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ALTERNATIVE SOURCES OF VEGETATIVE MASS FOR BIOFUELS IN POLISSIA ZONE

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Aim. To determine the optimal vegetative biological resources in the area of Polissia for the introduction of the domestic green fuel and energy complex. **Methods**. Field, laboratory, mathematical. The estimation of the biomaterial was carried out, taking into account its biochemical properties and technological growth. **Results.** Based on the results of the research, the estimation of the biomaterial was carried out, taking into account its biochemical properties and technological growth. It was established that perennial crops can annually provide renewable biomass inputs at the level of 4.6–11.7 t/ha from cereal grasses and 5.5–25.8 t/ha from non-traditional crops, respectively yielding biomethane 722–1857 m^3/ha and 1161–4715 m^3/ha per year. The content of useful substances of the processed substrate was determined as follows: N – 0.49–2.58%, P_2O_5 – 0.14–1.98%, K_2O – 0.38–2.64 %. **Conclusions.** The vegetative mass of the seeds of perennial grasses along with other renewable sources can be used as vegetative fillers of methane tanks in the Polissya zone.

Key words: long-term crop, vegetative sources, renewable energy, biogas, performance.

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INTRODUCTION

The development of green economy of Ukraine should be based on alternative sources of energy and fuel, technologies of environmentally-friendly manufacturing, agriculture and green building as well as programs of ecological recovery of air, water and soil, processing and utilization of waste products.

In the experts' opinion, Ukraine has a great agricultural potential and thus an opportunity of obtaining raw materials for biofuel production: "We have figures which prove that in Ukraine biogas may be manufactured in the volumes which would allow decreasing the state's dependence on Russia by 50 % and transporting biogas to Europe using the current gas pipeline." Claude Turmes, MEP, the Group of the Greens, believes that the management bodies of the European Union could use the loans of the European Investment Bank to finance this project [1].

The need of increasing the use of renewable sources of energy is conditioned both by environmental safety of biofuel application and the exhaustion of traditionally mined fuel [2]. As Ukrainian regions differ in the availability and assortment of bioenergetic resources, it is a priority to determine economic reasonability of using these resources in Polissia region.

Perennial grasses are the most optimal ones to be introduced into the national fuel and energy complex of bioresources, as they may become a key element of bioenergetic independence of the regions of Ukrainian Polissia and promote the development of other branches of agricultural production. This selection was caused by natural conditions and resources as well as economic situation in these regions [3]. The analysis of the current status of land use demonstrated that about 40 % of agricultural fields are not used in Polissia zone now, including 1,380 thousand ha of fallows, 2,444 thousand ha of natural fodder land which are not used in the full scope due to the absence of animal breeding. In addition, pursuant to the program of promoting the development of animal breeding, the zone should envisage growing perennial grasses in the area of 115 thousand ha. It proves potential possibilities of developing the bioenergetic industry without considerable energy expenses to grow the biomaterial.

The advantages of this variant are high performance of perennial cereal crops, which excel annual plants in terms of performance of dry biomass, efficiency of accumulating solar energy, environmental safety and economy of technologies of growing. It should be noted that the crops, the biomass cultivation of which requires less energy consumption, will be more attractive for agricultural producers [4]. The technologies of growing perennial grasses meet these main requirements. Thus, we suggest expanding the area for the latter in Polissia zone by introducing them into current crop rotations and using the no longer utilized low fertility land in Polissia for further complex application as a source of renewable energy for fodder and other purposes [5]. In its turn, the expansion of the area of sowing perennial grasses will promote the restoration of animal breeding in the zone, while the use of biofuel as alternative energy will promote the reduction of the cost of animal breeding products. However, it should be noted that the development of biogas production in this zone will also have a positive effect on the plant growing industry due to the production of alternative organic fertilizers. All the abovementioned proves the urgency of this matter.

Materials and Methods. The study was conducted in 2011–2015 at the experimental field of the Institute of Agriculture of Polissia, NAAS, which has turf-medium podzolic sandy soil with the following agrochemical indices: humus content – 1.28 % (according to Turin), labile phosphorus – 69, exchange potassium – 107 mg/100 g (according to Kirsanov), total of absorbed alkali – 2.2-2.24 mg.-equiv/100 g (method of Kappen-Hilkovitz), pH saline – 5.4 (potentiometrically).

