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THE EFFECT OF NITROGEN FERTILIZER RATES ON GREEN BIOMASS AND DRY MATTER YIELD OF *Sorghum sp.* AT DIFFERENT GROWTH STAGES

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Abstract: The paper investigated the production properties of three sorghum genotypes: NS-Džin (forage sorghum), Zora (Sudan grass) and Siloking (interspecies hybrid) in terms of different nitrogen rates used in side dressing in 2009 and 2010. The subject of study was green biomass and dry matter yield in the stages of intensive growth and tasseling. The results have shown that there have been significant fluctuations in production indicators between the genotypes. In the total average, the lowest yield was recorded for the Sudan grass (85.41 t ha^{-1}). Significantly higher yields were recorded for the interspecies hybrid (90.22 t ha^{-1}) and the forage sorghum (93.51 t ha^{-1}). Although the effect of nitrogen rates depended on weather conditions, i.e. rainfall distribution, the optimal nitrogen rate in both years was 180 kg ha^{-1}.

Key words: nitrogen, sorghum, Sudan grass, interspecies hybrid, yield, green biomass.

Introduction

Sorghum species are becoming popular nowadays, especially as fodder crops, because they regenerate well under favourable weather conditions and give more cuts in a production year, depending on water regime (*Glamočlija et al., 2010).*

Beside water regime, what greatly affects the productivity and quality of green biomass is crop nutrition. Previous studies on this topic have also confirmed the positive effect of side dressing on the quality of forage sorghum. The effect of nitrogen on plant metabolism has been well studied and known (*Avner et al.,* *2006*). The optimal nitrogen supply makes plants intensively form nitrogen compounds to synthetize storage proteins (*Glamočlija et al., 2011*).

A general precondition for high yields is to satisfy plant requirements in the best way during the whole growing period. Besides regular food and water supply, this also implies good nutrient absorption, as well as the formation and use of necessary compounds in the optimum ratio and optimum amounts for plant growth (*Ikanović et al., 2010*). Using nitrogen mineral fertilizers in the right way should enable better and more efficient utilisation of the environment (agro-ecological and soil conditions) and crop potential of this plant for higher yields of animal feed per unit area. Yield reflects the potential of a plant to accumulate dry matter and its adaptability to different agro-ecological conditions.

Nitrogen is an element necessary for growth and development of plants in all stages, and symptoms of nitrogen deficiency in actual production are quite intensive and easy to spot (*McLaren, 2003*). Increased nitrogen rates in plants positively affect photosynthesis, as well as the intensity and duration of vegetative organs' activity, thus implying that increased nitrogen accumulation will be a precondition for improving the quality of crop potential of new cultivars.

According to recent research (*Booker, 2007*), nitrogen pollution of ecosystems in global changes has alarmingly increased, so it is assumed that participation rate of Asia in the total nitrogen production from current 35% will have been doubled by 2030. From the aspect of human population, the most unwanted consequences of excess nitrogen use in plant production are those related to accumulating harmful and toxic elements in plant and animal products and jeopardizing food safety (*Erisman et al., 2007*).

Materials and Methods

The study was conducted in 2009 and 2010. A two-factorial field experiment was set up on the experimental field "Radmilovac", in a randomized block system in ten repetitions. The size of basic plots was 10 m^2 (5m by 2m). The study was conducted on samples of three genotypes: *Džin* (forage sorghum bred in 1983), *Zora* (Sudan grass bred in 1983) and *Siloking* (interspecies hybrid bred in 2007) all bred in the Institute of Field and Vegetable Crops in Novi Sad. Different nitrogen rates were used in pre-sowing preparations: 105 kg ha^{-1} (N_2), 150 kg ha^{-1} (N_3), 180 kg ha^{-1} (N_4) and control (N_1) – natural soil fertility, estimated as 60 kg ha^{-1}. Standard cropping practices for forage sorghum were used. Plants were cut in the stage of intensive growth and at the beginning of tasseling (second decade of July and the last decade of August). Mineral fertilizers, such as ammonium-nitrate were applied before sowing. There were two cuts in both years. The productivity of the first and second cuts was determined by measuring fresh biomass from each plot and expressing it in t ha^{-1}.

