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The influence of magnetized water on soil water dynamics under drip irrigation systems

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ABSTRACT

Soil water dynamics under drip irrigation systems are of considerable importance in designing, managing and operating these systems. Emitter discharge, soil type, soil chemical properties, crop water-requirements, and quality of applied water are the main factors affecting soil water dynamics under drip irrigation. In this study, laboratory experiments were conducted to study the effect of magnetized water on wetting pattern dimensions and water content distributions under surface emitter. Passing water through permanent or electro magnets installed on feeding pipeline resulted in producing magnetized water. Two emitter discharges (3 and 4.5 l/h, in average), two soil types (sand and clay), two soil profiles (homogeneous and layered-textural) and two water types (plain and magnetized water) were considered in the experiments. It was found that using magnetized water led to increase surface wetted radius by 6.2% and decrease vertical wetted depth by 6.3% in homogeneous soil profiles. In layered-textural soil profiles, the surface wetted radius slightly decreased by 1.8% while the vertical wetted depth increased by 7.0% in case of sand over clay and decreased by 2.0% in case of clay over sand when using magnetized water. As a result of using magnetized water, the total wetted area decreased for homogeneous profiles and increased for layered-textural profiles. It was concluded that the impact of magnetized water is statistically significant on wetted bulb dimensions and not statistically significant on water content distributions. The results revealed that using magnetized water is recommended especially in homogeneous soil profiles.

1. Introduction

Wetting patterns under single emitter are prerequisite needs in designing, managing, and operating drip irrigation systems. An efficient design of these systems should include optimal combination among wetting pattern dimensions, spacing between emitters and laterals, root zone depth, emitter discharge, and soil characteristics. Many factors affect soil water dynamics under surface emitter such as soil characteristics, emitter discharge, volume of applied water, application time, and type of applied water. Most of these factors have been widely studied over the last decades. However, little attention has been paid on the effect of water type, especially magnetized water, on soil water dynamics. Passing water through permanent or electro magnets installed on feeding pipeline resulted in producing magnetized, magnetic or magnetically treated water (Higashitani et al., 1993). It has been concluded by many studies that even a low magnetic field can change the water to be magnetized (Amiri and Dadkhah, 2006; Chang and Weng, 2006; Ji et al., 2007; XiaoFeng and Bo, 2008). Water characteristics including electromagnetism, thermodynamics, optics, and mechanics change as a result of magnetization, for instance, changes in viscosity, density, salt solution capacity, boiling and freezing points, pH, electrical conductivity, surface tension, and dielectric constant (Amiri and Dadkhah, 2006; Chang and Weng, 2006; Ghauri and Ansari, 2006; Higashitani et al., 1993; Ji et al., 2007; XiaoFeng and Bo, 2008). Maheshwari and Grewal (2009) conducted set of experiments to assess the influence of magnetic treatment of several types of irrigation water on water productivity and yield of celery, snow pea and pea plants. The different types of irrigation water were magnetically treated by a magnetic treatment device of intensity 3.5–136 mT. The results revealed that the influences of the water magnetization varied with the type of irrigation water used and plant type, and the plant yield and water productivity increased significantly. Patil (2014) studied the influ-

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ences of magnetized irrigation water on the yield of banana. Field experiments were conducted on banana farm which was divided into two plots, one irrigated using plain water and the other using magnetized water. In general, there was improvement of germination, flowers, plant growth, fruit and crop yield resulted from using magnetized water which also led to avoid growing white salty deposits near the plant. It was also noted that the average yield per plant was 19 kg and 15 kg in plot irrigated by magnetized and plain water, respectively which means that the increase in yield was 26.67%. Khoshravesh et al. (2011) and Mostafazadeh-Fard et al. (2011) conducted field experiments to investigate the influence of magnetized water and water irrigation salinity on the distribution pattern of soil moisture under drip irrigation systems. Two sub-units of three laterals were selected to study the two main treatments, magnetized and non-magnetized water. Three sub-treatments of irrigation water salinity for each lateral of a sub-unit were considered: Well water as a control, 200 ppm calcium carbonate, and 400 ppm calcium carbonate. In general, there was an increase in the soil moisture content up to 7.5% for the magnetized water treatment with comparison to non-magnetized water, and that increase was significant at 1% level. The authors concluded that using magnetized water is recommended for increasing the soil moisture and reducing the deep percolation, and consequently decreasing the irrigation intervals to achieve higher irrigation efficiency.

