DESERT

Desert
Online at http://desert.ut.ac.ir

Desert 20-2 (2015) 217-230

Investigating strategies for optimum water usage in green spaces covered with lawn

S.M. Rabbani KheirKhah, F. Kazemi*

Department of Horticulture and Landscape, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran

Received: 5 May 2015; Received in revised form: 3 August 2015; Accepted: 13 September 2015

Abstract

Water supply of green spaces in arid areas is a major challenge. A high percentage of green spaces create lawns, which are high water consumer landscapes. Due to the environmental, recreational and athletic values of lawns, they are considered as non-removable elements in urban green space development. This paper reviews and discusses strategies for efficient water usage in lawn areas using library study methods. According to the results, first, it was recommended that water demands of turfgrasses are calculated using precise scientific methods. Eleven strategies including selecting appropriate plant species, clipping from appropriate height, removing the thatch layer, using wastewater as an irrigation water source, the use of superabsorbents, application of regulated deficit irrigation, the use of subsurface irrigation systems, replacement of lawns with appropriate ground cover plants, the use of surfactants and other chemicals such as paclobutrazol and endophyte fungi, as individual or combined strategies were suggested for efficient water usage in turfgrass areas. These results, in some cases, can be used as executive guidelines by green space professionals in order to reduce water usage in this sector and in other cases, they can be used as preliminary studies for research in the field of sustainable management of turfgrasses in arid and semi-arid areas.

Keywords: Efficient water usage; Turfgrass; Arid areas; Lawn; Green space

1. Introduction

Urban green spaces are part of open spaces with natural or artificial arenas in the urban area covered by trees, flowers, turfgrasses or other plants (Pasban *et al*., 2014). The importance of green spaces, such as reduction of air pollutions, sound pollutions, positive impact on human mental health, reduction of violence in societies, mitigating urban heat islands, decreasing urban run offs by reducing hard surfaces and controlling soil erosion in urban spaces, has been discussed greatly (Ruhani, 1993).

Standard for green spaces per capita in the world is between 5 and 50 m^2. This standard is defined as 30 m^2 in Iran. However, none of the large cities of Iran has the possibility to develop green spaces according to the global standards. Shortage of water resources is one of the major limiting factors in developing green spaces in Iran (Ruhollahi *et al*., 2008). One of the important components forming urban green spaces is turfgrasses. According to the surveys conducted in 1977, turfgrasses have covered more than 20 million hectares of the public lands around the world (sport grounds, parks, etc.) (Ansari, 2012).

Kafi (2003) listed the importance of turfgrasses in human daily life in three aspects: first, its

* Corresponding author. Tel.: +98 915 5503742
Fax: +98 51 38787430.
E-mail address: fatemeh.kazemi@um.ac.ir

performance in improving environmental conditions; second, its role in recreational and sport activities, and finally, its ornamental role. However, playing these roles and functions are only achievable if enough water is supplied for lawn cultivation. Water contains an average of 80% of the turfgrass weight; obviously, this amount can vary depending on the type and variety of lawn, lawn planting density and location, and its climate conditions. Stems, leaves and roots in turfgrass species have the maximum amount of water, respectively. Reducing a certain amount of water in different parts of turfgrasses leads to plant wilting and eventual death. Ansari (2012) while explaining the role of water in turfgrass physiology, added that water with carbon dioxide and energy is needed for the photosynthesis processes in lawns. Water is involved as a solvent or catalyst in metabolic reactions of living cells. Specific heat capacity of water in plant cells can help to adjust temperature changes in the protoplasm. This feature in turn leads to the protection of the grass against sudden temperature fluctuations. Water also plays an important role in cells inflammation and leaving the stomatas open, thus gases exchanging. The cellular inflammation can also increase tolerance of grasses to footing.

The amount of water consumption in most lawns is between 25 and 75 mm/day compared to many other plant species that commonly considered high consumption of water. Factors, such as the amount of evaporation and respiration, growth season duration, the grass variety, planting density, footing intensity, soil type, rainfall amount and available are the main factors affecting water consumption of turfgrasses (Alami, 2011; Birad, 1973).

Efficient management is required to ensure high quality turfgrasses. Efficient management of turfgrasses includes adequate and timely irrigation and fertilization, dethatching, and top dressing, among which supplying enough irrigation water is the most important management tool. In Iran, agriculture and green spaces are the major consumers of water resources to the extent that if existing varieties are maintained, about 90% of the consumed water is used in these two sectors and the highest water losses are related to these sectors in Iran (Haghayeghi, 2004). Iran is located in the northern hemisphere between latitudes of 25 and 40 northern degrees and 44 and 63 eastern degrees, and is located in one of the driest regions of the world. Average rainfall in this country is 252 mm which is equivalent to a third of the average world rainfall. This is the reason why about 179 mm (71%) of low rainfall amount in the country is evaporated directly, due to the high evapotranspiration potential in the country (15000 to 20000 mm). Therefore, critical water shortage in this country should be taken into consideration (Ansari, 2012). Some studies have been conducted by previous researchers about efficient water usage in urban landscaping. For example, Safari and Kazemi (2014) examined the effect of using non-living mulches and their environmental benefits, such as water consumption reduction in urban green spaces. In other studies, Kazemi *et al.* (2005) introduced the concept of xeriscaping and its principles and Kazemi (2014) introduced the concept of water sensitive urban design for efficient management of urban water in order to use them in green spaces. This study follows previous research work by Kazemi *et al*. (2009a, 2009b, 2010b, 2011) in Australia in relation to this concept. Also, Kazemi and Beecham (2008, 2007) in another article discussed the experiences of Australians and their methods of planning and efficient management of water use in arid regions of this country. The employed strategies in urban areas, included water harvesting, reuse of treated wastewater, drip irrigation, night irrigation, the use of mulch, reduction in planting areas of grass in gardens and green spaces, public education, public participation and the most important factor, is correct choice of appropriate native plants. According to these guidelines, the authors raised guidelines for the efficient use of water in arid regions of Iran. In spite of all these studies conducted so far, yet the optimization of water usage in green spaces especially those covered with lawns face different challenges and require further research work. This article at first briefly explains the methods needed to determine water need in lawns and then discusses and studies the proposed strategies for reducing water consumption in lawn spaces.

2. Materials and Methods

This research was conducted in the format of a library research and it reviews published literatures that have passed the process of refereeing before publishing. Thus, the major studied sources include scientific-research papers and arbitrated journals or books at least in one of the Persian or English languages.

3. Results and Discussion

3.1. Determination of water demand

According to Vaziri *et al*. (2009), the water requirements to compensate plant evapotranspiration losses in cultivated lands is called water requirement. One of the important steps in proper consumption of water resources used in landscaping is accurate estimates of water required by plants. If this estimation is not correctly conducted, it may cause loss of water, not achieving proper performance and decrease in production potential. It can also make soil resources to be destroyed, because of excessive irrigation. It may also lead to water logging and/or lack of enough leaching and soils salinating, and these will in turn ultimately undermine sustainable development of agriculture and green space (Minayee, 2000). It should be noted that the issue of crop water requirement and irrigation water requirement should not be confused with each other. It should be noted that without calculation of crop water requirements, the estimation of irrigation water requirements will not be possible. Nouri *et al*. (2013a, 2013b, 2013c) performed extensive studies on the best ways to measure water requirement of public green spaces.

