Selcuk Journal of Agriculture and Food Sciences

http://sjafs.selcuk.edu.tr/sjafs/index

Research Article

SJAFS
(2022) 36 (1), 1-7
e-ISSN: 2458-8377
DOI:10.15316/SJAFS.2022.001

Determination of Forage Yield and Some Quality Characteristics of Silage Sorghum Genotypes at Different Water Stress Levels **

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ARTICLE INFO

Article history:
Received date: 14.09.2021
Accepted date: 21.12.2021

Keywords:
Climate Change
Drought
Water Stress
Forage Crops
Sorghum

ABSTRACT

The study was conducted in order to determine the forage yield and some quality characteristics of silage sorghum genotypes at different water stress levels in the Randomized Complete Block Design arranged in split plots under Konya ecological conditions in 2020.
Three irrigation treatments (I_1: Full irrigation; I_2: 75% of I_1; I_3: 50% of I_1) and 14 silage sorghum genotypes supplied from other countries were used in this study, irrigation subjects formed the main parcels and the genotypes sub-plots. In the study, the lowest and highest values were; 4756 kg da^{-1} (I_3)-6757 kg da^{-1} (I_1) for green herbage yield; 1149 kg da^{-1} (I_3)-2002 kg da^{-1} (I_1) for dry matter yield, 8,1 % (I_1)-9,6% (I_2) for crude protein, 33.3% (I_2)- 34.5% (I_1) for ADF ratio, 55% (I_3)- 58.4% (I_2) for NDF ratio and and cellulose ratio was determined as 25.6% (I_3)-28.2% (I_1) respectively. The genotypes used in the study, in which the efficiency of irrigation water use efficiency increased as water stress increased, the lowest and highest dry matter yields were obtained from genotypes G-11 (4214 kg da^{-1}) and G-4 (6961 kg da^{-1}), respectively, while a total of 8 genotypes had higher green herbage yield values than the study average

1. Introduction

Nowadays, climate change, which threatens agricultural production and access to safe food, especially drought in many parts of the world, emerges as one of the most important problems of human beings. As a result of global climate change, temperature increases and decreasing precipitation in many parts of the world significantly increase the severity of the drought event.

The areas most affected by drought are agricultural areas. It is one of the main problems of agricultural production even in countries that are advanced in agriculture. In the world, 21-22 million km², which corresponds to approximately 16% of the terrestrial area, is considered to be arid and semi-arid regions.

Solving the drought problem caused by water scarcity and lack of precipitation and making agriculture more sustainable requires the application of more drought-tolerant agricultural products and technologies (Kapluhan, 2013). The water required for the production of food and other agricultural products corresponds to 3.100 billion m³, which corresponds to approximately 70% of the water withdrawn from rivers and groundwater.

It is stated that if water resources cannot be increased and used efficiently, this amount will increase to 4.500 billion m³ by 2030 (Anonymous, 2011). Unless there is an increase in the amount of land and water, it is expected that the water consumption used in agriculture will increase by 70-90% until 2050.

Negative effects of climate change around the world, it is also likely to be seen in the Mediterranean basin, where our country is located, negative effects are expected especially on water resources and precipitation regime.

The annual precipitation average of our country is 574 mm, this value shows significant differences according to regions, It is much lower especially in Central Anatolia (320 mm) and S. Eastern Anatolia regions (532 mm), where field agriculture is intense and which contains a significant part of the country's agricultural lands (Anonim, 2020).

The Konya basin, which is foreseen as one of the regions that will be adversely affected in climate change scenarios, is a region that is not very rich in terms of water resources and where groundwater is used significantly in agriculture. Although the amount of water withdrawn in the region per year is approximately 2.6

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**This study has been produced from a part of the first author's doctorate thesis prepared under the supervision of the first author.

billion m^3, the amount of safe water is foreseen as 1.8 billion m^3. This situation, together with the decrease in precipitation, causes a water deficit every year (Anonymous, 2009).

According to TUIK (2017) data, Turkey has 16.6 million cattle and 44.3 million sheep and goat. Approximately 60 million tons of quality roughage is needed annually for this animal availability. However, our quality roughage production remains at the level of 40 million tons.

Konya closed basin is an area where plant and animal production is intensively carried out and has an important place in the formation of agricultural policies of our country. Animal husbandry has increased significantly in the region with support policies carried out in the last 20 years.

