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Effect of Irrigation Intervals and sowing method on Production of Fodder Sorghum on Saline Soil

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Abstract

A field experiment was conducted during the period from November (2010) to early January, (2012), during two consecutive seasons, in the demonstration Farm of the College of Animal Production, Sudan University of Science and Technology, at Kuku, to study the effect of Water Use Efficiency under four irrigation intervals 7-10-14-21 days, on two different land preparation methods (ridged and flat) on production of fodder Sorghum Cultivars (*Sorghum bicolor)* "Abu 70" and (*Sorghum sudanense*) "Garawia" on a saline soil. Irrigation was from domestic water supply net work. Soil samples and irrigation water samples were analyzed chemically to determine the actual soil and irrigation water salinity degree, the average Ec_e and Ec_w, were 4.4 ds/m, 0.285 ds/m for soil and irrigation water respectively. The treatments were arranged in a Randomized Complete Block Design (RCBD), with four replications, with an area of 4*5 =20 m^2, the data were subjected to statistical analysis using, MSTAT, Computer program. Calculation was done to determine the amount of crop water requirements in (m^3) per plot, the application of irrigation water was measured by a (2 inch) flow meter.The main parameters were dry and fresh matter yields. The crop factor (kc) was taken using CROP WAT Program .based on Penman Monteith equation for Khartoum area. The growth measured were: the water use efficiency effect on dry matter yields. The highest value for calculated Eto (Penman Monteith) was during the developing and maturity stage. The values ranged between: (6.99, 6.08, 5.29) mm/ day. This trend was similar for the values of crop factors (kc), which ranged between (0.3 to 1.02). The results showed a higher dry matter yields and water use efficiency in favor of the shorter intervals 7, 10 days, with significant differences on different soil preparation methods within two seasons. Abu 70 within the two seasons on different soil preparation methods under different irrigation intervals, scored a higher dry matter yield than Garawia. The results of water use efficiency followed the same pattern. Abu 70 crop under the two soil preparation methods gave significant differences in favor of the shorter irrigation intervals

Keywords: Sorghum DM, Water use efficiency, Sowing methods.

Introduction

Saline soils occur within the arid and semi-arid regions of the world. Most of the salt accumulations occur at soil depth, of 0.3 -0.6 meters, . (Nachtergaele, 1976). Khartoum State is an important area for fodder production to satisfy the requirement of increasing animal numbers for meat and dairy products, the demand for which is continuously increasing due to normal population growth and mass immigration of rural communities to the capital towns and other settlement areas. In addition to this, a remarkable activity for cattle and sheep for export has resulted in increasing the area of fodder crops. Irrigation cost and management, no doubt, play an important role in the production of fodder crops.. The area under Abu Sabein is estimated about 6300 ha (15000 Fedan) / year, (Abu Swar., 2005). This fodder is usually cut and transported to dairy animals, fattening or export animals before their journey abroad to be consumed as fresh matter. It is a rich source of nutrient containing 5% crude Protein and 55 % total digestible nutrient (Osman *et al.*, 1968).

