U. of K. J. Agric. Sic. 23(2), 203-216, 2015

Effect of Sowing Season, Age and Height of Cutting of the Primary Crop of *Sorghum bicolor* cv. 'Abu Sabeen' on Growth and Forage Yield of the Secondary Crop

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Abstract: A field experiment was conducted for two consecutive seasons at the Gezira Research Farm to study the effect of growing season, age and height of cutting of the primary crop of 'Abu Sabeen', on the regrowth yield. The first experiment was sown on 4th of September 2005 and the second was on 7th of June 2006.The treatments comprised cutting the primary crop at 5 ages *i.e*. 6, 7, 8, 9 and 10 weeks from sowing and 4 cutting heights *i.e.* 5, 10, 15 and 20 cm above ground. The 20 treatments were allotted to a randomized complete block design with 3 replications. Data were collected on weather conditions, forage yield, plant height, and culm density of the first regrowth. The growing season was crucial for multiple -cut crop of 'Abu Sabeen'; long days and high temperature being more conducive for high dry matter yield of the regrowth mainly through the increase in plant height, and shorter days and relatively lower temperature being conducive for high culm density and retarded growth. Taller plants were determinant of the regrowth yield than the increase in the culm density. Highest dry matter yields of the regrowth were associated with June sowing and cutting the primary crop at the age of 7 weeks and cutting height of 15 or 20 cm above ground.

Keywords: Forage sorghum; regrowth; cutting age; cutting height.

INTRODUCTION

Time course inverse relation between the dry matter yield and the quality in forage crops (Khair 1999) and probably in the regrowth potential after cutting (Ishag 1989) in sorghum were reported. Anderson and Matches (1983) found that early harvesting of forage grasses resulted in forage yield of higher quality and better regrowth potential than harvesting at later growth stages. Swards, which had initially been defoliated late at a mature stage of growth, produced small yield in the second defoliation due to reduced regrowth potential (Binnie and Chestnutt 1980). Likewise, Mislevy *et al*. (1977) reported that delaying the first harvest of timothy grass and orchard grass until later maturity (boot and anthesis) significantly reduced regrowth yields. Residual stubble height of pasture plants after cutting, on the other hand, reflects defoliation severity which in turn affects water-soluble carbohydrate reserve levels (Fulkerson and Donaghy 2001). These carbohydrate reserves are important in the regrowth (Cullen *et al*. 2006). Close defoliation depletes carbohydrate reserves (White 1973) and reduces yield and number of tillers of the regrowth of the range grasses (Stout *et al*. 1980). It also reduced tillering, dry matter yield and soluble carbohydrates reserves in ryegrass (Slack *et al*. 2000), and had further suppressing effect on regrwoth rate of some ryegrass genotypes (Fulkerson *et al*. 1994). Raising the height of cutting from 3cm to 8cm, on the other hand, significantly increased the number of tillers of perennial ryegrass in the second harvest (Binnie and Chestnutt 1980). Lee *et al*. (2008) reported that regrowth dry matter yield of perennial ryegrass increased with increasing cutting height. Similarly, regrowth following cutting of the primary crop of forages depends on both or either of the quantity of the carbohydrate reserves and/or the lower leaves which are retained in the stubble (Miller 1984).

'Abu Sabeen' (a local variety of *S. bicolar*) is primarily a warm season crop (Khair 1999). Its height and yield in the winter season is almost 50% of its potential in the warm season. That could be due to the effect of the day length on stem elongation and, therefore, on plant height (Salisbury and Ross 1992). Hence, the time of sowing of seed crop of 'Abu Sabeen' may have an impact on the performance of the main and the subsequent regrowths.

Based on the foregoing information, the cropping season might affect the performance of the primary and the subsequent growth of 'Abu Sabeen' in Sudan through the effect of the day length on stem elongation and heading. Moreover, as 'Abu Sabeen' hardly retains the lower most leaves at the time of harvesting, the regrowth is likely to depend solely on carbohydrate reserves in the remaining stubble. The age of cutting of the primary crop of 'Abu Sabeen', on the other hand, might affect the trafficking of the carbohydrate to the grains at the expense of the storage at the stem base and vice versa. A compromise should, therefore, be set between the cutting height and crop age to guarantee adequate regrowth after cutting. The objective of this study, therefore, was the investigation of the effect of the season, cutting height and cutting age of the primary crop on the regrowth yield of 'Abu Sabeen'.

