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APPLICATION OF MYCORRHIZAL FUNGI IN LANDSCAPE TURFGRASS ESTABLISHMENT UNDER ARID AND SEMIARID ENVIRONMENTS

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ABSTRACT

Turf grasses are considered an integral part of landscape ecological systems worldwide which provide functional, recreational and aesthetic benefits to society and the environment. In arid and semiarid regions (e.g., Mediterranean region), turf grass is usually grown under harsh and unfavorable growing conditions with low rainfall and high rates of evapotranspiration as well as in soils with nutrient deficiencies. Hence, growing turf grass in these regions becomes dependent on application of high levels of fertilizers as well as on excessive use of irrigation water, resulting in an environmental pollution. Therefore, it is important that turf grass plantations are managed in a sustainable way to reduce the impact of turf grass cultivation on ecosystems while maintaining healthy and productive turf through using such practices as mycorrhizal fungi technology. The application of mycorrhizal fungi technology is an option that can benefit both agronomic plant health and ecosystems. Mycorrhizae confer numerous benefits to host plants including improved plant growth, mineral nutrition, water uptake, tolerance to diseases and stresses such as drought and salinity. The aims of this paper were to review how mycorrhizal fungi might play a role in enhancing landscape turf establishment and productivity in arid and semiarid regions and to evaluate the effectiveness of application of commercial mycorrhizal inoculum to enhance plant growth and survival under field conditions. Field experiment was conducted to study the effects of arbuscular mycorrhiza (AM) fungi inoculation on water use efficiency and establishment of a landscape turf. The results showed that turf grass inoculated with AM fungi used water more efficiently, established lawn more quickly and had more biomass than uninoculated turf grass. The conclusions of this paper indicated the potential of mycorrhiza inoculation in improving the fast establishment of turf landscape plants under arid and semiarid environments.

Keywords: *Arbuscular mycorrhizal fungi, sustainability, urban, irrigation, Jordan.*

INTRODUCTION

Turf grasses are consider an integral part of landscape ecological systems worldwide, which provide functional, recreational and aesthetic benefits to society and the environment. However, to maintain homogeneous and dense turf lawn, with an intense color, and free of diseases, it becomes dependent on application of high levels of chemical fertilizers and pesticides as well as on excessive use of irrigation water (Al-Karaki et al., 2007).

The present paper aimed at to provide an overview of how mycorrhizal fungi might play a role in enhancing landscape turf establishment and productivity in arid and semiarid regions and to evaluate the effectiveness of application of commercial mycorrhizal inoculum to enhance plant growth and survival under experimental field conditions.

Mycorrhizal fungi role in enhancing landscape turf establishment in arid and semiarid regions: Review

In arid and semiarid regions (e.g., Mediterranean region), turf grass is usually grown under harsh and unfavorable growing conditions with low rainfall and high rates of evapotranspiration as well as in soils with nutrient deficiencies (Al-Karaki, 2013). In these regions, water use for watering lawns is a major concern due to limited access to water resources, and application of high levels of fertilizers and plant protection chemicals which might not always offer the desired result and resulting in an environmental pollution (Law et al., 2004). Furthermore, the costs of maintaining a lawn are very high when considering the full cost of water and the fertilizer and plant protection products application. Therefore, it is important that turf grass plantations are managed in a sustainable way that use of appropriate water supply and reduce the impact of application of fertilizer and plant protection products on ecosystems while maintaining healthy and productive turf through using such biological agents as mycorrhizal fungi inoculants (Al-Karaki, 2013;Gemma, et al., 1997).

Arbuscular mycorrhizal (AM) fungi are beneficial symbiotic fungi that form an association on the roots of most of the world's plants (Marschner, 1995). The mycorrhizal fungi once established on the host plant root system radiate out from the roots to form a dense network of filaments. These filaments form an extensive system of hyphae that extends from root system, grow into the surrounding soil, and greatly improve access to water and nutrients far from roots (Marschner and Dell, 1994). AM fungi provide a variety of benefits for the host plants, including improved access to immobile nutrients especially P, Cu and Zn (Miyasaka and Habte 2001) as well as inorganic N (Govindarajulu et al. 2005), thus reducing fertilizer requirements (Gemma et al. 1997), improved water use (Naghashzadeh et al., 2015), improved tolerance to disease (Matsubara, *et al.* 2001), and tolerance to abiotic stresses such as drought (Rapparini and Peñuelas. 2014; Al-Karaki, *et al.* 2004), and salinity (Aroca and Ruiz-Lozano, 2012; Al-Karaki, 2006). AM fungi also enhance soil aggregation and water-holding capacity both by producing external hyphae and by exuding glomalin, a glycoprotein, from extraradical hyphae (Wright and Upadhyaya, 1998).