The object of studies was the processes of forming biological potential of high stem traditional and non-traditional crops as sources of renewable energy. The empirical determination of biogas input was performed according to calculations, suggested by Pavlisky V.M. and Nahirny Yu.P. [6]. The estimated biogas input was determined according to the ratio:

where V_T – estimated biogas input, m^3/kg; E_T – estimated biomass energy, Mjoule/kg, which is determined

$$V_T = \frac{E_T}{g_{bg}};$$

by its chemical composition using the formula:

BE = 0.02338*P + 0.0397*F + 0.0188*A + 0.0175*NES

where P – protein content, g in 1 kg; F – fat content, g in 1 kg; A – ash content, g in 1 kg; NES – content of nitrogen-free extractive substances, determined by calculations, g in 1 kg. g_{bg} – heat-forming capability of biogas, which equals 21 Mjoule/m^3.

The lignification coefficient was found using the formula:

$$C_l = 1 - \frac{3.296}{E_T};$$

where 3.296 Mjoule – reduction in estimated methanogenic energy of 1 kg of dry biomass.

The estimated methanogenic energy of 1 kg of dry mass was found using the formula:

$$E_M = E_T \times C_b \times C_l, \text{ Mjoule/kg},$$

where C_b – coefficient of reducing the biogas input due to ensuring the viability of microorganisms in the process of anaerobic fermentation of the substrate, which is taken as 0.93; C_l – lignification coefficient.

The possible input of biogas:

$$V_p = \frac{E_M}{g_{bg}} = \frac{E_T \times C_l \times C_b}{g_{bg}}, \text{ m}^3\text{/kg}$$

V_p – possible input of biogas.

The actual energy, transformed into biogas energy (via exchange energy), was found using the formula:

$$E_a = \frac{OE}{0.82}, \text{ Mjoule/kg}$$

where E_E – exchange energy, Mjoule/kg using the formula:

E_E= 17.46*Pp+31.23*Pf+13.65*Pc+14.78*PNES.

The actual input of biogas from 1 kg was found using the formula:

$$V_a = \frac{E_a}{g_{bg}} = \frac{OE}{0.82 \times g_{bg}}, \text{ m}^3\text{/kg}$$

The content of methane in biogas is accepted as 0.505 %.

C_b – coefficient of breakdown during fermentation, according to the ratio:

$$C_b = \frac{E_M}{E_m}$$

C_{bae} – coefficient of energy breakdown, the actual to estimated one:

$$C_{bae} = \frac{E_a}{E_T}$$

C_{bam} – coefficient of energy breakdown, the actual to methanogenic one;

$$C_{bam} = \frac{E_a}{E_m} \times 0.75$$

The relative input of gas from one area unit was found using the formula:

$$V_{as} = V_a \times Y_i$$

where Y_i – crop input from one area unit.

The method of fermenting the organic matter obtained from vegetative sources was used according to the standard of organization of the Housing and Utilities Sector 10.09-014:2010 "Household wastes. Technology of processing the organic matter which is a component of household wastes." [7] The content of the main nutrients was determined in organic fertilizers: total nitrogen, total phosphorus, total calcium.

The agrotechnology of growing crops is common for Polissia conditions.

RESULTS OF INVESTIGATIONS

One of the ways of using the potential of low fertility turf-podzolic soils, taken out of utilization patterns, is the cultivation of multicut perennial crops with the purpose of their complex use (seeds, fodder, biogas). Practically all the biomass is used in this case. The main task of growing agricultural crops for energetic purposes is obtaining the maximal amount of biomass with minimal expenses.

The selection of energy-efficient plants for Polissia conditions and the rational technologies of their cultivation involved the study of the performance formation for minor (*Sida hermaphrodita Rusby*, *Silphium perfoliatum L.*, *Galega orientalis L.*) and traditional perennial cereal grasses for the zone.

The performance analysis of different vegetative sources demonstrated that in annual total the performance of perennial cereal grasses is 11.2-27.0 t/ha of green or 4.6-11.7 t/ha of dry mass, that of non-traditional crops – 15.3-100.0 and 5.5-25.8 t/ha respectively (Table 1).

