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Effect of disturbed irrigation regime on the yield of Sudan grass, grown for the Southern Bulgaria environmental conditions

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Abstract

The aim of this study was to determine the effect of disturbed irrigation regime on dry biomass yield of Sudan grass. In the period 2021 - 2023 for the region of Stara Zagora on meadow - cinnamon soil was conducted an experiment with Sudan grass variety Endje - 1, grown after the precursor barley. The following variants were studied in the field trial 1 No irrigation (control), var. 2 Optimal irrigation 75-80% of FC (100% irrigation rate), var. 3 Irrigation with 70% of calculated irrigation rate, 4 Irrigation with 40% of calculated irrigation rate. It was found that the highest average yield of 13940 kg/ha dry biomass was obtained with the optimally irrigated variety, which was 36.5% higher than the yield of the non-irrigated variety. When the irrigation rate is reduced by 30% compared to the optimal option 1 (100%), the dry biomass yield decreases by 8.5%.

Key words: Sudan grass, irrigation regime, yield

Introduction

In recent years, there has been interest in the cultivation of Sudan grass under irrigated conditions (Bazitov & Kikindonov, 2016). Despite attempts at wider adoption in recent years in Bulgaria, this alternative crop to maize remains poorly adopted due to lack of knowledge about the characteristics of modern varieties and technologies. It is an annual fodder crop that is favourable for cultivation in arid regions, as it can tolerate a solid water deficit and has a high capacity to produce higher biomass yield T (Ismail et al, 2018).

It has a very good water use efficiency and a high response to fertilization (Machicek, 2018). Its productivity is particularly high during periods of good soil moisture (Basaran et al., 2017). It also tolerates soil salinity very well (Ziki et al., 2019).Its water requirement during development varies from 350 mm to 700 mm depending on weather conditions and length of flowering period (Silva et al., 2015) .Sudan grass (Sorgum vulgare, var. sudanensis) is mainly cultivated for green fodder and silage production. With proper cultivation technology, the yield and quality of fodder produced are increased (Villar-Salvador et al., 2013).Sudan grass grown on heavy clay soils requires about 7-11 acre-inches of water per month for the region of Arizona and California states, (Knowles & Ottman, 2015). Taha et al. (2019) reported for the region of Egypt that the highest water use efficiency values were 8.08 and 8.88 kg m-3 obtained by irrigation with 125% ETo in the 1st-2nd year MA experiment, respectively. For the conditions in Turkey, in an experiment conducted with irrigation and nitrogen fertilization, Kaplan et al. (2019) found that with an increase in irrigation rates, green mass yield increased, yield structural elements. In our country, in recent years, intensive research has been carried out for the mass introduction of this alternative crop to maize in Bulgaria.

There have been many trials with it in northeast Bulgaria, but under non-field conditions (Slanev & Enchev, 2014). Despite the fact that Sudan grass is not a traditional irrigated crop, the factor that determines its yield under our soil and climatic conditions is moisture, which is mainly achieved by timely and proper irrigation (Bazitov 2021). In recent years, there have also been trials with irrigation of Sudan grass, but grown as a second crop for the region of Southern Bulgaria (Bazitov & Kikindonov, 2016; Bazitov 2020). These are extremely insufficient given the emerging trend of the climatic situation in recent years in our country and in the world Moashab, which imposes the need for irrigation. It is of great interest to test Sudan grass as a staple crop under irrigation. The aim of the present study was to find out the effect of disturbed irrigation regime by cancellation of irrigation on dry biomass yield, number of irrigations and irrigation rates in Sudan grass Endje-1.

