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The effect of traffic on turfgrass root morphological features

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ABSTRACT

Foot traffic is recognised as the most frequent and damaging stress to sports turf. Wear and compaction caused by play can be a greater factor contributing to differences among turfgrass species to traffic stresses. A better understanding of factors affecting wear tolerance is likely to be a useful tool for grass breeders in terms of cultivar recommendations for sports fields. The objective of this study was to determine whether the wear tolerance of turfgrass cultivars was dependent on root morphology. The experiment was conducted in 2012 and 2013 in Paczoltowice in the south of Poland. This field trial was set out in a split-plot design arranged in randomised complete blocks with three replications with cultivars as a main plot and traffic treatment as a subplot compared with an untreated control. Thirty seven cultivars, representing seven turfgrass species were established on loamy sand. Traffic treatments were applied as a strip using Brinkman traffic simulator (BTS). Roots in the experimental plots were sampled from the 0 to 15 cm soil layer in June 2012 and June 2013. Root morphological parameters were determined namely root length density (RLD), mean root diameter (MRD), root surface area (RSA) and root dry matter (RDM). Wear resistance of turfgrass cultivars was estimated using the Turf Cover Index (TCI) based on the percentage of turf cover on control and treated plots.

The results showed significant differences among the tested cultivars, in terms of all root morphological characteristics. The highest root biomass and length was produced by cultivars in the upper 0–5 cm soil layer. The most frequent fraction of the RLD for all tested cultivars was that with a diameter of 0.05–0.1 mm, representing approximately 63% of all root length. It was observed that the tested cultivars significantly differed in their TCI after the BTS compaction. The poorest wear tolerance, was recorded for most of *Festuca ovina*cultivars, namely 'Bardur', 'Barok', and 'Noni' and some of *Festuca rubra*, 'Audubon', 'Dark' and 'Nimba'. All cultivars of *Lolium perenne* were assessed as having a very good wear tolerance. The roots of investigated turfgrass cultivars showed a different reaction to trafficking. Most of the investigated cultivars reacted negatively to the traffic simulation by Brinkman roller. The BTS treatment reduced root length, dry matter and surface. However, some cultivars, mainly those of *L. perenne*,showed positive reactions to trafficking. It was found that the wear tolerance was positively correlated with the RLD in the root diameter range from 0.1 to 2.0 mm. The higher RDM, RSA and MRD increased wear resistance of turfgrass cultivars.

1. Introduction

Foot and vehicular traffic cause mechanical injury to turfgrass (Hoffman et al., 2010). This is a serious problem on recreation and sport turfs, such as football pitches, golf courses etc. Grass cultivars designed for these turf sites should have good wear tolerance and the ability to withstand forces that crush the leaves, stems, crowns and roots of the plant. The degree of damage caused by traffic on turf mostly depends on turfgrass species, environmental factors, intensity of traffic and turfgrass management activities, namely moving, fertilisation, irrigation, and aeration etc. Numerous agronomic practices are recognised as improving wear tolerance and turfgrass recovery, such as fertilisation, irrigation, overseeding or even plant growth regulator application (Hoffman et al., 2010; Thoms et al., 2011; Deaton and Williams, 2010).

Turfgrass breeders worldwide continually work to develop improved cultivars with higher wear tolerance, with the goal of understanding the plant characteristics that contribute to turfgrass wear tolerance. Wear tolerance is usually ascribed to the anatomy and morphology of grass stems and leaves. Investiga-