Mostafazadeh-Frad et al. (2012) investigated the influence of magnetized water on soil chemical characteristics such as soil cations and anions under drip irrigation systems. They utilized the same field experiments with same treatments of Mostafazadeh-Fard et al. (2011). The measurements of soil chemical parameters were done by soil sampling at different positions around the emitters 24 h after irrigation for the first and tenth irrigation. It was concluded that using magnetized water led to reduce soil cations and anions, and this reduction was significant. Yildirim (2014) presented intensive discussion by focusing on some points that may improve the study of Mostafazadeh-Frad et al. (2012). Three main points were discussed: hydraulic principles for flow in in-line helical long-path emitters, influence of viscosity change on the flow regime through the same emitters, and the impact of magnetized water on soil chemical elements. This discussion led to an important point that needs more research on the positive relative influence of magnetized water on reducing the clogging problem for the helical long-path emitters tested in the study of Mostafazadeh-Frad et al. (2012). Recently, Surendran et al. (2016) assessed the impact of magnetized water on water properties, soil moisture, and on growth and yield parameters of cow pea and brinjal using pot and field experiments. It was concluded that magnetization treatment resulted in changing water properties such as electrical conductivity, total dissolved solids, salinity level and pH. The soil moisture was found to be higher for magnetized water as compared to non-magnetized water. Additionally, the crop growth and yield parameters of cow pea under pot experiments improved and the yield of brinjal in the field experiments improved when using magnetized water. The objective of this study is to investigate the effects of magnetized water on soil water dynamics under drip irrigation systems.

2. Materials and methods

Detailed information about the experimental setup, soils, emitter discharges, and procedure followed in this study was illustrated in Al-Ogaidi et al. (2016). However, concise description is presented here. Series of laboratory experiments were performed at Irrigation and Drainage Laboratory, Faculty of Engineering, Universiti Putra Malaysia. The experiments were conducted using a soil container of internal dimensions of 50 cm length, 50 cm width, and 70 cm depth. To monitor the wetting front movement, two sides of the container were fabricated from plexiglass sheets. The water was applied at the corner of the container where the plexiglass sheets intersected, so this container represents one part of four parts of complete cylinder. Therefore, quarter of the wetted soil zone was simulated so the actual emitter discharges were multiplied by 4 and displayed here (Li et al., 2003, 2004, 2005, 2007; Zhang et al., 2015). The water application system consists of two tanks installed on a stand where the upper tank was fixed and supplies water to the lower tank which is movable to adjust the hydraulic head and set the required emitter discharges. Tap water was used in the experiments after passing through a domestic water filter of two stages to avoid emitter clogging (Fig. 1). The laboratory experiments were carried out assuming that the soil surface is flat as slopped surfaces behave differently. At the end of each experiment, the vertical plane of the container was placed on a horizontal surface to prevent moisture redistribution. Then, one transparent side of the container was opened for soil sampling purpose to investigate water content distribution. The soil sampling was done based on a horizontal and vertical intervals of 5 cm starting 2.5 cm from the emitter position.

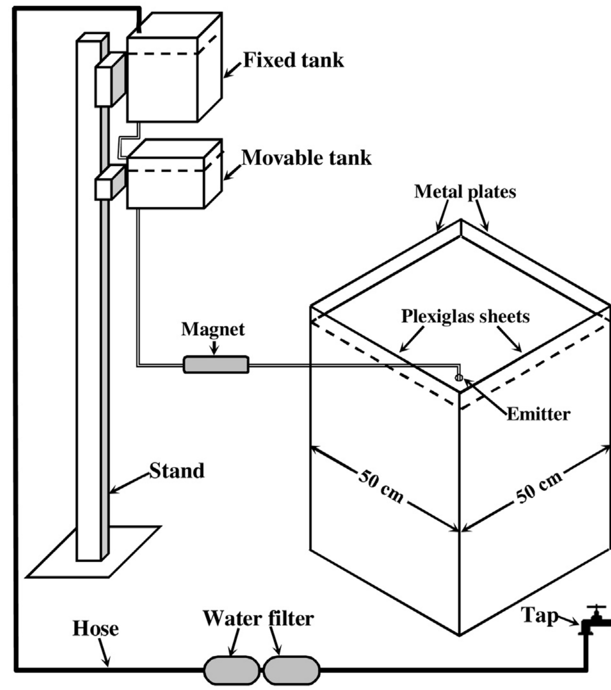

Fig. 1. Schematic view of the soil container and water application system.

Two soils were used in the experiments, clayey soil (29.28% sand, 10.57% silt, and 60.15% clay) and sandy soil (94.02% sand, 4.11% silt, and 1.87% clay). An adequate amount of each soil was collected, spread, air dried, passed through a 2 mm sieve, mixed carefully, and kept in plastic bags. The soil profile was prepared by packing the soil in the container gradually until reaching 65 cm depth with average bulk density of 1.21 and 1.61 g/cm^3 for clayey and sandy soils, respectively. The average initial volumetric water content were 0.052–0.060 and 0.011–0.016 for clayey and sandy soils, respectively. In total, 16 experiments were conducted using two application rates (3 and 4.5 l/h, in average), two homogeneous profiles (sandy and clayey profiles), two layered-textural profiles (sand over clay and vice versa), two types of water (plain and magnetized water) with application time of 430 min for all experiments. The magnetization device consists of two magnetization stages of strength; 0.4 and 0.2 T. Table 1 shows a summary of these experiments.