Materials and methods

In the period 2021 - 2023 in the region of Stara Zagora on the soil type meadow - cinnamon soil was conducted an experiment with Sudan grass under irrigation, variety Engje-1 grown at the sowing density of 150,000 thousand plants per hectare after the precursor barley. Phosphorus and potassium fertilizers at the rate of 8060 kg/ha act. In water were applied as main fertilizers for both crops against barley. Sudan grass was fertilized with ammonium nitrate at the 3-5 leaf stage of the crop, at a rate of N90 kg/ha active weight. The soil type was characterized by the following hydro-physical properties PPV - 26.57%, wilting coefficient (WFC) - 18.19%, porosity - 47% and bulk density - 1.45. The trial was designed using the long plot method in four replications, with a trial plot size of 25 m2 and a harvest plot size of 20 m2. Sudan grass was harvested at the milky stage. Gravity irrigation was used with a seasonal fixed installation. The following options were investigated in the field trial 1 no irrigation (control), var. 2 optimal irrigation 75 - 80% of PPV (100% irrigation rate), var. 3 irrigation with 70% of calculated irrigation rate, var. 4 irrigation with 40% of calculated irrigation rate. Soil moisture dynamics were determined by the weight thermostat method in variant 2 and the irrigation rate was calculated using the water balance equation. The irrigation rates of all variants were implemented together, but with a percentage reduction of the irrigation rate compared to variant 2. Irrigation was carried out by gravity in short closed furrows. During the growing season, fertilization was carried out with N 9 kg/da act, at the 3-5 leaf stage of the crop. The amount of dry biomass (DM), as a percentage (%) of the green biomass weight (kg), was determined by the method of drying the green biomass at 70° C for 24 h.

The yield was determined by variants and replicates, the data obtained were processed using the MsExcel 2007 software product, module ANOVA-1 and the evidence between the differences sought was established.

Results and discussion

Of all the studies carried out to date, the results for determining the influence of the irrigation regime on the productivity of agricultural crops, including Sudan grass, are closely linked to the nature of the months of active vegetation in meteorological terms (rainfall, temperature, etc.). For Sudan grass, the amount of rainfall during the months of active vegetation - June, July and August - was crucial in all three years of the experiment. These are the months with the most significant contribution to yield formation. In terms of rainfall availability, June, July and August for 2021 are 46.51%, 88.7.8% and 65.11% respectively, i.e. June is an average wet month, July is a dry month and August is an average dry month, for 2022 are 25.3%, 99.2% and 13.33% respectively, i.e. June is moderately wet, July is dry and August is wet and in the last experimental year (2023). June was moderately dry - 71.9%, July and August were dry - 95% and 90.1%. The same months of the 50-year transition period are characterized as moderately wet in terms of the probability of precipitation. June with 29.3%. July with 25.4% and August with 37.20% (fig.1)As a result of specific natural wetting conditions and the provision of vegetation, rainfall is expected. Two irrigations were carried out in 2021 and three in 2022 and 2023. The values of average daily air temperatures during the maize growing season do not differ much from those of the perennial period, with values for May, but for June, July and August they are about 1-2° C higher (fig. 2).

In order to maintain pre-flood moisture within 75-80% of FC during the first year of the trial for the duration of Sudan grass cultivation under option 2, three gravity irrigations of 85, 80 and 80 mm were applied. The first irrigation was applied in the first ten days of June (tillering), the second irrigation in the second ten days of July (spindle emergence) and the third irrigation in early August during the emergence phase. In 2022, 2 irrigations of 80 mm and 90 mm were applied. The first irrigation was applied in the second ten days of May (5 - 6 leaves of the plant) and the second irrigation in the second ten days of July in the wilting phase of the plant. In the last year of the experiment (2023), 2 irrigations of 80 and 90 mm were applied. The irrigations for the other variants for the three years of the trial were carried out together with Variant 2, but with a percentage reduction in the irrigation rate. The irrigation rates applied satisfied the need for readily available moisture during critical periods of crop development. (Plate 1) Temperature is the other main factor influencing crop development and yield size (table 1).