Various methods have been used to determine water requirement of turfgrasses. Rana and Katerji (2000) methods of determining crop water requirements are as follows:

1. The methods for measuring evapotranspiration (ET)

1.1. Hydrological methods including (1) soil water balance, (2) weight lysimeters

1.2. Micrometerological methods including (1) the energy balance and Bowen ratio, (2) streamlined procedures, (3) Eddy covariance

1.3. Plant physiological methods including (1) sap flow method, (2) room system

2. Methods of estimating evapotranspiration

2.1. Analytical model of evapotranspiration (Penman-Monteith model),

2.2. Models based on the product coefficient,

2.3. Methods based on modeling soil-water balance.

In terms of choosing the best method to estimate grass water requirement, many studies have been conducted. For example, in a study conducted by Rahim (1996), several computational methods for estimating evapotranspiration potential of reference crop were compared with lysimeteric method and finally Jensen Hayes's method was introduced as the most appropriate method (Panahi, 2009). Romero and Duker (2009) in their study declared a common method for measuring evapotranspiration of lawns by using a mini-lysimeter and suggested the calculation of reference evapotranspiration using different Penman equations as the most common measuring method.

Ruhani and Hedayat (2011) calculated and reported water requirement of warm grasses in Zahedan with an average value of 7.63 mm/day by using weight lysimeters. This average value had little difference with evapotranspiration amount of reference grass measured by Penman-Monteith method. Shariati (1994) also studied the amount of turfgrass evapotranspiration as reference crop by lysimeters for four years and reported the amount of 1390 mm for a seven-month period (Sharifi Ashoorabadi *et al*., 2012). Tovey *et al*. (1969) in their study measured evapotranspiration of two cultivars of Bermuda grass (*Cynodon dactylon*) in summer using drainage lysimeters methods. Zhang *et al*. (2007) measured evapotranspiration of three varieties of cold turfgrasses and three varieties of warm grasses by using lysimeteric method (Ruhani and Hedayat, 2011). An experiment was conducted by Atkin *et al*. (1991) to determine evapotranspiration rate and growth characteristics of 10 genotypes of St. Augustine grass. The result showed that evapotranspiration rate in September 1985 (0.21 inch/day) was lower than the rate in August 1986 and September 1987 (0.51 inch/day), respectively. Evapotranspiration rates in this experiment were estimated by soil-water balance method in controlled room and in a farm. This experiment showed that the effect of variety on plant evapotranspiration rate and leaf expansion in chamber was remarkable.

3.2. Strategies to reduce water consumption of turfgrass species

3.2.1. Selection of appropriate plant species

One of the most effective strategies to reduce water consumption in turfgrass species is to select varieties and cultivars that adapted to climatic conditions of the region (Christians and Engelke, 1994). Some turfgrasses native to arid regions due to their high plant density and drought resistance are appropriate selections as turfgrass species (Saeedipooya, 2014). To reduce water consumption of turfgrasses, selected turfgrasses should have a strong and long root system to be able to reach deeper penetrated water in the soil.

In terms of plant species diversity to be resistant to drought, Iran has the richest germplasm of the world and Geramineae family in this term has a high diversity. It should be noted that different plant varieties have different water needs. For example, Bufalo grass can tolerate very dry conditions without irrigation, while cool season grasses need significant amount of irrigation to survive (Christians, 2013).

Kim and Brid (1988) examined evapotranspiration rate of a number of warm and cool season grasses. The result showed that the difference in evapotranspiration of different turfgrasses was related to the difference in their morphological characteristics, such as stem density, leaf number per unit area, leaf orientation and vertical development of the leaves. In another experiment conducted, Feldhak *et al*. (1983) used weight lysimeters to measure evapotranspiration of cool and warm season grasses under different nitrogen fertilization rates and different lawn clipping heights. The results showed that Meryon Kentucky bluegrass cultivars and ryegrass consumed 20% more water than Tifway Bermuda grass and Buffalo grass cultivars as warm season grasses and they had 6% reduced evapotranspiration rate in clay soil.

3.2.2. Lawn clipping height

Some people believe that under stress conditions, lawns should be clipped from a lower height, because when having less plant biomass, evapotranspiration rate and water losses of the lawn will be reduced. On the other hand, there are positive correlations between the amount of rooting system and above ground plant green tissue photosynthesis and carbohydrate production rate of the plants. Reducing lawn height by clipping may decrease carbohydrate production. This can create a weak root system with a less efficiency in absorbing water from the soil. As a result, clipping from high heights in times of stresses causes larger root systems and absorb moisture from a larger volume of soil. Increasing the clipping height may cause a thick covering canopy, which in turn may slow down the air flow and reduce evapotranspiration (Howell, 1996).

3.2.3. Removing thatch layer

Thatch layer or straw is the dead or alive parts of the stems, leaves, roots, rhizomes and grass pickets formed between the surface layer of the soil and the surface part of the grasses (Nouri *et al*., 2009). The layer is formed in grasses with a prostrate growth habit, such as Bermuda grass, St. Augustine, Agrostis, Zoysia and Poa (Fallahian, 2004; Kafi and Kaviani, 2003; Nouri *et al*., 2009). Of its positive effects, reduced evaporation, reduced sudden changes in soil temperature and increased elasticity of the turf grasses can be noted (Harivandi, 2004; Nouri *et al*., 2009).

Thatch layer in lawn bed can reduce water use efficiency in a number of ways. This generally acts as a barrier against water penetration in the soil and it can cause an increase in the surface runoff and evaporation. This layer also contributes to the surface rooting of the grass and efficiency of the plant will be decreased when water penetrates deep into the soil. To solve the problems and also to prevent the spread of diseases and insects, operation of aeration and removing the thatch layer can be effective (Nouri *et al*., 2009). Of the methods to struggle with thatch, the methods of mechanical control increased the activity of the soil microorganisms and proper nutrition with nitrogen fertilizers can be stated (Nouri *et al*., 2009). Aeration time should be set to avoid stress periods. For cool season grasses, late summer to early fall are recommended as the best time for aeration. Early growth season and before mid-summer is the best time for aeration of warm season grasses.

Schlossberg *et al*. (2008) stated that by aeration in turfgrasses sensitive to thatch, the problem of water infiltration is partly solved, but it is not an effective method to remove this layer. Nouri Imam Zadeyee *et al*. (2011) conducted a trial to evaluate the effect of aeration and top dressing on cumulative infiltration and final infiltration rate of the soil on Lolium grass. Treatments consisted of three levels of aeration (without aeration, creating holes in sizes of 5×5 and 5×10) and two levels of top dressing (with or without top dressing). The results showed that aeration treatments with top dressing increased 286% in cumulative infiltration and decreased basic infiltration rate as compared to the control treatment. In fact, aeration increases soil permeability and top dressing increases its durability.

3.2.4. Using wastewater

The term wastewater means the output water from any process (Mohammadi *et al*., without year). This process can be an industrial or refining process. In the world, using alternative water sources for a long time for irrigation of different types of green spaces, like green roofs and vertical gardens, have become very popular (Hassanli and Kazemi, 2012a, 2012b; Kazemi *et al*., 2013; Razzaghmanesh *et al*., 2014a, 2014b). In fact, waste water is an available source and close to the consumer (Malekian *et al*., 2009; Saadat *et al*., 2008), valuable in terms of nutrients needed for plants (Malekian *et al*., 2009; Saadat *et al*., 2008; Shooshtarian and Tehranifar, 2011; Soroush *et al*., 2009), and it is possible to replace it with potable water if its pollutants are controlled efficiently (Bliss *et al*., 2008; Shooshtarian and Tehranifar, 2011).

