بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Effect of Water Interval on Growth and Yield of Three Forage Sorghum Spp.

على نمو وإنتاجية ثلاثة أنواع من أعلاف الذرة الرى فترات تأثير

A Thesis submitted in partial fulfillment of the requirements for the Degree of Master (M.Sc.) in Agronomy

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الآيـــــة

بسم الله الرحمن الرحيم

قال تعالى:

(وَلَئِن سَأَلْتَهُم مَّن نَّزَّلَ مِنَ السَّمَاءِ مَاءً فَأَحْيَا بِهِ الْأَرْضَ مِن بَعْدِ مَوْتِهَا لَيَقُولُنَّ اللَّهُ قُلِ الْحَمْدُ لِلَّهِ بَلْ أَكْثَرُهُم لَا يَعْقِلُونَ)

سورة العنكبوت الاية (63)

DEDICATION

In the name of Allah the merciful, dedicate this work to:

The Soul of my father and Allah bless him

My Intimate mother

My Brothers and sisters

My friends

To all my teachers in the department of Agronomy.

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Thanks to Allah almighty who enabled me to complete this study. I revere the patronage and moral support extended with love to the soul of my father and my mother and family whose support and encouragement made it possible to complete this project. My thanks are due to my Supervisor Dr. Nahid Abdel Fattah for her support and careful guidance. Special thanks to Professor Dr. Yassin Mohamed Ibrahim Dagash and TajElain Elkhalil Belal Who helped alot, Iam really thankful to them. My thanks are due to the members of the Department of Agronomy and to my colleagues. Finally, I owe the gratitude for all who helped me in one way or other.

ABSTRACT

A field experiment was conducted at the College of Agricultural Studies, Sudan University of Science and Technology (SUST) at Shambat, during summer season of 2016, to study the effect of water intervals on growth and fodder yield of three varieties of forage Sorghum namely Abusabein [S*orghum bicolor* (L) Moench], Sudan grass (*Sorghum Sudanenses*), and Pioneer (*Sorghum bicolor* (L) Moench) X Sudan grass (*Sorghum sudanenses* (Piper). The experiment was laid out in randomization complete block design (RCBD) in four replications, varieties were assigned to main plots and water intervals (7, 14 and 21 days) to sub plots. The seed rate was (20kg/h) for all varieties. Watering intervals were applied after one month after sowing. Growth parameters studied were plant height (cm), stem thickness (cm), number of leaves/plant, number of tillers /plant and plant density. In addition yield components were fresh and dry weight and chemical composition which included protein and fiber content. The general trend was that water intervals, varieties and their interactions had significant effect on some parameters of growth (plant height and number of tillers/ plant). Irrespective of water intervals Abusabein showed the highest yield in terms of fresh and dry weights. Generally, application of water at 7 and 14 days resulted in a significant affect on plant height, numbers of leaves/plant, stem thickness, number of tillers/plant, plant density and dry weight.

الملخص

أجريت تجربه حقليه بمزرعه كليه الدراسات الزراعيه- بشمبات ، جامعه السودان للعلوم والتكنولوجيا . في صيف عام 2016 لدراسه تاثيرمستوي ريات مختلفه على نمو وانتاجيه ثلاثة أصناف من علف الذرة ابوسبعين - بايونير و حشيشة السودان . اجريت التجربة باستخدام نظام القطع العشوائيه الكامله باربعة مكررات حيث كانت الاصناف في القطع الرئسية وفترات الري (7,14,21) في القطع المنشقه من تجربة القطع المنشقه. كان معدل البذر 20 كجم للهكتار. طبقت فترات الري بعد شهر من تاريخ النمو. تم قياس طول النبات وسمك الساق وعدد الاوراق وعدد الخلف وكثافة النباتات إضافة إلي مكونات الانتاجة من الوزن الرطب والوزن الجاف ، إضافه إلي نسبة البروتين والألياف. وكان تأثير فترات الري معنوياً في بعض عوامل النمو(طول النبات وعدد الخلف) كما أعطي صنف ابوسبعين أعلي إنتاجية وبصفة عامة الري كل سبعة واربعة عشر يوماً أعطي فرقاً معنوياً مقارنةً بفترات الري الأخري في طول النبات ، عدد الاوراق ، سمك الساق عدد الخلف، الكثافة النباتيه والوزن الجاف.

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CHAPTER ONE

INTRODUCTION

(*Sorghum bicolor L .Moench*) belongs to family Poaceae, it is a cereal grass native to Sub-Saharan Africa and has been cultivated for centuries as staple cereal grain (Menz *et al*., 2004). Sorghum is indigenous to Africa and many of today's varieties originated in that continent. Sorghum spread throughout highlands and native probably from Ethiopia (Ecoport, 2011).Moreover, it was taken from eastern Africa to India during the first millennium B.C and that it existed there around 1000 B.C (FAO, 1995a) and Assyria as early as700 B.C. The first known record of sorghum in the United States comes from Ben Franklin in (1757) who wrote about its application in producing brooms. Sorghum was initially cultivated since five thousand years ago and from that time the crop has been developed (FAO, 2006).