The region ranks first in the country in terms of the presence of cattle and small animals (the number of small animals is 13% of the country, and the number of cattle is 5%), the need for roughage has also increased significantly. Although there is a significant range of pastures in the region, most of these pastures have lost their qualifications and due to its very low herbage yield roughage shortages occur and roughage transfer occurs to the region at high cost from other regions within the country. However, a significant part of the roughage produced in the region is produced in irrigated areas, this puts pressure on water resources.

The animal potential of the region, using water effectively for a sustainable agricultural production that will be planned considering the soil and climate structure and water resources, resistant to water stress and in this case, it can produce more and quality biomass compared to similar purpose plants and it is important to reproduce and adapt new plants in the region, which reduce pressure on water resources. In this context, sorghum is an important plant, and has an important place for arid semi-arid regions, ts adaptability is quite good in areas with high temperature, limited rainfall and low soil fertility. At the same time, sorghum stands out as a plant that can respond positively to additional irrigation in arid areas with low and irregular rainfall (Wani ve ark., 2012)

Sorghum is a C4 plant that has high and quality herbage yield and has the opportunity to grow in different ecologies. It is mostly grown for fodder, food and industrial use. Sorghum produces twice as many roots as corn (House, 1985) It produces more biomass by using water and plant nutrients (N,P,K) more effectively (House, 1985; Sanderson ve ark., 1992; Howell ve ark., 2008) than corn and other plants (Kimbrough, 1990; Bean ve ark., 2002).

Silage sorghum is a plant that can be used as an alternative to corn in animal feeding, At the same time, it can be stable in dry periods, more resistant to high temperatures and droughts, able to grow back rapidly after harvest, it stands out as a plant that can be used as an alternative to corn because it is more resistant to pests and diseases.

With this study, Konya closed basin with an important agricultural area in our country and similar regions can produce biomass in high quantity and quality by using water resources more effectively, able to drought tolerant, it was aimed to determine the green and dry matter yield, some quality parameters and irrigation water use efficiency of sorghum silage genotypes obtained from abroad in sorghum plant at different water stress levels.

2. Materials and Methods

The study was carried out in the experimental field of Konya Bahri Dağdaş International Agricultural Research Institute in 2020 growing season (370 86' 03.41" N ve 320 55' 63.64" E). The place where the research is conducted has characteristics of a continental climate, summers are hot and dry, winters are cold and barely snowy. The average precipitation of the region for many years is 320 mm and the precipitation regime is irregular. A large amount of precipitation falls during the winter months. While the total precipitation in the study period was 321.4 mm, the precipitation between May and August, which is the growing period of sorghum, was 74.3 mm. While the total precipitation of the region for many years was around 329.2 mm, the precipitation amount between May and August was 82.4 mm (Table 1).

The area where the study was carried out has a clayey-loam structure, its organic matter is 2.3%, pH 7.4, and the amount of lime is determined as 23.5%.

The experimenatl area don’t have any salt problem and some physical and chemical analysis results of the study area given in Table 2.

Table 1
Precipitations and tempereature throughout the growing season of the experimental are

		Months (May.- August.)				
Years	Climatic data	May	June	July	August	Annual total precipitation (mm)
1929-2020	Mean Temp. (ºC)	15.9	20.1	23.5	23.3	
	Precipitation (mm)	43.4	25.7	7.0	6.3	329.2
2020 Years	Mean Temp. (ºC)	16.2	20.3	25.5	23.3	
	Precipitation (mm)	23.4	35.8	0.5	12.8	204.2

Table 2
Some soil properties of the experimental area

Deepth (cm)	Sand (%)	Silt (%)	Clay (%)	Structure	Field capacity (%)	Willing point (%)	Volume weight(g cm^{-3})	pH	EC (dSm^{-1})	Lime (%)	Organic Matter (%)	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})
0-30	7.4	30.8	61.8	CL	26.9	17.2	1.26	7.6	0.80	34.4	2.4	14.5	113
30-60	8.6	29.4	62.0	CL	27.8	18.9	1.39	8.2	0.48	30.7	2.1	11.9	65
60-90	6.1	27.8	66.1	CL	26.4	17.1	1.32	8.3	0.41	29.9	1.9	13.2	54

A total of 14 genotypes were used in the study, including 12 silage sorghum genotypes obtained from the USDA (U.S. Department of Agriculture) and 2 standart genotypies (Table 3).