The amount of wastewater produced from each liter of drinking water is over 75%. As such considering the high population of citizens in the world and their water consumption, it can be deduced that this water source can be used by proper planning to fit for various purposes (Shooshtarian and Tehranifar, 2011). Since ornamental plants, such as grasses, are not edible plants, the use of wastewater as their irrigation water supply source raises less public concern as compared to using this water source of irrigation for productive plants (Soroush *et al*., 2009). Wastewater can also provide a large amount of grass requirements to nutrient elements, such as phosphorus, nitrogen, potassium and micronutrients. In addition, physiological characteristics of turfgrasses usually assist them to handle hazardous effects of wastewater (Soroush *et al*., 2009). In most cases, wastewater after advanced and secondary refining processes is suitable for irrigation of turfgrass (Harivandi, 1982). In some cases, toxicity can be created due to accumulation of elements, like chlorine, boron, copper, cadmium, nickel, and zinc. If irrigated plant with wastewater is turfgrass, then it is more tolerant to toxicity than other plants due to its continuous clipping. However, there are concerns about exposure of people to contaminants when they have direct contact with turfgrasss, while there are methods to reduce this concern. In a study, Oron *et al*. (1999) introduced subsurface drip irrigation system as an alternative to surface drip irrigation system when irrigation was undertaken by wastewater. In this method, biological contaminants on the surface soil and direct contact of people with the contaminants became less. The results of Najafi (2008) showed that firstly, filtration of drip irrigation is significantly effective in reducing biological pollutants. Secondly, the gradual injection of wastewater into the subsurface of the soil through subsurface drip irrigation can be effective in reducing biological pollutants from the soil and plant top tissues.

Soroush *et al*. (2009) examined the effect of irrigation with wastewater on characteristics of Zoysia grass in various soil textures. The use of effluent increased the height and dry weight of the turfgrass and improved its color. Mortram (2003) in his study conducted on irrigation of lawn with effluent concluded that Festuca and Agrostis grasses showed darker color than the control species at the beginning of effluent application. At the end of the experiment, the height and yield of turfgrasses irrigated with wastewater were significantly more than that in the control plants. However, salinity of the wastewater caused bud burning at the end of the experiment. Malekian *et al*. (1384), in a trial was administered to evaluate the impact of wastewater on characteristics of Bermuda grass with two irrigation methods (surface and subsurface systems) and two water quality (wastewater and well water). It showed that irrigation with wastewater increased the height, yield and phosphorus and potassium absorption in lawns as compared to well water, while irrigation method had no effect on any of these factors. Therefore, the use of wastewater for irrigation of lawns can be an effective way for consumption of wastewater and most importantly, reduce the consumption of potable water for irrigation of green spaces.

3.2.5. Using superabsorbents

Superabsorbents are substances that will be able to attract large quantities of rainfall and irrigation water for plant use and prevent their non-accessibility due to deep percolation in the soil in dry conditions of the soil. Therefore, it prevents drought stress on plants. Sometimes, these materials absorb water up to 400 times of their weight mass (Moradi *et al*., 2011). Absorbing water quickly and keeping it by superabsorbents increases the efficiency of water absorption from rainfall and irrigation and it can reduce irrigation intervals (Ellahedadi *et al*., 2005). The beginning of studies on superabsorbents dates back to 1980. In early 2000, wider research, especially in arid regions of the world, such as Africa, South America, Middle East and some Far East regions was conducted (Sarafrazi *et al*., 2012).

The advantages of using superabsorbents include increasing productivity coefficient of agricultural water (Sheykh Moradi *et al*., 2011), stability of soil structure and increasing water infiltration into the soil and reducing soil erosion (Lentz *et al.*, 1998; Sarafrazi *et al*., 2012), increasing germination strength and plant performance (Jahan *et al*., 2014), reducing evaporation from the soil surface and increasing cultivation level of crops (Beygi, 2013) and increasing irrigation intervals (Abedi Koohpayee and Assdkazmi, 2006; Dasht Bozorg *et al*., 2014; Zanguyinasab *et al*., 2013). The disadvantages include creating sensitivity and environmental pollution, reducing soil air by filling the empty spaces of the soil (Beygi, 2013) and their high cost.

Sheykh Moradi *et al*. (2011) conducted a study on sport turfgrasses to evaluate the effect of irrigation round and a superabsorbent polymer on qualitative characteristics of the turfgrasses. The results showed that applying 30 to 35 g superabsorbent together with an irrigation interval of two days preserved the quality characteristics of the lawn appropriately, but with long irrigation intervals, yellowing and wilting appeared in the lawns with no superabsorbents being applied in their media and only treatments in which superabsorbents had been applied obtained their freshness after irrigation.

In another research by Nazarli *et al*. (2010), the highest amount of superabsorbent was shown to have the best effect in all levels of water stress on characteristics like usable water, weight of thousand seeds, seed performance, morphological characteristics and the chlorophyll amount in sunflower plants. Sarfarazi *et al*. (2012) performed a test to examine the volume moisture changes of soil and water potential of the soil of turfgrasses by applying different quantities of superabsorbent polymer, potassium amide acrile. The results revealed that in treatments containing polymer, water consumption was saved up to 75% when compared with the control treatments.

Yasuda *et al*. (1998) found out that zeolite in addition to increasing water-holding capacity, acts as moderator of salinity for plants that are irrigated with saline water, after running an experiment to determine the effect of zeolite on controlling water and soil salinity. A ten-year study on protection of the sloped areas of rocky mountains in America with an annual rainfall of about 500 to 550 mm indicated that superabsorbents could control about 65% erosion level in these areas. These materials were added to the soil in steep area and after establishment of native plants in the area, organic matter content of the soil was increased about 2.3%. Savings in irrigation water of the plants in the region was recorded to be an average of 50% (Karimi *et al*., 2009). Karimi *et al*. (2009) examined the effect of superabsorbent (Igeta) on plant growth, wilting condition, possibility of survival, ability of holding and absorbing moisture in the soil, irrigation interval and the amount of consumed water on sunflower in three soil textures of clay, loam and sand. The results show that: (1) adding this material to the soil caused an increase in soil volume and changes in the solid, liquid and gas phases of the soil; (2) uptaking nitrogen, phosphorus and potassium was increased; (3) water holding capacity and available water for plants irrigation interval were increased; (4) wilting time of plants was delayed.

Abedi and Sohrab (2005) studied the effect of four usage levels (2, 4, 6 and 8 g/kg) of Zeolite and Bentonite on three soil types (light, medium and heavy) on moisture characteristics of the soils. The results showed that the use of these inorganic materials will improve soil structure due to an increased adherence of the soil particles especially in light texture soils. The volume percentage of residual saturation moisture and residual moisture of the soil increased. Alami *et al*. (2011) also examined the effect of superabsorbent, paclobutrazol and irrigation intervals, in climate conditions of Mashhad, on quantitative and qualitative characteristics of the turfgrass (*Loliumperenne* 'Barbal'). The results showed that the best density of the turfgrass was achieved when 6 g/kg of superabsorbents was applied. Also, color quality, density and chlorophyll content of the turfgrasses that received superabsorbents were increased to 33, 42 and 48% compared to the control species, respectively. In general, the use of 6 g/kg superabsorbent with paclobutrazol is effective in achieving high quality turfgrass with less water consumption.

Xiubin and Zhanbin (2001) concluded that zeolite in soil can increase soil moisture from 0.4 to 1.8% in very dry conditions and increase it from 5 to 10% in regular conditions. Also, Piper *et al*. (1982) reported that increasing 10% zeolite to washed sand increased germination and establishment of the turfgrass as compared to using sand as controlled growing medium.

