agencies, including the Plant Materials Center, have begun developing varieties with broader genetic bases. Varieties with broad genetic bases have two advantages. First, they may be more adaptable to a broader range of climate. Secondly, native genetic materials are potentially preserving this material for future generations (Pfaff, 2002). Therefore, native plants provide excellent choices for large commercial landscapes as well as residential gardens (Pessarakli and Kopec, 2008). These grasses are excellent candidate species for producing cultivars which have more attractiveness and require less maintenance to be used as a turf grass in arid and semi-arid regions of the world (Bormann et al., 2001).

Because of different growth patterns, a mixture of two or more grasses types may complement each other to provide both functional and aesthetic improvements in turf quality. The use of polycultures of native turfgrasses has not been extensively investigated (Simmon, 2011). But, there are several reports on the comparison and selection between different genotypes of turf grasses (Salehi and khosh-khui, 2004; Dunn et al., 1994; Newell et al., 1996; Skirde, 1989).

A significant amount of research in the past 15 to 20 years has focused on reducing costs in turfgrass, especially fertilizer and irrigation. In the point of view, breeding programs around the world have improved species and varieties to meet these needs (Johnson, 2003).

A lush green turf is a dream for every green keeper. Establishing and maintaining quality turf requires ensured supply of irrigation water which is the most important challenge worldwide (Alshehhi et al., 2010).

Drought stress is one of several environmental factors greatly limiting plant production and distribution worldwide. Previous studies have shown that drought stress can lead to water deficit in plant cells, inhibiting plant growth and development (xu et al., 2007).

Regulated deficit irrigation (RDI) is water-saving strategy under which crops are exposed to a certain level of water stress either during a particular period or throughout the whole growing season (Pereira et al., 2002; English and Raja, 1996). In arid and semi-arid areas, soil water deficit is rather frequent. Water saving irrigation strategies such as deficit irrigation may allow optimizing water productivity in such areas and improving quality (Costa, 2007). A number of studies have analyzed the economics of deficit irrigation in specific circumstances and have concluded that this technique can increase net income (English, 1990). The potential benefits of deficit irrigation derive from two factors; increased irrigation efficiency, reduced costs of irrigation.

Guttieri et al. (2001) reported two different water deficit regimes to screen out sixteen wheat varieties to find out the impact of moisture deficit on wheat growth and yield. Many studies have investigated adaptations of grasses to water stress (Blicker et al., 2003; Mohsenzade et al., 2006; Banuelous, 2010; Sammar Reza et al., 2012).

So, the objective of this study was to assess the responses of native turfgrass accessions to different levels of regulated deficit irrigation applied.

Material and Method

Experimental design and site description

This field experiment was performed at the experimental farm of the Department of Horticultural Science, Agricultural College, Ferdowsi University of Mashhad, Mashhad, Iran, in 2012 (59º 38′ E and 36º 16 ′ N; elevation 989 m; mean annual rainfall 255.2 mm). Climate is arid and semi- arid. Long term averages of maximum and minimum temperature are 22ºC and 8.9 ºC, respectively. This research project was conducted in a split-plot based on completely randomized experimental design with three replications. Water treatments (25, 50, 75, 100 percentages of regulated deficit irrigation) (RDI) were considered as main plot and turf grass types as subplot.

Plant material

Turf grasses were consisting:

1. Native monoculture: perennial ryegrass (*Lolium perenne* L. 'Shadegan'), which is native accession from Shadegan, in Esfahan province, Iran.
2. Native low-variety mixture (NM1): consisting 50% *Lolium multiflorum* 'Shadegan', 50% *Festuca* spp.'Shadegan'.
3. Native high-variety mixture (NM2): consisting 55% *Lolium perenne* L. 'Yarand', 35% *Lolium perenne* L. 'Shadegan', 5% *Lolium multiflorum* 'Shadegan' and 5% *Festuca* spp. 'Shadegan'.
4. Commercial mixture (NAk-Nederland): consisting 2% *Lolium perenne* BE, 33% *Lolium perenne* NL, 20% *Lolium perenne* DK, 35% *Poa pratensis* US and 10% *Festuca rubra* commutata FR.

Thus, turf grass treatments were abbreviated as *Lolium perenne* L. 'Shadegan'= LPS and seed mixtures of NM1, NM2 and Commercial mixture= CM.