If perennial cereal grasses are used for seeds, their vegetative mass is formed in two stages during the vegetation period. The first one is at the end of June - at the beginning of July, during the period after thrashing of grasses. Thus, after thrashing the seeds, perennial cereal grasses ensure the input of renewable vegetative mass at the level of 6.5–16.5 t/ha or 2.6–6.8 t/ha, when calculated as dry substance, depending on fertilizers. The largest weight of 15.3 and 16.5 t/ha of green mass or 5.9–6.8 t/ha of dry mass was ensured by *Bromus inermis* and *Elytrigia repens* in the variants of introducing the fertilizers according to the norm of $N_{90+30}P_{60}K_{90}$. The second stage (after-grass) takes place in the third decade of October – the first decade of November, when the input of green vegetative mass is formed at the level of 3.9–11.3 t/ha or 2.3–4.9 t/ha, when calculated as dry substance, depending on fertilizers. While harvesting the after-grass the input of vegetative mass was remarkable for *Phalaris arundinacea* and *Elytrigia repens* with the parameters of 11.3 and 10.5 t/ha of green mass or 4.6 and 4.9 t/ha of dry mass while fertilizing according to the norm of $N_{90+30}P_{60}K_{90}$. In total for a year, the most productive ones were also *Phalaris arundinacea* and *Elytrigia repens* with 27 and 25.9 t/ha of green mass or 11.7 and 10.3 t/ha of dry mass while fertilizing with $N_{90+30}P_{60}K_{90}$.

In Polissia conditions, non-traditional perennial crops are also capable of ensuring two scythings of the vegetative mass and providing for the input of the renewable biomass at the level of 15–100 t/ha of green mass or 5.5–25.6 t/ha of dry mass annually, depending on the fertilizers. During the first scything (the end of June – the beginning of August), their input is at the level of 10.8–82.0 t/ha of green mass or 4.1–20.0 t/ha of dry mass. During the second scything (November), the figures are 4.5–18.0 and 1.4–5.6 t/ha respectively. The highest input was obtained from *Silphium perfoliatum L.*, with the input of the vegetative mass of 53.8–82.0 t/ha for the first scything or 12.8–20.1 t/ha of dry mass during the first scything, and 13.9–18.0 and 4.0–5.6 t/ha during the second one respectively, depending on the fertilizers.

The optimal crop for energetic purposes is the one, containing more dry substance. According to our data, the estimated input of biogas from 1 kg of mass is in close correlation (r=1.0) with the content of dry substance in 1 kg of dry mass. Perennial cereal grasses during late harvesting contain the maximal amount of dry substance. In our experiment, the first scything was conducted in the phase of cereal grasses ripening for seeds, the after-grass was collected in November, thus the content of dry substance was found to be maximal, ranging as 32.9–46.3 % and 32.2–52.1 % in the vegetative mass (Table 1). The non-traditional crops had the content of 18.4–36.7 % and 25.4–40.4 % respectively.

The chemical analysis revealed that the heat energy of organic dry mass in the vegetative mass of cereal grasses and non-traditional crops is at the level of 17.82–18.52 Mjoule/kg and 17.31–18.03 Mjoule/kg (Table 2). The lowest amount of heat energy of organic dry substance – 17.31-17.70 Mjoule/kg – regardless of the period of harvesting, was established for *Silphium perfoliatum L.*, and the highest ones of 18.52 and 18.28

Table 1. The specificities of forming the vegetative mass of agricultural crops, t/ha, average for 2011–2015

