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Determination of Water Requirement and Crop water productivity of Crops Grown in the Makkah Region of Saudi Arabia

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Abstract: Determination of crop water requirement is one of the key parameters for precise irrigation scheduling, especially in regions with limited water resources, such as Saudi Arabia. Neutron probe and lysimeter measured Evapotranspiration (ET) data acquired at different crop growth stages were used to assess the total water requirements of different crops for an entire growing season. The crops included in the study encompassed seasonal crops (wheat, corn, broad beans, millet, cowpea, okra and eggplant) and forage crops (alfalfa, blue panic grass, rhodes grass and Sudan grass) grown in Makkah region, Saudi Arabia. The investigations were carried out at the Research Farm of King Abdul-Aziz University, Hoda Al-Sham, Makkah area. Results revealed that crop water requirements were found to vary from 303 to 727.8 mm in seasonal crops and from 436.7 to 1821.94 mm in forage crops. In addition, crop water productivity (CWP) of summer season crops (1.478 kg/m^3) was found to be higher than the values associated with forage (1.079 kg/m^3) and winter season (0.942 kg/m^3) crops. The lowest value of CWP was observed in corn (0.794 kg/m^3), while the highest value of 1.724 kg m^{-3} was associated with okra.

Key words: Crop water requirement, crop water productivity, neutron probe, lysimeter

INTRODUCTION

The geological surveys and exploration of arid lands during the last fifty years revealed vast natural resource endowments in parts of the Kingdom of Saudi Arabia and adjacent countries. Increase in population in the arid ecosystem of Saudi Arabia resulted in higher demand for food. This ever increasing demand has resulted in the transformation from arid land farming to irrigated agriculture relying, to a great extent, on the ground water as the main source of irrigation water. The groundwater is a non-renewable resource in the fragile arid ecosystems of the world, and its exploitation calls for an environmentally compatible and ecologically sustainable water resource management (Saif-ud-din, *et al*., 2004; FAO-Aquastat, 2009). Ground water in the Kingdom of Saudi Arabia, which is a non-renewable fossil water of age ranging from 10000 to 28000 years B.P. (Edgell, 1997), is exploited as the major source of irrigation (El-Quesy, 2009). Irrigation utilizes about 80 to 88% of the total water consumption in the Kingdom (Sadik and Barghouti, 1994). Moreover, the volume of water used for irrigation has tripled from about 6.8 km^3 in 1980 to about 21 km^3 in 2006 (FAO-Aquastat, 2009). The groundwater exploitation, if not managed judiciously, will result in environmental degradation of the fragile arid ecosystem and increase in the frequency and intensity of extreme weather events, such as droughts and floods (El-Quesy, 2009), which may cause economic, social and environmental effects (AbuZeid and Abdel Megeed, 2004; Ouda *et al*., 2011). Under such circumstances, adoption of optimum water management practices assumes prime importance for attaining national food and water security.

Efficient use of water resources can be made possible through the assessment of crop water requirements and proper scheduling of irrigation. Temporal prediction of soil moisture and evapotranspiration (ET) plays a crucial role in irrigation water management (Abdelhadi *et al*., 2000; Ali *et al*., 2007) and drought monitoring (Narasimhan and Srinivasan, 2005). ET from the field is an actual unrecoverable water loss within the irrigation schemes (Bryla *et al*., 2003). It has been demonstrated that optimal irrigation scheduling requires accurate estimates of crop evapotranspiration (ETc) (Doorenbos and Pruitt, 1977; Kamel *et al*., 2012). Allen *et al*. (1998) reported that factors, such as soil salinity, poor land fertility, limited application of fertilizers, presence of hard or impenetrable soil profiles, lack of proper control of diseases and pests and poor soil management may limit crop development and reduce ET. Other factors to be considered when assessing ET are ground cover, plant density and soil water content, however, ET is not an easy factor to measure (Allen *et al*., 1998). Specific devices, accurate measurements of various physical parameters and soil water balance determined by lysimeters are usually necessary measures to determine ET. However, these methods are expensive and tedious, and are best done in research settings. Although these methods are inappropriate for routine measurements, they remain

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