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Features of growing miscánthus large on sewed organogenic soils of left-bank forest-steppe

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The purpose. To determine productivity of Misc nthus large depending on elements of technique of growing, to analyze their influence on growth and development of plants, to determine economic efficiency of growing crop in conditions of the sewed peat soils of Left-bank Forest-steppe of Ukraine. **Methods**. Field, laboratory, analytical, calculation-comparative, mathematical-statistical. **Results.** Influence of elements of technique of growing Misc nthus large on its productivity in conditions of sewed peat soils of Left-bank Forest-steppe of Ukraine is probed. Results of probes of influence of time of sowing, seed spacing, mass of rhizomes and depths of their ploughing, fertilizing, measures on struggle against weeds and pests on productivity and economic efficiency of growing crop are brought. It is established that the given technique for 3-rd year of growing Misc nthus ensures a yield of dry biomass at the level of 23.7 – 26.1 t / hectare, or 403 – 444 GJ / hectare of energy. **Conclusions.** Technique is developed and justified of growing Misc nthus large for the power purposes on calcareous peat bogs of Left-bank Forest-steppe which consists in importation of fertilizers into dose of K60, planting rhizomes at density 0.7 1.4 m (10 thousand pieces/ hectare) and their mass 50–70 g. Application of agrotechnical in aggregate with biological method of struggle against wireworm ensures effective protection of plants of Misc nthus at backfilling power plantations. The designed technique for years of probes has ensured an exit of dry biomass at the level of 44.5 t / hectare, or 756 GJ / hectare of thermal energy, at 13157 hrn / hectare of conditionally net profit, cost prices of 529,6 hrn / hectare and profitableness of 56%. The designed technique of growing Misc nthus large for long-term use (20–25 years) with deriving raw material for production of solid fuel can be used by farms and state factories which have sewed soils in land use.

Key words: *Misc nthus, mass of rhizome, plant stand, fertilizers, productivity, profitableness*.
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For today, one of the ways to solve the energy issue for Ukraine is the transition from fossil energy sources to renewable energy sources, i.e. biofuels [1, 2]. For this purpose, it is important to create own sources of renewable energy based on the cultivation of plant bioenergy raw materials extracted from intensive cultivation of lands [3, 4]. Such lands include and dried peat soils in Ukraine are estimated to be about – 1mln / ha.Old-age hayfields occupy an area of about 0,8mln / ha. They are optimally suited for growing energy crops because they are well-fed with moisture and nitrogen, which allows them to accumulate a fairly powerful biomass with moderate fertilizer application [5].

Among the wide range of high-yielding herbaceous perennials, the giant Miscanthus is a promising energy culture [2, 6].

According to preliminary researches, the miskanthus in the given conditions gives the highest among other perennial herbaceous crops 25-28 tons / ha of dry matter.

The gross output of energy per hectare (in the case of pellet burning) may be about 450 GJ / ha. Giant Miskanthus loses its dry matter at the end of the growing season, this culture is resistant to sinking. Miskanthus requires little cultivation, a crop of crops is harvested by a conventional forage harvester, and the resulting mass can be immediately fired for burning or for the production of fuel pellets, pellets or braces. At that time biomass of other energy crops usually requires pre-drying [7].

The mentioned factors prove that the giant Miscanthus is one of the most promising crops for growing it on isolated from intensive cultivation of soils [8, 9]. However, for its industrial use there is no growing technology that would be adapted to the conditions of the dried peatlands of the Left Bank Forest-steppe of Ukraine.

The purpose of research. To establish the productivity of the miscanthus depending on the elements of cultivation technology, to analyze their influence on the growth and development of plants, to analyze the economic efficiency of cultivating the culture in the conditions of the depleted peat soils of the Left Bank Forest-steppe of Ukraine.