Crops	Fertilization variant	First scything			Second scything			Total for a year	
		Green mass	Content of dry substance, %	Dry mass	Green mass	Content of dry substance, %	Dry mass	Green mass	Dry mass
Sida hermaphrodita Rusby	1	10.8	36.7	4.09	4.5	31.4	1.4	15.3	5.5
	2	13.5	32.6	4.90	6.3	28.9	1.8	19.8	6.7
	3	15.6	29.2	5.23	7.3	30.9	1.9	23.0	7.1
LSD_{05}				0.45			0.15		
Silphium perfoliatum L.	1	53.8	22.8	12.79	13.9	25.4	4.0	67.7	16.8
	2	63.5	18.4	15.08	16.3	32.1	5.5	79.8	20.6
	3	82.0	21.1	20.21	18.0	31.2	5.6	100.0	25.8
LSD_{05}				1.67			0.98		
Galega orientalis L.	1	19.0	31.5	5.11	7.8	38.9	4.7	26.8	9.8
	2	23.0	28.7	6.04	9.5	40.4	3.7	32.5	9.7
	3	24.5	29.1	6.61	12.2	38.6	3.8	36.7	10.4
LSD_{05}				0.25			0.11		
Festuca arundinacea Schreb.	1	6.5	39.1	2.57	4.6	34.6	2.0	11.2	4.6
	2	12.7	39.4	5.04	6.6	32.2	2.3	19.4	7.4
	3	13.4	34.9	5.03	8.6	35.4	3.2	22.0	8.3
LSD_{05}				0.65			0.35		
Dactylis glomerata	1	8.4	37.6	3.22	5.3	43.6	1.9	13.6	5.1
	2	11.7	35.1	4.17	5.7	41.7	2.5	17.3	6.7
	3	13.6	32.9	4.53	6.3	40.4	2.5	19.9	7.0
HIP_{05}				0.68			0.57		
Phalaris arundinacea	1	10.8	46.3	4.71	4.8	52.1	2.9	15.6	7.6
	2	14.9	42.0	6.13	6.9	47.6	3.5	21.8	9.6
	3	16.5	40.0	6.83	10.5	49.4	4.9	27.0	11.7
HIP_{05}				1.02			0.54		
Phleum pratense	1	8.1	40.5	3.17	3.9	50.5	2.3	12.0	5.4
	2	9.1	38.5	3.59	5.6	49.2	3.1	14.7	6.6
	3	11.1	40.8	4.56	6.1	49.8	4.1	17.2	8.7
LSD_{05}				0.37			0.46		
Elytrigia repens	1	9.1	39.9	3.73	8.0	45.4	2.8	17.1	6.5
	2	12.3	36.8	4.94	8.8	44.8	3.0	21.1	8.0
	3	14.6	36.2	5.69	11.3	44.4	4.6	25.9	10.3
LSD_{05}				0.88			0.43		
Bromus inermis	1	10.0	36.2	3.54	5.1	43.8	3.2	15.1	6.7
	2	11.5	37.1	4.23	6.5	42.8	3.5	18.1	7.8
	3	15.3	39.6	5.87	8.5	41.1	4.7	23.9	10.6
LSD_{05}				0.23			0.34		

Note: 1 – Control; 2 $N_{30}P_{60}K_{90}$; 3 $N_{90+30}P_{60}K_{90}$

Mjoule/kg respectively – for *Phleum pratense* and *Elytrigia repens*. The estimated input of biogas via the heat energy of organic substance from the biomass of perennial cereal grasses after thrashing is from 0.870 to 0.905 m^3/kg, that of non-traditional perennial grasses – 0.843–0.879 m^3/kg. Thus, the estimated content of methane is almost a half from the abovementioned, namely 0.426–0.457 and 0.426–0.444 m^3/kg.

In case of anaerobic fermentation, only 90–93 % of energy potential of substrates may be transformed into

Table 2. The estimation of heat and methanogenic energy of perennial crops, on average in 2011–2015 in total for two scythings

