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Evaluation of productivity of maize and sorghum to be used for energy purposes as influenced by nitrogen fertilization

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Abstract

It is assumed that the development of renewable energy can multiply the demand for agricultural raw materials used for energy purposes. Independent estimates indicate that one of the major energy carriers would be biogas produced from agricultural substrates. As a result, the present paper presents the results of the research on the assessment of yield and productivity of biogas from maize and sorghum grown on a sandy soil at different nitrogen fertilization levels. The field experiment was conducted in 2008–2010 in the Experimental Station of Institute of Soil Science and Plant Cultivation, State Research Institute in Osiny (N 51°27′59.98″ E 21°39′44.28″) in a randomized complete block, split-plot design, in four replications. The obtained results indicate that in 2008 and 2009, with a favourable amount and distribution of rainfall during the growing season, maize yielded better than sorghum. However, in 2010, with a small amount of rainfall in the third ten-day period of June and the first and second ten-day periods of July, maize yielded significantly lower than sorghum. Higher biogas and methane yield per kg of dry organic mass, as well as the production of these gases, were obtained from one hectare of maize silage compared to sorghum silage.

Key words: productivity, biogas, maize, sorghum.

Introduction

Intensive development of the global economy contributes to the rapid growth in conventional energy consumption. According to various scenarios, it is anticipated that after 2020 there will be a reduction of conventional fuels because of the depletion of resources and the related increase in energy prices (Matyka, 2008). The adopted European Union climate-energy package assumes that by 2020, member countries will have achieved a 20% market share of renewables in energy consumption and a 10% share of liquid biofuels. In addition, an approximately 20% reduction in emissions of greenhouse gases and an increase in energy efficiency are expected as well. Implementation of these objectives is presumed to multiply the demand for raw agricultural products intended for energy (Kuś, Faber, 2009). At present, the biogas produced from agriculture constitutes a very small part in the energy balance, but according to independent forecasts, its production in the nearest decade will develop dynamically at the rate of even tens of percent per year and it will become one of the largest in the so-called "green cart of energy" (Curkowski et al., 2011). Biogas can be produced from organic fertilizers (reduction of emissions of CH_4 to the atmosphere), organic waste and biomass of many plant species. The most important parameter when selecting plant species for cultivation for the production of biogas is their efficiency of net energy per hectare, which is determined mainly by the yield of biomass and productivity of methane (Kacprzak et al., 2010). The most useful species for its production are those rich in readily fermented carbohydrates and protein substances and poor in hemicellulose and lignin, characterized by low capacity for biodegradability (El Bassam, 1998). In addition, such material should be easy to store and thus it could be available throughout the year. So far, there has been research on the choice of species in Central Europe (Weiland, 2003), but there is little data assessing the potential of biogas production from plant species cultivated in Eastern Europe.

It was assumed that on light soils (sandy soils with a low content of silt, airy, not rich in nutrients, vulnerable to drought which contain over 70% of sand fraction), whose share in Eastern Europe is significant (Jones et al., 2012), cultivation of sorghum may be an alternative solution to gain a satisfactory level of biomass yield, while cultivation of other species is unreliable (Tuck et al., 2006).

The aim of this study was to evaluate the yield and productivity of biogas obtained from biomass of maize and sorghum grown on a sandy soil at different levels of nitrogen fertilization.

Materials and methods

The field experiment was carried out over the period of 2008–2010 in the Experimental Station of Institute of Soil Science and Plant Cultivation, State Research Institute in Osiny (N 51°27′59.98″, E 21°39′44.28″) in the split-plot system in four replicates. In the experimental design, factor I represents crop species: maize cultivar 'Anjou 290', sorghum cultivar 'Sucrosorgo 506', and factor II – the level of nitrogen fertilization: N1 – 80, N2 – 120, N3 – 160 kg ha^{-1}.