A series of experiments started since 1975 and continued to 2005, to give complementary information relating crop productivity to irrigation level and variation to climate (Saeed, and EL.Nadi, 1988). Most of the salt affected soils of Sudan have relatively low nutrient contents. The potassium (K) content is considered adequate but sodium bicarbonate and extractable Phosphorus are deficient for most important agricultural crops, (Mustafa, 1986). Response of barley to water stress at different growth stages at various levels of soil salinity resulted in significant (P<0. 05) variations in both the above shoot and root dry weights between different treatments at each sampling data. In addition, the interaction between level of salinity and water stress was also significant (Al khafaf *et al*, 1990). It is not always possible or practical to eliminate all salt from the soil, but managing the soil may reduce salt effects. The most effective way of using saline land and saline water is by growing tolerant. The choice of tolerant is essential for successful crop production (Rastegari and Farahangisabet, 2006). Crops differ in the ability to tolerate salt accumulation in soils, but if levels are high over 16 ds/m) only tolerant will survive. As salts accumulate in the soil, soil solution osmotic pressure increases. When this happens the amount of water available for plants uptake decreases and plants exhibit poor growth and wilting will occur even though the soil is not dry. Forage production and consumption in Sudan is increasing over time due to the increasing rate of livestock population (140 million head) (Ministry of Animal Resources, 2007). The main forage crops produced in the country are Abu sabein *(Sorghum bicolor* L Moench) constituting about 43% of the total annual yield occupying an area of 70 thousand hectares. No wonder if forage sorghum can be produced in all types of soils as it is tolerant to salinity and sodicity. Sorghum (*Sorghum bicolor* L. Moench) is a crop of world –wide importance. The tremendous increase in demand for animal products has led to great expansion in the area allocated for fodder crops. Sorghum is the most important irrigated forage crop in the Sudan. The traditional sorghum cultivar (Abu Sabein) is the most important cultivar grown for forage in the Sudan. In Khartoum State, it represents more than 60% of the total area cultivated. According to the statistics of the Ministry of Agriculture in 2009, the area cropped with fodder crops in Khartoum State was estimated at 200000 fed., in the River Nile and Northern States for the same year, they were 55000 and 29000 fed respectively. Research efforts aiming at developing improved forage types were very few. The seed of all forage sorghum hybrids currently in use are imported. Four hybrids were tested and

released by the Agricultural Research Corporation (Mohammed, 2007). The improper cultural practices, sowing methods, irrigation intervals and nitrogen fertilization properly used by many farmers in the country. Forage sorghum has not reached its required level of production both in quality and quantity . Recent studies were focused on improving sorghum forage both quantitatively and qualitatively (Ibrahim, 2013)

The main objective of this work was to study the performance of two fodder crop cultivars mainly "Abu 70" and "Garawia", on saline soil, under different irrigation intervals, and two types of soil preparation methods.

The specific objectives are:-

1-To determine the appropriate irrigation interval under the treatment conditions.

2-To investigate the effect of two soil preparation methods coupled with four irrigation intervals on the performance of two sorghum forage crops in saline soil.

3- To study the effects of the different treatments on growth parameters.

Materials and Methods

The study was conducted at the Demonstration Farm: College of Animal Production Science and Technology. Sudan University of Science and Technology Sudan - Kuku - for two consecutive seasons. (Nov2010 to Oct 2012). The study area lies in Khartoum North. latitude 15.40 N longitude 32.32 E and altitude 380 meters above mean sea level (msl). (Oliver 1965). The soil of the experimental site is clay (fine montmorillonite, hyper thermidentic chromu-sterts. Initial chemical and physical charac-teristics of the soil (0-60 cm) were collected from the experimental site . The soil recorded Ec_e above 4.4 ds / m hence it is slightly saline soil. The climate of the locality is tropical semi-arid with low relative humidity, maximum temperature is about 40 ^{0}C in summer and 20 ^{0}c in cool season but night temperatures are lower (Oliver, 1965). The mean annual rainfall is about 160 mm. However, there is considerable fluctuation in the annual rain fall from year to year (Adam, 2005).

The experimental field layout: The experimental field area was 1280 m^2 divided into 64 plots each 20 m^2 (4*5 m). These were divided into two sub-plots each having 32 plots, for two soil preparation methods (ridged and flat) each (32 plots) divided into two sub-sub plots each having 16 plots, sub-sub-plots were divided into four irrigation intervals (7-10-14-21 days), each replicated four times .

Soil sampling: A screw auger was used to take soil samples at (0-10),(10-20),(20-30), (30-40)-(40-50-) -(50-60) cm.

Land preparation: The experimental area was first ploughed to a depth of 30cm-followed by disc harrowing and adequately leveled, and ridged (furrow width 70cm) for only 32 plots, the other 32 plots were leveled to flat, a buffer zone of 150 cm separated the ridged and flat plots, and a buffer zone of 70 cm between different irrigation interval plots.