Crop	Fertilization variant	Estimated values			Attainable values			Actual values		
		heat energy of crops Eh, Mjoule/kg	biogas input Vb, m^3/kg	methane input Vmt, m^3/kg	methanogenic energy of 1 kg of dry mass, Em, Mjoule/kg	biogas Va, m^3/kg	methane Va, m^3/kg	heat energy, transformed into biogas Ef, Mjoule/kg	biogas Va, m^3/kg	methane Va, m^3/kg
Sida hermaphrodita Rusby	1	18.03	0.879	0.444	13.45	0.641	0.324	10.04	0.478	0.241
	2	17.92	0.872	0.440	13.35	0.636	0.321	10.12	0.482	0.243
	3	17.99	0.873	0.441	13.42	0.639	0.323	10.23	0.487	0246
Silphium perfoliatum L.	1	17.31	0.845	0.427	12.78	0.609	0.307	9.63	0.459	0.232
	2	17.71	0.844	0.426	12.85	0.612	0.309	9.61	0.458	0.231
	3	17.70	0.843	0.426	12.84	0.611	0.309	9.77	0.465	0.235
Galega orientalis L.	1	17.9	0.871	0.440	13.33	0.635	0.321	12.26	0.584	0.295
	2	18.01	0.876	0.442	13.44	0.640	0.323	12.52	0.596	0.301
	3	17.9	0.872	0.441	13.33	0.635	0.321	12.05	0.574	0.301
Festuca arundinacea Schreb.	1	18.03	0.884	0.426	13.45	0.641	0.324	10.09	0.480	0.243
	2	18.09	0.883	0.446	13.51	0.640	0.323	10.10	0.481	0.243
	3	17.99	0.879	0.444	13.44	0.643	0.325	9.93	0.473	0.239
Dactylis glomerata	1	18.09	0.884	0.447	13.51	0.643	0.325	9.88	0.477	0.241
	2	18.11	0.883	0.446	13.53	0.644	0.326	9.88	0.470	0.238
	3	18.09	0.883	0.446	13.51	0.643	0.325	9.85	0.469	0.237
Phalaris arundinacea	1	18.24	0.893	0.451	13.65	0.650	0.328	10.02	0477	0.241
	2	18.28	0.893	0.451	13.69	0.652	0.328	10.16	0.484	0.244
	3	18.13	0.885	0.447	13.55	0.645	0.326	10.20	0.485	0.245
Phleum pratense	1	18.52	0.905	0.457	13.91	0.662	0.334	10.27	0.489	0.247
	2	18.12	0.884	0.446	13.91	0.645	0.326	10.18	0.485	0.245
	3	18.52	0.891	0.450	13.72	0.653	0.330	10.21	0.486	0.245
Bromus inermis	1	18.07	0.884	0.446	13.58	0.647	0.327	9.98	0.475	0.240
	2	17.90	0.875	0.442	13.33	0.635	0.321	9.90	0.472	0.238
	3	17.82	0.873	0.441	13.26	0.631	0.319	9.76	0.465	0.235
Elytrigia repens	1	18.05	0.881	0.445	13.47	0.642	0.324	9.98	0.475	0.240
	2	18.13	0.885	0.447	13.55	0.645	0.326	10.02	0.477	0.241
	3	17.82	0.870	0.439	13.26	0.631	0.319	9.95	0.474	0.239

Note: 1 – Control; 2 – $N_{30}P_{60}K_{90}$; 3 – $N_{90+30}P_{60}K_{90}$

the biogas energy, which is related to spending the energy to ensure the viability of microorganisms and performing the bioconversion of organic substances into biogas. In addition, it should be noted that lignin is not broken down by microorganisms thus it passes into sludge. The average value of lignin content in the chemical composition of perennial grasses is 11.8 % in 1 kg of dry substance, and that of less common ones – at the level of 3.12–3.78 %. Therefore, the estimated methanogenic energy E_m of 1 kg of dry substance of crops decreases by 3.296 Mjoule and is determined by the coefficient of lignification, which, in our case, is 0.688–0.811 depending on the species of grasses.

Taking into consideration the coefficients of C_b (the decrease in the input of biogas, related to ensuring the viability of microorganisms) and C_l (lignification coefficient) the estimated methanogenic energy in 1 kg of dry mass of these crops is from 12.78 to 13.91 Mjoule/kg which is 72.3–75.3 % from the estimated heat energy. Therefore, the attainable input of biogas is: for cereal grasses − 0.631–0.662 m^3/kg, methane (50 %) 0.319–0.334 m^3/kg, for non-traditional ones − 0.609–0.641 m^3/kg, methane (50 %) 0.309–0.324 m^3/kg. The coefficient of breakdown for biomass of crops corresponds to 0.72–0.73 %. The actual input of biogas from 1 kg of dry mass of crops is much lower than the attainable one due to lignin blocking the access of microorganisms and enzymes to the nutritional medium, being for cereal grasses − 9.76–10.27 Mjoule/kg, for non-traditional ones − 9.61–12.52 Mjoule/kg, which is 32–47 % less than the content of heat energy of organic dry substance. Thus, the actual input of biogas from 1 kg of organic dry substance is for cereal grasses − 0.465–0.489 m^3/kg (0.237–0.245 m^3/kg of methane), for non-traditional crops – 0.459–0.596 m^3/kg (0.231–0.301 m^3/kg of methane). The highest actual amount of energy – 12.52 Mjoule/kg, the biogas input – 0.596 and that of methane – 0.301 m^3/kg was noted for *Galega orientalis L.* with fertilization using $N_{90+30}P_{60}K_{90}$. Similar indices were lower for *Silphium perfoliatum L.* – 9.61 Mjoule/kg, 0.458 and 0.231 m^3/kg respectively. This is explained with different amounts of lignin in the chemical composition: it is 4.2–5.17 % for *Galega orientalis L.* and 10–11 % for *Silphium perfoliatum L.* The results of estimating the actual energy demonstrate that its share, which is transformed into the energy of biogas, is 53.0–68.1 % from the estimated heat energy and 72.94–93.21 % from the estimated methanogenic energy.