Sorghum forages are warm season crops and known for their drought resistance. They are more efficient because they have twice as many secondary roots per unit of primary root as corn and half as much, leaf area as corn to reduce transpiration. Their water requirements are the same as corn but they have the ability to tolerate extended drought periods. Sorghum is known for its tolerance to high temperature, it performs best when average daily temperatures are 24-30^{o}c (FAO 1996). It was shown to be drought tolerant and can be grown in areas where rain fall is not sufficient for other crops and responds well to irrigation (El Tayib, 1991). Sorghum species are gathered into four groups namely grain sorghum (for food), grass sorghum (for pasture and hay), sweet sorghum (normally used to produce sorghum syrups) and broom corn (for brooms and brushes). Worldwide, sorghum is a food grain for humans,

but in the United States, sorghum is used primarily as a feed grain for livestock (Carter, 1989). Forage crops play an important role and are essentially tropical crops. Pasturing cattle or sheep on sorghum stubble, after the grain has been harvested, is a common practice (Carter, 1989). Both roughage and dropped heads are utilized stubble with secondary growth must be pastured carefully because of the danger of prussic acid (HCN) poisoning.

In Sudan forage production is very important for livestock production due to the fact that Sudan has a huge number of animal wealth. Overgrazing of natural pasture, expansion of rainfed agriculture, wild fire and drought resulted in reduction of rangeland. Sorghum is generally used as animal feed (Lendzemo , 2004).

Forage production which provides almost 74% of the total annual livestock feed requirement for the improvement of seasonal livestock feed balance. The government comprehensive 25 years strategy (2002-2027) is to increase the green forage production from 4 million tons/year to almost 9 million tons by year in 2027. On a cultivated large scale in Sudan specially in Khartoum and river Nile states about 70000 hectares are cultivated with forage (Khair and Jarrel, 1987, Mustafa and Magid, 1982, Abu suwar, 1994).

The objectives of this study are to**:**

1- Determine the best water intervals for Sorghum forage varieties.

2- Compare between Sorghum forage cultivars in terms of forage, fresh and dry yield.

CHAPTER TWO

LITERATURE REVIEW

2.1 History:

Sorghum (*Sorghum bicolor* (L) Moench), is native to Africa. Evidence indicates that it started in eastern Africa (probably Ethiopia or Sudan) in prehistoric times perhaps 5000 to 7000 or more years ago (Wall and Ross, 1970). Sorghum was planted extensively in parts of the Middle East, North Africa and Europe (Watson, 1983).

2.2 Botanical description:

2.2.1 Abusabein (*Sorghum bicolor* .L)

Abu Sabein is an annual plant considered as the principal cereal forage grown in Sudan in summers season (Khair, 1999 and AbuSuwar, 2005). The implication of the Arabic name, Abu Sabein is that it completely matures in about seventy days (Bacon, 1948). Abusabein is a leafy forage sorghum with extensively branching roots, and the leaves constitute about 20 percent of the total dry weight and has low regrowth capacity hence it is suitable for single cut system (Khair, 1999). The leaves, generally, are differentiated into a lower sheath hugging the stem for a distance. Inflorescences is panicle, around 60 cm long, bearing up to 6000 spikelets (Balole and Legwaila, 2006). The stem is part of the plant and that shows the greatest difference between genotypes, ranging from thin to thick, with low or multiple tillering (Rattunde *et al*., 2001).The fruit merged together to form a hard dry grain. It contains toxic material hydrocyanic acid (HCN) in early growth stage (Khair, 1999).

2.2.2 Sudan grass (*Sorghum sudanense*)

Sudan grass is one of the important sorghum forages locally named as Grawia in Sudan. The crop is a fine stemmed and leafy plant with very quick regrowth and sweet juicy thinner stems (Khair, 1999). It has good green fodder and hay. The yield of the crop is generally lower than other forages harvested for silage, but they have advantage that they can be cut 2 to 3 times during the season, so it is best used for pasture or in multiple cut system. If used in a one cut system, yield will be less and fiber content is lower if cut frequently. Moreover, it is valuable for hay silage or pasture. Sudan grass was characterized by high nutritive value compared to Abu Sabein as it has greater crude protein probably due to its greater number of leaves and slender stems (Khair, 1999). If growth is short and stunted the prussic acid content may be high enough to make pasturing hazard to livestock but it is safe to use as hay (Magness *et al*., 1971).However, the prussic acid content is lower than Abu Sabein.