Obtained data were analysed with STATISTICA 8 for Windows (Stat Soft 2009). Differences between treatments and their significance were determined with the analysis of variance (MANOVA) and LSD- test (0.01% and 0.05%).

Meteorological conditions. Meteorological data were taken from the Meteorological station in Belgrade, Serbia. In the first year, the amount of rainfall in the growing period was about 9.5% higher than a ten-year average. In April and May there was less rainfall than in the summer. Rainfall amounts in the second year were 27% higher than a multi-year average, and about 20% higher than in the first year. The distribution of rainfall in the growing period was even, with maximum rainfall in June (180 litres per square meter).

Table 1. Rainfall (mm) and daily mean temperature ^{0}C for sorghum growing period, Belgrade

Year	Parameter	*Month*						*Average Sum*
		IV	V	VI	VII	VIII	IX	
2009	Temperature	16	20	21	24	24	20	21
	Rainfall	6	34	153	79	45	45	362
2010	Temperature	14	18	21	24	24	18	20
	Rainfall	41	85	180	41	54	51	452
Average Sum, ten years	Temperature	15	26	23	25	25	18	21
	Rainfall	15	58	102	53	54	49	331

Monthly heat distribution in the first year has shown that mean temperatures in the summer were lower than a multi-year average for this region. In the second year, lower temperatures were recorded in the spring and the autumn, while in the summer temperatures were at the level of first year (Table 1).

Results and Discussion

The studied production properties of the genotypes have shown great dependence on both treatments (genotypes and applied nitrogen rates) – (Tables 2 and 3).

Green biomass yield. The genotypes had higher production values in 2010 since there was more rainfall in the summer when plants needed more water. This more favourable water regime caused higher productivity of green biomass of these genotypes, when compared to 2009.

Observed by stages, higher green biomass yield was obtained in all genotypes in the stage of growth, while higher dry matter yield was obtained in the stage of tasseling. Dry matter content, however, was also affected by different nitrogen rates. When compared to the total average, the Sudan grass had the lowest yield (85.41 t ha^{-1}), while considerable higher yields were recorded for the interspecies hybrid (90.22 t ha^{-1}) and the forage sorghum (93.51 t ha^{-1}). Nitrogen nutrition affected green biomass yield, so it was considerable higher in all treatments when compared to control. The highest yield, on average for all genotypes, was obtained when 180 kg N ha^{-1} was used. The average green biomass yield obtained in the second year was about 15% higher, as a result of more favourable water regime, Table 2.

According to *Erić et al.* (2004), Sudan grass yield depends on the time of sowing as well. These authors identified a positive correlation between yield and growing period, i.e. the time of sowing, therefore determining that late sowing make plants have shorter vegetative growth, early-coming generative growth and lower biomass yield.

Table 2. Green biomass yield, t ha^{-1}

Genotypes *N rates*	*2009*	*2010*	*Two-year average*	*LSD* *0.05% and 0.01%*
Genotype (A)				
Siloking	84.52	95.92	90.22	3.3556
NS Džin	85.06	101.95	93.51	4.5661
Zora	80.22	90.60	85.41	
N rates (B)				
N105	84.64	94.06	89.35	
N150	86.31	101.60	90.00	5.851
N180	86.58	102.10	94.36	9.245
Control	79.55	86.96	83.30	
Average	83.84	96.17	89.45	

Table 3. Effect of genotypes and N rates on green biomass and dry matter yield of the investigated sorghum genotypes in 2009-2010

Factors	Green biomass yield		Dry matter yield	
	Stage of growth	Tasseling	Stage of growth	Tasseling
Genotype (A)		***2009***		
Siloking	48.462 b	43.906 a	6.722 b	9.446 a
NS Džin	53.436 a	43.657 a	6.123 c	5.626 c
Zora	45.565 c	36.539 b	8.242 a	7.864 b
N rates (B)				
N105	49.206 c	40.902 c	6.861 b	7.746 c
N150	52.379 b	43.223 b	8.077 a	8.431 b
N180	54.734 a	43.922 a	8.081 a	8.692 a
control	40.299 d	37.421 d	5.099 c	5.712 d
Average ± $S\overline{x}$	**49.154±1.094**	**41.367±0.734**	**7.029±0.260**	**7.645±0.340**
Genotype (A)		***2010***		
Siloking	45.732 a	35.486 a	7.698 b	10.010 a
NS Džin	38.726 b	32.228 c	7.434 c	7.408 c
Zora	36.130 c	33.350 b	8.285 a	9.472 b
N rate (B)				
N105	38.646 b	34.776 c	7.652 c	9.098 b
N150	45.831 a	36.557 b	8.424 b	9.438 a
N180	47.036 a	38.474 a	8.748 a	9.430 a
control	29.272 c	26.278 d	6.399 d	7.889 c
Average ± $S\overline{x}$	**40.196±1.413**	**34.021±0.896**	**7.806±0.167**	**8.964±0.227**