Source of irrigation water: The source of the irrigation water was from a domestic water tank. Chemical and physical analysis of water was carried out at the National Rural Water Development Corporation (NRWDC) Khartoum, Sudan. The irrigation water EC_w recorded 0.285 ds/m. The applied amount of water was controlled by a 2 inch flow meter, attached at the end of the pipe. The irrigation pipes were two inch diameter attached to the two inches flow meter was a flexible two inch (PE) pipe used to distribute water among plots controlled by a ball valve.

Field practices:

Fodder varieties used: Two cultivars of sorghum forage seeds were used; *Sorghum bicolor . L. Moench* cv. Local breed Alyab. Abu sabein and *Sorghum sudanense* C F S H 30. Garawia.

Seed rate: The seed rate used for Abu sabein was 20 kg per fadden and 4 kg per fadden for garawia.

Sowing methods: Two different sorghum varieties (Abu sabein and garawia), four plots each , were broadcasted on ridges (0.7m between ridges) and all over the flat plots. A hand fork was used to cover the seeds. The effective sowing date is at the first irrigation which was given immediately after sowing. Subsequent irrigations followed.

Fertilizer application: Urea (46% N) was applied as source of Nitrogen at 77 kg per fadden in two equal doses, applied over the plots at the second and fourth watering at 200 g / plot per dose.

Determination of reference evapotranspiration in mm /day: The computer software (CROPWAT), designed by FAO-Penman-Monteith approach (Smith *et al.,* (1991), was chosen to compute the reference evapotranspiration (ETo) in mm/day for each month of the growing season .Meteorological data taken from Shambat Meteorological Observatory station were entered as input data. The first season started at November , through December to early January, for (70 days) using ETo values (6.15 , 5.30, 5.91 mm/day) respectively . The second season started on November through December, to early January for (70 days) using the same ETo values .

The crop growth stages: The phonological cycle was divided into three stages since the crop is harvested before grain maturity . i.e :

A: Initial stage (20 days)
B: Development stage (30 days)
C: maturity stage (20 days)

The total duration of the cycle was 70 days.

Irrigation intervals: Four irrigation intervals were adopted (7 -10 -14 -21 days). The amount of irrigation water (ET_C), was calculated according to crop factor and ETo values (Crop -Wat 8 windows ver 4.3). The irrigation intervals (7-10-14, 21 days), were adopted to test their effects on the concentration of soil soluble salts on crop performance.

Water use efficiency (WUE): The water use efficiency was calculated to each crop sampling according to (Micheal , 1978) , by dividing crop dry matter (DM) weights (ton/ha) by monthly evapotranspiration ET_c crop, in the period between successive cuts . Water management in arid areas is the most important factor that determines productivity. With the increase of the irrigated area and the onset of the drought cycle, water resources become limiting and endangered by salinity. Rainfall is very scanty and erratic in arid areas with annual total ranges between less than 100 and 400 mm. Water use efficiency (WUE) is a useful relative term in drought selection. Under stress conditions, the main concern is the production per unit of applied water rather than absolute production (Stewart *et al* 1983).

Field water use efficiency (FWUE): FWUE was obtained by dividing yield of dry matter (DM) by the amount of water applied to the field during that period .

Water Use Efficiency (WUE) can be calculated using the total amount of applied water for grain and dry matter as follows (Ibrahim 1997).

$WUE = Y_{DM} / Wt$ ……(7)

Where:

WUE = Water use efficiency (kg / ha. cm)
Y_{DM} = Dry matter yield (kg/ha)
W_T = total water applied (cm)

Fodder crop yields determination: By the end of the growing season and at maturity stage 70-days from sowing, one square meter area was harvested in a randomized manner from the middle of each plots, for different irrigation intervals, the harvested plants were immediately weighed in Kg / m^2, for the total fresh yields, and then left to dry for dry matter in (kg / m^2). and then left to sun dry till a fixed weight was obtained.

Statistical Analysis: The data were analyzed by the analysis of variance (ANOVA), then the means comparison was made by the LSD. The analyses were conducted using the MSTAT program.