2.2.3 Pioneer

Pioneer is produced from crossesing between Abusabein (*Sorghum bicolor* (L) (Moench) X Sudan grass (*Sorghum sudanense (*Piper). High yielding similar hybrids have been developed in many parts of the world and released as cultivars (Bowman *et al*, 2000). Until the early eighties, Abu Sabein (fodder sorghum) had no competitors as forage sorghum in the Sudan, and at that time Pioneer International Company introduced the cultivar Pioneer 988, which was evaluated and released by the Agricultural Research Corporation (AbuSuwar, 2005). Moreover, this cultivar is characterized by fine, sweet and juicy stems and out yielded Abu Sabein in fresh and dry forage yield (Bebawi and Mazloum, 1986). Therefore it responded better to the frequent cutting (Khair *et al.*, 1995),

and more successful growth in the cool season compared to Abu Sabein and Sudan grass

2.3 Usage:

In most growing areas of sorghum in the world, the crop is grown for human consumption, however, in U.S.A it's grown primarily for livestock and poultry consumption (FSD, 2007; USGC, 2008). Sorghum grain is the staple food of poor and most food-insecure people, living mainly in the semiarid tropics (Ali *et al*., 2011). In Sudan, sorghum variety (Abu Sabein) is considered as the main cereal forage crop. Forage sorghums are used primarily for cut several times (multicut) because of their regrowth habit and short growing period. Sorghum has been demonstrated as a viable bio-energy feed stock (Wang and Shi, 2008). Its remarkable ability to reliably produce grains under adverse conditions makes sorghum important, sources of food, feed and fuel (Addissu, 2011), in addition as silage for livestock. They are sometimes grown and harvested with soybean to improve the protein content of the silage. Sudan grass and Pioneer are grazed by livestock or fed as green chop or hay. Sorghum harvested at the soft dough stage of development and stored as silage contains, 52 to the 65% dry matter digestibility, 8 to12% crude protein, 60 to 75% neutral detergent fiber and 34 to 40% acid detergent fiber (Rohweder, 1965). To obtain the optimum rate of gain for most livestock, sorghum silage must be supplemented with protein, minerals and vitamins. It's generally suggested that sorghum silage constitute not more than 50% of the forage in dairy cow rations but may be adequate alone for other categories of animals (Hughes and Metcalfe, 1972). Sorghum forage dry matter production is greater compared to other fodder crops and the feed is more palatable. Thus, it may be particularly useful in regions with high concentration of livestock. The

higher the grain content, the higher the digestibility.Grain has digestibility of about 90%. Forage sorghum usually produces as much silage per acre. Sorghum used for forage. It's the fifth most important cereal crop grown globally after wheat, maize, rice, and barely production (Sato *et al*., 2004 ; Khalil., 2008).

In the United States, and other countries across the globe, sorghum grain is primarily used for livestock feed and ethanol produce, but is becoming popular in the consumer food industry and other emerging markets. Livestock industry is one of the longest-standing market places for sorghum in the U.S. in the livestock industry, sorghum is utilized in feed rations for poultry, stems and foliage are also used for pasture. Moreover, it is used for food, forage building material and in industry for biosynthesis of starch and alcohol (ICRISAT, 2011).

2.4 Adaptation:

Sorghum is well adapted to growth in hot and arid or semi-arid areas. It grows in harsh environments with limited water, hence it is resistant to drought and adaptation to regions of limited rainfall where other crops may do poorly (FAO, 1995a). Sorghum is well-known for its capacity to tolerate conditions of limited moisture and to be productive during periods of extended drought, circumstances that would affect production of most other grains. It's considered more tolerant to many stresses, including heat, drought, salinity and flooding as compared to other cereal crops (Ejeta and Knoll, 2007; Ali *et al*., 2011). However, the crop grown in rain-fed areas is highly affected by drought stress (Kebede *et al*., 2001). Also, it has an extensive root system, waxy leaves and the ability to temporarily stop growing in periods of drought and recovering when moisture becomes available again. It grows on a wide range of soil types

and is moderately tolerant to salinity and is grown on salt affected soils (Khair *et al*., 1987; Mustafa and Magid., 1982; AbuSuwar, 1994). In Sudan, about 250 thousand hectares in Northern region were affected to some degree by sodicity and /or salinity (Ali *et al*., 1977) The largest affected areas are mostly North Khartoum, about 49% of Khartoum State areas are classified as salt affected soils, of which 38%, 7%, and 4% are saline, saline-sodic and sodic soils, respectively (Ali *et al* ., 1977).