Although the majority of grass species form an AM symbiosis (Newman and Reddel, 1987), less research has been conducted until recent times on the mycorrhization of turf, due to the believes that turf grass are less dependent on AM fungi because it is grown under almost perfect growth conditions. Recent scientific studies and practical applications of AM fungi inoculants demonstrated that many species of AM fungi are associated with highly maintained turf grasses (Miyasaka and Habte 2001; Govindarajulu et al. 2005). In arid and semi-arid climates, an efficient management of irrigation water as well as fertilizer and plant protection products application are of ecological and economic importance, which calls for mycorrhizae application as growth promoters, biofertilizers and bioprotectors. Research studies have shown that AM fungi can improve plant growth, fertilizer utilization, rooting depth, the speed of establishment, disease and drought and salinity resistance of turf (Al-Karaki et al., 2007; Gemma etal., 1997; Pelletier and Dionne, 2004; Aroca and Ruiz-Lozano, 2012). Warm-season grasses with coarse root systems such as bermuda grass are very dependent upon mycorrhiza for sustained growth (Hetrick et al 1988). Some other studies indicate that cool-season, finer rooted bentgrass species also form abundant mycorrhiza and benefit from the relationship, especially where the phosphorous levels are not too high (Gemma et al., 1997; Koske et al., 1997). It is also well documented that inoculation of grasses with mycorrhizal fungi in soil with low phosphorous concentrations can produce greater shoot and root biomass (Hetrick et al., 1991). Gemma et al. (1997) reported that Kentucky bluegrass produced more aboveground biomasses over time when inoculated with mycorrhizae compared with the uninoculated control. Besides positive impacts of AM fungi on plant nutrition and water uptake, mycorrhizal fungi protect annual grasses from root pathogenic fungi and nematodes in the field (Newsham et al. 1995; Little and Maun 1996), since these pathogens can be a severe problem in turf grass management.

Evaluation of application of mycorrhizal inoculum in enhancing plant growth and survival under experimental field conditions: Experimentation

MATERIALS AND METHODS

To confirm its practical application and to corroborate the mycorrhiza functionality, a field study was conducted during the summer of 2012 at the Experimental Farm of Faculty of Agriculture, Jordan University of Science & Technology, Irbid, Jordan. Experimental plots [(1m x 1 m x 0.35m); LxWxD] were constructed and filled with 90:10 (v: v) sand: peat rootzone. Plots were seeded with a standard commercial lawn seed mixture composed of 30% Kentucky bluegrass (*Poa pratensis* L. Nustar and Rugby II) and 70% perennial ryegrass (*Loliumm perenne* L. Goal Keeper) at 25 g m^{-2}. AM fungal treatments included inoculation (AM) or no inoculation (nonAM) with a commercial AM BioMyc inoculum. Both AM inoculum and seeds were uniformly sprinkled by hand over the surface plots and mixed into the top 1 cm of the soil. The turf plots were watered daily with 5 L m^{-2} for the first month after seeding, and 10 L m^{-2} thereafter. No rainfall is usually received during summer. Prior to seeding plots, inorganic fertilizer was applied at a rate of 40 g N, 3.3 g P and 27 g K per m^2 and all were incorporated into the upper 20 cm of plots.

Percentage of plot area covered by turf grass was evaluated by visually estimating the surface covered by turf grass4 and 8 weeks after seeding. To assess shoot and root growth and mycorrhizal colonization of roots, ten plants were collected randomly with their intact roots from each plot 8 weeks after seeding. After that, plants were clipped to the height of about 5 cm from soil level, and clippings were collected to determine clipping yield. Five of sampled plants were used for determination of shoot and root

growth parameters. Root samples from the other sampled five plants were cleared with 10% (w/v) KOH solution and stained with 0.05% trypan blue in lactophenol as described by Phillips and Hayman (1970), and microscopically examined for colonization using a gridline intercept method (Giovannetti and Mosse, 1980).
The experiment was arranged in a randomized complete block design with three replicates. Data were statistically analyzed using analyses of variance (ANOVA). Probabilities of significance among treatments were used to compare means between treatments.

RESULTS AND DISCUSSION

Turfgrass roots in AM plots after 8 weeks of seeding had been colonized extensively with AM fungi (~83%), while no root colonization with AM fungi has been noted in the control plots (Table 1). It has been reported that extensive system of hyphae that are growing out of colonized roots into the surrounding soil can provide a variety of benefits to the host plant (Pelletier and Dionne, 2004). The distributed network of hyphae beneath soil surface greatly increases the capacity of root system to absorb water and uptake of nutrients (especially low mobile nutrients in soil). The network of fungal filaments also helps in improving soil structure, porosity and aeration by binding soil particles (Pelletier and Dionne, 2004).
Highly significant differences in turf seedling size (shoot and root lengths an weights) andclipping yields were observed for the AMplots compared to the nonAM plots 8 weeks after seeding (Table 1). These results revealed that the mycorrhizal plants produced more biomass (high clipping rate) per unit of water applied through irrigation than control plants. Early establishment of turfgrass might reduces the need for high water use which help growers to increase irrigation intervals (less number of irrigation times) due to improved water holding capacity and extended root system by mycorrhiza, so help the plants to utilize water more efficiently (Pelletier and Dionne, 2004).