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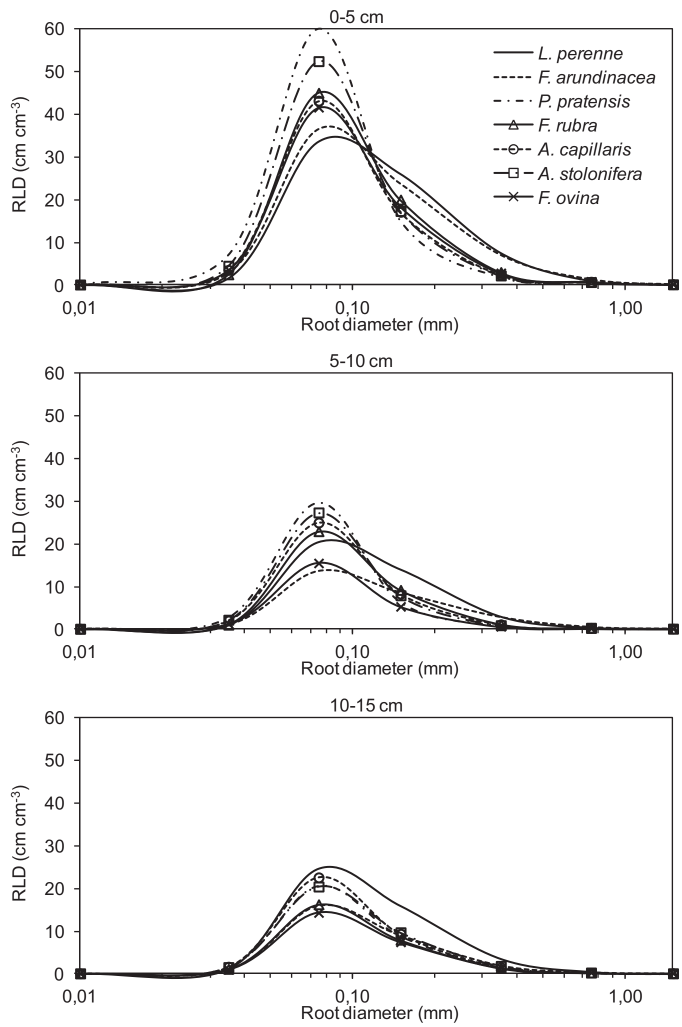

Fig. 1. Root length density (RLD) distribution at the different root diameter values for different turfgrass species. Results are the averages of two years, 2012–2013, Paczółtowice, Poland.

tions suggested that wear tolerance corresponds to anatomical and morphological plant characteristics, namely total cell wall content, quantity of sclerenchyma fibres, tiller density, tiller dry weight, leaf width and leaf tensile strength, and shoot density (Głąb et al., 2015; Hoffman et al., 2010; Trenholm et al., 2000; Shearman and Beard, 1975a,b).

A previous study by Głąb et al. (2015) showed that wider leaves with a higher number of vascular bundles together with a higher angle between the leaf and tiller axis, improved wear resistance. These relationships were also confirmed by Dowgiewicz et al. (2011) for *Agrostis* spp. They recommended breeders of *Agrostis* to give priority to greater tiller density and cell wall content with secondary emphasis to breeding for a more upright growth habit. Lulli et al. (2011) stated that lignin was the principal constituent determining tissue tensile strength in C4 turfgrass species. Brosnan et al. (2005) and Dowgiewicz et al. (2011) suggested that wear tolerant genotypes are associated with a more vertical leaf angle, greater total cell wall and lignocellulose content, and a lower shoot moisture content and leaf turgidity. Other physiological parameters are recognised to impact on wear tolerance; namely, modified acid detergent fibre (Canaway, 1981), sucrose phosphate synthase and sucrose synthase activity, stem and leaf moisture (Trenholm et al., 2000; Babb and Haigler, 2001; Bayrer et al., 2006), leaf flexibility (Sun and Liddle, 1993), evapotranspiration rate, leaf chlorophyll concentration, membrane permeability, leaf peroxidase activity, spectral reflectance, tissue potassium (Carrow and Petrovic, 1992) and silica concentration (Trenholm et al., 2001).

On grasslands, root biomass and its distribution in soil affects above ground yields (Głąb, 2013b; Hejduk and Hrabe, 2010). The research conducted by Głąb (2013b) showed that plant root morphology is strictly dependent on traffic and related soil compaction. Soil compaction increases mechanical impedance, creates unfavourable growing conditions for roots and restricts the supply of oxygen, water and nutrients (Chen and Weil, 2010; Głąb and Kopeć, 2009). A common response of the root system to increasing bulk density is to decrease rooting depth, concentrating root biomass in the upper layer (Głąb, 2013a; Lipiec et al., 2003). However, sometimes a positive correlation between root morphological parameters and traffic intensity is found. For instance Głąb (2013b) stated that intensive tractor traffic significantly increased the root length of *Poa pratensis*. These results indicated that this species could be recommended for compacted soils when intensive traffic is present. *P. pratensis* is the one of major species sown in mixtures with *Lolium perenne*, to create winter and summer sports pitches (Sampoux et al., 2012). However, the productive function of grasses is less important on sport turfgrass where the visual turf quality and playing quality are in the spotlight. Most of the investigation of the traffic:soil:root relationships were conducted in terms of for-