Impact of Soil Water Repellency on Seedling Emergence and Growth

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Abstract

Water repellent soils do not wet spontaneously when water is applied on the surface. Water repellency may affect seedling success by decreasing available moisture contents. The objective of this study was to identify the effects of soil water repellency on seedling emergence and seedling growth, using arable soils under laboratory conditions. Two initial moisture contents, three clay levels, five organic matter levels, and one crop species were arranged in a complete randomized design with twenty replicates per treatment. Soil water repellency was estimated using water drop penetration time test and sessile drop method. Seedling emergence and seedling growth were assessed using the time taken for seedling emergence, and seedlings to reach three inches height after planting, height and dry weight of shoots and roots at seven days after the germination. Under low initial moisture condition (1/3 of field capacity; FC) clear relationship could not be detected because of several unexpected problems due to high water stress. Under high initial moisture condition (FC), time taken for the seedling emergence and seedlings to reach 3 inches increased, whereas the shoot growth decreased, with increasing water repellency (contact angle from 20° to 100°) in samples with 0–2% clay. Soil water repellency did not show clear effects on root growth. The results revealed that soil water repellency has negative effect on both seedling emergence and seedling growth.

Keywords: clay, contact angle, organic matter, soil water repellency

Introduction

Water repellent soils do not wet spontaneously when water is applied on the surface. Water repellent soils are found worldwide in adverse soils under different kinds of cropping systems (Wallis and Horne, 1992). Soil organic matter and clay play an important role in making a soil wettable or repellent (Leelamanie and Karube, 2007). Water repellent organic coatings around mineral particles limit water entry into soils. Clay additions have long been used as an effective way to reduce water repellency in sandy soils, where kaolinitic clays are the most successful (McKissock *et al.*, 2000).

Poor seedling emergence results reduction in yield, which may take place as a result of poor soil water content, low and high soil temperature, poor seed-soil contact, soil compaction or smearing, surface crusting after sowing and poor quality seeds.

A suitable seedbed condition for germination and seedling emergence depend on the soil physical properties. DeBano (1969) found that soil water repellency cause reduction in seed germination and seedling survival. Soil water repellency can promote run off, decreases soil water content and impair seedling emergence, growth and plant survival.

The objectives of the present study were (i) to identify the effects of organic matter induced soil water repellency on seedling emergence, seedling growth, and root elongation, (ii) to examine the relation of initial water content to the water repellency effects on seedlings, and (iii) to examine the relation of clay addition to the water repellency effects on seedlings using arable soils under laboratory conditions.

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Methodology

Arable top soil (0 - 10 cm) obtained from Udupila, Mirissa was used for the experiment. Soil samples were air dried and sieved through 2 mm sieve.

Ground powder of *Casuarina* leaves was used as the organic matter to obtain different water repellency levels. *Casuarina* leaf litter was collected from *Casuarina* forest at Mirijjavila, Hambanthota. *Casuarina* leaves were air dried and ground using mechanical grinder and sieved with 1 mm sieve.

Clay was used as a wetting agent in this experiment. Clayey soil samples were collected from field at Malana, Kamburupitiya (under 10 feet depth). Clayey soil samples were dissolved in water and the clay fraction was separated. The separated clay solution was dried under the sunlight and powdered. The major clay was found to be kaolinite.

The experiment was conducted under shaded condition in the Faculty of Agriculture, University of Ruhuna. Treatments were consisted of two initial moisture contents (field capacity, FC and 1/3 of FC), three clay levels (0, 2 and 5%), five organic matter levels (0%, 5%, 10%, 15%, and 25%), and one crop species (Cowpea- *Vigna unguiculata*), where all the combinations were arranged in complete randomized design with twenty replicates per treatment. One pot was used for one seed.

Soil water repellency was determined using water drop penetration time and contact angle measurements. Seedling emergence and growth were estimated using the time taken for the seedling emergence and the time taken to reach 3 inches height after planting, respectively. Shoot and root height and dry weight after 7 days from germination were also recorded. Data were analyzed using SAS software. Duncan's' mean separation method was used for mean separation.

Results and Discussion

Water repellency

Water drop penetration time (WDPT) of soil samples with 0% clay increased with increasing organic matter content. Samples with 2-5% clay did not show an increase in WDPT. Contact angle continuously increased with organic matter content demonstrated decreasing slope, where the increase in contact angle was negligible at higher organic matter contents. Although 2-5% clay addition obviously decreased WDPT of the soil samples, clear effect of clay addition on contact angle of the same soil samples could not be detected.

Time taken for seedling emergence

Figure 1 shows the time taken for the seedling emergence after planting changes with contact angle (water repellency) under initial moisture content at FC. Up to about 90°, increase in contact angle did not increase the time taken for the seedling emergence in a considerable manner. Clear increase in the time taken for the seedling emergence was observed with increasing contact angle to values above 90°. Under this initial moisture content, 5% clay level showed longer time than other two clay levels for emergence, which might have caused by the crust formation due to high clay content.

When the initial moisture content was 1/3 FC, time taken for the seedling emergence in soils with 0-2% clay levels continuously increased with increasing water repellency up to a contact angle of about 90°. This might be related to the evaporation of water from the pots. Evaporation reduces with increasing water repellency in soils. As a result of that, drying of the particular soils would be avoided. At high water stress under 1/3 of FC, this water conserving effect at high water repellency might have caused the decrease in the time taken to seedling emergence. In samples with 5% clay, the time taken to seedling emergence continuously decreased with increasing contact angle that might be a result of further water conserving effect. The clay effect on seedling emergence disappeared with increasing water repellency.

Compared with the initial moisture content at FC, the time taken to seedling emergence was considerably longer in soils with initial moisture content at 1/3 of FC.