The experiment was conducted on a light soil. The content of available phosphorus was 17.6, potassium 19.9, magnesium 9.3 mg in 100 g of soil; the content of the humus 1.46 and pH slightly acid 5.05. Phosphorus 26.2 kg ha^{-1} and potassium 74.7 kg ha^{-1} fertilization was used in the experiment. The seeds were sown with a single seed drill at a rate of 130 thousand ha^{-1} for maize from 28 April to 6 May and at 220 thousand ha^{-1} for sorghum from 13 to 18 May. Before sowing, the seeds were treated with insecticides and fungicides. In maize, weeds were controlled with Milagro 040 SC, in sorghum with Primextra Gold 720 SC at a dose of 2.5 l ha^{-1}.

The evaluated species were grown for silage. Maize was harvested on 7–11 September, and sorghum on 19–28 October. The yields of green and dry mass were determined, as well as the content of dry mass, protein, fat, fibre, ash and digestibility (by the enzymatic method). In addition, the contents of the main macroelements including P, K, Mg and Ca were determined by the methods commonly used in such research. Before the harvest, plant height was determined on 10 randomly selected plants from each sub-plot. The silage was prepared from the plants fertilized with 120 kg ha^{-1} N, in which the content of the before mentioned elements and efficiency of biogas were determined. But some laboratory analyses were made only for the years 2008 and 2009. The weight of fermented silage for the assessment of biogas was determined so that an initial load amounted to approximately 5 kg dry organic mass per m^3. A portion of silage with anaerobic sludge was then placed in a tightly closed fermentation vessel with a capacity of 500 ml. Fermentators were then placed in a water bath at a temperature of 37°C. The obtained biogas was discharged into the cylinder, a calibrated gas collector filled with acidified water. The accumulated gas pushed out water from the collector to the overflow tank. The level of gas in the collector was read every 24 hours, and its composition was analyzed using a gas composition analyzer "Gas Data" (UK). Fermentation was carried out to the point where there were no significant increases in the volume of biogas. At the beginning and the end of batch fermentation of the bioreactor content, pH, dry mass content, and the content of dry organic mass (PN-75 C-04616/01), chemical oxygen demand (COD) were determined by the dichromatic method using reagents and a DR 5000 spectrophotometer made by "Hach-Lange's" company (method 435). Starved and unadapted anaerobic sludge obtained by incubation of bovine manure properly prepared in mezophilic temperature range was used as an inoculum. Significant differences between the examined parameters were evaluated by the analysis of variance, setting Tukey's confidence half-intervals at significance level $\alpha = 0.05$.

Results and discussion

The dry mass yields of the evaluated plant species significantly depended on the weather conditions during the vegetation period, while significantly lower effect was exerted by nitrogen fertilization level (Table 1). In the years 2008 and 2009, characterised by a favourable amount and distribution of rainfall during the growing season, maize yielded better than sorghum. However, in the year 2010, characterised by a small amount of rainfall in the third ten-day period of June and first and second ten-day periods of July, maize yielded far lower than sorghum. Also, sorghum was less sensitive to the droughty soil than maize. In addition, sorghum panicles emerged earlier than in the previous two years, and before the harvest, it had a similar dry mass content to that of maize. Dry mass yield of sorghum in that year was by about 7 tons higher than that of maize (Table 1).

Table 1. The yield of green and dry mass as influenced by nitrogen fertilization level

Dose of N kg ha^{-1}	Green mass yield t ha^{-1}				Dry mass yield t ha^{-1}			
	2008	2009	2010	×	2008	2009	2010	×
				maize				
80	64.0	69.6	44.1	59.2	24.3	23.9	14.8	21.0
120	66.2	74.3	48.7	63.1	25.0	24.4	15.6	21.7
160	66.4	75.3	54.1	65.3	24.8	24.0	17.7	22.2
×	65.5	73.1	49.0		24.7	24.1	16.0	
				sorghum				
80	73.4	90.8	73.0	79.1	18.8	17.8	21.5	19.4
120	73.2	96.5	75.4	81.7	19.3	18.6	23.2	20.4
160	75.4	96.6	86.3	86.1	19.1	18.3	25.5	21.0
×	74.0	94.6	78.2		19.1	18.2	23.4	
LSD*								
for species					5.63	0.23	0.44	
for fertilization					n.s.d.**	n.s.d.	0.73	