Culture and Maintenance

Turf grass plots were established by directly sowing the seeds at autumn season in 2011. The rate of seedling was 25 g/m^{-2} for LPS, 28 g/m^{-2} for NM1, 33.5 g/m^{-2} for NM2 and CM according to seeds size and physical purity. The soil characteristics was loamy texture, pH= 7.21, cation exchange capacity of 6.6 meq/100 g, organic matter of 0.9%.

Plots were prepared after plowing and leveling the soil. The plots were hand sown in plots of 1.2 m^2 (1m×1.2m) and covered with a thin layer of leaf compost and manure. Irrigation was carried out daily (2 or 3 times a day) during establishment.

In summer Plants were under water stress for 42 days in the field. Irrigation timing was once every 2 days. Irrigation depths varied with daily reference evapotranspiration (ET_O). Evaporation pan was used to estimate ET_O; multiplying daily pan evaporation measurement by pan coefficient (K_p= 0.77 for the study area) yielded the reference evapotranspiration which equals to irrigation depth. All weed species, both grasses and forbs, were hand pulled during study.

Data collection

Turgrass can be qualitatively evaluated for drought stress through visual field assessments developed by the National Turf grass Evaluation Program (NTEP).

Color

Color was assessed using a visual score based on a 1–9 scale, as used in the National Turf grass Evaluation Program (NTEP) in the USA (Salehi and khosh-khui, 2004). The lowest level (1) defines very poor turf color (light green) and highest level (9) defines very ideal visual color (dark green).

Yellowed cover percentage

Percent Yellowed cover is based on surface area covered by the yellowed leaves. It is used to express damage caused by water stress. Yellowed cover Percentage was measured in during stress.

Texture and Quality after clipping

The visual rating of texture is based on 1 to 9 rating scale with 1 equaling coarse and 9 equaling fine. Quality after clipping have also evaluated using rated on 1 to 9 scale (1= poorest, 9= best quality).

RWC

The percentage of relative water content (RWC) was calculated according to Saini et al, (2001):

$$RWC\ (\%) = (\text{fresh weight} - \text{dry weight} / \text{turgid weight} - \text{dry weight}) \times 100$$

Relative Saturation Deficit (RSD)

Leaves were taken and then weighed immediately. Then at room temperature they were kept for 5 hours in test tube containing 25 ml of distilled water. The water was removed from the leaves surfaces and leaves were weighed again to obtain turgid weight (saturated weight). Relative saturation deficit was determined as follows (Sammar Raza et al., 2012):

$$RSD\ (\%) = \text{Saturated weight} - \text{Fresh weight} / \text{Saturated weight} \times 100$$

Growth parameter

Plant height and fresh and dry weight of plant was measured as growth parameters.

Statistical analysis

All data were subjected to analysis of variance (ANOVA) using JMP8 software. Where significant ($P<0.05$) treatment effects were determined by ANOVA, data means were separated by the LSD test.

Results

According to the data presented in the present study, significant differences among irrigation levels for color, yellowing leaves percentage and quality after clipping ($p<0.01$) (Table 1) and in the case of physiological parameter for RWC, RSD, height and fresh and dry weight were evident ($p<0.01$) (Table 2).

Significant different responses in all trails were observed between grass-types. Results indicated that Interaction of Irrigation levels and grass- types had significant effect on RWC and RSD ($p<0.01$) (Table 2).

Color and Yellowed cover percentage

Color and yellowed cover percentage of grasses were drastically affected under irrigation levels and turf-type ($p<0.01$) (Table 1). The poorest performance for color and highest yellowed cover was noted in accession NM1. There was no significant difference among other grasses (Table 3). With the development of the water stress, green color of grasses decreased and yellowed cover percentage increased (Fig 1a and b). In treatment of 100% RDI with average of 8.18 (1-9 scale) and 18.16% showed best color and lowest yellowed cover percentage, respectively. However, in 25% RDI, the average of 6.2 (1-9 scale) and 65.37% showed poorest color and most yellowed cover percentage (Fig 1a and b).

Texture

Variations between grass types were only obvious, irrigation treatments were not significant difference (Table 1). The most slender leaves were belonged to NM1 whereas the coarsest leaves attained in NM2 (Table 3).