For initial moisture content at 1/3 of FC, a clear relationship between the time taken for seedlings to reach a height of three inches and water repellency could not be detected.

Shoot Growth

Under the high initial moisture condition (FC), the shoot height slightly decreased with increasing water repellency up to about 90° of contact angle. However, 2-5% clay added samples showed a slight increase in shoot height with increasing contact angle up to about 90°. At high water repellency conditions with contact angles above 90°, samples with all the three clay levels showed similar behavior in shoot height, demonstrating sharp decrease in seedling height with increasing water repellency. Therefore, it was clear that water repellency has strong effect on shoot height at contact angles above 90°. However, a clear

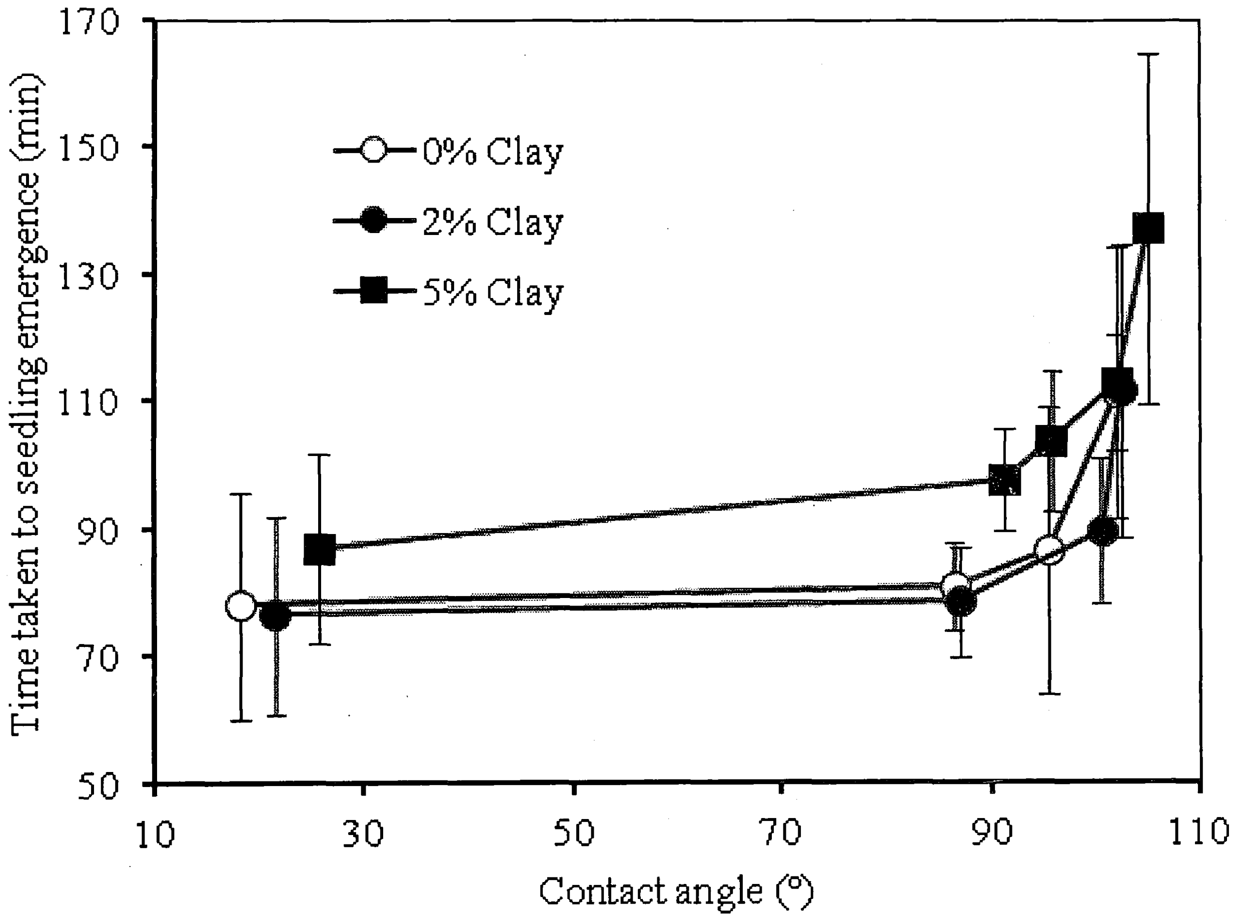

Figure 1. Time taken to seedling emergence after planting changes with contact angle (water repellency) under initial moisture content at FC

Time taken for seedlings to reach 3 inches

In general, the time taken for seedlings to reach a height of three inches increased with increasing water repellency. This increase was more prominent at contact angles higher than 90°.

relationship between shoot height and water repellency could not be detected in case of initial moisture content at 1/3 of FC.

Root Growth

The root length of seedlings with initial moisture content at FC slightly increased with contact angle up to about 90°, and thereafter slightly decreased with contact angle. Root growth did not show clear relation to water repellency under initial moisture content at 1/3 of FC.

Conclusions

The time taken to seedling emergence and the time taken for seedlings to reach a height of three inches increased, whereas the shoot growth of seedlings decreased, with increasing water repellency for samples with initial moisture content at FC. Root growth was not clearly affected by the water repellency of soils. Due to the high water stress under initial moisture content at 1/3 of FC, seedlings faced several unexpected factors besides the effects of water repellency. Therefore clear relationships between water repellency and seedling emergence shoot and root growth could not be detected. Clay addition is usually used to remove the water repellency hazards. However, in this study, clay addition was not effective in amending water repellency.

The major conclusions of the study are; (1) Water repellency has detrimental effect on seedling emergence and seedling growth; (2) Soil water repellency did not show clear effect on root growth of seedlings

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