* $\alpha = 0.05$, ** n.s.d. – not significant difference

Sowiński and Liszka-Podkowa (2008), in their experiment in Lower Silesia obtained a significantly higher yield of fresh weight of sorghum than maize. Also, Kozłowski et al. (2007) reported a greater yield of dry mass of maize compared to sorghum (about 4 tons). Increasing of nitrogen fertilization level had a lesser impact on the evaluated species. Sowiński and Liszka-Podkowa (2008) suggested that nitrogen fertilization did not have any significant impact on the yield of fresh and dry mass of sorghum and maize. There was only a minor trend towards increasing in the yield under the influence of increasing nitrogen rates.

Księżak and Machul (2007), by increasing nitrogen rate from 120 to 160 kg per ha, found a significant increase in maize yield and only a small increase in sorghum yield. In these studies, dry mass yield of maize was about 5 tons higher than that of sorghum. Buxton et al. (1999) after application of 140 kg ha^{-1} obtained a slight increase in dry mass yield (0.8 t ha^{-1}) compared with half the dose, and a further increase of the dose led to a yield reduction. Similarly, Geng et al. (1989) did not receive any growth of sorghum yield with an increase of nitrogen dose above 100 kg ha^{-1}. Also, Kozłowski et al. (2007) in their study recorded a higher dry mass yield of maize than sorghum (about 4 tons). Fotyma (1994) found that for corn grown for silage, the optimal dose of nitrogen was 140–150 kg ha^{-1}. According to Kruczek (1996), the optimal dose of N determined from the relation between dry mass yield and N fertilizer is 150 kg. This dose provides a possibility to achieve the maximum grain yield of 14.5 t ha^{-1}. In another work, the same author reported that grain yields of maize fertilized with N doses from 60 to 135 kg ha^{-1} did not differ, but they were higher than those obtained by N fertilization at a dose of 25 kg ha^{-1} (Kruczek, 2005). In other studies (Gonet, Stadejek, 1990), it was shown that the optimal dose of N estimated on the basis of mathematical non-continuous functions for maize cultivated for green fodder and harvested at the stage of the panicle emergence was 130 kg ha^{-1}. The optimal dose of N for maize reported by various authors (Gonet, Stadejek, 1992; Fotyma, 1994; Kruczek, 1996) ranged between 90–180 kg ha^{-1}. Such different maize responses to N fertilization are mainly due to different methods of cultivation, and therefore the use of different varieties, different plant density, harvest date, limiting the length of the growing season, caused the estimated plant biomass to differ quantitatively and qualitatively. Bogucka et al. (2008) pointed out to the significant differences between maize responses to N fertilization and stated that for a 'Junak' variety, N fertilization at 150 kg ha^{-1} turned out to be sufficient, while 'Boruta' hybrid reacted to the dose of 180 kg ha^{-1} with an increase in grain yield.

Sorghum grown on a light soil achieved a much greater height than maize, and average differences, depending on the year ranged from 30 to 90 cm (Table 2). Also, Sowiński and Liszka-Podkowa (2008) observed a significant difference in height between sorghum and maize. Higher plants of sorghum under the influence of increased nitrogen fertilization in the presented studies were only observed in one year (2008), while in other years it had little impact on this characteristic of the species.