Materials used as soil modifier and those which increased the water holding capacity of the soil, can be divided into the following three groups: (a) plant materials, such as sawdust, wood chips, leaves, peat and mucilage; (b) mineral materials, such as perlite, kaolin, peat, bentonite, diatomite, gypsum leca and zeolite; (c) organic materials such as synthetic mulches and polymers, hydro plus and Igeta.

In most cases, superabsorbent materials last in the soil for other plants between 4 and 6 years. However, in case of turfgrasses, the time is reduced to 2 years due to repeated clipping of the lawn and its high elasticity (Glory, 2011). However, irrigation methods also affect durability of the polymers (Terry and Nelson, 1986). The use of 6 g/m^2 of polymer potassium acrylamide can reduce water consumption of turfgrass from 15 to 40% (Glory, 2011). Therefore, according to these guidelines and type of the soil and climate of the region, compatible and accessible superabsorbents can be used to guarantee reduction in water consumption of the turfgrasses.

3.2.6. Regulated deficit irrigation

In irrigation management, deficit irrigation is a method by which severe damage cannot happen to the plants as a result of drought stress; some amount of irrigation water can also be saved (Ansari, 2011; Salemi *et al*., 2006). In conditions when water sources are limited, using less water, reducing irrigation costs, especially in pressurized irrigation systems (costs of investment, maintenance and operation) and also the efficiency of water usage raises should also be taken into consideration (Sepahkhah *et al*., 2007). In a study by Da Costa and Huang (2004), appropriate use of deficit irrigation reduces the amount of water consumption or irrigation intervals and also led to an increase in the efficiency of water consumption in lawns and a decrease in total water consumption for *Agrostis stolonifera*, *Agrostis capillaries*, *Agrostis canina* in summer months. Irrigation with 60% evapotranspiration rate of the reference plant was not associated with a loss in quality and physiological characteristics of these turfgrasses.

Gybolet *et al*. (1985) observed that by applying deficit irrigation with 80% rate for reference evapotranspiration of sport turfs, turf quality characteristics were not significantly damaged. Ferry and Butler (1983) in a study on Tall Fescue grass (*Festuca arundinacea*) observed that when irrigation was applied up to 50% rate of reference evapotranspiration with irrigation interval of two days, a slight reduction was seen in visual quality of lawns. Similarly, in a study by Bastug and Bayoktas (2003), which was undertaken on a mixed turfgrass under different drought stress regimes, it was observed that the color of the turfgrass was not affected by different irrigation regimes. In line with these studies, Alami *et al*. (2011) studied the irrigation intervals on *Lolium perenne*. The results showed that an increase in irrigation interval from two days to six days significantly reduced the relative water content of the leaves.

3.2.7. Subsurface irrigation system

Improving irrigation management programs and irrigation systems are the two important factors that have considerable impacts in enhancing the efficiency of water usage in agriculture and green spaces (Najafi, 2007). Currently, sprinkle irrigation at the best case is a usual irrigation system in lawns which has disadvantages, such as high evaporation in arid areas. To overcome this water loss, the method of subsurface irrigation, where the emitters are placed below the soil surface, can be used. The use of subsurface irrigation system as compared to sprinkler irrigation systems has advantages, such as reducing water evaporation from the soil surface and possibility for irrigation with lower quality of water resources (Naseri and Pour Abbas, 2006), and also possibility of irrigation only in root zone. Subsurface irrigation is applied in different plantings, such as vegetables, fruits, green spaces and lawn areas (Naseri and Pour Abbas, 2006). This method was first introduced in California in 1359 (Najafi, 2007). The restriction of roots in the soil surface can be its disadvantage.

3.2.8. Replacing turfgrasses with groundcover plants

Considering that a very large area of the world is located in arid and semiarid regions, meaningful strategies for water efficient landscape design of these areas is essential. The so-called building dry landscape (Xeriscpae) was stated by urban planners in America in 1980s due to shortage of water resources and from that time onward, in many other areas of the world, including Iran, distribution of the concept was increased (Kazemi and Beecham, 2007, 2008; Kazemi *et al*., 2005). Dry landscaping by definition means a method of landscaping based on seven basic principles; one of its important principles is the selection of plants resistant to drought without the need for regular maintenance. Given that turfgrass species are demanding in terms of maintenance and water needs, their covered area should be minimized in this landscaping method, according to the xeriscape principles (Windust, 1995).

In recent years, groundcover plants in many cases are presented as alternative plants to turfgrasses. These plants have several advantages over turfgrasses: the ability to grow in sloped areas or areas with full shade and high moisture or with very dry soils (Safari and Kazemi, 2014) are some of the advantages. Generally, growth and germination of weeds are less in some of them and others well tolerate irrigation with wastewater (Shooshtarian and Tehranifar, 2010) and they have the ability to grow in areas with saline soils and water resources (Easton and Klindrofar, 2009) and with extreme temperature conditions (Shooshtarian and Tehranifar, 2010) and maybe more important; in some cases, they need less irrigation water (Safari and Kazemi, 2014). Of course, the use of these plants in green spaces as a substitute for turfgrasses had deficiencies, such as less tolerance to footing and elasticity as compared to turfgrass species.

3.2.9. Using surfactants

Water disposal is as a management problem in most soil types. But, so far, little definitive research has been conducted to clarify its effects on lawns. Generally, water disposal of the soil can be attributed to hydrophobic organic coating around soil particles or accumulation of these substances in the soil environment (Kostka, 2000). Sources creating the hydrophobic materials may include accumulation of organic derivatives of plants (material derived from decomposition of the roots, decomposition of plant tissues and root sections), derivatives of waxes or vegetable organic acids, fungal hyphae, or organic acids and polysaccharides. Water disposal occurs in all types of the soil and climatic conditions (Muller and Deurr, 2011). Muller and Deurr (2011) divided the methods to tackle the dangers of water repellency of the soil into two groups: direct and indirect methods. Indirect methods can be used to treat symptoms of the problem, including the use of surfactant changing the soil texture to clay type, aerating the soil and choosing suitable vegetation, while direct methods includes bioremediation methods by using proprietary microorganisms of the soil that can create rapid degradation conditions for hydrophobic materials. In most regions, to improve the existing soil, sand is used and sand is very susceptible to join to the hydrophobic materials. The soil in these areas usually remains dry and water penetration rate in these areas is low. Therefore, these areas will have a non-wetting character. This character can greatly affect the quality of the turfgrass and playing especially in sport fields. Surfactants are surface active materials which would be able to reduce surface tension of the fluids where they are solved and can increase driving power for absorbance of water by soil through reducing the surface tension of water and surface contact angle between water and the soil (Halt, 2008).

Studies have been conducted on the effect of surfactants in improving soil water repellency and reducing dry spots on the lawn surface. Henley *et al*. (2007) examined the influence of more than 10 types of wetter materials in 9 different places in turfgrasses of golf lands in USA in the year 2003 to 2004. They concluded that none of these materials had a superior effect over others. Nevertheless, the influence of these materials depends on the climate and the location of their application. In another study, Oostindie *et al*. (2008) demonstrated that in a sandy soil covered by lawn, after four applications of a surfactant (methyl-capped triblock copolymer), water absorption and moisture in soil surface increased and soil water repellency vanished to 250 mm depth.

