



## **Evaluation of Alfa Alfa water productivity under center pivot irrigation system at New Hamdab Scheme, Northern State, Sudan**

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### **Abstract**

This study was conducted under center pivot irrigation systems at the farm of Authority of Merowe Dam Area for Agricultural Development (AMDAD) in New Hamdab Scheme, Northern State, during November, 2011 to December, 2012. The objectives of this study were to assess and evaluate the water productivity of alfalfa under the center pivot irrigation system in desert areas. Operation hours (O.H) and fuel consumption (F.C) were calculated for thirteenth cuts, applied water (AW) was measured using flow meter and then the observed forage yield was sampled and weight in the field in (ton/ha). The results showed that there was a variation in operation hours (hr/ha), applied water (m<sup>3</sup>/ha) and forage yield (kg/ha), which was affected the water productivity (kg/m<sup>3</sup>) of alfalfa. The results showed that the water productivity (WP) was 0.46, 0.33, 0.43 and 0.48 kg/ m<sup>3</sup> for center pivot number one, two, three and four, respectively. The mean average of water productivity was 0.42 kg/m<sup>3</sup>. Generally, the water productivity values were below the recorder value (Steduto *et al.*, 2012). However, since the applied water was not equally distributed at all centers, this resulted in poor forage yield. From these results it could be recommended that alfalfa should be irrigated according to its water requirements using proper irrigation schedule.

**Keywords:** Water productivity, center pivot, alfalfa.

### **Introduction**

Alfalfa (*Medicago sativa* L.) or lucerne, is probably the oldest fodder legume in the world. The crop, which belongs to the family Papilionaceae, is considered the queen of forages. Alfalfa is a better source of protein to livestock and adds high levels of nitrogen to the soil,

reducing its erosion. Production agriculture in the arid area predominantly depends on both surface water and groundwater from wells. Alfalfa is a high water use crop. The cost of pumping is also going up due to rising energy costs. Thus, the efficient use of available water is needed to produce a high water use crop such as alfalfa (Alam *et. al.*, 2016).

Large areas of alfalfa recently are grown under Sprinklers (center pivot) irrigation in the northern Sudan. Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils and to any farmable slope, whether uniform or undulating (Brouwer, 1994). Al-Doss, (1997) reported that Alfalfa uses between 35000 - 37000 m<sup>3</sup>/ha/ year under sprinkler irrigation and up to 45000 m<sup>3</sup>/ha/year under flood irrigation. High water consumption by forage crops has made some concerned people to request a hold on the expansion of forage crop cultivation to conserve ground water from depletion.

The forage producing sector in Sudan is suffering from several problems. These problems include low production efficiency. In addition, alfalfa is a tap rooted crop that is not adapted to sprinkler irrigation especially during summer. Forage producers are also suffering from lack of information on adapted species and cultivars and their production requirements. Moreover, seeds of adapted cultivars are hard to find at affordable price. As a forage crop, alfalfa is cut several times during the season. The crop therefore has an important place in sustainable agriculture and environmental conservation. In Sudan, alfalfa is thought to be the chief fodder crop. The area under alfalfa production is estimated at 52521 hectare; however, the yield of the crop is relatively low (19.5 ton ha<sup>-1</sup> fresh matter, Abu-Suwar, 2004). Elfatih and Abu-Suwar (2012), found that a maximum forage dry matter yield of 2.85 ton/ ha was obtained. Water productivity (WP) is defined as either the amount of yield produced per

unit volume of water consumed (kg /m<sup>3</sup>) or as a monetary value of the yield produced per unit volume of water. Putnam (2012) stated that alfalfa has very high water use efficiency (WUE) as defined by unit of economic dry matter production per unit water. Also, Virupakshagowda *et al.* (2015) reported that water use is high in alfalfa because it has a long growing season, a deep root system, and a dense canopy of vegetation. Alfalfa's high water use is attributable to its long growing season. It is undeniable that alfalfa production requires large amounts of water (Orloff, *et. al.*, 2005). The main objective of this study is to determine the alfalfa water productivity under center pivot system in the Northern State.