Table 2. The content of dry mass and height of plants as influenced by nitrogen fertilization level

Dose of N kg ha^{-1}	Content of dry mass %				Plant height cm			
	2008	2009	2010	×	2008	2009	2010	×
maize								
80	38.3	34.5	32.5	35.1	260	256	204	240
120	37.9	32.8	31.9	34.2	249	262	214	242
160	37.4	31.1	32.5	33.7	259	257	221	246
×	37.9	32.8	32.3		256	258	213	
sorghum								
80	26.0	19.7	29.5	25.1	317	350	289	319
120	25.7	19.4	30.8	25.3	331	342	283	319
160	25.6	19.0	29.6	24.7	338	353	284	325
×	25.8	19.4	30.0		329	348	285	

In 2009 and 2010, a higher content of dry mass was characteristic of maize compared to sorghum (Table 2). This agrees with the results obtained by Sowiński and Liszka-Podkowa (2008). Increasing levels of nitrogen fertilization of maize (2008 and 2009) resulted in a reduction in dry mass content in plants. Diversification of N fertilization doses had little effect on its concentration in sorghum and maize crops in 2010. The determined content of dry mass in silage of both species evaluated in the studies was very similar to that in green fodder. In the climatic conditions in which the experiment was carried out, the content of dry mass in maize silage should range from 30% to 35%, while the observed content was below 30%, which indicates that the crops were harvested too early (Podkówka et al., 2001). The literature gives examples of the experiments (Johnson et al., 2002), in which the dry mass content in silage was higher than 43%, or, on the other hand, significantly lower (Meeske, Basson, 1995).

The evaluated species were characterized by similar protein content (Table 3). Its higher concentration in maize was observed in 2009, while in sorghum in 2010. Sowiński and Liszka-Podkowa (2008) found a lower total protein content in sorghum than in maize, and under the influence of nitrogen fertilization, its content in the biomass of both species increased. Increasing nitrogen fertilization from 80 to 160 kg ha^{-1} caused an increase in the protein content in plants of the investigated species. The results indicate that the protein content in the silage made from both crops in 2008 was higher than in the green fodder, and in 2009, it was slightly lower (Table 4). The low pH of the silage (from 3.3 to 4.1) and the favourable ratio of lactic acid to total organic acid (LA/TA) (from 0.804 to 0.568) and acetic acid to lactic acid (AA/LA), (from 0.241 to 0.741) indicate that the ensiling process ran properly and was conducted by lactic acid bacteria, which resulted is a small protein decomposition. The protein content of silage recorded by Tillmann (2002) is similar to that recorded in the present study, while Linn and Martin (1989) have reported that the protein constitutes up to 17% dry mass of silage. However, Johnson et al. (2002), Korniewicz et al. (2004) have recorded about 2% more protein in maize silage than obtained in the present study. Nitrogen fertilization has a significant impact on the share of ear maize, chemical composition of plants, and thus the level of the yield. Many authors (Gonet, Stadejek, 1992; Kruczek, 1996) reported an increased protein content in both the vegetative green mass and grain of maize under the influence of increasing doses of nitrogen. Kruczek (1996) showed that the nitrogen fertilization most differentiates N-total content in the maize crops in their early stages of growth. he same author stated that the content of total N and N-nitrate in both the aerial mass of plants as well as in nerve of lower leaf increases with increasing doses of N at all sampling times and decreases with the progress of vegetation. Kozłowski et al. (2007), prior to harvest recorded about 3% higher increase in protein content of sorghum in comparison with maize. According to Księżak and Machul (2007), increasing N fertilization did not have any significant effect on the protein content in maize and sorghum.

Table 3. The nutrient content in dry mass as influenced by nitrogen fertilization level (%)

Dose of N kg ha^{-1}	Protein			Fat			Ash			Fibre			Digestibility		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
maize															
80	5.5	6.6	6.1	2.7	2.9	3.3	5.5	5.3	4.6	19.2	19.4	22.2	69.8	67.0	65.9
120	6.3	7.0	6.4	2.5	2.8	3.2	6.3	5.5	4.9	19.3	19.2	21.8	68.3	66.1	67.0
160	6.2	7.3	6.9	2.4	2.8	2.7	6.2	5.3	4.5	19.4	18.2	22.9	67.2	66.0	64.7
sorghum															
80	5.8	6.7	7.5	2.4	2.2	2.7	5.8	6.0	6.8	34.1	37.0	32.1	44.3	43.5	52.7
120	6.3	6.9	7.6	2.5	2.7	2.8	6.3	6.1	7.0	32.7	37.1	30.3	44.3	46.7	54.1
160	6.8	6.7	7.8	2.6	2.7	3.0	6.8	7.0	7.1	34.4	35.3	31.6	46.1	44.6	52.2

