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SORGHUM BIOMASS YIELD AT DIFFERENT PLANT DENSITIES

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Abstract

Sorghum (Sorghum bicolor (L.) Moench) is among the most important energy crops used for biomass production as substrate for obtaining biogas which is converted by combustion into power energy and heat. The importance of sorghum as an energy crop is given by some advantages such as the drought tolerance, the great potential to produce biomass even under less favorable growing conditions, and the easiness to be cultivated.
For sorghum energy crops aimed to produce biomass, already there are created specialized hybrids for this purpose, but there is necessary also a specific crop technology according to this purpose. Among the important elements of the crop technology there are counted the plant density. From this perspective, the aim of this paper is to present the biomass yields of two sorghum hybrids at different plant densities. In view to accomplish this aim, a field experiment was performed in the specific conditions from South Romania and under the climatic conditions of 2016, with two sorghum hybrids (BMR Gold X and EUG 542 F) sown under three plant densities: 22 plants.m^{-2}, 28 plants.m^{-2}, and 34 plants.m^{-2}. The biomass determinations were performed in the early dough – dough plant growth stage. For each experimental variant, there was calculated the fresh and dry biomass yield which was expressed in tons.ha^{-1}.

***Key words**: biomass, sorghum, yield, plant density.*

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is an important fodder crop for both arid and semi-arid regions of the world (Tookalloo, 2014). Also it is used as food in Africa, India, China, and Central America, as well as in the food industry for starch, alcohol and beer production (Oprea et al., 2015). Moreover, sorghum is among the most important energy crops used for biomass production as substrate for obtaining biogas which is converted by combustion into power energy and heat.
Biomass, as a renewable energy source, is an important substitute for fossil fuels (Trulea et al., 2016). In fact, biomass is the most common form of renewable energy (McKendry, 2002). In the biogas production from biomass, sorghum may constitute an alternative for maize, which is characterised by a relatively high methane yield in biogas (Sałagan et al., 2012; Mahmood et al., 2013).
Compared to sorghum, the methan potential of maize was about 10% higher according to the "Baserga-model" (Zeise, 2014). But, in a field experiment performed in US in 2008 and 2009, sorghum bioenergy crops yielded more aboveground dry matter than maize in both years and in both irrigation and conservation tillage conditions; thus, in some production scenarios, sorghum may be superior to maize for cellulosic biomass (Rocateli et al., 2012).
The importance of sorghum as an energy crop is given by some advantages such as the drought tolerance, the great potential to produce biomass even under less favourable growing conditions, and the easiness to be cultivated. Therefore, in more arid areas, it could replace maize as a biofuel feedstock (Mekdad and Rady, 2016).
Sorghum as an energy crop is important especially in a system specialised for biomass production used as source of energy, which cannot rely only on maize because of the specific problems that could appear in a long term monoculture (Bășa et al., 2014).
Energy crops used for biogas production have to be easy to be cultivated and they have to be

not too much demanding for inputs (Dicu et al., 2016). For sorghum energy crops aimed to produce biomass, already there are created specialized hybrids for this purpose, but there is necessary also a specific crop technology. Among the important elements of the crop technology there are counted the plant density.

The optimum average seeding rate for sorghum grown for biomass is 247,000 seeds.ha^{-1}, but this value can be as high as 296,000 seeds.ha^{-1} and as low as 185,000 seeds.ha^{-1} depending on input and management scenarios (Kludze et al., 2011). In two field experiments carried out at three experimental stations in Germany in years 2008 and 2009, in most cases dry matter yield was not significantly affected by plant density as well as by row spacing (Mahmood, 2011).

Considering the importance of the plant density, the aim of this paper is to present the biomass yields of two sorghum hybrids at different plant densities.

MATERIALS AND METHODS

Our research was performed in a field experiment located in South Romania (44^{o}29' N latitude and 26^{o}15' E longitude) and under the climatic conditions of 2016, with two sorghum hybrids (BMR Gold X and EUG 542 F) sown under three plant densities: 22 plants.m^{-2}, 28 plants.m^{-2}, and 34 plants.m^{-2}.

The soil from the area where the field experiment was located is reddish preluvosoil, which is characterised by a humus content between 2.2 and 2.8%, clay loam texture, and pH between 6.2 and 6.6.

The climatic conditions in 2016 for the period April-August were characterised by the average temperature of 20.1^{o}C and by the sum of rainfall of 284 mm. For the same period (April-August), the multiannual average temperature is 18.5^{o}C and the multiannual average rainfall is of 313.2 mm. Thus, the year 2016 was warmer and drier than normal years for the studying area.