2.5 Irrigation:

The objective of irrigation is to supply sufficient water to keep the plant growing normally. This is usually accomplished by keeping the soil moisture within the root zone, somewhere between the wilting point and field capacity. Soil moisture deficiency may also affect the growth of the root apparatus, which is responsible for establishing the soil – plant – atmosphere continuum in the flow of water (Kuchenbuch *et al*., 2006). Previous studies in sorghum have shown that total leaf area and specific leaf area decrease under water stress (Munamava *et al*., 2001). Water stress affects almost every developmental stage of plant. However, damaging effects of this stress were more noted when they coincided with various growth stages such as germination, seeding, shoot length, root length, and flowering (Rauf, 2008; Khayatanezhad, *et al*. 2010). In sorghum, water stress occurring during seed filling, decreases seed size and number, thus leading to strong yield reduction or even total crop loss (Tuinstra *et al*., 1997). Sorghum avoids dehydration by enhanced water uptake regulation (Singh (1990); Odell (1959) reported that if too much water was applied during the period of early vegetative growth, lodging may occur, adversely affecting yield. Water stress usually refers to deficiency of available soil moisture, which produces water deficit in plants sufficient enough to cause reduction in growth and yield. In

autumn when the relative humidity is high, the irrigation interval used to be 15 days and reduced to 7 days in summer. With developing water stress transpiration rate, usually decreases mainly due to stomata closure (Hsiao, and Emundo, 1975). Photosynthesis is severely inhibited by water stress (Boyer, 1976; Eastin *et al*, 1983). Arnon, (1972) found that 100 centimeters of moistened soil layer during sorghum sowing produced satisfactory yield of this crop. Complexities of inheritance pattern of drought resistance encourage breeders to adopt alternative strategies to improve stress resistance (Borrell *et al* 2006).

In Sudan ElAmin (1976) and Saeed (1984) found that green fodder yield and dry matter production were affected by seasonal variation of climatic conditions. The shorter irrigation intervals were the best (Saeed, 1984). The water use efficiency for total dry matter and nutrient production was lower for grain than for forage sorghum because grain sorghum had longer season (Unger, 1988). With the rising demand for animal products and the establishment of more dairy farms and fattening centers, there is an obvious need for an improved forage culture programme. This improved forage culture programme is expected to result in "a package" of recommendation for increasing production starting from seeding to harvest operations. It also has traits essential for survival and productivity in arid and semi-arid areas with limited irrigation capability (Zhanguo *et al*., 2008). The period for cutting may be about 80-85 days from sowing. Kambal (1972), reported that the variety of sorghum grown in Khartoum area is a mixed variety but well adapted to local conditions. Ishag (1989), reported that there is no change in forage production of Abu Sabein whether using seed rate of 10 Kg/fed or 70 kg/fed, and the best result was obtained when using 20 kg/fed. In India the total yield of Sudan grass of four cuts was about 37-55 t/h, but Relwani (1968) concluded that Sudan

grass in good condition yielded about 40-50 t/ha as green fodder and about 20 t /ha with limited irrigation facilities.

2.6 Nitrogen fertilizers:

Fertilizers are applied to the soil to promote plant growth, improve quality and increase herbage production, but the response varies with climatic variations and soil capability (Smiska *et al.*, 1965). Nitrogen is absolutely essential to plant growth and it is the nutrient that most frequently limits yield .Africa soils suffer from nitrogen deficit .Most of the plant grown on the soils with sufficient amount of available nitrogen makes thrifty, rapid growth with healthy deep green color, and greater of forage yield , Ibrahim (2004). Ample nitrogen has tendency to encourage stem and leaf development. Lack of nitrogen results in poor plant growth and uniform yellowing of leaves, Jules (1974). Nitrogen fertilizer in form of urea is very important for plant because it increase plant height, density and number of leaves as reported by Mohammad (1990) at Shambat, when he studied the effect of different levels of nitrogen using (pioneer, elephant-grass and sorghum forage). Nitrogen application increases the crude protein content and metabolizable energy, besides improving succulence and palatability of fodder crops (Patel *et al* ., 2007), also Patel in (2005) reported that application of 120 KgN/ha gave significantly higher green dry fodder yield of Napier grass ,while lower nitrogen rat of 40 and 80 KgN/ha produced lower yield. He also reported an increase of forage yield as result of nitrogen fertilizer. Green leaves play an important role in the process of photosynthesis. Active leaves receive the sunlight and oxygen and produce the carbohydrates which are distributed to different parts of plant for maintaining the plant duration. Farmers are usually interested in yield of different crops per unit area.

Nitrogen uptake efficiency is attributed to morphological, physiological and biochemical processes in plant (Baligar *et al*., 2001).

CHAPTERTHREE

MATERIALS AND METHODS

3.1. Location:

The experiment was carried out in summer of 2016 under irrigation system at the demonstration farm of Shambat, Sudan University of Science and Technology, College of Agricultural Studies, (15^0 40N, 32^0 32E and altitude, 288 meters above sea level).The climate of the area is semi arid (Oliver, 1965). The temperature range is 42.6^{o}C – 35. 3^{o}C / 27. 2^{o}C - 18.1^{o}C day and night, respectively. Humidity is 15-55 % and rainfall (0.1-24.7mm). (Meteorological Station at Shambat).The soil at Shambat site is heavy clay with pH 7. 5- 8 as described by (Abdelgader 2010).