Table 3
Genotypes used in the study

Variety no	Pedigri	Orjin
G-1	PI 155519	South Africa
G-2	PI 181081	Sudan
G-3	PI 501106	Turkey
G-4	PI 552851	Taiwan
G-5	PI 560351	Mexico
G-6	PI 560355	İndia
G-7	PI 591005	Mexico
G-8	PI 599917	Ethiopia
G-9	PI 601925	Ethiopia
G-10	PI 602844	Ethiopia
G-11	PI 602851	Ethiopia
G-12	PI 602852	Ethiopia
G-13	Rox	BATEM
G-14	Sumac	BATEM

After the first soil preparation was done with a plow, duplication was done before planting and the field was made ready for planting. Considering the results of the analysis together with the soil preparation, 10 kg of phosphorus and 4 kg of nitrogen were given per decare. The remaining part of the nitrogen fertilizer was given in parts by drip irrigation system and completed to 15 kg da^{-1}. The sowing was carried out in six rows with a seeder on May 06 2020, with 45 cm row spacing and 5 cm row sowing norm. The plot area is designed as 5 m long x 2.7 m wide, a total of 13.5 m^2. Harvesting was done by removing the edge effects from the sides and the ends of the rows, and mowing the middle rows with a motor scythe during the dough formation period. Weed control was done mechanically and chemically.

In the study, a pressure regulated drip irrigation system was used, and irrigation was applied with pipes with a flow rate of 2 l/h and a dripper pitch of 30 cm, one lateral to each row. In the study, the amount of irrigation water to be applied to the gravimetric method was calculated by taking soil moisture at a depth of 0-90 cm, which is the effective root depth of sorghum.

Three irrigation applications were studied in the study, for full irrigation (I1), after determining the volume weight of the trial area, field capacity, wilting point, When 50% of the useful water at 0-90 cm effective root depth is consumed, the reduced water according to Equation-1 is completed to the field capacity (Kara, 2011).

$$dn = \frac{(FC - CM) \times D}{100} \quad (1)$$

Equation-1;

dn = The net amount of irrigation water to be applied in each irrigation (mm),

FC = Field Capacity (% Volume),

CM = Current moisture (% Volume),

D = Effective root depth (mm)

In 75% irrigation (I_2), 75% of the irrigation water to be applied to the I_1 subject, and 50% of the irrigation water to be applied to the I_1 subject in the 50% irrigation (I_3) irrigation water was given. In this study, 50 mm of irrigation water was applied to all plots in order to bring a uniform plant emercing and soil moisture to field capacity after planting. In the study in which the green herbage yield, dry matter yield, protein ratio, acid detergent fiber (ADF) ratio, neutral detergent fiber (NDF) ratio, cellulose ratio and irrigation water utilization efficiency (IWUE) properties were researched, the observations of yield and yield components were determined by Mülayim et al. (2009) ADF and NDF, crude cellulose measurements according to Van Soest et al. (1991) and protein analysis was determined according to Soylu et al. (2010). Irrigation water use efficiency was determined by Howell et al. (1990) using by the Equation-2.

$$IWUE = Y/I \quad (2)$$

Equation-2;

IWUE: Irrigation water use efficiency (kg da^{-1} mm^{-1}),

Y: Dry matter yield (kg da^{-1}),

I: Amount of irrigation water (mm).

The results obtained from the study, which was carried out in three replications according to the split-plots trial design in random blocks, variance analysis was performed with the JMP 11.1 statistical package, and the groupings between the subjects were made according to the LSD test.

3. Results and Discussion

3.1. Green and Dry Herbage Yield (kg da^{-1})

In the study, there was a decrease in green and dry herbage yield with the decreasing amount of irrigation water. While the highest green and dry herbage yield (6757 kg da^{-1} – 4756 kg da^{-1}) was obtained in full irrigation (I_1), the lowest value was obtained from I_3 (2002 kg da^{-1} – 1449 kg da^{-1}), (Table 4).