The yield data obtained by year for the different experimental treatments are presented in table 2. Under the experimental conditions, the variety Endje-1 tested gave a relatively stable yield under non-irrigated conditions (option 1). Its yield varied from 9530 kg/ha to 10750 kg/ha and the average for the three years was 10210 kg/ha. By optimizing soil moisture throughout the growing season, yields are significantly increased and stabilized. By applying 2 to 3 irrigations during the vegetation period of Sudan grass from the optimal irrigation (100%) variety - variety 2 - the highest yields of dry biomass are obtained. Yields reach 14530 kg/ha in 2021, or 13940 kg/ha averaged over the three years. As irrigation rates are reduced, yields vary from year to year over the study period, ranging from 86.1% to 91.5% of the yield obtained with option 2 (optimal irrigation).

The results obtained in variants 3 and 4 with a reduction of 30% and 60% of the calculated

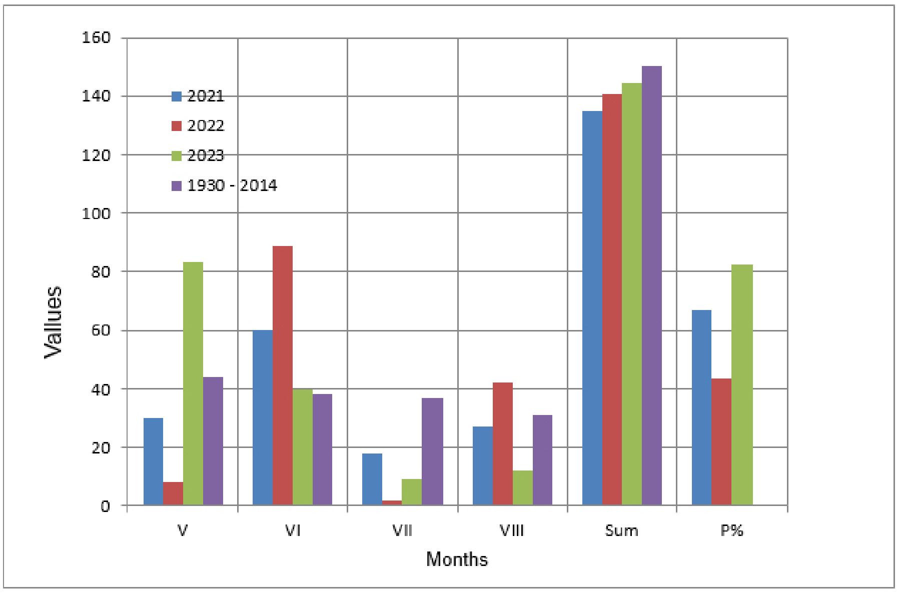

Fig. 1. Sum of precipitation by month, year and total for the period

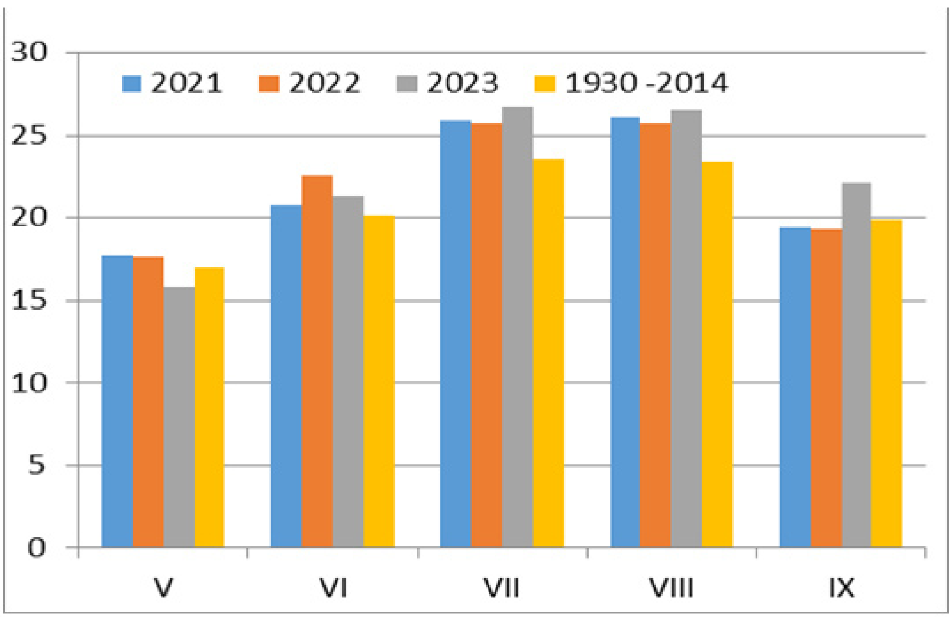

Fig. 2. Average daily air temperature at ^{0} C

Table 1. Number of irrigation and irrigation rates for irrigation in Sudan grass

Variants	Years								
	2021			2022			2023		
	n	m	M	n	m	M	n	m	M
1. No irrigation	0	0	0	0	0	0	0	0	0
2. Optimal irrigation		85			80	170		80	170
		80							
	3	80	245	2	90		2	90	
3. Irrigation whit 70% irrigation rate		59.5							
	3	56	171.5	2	56		2	56	
		56			63	119		63	119
4. Irrigation whit 40% irrigation rate		34			32			32	
	3	32	98	2	36	68	2	36	68
		32							

Table 2. Yield of dry biomass from Sudan in kg/ ha under irrigation by years and average for 2021 – 2023

Variants of irrigation	Dry biomass yield, kg/ ha							
	Years							
	2021		2022		2023		Average	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
1. Without irrigation - (control).	10750	73.9	9530	69.0	10350	76.6	10210	73.2
2. Optimal irrigation 100% irrigation rate	14530	100.0	13800	100.0	13500	100.0	13940	100.0