### Materials and Methods

Experiments was carried out during the seasons 2010/2011 and 2011/2012 at the farm of Authority of Merowi Dam Area for Agricultural Development in New Hamdab Scheme, Northern State, under desert climate condition. A center pivot irrigation system was used to irrigate an alfalfa crop, and crop water productivity components were measured and calculated accordingly. Four center pivots were tested. The soil under investigation belongs to El Multaga soil series. The texture is sandy loam to heavy sandy clay loam. It has slightly hard consistence when dry, friable when moist and sticky and plastic when wet. Some physical and chemical properties of the soil of experimental site are presented in Table 1.

**Table 1: Soil physical and chemical properties at the experimental site**

Depth (cm)	CS %	FS %	Si %	C %	Bulk density (gm/cm <sup>3</sup> )	H.C	pH	N %	O.C %	SAR	ESP	Av.P Mg/kg
0 - 25	52	11	14	23	1.62	1.70	7.87	0.025	0.113	2.3	3.7	2.9
25-50	53	11	16	20	1.78	2.63	7.90	0.026	0.105	1.7	2.7	2.5
50-75	46	10	16	28	1.75	1.81	7.87	0.027	0.110	1.7	2.3	2.5
75-100	45	10	15	29	1.65	2.68	7.90	0.027	0.119	1.7	2.7	2.3

Source: Hisham (2011)

**Operation hours and fuel consumption:**

Operation hours per irrigation were recorded and then the total operation hour per hectare for each cut was calculated (hr/ha). The method used for determination of the fuel consumption for each irrigation was as follows:

The center fuel tank was filled to a specified level. At the end of completion

of the run test measuring cylinder was used to refill the fuel tank to the pre-specified level again. The amount of fuel required to refill the tank to the starting level was the amount of fuel consumed. The fuel consumption (gal/ha) for the test run was determined by the follows equation:

$$\text{Fuel consumption (gal/ha)} = V (\text{gal}) / A (\text{ha}) \dots\dots\dots (1)$$

Where:

V = Volume of consumed fuel (gal).

A = center area (ha).

**Measurement of applied water (m<sup>3</sup>/ha):**

Applied irrigation water was started from the second cut until the thirteenth. Applied water into each center pivot is measured by the following formula:

$$\text{Application water (m}^3\text{)} = q \times h \dots\dots\dots (2)$$

Where:

q = is the pump discharge (m<sup>3</sup>/hr).

h = is the operating hours (hr).

**Yield production (ton/ha):**

The first cut harvest for center pivot is not included, because of a high applied water during the sowing.

**Determination of water productivity (WP):**

The water requirement (consumptive use) and water productivity (WP) of crops are two important factors that should be

considered when assessing the feasibility of growing crops in any region. The water productivity was determined for the cumulative yield of 2<sup>nd</sup> harvest to 13<sup>h</sup> harvest. The following formula was used:

$$WP \text{ (kg/ m}^3\text{)} = \frac{\text{Fodder dry matter yield (kg/ha)}}{\text{Applied water (m}^3\text{)}} \dots\dots\dots(3)$$

**Results and Discussion**

**Operation hours (hr/cut/ha) and fuel consumption (g/ha)**

Figure1 shows the mean operation hours of the four center pivots . The Center pivot number two has the highest value of operation hour (12.4 hr) and the lowest value was in center pivot number three and four (11.2 hr). The fuel consumption is shown in Figure 2 and shows that fuel consumption ranged from 69.1 gal/ha to 76.7 gal/ha with an average of 71.7 gal/ha. Result shows that fuel consumption increased with number of operation hour. The difference in operation hours is due to stopping for maintenance and other technical reasons.

