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PRODUCTIVITY AND CHEMICAL COMPOSITION OF GREEN BIOMASS FROM SUDAN GRASS, GROWN AS A SECOND CROP, WITH OPTIMAL AND INSUFFICIENT WATER SUPPLY

Rumen Bazitov[1*], Stanimir Enchev[2]

[1]Agricultural institute, 6000, Stara Zagora, Bulgaria
[2]Agricultural institute, 9700, Shumen, Bulgaria
[*]**E-mail: rumen7588@abv.bg**

Abstract

The aim of the present study is to determine the impact of the disturbed irrigation regime on the yield and the chemical composition of Sudan grass, grown as a second crop. To accomplish this goal, a trial was conducted in the experimental field of the Agricultural Institute - Stara Zagora with Sudan grass on meadow-cinnamon soil under irrigated conditions. The following variants have been studied: 1 - without irrigation (control variant); variant 2 - optimal irrigation, 75-80% of field capacity (FC); variant 3 - irrigation as in variant 2, but with the removal of the first watering; variant 4 - irrigation as variant 2, but with the removal of the second irrigation; variant 5 - irrigation as variant 2, but with the removal of the third watering. It was found that when growing Sudan grass as a second crop with optimal irrigation and disturbed irrigation regime done by canceling successive watering, the highest yield of dry biomass is obtained with optimal irrigation including three irrigations. Its yield increased by 24.2% compared to the control treatment. Irrigation of Sudan grass with only the second and the third irrigation in a row, without the first irrigation provided, leads to the lowest yield of dry biomass - 11290 kg / ha. Among the chemical composition indicators, the most significant change is observed in the content of the crude fat, followed by that of the crude fiber and crude protein, depending on the method of growing Sudan grass (with or without irrigation).

Key words: Sudan grass, irrigation regime, yield, chemical composition

INTRODUCTION

Sudan grass (Sorgum sudanense (Pepir) Stapf.), harvested at an appropriate stage of development is a valuable raw material for silage, long-term storage and feeding of ruminants throughout the year. It is a relatively new forage crop poorly represented in our country. The increasing trend of extreme deviations from agro-climatic indicators is a prerequisite for its use as an alternative to maize crop (Slanev, 2012; Undersander, 2003; Kertikov, 2005). Sudan grass allows for obtaining stable and high yields of green and dry biomass of high quality per unit area (Akash and Saoub, 2000; Djukic´ et al., 2003; Kikindonov et al., 2013) as in self-cultivation, as well as in mixed crops with soybeans, corn, sunflower, etc. (Undersander, 2003). It is resistant to extremely high temperatures, drought and has a high productive potential. The phenophases of crop development and soil conditions have an impact on the content of nutrients in the green biomass and hay from Sudan grass (Zakonović et al., 1997 - very old reference; Moyer et al., 2004). The crude protein content decreases with growing vegetation and varies depending on the variety and agrotechnology, while the fiber levels increase, which is a prerequisite for reducing the nutritional value and digestibility of feed (Casler, 2001 and Sulungwe, 2011). Krachunov and Ilieva (2005) found that with the

progression of the growth and development of Sudan grass, there is a consistent decrease in the digestibility of all nutrients. Golubinova et al. (2016), in a study over the mutant forms of Sudan grass, conducted in 2016, in a competitive experiment found a higher quality of biomass compared to control treatments. Studies on the cultivation of Sudan grass as a second crop for green mass are insufficient and do not provide enough information for the rational use of its productive potential under irrigation conditions as a second culture. The aim of the present study is to determine the impact of the disturbed irrigation regime on the yield and the chemical composition of Sudan grass, grown as a second crop.