The complete evaluation of vegetative renewable sources using perennial grasses involved the estimation of their energy potential based on an area unit (1 ha). The evaluation of crops was conducted using the criteria of their energy efficiency and performance based on one hectare.

75 % from the total input of biomass may be used as material for processing perennial grasses into biogas in methane-tanks. The vegetative mass of high stem non-traditional perennial fodder crops may be used completely.

Therefore, perennial cereal crops ensure the input of estimated energy out of one hectare, which is transformed into biogas, in the total amount for two scythings per year, 30,039–77,236 Mjoule/kg (Table 3). Non-traditional perennial crops are capable of ensuring the average input of energy for two scythings per year at the level of 48,276–196,074 Mjoule/kg.

Perennial cereal crops ensure the actual input of biogas from one hectare, total for two scythings per year, at the level of 1,430–3,679 m^3/ha, methane − 722–1,857 m^3/ha. The following indices were registered for non-traditional crops: biogas – 2,299–9,337 m^3/ha, methane – 1,161–4,715 m^3/ha.

The highest input of heat energy, biogas, and methane, on average for five years, in Polissia conditions is ensured by *Phalaris arundinacea* using the fertilization system $N_{90+30}P_{60}K_{90}$. For instance, the energy input for this crop is 77,236 Mjoule/kg, that of biogas − 3,678 m^3/ha, biomethane − 1,857 m^3/ha

Among the non-traditional crops the maximal input of energy in the amount of 196,074 Mjoule/kg and that of biogas – 9,337 m^3/ha (that of methane – 4,715 m^3/ha), both in scythings and total for the year, was ensured by *Silphium perfoliatum* L. with the fertilization using $N_{90+30}P_{60}K_{90}$. However, while selecting this crop, one should take into consideration that it has the lowest production effectiveness of cultivation among the presented crops due to high prices for seeds, the complexity of obtaining the robust grass during the first year of life. Thus, while planning the fields for obtaining the vegetative mass using perennial grasses, it would be wise to prefer cereal grasses, which compensate the expenses for their cultivation due to harvesting the seeds (as of 2015, the expenses for starting the grasses were UAH 9.5 thousand/ha, annual expenses to maintain the grasses were UAH 1.2 thousand/ha, the cost of the main harvest of seeds was UAH 30–75 thousand/t).

Table 3. The specific input of energy and biogas from one hectare while cultivating perennial crops, average for 2011–2015

Crop	Fertilization variant	The input from one unit of area		
		actual heat energy, transformed into biogas, E_a, Mjoule	biogas V_a, m^3	methane V_a, m^3
Sida hermaphrodita Rusby	1	48276	2299	1161
	2	58986	2809	1418
	3	64357	3065	1548
Silphium perfoliatum L.	1	127436	6068	3065
	2	156447	7450	3762
	3	196074	9337	4715
Festuca arundinacea Schreb.	1	30039	1430	722
	2	48382	2304	1163
	3	53349	2540	1283
Dactylis glomerata	1	32620	1574	795
	2	42853	2041	1031
	3	45300	2157	1089
Phalaris arundinacea	1	49330	2349	1186
	2	63145	3007	1518
	3	77236	3678	1857
Phleum pratense	1	35903	1710	863
	2	35903	2072	1046
	3	57500	2738	1383
Bromus inermis	1	43277	2061	1041
	2	50012	2382	1203
	3	66961	3189	1610
Elytrigia repens	1	41985	1999	1010
	2	51926	2473	1249
	3	66367	3160	1596
Galega orientalis L.	1	77771	3703	1870
	2	78663	3746	1892
	3	81136	3864	1951

Note: 1 – Control; 2 – $N_{30}P_{60}K_{90}$; 3 – $N_{90+30}P_{60}K_{90}$

Taking into consideration the current situation with the amount of organic fertilizers, introduced into one hectare of ploughed soil (calculated per underlayer manure) of 0.5 t/ha, and the fact that in some cases only by-products are left in the field or green manure crops are sown (in early 1990s 8–10 t/ha were introduced per one hectare of ploughed soil or crop rotation field), there is a need to search for alternative organic fertilizers, which may be eluents (products of fermentation of methane tanks). To solve the problem of deficiency of organic fertilizers and reduction in the energetic burden of technologies of growing agricultural crops in Polissia, there was a study of agrochemical composition of the processed substrate.