MATERIALS AND METHODS

The study was conducted for two environmentally contrasting seasons for the regrowths, viz. September 2005 and June 2006, at the Experimental Farm of the Gezira Research Station of the Agricultural Research Corporation (ARC), Wad Medani, Sudan (latitude 14°24′N., longitude 33°29′E., and altitude 406.9 m above sea level. The soil is vertisol with high clay content (40%– 65%), pH values ranging from 8 to 9.6, less than 1% organic carbon, 0.03% total nitrogen and 406 to 700 ppm total phosphorus. The climate is hot semi-arid tropical with an average annual rainfall of 300 mm, occurring mostly during May through October with the peak in August. The average maximum air temperature ranges from 32.9°C in January to 41.6°C in May, while the minimum air temperature ranges from 14.3°C in January to 24.9°C in June. The average relative humidity ranges from 18% in April to 67% in August (Adam 1996).

The soil in both seasons was disc ploughed, disc harrowed and leveled. Subplot size was 3.2 × 5.25 m and consisted of four ridges 5.25 m long and 0.8 m apart. The experiment comprised 20 treatments which were a combination of five cutting ages viz. at 6th, 7th, 8th, 9th or 10th week after sowing and four cutting heights of the primary crop of 'Abu Sabeen' viz., 5, 10, 15 or 20 cm above ground level. The treatments were arranged in a randomized complete block design, with three replications. The experiment was planted on the 4th of September 2005 (referred to

hereinafter as September sown) and on the 7th of June 2006 (referred to hereinafter as June sown). The seeds of *S. bicolor* cv. 'Abu Sabeen' were purchased from Wad Medani market. The germination percentage of the seeds, as tested in the laboratory before sowing, was 99% and 97% for 2005 and 2006, respectively. In each season, seeds were hand drilled on top of the ridge at the rate of 24 kg per ha to about 5 cm deep. All plots were fertilized with urea (46% N), added simultaneously with the seeds at the rate of 186 kg urea/ha. Irrigation was applied immediately after sowing and thereafter every 15 days. The plots were maintained weed - free by hand hoeing.

In each subplot, the two outer most ridges as well as half a metre from each end of the central ridges were left unharvested as margins, leaving the central 1.6×2.5 m area for measurements of forage yield and its attributes.

In both seasons, the primary crop of each treatment was cut according to the prescribed age and cutting height, whereas the regrowths were cut at the ground level and at the stage of 50% booing which coincided with the age of 49 and 60 days for September and June sowing, respectively. At harvest, the collected data on the regrowth crop were plant height (as a mean of 5 randomly selected plants), culm density (CD) (the number of stems in the harvested area) and dry matter yield. The fresh weight of the regrowth crop was immediately recorded in the field and a subsample of known fresh weight was oven dried at 80ºC for 48 hours for the dry matter determination.

Data were statistically analyzed according to the randomized complete block design by using IRRISTAT package. Combined analysis of variance over the two seasons was computed. Means were separated by the least significant difference (LSD) (Gomez and Gomez 1984).

RESULTS

Regrowth growing conditions

The growing conditions of the regrowth of June sown 'Abu Sabeen' were characterized by lower maximum, higher minimum and relatively higher daily mean temperatures than those of September sown crop (Table 1). The most noticeable differences between the two seasons, however, were in the minimum temperature and in the day length of the regrowth period. September sown regrowth crops were subjected to low minimum temperature which was at least 3ºC less than that of June sown ones. Regarding the day length, the mean day length of the regrowth period of September sown regrowth crops was shorter by at least one hour than their counterparts of June sown one. Although not large, the day length of the regrowth periods in each season, decreased progressively as the harvest of primary crop was advanced from 6 weeks through to 10 weeks.

Seasonal effect

Marked differences were shown among the regrowth attributes of June and September sown 'Abu Sabeen' (Table 2). While the seasonal mean plant height and dry matter yields of the regrowths were higher in June than September sown crop, the CDs of the regrowth were higher in September than June sown one.

Effect of cutting age of the primary crop

Cutting ages of the primary crop significantly affected the plant height and dry matter yield of the regrowth in both September and June sown 'Abu Sabeen' (Table 3). In each season as well as in the mean across both seasons, the tallest plants in the regrowth were obtained when the primary crop was cut at the age of 7 weeks. Thereafter, progressive reductions in the plant heights of regrowths corresponded to progressive delays in the cutting age of the primary crop especially in June sown one. The shortest plants in the regrowth of June sown 'Abu Sabeen' was obtained when the primary crop was cut at the age of 10 weeks.

CDs of the regrowth were significantly different, though with different trends, in both seasons (Table 3). The highest CD of the regrowth in September- sown 'Abu Sabeen' was obtained when the primary crop was

cut at the age of 7 weeks. Contrastingly, however, the culm density of the regrowth of June sown crop was the lowest in the first two cutting ages (6 and 7 weeks). Thereafter, significant increase in the CD of the regrowth followed progressive delays in the cutting ages of the primary crop up to 10 weeks. The mean CD across both seasons followed a close trend to that of June sown crop.