MATERIALS AND METHODS

During the period 2014 - 2016 in the experimental field of the Agricultural Institute in Stara Zagora a trial was conducted with Sudan grass, Endzhe -1 cultivar on meadow-cinnamon soil type. The soil is characterized by a moderately developed humus horizon, poor in nitrogen (31.3 - 38.1 mg / kg soil), poorly stocked with absorbable phosphorus (3.1 - 4.3 mg / kg soil) and well stocked with absorbable potassium (42.3 - 481 mg / 100 g soil). This type of soil has the following water-physical properties: field capacity (FC) - 26.67, wilting coefficient - 18.19%, porosity - 47% and bulk density - 1.45.

The preparation of the soil for the sowing of Sudan grass was carried out by double disking and the sowing itself - in the optimal agro-technical sowing period for the region. Phosphorus fertilizer at a rate of 80 kg /ha was imported before the main tillage. Nitrogen fertilizer was applied manually during the growing season at a rate of 90 kg / ha.

Sudan grass was sown after barley as a preceding crop. The trial was set using the block method in four replications with a size of the harvest plots of 25 m2. The Sudan grass was harvested at the blooming stage.

Irrigation was performed by gravity flow irrigation with seasonal stationary installation. In order to determine the irrigation rate, the dynamics of soil moisture was monitored by taking soil samples from variant 2. Irrigations in all variants were applied simultaneously. The following variants have been studied: Variant 1 - without irrigation; Variant 2 - optimal irrigation through three waterings; Variant 3 - irrigation as Variant 2, but with the removal of the first watering; Variant 4 - irrigation as Variant 2, but with the removal of the second watering; Treatment 5 - irrigation as Variant 2, but with the removal of the third watering. The time for watering was adjusted to the available soil moisture. The content of the crude protein was determined by the classic Weende method (Henneberg W., 1859). The nitrogen free extract (NFE) was calculated according to the formula 100-Crude Protein %-Crude Fibre %-Crude Fat %– Crude Ash %. The yield of dry biomass was determined by the method of drying the green biomass at 700C temperature for 24 hours. Mathematical processing of the data was performed by the software product ANOVA– 1.

RESULTS AND DISCUSSION

The productivity of Sudan grass depends on both agro-technical activities and the meteorological conditions during the year. The watering time is regulated in accordance with the available moisture at the time of the soil sampling, which depends on the temperature and the amount of precipitation. In the cultivation of Sudan grass as a second irrigation crop, for the formation of high and stable yields, the amount of precipitation that fell during the months of active vegetation (VII-VIII) was of great importance. In our experiment, the distribution of precipitation during the growing season of Sudan grass was unevenly spread over the three experimental years (Table 1). Regarding the probability of precipitation (P%), the months of July and August, which had the most significant contribution to the formation of

Sudan grass yield in 2014, were respectively dry and wet: July with 33.0% and August with 2.0%. For the second year (2015), July was dry (89.8%) and August – on average dry month (62.4%). In the last experimental year (2016), July and August were dry, 95% and 90.1%. The same months of the transitional 83-year period were characterized as moderately wet, July - 33.7% and August - 32.60%, respectively, compared to the previous 83-year period (1930 – 2013) of the same months which were July – averagely wet (33.7%) and August - also averagely wet (32.60%).

Table 1. Precipitation amount by months and years of the Sudan grass.

Years	Months						Period of active vegetation
	June, mm	July, mm	P, %	August, mm	P, %	September ,mm	July –August mm
2014	36.5	48.4	33.0	62.5	2.0	146.5	110.9
2015	125.8	34.9	89.8	26.0	62.4	33.4	60.9
2016	50.8	3.0	9	14.5	90.1	11.7	17.5
1930 -2013		55	33.7	48	32.6		103.0

***P- probility of precipitation (%)**

The soil moisture after sowing Sudan grass during all three experimental years was sufficient for its even growth. Temperature is the other main factor that influences the development of Sudan grass during the growing season and its yield. In 2014 the average daily temperatures during the vegetation of Sudan grass were as close as possible to their long-term values for the individual months, and in 2015 and 2016 the average daily temperatures during the vegetation for July and August were about 1.5 - 2 ° C higher (Figure 1)

