Dry Spots in Golf Courses: Occurrence, Amelioration and Prevention

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Abstract

Although soils are generally considered to wet readily, numerous sandy soils are actually water repellent at the surface and in the rhizosphere during dry periods. The failure to absorb water has been observed under a range of vegetation types, including grass. As soils dry, hydrophobic compounds polymerize and water repellency increases. Once a critical moisture content is reached, soils shift from wettable to non-wettable, impacting infiltration and unsaturated flow, in affected soils, and consequently water use efficiency and turf quality. Localized dry spot (LDS) caused by water repellent soil continues to be a problem for many golf course superintendents. We investigated this common soil condition in the greens and fairways of Dutch golf courses. Spatial variability in degree of water repellency and soil water content were studied in vertical transects by intensive sampling. Dry spots exhibited extreme water repellency (water drops remaining for more than six hours on the surface of soil samples) to a depth of more than 200 mm. Treatments with surfactants reduced water repellency in the surface layer, decreased critical soil moisture content, improved temporal infiltration rate of applied irrigation water, and increased the volumetric water content in the rootzone. To prevent soil water repellency the soil profiles have to be kept above the critical soil moisture content by regular irrigations.

INTRODUCTION

The problem of water repellent (difficult to wet) soils has been recognized in various parts of the world and has caused for instance serious land use problems in sandy soils with grass vegetation (Dorman et al., 1964; York, 1993; Wallis et al., 1989; Dekker et al., 2001; Hallett et al., 2001; Karnok and Tucker, 2001). Symptoms of these water repellent soils are often found in the greens, fairways and tees of golf courses as irregular shaped areas of drought-stressed turfgrass, known as localized dry spots (Wilkinson and Miller, 1978; Tucker et al., 1990; Thomas and Karcher, 2000) and as dry patch (Bond, 1978; Shiels, 1982; Rankin and Ross, 1982; Baldwin, 1989). Water repellency of a soil is a function of the type of organic matter incorporated in it, and can be induced by several means. Micro-organisms in soil, sand or thatch produce waxy secretions which are water repellent. Sand particles are aggregated by sticky polysaccharide secretions from bacteria, by fungal hyphae, filaments from actinomycetes and mucilage from algae (Miller and Wilkinson, 1977; Rankin and Ross, 1982).

Water repellency may dramatically affect water and solute movement and have been shown to cause nonuniform wetting and preferential flow in many soils, including sandy soils of greens, fairways and tees of Dutch golf courses (Dekker et al., 2001, 2003).

The remainder of this paper will focus on the variability in degree of soil water repellency and the spatial variation in soil water contents in a sandy green of the golf course Cromstrijen, located at Numansdorp in the southwestern part of the Netherlands.

MATERIALS AND METHODS

Soil samples were taken at seven depths in a transect of the green, using steel cylinders with a diameter of 50 mm. At each depth 35 samples were taken in close order over a distance of about 1.75 m. Water repellency of the soil samples was assessed for all samples in a field moist status. These measurements are considered to provide the most meaningful repellency results, since they represent repellency conditions as they actually occur in the field. Water repellency was measured using the Water Drop Penetration Time (WDPT) test. This involved placing three drops of distilled water onto the surface of the soil sample and recording the time for their complete penetration. In addition water repellency was assessed for all samples after air-drying, again using the WDPT method. Thereafter soil samples had been oven-dried to calculate the soil water content.

Soil water contents in the upper 80 mm of the green were measured with Time Domain Reflectometry (TDR) in a grid of 100 mm x 100 mm over an area of 1.8 m by 1.8 m on 27 March 2003.

RESULTS AND DISCUSSION

The occurrence of poor grass growth at the surface of the green of Cromstrijen on 27 March 2003 was related to the lower soil water contents in the upper 80 mm of the soil profile, as measured by TDR (Fig.1). In addition, the measurements indicated that soil moisture variability was still high after a precipitation surplus during the winter period.

The water repellency measurements on 20 November 2002 showed that water repellency is not only a surface phenomenon, as often assumed (e.g. Kostka, 2000) but can extend beyond 200 mm depth (Fig. 2). The soil water contents varied greatly along the transect, with volumetric water contents ranging between 19 and 68% (v/v) in the upper 25 mm (Fig. 3). A large number of the field-moist samples were wettable, with water drops infiltrating in less than 5 sec, but nearly all water repellent samples exhibited extreme hydrophobicity with infiltration times of more than 6 h (Fig. 4A). However, air-drying of the wettable samples resulted in slight to extreme water repellency (Fig. 4B).