A significantly lower (almost twofold) content of crude fibre content was found in the plants of maize compared to sorghum (Table 3). Different nitrogen fertilization and weather conditions during the growing season in the studied period had little effect on the accumulation of this component in plants of maize and sorghum. Maize biomass, according to Sowiński and Liszka-Podkowa (2008), was characterized by more than 10% lower fibre content compared to sorghum, and nitrogen fertilization had little impact on its content. Determination of fibre content in dry mass shows that its concentration in maize and sorghum is smaller by about 1–2%, compared to the silage (Tables 4 and 5). The content of fibre in maize silage observed by Korniewicz et al. (2004) was higher than in our study. Kozłowski et al. (2007) has indicated that maize has lower content of cellulose, ADF (acid detergent fibre) and NDF (neutral detergent fibre) than sorghum, while the hemicellulose content is very similar. Księżak and Machul (2007) reported significantly higher crude fibre content in the plants of sorghum than in maize. These authors also found a higher fibre content in the species fertilized with higher dose of nitrogen. In addition, they observed a higher content of fibre in sorghum plants grown in a stand with a high population density.

The evaluated species were characterized by a very similar average fat content in dry mass (Table 3). Each year, the variation of fat concentration was insignificant. By contrast, they responded very differently to increasing doses of nitrogen.

Sorghum plants showed a small increase in fat content, and maize plants fertilized with higher doses of nitrogen accumulated less of this ingredient. Average fat content in plants of sorghum and maize, according to Księżak and Machul (2007), did not change under the influence of nitrogen fertilization. Determination of fat content in silage shows that its concentration was by about 0.5% higher compared to that in the dry mass of fodder (Table 4).

Higher ash content was found in sorghum compared to maize (Table 3). The application of increased doses of nitrogen fertilization caused a greater accumulation of ash in sorghum, while for maize in all years of study, more ash was found in the plants fertilized with 120 kg ha^{-1}. According to Kozłowski et al. (2007), maize and sorghum have a similar ash content, while Księżak and Machul (2007) recorded a higher content of this component in the plants of sorghum compared with maize. In addition, higher ash concentrations were found in the plants treated with higher dose of nitrogen. Ash contents were higher in maize silage than green fodder, while for sorghum, it was the opposite (Table 4).

The digestibility of dry mass of maize was by approximately 20% higher than that of sorghum, which is very closely associated with a significantly higher content of fibre in the plants of these species (Table 3). Diversification of the dose of nitrogen fertilization had relatively little effect on the digestibility of both maize and sorghum, but in 2008 there was a reduction in maize digestibility in plants fertilized with higher doses of nitrogen. It is difficult to explain, as in other years there was no such reaction of maize and sorghum. Varied weather conditions during the growing season had a relatively low effect on the digestibility of the compared species. Podkówka et al. (2001) observed the highest digestibility of maize at 30% content of dry mass, and the delay of harvest caused its decrease. According to Eder and Krützfeldt (2000), the factor determining the time of maize harvesting for silage should be the dry mass content. Fragmentation of ensiled green fodder of maize has a significant effect on digestibility of silage nutrients, especially volatile non-nitrogen compounds and crude fibre (Podkówka, 1995). According to the study by Brzóska (2001), organic mass digestibility of maize silage was 65.1–71.1% and increased with increasing content of dry mass in silage from 20–30%. Digestibility of maize silage was very similar to that of green fodder material, while for sorghum, it was by about 10% higher than the digestibility of raw material (Table 4).