Cicer *et al*. (2000) implemented an experiment in 1996 to 1998 in a sandy soil covered with *Cynodon dactylon*×*Cynodon transvaalensis cv*. *Tifdwarf*. In this experiment, in order to reduce water disposal of the soil and remove dry spots from the water repulse of the soil, a number of formulas were used in each year: AquaGro (AG), Primer (P), Aqudect (AD)t, ACA 1257, ACA 1313, ACA 1455, ACA 1457, Cascade, LescoFlo NO. 07/05. Generally, using each of these materials led to an increase in the quality of turfgrass and a decrease on dry spots resulted from the hydrophobicity character of the soil.

Thomas and Karcher (2000) used a moisturizing agent Aqudect (AD) on the ground covered with creeping bentgrass cultivar Crenshaw and measured the soil moisture under the turfgrass. They found an increased infiltration rate on dry spots of the lawn, but the moisture content of the soil did not increase. They justified the findings that moisturizing agent has been absorbed by thatch layer of the turfgrass and resulted in reducing the moisture content in the soil. In warm and dry climate, if the amount of replaced irrigation is 60% of evaporation rate, water repellency of the soil under the turfgrass can be reduced by using liquid or granular moisturizing agents of the soil (Barton and Cohmer, 2001).

The disadvantages of surfactants include that they can be costly (Muller and Dourr, 2011), they have toxicity effects on turfgrasses in some cases (Wallis and Horne, 1992), and they create problems in soil structure (Holt, 2008). However, according to the conducted research, surfactants can be used as important elements to reduce water consumption of lawns.

3.2.10. Using other chemicals

Some anti-transpiration materials (Antitranspiranta) are able to reduce water consumption by reducing the plant transpiration. Sometimes, this reduction is done by creating a temporary coating on the outer surface of the plant. Sometimes, these materials enforce their anti-transpiration effect through biochemical and physiological changes on the plants (Bayat *et al*., 2011; Razavizadeh and Amoobeygi, 2014). Among these materials is paclobutrazol, which is a plant growth hormone and belongs to azoles group (Alyani *et al*., 2014). This substance may cause resistance to drought, salinity, cold, heat, air pollution and flooding conditions (Bayat *et al*., 2011; Rademacher, 1995; Razavizadeh and Amoo Beigi, 2014) and create the effect of its drought resistance by reducing transpiration, height (Bayat *et al*., 2011; Nishizawa, 1993; Razavizadeh and AmooBeygi, 2014), dry matter, leaf area (Nishizawa, 1993; Razavizadeh and Amoo Beygi, 2014), increased root growth (Bayat *et al*., 2011) and increased stomata resistance (Nishizawa, 1993; Razavizadeh and Amoo Beygi, 2014). A general method of its application is spraying solution and application in soil (Shakeri *et al*., 2010;

Alayni *et al*., 2014). A research was performed by Aliani *et al*. (2014) in Karaj in order to investigate the effect of paclobutrazol on lavender under dry conditions. It showed that by applying 250 mg/L of paclobutrazol in soil prevents water losses from the soil and make it available for plants. Also, other studies showed that peach seedlings treated with paclobutrazol reduced their dry and fresh weight and consumed less water in greenhouse conditions (Arzani and Roosta, 2004; Alayni *et al*., 2014). It seems that the impact of this material on trees and shrubs is more than that in turfgrasses. This might be because this substance which is associated with turfgrass tissues is continuously harvested during the growing season by clipping the lawn (Christians, 2013). However, despite the benefits associate with applying such materials via reducing water consumption through reduction on evapotranspiration, it seems that since one of the benefits of transpiration is cooling the plants, applying these materials which are followed by reducing evapotranspiration can increase tip burning potential in turfgrasses especially during warm months of summer.

Plant growth regulators also are able to reduce water consumption of plants. As an example, it has been seen that materials like Flureprimidole (Canlex) and Mephloydad (Ambark) reduced water consumptions as much as 20 to 30% in St. Agustine and Bermuda grass (Beard, 1985).

3.2.11. Using endophyte fungi

Endophytic fungi belonging to the genus *Neotyphodium* have a symbiotic relationship with most cold grasses (Khayyam Nekooyi *et al*., 2010; Parsaiyan *et al*., 2007). These fungi are seed-generating and transmitted to the next generation (Bacon and White, 1994). In a study, the fungus was identified in Fescue plants native to Iran (Khayyam Nekooyi, 2001). This fungus has many benefits for its host plant which include resistance to insects, bacteria, viruses and nematodes (Parsayyan *et al*., 2007; Malinowski and Blusky, 2000; Khayyam nekooyi *et al*., 2010), resistance to environmental stresses, like drought and cold (Baken and White, 1994; Robert *et al*., 2005, Parsayyan *et al*., 2007; Khayyam Nekooyi *et al*., 2010), resistance in dealing with toxic elements and acidity changes and increase in plant performance (Parsayyan *et al*., 2007). In terms of resistance to drought, this fungus can act by mechanisms like rapid stomata closure, osmotic pressure adjustment (Malinowski and Blusky, 2000; Khayyam Nekooyi *et al*., 2010), increased stomata resistance, rolling of the leaves, rapid growth, increasing effective root depth (Parsayyan *et al*., 2007; Robert *et al*., 2005; Khayyam Nekooyi *et al*., 2010), increase resistance of the grass to drought and less irrigation.

Other research in which Khayyam Nekooyi *et al*. (2010) studied tolerance of long Fescue to drought in the presence of endophyte fungus also resulted to the similar conclusions in that this fungus increased drought resistance of the lawn and treated turfgrasses with these fungi had better growth than the non-treated control turfgrasses in drought stress conditions.

4. Conclusion

Due to the scarcity of water resources in arid countries and high requirement of the turfgrasses to these resources, achieving strategies for efficient water usage is essential for lawn scaping. This achievement in the first step depends on accurate determination of water needs of the turfgrasses. Such method can be selected with regard to available facilities and the level of the accuracy required.

Apart from the need for determination of water requirement of the turfgrasses, different strategies may affect water required in lawns which can be used as single or combined strategies. In some cases where the use of turfgrasses is necessary, the first and most important strategy in the planning stage is choosing suitable species that requires less water and more resistance to drought. Some management strategies, such as clipping of the lawn from an appropriate height and managing thatch layer are relatively low cost and environmentally friendly water efficient management strategies in lawns. In soils which are covered with turfgrasses for a long time and usually are faced with water penetration issues due to accumulation of their root systems or having hydrophobic organics in the soil, using relatively low-cost surfactants from locally available materials can be a useful water efficient strategy to grow lawns. Among these materials, zeolite and bentonite from mineral groups and potassium acrylamide from synthetic groups can be useful. Deficit irrigation practices, as a single strategy or together with the use of superabsorbents in the soil can result in lower water consumption and produce better quality turfgrasses. Finally, using anti-transpiration materials or endophytic fungi that can reduce transpiration in plants are useful strategies for maintaining quality lawns with less water. It should be noted that all the afore-mentioned strategies together with the use of alternative water resources other than potable water for irrigating of lawns should be considered as highly important. Tolerant grass species to wastewater should be determined and strategies should be applied for using subsurface irrigation methods with sewage for optimal water resources usage and maintaining public health. In places where there is no need for the characteristic of turfgrass elasticity, lower water consuming plants with similar applications such as ground cover plant species should be planted as alternatives. Such plants, in some cases, in addition to consuming less water can provide more aesthetics and environmental benefits in design and construction of urban green spaces.