Considering the average of varieties, the highest green herbage yield is from genotype G-4 (6961 kg da^{-1}), the lowest yield was obtained from genotype G-18 (4214 kg da^{-1}) and seven genotypes (1, 3, 4, 5, 6, 9 and 10) were given higher values than the trial average. While the highest and lowest values in terms of dry matter yield were obtained from genotypes G-10 (2108 kg da^{-1}) and G-11 (1156 kg da^{-1}) respectively, six genotypes (3, 4, 5, 6, 9 and 10) had higher values than the trial average. When the water stress x genotype interaction is examined in terms of green herbage yield, the highest and lowest values for I_1 are from genotypes G-4 (8833 kg da^{-1}) and G-12 (4509 kg da^{-1}), As for I_2, it is obtained from genotypes G-10 (7434 kg da^{-1}) and genotype G-11 (4061 kg da^{-1}), In I_3 subject where water stress is the highest, the highest value was obtained from genotype G-4 (5868 kg da^{-1}), and the lowest value was obtained from genotype G-2 (3751 kg da^{-1}).

In terms of hay yield, the highest and lowest values are from genotypes G-4 (2525 kg da^{-1}) and G-12 (1267 kg da^{-1}) subject I_1, regarding to I_2, genotype G-10 (2344 kg da^{-1}) and genotype G-12 (1152 kg da^{-1}), and as for I_3, were obtained from genotype G-4 (1961 kg da^{-1}) and genotype G-2 (998 kg da^{-1}) (Table 4). Dahmardeh et al., (2015) reported that water stress decreased the green and dry herbage yield and increased the water use efficiency in their study where they irrigated the silage sorghum plant at the rate of 80%, 60% and 40% of their water consumption in semi-arid climate conditions.

Table 4
The values of green and dry matter yield obtained from sorghum genotypes at different water stresses from the study (kg da^{-1})

	Green herbage yield (kg da^{-1})				Dry matter yield (kg da^{-1})			
Genotype	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
G-1	7465 bc	5561 g-j	4599 l-p	5875 DE	2211 b-d	1551 l-o	1250 p-r	1671 CD
G-2	5802 f-ı	4719 k-o	3751 q	4757 G	1769 g-l	1388 n-q	998 r	1385 F
G-3	6341 ef	6094 e-h	5416 h-k	5950 CD	1902 e-ı	1766 g-l	1595 j-n	1754 C
G-4	8833 a	6183 e-g	5868 e-h	6961 A	2525 a	1833 f-k	1961 c-g	2106 A
G-5	7804 bc	6041 e-h	4769 k-n	6205 CD	2233 bc	1683 ı-m	1392 n-q	1769 C
G-6	7967 b	5758 f-ı	4952 j-m	6226 CD	2521 ab	1698 h-m	1577 k-n	1932 B
G-7	6202 e-g	5595 g-j	4463 l-p	5420 F	1924 e-ı	1677 ı-m	1330 n-q	1644 C-E
G-8	6563 de	5611 g-j	4264 m-q	5480 EF	2030 c-g	1685 ı-m	1370 n-q	1695 CD
G-9	7141 cd	6095 e-h	5828 f-h	6354 BC	2220 b-d	2054 c-f	1929 e-ı	2068 AB
G-10	7700 bc	7437 bc	4924 j-m	6687 AB	2057 c-f	2344 ab	1925 e-ı	2108 A
G-11	4643 l-p	4061 n-q	3938 pq	4214 H	1278 p-r	1170 q-r	1020 r	1156 G
G-12	4509 l-p	4411 l-q	4056 o-q	4325 H	1267 p-r	1152 q-r	1182 q-r	1200 G
G-13	5861 e-h	5096 ı-l	4310 m-q	5089 FG	1852 e-ı	1600 j-n	1296 o-q	1583 DE
G-14	7767 bc	7344 bc	5094 ı-l	6735 AB	2236 bc	2118 b-e	1464 m-p	1939 B
Mean	6757 A	5715 B	4756 C	5734	2002 A	1694 B	1449 C	1715
CV (0.01)	7.6				CV (0.01)	9.6		
LSD Genotype	411		LSD G*I	711	LSD Genotype	157	LSD G*I	272
LSD Irrigation	141				LSD İrrigation	115		

In previous studies, Aydinşakir et al. (2018) reported the fresh grass yield of 4442 - 9926 kg da^{-1}, dry herbage yield in the range of 744 - 2107 kg da^{-1} in 5 different irrigation subjects (100% - 75% - 50% - 25% - 0%) in sorghum, Keten and Değirmenci (2020) reported green herbage yield as 3200-6000 kg da^{-1}, Özmen (2017) reported green herbage yield as 4003-11812 kg da^{-1}, dry herbage yield between 534-2560 kg da^{-1}.