3. Irrigation with 70% of the designed irrigation rate	13400	92.2	12020	87.1	12850	95.1	12760	91.5
4. Irrigation with 40% of the designed irrigation rate	12770	87.9	11220	80.3	12000	88.9	12000	86.1

GD 2021 5% = 4.603 kg/ha; 1% =% 6.366kg/ha; 0.1% =8.798 kg/ha
2022 5% = 4.921 kg/ha; 1% =6.805 kg/ha; 0.1% = 9.406 kg/ha
2023 5% = 4.018 kg/ha; 1% =5. 556kg/ha; 0.1% =9.0521 kg/ha
Average 5% = 3.7488 kg/ha; 1% =5.1241 kg/ha; 0.1% =7.680 kg/ha

irrigation rate of option 1 (100% irrigation rate) show the dependence of the yield on the water availability of the crop during its vegetation, the dynamics of the meteorological factors and the biological characteristics of Sudan grass associated with the different phases of its growth and development. In the case of option 3 (70% of the calculated irrigation rate), in the crop year 2021, the dry biomass yield decreased by 7.8% or - 1130 kg/ha compared to the optimal variant.

In 2022 the yield reduction is 12.9% or 1780 kg/ha and in 2023 4.9% or 650 kg/ha. Averaged over the study period, the reduction is 8.5% or 1180 kg/ha dry biomass. In option 4 with a 60% reduction in irrigation rate compared to option 1 (100% irrigation rate), the yield is reduced by 12.1% or 1760 kg/ha in 2021 compared to the optimal option. In 2022 the reduction is 19.7% or 2580 kg/ha. In the last year, 2023, the yield is reduced by 11.1% or 1500 kg/ha

The average yield reduction for the period was 6.49%, or 817 kg/ha dry biomass. The highest reduction in yield of 26.8% was obtained when the Sudan grass was grown without budding. The differences in yields from the data for the different variants by year can be justified by, among other factors, the peculiarities in the growth and development of the Sudan grass during its different phenol stage. The results obtained from them and averaged over the study period are of very high reliability.

Conclusions

During the three-year period of cultivation of Sudan grass for the region of southern Bulgaria, two to three irrigations of 80-90 mm are needed to optimize soil moisture.