3.2. Design and Description of the experiment:

Treatments were arranged in randomized Complete Block Design (RCBD) with four replicates. The experiment was composed of two treatments water intervals (7, 14, and 21 days) considered on the main plots and Sorghum varieties were sub plots. The field was disc ploughed; disc harrowed, leveled and ridged up north-south, (70cm) apart land divided into(3^mx3.5^m) plots, each one includes 3ridges, 3 meters long, Seeds were sown on the 24th of June 2016 at20cm spacing between holes, at seeds rate of 2.5 kg/fed. Nitrogen fertilizer (urea 46%N) was applied at (4okg/fed), three weeks after planting. Manual weeding was carried out when needed. Irrigation was given at one week interval for four weeks then treatments were applied thereafter.

3.3 Data Collection:

Five plants from the two inner ridges at each plot were randomly selected and tagged, parameter were recorded from these plants at (45, 60, and 90) days after sowing.

3.3.1Vegetative growth attributes:

3.3.1.1 Plant height (cm)

Plant height was measured from the base of the main stem to the tip of panicle using a meter tape. Then the average was calculate.

3.3.1.2 Number of leaves/plant

Leaves were counted for the five tagged plants and the average was determined.

3.3.1.3 Stem thickness (cm)

Stem thickness for the five selected plants was measured and the average was recorded for each treatment.

3.3.1.4Number of tillers/plant

Tillers were counted for the five tagged plants and the average was determined.

3.3.1.5 Plant density

Number of plants was counted from one mertr^2 in each plot randomly after 45and 60 (DAS) and the average was calculate.

3.3.2 Yield attributes:

3.3.2.1 Fresh weight (kg)

At harvest 90 (DAS) one meter^2 in each plot was harvested. Then the plants were weighed to take the fresh weight.

3.3.3.2 Plant dry weight (kg)

The above mentioned plants were dried using natural drying for two week and then weighed and recorded.

3.3.4 Crude Protein and Fiber (%)

Crude protein and crude fiber contents were determined followings the standard methods of the Association of official Analytical chemists. The organic nitrogen content was quantified using the micro kjeldahl method and crude protein content was estimated by multiplying the organic nitrogen content by a factor of 6.25(Sosulski and Imafidon, 1990). Two different samples were analyzed in triplicate

3.3.4 Crude Fiber (CF)

It is generally recognized that the nutritive value of tropical pasture falls as they mature due to arise in fiber content with increasing maturity (Keftasa,1990). Bogdan (1969), stated that the content of crude fiber in Rhodes grass usually vary between 30-40 percent. Ibrahim (1999) reported that crude fiber content increased with cuts for all cultivars of Rhodes grass. The late application (after 35 days from sowing) resulted in highest crude fiber on all sorghum cultivars (Abusabein, Sudan grass, panar and Speed feed) Eltelib (2004).

CHAPTER FOUR

RESULTS

4-1 Plant height (cm)

Statistical analysis showed no significant differences of varieties and water intervals on plant height at 45 and 60 (DAS) ($p \leq 0.01$) (Table1). The interaction between varieties and water intervals displayed significant effect on plant height (Table2). Water applied every 14 days resulted in tallest plant height (173.75cm) with Abusabein variety, and 21 days intervals achieved lowest plant height (144.90m) from Pioneer variety (Table 3).

4-2 Number of leaves/plant

Varieties and water intervals had no significant effect on these parameters at 45 and 60 (DAS) (Table 2). Interaction of water intervals and varieties showed no significant affect. But water applied every 14 days had increase number of leaves/plant with Abu Sabein variety (10.55) compared to other water intervals and varieties.

4-3 Stem thickness

According to statistical analysis it was clear that varieties and water intervals had no significant effect on stem thickness at 45 and 60 (DAS) (Table1, 2). Moreover the interaction between water intervals and varieties had no significant effect. Applied water every 7 days increase stem thicker this increment was not significant .Irrespective of water intervals Pioneer produced more stem thickness compared to other varieties.

4- 4 Number of Tillers/ plant

Differences between water intervals on number of tillers/plant were not significant at 45 (DAS) (Table 1). However, at 60 (DAS) Water intervals and the interaction of treatments had considerable effect on number of tillers/plant (Table 3). The highest number of tillers for Sudan grass variety (3.00) was obtained from 21 days water interval and the lowest for Pioneer variety (0.35) from 7 days water interval (Table 3).

4-5 Plant density

Statistical analysis showed no significant affect of varieties and water intervals on plant density (Table 2) and the interaction between varieties and water intervals had no significant effect, but Abu Sabein variety showed an increase in plant density compared to other varieties and water intervals.