The green and hay yields obtained from this study are compatible with previous studies, and the differences are thought to be due to the environment and genotype.

When the protein ratio of the genotypes was examined in the study, it was found that the protein ratio was lower in full irrigation, the highest and lowest protein ratio values were obtained from genotypes G-9 and G-7 in I_1 irrigation, from genotypes G-12 and G-7 in I_2, and from genotypes G-2 and G-1 in I_3. In terms of variety averages, the highest value was 11.5% (genotype G-2) and the lowest value was 6.8% (genotype G-7) (Table 5).

ADF ratios also had lower values with decreasing irrigation water. When the genotype averages are examined, it is seen that the highest value was obtained from genotype G-11 (40.1%) and the lowest value was obtained from genotype G-9 (30.4%). The highest and lowest

ADF values are among the genotypes G-11 (43.9%) and G-9 (26.7%) in full irrigation, G-2 (36.2%) and G-9 (30.9%) genotypes (I_2) in 75% irrigation, and for I_3, G-11 (39.8%) and G-8 (29.1%) genotypes were obtained (Table 5).

While I_1 and I_2 subjects had similar values in terms of NDF ratios, I_3 had the lowest value. In terms of varieties, it is seen that the highest NDF value was obtained from genotype G-11 (%) 68.2, and the lowest value was obtained from genotype G-7 (51.5%). The highest and lowest NDF values are from genotypes G-11 (70%) and G-9 (49.0%) for I_1, G-11 (67.9%) and G-7 (51.2%) for I_2, and for I_3, It was obtained from genotypes (66.5%) and 8 (50.4%) (Table 6).

It was observed that cellulose ratios decreased with decreasing water, similar to ADF values in terms of cellulose ratios, when the average of the genotypes is examined, it is seen that the highest cellulose ratio value is obtained from genotype G-11 (34.0%) and the lowest value is obtained from genotype G-9 (22.9%). When examined in terms of water x genotype interaction, the highest and lowest cellulose values are from genotypes G-11 (36%) and G-9 (20.7%) in I_1, from genotypes G-11 (33.1%) and G-10 (22.8%) in I_2, As for I_3, it is seen that it was obtained from genotypes G-11 (32.9%) and G-8 (22.5%) (Table 6).

Table 5
The values of protein and ADF ratios obtained from sorghum genotypes at different water stresses from the study (%)

	Protein ratio (%)		ADF (%)					
Genotype	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
1	8.4 m-o	9.5 jk	5.0 x	7.7 F	37.6 cd	33.0 k-q	35.1 g-j	35.2 C
2	10.1 hı	12.0 bc	12.4 ab	11.5 A	37.8 cd	36.6 d-g	35.1 g-j	36.5 B
5	9.7 ı-k	10 h-j	8.8 lm	9.5 C	34.7 h-k	33.6 ı-p	32.1 o-r	33.4 D
4	8.5 mn	8.8 lm	9.3 kl	8.9 D	38.7 bc	34.3 h-l	32.6 l-r	35.2 C
5	7.4 r-t	7.9 o-r	7.5 q-s	7.6 F	37.2 c-e	34.0 h-n	33.5 j-p	34.9 C
6	6.9 tu	6.9 t-v	7.7 p-r	7.2 G	35.6 e-h	35.2 e-j	34.3 h-l	35.0 C
7	6.0 w	6.3 vw	8.1 n-p	6.8 H	32.9 k-q	30.1 st	31.5 q-s	31.5 EF
8	6.9 s-u	10.3 g-ı	8.1 n-p	8.4 E	32.1 n-r	31.6 q-r	29.1 t	30.9 FG
9	10.9 ef	10.8 e-g	9.2 kl	10.3 B	26.7 u	30.9 r-t	33.5 j-p	30.4 G
10	6.0 w	11.8 cd	8.9 lm	8.9 D	31.0 r-t	31.3 q-s	32.7 l-r	31.6 EF
11	7.0 s-u	7.7 p-r	6.7 uv	7.1 GH	43.4 a	37.1 c-f	39.8 b	40.1 A
12	7.7 p-r	7.9 o-r	8.9 lm	8.2 E	34.1 h-m	35.6 e-h	35.5 e-ı	35.0 C
13	7.5 q-s	11.3 de	10 h-j	9.6 C	32.3 m-r	32.3 m-r	32.2 n-r	32.3 E
14	10.5 f-h	12.6 a	10.7 fg	11.3 A	33.8 h-o	30.9 r-t	31.9 p-s	32.2 E
Mean	8.1 C	9.6 A	8.7 B	8.8	34.9	33.3	33.5	33.9
CV (0.01)	4.0				CV (0.01)	3.4		
LSD Genotype	0.33		LSD G*I	0.56	LSD Genotype	1.08	LSD G*I	1.87
LSD Irrigation	0.24				LSD Irrigation	ns		