Results and Discussion

Crop water use efficiency and Dry Matter Yield: Sorghum water use efficiency expressed as tons of dry matter produced by ha and cubic meter of water was obtained by dividing the yield of dry matter (DM) per cut by the total crop evapotranspiration (ET_C).Irrigation under shorter intervals resulted in higher WUE and dry matter yield than under longer intervals. The average WUE for all intervals on two seasons on ridged and flat, Figures (1 and 3). Tables (1, 2, 5, and 6) showed the dry matter yield for Abu 70, and Garawia in two seasons on ridge and flat. Figures (2) and (4), Tables (3, 4, 7, and 8).

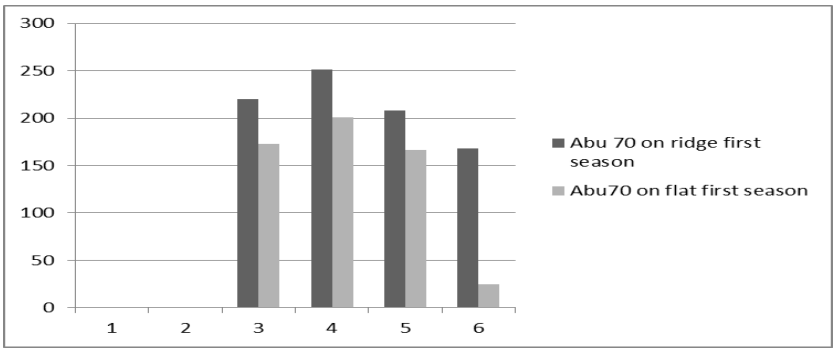

Figure 1: The water use efficiency for Abu70 in kg/ ha on ridge and flat in the first season

Table 1: Dry Matter Yield for Abu 70 on ridged plots at the first season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	9300
10 days	4220	10600
14 days	4520	9300
21 days	5230	8800

Table 2: Dry Matter Yield for Abu 70 on flat plots at the first season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	7300
10 days	4220	8500
14 days	4520	7500
21 days	5230	1300

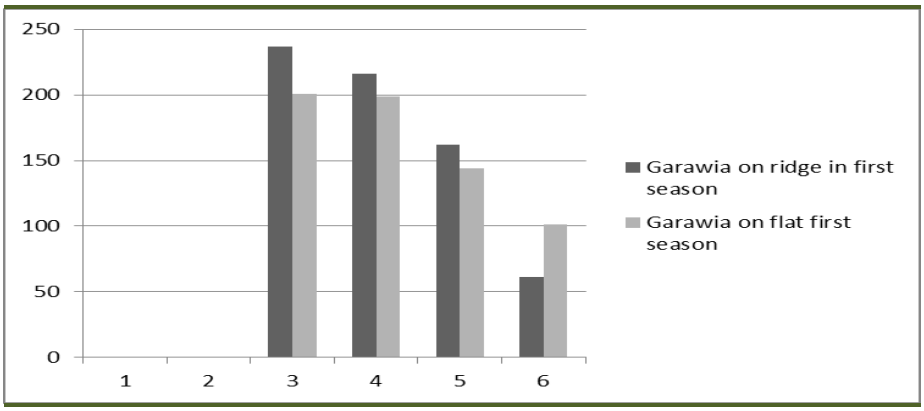

Figure 2: The water use efficiency for Garawia in kg /ha on ridged and flat plots in the first season.

Table 3: Dry Matter Yield for Garawia on ridged plots at the first season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	10000
10 days	4220	9100
14 days	4520	7300
21 days	5230	3200

Table 4: Dry Matter Yield for Garawia on flat plots at the first season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	8500
10 days	4220	8400
14 days	4520	6500
21 days	5230	5300