Quality after clipping

Quality after clipping varied significantly depending on the irrigation levels and grass-type ($p< 0.01$) (Table 1). Mean quality after clipping was lowest in NM1 than other grasses; there was no significant difference among other grasses (Table 3). Figure 1c showed that the most severe water treatment (25% RDI) had poorest quality (mean= 5.7) (1-9 scale), and its average decreased 25.48% rather than 100% RDI. There was no significant difference among 50% and 75% RDI.

Relative water content (RWC)

The results of analysis of variance represented that effect of grass-type and irrigation levels and interaction effect was significant ($p<0.01$) on RWC (Table 2). Native accession of LPS and NM2 could preserve more water content than NM1 and commercial mixture of CM (Table 3). In this experiment, the water content (RWC) of leaf was decreased from 60.06% of 100% RDI to 51.50% of 25%RDI (Fig 1d).

Table 4 shows that the interaction affects of irrigation levels and grass-type. There was no significant difference between levels of 75% and 100% RDI for all grasses. The lowest water content (41.25%) was belonged to 25% RDI in NM1. The values of water content were lower in commercial mixture (CM) than native accessions.

Relative Saturation Deficit (RSD)

Table 2 shows results of main factors and interaction effects for RSD. These results show that all factors had considerable effect. According to figure 1e, there was a gradual increase in RSD with increasing water stress, while RSD was highest in most severe water stress (25% RDI). Among different turfgrasses in this experiment, commercial mixture (CM) had most relative saturation deficit and NM2 showed lowest value of it (Table 3). There is considerable variation among irrigation levels and grass-type for RSD (Fig 2). RSD values range varied from 17.04% to 47.41%. The commercial turf mixture CM showed higher amount of RSD than native accession of LPS and NM2 (Fig 2).

Growth parameters

Among plants exposed to deficit irrigation during the experiment, native accession of LPS showed highest value of plant height (20.03 cm) and fresh and dry weight (12.65 and 3.24 gr, respectively) and NM1 showed lowest plant height (14.07 cm), lowest fresh and dry weight among other grasses (6.06 and 2.02 gr, respectively) (Table 3).

There were significant differences in the plant growth of the grasses with different levels of irrigation. Deficit irrigation reduced plant height (Fig 1f) fresh and dry weight (Fig 1g and 1h) approximately to the imposed drought levels. The level of 100% RDI produced higher value of plant height (20.41 cm) and fresh and dry weight (12.01 and 3.13 gr), respectively. However, the plant height and fresh and dry weight of grasses were significantly inhibited only by the severe water treatment (25% RDI) compared with the other levels (Fig1f, g and h).

Table 1. Analysis of variance of irrigation levels and turfgrass types on visual quality.

Source	df	color	Yellowed cover (%)	texture	quality after clipping
Irrigation levels (RDI)	3	8.50 **	4707.73**	0.066	8.807**
Error a	8	0.71	405.1	0.160	0.648
Turfgrass (T)	3	7.39**	3851.60**	1.295**	5.706**
T*RDI	9	0.19 ns	75.01 ns	0.192	0.129
Error b	24	0.18	107.09	0.115	0.183

ns,**,* Non significant and significant of 1 and 5 percent of probability.

Table 2. Analysis of variance of irrigation levels and turfgrass types on physiological growth parameters.

Source	df	RWC	RSD	height of plant	Fresh weight	Dry weight
Irrigation levels (RDI)	3	282.96**	153.17*	126.35 **	82.22**	4.55**
Error a	8	57.16	45.57	14.87	21.24	1.13
Turfgrass (T)	3	428.28**	334.17**	36.22**	98.95**	3.13**
T*RDI	9	217.19**	172.06**	10.84	11.40	0.46
Error b	24	53.77	37.86	7.44	9.98	0.49

ns,**,* Non significant and significant of 1 and 5 percent of probability, respectively; RWC= relative water content, RSD= relative saturation deficit.

Table 3. Comparison between turfgrass types on visual quality assessment and physiological growth parameters.