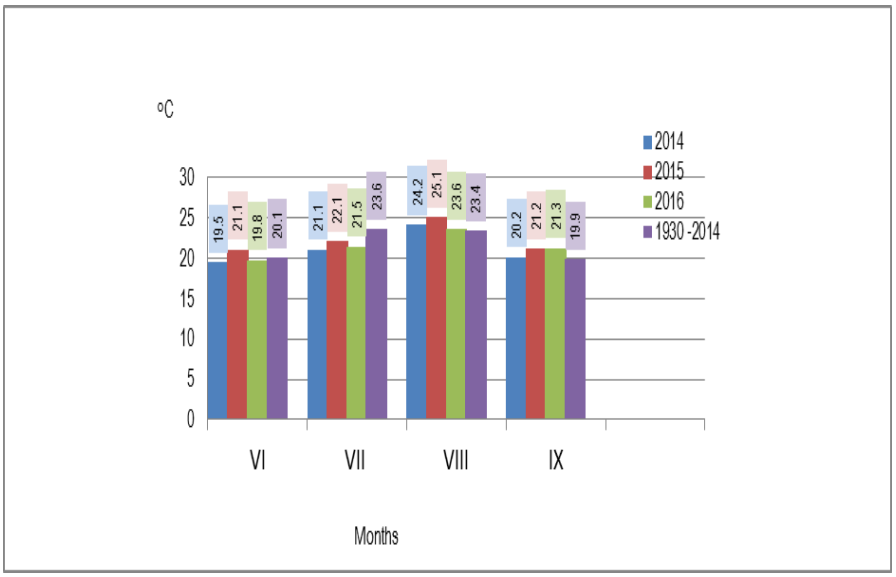

Fig.1. Sum of average daily air temperature (°C)

The yield and the chemical composition of the green mass from Sudan grass to a large extent depend on the meteorological conditions and the degree of nutrient supply of the soil, as well as on the irrigation. From the data on the yield of dry biomass from Sudan grass as a second crop it is evident that it varied in the range from 10356 kg/ha (100%) to 12870 kg/ha (124.8%), respectively in the control variant and in the optimal variant with three irrigations.

(Table 2). In the variant with the removal of irrigation the yield increased in the amount of 9%; in the variant with the removal of the first watering to 16.3%; in the variant with the removal of the second watering, compared to the non-irrigated control. In variant 3 -with the removal of the first watering, but with a second and a third watering present, the lowest yields of dry biomass were obtained - 11290 kg / ha. That is explained with the fact that the removal of the first irrigation at the early stage of vegetation of Sudan grass negatively affected its yield. In cases with variant 4 and variant 5, where the first and the third watering were applied in variant 4 and the first and the second watering in variant 5 respectively, the dry biomass yields increased by 6-7% compared with variant 3 and 15.5 –16.3% compared to the control variant. The obtained differences in yields between the four variants and compared to the control variant are of high statistical significance.

Table 2. Yield of dry biomass from Sudan grass, grown as a second crop by years and average for 2014 - 2016

Variants of irrigation	2014 kg/ha	2015 kg/ha	2016 kg/ha	Average kg/ha	%
Variant 1 – No irrigation(control)	9800	11250	10020	10356	100.0
Variant 2 – Optimal irrigation	12030	14050	12550	12870	124.2
Variant 3 - Irrigation as Var.2 but with removal of the first watering	10050	12200	11620	11290	109.0
Variant 4 - Irrigation as Var.2 but with removal of the second watering	10490	13400	12270	12053	116.3
Variant 5 - Irrigation as Var.2 but with removal of the third watering	10310	13650	11930	11963	115.5
GD 5.0% - 37.488 kg/ha 1.0% - 51.241 kg/ha 0.1% - 70.521 kg/ha					

Table 3. Influence of irrigation on the chemical composition of Sudan grass green mass (% dry matter)