The highest average yield of 13940 kg/ha of dry biomass was obtained with the optimally irrigated variant, which was 36.5% higher than the yield obtained with the non-irrigated variant. When the irrigation rate is reduced by 30% compared to the optimal variant 1 (100%) the dry biomass yield decreases by 8.5%.

The natural water supply of the Sudan grass provides the lowest average dry biomass yield of 10210 kg/ha.

References

Basaran, U., Dogrusoz, M. C., Gulumser, E., & Mut, H. (2017). Hay yield and quality of intercropped sorghum-sudan grass hybrid and legumes with different seed ratio. *Turkish Journal of Field Crops, 22*(1), 47-53, https://doi.org/10.17557/tjfc.301834.

Bazitov, R. & Kikindonov, Tz. (2016). Evapotranspiration of a Sudan grass cultivated as a second irrigation crop. *Bulgarian Journal of Crop Science, 53*, 85-89 (Bg).

Bazitov, R. (2020). Evapotranspiration in Sudan grass second culture grown under non – irrigated and optimal irrigated conditions. *Agricultural science and technology, 12*(4), 335-339.

Bazitov, R. (2021). Influence of the violated irrigation regime on the yield of sudan grass grown as a second culture for the conditions of Southern Bulgaria. *Bulgarian Journal of Soil Science Agrochemisty and Ecology, 55*(3-4), 74-82.

Ismail, S. M., El-Nakhlawy, F. S., & Basahi, J. M. (2018). Sudan grass and pearl millets productivity under different irrigation methods with fully irrigation and stresses in arid regions. *Grassland Science, 64*(1), 29-39, https://doi.org/10.1111/grs.12179.

Kaplan, M., Kara, K., Unlukara, A., Kale, H., Buyukkilic Beyzi, S., Varol, I.S., Kizilsimsek, M., & Kamalak, A. (2019). Water deficit and nitrogen affects yield and feed value of sorghum Sudangrass silage. Agric. *Water Manag. 218*, 30–36.

Knowles, T.C. & Ottman, M.J. (2015). *Sudan grass hay production in the irrigated deserts of Arizona and California*. College of Agriculture and Life Sciences, University of Arizona (Tucson, AZ).

Machicek, J. (2018). *Evaluating forage sorghum and pearl millet for forage production and quality in the Texas high plains*," Ph.D. thesis, West Texas A & M University, Canyon, Texas, US.

Silva, F. A., de Freitas, F. C. L., Rocha, P. R. R., Cunha, J. L. X. L., Dombroski, J. L. D., Coelho, M. E. H., & de Lima, M. F. P. (2015). Milho para ensilagem cultivado nos sistemas de plantio direto e convencional sob efeito de veranico. *Semina: Ciências Agrárias, 36*(1), 327-340, https://doi.org/10.5433/1679-0359.2015v36n1p327 (Br).

Slanev, S., & Enchev, S. (2014). Influence of variety and crop productivity of sorghum x Sudan grass hybrids in flowering stage. *Bulgarian Journal of Agricultural Science, 20*(1), 182-185.

Taha, A. M., Salem, A. K., & Mekhaile, N. E. (2019). Maximizing land and water productivity of Sudan-grass under sprinkler irrigation in sandy soil. *Journal of Soils and Crops, 29*, 207-217.

Villar-Salvador, P., Peñuelas, J. L., & Jacobs, D. F. (2013). Nitrogen nutrition and drought hardening exert opposite effects on the stress tolerance of Pinus pinea L.

seedlings. *Tree physiology, 33*(2), 221-232.

Ziki, S. J. L., Zeidan, E. M. I., El-Banna, A. Y. A., & Omar, A. E. A. (2019). Influence of cutting date and nitrogen fertilizer levels on growth, forage yield, and quality of sudan grass in a semiarid environment. *International Journal of Agronomy, 2019*(1), 6972639, https://doi.org/10.1155/2019/6972639.

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