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Full Length Article

Delineation of Management Zones and Response of Spring Wheat (*Triticum aestivum*) to Irrigation and Nutrient Levels in Saudi Arabia

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Abstract

This study was conducted to assess the soil spatial variability and determine the optimum fertilizer rate and irrigation regime to optimize grain yield of wheat. The experiment was carried out in a clay loam soil with center pivot irrigation system. Management zones of the field were delineated based on laboratory analyzed and geo-referenced soil EC, surface elevation from ASTER DEM (AST3A1) and historic composite Normalized Difference Vegetation Index (NDVI) from Landsat ETM+satellite imagery. A split plot experiment design with three replications was adopted. Main plot treatments consisted of four irrigation levels at 100, 90, 80 and 70% evapotranspiration (ET_c) and three fertilizer levels with 300:150:200 (low); 400:250:300 (medium) and 500:300:300 (high) kg $N:P_2O_5:K_2O$ ha^{-1} formed sub-plot treatments. The highest grain yield of 6.09 t ha^{-1} with water use efficiency (WUE) of 7.65 kg ha^{-1} mm^{-1} was obtained at 100% ET_c and lowest rate of fertilizer. Irrigation at 70% ET_c with fertilizer level of 300:200:200 kg $N:P_2O_5:K_2O$ ha^{-1} produced yield of 6.06 t ha^{-1} at WUE of 10.67 kg ha^{-1} mm^{-1}. This treatment combination resulted in saving of 30% water used in irrigation without sacrificing the yield.

Key words: Spring wheat; Management zones; Irrigation levels; Nutrient levels; Saudi Arabia

Introduction

Wheat is one of the important crops of Saudi Arabia, cultivated on an area of 219,505 ha producing 1,349,389 metric tons of grain. An average yield of 4.5 t ha^{-1} with fertilizer productivity of 40 kg wheat per kg fertilizer nutrient was reported (FAO, 2000). Oweis *et al*. (2000) reported that WUE in wheat can be substantially improved by adopting deficit irrigation to satisfy up to 66% of irrigation requirement in West Asia and North Africa (WANA) regions. Zhang *et al*. (2005) observed that grain yield and WUE of spring wheat in arid environments can be greatly improved by regulated deficit irrigation with reduced amounts of water. The amount of irrigation water used for spring wheat in Saudi Arabia varied from 600 ha^{-1} mm^{-1} in central region (Alderfasi, 2000) to 1200 ha^{-1} mm^{-1} in Al-Hassa region (Al-Barrak, 2006).

The concept of Precision Agriculture is quite new to Saudi Arabia. Delineation of management zones was used as a basis for site specific application of crop inputs (Fridgen *et al*., 2004; Farid *et al.,* 2013). Many ways of developing Variable Rate Application (VRA) maps, using spectral reflectance of soils and crops (Read *et al*., 2002; Daniel *et al*., 2003), aerial photography and satellite imagery (Fleming *et al.,* 2000; Seelan *et al*., 2003; Moran *et al.,* 2007; Sullivan *et al*., 2007) and multi-temporal images (Murthy *et al*., 2003) within a growing season of crops, were reported. Lobell *et al.* (2003) and Liu *et al*. (2006) used satellite imagery in the estimation of wheat yield. There are no reports of studies from Saudi Arabia on delineation of management zones and use of VRA of inputs in crop production. Therefore, this research was carried out with the following objectives: (1) to create management zones of the study field and (2) to study the response of spring wheat to irrigation and nutrient levels.

Materials and Methods

The experiment was conducted on a farmer's field located between Al-Kharj and Haradh cities of Saudi Arabia within

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