Table 1. Root colonization, shoot and root growth and clipping yield of mycorrhized (AM) and non-mycorrhized (NonAM) turf grass 8 weeks after seeding.

Treatment	**Root colonization**	**Clipping yield**	**Shoot dry weight**	**Root dry weight**	**Shoot length**	**Root length**
	%	g m-2	mg plant-1	mg plant-1	cm plant-1	cm plant-1
AM	0 b	32 b	18 b	5.1 b	7.3 b	6.8 b
Non-AM	83 a	182 a	38 a	13.5 a	18.1 a	10.7 a

Different letters denote significant differences between means of treatments.

Several studies have shown that grass species benefit greatly from mycorrhizal inoculation in terms of enhancement in the shoot and root growth (Gemma and Koske, 1989; Koske et al., 1995). Enhanced mycorrhizal inoculated turf was related to improved plant nutrition (Gemma and Koske, 1989), higher chlorophyll concentrations which enhance photosynthates production (Gemma et al., 1997), improved rooting depth, speed of establishment, disease and drought and salinity resistance of turf (Gemma etal., 1997; Koske et al., 1995).
After 4 weeks of seeding, turfgrass inoculated with AM fungi established more quickly than turfgrass not inoculated with AM fungi. This attained when percentage of plots area covered by turfgrass significantly higher in AM than nonAM inoculated plots (Fig. 1). After 8 weeks of seeding, no significant differences were observed between AM and nonAM plots (Fig 1.).

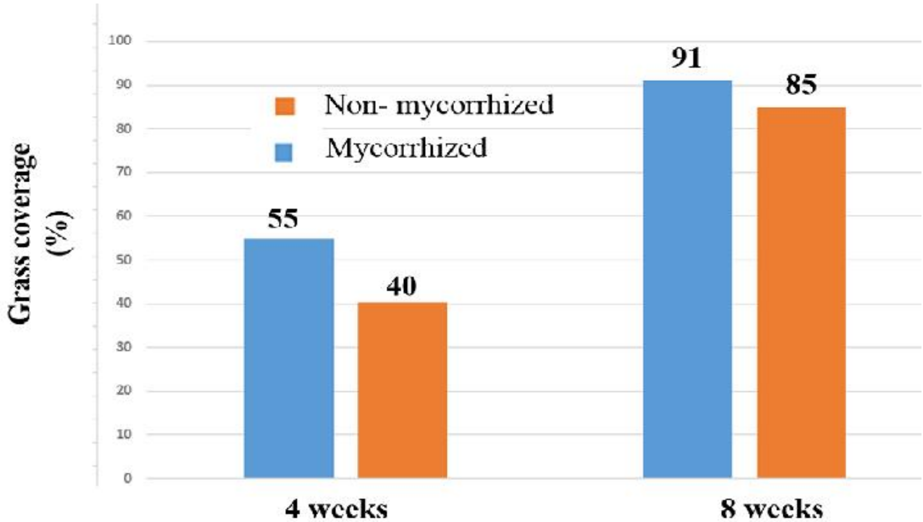

Fig. 1. Average grass coverage of mycorrhized and non-mycorrhized turf grass after 4 and 8 weeks of seeding.

However, shoot and root shapes were clearly different, AM plants having a greater size of shoots and longer and extensive roots (Fig. 2). These results suggest that inoculation with AM fungi is very efficient in increasing the speed of establishment of turfgrass seedlings in comparison to the controls at early time. The increase in establishment of turf grass is an important benefit to landscape owners as it improves the aesthetics of lawns, covering the surface and increasing the quality of grasses by reducing weed development. A dense cover may require less fertilizer due to high utilization of fertilizer directly into turf plants growth which reduces the fertilizer movement into ground water (Amaranthus, 2001).

Fig. 2. Shoot and root growth of mycorrhized (left) and nonmycorrhized (right) turf grass after 8 weeks of seeding.

CONCLUSIONS

It is apparent that mycorrhizal fungi are essential components of landscape ecological systems. Inoculation techniques for the management of turf grass plantations may be used, especially with improved inocula production methods development. The application of mycorrhizal fungi technology is an option that can benefit both agronomic plant health and ecosystems. Results of the field study indicated that inoculation of turfgrass with AM fungi is very efficient in increasing plant biomass and the speed of establishment of a standard turfgrass lawn seed mixture in comparison to uninoculated turf grown with low fertilizer inputs under arid and semiarid environments.

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