24) PERSPECTIVE OF CORN AND SWEET SORGHUM GROWING AS BIOENERGY CROPS FOR BIOGAS PRODUCTION

Mykola Grabovskyi

Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine, Email: nikgr1977@gmail.com

Abstract
Corn is the main silage crop, but it contains a low percentage of protein and a low amount of organic matter. Therefore, it is quite promising to combine corn with sorghum, which is able to form a huge vegetative mass. The similarity of morphological indicators makes it easy for these crops to be compatible. It is also important that compatible crops of corn and sorghum more fully and productively use the moisture and nutrients of the soil, which determines the good yield and nutrition of the green mass.
The studies were conducted in Scientific and Production Center of Bila Tserkva National Agrarian University, Ukraine. The studies were conducted in 2013-2016 with the following scheme: hybrids of sweet sorghum and corn (factor A): 1. S 42; 2. A Dovista; 3. Monica 350 MV; 4. Bistrica 400 MV. Method of sowing (factor B): 1.one species; 2. compatible.
Compared to one-species crops of corn and sweet sorghum, higher productivity of compatible crops is established. At the same time, the increase in the yield of green mass and the output of biogas, compared with corn, was on average 49.8 and 13.4%, and with sweet sorghum – on 13.0 and 44.5%. The maximum yield of green mass and the estimated output of biogas were obtained in compatible crops of the hybrid sweet sorghum Dovista and corn hybrid Bistritsa 400 MV – 85.5 t/ha and 10.3 thousand m^3/ha.

Introduction
An important area of agricultural production is the creation of compatible and mixed crops. In the practice of agriculture, compatible crops bear make functional load. The use of certain agrotechnical measures may affect the growth and development of corn and sorghum and their productivity. Knowledge about the timing of phenological phases in corn and sorghum when grown in single and compatible crops is important for determining measures to increase the yield of green mass and improve quality (Kashevarov et al., 2017).

Corn is the main silage crop, but it contains a low percentage of protein and a low amount of organic matter. Therefore, it is quite promising to combine corn with sorghum, which is able to form a huge vegetative mass. The similarity of morphological indicators makes it easy for these crops to be compatible. It is also important that compatible crops of corn and sorghum more fully and productively use the moisture and nutrients of the soil, which determines the good yield and nutrition of the green mass (Abeuov, 2014). Concerning feed value, the vegetative weight of sweet sorghum is inferior to corn on 5-10%. However, due to the versatility of its use, it can be a complete adding to corn that is traditional silage crop (Krasnenkov, 1999).

For the biogas production from energy crops, corn as a raw material is paramount due to its high yield potential. The cultivation and storage of silage corn is technically advanced and widely optimized (Amon et al., 2006). As a substrate for biogas production, special energy hybrids of corn are grown with a dry weight yield of 9-30 t/ha (Braun, 2007). This is roughly 5300-9000 m^3/ha of methane, depending on the corn hybrid, agro-climatic growing conditions and harvesting phase (Amon et al., 2004).

The use of energy crops (in particular, silage corn) has increased in the last 10 years in some European countries (Germany and Austria), which use them due to high methane yields, it increases the profitability of biogas production. Co-fermentation of various substrates greatly contributes to the improvement of this process and the increase of biogas output. Discussion of the use of energy crops and their impact on land

use change and food security has led to restrictions on the share of energy crops for biogas production (Scarlat et al., 2018).

The Renewable Energy Act (EEG 2012) has been introduced in the European Union countries, according to which the mass fraction of corn in the nutrient substrate for biogas plants should not exceed 60%. In the arid conditions of the southern steppe of Ukraine, sorghum is a promising crop for biogas production. Scientists estimated that if sorghum is grown on an area of 500 00 hectares with crop yield 100 t/ha it is possible to get about 4.4 billion m^3 of methane (Roik et al., 2014).

Materials and Methods

The studies were conducted in Scientific and Production Center of Bila Tserkva National Agrarian University, Ukraine. Soil of the experimental site is black typical leached. The area continental climate and is located in conditions of unstable humidity.

The studies were conducted in 2013-2016 with the following scheme: hybrids of sweet sorghum and corn (factor A): 1. S 42; 2. A Dovista; 3. Monica 350 MV; 4. Bistrica 400 MV. Method of sowing (factor B): 1.one species; 2. compatible. Line Ratio 2:2. Plot area is 56.0 m^2, the accounting area is 33.6 m^2, and the repetition is three times. Replicating options is randomized.