The preceding crop was maize. The ploughing was performed on 30th of October 2015. In the spring of 2016, the soil tillage consisted of a harrow work performed on 18th of March, which was followed by a combinator work performed on 28th of March. The sowing was performed on 20th of May 2016. The fertilization was performed after sowing with 80 kg of nitrogen per hectare applied as ammonium nitrate. Immediately after sowing and nitrogen fertilization, there was performed the weed control by the help of herbicide Glyphogan 480 SL based on active substance glyphosate 360 g.l^{-1} as isopropylamine salt, which was applied in a rate of 4 l.ha^{-1}.

The biomass determinations were performed in the early dough-dough plant growth stage, respectively in the moment when the sorghum biomass can be used as substrate for biogas production. The sorghum plants from one square meter in each experimental variant were cut at soil level and they were weighed immediately. The samples were taken in four replications. One sorghum plant for each variant and replication was taken into the laboratory for the determination of the dry biomass by oven drying at 80^{o}C for 24 hours. For each experimental variant, there was calculated the average fresh and dry biomass yield which was expressed in tons.ha^{-1}. For each hybrid, the obtained data at different plant densities were statistically processed by analysis of variance (ANOVA), the control being taken the variants with 22 plants.m^{-2}.

RESULTS AND DISCUSSIONS

Increasing the plant density from 22 to 28 and respectively to 34 plants.m^{-2} leaded to an increase in the biomass yields at both sorghum hybrids (Figures 1 and 2). The increases were more consistent for fresh biomass yields then for dry biomass yields. However, increasing the plant density determined differences statistically significant only at the hybrid BMR Gold X, while at the hybrid EUG 542 F the differences were not statistically significant.

Even the hybrid BMR Gold X obtained important increasing in biomass yields determined by the increasing of plant density, the differences registered for the fresh biomass yields were statistically significant at both plant density, respectively at 28 and 34 plants.m^{-2}, while the differences registered for the dry biomass yields were statistically significant only for the plant density of 34 plants.m^{-2}.

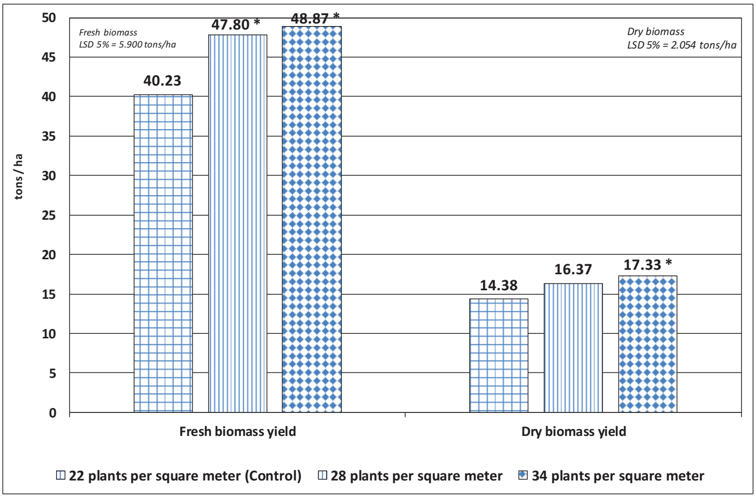

Figure 1. Fresh and dry biomass yields at different plant densities and at sorghum hybrid BMR Gold X

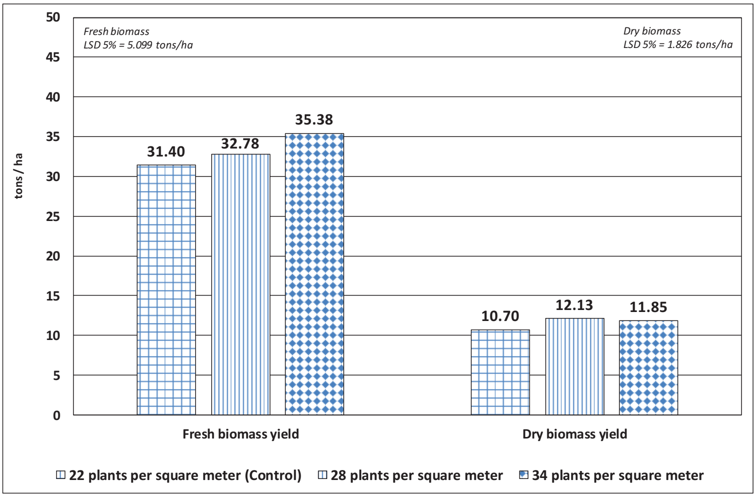

Figure 2. Fresh and dry biomass yields at different plant densities and at sorghum hybrid EUG 542 F

The fresh and dry biomass yields registered higher values at sorghum hybrid BMR Gold X (Figures 3 and 4).

Thus, average fresh biomass yield was of 45.63 tons.ha^{-1} at hybrid BMR Gold X, while at hybrid EUG 542 F it was of 33.19 tons.ha^{-1}.

The average dry biomass yield was of 16.03 tons.ha^{-1} at hybrid BMR Gold X, while at hybrid EUG 542 F it was of 11.56 tons.ha^{-1}.