References

Abedi koohpayee, J., F. Sohrab, 2005. The effect of Zeolite minerals and Bentonit on soil hydraulic characteristics. Proceedings of Twelfth Congress Crystallography and Mineralogy in Iran, Chamran University, Ahvaz, Iran .pp. 567.

Abedi koohpayee, J., J. Asadkazemi, 2006. Effect of Zeolite in soil on optimizing water for green spaces. Proceedings of Technical Workshop on Automated Surface Irrigation,karaj, Iran. pp. 158-151.

Alami, M., 2011. Studying the effect of superabsorbent and Paclobutrazol on decreasing water need of *Lolium sp*., M.Sc. Thesis, Ferdowsi University of Mashhad, Iran.

Alami, M., A. Tehranifar, Gh. Davarinezhad, Y. Selahvarzi, 2011. Studying the effect of superabsorbent on (*Lolium perenne cv. Barbal*) in Mashhad climate conditions. Journal of Horticultural Science, 3; 288-292.

Alyani, H., A. Imani, A. Akbarpour, 2014. Studying the effect of Paclobuterazol on some physiological and morphological parameters of ornamental plant of lavander in drought stress conditions. Proceedings of The 1th National Electronic Conference in Agricultural Sciences and Environment, Iran. Available from http://pad.um.ac.ir/file/view/2125168.Accessed 19th April2014.

Ansari, H., N. Azimi, 2012. Studying the effect of deficit irrigation and different nitrogen levels on some qualitative and quantitative characteristics of turfgrasses. Research Centre of Mashhad Islamic Council. Mashhad. Iran, 11p.

Arzani, K., H.R. Roosta, 2004. Effects of ppz on vegetative and reproductive growth and leaf mineral content of mature apricot (*Prunus armeniaca*) trees. Journal of Agricultural Science, 6;43-55.

Atkins, C. E., R. L. Green, S. I. Sifers, J. B. Beard, 1991. Evapotranspiration rates and growth characteristics of ten St. Augustine grass genotypes. Horticultural Science, 12;1488-1491.

Bacon, C. W., J. F. White, 1994. Biotechnology of endophytic fungi of grasses, 2th ed., CRC press, Boka Raton, USA.

Barton, L., T.D. Cohmer, 2001. Ameliorating water repellency under turfgrass of contrasting soil organic matter content: effect of wetting agent formulation and application frequency. Agricultural Water Management, 99; 1-7.

Bayat, S., A. Sepehri, H. Zare Abyaneh, M. R. Abdollahi, 2011. The effects of salicylic acid and Paclobuterazol on some growth indices and performance of corn under drought stress. Quarterly Scientific Journal of Farming Plant Ecophysiology, 1; 34-40.

Beard, J. B., 1985. Turfgrass water conservation strategies. Proceedings of the 55th Annual of Michigan Turfgrass Conference.pp. 124-135.

Bastug R., D. Buyuktas, 2003. The effects of different irrigation levels applied in golf courses on some quality characteristics of turf grasses. Irrigation Science, 22; 87-93.

Beygi, S., 2013. Effect of super absorbents and natural compounds on vegetative growth and reproductive characteristics of the *Ocimum basilicum* L. 'Keshkenylevelu'. M.Sc. Thesis, Ferdowsi University of Mashhad, Mashhad, Iran.

Christians, N., M. Engelke, 1994. Choosing the right grass to fit the environment. In: Leslie, editors. Handbook of integrated pest management for turfgrass and ornamentals. United States of America: Lewis Publishers.; p. 99-112.

Christians, N., A. Nik Bakht, E. Kiani, N. Etemadi, (Eds.), 2013. Fundamentals of Turfgrass Management, 3th ed., University of Isfahan, Isfahan, Iran.

Cisar, J.L., K.E. Williams, H.E. Vivas, J.J. Haydu, 2000. The occurrence and alleviation by surfactants of soil-water repellency on sand-based turfgrass systems. Journal of Hydrology, 231–232; 352–358.

Da Costa, M., B. Huang, 2004. Evaluation of irrigation requirements and water use characteristics among three bentgrass species, Rutgers Turfgrass Proceedings, The New Jersy Turfgrass Association, 7-9 December, New Jersy.

Dasht Bozorg, A., Gh. Sayad, A. Kazeminejad, M. Mesgrbashi, 2014. The effect of different particle size of a superabsorbent polymer on the water holding capacity in two different soil textures. Agricultural Engineering (Scientific Journal of Agriculture), 1; 65-74.

Easton,C.L.,S. kleindorfer, 2009. Effects of salinity levels and seed mass on germination in Australian species of Frankenia (Frankeniaceae). Environmental and Experimental Botany, 65;345-352.

Falahian, A., 2009. The grass technology, construction and maintenance.1th ed., University Jahad of Mashhad publications, Mashhad.

Feldhake, C. M., R. E. Danielson, J. D. Buttler, 1983. Turfgrass evapotranspiration. I. Factors influencing rate in urban environments. Agronomy Journal, 75; 824-830.

Fry, J.D., J.D. Butler, 1989. Responses of tall and hard fescue to deficit irrigation. Crop Science, 29; 1536-1541.

Gibeault V.A., J.L. Meyer, V.B. Younger, S.T. Cockerham, 1985. Irrigation of turf grass below replacement of evapotranspiration as a means of water conservation: performance of commonly used turf grasses, In: Lemaire F(ed) Proceedinds of the 5the International Turfgrass Research Conference. Avignon. France. 1-5 July. Institute national de la recherché Agronomy, Paris.pp. 347-356.

Haghayeghi moghadam, S., 2004. The possibility of using the reform and moisture keeper in the soil to increase the efficiency of water use. Journal of Aridity and Drought in Agriculture, 9; 77-78.

Hallett, P.D., 2008. A brief overview of the causes, impacts and amelioration of soil water repellency- a review. Soil Water Research, 3; 21–29.

Harivandi, A., 1982. The use of effluent water for turfgrass irrigation. California Turfgrass Culture, 3(4); 1-4.

Harivandi, M.A., 2004. Thatch, the turf manager's hidden enemy. California Turfgrass Culture, 34; 15-23.

Hassanli, A.M., F. Kazemi, 2012a. Tolerance and sensitivity of the Adelaide parklands' landscape plants to the Glenelg recycled wastewater. Proceedinds of ICID and Irrigation Australia Conference, 24-29 June, Adelaide, Australia.

Hassanli, A., F. Kazemi, 2012b. An investigation into the tolerance and sensitivity of the Adelaide parklands' landscape plants to the Glenelg recycled water. 1th ed., University of South AustraliaPress,Adelaide.

Henle, W., C. Horn, J. Morhard, H. Schulz, U. Thumm, W. Claupein, 2007. HydrophobeBoeden, local dry spot (LDS) und die Bekaempfungmit wetting agents. Rasen-Turf-Gazon, 4; 228–240.

Hull, R., 1996. Managing turf for minimum water use, Turfgrass Trends, 5; 1-9.

Jahan, M. K., N. Mayestani, F. Ranjbar, 2014. Studying possibility of using humidity superabsorbent in order to reduce drought stress to corn (*Zea mays L.*) in a little input farming system in Mashhad Conditions. Journal of agricultural Canvas Biology, 3; 281-272.

Kafi, M., Sh. Kaviani, 2003. The grass, technology, construction and maintenance.1th ed., Cultural and Art Institute of Shaghyeghe Rusta Publications, Tehran.

Karimi, A., M. Noshadi, M. Ahmadzadeh, 2009. Effects of applying watersuper-absorbent (Igeta) on soil water content, plant growth and irrigation intervals. Journal of Science and Technology of Agriculture and Natural Resources, 46; 403- 414.