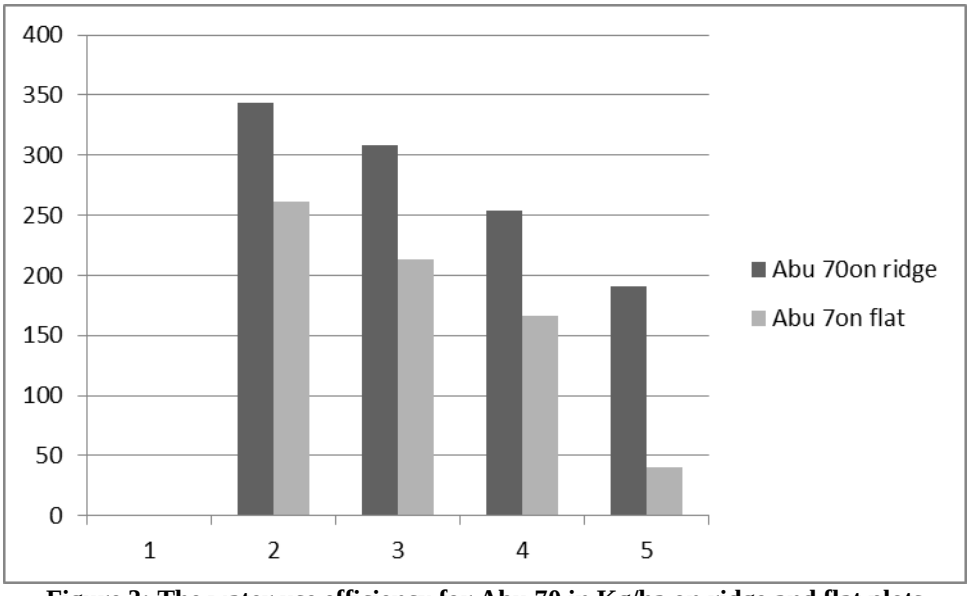

Figure 3: The water use efficiency for Abu 70 in Kg/ha on ridge and flat plots in second season

Table 5: Dry Matter Yield for Abu 70 on ridge plots at the second season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	14500
10 days	4220	13000
14 days	4520	11500
21 days	5230	10000

Table 6: Dry Matter Yield for Abu 70 on flat plots at the second season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	11000
10 days	4220	9000
14 days	4520	7500
21 days	5230	2100

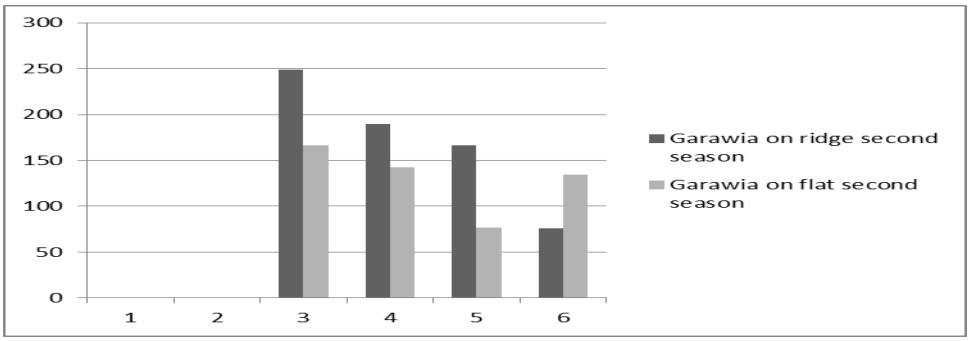

Figure 4: **The water use efficiency for Garawia in kg /ha on ridged and flat plots in the second.**

Table 7: Dry Matter Yield for Garawia on ridge plots at the second season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	10500
10 days	4220	8000
14 days	4520	7500
21 days	5230	4000

Table 8: Dry Matter Yield for Garawia on flat plots at the second season

Intervals	Water used (m^3 / ha)	DM yield (Kg / ha)
7 days	4220	7000
10 days	4220	6000
14 days	4520	3500
21 days	5230	7000

Discussion:

Previous studies showed that infrequent irrigation reduced WUE of sorghum plants. These results agreed with that of Saeed (1984), in that the variability in water use efficiency with season (for Lucerne and fodder sorghum) can be mainly accounted for the different climatic conditions for the different crops and for temperature and relative humidity values in different season practices. Table (3.2) showed the differences in climatic conditions during the experimental

period. However, Hatfield *et al* (2001) found that the efficiency of water use decreased as the evaporative power of the atmosphere increased. Shorter irrigation intervals resulted in higher values of WUE (382) compared to longer irrigation intervals (208), for Abu 70 at 7 days on ridged plots. AL-Jamal, *et al*, (2001) reported that irrigation practice that maintains moist soil for longer periods, allows transpiration rates approaching the potential, prevents the occurrence of water deficits and consequently results in higher WUE. The decrease in dry matter agreed with Chaudhuri and Kanemasu (1982), who found that increasing the watering level increased WUE for total dry matter. This has also been observed in the investigations conducted in Mexican high lands endowed with 93% dry land agriculture where barley showed the higher values of WUE in terms of both grain and biological yields. Fernandez *et al* (1993).