Table 6
The values of NDF and cellulose ratios obtained from sorghum genotypes at different water stresses from the study (%)

	NDF (%)				Cellulose ratio (%)			
Genotype	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
G-1	64.2 d	60.0 g-ı	52.8 s-v	59.0 C	29.9 d	26.3 l-n	27.8 h-j	28.0 C
G-2	63.8 de	64.8 cd	59.1 h-j	62.6 B	30.1 d	28.2 g-ı	26.1 l-o	28.1 C
G-5	58.6 h-k	58.3 ı-k	54.4 p-s	57.1 D	26.5 l-n	25.5 o-q	24.4 rs	25.4 D
G-6	62.3 ef	55.9 m-p	53.8 q-s	57.4 D	31.3 c	27.7 ıj	25.9 m-o	28.3 C
G-7	58.7 h-k	57.9 j-k	53.3 r-t	56.6 DE	29.4 d-f	28.6 f-h	25.7 n-p	27.9 C
G-8	55.8 m-p	61.0 fg	55.6 n-p	57.5 D	29.7 de	29.0 e-g	27.9 h-j	28.9 B
G-9	51.5 u-w	51.2 vw	51.9 t-w	51.5 I	26.0 l-o	24.3 r-t	23.2 u-w	24.5 F
G-10	51.8 t-w	54.7 o-r	50.4 wx	52.3 I	24.7 q-s	24.0 s-u	22.5 w	23.7 G
G-15	49.0 x	56.3 l-o	54.8 o-r	53.4 H	20,7 x	23.9 s-u	24.2 r-t	22.9 H
G-17	53.2 r-u	57.7 j-l	53.7 q-s	54.9 G	26,7 k-m	22.8 vw	24.0 s-u	24.5 F
G-18	70.0 a	67.9 b	66.5 bc	68.2 A	36.0 a	33.1 b	32.9 b	34.0 A
G-19	61.2 fg	60.3 gh	55.7 n-p	59.0 C	29.8 de	30.0 d	24.9 p-r	28.2 C
G-21	57.5 j-m	56.3 l-o	52.6 s-v	55.5 FG	27.3 jk	23.9 s-u	23.2 u-w	24.8 EF
G-22	57.1 k-n	55.4 n-q	55.7 n-p	56.1 EF	26.8 kl	23.5 t-v	25.0 p-r	25.1 DE
Mean	58.2 A	58.4 A	55.0 B	57,.2	28.2 A	26.5 B	25.6 C	26.8
CV (0.01)	1.9				CV (0.01)	1.95		
LSD Genotype(G)	1.0		LSD G*I	1.76	LSD Genotype(G)	0.49	LSD G*I	0.85
LSD Irrigation (I)	1.17				LSD Irrigation(I)	0.27		

Since the digestion level of ADF and NDF is very slow in animal nutrition, a low ratio in the ration (Van Soest, 1994) is desirable features, and an increase in insoluble fibers in plants experiencing water stress, It is one of the physiological responses of plants to prevent moisture loss (Jahansouz et al., 2014), With the increase in the amount of irrigation, the amount of ADF, NDF and crude fiber and ash increased, similar results Uzun et al. (2017), Cotton et al. (2013) reported by. This situation is thought to be due to the decrease in the leaf/stem ratio with the increase in plant height under irrigated conditions (Pedersen et al., 2005). Contrary to these aspects, Kızıloglu et al. (2009) found that ADF and NDF values increased with water stress, Islam et al. (2012) reported that the amount of irrigation water did not affect the ADF values.