Kazemi, F., 2014. Using water sensitive urban design for urban water management. Journal of Water and Sustainable Development, 1; 29- 34.

Kazemi, F., M. Abbasi, M.R. Golzaryan, 2005. Xeriscape, a concept for efficient water use in landscaping. Promotional and scientific Journal of landscaping, 2; 62-74.

Kazemi, F., S. Beecham, B. Myers, 2013. Water quality effects of a water sensitive urban design retrofit in an urban streetscape in Adelaide, Australia. Acta Horticulturae, 999; 321-327.

Kazemi, F., S. Beecham, 2007. Water efficient planning and management in arid regions, a case study of South Australia. Proceedings of the 1th Conference on Urban Planning and Management, 2 and 3 March, Mashhad, Iran.pp. 341-369.

Kazemi, F., S. Beecham, 2008. Strategies for sustainable arid landscape design, a review on perspective from Australia. Proceedings of the 3th National Conference on urban green space and landscape. pp. 421 -437. Mashhad, Iran.

Kazemi, F., S. Beecham, J. Gibbs, 2010. Bioretention swales as multifunctional landscapes and their influence on Australian urban biodiversity: Hymenoptera as biodiversity indicators. Acta Horticulturae, 881; 221-228.

Kazemi, F., S. Beecham, J. Gibbs, 2011. Streetscape biodiversity and the role of bioretention swales in an Australian urban environment. Landscape and Urban Planning, 2;139–148.

Kazemi, F., S. Beecham, J. Gibbs, R. Clay, 2009a. Factors affecting terrestrial invertebrate diversity in bioretention basins in an Australian urban environment. Landscape and Urban Planning, 92; 304-313.

Kazemi, F., S. Beecham, J. Gibbs, 2009b. Street-scale bioretention basins in Melbourne and their effect on local biodiversity. Ecological Engineering, 35;1454-1465.

Khayyam nekooyi, S. M., R. Mohammadi, H. Arab nezhad, 2010. Enhancing drought tolerance of fescue grass using endophyte coexistence fungi. Proceedinds of 2th National Conference on effects on Drought Stress and its Management Strategies, Isfahan. Available from http://www.civilica.com/Paper-NSDEM02-NSDEM02_192.htm,Accessed 1th July 2014.

Kim, K. S., J. B. Beard, 1988. Comparative turfgrass evapotranspiration rates and associated plant morphological characteristics. Crop Science, 28; 328-331.

Kostka, S.J., 2000. Amelioration of water repellency in highly managed soils and the enhancement of turfgrass performance through the systematic application of surfactants. Journal of Hydrology, 231–232; 359–368.

Lentz, R.D., R.E. Sojka, C.W. Robbins, 1998. Reducing phosphorus losses from surface-irrigated fields: emerging polyacrylamide technology. Journal of Environmental Quality, 27; 305-312.

Malekian, R., M. Haider pur, B. Mustafa zadeh fard, J. Abedi koohpayee, 2009. The effect of surface and subsurface irrigation with treated wastewater on characteristics of Bermuda grass. Journal of Agricultural Sciences and Natural Resources, 4; 248- 258.

Malinowski, D. P., D. P. Belesky, 2000. Adaptation of entophyte- infected cool season grasses to environmental stresses: mechanisms of drought and mineral stress tolerance. Crop Science, 40; 923- 940.

Minayee, S., A. Madeh khaksar, 2000. Investigating and surveying the procedares and amounts of estimated water requirement of water national document in Khorasan province and offering suggestions.Proceedinds of 1th Conference of National Committee of Irrigation and Drainage in Iran. pp. 65-82.

Mohammadi, P., M. Siahi, N. Mehrdadi, A. Liaghat, M. Adl, M. Ehteshami, et al, (without year). An overview on the standards and expriences of applying wastewater for irrigation, working group of environmental effects. Iranian National Commitee on Irrigation and Drainage. Available fromhttp://irncid.org/PublicationDet.aspx?ID=135&CatId=7. Accessed 10th March 2014.

Mortram, A., 2003. The effects of irrigating turfgrass with wastewater. International Turfgrass Bulletin, 219; 30-32.

Muller, M., M. Deurer, 2011. Review of the remediation strategies for soil water repellency. Agriculture, Ecosystems and Environment, 144; 208-221.

Najafi, P., 2008. Studying the microbial contamination from irrigation grass with municipal treated wastewater. Journal of Ecology, 44; 32-27.

Najafi, P., 2007. Effect of subsurface drip irrigation on WUE increase in irrigation of some crops. Research and construction journal in agriculture and horticulture, 73; 156-162.

Naseri, A., F. Pour abbas, 2006. Applicability of subsurface drip irrigation. Proceedinds of 2th Conference of Watersheding and Management of Soil and Water Resources, Kerman. pp. 95-98.

Nazarli, H., M. R. Zardashti, R. Darvishzadeh, S. Najafi, 2010. The effect of water stress and polymer on water use efficiency, yield and several morphological traits of sunflower under greenhouse conditions. Notulae Scientia Biologicae, 2; 53-58.

Nouri imam zadeyee, M. R., A. Rahmati, B. Ghorbani, A. Mohammad khani, 2012. Investigating the effect of aeration and top dressing on cumulative infiltration and final soil infiltration rate in Lolium grass. Journal of Water and Soil (Agriculture Sciences and Industries), 6; 1227-1237.

Nouri, H., S. Beecham, A. Hassanli, F. Kazemi, 2013a. Water requirements of urban landscape plants: a comparison of three factor-based approaches. Ecological Engineering, 57; 276-284.

Nouri, H., S. Beecham, F. Kazemi, A.M. Hassanli, 2013b. A review of ET measurement techniques for estimating the water requirements of urban landscape vegetation. Urban Water Journal, 4; 247-259.

Nouri, H., S. Beecham, F. Kazemi, A. Hassanli, S. Anderson, 2013c. Remote sensing techniques for predicting evapotranspiration from mixed vegetated surfaces. Hydrology and Earth System Science Discussion, 10; 3897–3925.

Nishizawa, T., 1993. The effect of paclobutrazol on growth and yield during first year greenhouse strawberry production, Scientia Hortculturae, 54; 267-274.

Oostindie, K., L.W. Dekker, J.G. Wesseling, C.J. Ritsema, 2008. Soil surfactant stops water repellency and preferential flow paths. Soil Use Management, 24; 409–415.

Oron, G., C. Campos, L. Gillerman, M. Salgot, 1999. Wastewater treatment, renovation and reuse for agricultural irrigation in small communities. Agricultural Water Management, 38; 223-234.

Panahi, M., 2000. Calculation of daily evapotranspiration of reference crop and comparing with the measured value by electronic lycimeter. Proceedings of the 10th National Conference on Strategies to Deal with Water Crisis, Zabol University, Zabol, Iran. pp. 485-496.

Parsaeeyan, M., A. F. Mir Lohi, A. Rezaei, M. Baradran, 2007. Morphologic changes caused by endophyte coexistence on two festuca species resistant to cold. Iranian Agricultural Sciences Journal, 8; 139-152.

Paseban islam, B., A. Taghi pour, Gh. Vesali, 2014. The vision on green space of Tabriz metropolitan. Proceedings of the 1th National Conference on Strategies on Green Space Development of Tabriz Metropolitan, Parks and Green Space Organization of Tabriz municipality. Tabriz, Iran. pp. 7-15.

