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IMPACT OF THE INSTALLATION DEPTH ON THE PERFORMANCE OF SUBSURFACE IRRIGATION SYSTEM AND ITS MODIFIED VERSION "KISSS" COMPARED TO THE SURFACE DRIP IRRIGATION SYSTEM

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ABSTRACT

Precision application of irrigation water, which is a key factor in improving water use efficiency as well as the quantity and quality of agricultural products, can be achieved through the application of modern irrigation technologies. Therefore, the objective of this research was to study the performance of subsurface irrigation system (SIS) and its modified version (the KISSS) installed at different soil depths against the conventional surface drip irrigation (SDI). The experimental work of this study was conducted on a field located in the Educational Farm of the College of Food and Agriculture Sciences of King Saud University, Riyadh, Saudi Arabia. Five irrigation systems were investigated in this study representing (i) the SDI, (ii) the SIS at 15 cm installation depth (SIS-15), (iii) the SIS at 25 cm installation depth (SIS-25), (iv) the KISSS at 15 cm installation depth (KISSS-15) and (v) the KISSS at 25 installation depth (KISSS-25). Experiments were conducted under two irrigation levels: (i) Level 1: 4 L h^{-1} × 2 hours, referred as 100% irrigation level, and (ii) Level 2: 4 L h^{-1} × 1 hour, referred as 50% irrigation level. The results indicated that the five tested irrigation systems responded significantly to the irrigation level and the elapsed time after the application of irrigation water. Also the results revealed that the distribution of soil moisture across the soil profile was significantly influenced by the installation depth of the laterals. When installed at the same soil depth, the modified KISSS showed the best results of soil moisture distribution compared to the SDI and SIS. The KISSS-15 and KISSS-25 distributed soil moisture in the horizontal direction more uniformly compared to the other systems as indicated by the high values of the coefficient of uniformity. On the other hand, the KISSS showed the highest moisture values in the upper part of the soil profile (soil depth ≤ 20 cm) and the lowest values of soil moisture values in deep locations (20 – 50 cm). These results imply that the KISSS improves the upwards movement of water and minimizes the deep percolation losses of irrigation water. Based on the best results of KISSS in terms of efficient distribution of soil moisture across the soil profile, especially in the horizontal direction; it is recommended to adopt the modified capillary irrigation subsurface system at depths commensurate with different crops.

Keywords: capillary irrigation, subsurface irrigation, installation depth, uniformity coefficient.

INTRODUCTION

The agricultural sector utilizes about 80% of total water resources on the global scale, and about 90% in Saudi Arabia (Multsch *et al.*, 2011). Severe arid conditions constrained agricultural production in the Arabian Peninsula. Except for the southwestern mountains, the average annual precipitation in the Kingdom of Saudi Arabia ranges from 80 mm to 140 mm; with maximum temperatures (in summer) often exceed 45 °C, very low relative humidity and clear skies most of the time (Alkolibi, 2002).

The use of modern technologies (e.g. sprinkler, drip and pot irrigation methods) in addition to the well planned irrigation systems (i.e. efficient irrigation systems) is a key factor in avoiding excessive irrigation which leads to wasting water as well as its negative impact on the performance of the cultivated crops. Connellan (2002) summarized the four major principles that need to be taken into consideration for efficient irrigation system as that: (i) the quantity of irrigation water must be optimum for both crop and soil, (ii) the irrigation schedule should match crop water requirements under various weather conditions, (iii) the irrigation water should be applied in a uniform and efficient manner, and (iv) the irrigation water must be precisely applied to the crop root zone; hence, water losses through runoff, deep percolation and poor coverage, will be minimized. Precise application of irrigation water improves water use efficiency and watering uniformity; hence, improves crop yield quantitatively and qualitatively (Singh and Rajput, 2007).

Drip (trickle) irrigation, refers to the application of water to the soil surface as drops or tiny streams through emitters (ASAE STANDARDS, 2003), is used to apply water and fertilizers on the soil surface (surface drip irrigation - SDI) or directly to the plant root zone (subsurface drip irrigation "or subsurface irrigation system" - SIS). The advantages of SIS over other irrigation systems have been reported by many scientists. Lamm (2002) summarized the major advantages of SIS related to irrigation water as that: (i) it increases water use efficiency by minimizing or eliminating evaporation, runoff and deep percolation, (ii) it minimizes water quality hazards by reducing runoff into streams and in addition to the less leaching of chemicals as a result of deep percolation, and (iii) it improves soil watering uniformity. Subsurface irrigation system (SIS) provides the highest