It was established that during anaerobic fermentation, with the duration of biomass fermentation for ten days, the content of nitrogen in the remains was 0.49–2.58; that of phosphorus – 0.14–1.98, calcium – 0.38–2.64 %, depending on the crop. The increase in the content of nitrogen in the substrate by 55–45 %, regardless of a crop, was registered for fermentation for twenty days. There was no stable increase in the content of phosphorus and potassium in the remains in any crops. Therefore, when the processed substrate of crops is introduced, one ton of organic mass will enrich the soil with 4.9 to 48.9 kg of nitrogen, 1.4–6.7 kg of phosphorus, and 3.3–25 kg of potassium, which will add nutrients to the soil and improve its aqueous and physical properties.

CONCLUSIONS

The vegetative mass of seeds of perennial grasses may be used as vegetative fillers of methane tanks in Polissia, as they are capable of providing the vegetative mass at the level of 4.6–11.7 t/ha from perennial cereal grasses and 5.5–25.8 t/ha from non-traditional perennial crops, ensuring the corresponding input of biomethane of 722–1,857 m^3/ha and 1,161–4,715 m^3/ha a year. The processed substrate from methane tanks was used as alternative organic fertilizer, which had high content of nutrients, including nitrogen 0.49–2.58; phosphorus – 0.14–1.98, calcium – 0.38–2.64 %.

Альтернативні джерела вегетативної маси для біопалива в зоні Полісся

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Мета. Визначення оптимальних вегетативних біоресурсів у зоні Полісся для впровадження у вітчизняний зелений паливно-енергетичний комплекс. **Методи.** Польові, лабораторні, математичні. **Результати.** За результатами досліджень проведено оцінку біосировини з врахуванням її біохімічних властивостей та технологічності вирощування. Встановлено, що багаторічні культури здатні щорічно забезпечити надходження відновлюваної біомаси на рівні 4,6–11,7 т/га від злакових трав і 5,5–25,8 т/га від нетрадиційних, відповідно вихід біометану – 722–1857 $м^3$/га та 1161–4715 $м^3$/га на рік. Визначено вміст корисних речовин переробленого субстрату: N – 0,49–2,58 %, P_2O_5 – 0,14–1,98 %, K_2O – 0,38–2,64 %. **Висновки.** Таким чином, в якості вегетативних наповнювачів метантенків в зоні Полісся можна використовувати вегетативну масу насінників багаторічних трав поряд з іншими поновлюваними джерелами.

Ключові слова: багаторічні культури, вегетативні джерела, відновлювана енергія, біогаз, продуктивність

Альтернативные источники вегетативной массы для биотоплива в зоне Полесья

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Цели. Определение оптимальных вегетативных биоресурсов в зоне Полесья для внедрения в отечественный зеленый топливно-энергетический комплекс. **Методы.** Полевые, лабораторные, математические. **Результаты.** По результатам исследований проведена оценка биосырья с учетом ее биохимических свойств и технологичности выращивания. Установлено, что многолетние культуры способны ежегодно обеспечить поступление возобновляемой биомассы на уровне 4,6–11,7 т/га от злаковых трав и 5,5–25,8 т/га от нетрадиционных, соответственно выход биометана 722–1857 $м^3$/га и 1161–4715 м3/га в год. Определено содержание полезных веществ переработанного субстрата: N – 0,49–2,58 %, P_2O_5 – 0,14-1,98 %, K_2O – 0,38-2,64 %. **Выводы.** Таким образом, в качестве вегетативных наполнителей метантенков в зоне Полесья можно использовать вегетативную массу семенников многолетних трав наряду с другими возобновляемыми источниками.

Ключевые слова: многолетние культуры, вегетативные источники, возобновляемая энергия, биогаз, продуктивность

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