The yield of green mass was determined by weighing the plants from the accounting area, then by conversion to one hectare. The dry matter content was determined by sampling plants up to 1 kg, after they were thoroughly milled and from this sample were taken 2 pieces of 10 g each, they were dried in an oven at + 105 ° C. The biogas yield was obtained by the calculation method according to the methods proposed by Amon et al. (2007) and Buswell & Mueller (1952). To calculate the biogas yield, it was assumed that 0.6 $m^3$of biogas with methane content 60% can be obtained from 1 kg of corn dry matter, 0.45 m^3– from 1 kg of sweet sorghum dry matter, and 0.5 $m^3$of biogas – from corn and sorghum mixtures.

Results and discussion

In average, over the years of research, sweet sorghum in a single crop provides a yield of green mass 67.8–76.1 t/ha, which is on 11.6–24.0 t/ha higher than corn (Table 1).

Table 1. Yield of corn and sweet sorghum green mass in one-species and compatible crops, t/ha

Hybrids of sweetsorghumandcorn	2013 p.	2014 p.	2015 p.	2016 p.	Mean
Sylosne 42	71,8	73,9	45,9	79,5	67,8
Dovista	80,2	82,7	51,2	90,1	76,1
Monica 350	53,6	57,5	40,3	57,0	52,1
Bystrysa 400	57,8	61,2	43,2	62,7	56,2
Sylosne 42+Monica 350	80,7	84,9	53,2	88,5	76,8
Sylosne 42+Bystrysa 400	83,6	87,5	55,3	92,4	79,7
Dovista+Monica 350	86,6	91,0	57,0	95,9	82,6
Dovista+Bystrysa 400	89,5	93,6	59,0	99,9	85,5
HIP_{05}	2,5	2,6	2,1	3,0	2,8

In combined sowing of these crops, the yield of green mass was higher on 9.0-30.5 t/ha than that of single-species sowing. The highest level of green mass yield (85.5 t/ha) was noted in compatible growing of corn and sweet sorghum hybrids Davista and Bystrica 400 MV.

When replacing the Bystrica hybrid 400 MV with Monica 350 MV, the yield decreases on 3.4% to 82.6 t/ha. The use of the silage sorghum Silo 42 as a component of mixture, let harvest yield of green mass 76.8–79.7 t/ha, which is on 5.6–5.8 t/ha less than the variants where the Dovista hybrid was sown.

The use of compatible crops with sorghum and corn hybrids of different FAO contributes to a yield increase on 57.4%, a dry matter harvest on 30.8% compared to one-species corn crops (Drozdova, 2015).

Analysis of the estimated output of biogas from corn and sweet sorghum shows that, depending on the variant of the experiment, in one-species sowing it amounted to 6,1–7,2 thousand m^3/ha in sorghum and 8,0–9,1 thousand m^3/ha in corn. In the case of compatible sowing, it was in the range of 8.8–10.3 thousand m^3/ha, which is more on 3.4–20.3% and 35.1–54.5%, respectively, compared to the one-species crops (Figure 1).

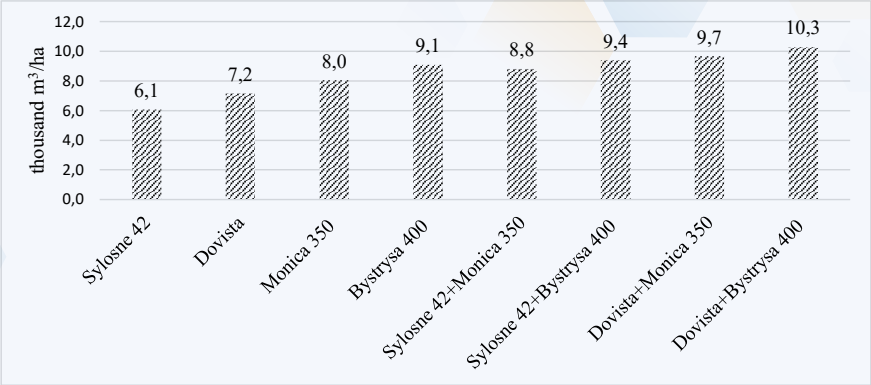

Figure 1. Estimated output of corn and sweet sorghum biogas in one-species and compatible crops, thousand m^3/ha (2013–2016).

Conclusions and Outlook

Therefore, compared to one-species crops of corn and sweet sorghum, higher productivity of compatible crops is established. At the same time, the increase in the yield of green mass and the output of biogas, compared with corn, was on average 49.8 and 13.4%, and with sweet sorghum – on 13.0 and 44.5%. The maximum yield of green mass and the estimated output of biogas were obtained in compatible crops of the hybrid sweet sorghum Dovista and corn hybrid Bistritsa 400 MV – 85.5 t/ha and 10.3 thousand m^3/ha.

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