Table 4. The content of nutrients in dry mass of silage (%)

Dose N kg ha^{-1}	Protein		Fat		Ash		Fibre		Digestibility	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
maize										
120	6.57	6.63	2.91	3.16	6.70	5.89	17.62	17.26	68.18	66.35
sorghum										
120	6.82	6.32	2.80	3.06	5.48	5.93	31.60	31.82	55.50	56.9

The results of the analyses indicated that regardless of nitrogen fertilization level, both of the evaluated species contained a similar amount of P (Table 5). Higher concentration of K, Ca and Mg were found in sorghum plants compared to maize. Increased nitrogen fertilization did not have any significant effect on the content of Mg, Ca and P, but caused a significant increase in the concentration of potassium in the plants of the evaluated species.

Table 5. The content of macronutrients in dry mass as influenced by nitrogen fertilization level (%)

Dose N kg ha^{-1}	P			K			Ca			Mg		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
maize												
80	0.13	0.18	0.22	1.02	0.94	0.97	0.26	0.23	0.24	0.14	0.16	0.18
120	0.16	0.17	0.21	1.08	1.03	1.10	0.28	0.26	0.23	0.17	0.17	0.19
160	0.14	0.15	0.19	1.13	1.17	1.12	0.25	0.23	0.22	0.14	0.16	0.20
sorghum												
80	0.14	0.19	0.21	1.37	1.60	1.29	0.35	0.38	0.39	0.23	0.25	0.23
120	0.17	0.17	0.21	1.48	1.70	1.38	0.34	0.36	0.38	0.25	0.26	0.23
160	0.17	0.18	0.20	1.52	1.73	1.44	0.35	0.39	0.38	0.26	0.26	0.24

Varied weather conditions during the growing season had little effect on the accumulation of these compounds, but caused an increase in potassium content in sorghum crops in the year with less rainfall. Silage made from the plants of the tested species contained similar amounts of Mg and P, but less Ca and K than green fodder (Table 6).

Table 6. The content of macronutrients in dry mass of silage (%)

Dose N kg ha^{-1}	P		K		Ca		Mg	
	2008	2009	2008	2009	2008	2009	2008	2009
maize								
120	0.16	0.14	1.16	1.13	0.19	0.16	0.16	0.16
sorghum								
120	0.17	0.18	1.33	1.38	0.33	0.27	0.24	0.25

Parameters of silage fermentation are shown in Table 7. Fermentation time and production 90% of biogas from the two species are the same.

Higher efficiency of biogas and methane per kg of dry organic mass was obtained from maize silage than sorghum (Table 8). Lewandowski (2002) has reported that a properly conducted fermentation of 1 kg of dry mass can give about 0.4 m^3 of biogas with a calorific value of 16.8–23.0 MJ (m^3)$^{-1}$, and after the separation of CO_2 its net calorific value increases to 35.7 MJ (m^3)$^{-1}$. According to Lemmer and Oechsner (2001), from 1 ton of biomass from grasslands, we can obtain 100 m^3 of biogas, and from 1 ton of maize harvested at wax maturity 180 m^3. In the opinion of Weiland (2007), maize is a more homogeneous material, which in the biogas plant can be converted up to 90%, and grasses to 50%. Goliński and Jokś (2007) reported that methane is an essential component of biogas, whose share in the total weight usually amounts to 50–55%, or even 75%. According to Amon et al. (2007), biogas production is positively correlated with the content of crude fibre, non-nitrogen compounds and water-soluble carbohydrates, but this process is negatively affected by the content of protein and ash. The same authors have reported that fodder raw material at advanced stages of development is more suitable for biogas production than that harvested at the phase of pasture maturity.

Table 7. The parameters of the fermentation process in 2008

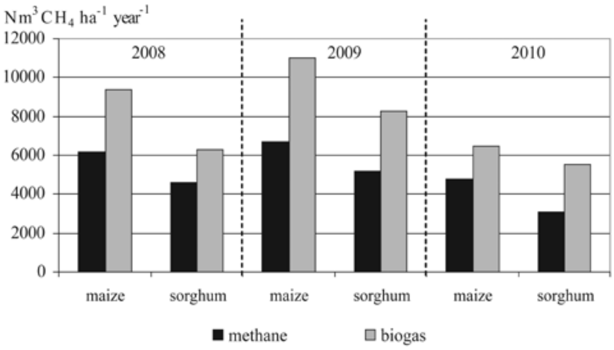
Species	Fermented mass g	Fermented dry organic mass kg $(m^3)^{-1}$	Retention times, days	Time of retention necessary to produce 90% of total biogas, days
Maize	7.27	4.94	37	18
Sorghum	10.7	4.71	37	19