Water content has a large effect on the actual water repellency of a soil. The critical soil water content is the soil water content below which the soil becomes water repellent and above which the soil is wettable (Dekker et al., 2001). The critical soil water content at 25-50 mm depth in the green was established at 8.5% (v/v) and at 3% (v/v) for the 165-190 mm depths (Fig. 5). The decrease in the critical soil water content with depth is related to the decrease in organic matter content with depth on this sandy soil.

Water repellency and its spatial variability do not only cause differences in grass growth, but also nonuniform wetting and preferential flow, which may dramatically affect water and solute movement. Soil surfactants have been used as a possible means for overcoming problems related to water repellency. Coring is also a method of turf cultivation in which soil cores are removed using hollow tines. Penetrating water repellent soils by coring encourages water movement down into the soil. Coring was more effective than spiking or slicing, but none of the cultivation techniques were as effective as a proper wetting-agent treatment combined with coring. Treatment of existing dry spots is more effective by using a high-pressure injection system. This sprayer has the capability of injecting materials up to 70 to 130 mm in a sand-based green. Initial results look very promising, and the study will be continued and expanded the coming years.

CONCLUSIONS

Treatments with surfactants reduce water repellency and improve the infiltration rate, but the best is to prevent soil water repellency by keeping the soil above the critical soil water content by regular irrigations.

