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***Full Length Article***

# Variable Rate Application Technology for Optimizing Alfalfa Production in Arid Climate

**Khalid A. Al-Gaadi[1,2], Virupakshagouda C. Patil[2*], ElKamil H.M. Tola[2], Rangaswamy Madugundu[2], Samy A. Marey[2], A.M. Al-Omran[3] and Ali Al-Dosari[4]**

[1]*Department of Agricultural Engineering, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia*

[2]*Precision Agriculture Research Chair, King Saud University, Saudi Arabia*

[3]*Department of Soil Science, College of Food and Agriculture Sciences, King Saud University, Saudi Arabia*

[4]*Department of Geography, College of Arts, King Saud University, Saudi Arabia*

[*]For correspondence: vcpatilksu@gmail.com

## Abstract

This study was to investigate the benefits of variable rate application technology for optimum production of alfalfa in arid climate. The study area was divided into two management zones by employing Fuzzy c-means cluster analysis. A field experiment was conducted in Split plot design. Irrigation treatments allocated to the main plots in January 2012 included: Irrigation at evapotranspiration ($ET_c$) of 100% (I1 ≈ 3130.54 mm/ha/annum), 90% (I2 ≈ 2817.49 mm/ha/annum), 80% (I3 ≈ 2504.41 mm/ha/annum), and 70% (I4 ≈ 2191.38 mm/ha/annum). The fertilizer levels ($N:P_2O_5:K_2O$ kg/ha/year) allocated to sub plots included: F1 – low (126:92:300), F2 – medium (234:138:400) and F3 – high (342:184:500). After retrofitting of variable rate irrigation (VRI) system on to the center pivot in May 2012, fertilizer levels formed main treatments and irrigation levels formed sub-treatments. The highest yield in both the harvests was obtained by irrigation at 80% $ET_c$. Across the two management zones and two harvests made in September and October 2012, medium fertilizer level (@ 234:138:400 kg/ha/year of N: $P_2O_5:K_2O$) resulted in higher alfalfa yield than the other two fertilizer levels. VRI showed benefits only in September 2012 harvest. In this harvest, adoption of VRI at 70% $ET_c$ in MZ1 and 80% $ET_c$ in MZ2 resulted in water saving of 30 and 20%, respectively. The following conclusions can be drawn from this study: 1. Variable rate application of irrigation water for the two management zones resulted in water saving of up to 30% in one out of two harvests. 2. Variable rate application of fertilizers was not effective and uniform rate application of fertilizers @ 234:138:400 kg/ha/year of N: $P_2O_5:K_2O$ resulted in higher alfalfa yield in both the management zones. 

**Keywords:** Fertilizer levels; Irrigation regimes; Management zones; Yield mapping; Saudi Arabia

## Introduction

With a mean annual average rainfall of around 100 mm (Hussain *et al*., 2010), agriculture in Saudi Arabia continues to use fast depleting ground water resources for irrigation to meet the ever increasing demand for food and fodder. Crops are irrigated through center/linear pivots using water pumped from deep aquifers. Under such circumstances, efficient use of scarce water resources assumes greater importance. This can be achieved by improving the water use efficiency of crops (Hussain *et al*., 2010). Forage production represents 23% of the total cropping area in Saudi Arabia, where alfalfa is viewed as the most important fodder crop cultivated (Zaharani *et al*., 2011; Abusuwar and Bakhashwain, 2012). Alfalfa consumes lot of water and its response to water application was reported to be linear (Bauder *et al*., 1978). The annual evapotranspiration of desert-grown alfalfa was estimated to be in excess of 1,900 mm/year (Phene, 2004). Studies in California (Donovan and Meek, 1983), Nevada, New Mexico, Nebraska and North Dakota (Sammis, 1981) revealed that 6-7 inches of water was required to produce a ton of alfalfa under non-limiting conditions. Water stress, especially under arid conditions, is considered as one of the key factors limiting its production (Hanson *et al*., 2008; Mushari, 2008). Saeed and El-Nadi (1997) reported that alfalfa grown under semi-arid conditions should be watered lightly and frequently to attain higher yield and water use efficiency (WUE). Proper irrigation system design adjustments combined with optimal fertigation practices resulted in water saving of 35% without loss in yield or quality of alfalfa irrigated by subsurface drip irrigation in California (Phene, 2004). Al-Noaim *et al.* (1978) investigated the production of alfalfa in Saudi Arabia, in a factorial experiment involving three irrigation rates (2730, 3850, and 5040 mm) and obtained 27.5, 31.4 and 31.9 tonnes of DM per hectare per year, respectively. Avila *et al.* (2003) recommended irrigation regime scheduled to replace 80% of ET for alfalfa in Mexico.

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