	Crude protein		Crude fat		Crude fiber		Ash		*NFE	
	%	% compared to *Variant 1	%	% compared to Var 1	%	% Compared to Var 1	%	% compared to Var 1	%	% compared to Var 1
*1. - - -	9.83	100.0	2.22	100.0	26.79	100.0	8.46	100.0	52.70	100.0
*2. + + +	9.56	97.2	2.46	110.8	27.95	104.8	8.66	102.8	51.37	97.5
*3. – + +	9.68	98.5	2.38	105.2	27.35	102.1	8.61	102.1	51.98	98.6
*4. + –+	9.73	98.9	2.33	104.9	27.14	101.2	8.59	101.8	52.21	99.0
*5. + +–	9.75	99.0	2.36	105.1	27.03	100.8	8.57	101.3	52.29	99.20

Treatment

*1. - - - - Variant without irrigation (control);

2. + + + - Variant irrigation, 75-80% of FC (3 waterings),

3. – + + - Variant as Variant 2, but with the removal of the first watering

4. + – + - Variant irrigation as Variant 2, but with the removal of the second watering

5. + + – - Variant irrigation as Variant 2, but with the removal of the third watering,

*NFE - nitrogen free extract

Table 3 presents data on the effect of irrigation on the chemical composition of Sudan grass green biomass grown under irrigation as a second crop. It can be observed that the crude protein content is lower compared to the non-irrigated control variants and varies from 1.0 to 2.8% in the individual variants. The difference in the crude protein content between irrigation variants is 0.1% – 1.8% in all variants, the crude fat content is higher than in the non-irrigated variant 1. The crude fat content varies from 4.9 % in the variant with the removal of the second irrigation to 10.8% in the optimally irrigated variants compared to the non-irrigated variant. The difference in the crude fat content among the irrigation variants is 0.08% to 0.13%. The obtained data on the content of the crude fiber and ash from the green mass of Sudan grass show a higher content in the irrigated variants, compared to the non-irrigated variants, and the increase is respectively 0.8% - 4.8% and 1.3% - 2.8%. Between the irrigation variants the difference is in the range - 0.61% - 0.92% and 0.05% -0.09%. The content of the nitrogen free extract (NFE) in the silage from the irrigated Sudan grass is lower compared to the non-irrigated Sudan grass and varies from 0.8% to 2.5% in the separate variants. The difference in the values of the NFE among the irrigation variants ranges from 0.08% to 0.92%. The results obtained for the productivity and the chemical composition of the green biomass from Sudan grass, grown as a second crop, correspond to those obtained by Krachunov and Ilieva (2005) and Golubinova et al. (2016) for the conditions in North Bulgaria. This is mainly due to the different weather conditions and the different fertilization rates under which Sudan grass was grown.

CONCLUSION

When growing Sudan grass as a second, post-harvest crop with optimal irrigation and with disturbed irrigation regime by the removal of successive irrigation, the highest yield of dry biomass was obtained with optimal irrigation with three irrigations. The yield increased by 24.2% compared to the control treatment (without irrigation).

In the variants where the first and the second watering, and respectively, the first and the third irrigations were applied, the yields of dry biomass increased by 6 - 7% compared to the treatment without the first watering, and by 15 - 16% compared to the treatment without irrigation.

Irrigation of the Sudan grass with only the second and the third watering in a row, without the first irrigation, has led to the lowest yield - 11290 kg / ha, which was 9.0% of that of the control treatment.

The chemical composition of Sudan green biomass was influenced by the method of cultivation (with or without irrigation), with the most significant change in the crude fat content, followed by the crude fiber and the crude protein, by 10.8% and 4.8 respectively, more and 2.8% less in the optimally irrigated Sudan grass compared to the non – irrigated crops. The disturbed irrigation regime of Sudan grass did not significantly affect the crude protein, the crude fiber, the ash and nitrogen free extract (NFE).

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