Table 4. Statistical significance of differences between the investigated sorghum properties, by years (F test and LSD test)

	Properties	Test	2009			2010		
			Genotype (A)	N rates (B)	AB	Genotype (A)	N rates (B)	AB
Green biomass yield	Stage of growth	F test LSD 5% 1%	*** 0.445 0.605	*** 0.514 0.699	*** 0.890 1.210	*** 1.138 1.548	*** 1.315 1.787	*** 2.277 3.095
	Tasseling	F test LSD 5% 1%	*** 0.490 0.664	*** 0.566 0.770	*** 0.980 1.332	*** 1.033 1.404	*** 1.193 1.621	*** 2.066 2.808
Dry matter yield	Stage of growth	F test LSD 5% 1%	*** 0.032 0.044	*** 0.038 0.051	*** 0.066 0.089	*** 0.043 0.058	*** 0.049 0.067	*** 0.086 0.117
	Tasseling	F test LSD 5% 1%	*** 0.047 0.064	*** 0.055 0.074	*** 0.094 0.128	*** 0.131 0.178	*** 0.152 0.206	*** 0.263 0.357

^{NS}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

Dry matter yield. Fluctuations in dry matter yield have shown their dependence on the time of cutting and the N rates. Dry matter yield was considerable affected by the N rates, but also the genotypes and the time of cutting.

Higher yield of dry matter was obtained at the stage of tasseling, but it was also affected by the N rates. It should be pointed out that the effect of N rates has shown a great dependence of rainfall distribution during the growing period. It affected both quantity and quality of dry matter in general, resulting in higher dry matter yield in 2010, when the weather conditions were more favourable. The highest dry matter yield was obtained for the interspecies hybrid Siloking, followed by the Sudan grass genotype Zora, whilst the lowest yield was obtained for the forage sorghum genotype Džin. With increasing N rates, the dry matter yield also increased, which was in line with the results of previous research by *Janković et al., 2012; Sikora et. al., 2012; Ikanović et al., 2013; Rakić et al., 2013*, and came as a result of higher yield and better quality of green biomass.

Conclusion

The results of the biennial research indicate that higher nitrogen rates have significant, positive and justifiable effect on production properties of the tested genotypes of sorghum, Sudan grass and interspecies hybrid.

The increased nitrogen nutrition significantly contributed to higher yield of green biomass in the growth stage, while higher dry matter yield was obtained during the tasseling stage depending on the used nitrogen rates, which was a result of higher yields and better quality of green biomass.

Intense nitrogen nutrition can be justified only when there is favourable water supply, which implies that the effect of using this fertilizer increases only when crops are irrigated and the loss of washing nitrogen into deeper layers of soil decreases.

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Uticaj azota na prinos zelene biomase i suve materije *Sorghum sp.* vrsta po fazama rastenja

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Rezime

U radu su proučavane produktivne osobine tri genotipa sirka i to: NS-Džin (krmni sirak), Zora (sudanska trava) i Siloking (interspecijes hibrid) u zavisnosti od upotrebljenih količina azota za dopunsku ishranu biljaka tokom 2009. i 2010. godine. Ispitivani su prinos zelene mase u fazama intezivnog porasta i metličenja.

Između ispitivanih genotipova postoje značajna variranja u pokazateljima produktivnosti. U ukupnom proseku najmanji prinos dala je sudanska trava 85,41 t ha^{-1}. Značajno viši prinos bio je kod interspecijes hibrida (90,22 t ha^{-1}) i krmnog sirka (93,51 t ha^{-1}).

Iako je efekat upotrebljenog azota zavisio od vremenskih uslova, odnosno od rasporeda padavina, u obe godine optimalna količina azota bila je 180 kg ha^{-1}.

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