Table 8. Productivity of biogas and methane

Species	Biogas						Methane					
	Nl kg^{-1} g.m.		Nl kg^{-1} d.m.		Nl kg^{-1} d.o.m.		Nl CH_4 kg^{-1} g.m.		Nl CH_4 kg^{-1} d.m.		Nl CH_4 kg^{-1} d.o.m.	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
maize	142	148	427	468	445	442	93	90	280	285	292	270
sorghum	86	86	368	368	394	394	63	54	268	232	286	248

Nl – normal liter, unit of mass for gases equal to the mass of 1 liter (0.035 3147 ft3) at a pressure of 1 atmosphere and at a standard temperature 20°C (68°F); g.m. – green mass, d.m. – dry mass, d.o.m. – dry organic mass

The largest biogas and methane production was possible from one hectare of maize (Fig.).



Nm^3 – unit of mass for gases equal to the mass of 1 m^3 (0.035 3147 ft3) at a pressure of 1 atmosphere and at a standard temperature 20°C (68°F)

Figure. Biogas and methane production per ha

Conclusions

1. In 2008 and 2009, characterised by a favourable amount and distribution of rainfall during the growing season, maize yielded better than sorghum. However, in 2010, with a small amount of rainfall in the third ten-day period of June and first and second ten-day periods of July, maize yielded far less than sorghum. Increasing levels of nitrogen fertilization had little effect on the yield of maize and sorghum. Significant increase of yield was observed only in 2010.

2. Dry mass digestibility of maize was by approximately 20% higher than that of sorghum. Diversification of nitrogen fertilization did not have a significant effect on the digestibility of crude fibre.

3. A higher productivity of biogas and methane per kg of dry organic mass as well as higher yield of these gases were obtained from one hectare of maize silage compared to sorghum silage.

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Kukurūzų ir sorgų, auginamų energiniais tikslais, produktyvumas priklausomai nuo tręšimo azotu

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Santrauka

Manoma, kad atsinaujinančios energijos plėtra gali padidinti žemės ūkio žaliavų, naudojamų energiniais tikslais, paklausą. Nepriklausomi vertinimai rodo, kad vienas pagrindinių energijos šaltinių galėtų būti biodujos, pagamintos iš žemės ūkio substratų. Straipsnyje pateikti rezultatai tyrimų, siekiant įvertinti biodujų išeigą ir produktyvumą iš kukurūzų ir sorgų, augintų smėlio dirvožemyje, taikant skirtingus tręšimo azotu lygius. Lauko bandymas vykdytas 2008–2010 m. Lenkijos valstybinio dirvotyros ir augalininkystės tyrimų instituto Osiny bandymų stotyje (N 51°27′59.98″, E 21°39′44.28″), taikant išskaidytų laukelių schemą, keturiais pakartojimais. Tyrimų rezultatai parodė, kad 2008 ir 2009 m., kai buvo pakankamas kiekis kritulių ir jie palankiai pasiskirstė vegetacijos laikotarpiu, kukurūzai derėjo geriau nei sorgai. Tačiau 2010 m., kai birželio trečią dešimtadienį ir liepos pirmą bei antrą dešimtadienį iškrito mažai kritulių, kukurūzai derėjo žymiai prasčiau nei sorgai. Didesnė biodujų ir metano išeiga iš sausos organinės medžiagos kilogramo, taip pat didesnė šių dujų gamyba buvo iš kukurūzų siloso iš hektaro, lyginant su sorgų silosu.

Reikšminiai žodžiai: produktyvumas, biodujos, kukurūzai, sorgai.