**Applied water (m<sup>3</sup>/ha)**

The result of applied water (AW) for the four center pivot is shown in the Table 1. The analysis of variance indicated that there were highly significant differences ( $P \leq 0.01$ ). Results showed that the highest applied water (4048.9 m<sup>3</sup>/ha) recorded in center pivot number one (CP1). Table 1 shows that the volume of applied water ranged from 3010.1 m<sup>3</sup>/ha to 4048.9 m<sup>3</sup>/ha with an average of 3433.5 m<sup>3</sup>/ha for each cut. The results are in agreement with those of Al-Gaadi *et.*

*al.*, (2015) who reported that in the Saudi Arabia, alfalfa requires about 25040 m<sup>3</sup>/ha/season. Figure 3 shows that the alfalfa yield increased with applied water. 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 productivity. FAO (2015), reported that alfalfa crop water requirements are between 800 and 1600 mm/growing period depending on climate and length of growing period.

**Forage yield production (ton/ha)**

The result of forage dry matter yields in ton/ha is shown in Table 1. The analysis of variance indicated that there were highly significant differences ( $P \leq 0.01$ ). Results showed that the highest forage dry matter yield (1.87 ton/ha) recorded in center pivot number one (CP1) followed by center pivot number four (CP4). On the other hand, the lowest forage dry matter yield (1.1 ton/ha) was obtained by center pivot number two (CP2). Forage yield ranged from 1.10 to 1.87 ton/ha. In general, the center pivot number one was much better than the others. The highest forage yield was obtained (1.87 ton/ha) when the applied water in the range

4048.9 m<sup>3</sup>/ha whereas the low forage yields (1.10 ton/ha) are mainly associated with low water application. Elfatih and Abu Suwar (2012) reported that a maximum forage dry matter yield of 2.85 ton/ ha was obtainable. According to Imrak (2007) a lack of water at any growth stage will lower the yield, causing the forage quality to peak in fewer days after harvest, and become overly mature faster than under normal conditions. The low quantity of applied water reflected on the yield. Figure 3 shows that the alfalfa yield was increased with increased water application. Saeed and Ebeidalla (2015) reported that the center pivot systems are generally operating at very low levels of performance in Sudan. This is attributed mainly to the fact that these systems have been introduced without being subjected to proper research study.

#### **Water productivity (kg/m<sup>3</sup>)**

The result of water productivity (kg/m<sup>3</sup>) is shown in Table 1. The analysis of variance indicated that there were highly significant differences ( $P \leq 0.01$ ). The irrigation water productivity figures were 0.46, 0.33, 0.43 and 0.48 kg/m<sup>3</sup> for centers 1, 2, 3 and 4, respectively. The average water productivity was 0.42 kg/m<sup>3</sup>, and in agreement with the findings of Virupakshagowda *et al.* (2015) who reported that in alfalfa in Saudi Arabia, the WP was in range from 0.38 to 0.46 kg/m<sup>3</sup>. The water productivity of the system was low compared with that obtained by Al Lawati *et al.*, (2010) who reported that wheat water productivity in Oman was 0.804 kg/m<sup>3</sup>; and Montazar and Sadeghi (2008) found that the water productivity of alfalfa was also high, 2.41 kg /m<sup>3</sup>. Also, the FAO (2015), reported that the water productivity or water utilization efficiency for harvested yield of hay with 10 to 15 percent moisture is 1.5 to 2.0 kg/m<sup>3</sup> after the first year. The

low water productivity was due to the shortage of water and it can be improved further by meeting the full crop demand through better irrigation. Results of Montazar and Sadeghi (2008) illustrated that water distribution in sprinkler irrigation systems has a direct effect on alfalfa growth, hay yield and water productivity such that the applied water reduction and the increased sprinkler water uniformity led to an increased alfalfa water productivity.

#### **Conclusion**

The water productivity (0.42 kg/m<sup>3</sup>) of alfalfa under the center pivot irrigation system was very low, therefore, the use of center pivot system in the arid environments of Northern Sudan, needs more attention. The highest forage yield was obtained (1.87 ton/ha) when 4048.9 m<sup>3</sup>/ha of irrigation water was applied.

#### **Recommendation**

From these results it could be recommended that alfalfa should be irrigated according to its water requirements using proper irrigation schedule.

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