Table (1) Vegetative growth parameters of forage sorghum cultivars as affected by water intervals 45(DAS).

Source of variation	F-values					
	Degree of freedom	Plant height (cm)	Number of leaves/plant	Stem thickness(cm)	Number of tillers/plant	Plant density
Replicate	3	2.24^{ns}	0.03^{ns}	0.84^{ns}	0.40^{ns}	1.11^{ns}
Varieties(v)	2	1.98^{ns}	0.39^{ns}	0.32^{ns}	0.18^{ns}	0.21^{ns}
Water Levels(w)	2	0.61^{ns}	0.95^{ns}	1.49^{ns}	0.58^{ns}	0.64^{ns}
V x W	4	0.45^{ns}	1.20^{ns}	1.47^{ns}	0.64^{ns}	0.72^{ns}
Error	24	-	-	-	-	-
Total	35	-	-	-	-	-
C.V%	-	14.90	11.95	21.16	12.37	18.91
S.E±	-	4.5631	0.2324	0.2369	0.3227	2.1996
L.S.D	-	9.4179	0.4796	0.4888	0.6661	4.5399

Ns= not significant, *= statically significant at p=0.05

Table (2) Vegetative growth parameters of forage sorghum cultivars as affected by water intervals 60 (DAS).

Source of variation	F-values					
	Degree of freedom	Plant height (cm)	Number of leaves/plant	Stem thickness(cm)	Number of Tillers/plant	Plant density
Replicate	3	1.91^{ns}	3.34*	0.95^{ns}	2.88*****	0.54^{ns}
Varieties(v)	2	0.81^{ns}	1.71^{ns}	0.52^{ns}	0.27^{ns}	0.29^{ns}
Water Levels(w)	2	0.90^{ns}	2.27_{ns}	0.91^{ns}	3.22*****	0.35^{ns}
V x W	4	2.60*	2.06^{ns}	0.42^{ns}	2.46*****	0.87^{ns}
Error	24	-	-	-	-	-
Total	35	-	-	-	-	-
C.V%	-	10.51	16.12	30.63	10.25	31.98
S.E±	-	6.7231	0.5520	0.6353	0.4804	2.1772
L.S.D	-	13.876	1.1394	1.3112	0.9914	4.4936

Ns= not significant, *= statistically significant at p=0.05

Table (3) Effect of water intervals and varieties interaction on growth and yield of forage sorghum cultivars.

crop	Irrigation internal (days)	Plant height (cm)		Number of leaves /plant		Stem thickness (cm)		Number of tiller /plant		Plant density		Fresh and Dry weight(kg/ha)	
		45	60	45	60	45	60	45	60	45	60	F.W(90day)	D.W(90days)
Abusabein	7	78.87A	155.85AB	4.60A	7.90B	2.59AB	4.83A	0.50A	0.70B	26.55A	21.10A	800.00A	327.50Ab
Pioneer		68.60A	151.60AB	4.33A	8.95AB	2.89AB	6.18A	1.00A	0.35B	25.00A	16.55A	775.00AB	372.50AB
Sudan grass		75.50A	148.00B	4.85A	8.05B	2.44B	4.50A	0.25A	0.50AB	29.85A	15.20A	775.00AB	442.50A
Abusabein	14	81.95A	173.75A	4.55A	10.55A	2.52B	4.80A	0.75A	1.85AB	31.75A	15.45A	762.50ABC	322.50A
Pioneer		78.60A	161.50AB	5.03A	9.00AB	2.42B	4.95A	1.00A	1.20B	29.50A	17.30A	650.50C	412.50A
Sudan grass		73.05A	147.00B	5.15A	7.50B	2.89AB	4.18A	0.75A	0.52B	27.45A	17.95A	762.50ABC	317.50AB
Abusabein	21	78.55A	154.00AB	4.80A	7.95B	3.44A	4.65A	0.50A	0.75B	27.80A	14.62A	700.00ABC	242.50A
Pioneer		76.60A	144.90B	5.03A	7.70B	2.82AB	5.10A	0.25A	1.45AB	28.60A	17.95A	675.00BC	390.00AB
Sudan grass		66.75A	173.50A	4.55A	7.90B	2.68AB	5.55A	0.75A	3.00A	29.95A	17.22A	812.50A	245.00B
L.S.D		16.312	24.034	0.8308	1.9734	0.4102	2.2710	1.1538	1.7172	7.8633	7.7831	121.06	149.80

Means followed by the same letters in each Column are not significantly different from each other using L.S.D test at 0.05 level of significance.

4- 6 Forage Fresh weight (kg/ha)

Statistical analysis showed significant affect of varieties on fresh weight. (Table 4) Varieties and water intervals interactions had no significant affect. On the other hand, water applied every 21 days increased forage fresh weight slightly (812.50A) kg/ for Sudan grass compared to other water intervals and varieties (Table 3).