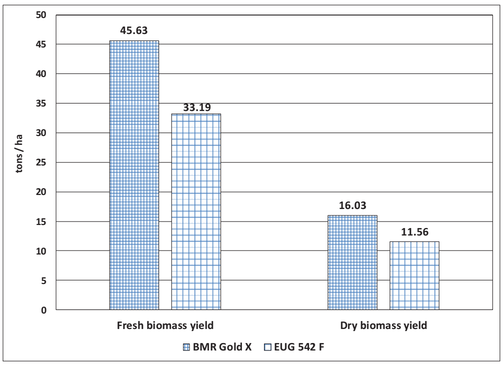

Figure 3. Fresh and dry biomass yields as average values at studied hybrids (BMR Gold X and EUG 542 F)

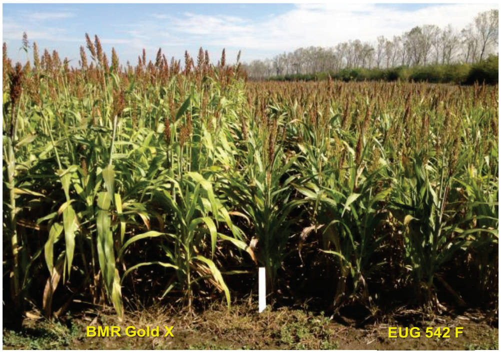

Figure 4. The field experiment with the two studied sorghum hybrids (BMR Gold X and EUG 542 F)

CONCLUSIONS

In our research, the hybrid BMR Gold X was more performant concerning the biomass yield compared to the hybrid EUG 542 F, and increasing of plant density leaded to the significant positive differences only for the hybrid BMR Gold X. These findings show that for biomass production, there is important the cultivated hybrid but also the choosing of the proper plant density according to the cultivated hybrid.

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REFERENCES

Băşa A.Gh., Ion V., Dumbravă M., Dicu G., State D., 2014. Biomass yield at sorghum at different distances between rows in the conditions of South Romania. 14th International Multidisciplinary Scientific GeoConference (SGEM), Energy and Clean Technologies Conference Proceedings, Vol. 1 - Renewable Energy Sources & Clean Technologies, p. 69-76.

Dicu G., Ion V., Horhocea D., State D., Ion N., 2016. Results regarding biomass yield at maize under different plant density and row spacing conditions. AgroLife Scientific Journal, Vol. 5, Nr. 2, p. 59-64.

Kludze H., Deen B., Dutta A., 2011. Report on Literature Review of Agronomic Practices for Energy Crop Production under Ontario Conditions. University of Guelph.

Mahmood A., 2011. Performance of Sorghum (*Sorghum bicolor* L. Moench) as an Energy Crop for Biogas Production. Thesis submitted for the requirement of doctoral degree in agriculture from Faculty of Agricultural and Nutritional Sciences, Home Economics and Environmental Management, Justus Liebig University Giessen, Germany.

Mahmood A., Ullah H., Ijaz M., Javaid M.M., Shahzad A.N., Honermeier B., 2013. Evaluation of sorghum hybrids for biomass and biogas production, Australian Journal of Crop Science, 7(10):1456-1462.

McKendry P., 2002. Energy Production from Biomass (part 1): Overview of Biomass. Bioresource Technology, 83, p. 37-46.

Mekdad A.A.A., Rady M.M., 2016. Productivity Response to Plant Density in Five Sorghum Bicolor Varieties in Dry Environments. Annals of Agricultural & Crop Sciences, 1(2):1009.

Oprea C.A., Marin D.I., Bolohan C., 2015. Influence of some technological factors on grain sorghum (*Sorghum bicolor* (L.) Moench var. *Eusorghum*) yield grown under the conditions of southeastern Romania. AgroLife Scientific Journal, Vol. 4, No 1, p. 123-130.

Rocateli A.C., Raper L.R., Balkcom K.S., Arriaga F.J., Bransby D.I., 2012. Biomass sorghum production and components under different irrigation/tillage systems for the southeastern U.S. Industrial Crops and Products, 36:589-598.

Sałagan P., Dobek T.K., Kołosowski P., 2012. Biogas yield from sorghum bicolor of Biomass 140 variety. Agricultural Engineering, Z. 4(140)T.2, p. 107-116.

Trulea A., Vintilă T., Popa N., Pop G., 2016. Mild alkaline pretreatment applied in the biorefinery of sorghum biomass for ethanol and biogas production. AgroLife Scientific Journal, Vol. 5, No 2, p. 156-159.

Tookalloo M.R., 2014. Effect of planting date and application of nitrogen on yield related traits of forage sorghum cultivars. Scientific Papers. Series A. Agronomy, Vol. LVII, p. 357-359.

Zeise K., 2014. Quality determining ingredients and methan potential of sorghum. Proceedings of 4th Central European Biomass Conference, 15-18 January, p. 247.