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Figures

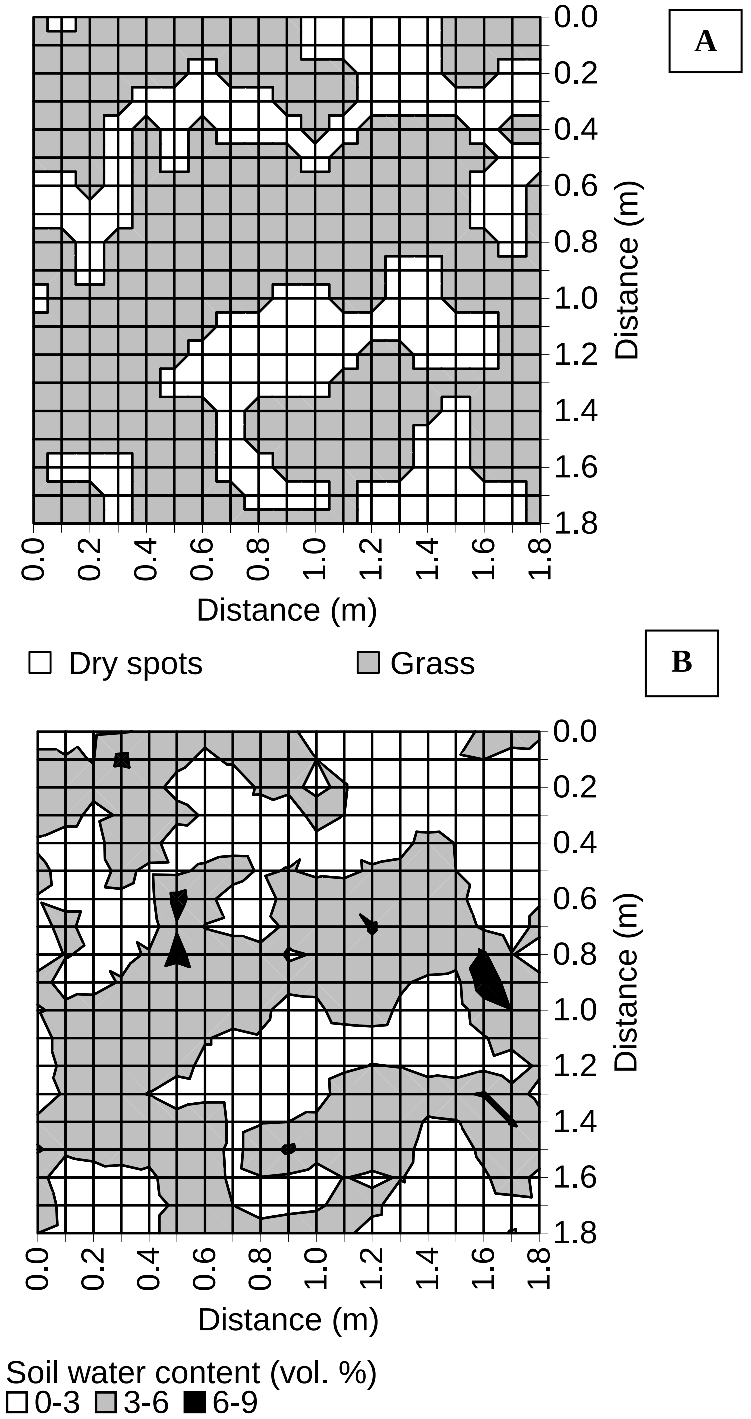

Fig. 1. Visual observation of dry spots at the surface (A) and measured soil water contents in the surface layer (B) of the green on 27 March 2003.

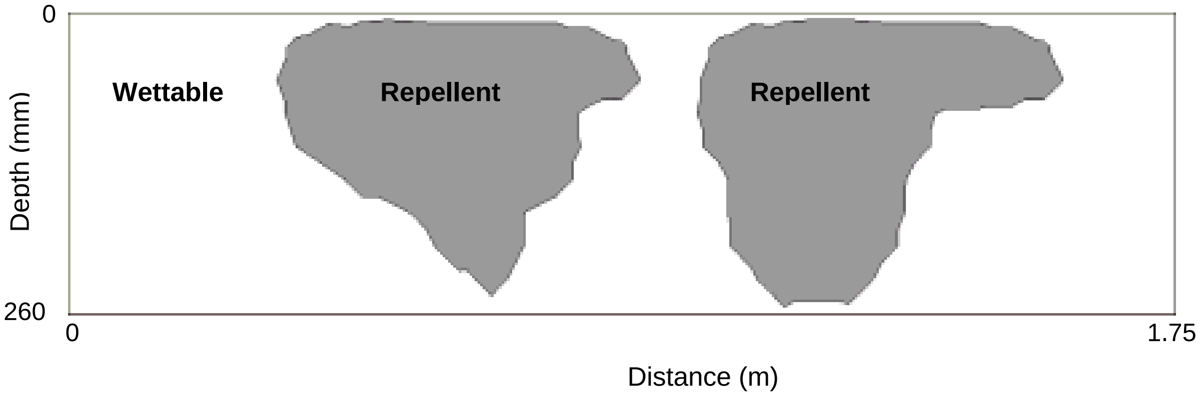

Fig. 2. Distribution of wettable and water repellent soil in a transect of the green over a distance of 1.75 m and over a depth of 260 mm on 20 November 2002.

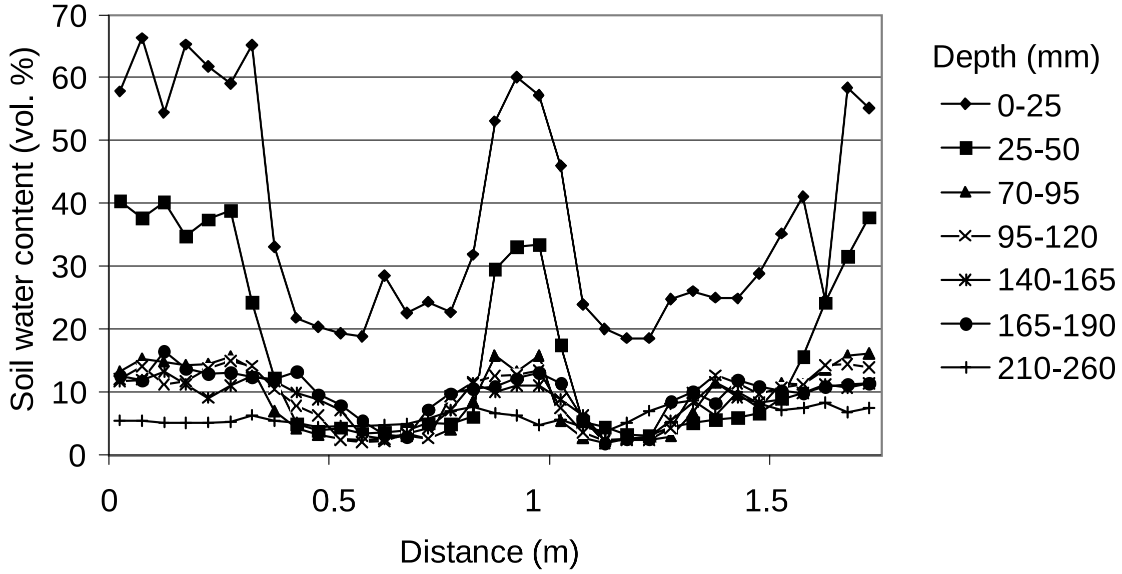

Fig. 3. Soil water contents at seven depths in the transect of the green over a distance of 1.75 m on 20 November 2002.