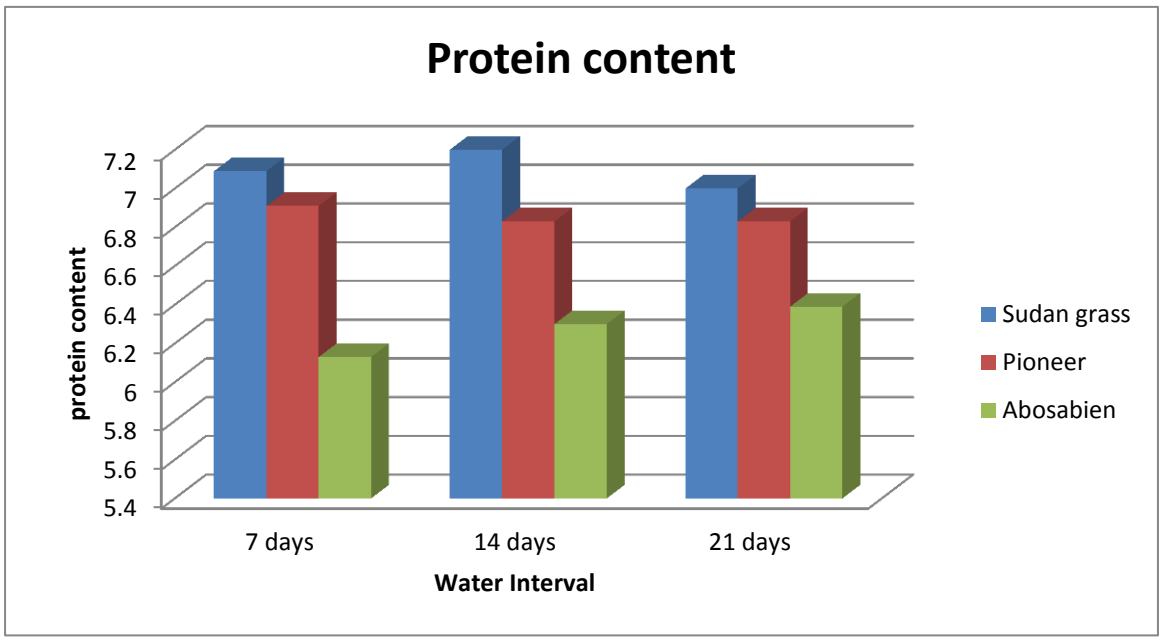
4-7 Forage dry weight (kg/ha)

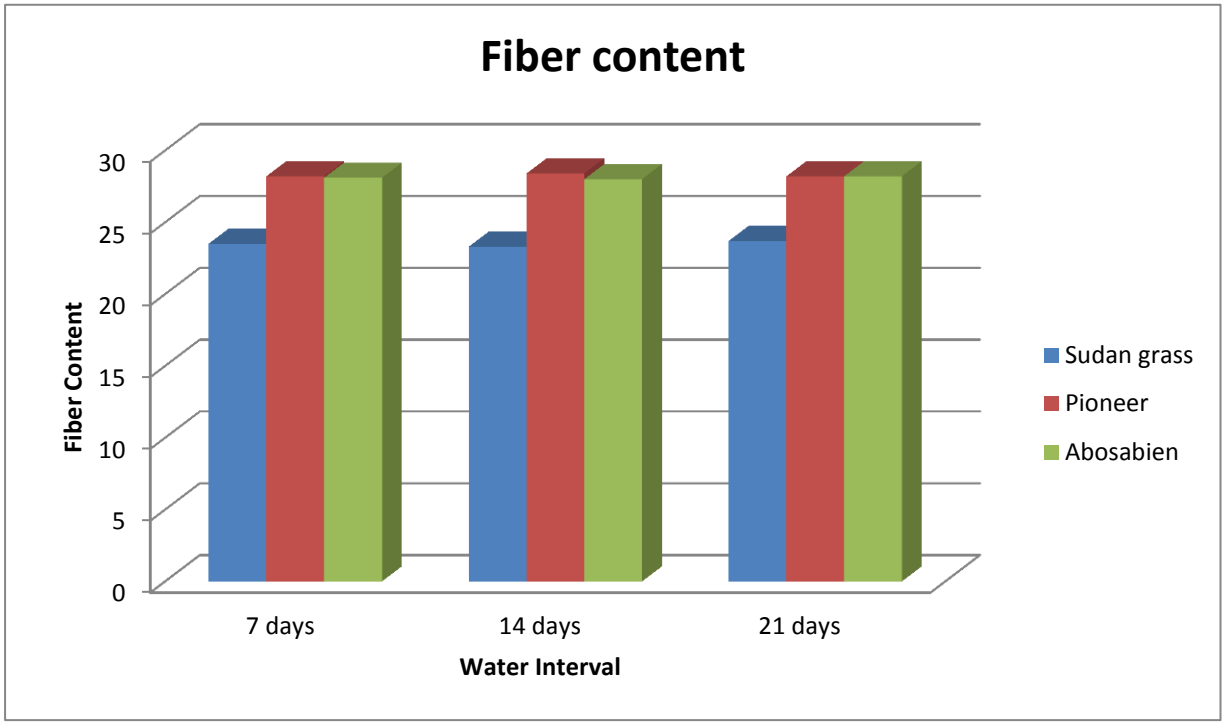
Water intervals and varieties displayed significant effect on forage dry weight and their interaction was also significant (Table 4). The highest dry weight 442.50 kg/ha was irrigated at 7 days interval for Sudan grass variety and the lowest dry weight 242.50 kg/ha was irrigated at 14 days interval for Adu Sabein variety (Table 3).