The dry matter yields of the regrowth in June sown 'Abu Sabeen' was higher than that of September. The highest dry matter yield was recorded when the primary growth was cut at 6 and 7 weeks in both seasons (Table 3)

Effect of the stubble height of the primary crop

Cutting the primary crop to the stubble height of 5 cm in September sown crop resulted in the lowest dry matter and CDs in both seasons (Table 4). Regarding the plant height, cutting the primary crop of September to the stubble height of 15 and 20 cm resulted in the tallest plants while the effect was not consistent in June crop.

Table 1. Mean seasonal temperature (ºC), day length (hours) and growing duration (days and range) of the first regrowth of September (S) (2005) and June (J) (2006) sown Abu Sabeen in the Gezira

Cutting age of the primary crop (weeks)	Growing duration of 1st regrowth range		(days)		Seasonal temperature ºC Maximum		Minimum		Day length (hours) Mean		S		J	
	S	**J**	**S**	**J**	**S**	**J**	**S**	**J**	**S**	**J**	**h**	**m**	**h**	**m**
6	15Oct.-3Dec.	19July-19Sep.	49	60	38.2	35.4	20.3	22.9	29.3	29.2	11	36	12	39
7	22Oct.-10 Dec.	26July-26Sep.	49	60	38.0	35.3	19.6	23.0	28.8	29.2	11	32	12	37
8	29Oct.-17Dec.	2Aug.- 30Oct.	49	60	37.8	35.7	19.5	22.8	28.7	29.3	11	27	12	34
9	5Nov.-24 Jan.	9Aug.-10Oct.	49	60	37.7	35.7	19.3	22.8	28.5	29.3	11	24	12	26
10	12Nov.-31Jun	16Aug-17Oct.	49	60	37.0	35.3	19.1	21.1	28.1	28.7	11	23	12	23

Table 2. Seasonal effects on the plant height (cm), CD (No/m^2) and dry matter yield (DMY) (t/ha) of the regrowth of Abu Sabeen

Growing season	Plant height	CD	DMY
September 2005	47	40.0	0.5
June 2006	140	32.4	3.3
LSD (0.05)	4.6	1.9	0.2

Table 3. Effect of the cutting age of the primary crop on the yield attributes of the regrowth of September and June sown 'Abu Sabeen' crop

Cutting age (weeks)	September 2005	June 2006	Mean
		Plant height (cm)	
6	50.6	152.2	101.4
7	58.1	156.3	107.2
8	41.5	143.0	92.3
9	37.7	130.6	84.1
10	46.9	120.6	83.8
LSD (0.05)	7.6	12.6	7.2
		Culm density (No/m^2)	
6	36.8	27.8	32.3
7	45.7	26.3	36.0
8	35.5	34.7	35.1
9	38.6	34.1	36.3
10	41.6	38.9	40.3
LSD (0.05)	5.0	3.5	3.0
		Dry matter yield (t/ha)	
6	0.6	4.2	2.4
7	0.8	4.0	2.4
8	0.4	3.2	1.8
9	0.5	2.5	1.5
10	0.5	2.7	1.6
LSD (0.05)	0.14	0.62	0.3

Table 4. Effect of the stubble height of the primary crop on the yield attributes of the regrowth of September and June sown 'Abu Sabeen' crop

Cutting height (cm)	September 2005	June 2006	Mean
		Plant height (cm)	
5	35.7	141.5	88.6
10	42.7	147.7	95.2
15	52.6	131.5	92.1
20	56.8	141.3	99.1
LSD (0.05)	6.8	11.1	6.5
		Culm density (No/m^2)	
5	33.0	28.1	30.6
10	36.2	33.4	34.8
15	42.3	33.3	37.8
20	46.9	34.5	40.7
LSD (0.05)	4.5	3.1	2.6
		Dry matter yield (t/ha)	
5	0.38	2.9	1.6
10	0.44	3.3	1.9
15	0.71	3.3	2.1
20	0.64	3.7	2.2
LSD (0.05)	0.10	0.60	0.3

DISCUSSION

S. bicolor cv. 'Abu Sabeen', the most cultivated forage crop in the Sudan, is mainly treated as a single cut crop. That is not because it is strictly a mono-cut crop, but because its first regrowth yield, which is about 25% of its primary yield (Khair 1999), might not be economically feasible. Hence, the possibility of production of an adequate regrowth yield through the manipulation of the agronomy of its primary crop deserves investigation.