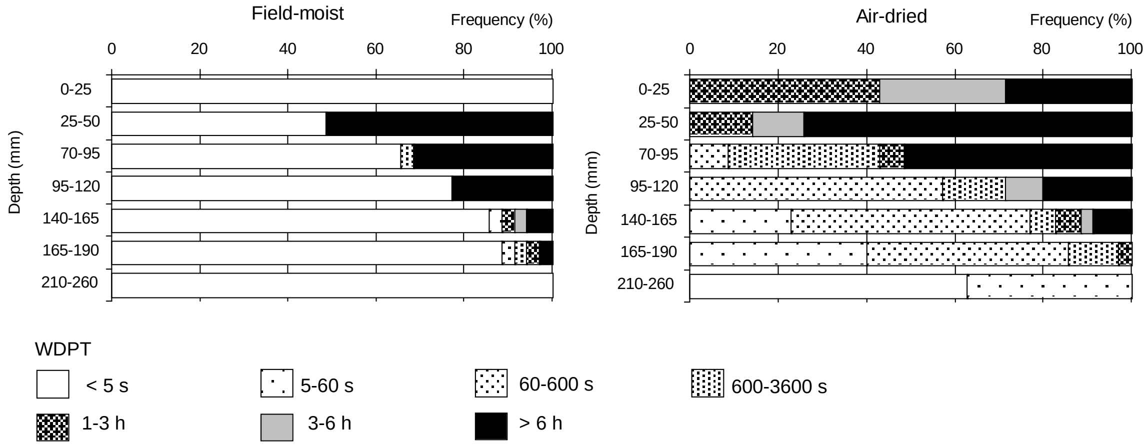

Fig. 4. Relative frequency of the persistence of water repellency of the field-moist and air-dried soil samples, taken at seven depths in the green on 20 November 2002 (n = 35).

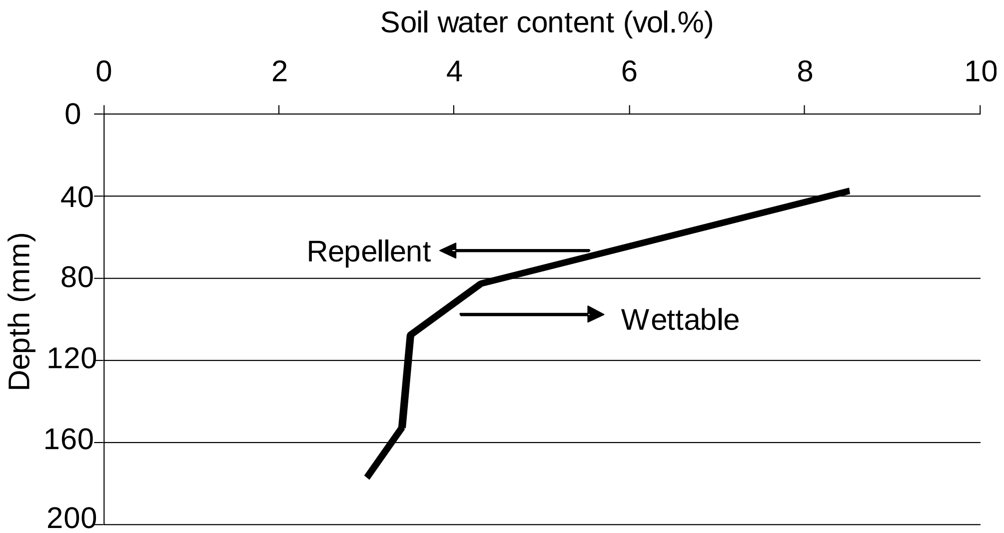

Fig. 5. Critical soil water content versus depth for the green, indicating actually wettable soil to the right, and actually water repellent soil to the left of the line.