Table (4) Comparison of parameters studied for water interval and varieties effect on yield.

Sources	**Degree Of freedom.**	**Fresh weight (kg/ha)**	**Dry weight (kg/ha)**
REP	3	0.14^{ns}	4.77**
Variety	2	3.12*****	2.56*
Water levels	2	1.85^{ns}	2.30*
(V×W)	4	1.29^{ns}	1.25*
Err	24	6880.8	10535.9
Tot	35		
CV%		11.12	30.07

Ns=not significant, *=statistically significant at p=0.05


Protein content
protein content
7.2
7
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
7 days
14 days
21 days
Water Interval
Sudan grass
Pioneer
Abosabien


Fiber content
Fiber Content
30
25
20
15
10
5
0
7 days
14 days
21 days
Water Interval
Sudan grass
Pioneer
Abosabien

CHAPTER FIVE

DISCUSSION

The general trend was that water interval had significant effect on some vegetative and yield parameter of forage sorghum.

Water intervals at 45(DAS) had no affect on plant height, number of leaves, stem diameter, number of tillers, plant density, but at 60(DAS) there were some significant differences between treatments on growth characters. Applying water every 7 and 14 days increased plant height, stem thickness and number of leaves /plant; this results agreed with Kabbashi (1991) who found that the effect of irrigation frequency on sorghum plant height was consistently decreasing with increasing the irrigation interval. Water stress reduced plant height. Mustafa and Magid, (1982) reported that plant height of sorghum increased with decreased irrigation frequency or interval. Ibrahim *et al* (1999) showed that water stress increased the plant height of drought tolerant varieties than non tolerant ones. Several investigations from different parts of the world showed that plant height of wheat increased with more frequent irrigation (Hussein *et al*. (1978). Morphological characters (plant height, stem diameter and leaf area index) increased by decreased water intervals (7days), as the increment was associated with developing growth stages. This result was in agreement with (Amir *et al*. 2011) who found that using 7, 15, 22 and 28 days water interval on safflower, indicated that plant height and stem diameter were negatively affected by the increased irrigation interval more than 15 days. Khabbashi (1991) showed that in sorghum the number of leaves /plant was not affected by water stress. Amin (1988) reported that in sorghum the number of leaves per plant was not significantly affected by water stress. Saeed (1988) reported that leaf

number per plant of fodder sorghum was significantly affected by irrigation interval. Shorter irrigation intervals resulted in higher number of leaves per plant and stem diameter. Khabbshi (1991) found that growth parameters were consistently decreasing with increasing irrigation intervals, water stress reduced stem diameter. Moderate water interval (14 days) resulted in a positive effect. The results showed significant effect on fresh and dry weight of forage sorghum. Increased irrigation intervals physiologically may affect plant by exposing it to prolonged interval which may decrease fresh and dry weight. Amin (1999) found an increase in fresh fodder with decreased watering intervals. Saeed (1988) reported that higher yields of fresh fodder in all sampling occasions were associated with frequent irrigation and the yield decreased as irrigation interval was prolonged. Saeed (1988) found that water interval treatment produced significant differences in the fresh yield and also found that dry yield increased with the decrease of irrigation intervals. The highest dry yield was obtained under short irrigation interval and the yield decreased with the long irrigation interval.

Cultivar Abusabein gave the best plant height at both 45 and 60 days (78.87cm and 155.85cm, respectively) at 7 days interval but the best height was obtained by Abu Sabein at 14 days interval. However, the dry weight is obtained from the fresh weight so the high fresh weight is expected to result in higher dray weight. Differences between cultivars might be due to genetic differences between the cultivar, (Salaheldin *et al* 2017) found similar results.

SUMMARY AND CONCLUSION

From the results obtained in this study, it can be concluded that the irrigation interval of 7 and 14 days resulted in the best forage yield. As for the cultivars, Abu sabein gave the best result in this study. It is recommended that further research in needed to confirm these findings.

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