Conclusions:

1- From the results of this study, the following conclusions are drawn:

The regular shorter irrigation intervals (7 and 10 days) resulted in higher dry matter yield than under longer irrigation intervals. 2- Sorghum bicolor Abu 70 showed a higher dry matter yield than Sorghum sudanense Garawia due to some physiological and botanical factors.

3- A higher water use efficiency can be obtained from shorter irrigation intervals for higher dry matter yield.

Recommendations:

1- Irrigation every seven to ten days was the best for forage sorghum.
2- Sorghum forage on ridge land was better and should be used at the moderately saline soils.

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اثركفاءة استخدام مياه الري و فترات وطرق الذ راعة على انتاج الذ رة العلفية فى التربة الملحية

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المستخلص:

اجريت التجربة الحقلية خلال الفترة من نوفمبر 2010 الي اوائل يناير–2012 ،خلال موسمين متتابعيين ، في المزرعة التجربية لكلية علوم وتكنولوجيا الانتاج الحيواني جامعة السودان للعلوم والتكنولوجيا – بكوكو لدراسة اثركفاءة مياه الرى على فترات 7–10–14–21 يوما وطرق الذراعة فى مهد مخطط (سرابات) ومستوي على انتاج الذرة العلفية ابو 70 والجراوية في التربةالملحية . مصدر الري من شبكة مياه المدن . تم تحليل عينات التربه ومياه الري كيميائيا لمعرفة درجة الملوحة فى مستخلص التربة و ماء الري (مياه المدن) . بمتوسط 4.4 و 0.285 ds/m للتربة و ماء الري على التوالى. وزعت معاملات التجربه باستخدام تصميم القطاعات العشوائيه الكامله (R C B D) بأ ربعة مكررات مع مساحة الحوض 20 مترمربع 4*5. تم تحليل البيانات احصائيا بواسطة برنامج MSTAT . اجريت العمليات الحسابيه لتقدير الاحتياجات المائية اللازم اضافتها بالمتر المكعب للحوض الواحد .تم قياس مياه الري المطلوبه والتحكم فيها باستخدام عداد 2 بوصه. تم استخدام معامل المحصول بالاستعانة ببرنامج ال CROP WAT لمنطقة الخرطوم باستخدام معادلة بنمان– مونتيث . الانتاجية الجافة تمثل اهم قياسات التجربة. القراءات التي تمت دراستها في التجربة شملت كفاءة المياه

المستخدمة و علاقتها بانتاج العلف الجاف. كانت اعلي قيمة للبخر نتح المرجعي بطريقة بنمان –مونتيث خلال فترتي الاستطالة و النضج حيث تراوحت هذه القيم (6.99–6.08–5.29) ملم/ اليوم. وهذه النتيجة تنطبق ايضا علي معامل المحصول حيث تراوح من 0.3 الي 1.02 . اظهرت النتائج اعلا انتاجية للمادة الجافة و كفاءة استخدام المياه لصالح الفترات القصيرة 7– 10 يوما بفروقات معنوية. كما اظهرت الفترات القصيرة فروقات معنوية خلال معاملات طرق تحضير التربة وايضا المقارنة بين المحصولين خلال الموسمين. ابوسبعين اظهر انتاجية اعلا من المادة الجافة متفوقا على الجراوية. اظهرت نتائج كفاءة استخدام المياه نفس النمط الوارد في الانتاجية بالوزن الجاف . محصول ابوسبعين تحت طريقتى تحضير التربة اعطى فروقات معنوية لصالح فترات الرى القصيرة.