Pepper, I.L., G.A. Ferguson, W.R. Kneebone, 1982.Clinoptilolitic zeolite: a new medium for turfgrass growth. Agronomy Abstracts, P. 148.

Rademacher, W., 1995. Growth retardants: biochemical features and applications in horticulture. Acta Horticulturae, 394; 57-73.

Rana,G., N. Katerji, 2000. Measurement and estimation of actual evapotranspiration in the field under Mediterranean climate: a review. European Journal of Agronomy, 13; 125–153.

Razzaghmanesh, M., S. Beecham, F. Kazemi, 2014a. Impact of green roofs on stormwater quality in a South Australian urban environment. Science of the Total Environment, 470–471; 651-659.

Razzaghmanesh, M., S. Beecham, F. Kazemi, 2014b. The growth and survival of plants in urban green roofs in a dry climate. Science of the Total Environment, 476–477; 288-297.

Roberts, C., C. West, D. OnaldSpiers, 2005. Neotyphodium in cool-season grasses. 1 ed., Blackwell Publishing, USA.

Romero, C., M. Dukes, 2009. Turfgrass and ornamental plant evapotranspiration and crop coefficient literature review. Agricultural and Biological Engineering Department, University of Florida Gainesville, FL. Available from http://abe.ufl.edu/mdukes/publications. Accessed 19th May 2013.

Razavi zadeh, R., M. Amoo beigi, 2014. The impact of Paclobuterazol on improving tolerance to drought in colza plants (*Brassica napus*) in conditions of inside glass. Journal of Plant Function and Processes, 1; 22-34.

Ruhani, Gh., 1993. Designing gardens and establishing green space. 2 ed., Farhang Jame publications Tehran.

Ruhani, A., N. Hedayat, 2011. Determination of water requirement of tropical grass in agricultural soil and its comparison with water requirement of reference irrigated grass in Zahedan.Proceedings of the 3th National Conference of Irrigation and Drainage Networks a Managment, Chamran University. Ahvaze. Available from http://www.civilica.com/Paper-IDNC03-IDNC03_237.htm. Accessed 3th July 2015.

Ruhollahi, A., M. Kafi, P. Sayyad Amin, M. Taghizadeh, 2008. Studying the effect of salinity on the process of sprouting nad early growth in three species Lolyom Perne, Sinodon Ductilon and Pua Pratnesis.Proceedings of 3th Conference on Green Space and Urban Landscape of Kish, Organization of Iran municipalities, Kish, Iran. pp. 187-197.

Saadat, Y., S. M. Mortazavi jahromi, A. Hassanli, 2008. The use of treated wastewater for irrigation of tree species for urban green space development. Proceedings of 3th Conference on Green Space and Urban Landscape in Kish, Organization of Iran municipalities, Kish, Iran. pp. 33-43.

Saeedi Pooya. A., 2014. Evaluation of climate adaptation and the effect of regulated deficit irrigation on different masses of cool season grasses native to Iran and their seed mixtures in comparison with commercial seed mixtures.

M.Sc. Thesis, Ferdowsi University of Mashhad., Mashhad, Iran.

Safari, N., F. Kazemi, 2014. Effect of applying non-living mulches for development of arid and semi-arid areas,Proceedings of 3th National Conference on sustainable development in arid and semi-arid Abarkooh, Yazd. Iran.

Salemi, H., L. Moshref, 2006. Effects of deficit irrigation and different nitrogen levels on some qualitative characteristics and yield of seed corn in Isfahan. Journal of Agricultural Engineering Research, 26; 84- 71.

Sarafrazi, H., S. R. Mir hosseini, M. Babaie, 2012. Role of water absorbent polymers (potassium acrylamide) on soil volume moisture and potential water of plant grass (*Poa pratensis*). Journal of Horticultural Sciences (Agricultural Science and Industry), 4; 391- 396.

Schlossberg, M.J., F.C. Jr. Waltz, J. Peter, 2008. Recent mechanical cultivation of lawns enhances lime application efficacy. Agronomy Journal, 100; 855-861.

Sepahkhah, A., B. Ghahreman, Sh. Zand-parsa, M. Ghasemi, 2007. Comparison of two methods of sorghum deficit irrigation. Research on Iran Water Resources, 5; 1- 9.

Shakeri, F., B. Bani Nasab, S. Ghobadi, H. Arvin, 2010. The effect of Paclobuterazol on vegetative and productive growth of apricot Lasjerdi species. Journal of Horticultural Science and Technology, 3; 240-231.

Sharifi Ashoorabadi, E., H. Rouhipour, M.H. Assareh, M.H. Lebaschy, B. Abaszadeh, B. Naderi et al, 2012. Determination of crop water requirement of yarrow (*Achillea millefolium*) using lysimetry. Iranian Journal of Medicinal and Aromatic Plants, 28; 484- 492.

Sheikh Moradi, F., F. Arji, A. Esmaili, V. Abdoosi, 2012. Study of the effect of irrigation interval and superabsorbent polymer on some qualitative characteristics of sport lawn. Journal of horticultural sciences (agricultural science and industry), 2; 170- 177.

Shooshtarian, S., A. Tehranifar, 2011. An overview of the use of phytoremediation systems to improve quality of domestic and industrial wastewaters in order to irrigate landscaping plants.Proceedings of 2 th National Seminar on Situation of Recycled and Waste Water in Water Resources Management, Applications in Agriculture and Green Spaces.Mashhad, Iran.Available from http://profdoc.um.ac.ir/paper-abstract-1020088.html. Accessed 7th July 2015.

Shooshtarian, S., A. Tehranifar, 2010. Evaluation of applying drought friendly plants in urban green spaces in Mashhad. Mashhad Research Journal, 2; 92- 105.

Soroush, F., S. F. Mousavi, Kh, Razmju, J. Abedi koohpayi, B. Mustafa zadeh, 2009. Impact of irrigation with sewage on some properties of Japanese grass in different soil textures. Journal of research in Agricultural Sciences, 1; 61-71.

Terry, R.E., S.D. Nelson, 1986. Effects of polyacrylamide and irrigation method on soil physical properties. America Journal of Soil Science Society, 5; 317-320.

Thomas, M., D. Karcher, 2000. Incidence and control of localized dry spot on Arkansas putting greens. Research Series-Arkansas Agricultural Experiment Station, 483; 77–79.

Vaziri, Zh., M. Entesari, N. Heidari, A. Salamat, M. Meschi, H. Dehghani sanych, 2009. Plants evapotranspiration (procedures to calculate crop water requirement). Iranian National Committee on Irrigation and Drainage, Publication No. 122.

Wallis, M.G., D. J. Horne, 1992. Soil water repellency. Advanced Soil Science, 20; 91–146.

Windust, A., 1995. Drought garden: management and design for plant survival and your enjoyment.1st ed., Manduaring Vic. Allscape, Australia.

Xiubin, H., H. Zhanbin, 2001. Zeolite application for enhancing water infiltration and retention in soil loses. Resources, Conservation and Recycling. 34; 45-52.

Yasuda H., K. T. Takuma Fukuda, J. Suzuki, Y. Fukushima. 1998. Effects of zeolite amendment on water and salt characteristics in soil. Proceedings of the International Agricultural Engineering Conference, Bangkok, Thailand. pp. 837-842.

Zanguyi nasab, Sh., H. Emami, A. Astarayi, A. Yari, 2013. Effect of different levels of superabsorbent and irrigation rounds on some soil physical properties and growth indices of Atriplex. Journal of Water Research in Agriculture, 2; 211- 223.