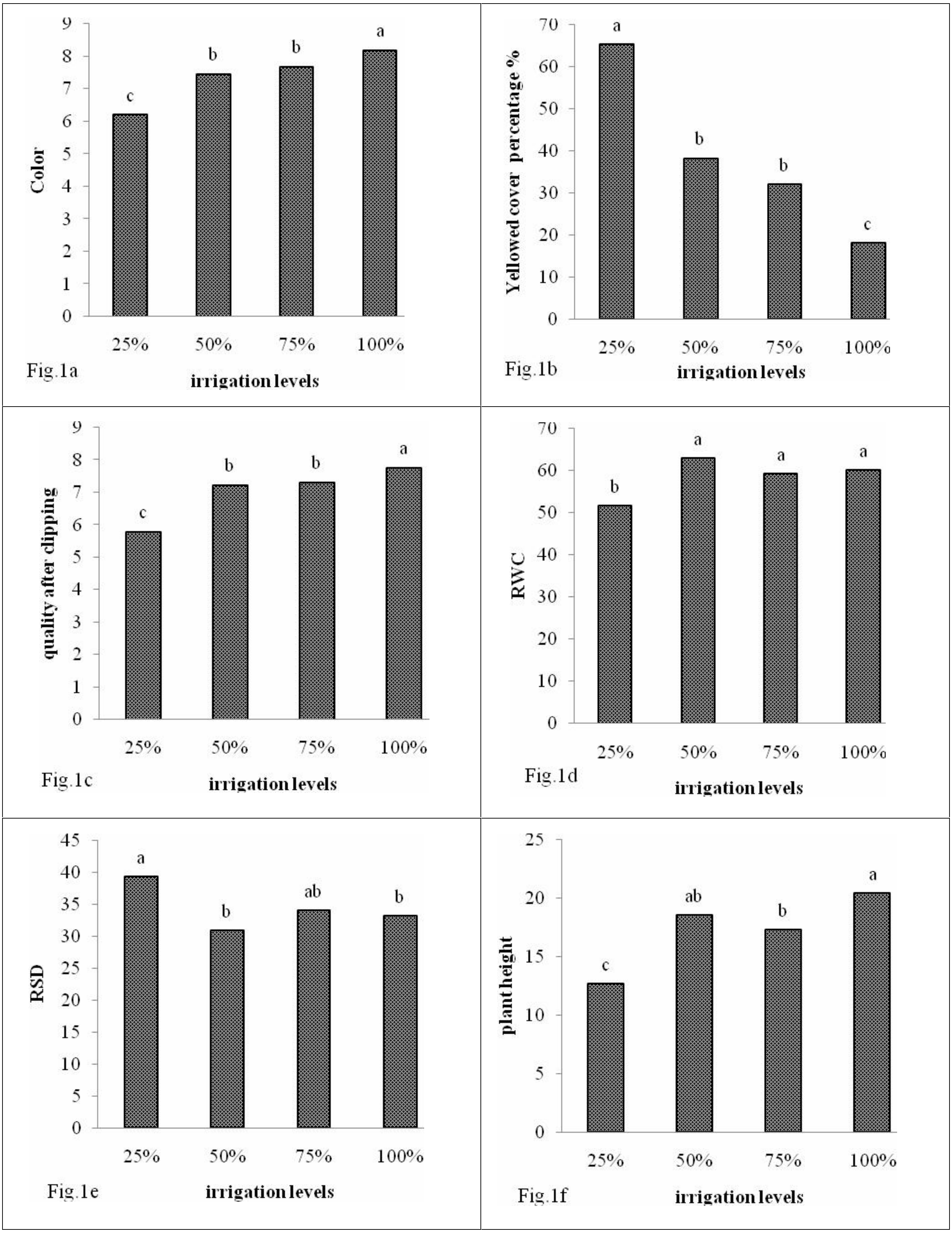
Turfgrass	color	Yellowed cover (%)	texture	quality after clipping	RWC	RSD	height of plant	Fresh weight	Dry weight
LPS	7.85 a	27.91 b	7.31bc	7.45 a	61.63a	31.87bc	20.03 a	12.65 a	3.24 a
NM1	6.22 b	65.16 a	7.95 a	6 b	55.22b	36.23ab	14.07 c	6.07 b	2.02 b
NM2	7.56 a	32.5 b	7.22 c	7.25 a	64.9 a	28.53 c	16.95 b	10.76 a	2.82 a
CM	7.89 a	28.31 b	7.58 b	7.39 a	51.75b	40.68 a	17.76 ab	11.39 a	2.84 a

Means in the same column followed by the same letter were not significantly different at the 5% level. LPS= *Lolium perenne* L. 'Shadegan', NM1= Native low-variety mixture, NM2= Native high-variety mixture, CM= Commercial mixture.