From previous studies, Jahansouz et al. (2014) NDF ratios in 50-75-100% irrigation in sorghum, respectively; reported as 59.4% - 55.8% - 55.6%, on the other hand, Keten and Değirmenci (2020) determined the ADF rate as 25.7%-26.1%; NDF rate of 50.8%-52%; reported in the range.

In another study, Cotton et al. (2013) found the ratio of ADF to be 36.5% - 31.5% and NDF ratio to be 59.2 - 54.4% in sorghum in irrigated and water stress conditions, respectively. As a result of the study, it was seen that decreasing irrigation decreased the rates of ADF, NDF and cellulose. There are different opinions about the effects of water stress on protein ratio. Similar to the results of this study, Keten (2020), and Khaton et al. (2016) reported that the protein value increased with increasing water (Jahansouz et al., 2014), Uzun et al. (2017) and Liu et al. (2013) reported higher protein content in water stress. Islam et al, (2012) reported that water stress had no effect on protein in maize plant. In previous studies on sorghum, Liu et al. (2013) 10.14% to 14.86; Saghafi et al. (2013) 8.11% to 10.48; Chakravarthi et al. (2017) 5.29% to 21.24; Canyiğit and Okant (2018) 9.1% to 13.1; Kır and Şahan (2019) reported that it was between 7.3% and 10.4%.

In this study, it is thought that the differences in the protein, NDF and ADF ratio values obtained under different water treatment conditions and the differences in their results are due to the characteristics of the environment and especially the genotypes.

Irrigation water use efficiency (IWUE), which is an important parameter for the regions where the negative effects of climate change are increasing and for the regions where water is limited, is a feature that determines the dry matter ratio obtained with unit water and should be considered in product planning in regions with water scarcity.

In the study, the IWUE value increased in water stress issues, and when the IWUE values obtained at different irrigation levels from the genotypes were examined, In I_1 irrigation, G-4 and G-6 have high IWUE values, in I_2 genotypes G-9, G-10 and G-14 came to the fore, and in I_3 where the most severe stress is applied, genotypes G-4, G-9, G-10 and G-11 have high IWUE values and observed that they used water more effectively under stress conditions (Figure 1).

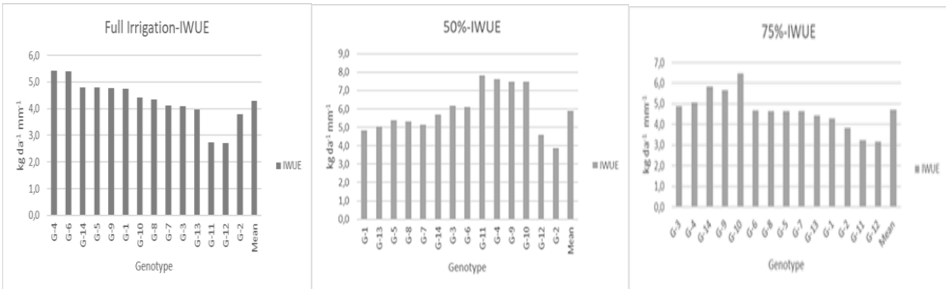

Figure 1

The values of NDF and cellulose ratios (kg da^{-1} mm) obtained from sorghum genotypes at different water stresses from the study.

In previous studies, Keten and Değirmenci (2020) reported the range of 7.8-6.3 kg da^{-1}mm^{-1}, Gönülal (2020), on the other hand, found the irrigation water usage efficiency (IWUE) in the range of 4.9 - 7.1 kg da^{-1} mm^{-1} in his study (100% - 50%) in which he applied two different water issues.

4. Acknowledgements

In the study carried out to determine the responses of different silage sorghum genotypes to water stress in Konya ecological conditions, green forage yields varied between 4756-6757 kg da^{-1} according to the genotype. In the study, it was observed that some genotypes gave better yields than other varieties in moderate and severe water stresses. It is thought that sorghum genotypes with high irrigation water use efficiency are suitable for arid and semi-arid regions and can be used as genetic resources in breeding studies.

5. Acknowledgements

The manuscript was produced from Ramazan Çağatay ARICI's PhD thesis.

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