The three primary agronomic variables which were tackled in this study, were the growing season, the cutting age of the primary crop and the stubble height. They have affected, to various degrees, the forage

attributes of the regrowth crop. The growing season had an over-riding effect compared to the other variables. That is, the dry matter yield and plant height of the regrowth crops were higher in June than September sowing, while the culm density was lower in June compared to September sown crop. This statement was further qualified by the fact that the highest regrowth forage yield components in both seasons were associated with cutting the primary crop at 7 weeks old, with the magnitudes of the yield in favour of June sowing.

Analysis of some environmental factors during the regrowth conditions might elucidate such seasonal differences. The mean seasonal temperature during the regrowth period of June sown crop (29.1°C) and September sown crop (28.7ºC) were neither too high nor low compared to that required by sorghum (30ºC) (Skerman and Riverus 1990) to cater for such seasonal differences in the regrowth attributes. However, two sorghum growth retarding environmental factors could be involved to explain the seasonal discrepancies. Those were the comparatively short days (11^h 28^m) and low minimum temperature (19.6°C), to which the regrowth of September sown crop was subjected. That is, long nights (short days) at such low minimum temperatures adversely affected the regrowth of September sown crop. Moreover, the short days might have impaired the stem elongation of the regrowth of September sown crop (Salisbury and Ross 1992). In fact, the high forage yield seemed to be associated with taller plants than with numerous culms as shown by the differences in the regrowth attributes between the two seasons.

As the regrowth was harvested according to the phenology, the shorter days enhanced harvesting the regrowth of September sown crop (49 days) compared to those of June sown crop (60days). Hence, longer regrowth periods are in favour of June sown crop.

Another environmental factor (though not measured in this study) which might have been in favour of the regrowth of June sown 'Abu Sabeen' is the high relative humidity. According to Adam (1996), the regrowth of June sown 'Abu Sabeen' was exposed to higher relative humidity than of September sown crop.

It is worth mentioning that the regrowth growing conditions of June sown crop resemble those of the primary crop of September sown crop. So no wonder if the regrowth attributes of June sown crop resemble more or less those of the primary crop of September sown crop (Eltalib 2009). Based on the environmental conditions of Wad Medani (Adam 1996), growing 'Abu Sabeen' in March 1st through June and cutting the primary crop at 7 weeks may result in high forage yield of the primary crop and equally high yield of the first regrowth and probably more than one regrowth crop. In fact, the total yield of the first crop of June sown 'Abu Sabeen' in this study and the first regrowth was 8.4 t/ha compared to only 4 t/ha for the primary crop of September sown 'Abu Sabeen' (Eltalib 2009). In conclusion, the highest first regrowth crop of 'Abu Sabeen' in this study was associated with June sowing and cutting the primary crop at the age of 7 weeks and cutting height of 15 or 20 cm above the ground.

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أثر موسم الزراعة وعمر وإرتفاع قطع المحصول الرئيس لمحصول الذرة الرفيعة (*Sorghum bicolor*) الصنف أبو سبعين على إنتاجية علف المحصول الثانى

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المستخلص: أجريت تجربة فى حقل محطة بحوث الجزيرة لموسمين متتالين ومتباينين لدراسة تأثير موسم الزراعة وعمر وإرتفاع قطع المحصول الرئيس على إنتاجية علف المحصول الثانى (القطعة الثانية) فى محصول أبو سبعين. زرعت التجربة الأولى فى الرابع من سبتمبر 2005م والثانية فى السابع من يونيو 2006م. اشتملت المعاملات على قطع المحصول الرئيس لأبو سبعين فى 5 أعمار هى الحصاد فى عمر 6 و 7 و 8 و 9 و 10 أسابيع وعلى أربعة ارتفاعات من سطح الأرض هى القطع على إرتفاع 5 و 10 و 15 و 20 سم. وزعت المعاملات العشرين عشوائياً على تصميم القطاعات العشوائية الكاملة و لثلاثة مكررات. جمعت بيانات فى الموسمين على الطقس وإنتاجية العلف وإرتفاع النباتات وكثافة السيقان (عدد/ متر^2) فى المحصول الثانى. أظهرت النتائج أن موسم الزراعة له تأثير واضح فى مقدرة أبوسبعين على إعادة النمو. حيث أن النهار الطويل ودرجات الحرارة العالية يؤديان إلى زيادة إرتفاع نباتات وإنتاجية علف المحصول الثانى بينما يؤدى قصر النهار وإنخفاض درجات الحرارة إلى قلة إنتاجية وقصر النباتات مع زيادة فى كثافة السيقان فى المحصول الثانى. إرتفاع طول النباتات محدد أساسى فى الانتاجية أكثر من كثافة السيقان فى المحصول الثانى. كانت أعلى إنتاجية للمحصول الثانى لأبو سبعين عند زراعته فى شهر يونيو وقطع المحصول الرئيس فى عمر 7 أسابيع وعلى إرتفاع 15 أو 20 سم من سطح الأرض.