Table 4. Interaction effect of irrigation treatments and turfgrass-type on RWC

Irrigation levels	Turfgrass types			
	LPS	NM1	NM2	CM
25%	56.44 cdef	41.25 g	57.26cdef	51.07defg
50%	60.35 bcde	77.61 a	62.99 bcd	50.53 efg
75%	62.47 bcde	54.27def	67.82 abc	51.68defg
100%	67.27 abc	47.75fg	71.53 ab	53.71 def

Means in the same column followed by the same letter were not significantly different at the 5% level.


Color
25%
50%
75%
100%
c
b
b
a
Fig.1a
irrigation levels
Yellowed cover percentage %
a
b
b
c
Fig.1b
irrigation levels
quality after clipping
c
b
b
a
Fig.1c
irrigation levels
RWC
b
a
a
a
Fig.1d
irrigation levels
RSD
a
b
ab
b
Fig.1e
irrigation levels
plant height
c
ab
b
a
Fig.1f
irrigation levels

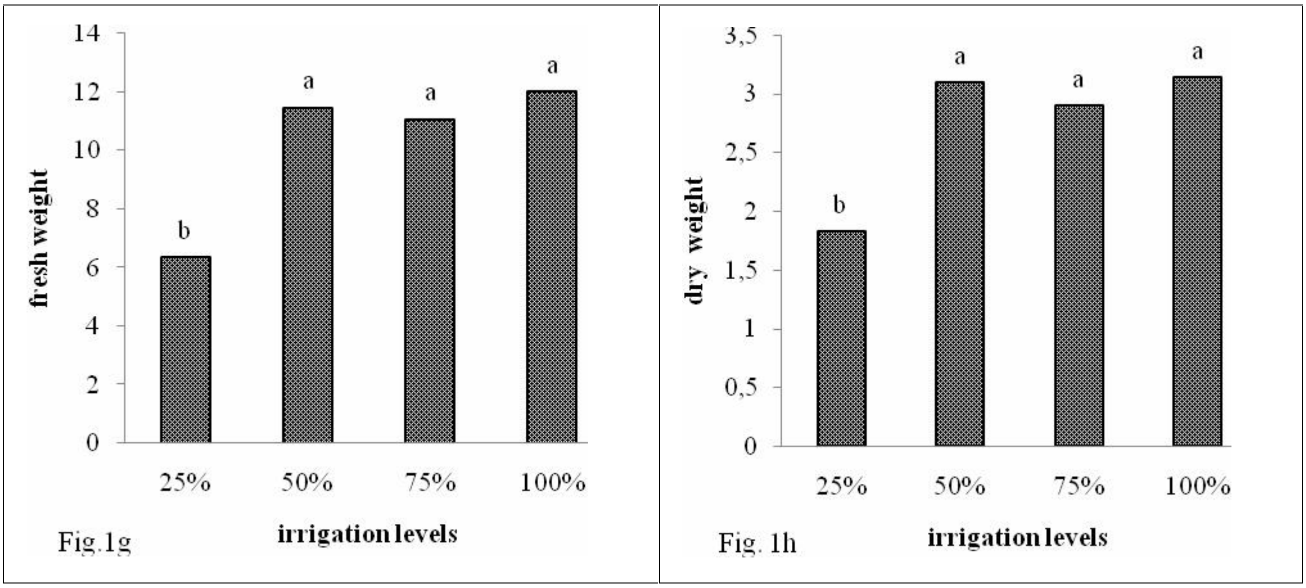


Figure1. The effects of irrigation levels on a) color, b) yellowed color percentage, c) quality after clipping, d) RWC, e) RSD, f) plant height, g) fresh weight, h) dry weight, in each fig, means with the same letter were not significantly different at the 5% level.

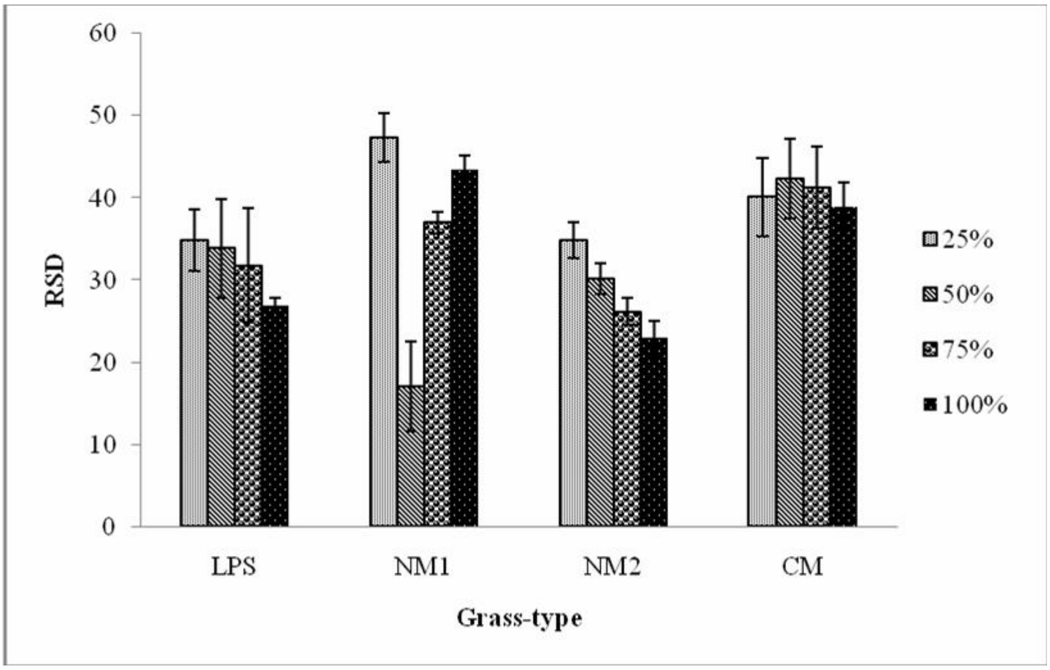


Figure2. Interaction effect of irrigation levels and turf grass types on RSD, LPS= *Lolium perenne* L. ‘Shadegan’, NM1= Native low-variety mixture, NM2= Native high-variety mixture, CM= Commercial mixture turf. Error bars represent± standard error.

Discussion

Drought, due to its osmotic effect in natural habitats can induce a wide number of responses such as growth inhibition and increase the osmotic potential of the cell plants (Turkan et al., 2005). In the present work, data showed different response among species. Native accession of LPS showed better response than other native and commercial mixture in all measured traits (Table 3). These results are in a good agreement with the result of Ritchie et al. (1990), Fu et al. (2004) and Rhman et al. (1996) that variation of adaptive mechanisms exists in different species. The results presented indicated the differences among irrigation levels for quality traits (color, yellowed cover percentage and quality after clipping). The results confirm the report of Fu et al. (2004), Banuelos (2010) and Sanchez-Blanco et al. (2009), where they found water stress decreases turf quality. Also, Sanchez-Blanco et al. (2009) reported that quality decline and increase in yellowed leaves in water stress condition.

Relative water content is one of the important physiological parameter in assessing water stress. The capacity of LPS and NM2 to maintain higher leaf RWC than CM and NM1 under water stress may be attributed to its ability to postpone dehydration. Significant difference had been reported between cultivars.

Resistant cultivars maintain high RWC than sensitive ones (Ritchie et al, 1990). It was found by several researches that reductions in RWC of the leaf by creating water stress (Sammar Reza et al., 2012; Mohsenzade et al., 2006; Bandurska and Gniazdowska- Skoczek, 1995).

We found the higher RWC or lower RSD in LPS and NM2 than NM1 and CM. RSD (relative saturation deficit) and RWC (relative water contents) of varieties under drought stress conditions indicated that varieties with lower RSD or higher RWC are more drought resistant. The similar results were also obtained by Sammar Reza et al. (2012). According to these results may be drought tolerant varieties have a smaller water deficit (relative saturation deficit) per unit decrease in water potential of leaf than drought sensitive plants.

In the present work, deficit irrigation reduced growth parameter approximately to the imposed drought level (Fig1 f, g and h). Shoot growth responses to drought stress include reduced clipping production, verdure, shoot density, and color was reported by Huang et al. (1997). The most common damaging effects of low moisture level or low water potential are the decline in fresh and dry matter production (Banuelos, 2010) and height plant (Sanchez-Blanco et al., 2009). This decreased may be was due to reduction in photosynthesis production under water deficit conditions. Similar findings were resulted by Ashraf and Yasmin (1995) in grasses.

Conclusions

LPS as a native turf could completely compete with commercial mixture for both measured quality and physiological traits under water stress. We recommend it to use in urban landscape. The native turf mixture of NM2 showed several good characteristic and preference to native mixture of NM1. These study results in more efficient use of native species in urban landscape with lower levels of irrigation.

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