Materials and methods of research. The research was conducted during 2016-2018 in the floodplain of the river Suvi on the site number 4 of the reclamation system of the Panfilsk research station. Soils of the experimental area are deep carbonate peatlands with total nitrogen content – 1.2%, phosphorus 07-092%, potassium – 012%, calcium – 20-26%, ash content 40–50%, pH-water – 7.2–7.5.

Field studies were performed according to “Guidelines for conducting scientific research on reclaimed land” (1984) [10].

Crop accounting was performed by continuous mowing of biomass in the plot and weighing the green mass with the determination of the content of dry matter in a threefold repetition [11].

The dry matter content was determined by the thermostat-weighted method at a temperature of 105 °C [11].

The content of thermal energy (MJ / ha) of dry matter of biomass was determined according to the methodology of the Derzhspozhyvstandart of Ukraine [12].

The nutrient regime of the soil was determined in a layer 0-30 cm, by sampling the soil samples in the experimental areas of the miskantus two times – at the beginning and end of the vegetation of cultures [10].

In soil samples, nitric nitrogen content was determined in a well-mineralized carbonate soil (Supii River flood plain) by potentiometric method (DSTU 4725-2007), ammonium nitrogen by extraction of potassium chloride solution (DSTU ISO / TS 14256-1: 2003), phosphorus and potassium for B P Machigin, followed by the definition of mobile phosphorus colorimetrically, and exchangeable potassium - on a flaming photometer [11]. Record of bullying in the experiment was carried out according to the method of VI Artemenko [13]. Establishing the number of wires and their harmfulness was carried out according to the method of VG Valley [14]. The mathematical processing of the experimental data obtained in the experiment was carried out by the method of dispersion analysis [15].

To ensure the greatest energy efficiency of the mescanthus, we used the following technology of its cultivation. On the square where the research will be conducted, in the autumn, milling is carried out on 10-12 cm. a layer of perennial grasses with subsequent plowing on 25-30 cm. In the spring of next year, on this square, a two-wheel drive, disk harrows BDT-3 is carried out. Under the last debate, fertilizers are introduced. Then it is carried out before and after sowing with heavy swamps.

In the experiment, we studied 2 methods of combating storms – agrotechnical, which includes – holding of the harvesting of harrowing with light harrows and two-way, and if necessary, three-way inter-row treatment and chemical way – the introduction of recommended herbicides for vegetation of plants.

When placement of a giant miscanthus after many years of cereal grass was used developed for these conditions, agrotechnical in conjunction with the biological method of controlling the wire [16].

Fertilizers were introduced from the calculation (kg / ha) – 1 option – 0; Option 2 – K2O-60; option 3 – K2O-120; Density of landing of the miskanthus parts of rhizomes (rhizomes) 1var. – 07 x 0,55 m (25 psi.st.g); 2 var. – 07 x 07 m (20 pcs. Hp); 3 var. – 07 x 09 m (15 pcs.Hp); 4 var. – 07 x 1.4m (10ft.st.yy). Distributed rhizomes (rhizomes) that are prepared for breeding should have at least 3-4 kidneys.

We studied the influence of the depth of wrapping and the mass of rhizomes of the mescanthus on its performance: the depth of wrapping – 4-6 cm, 6-8 cm, 8-12 cm, the weight of the rhizomes – 20-30 grams, 30-50 grams; 50-70 g.

The lines of the giant miscanthus:

Option 1 – Autumn (3decade of November)

Option 2 – spring (1 decade of April)

The trials were repeated three times.

Research results. For conducting preliminary studies it was established that in the first year of growing the miskanthus the main problems were the struggle with weeds and wires.

To fight the wand, which for the first year of its cultivation in the conditions of dehydrated peat because of its high density 26-40 hectares / m^2 and more that exceeds the threshold of harmfulness (5-7 bees / m^2), is the greatest threat. We have developed an ecologically safe and at the same time an effective agrotechnical combination with a biological way of controlling this pest. It includes: after perennial grasses – 2 slices sown an intermediate crop of mustard white with subsequent grinding and plowing its crops into the phase of formation and pouring of seeds. In the future, a deep plowing is carried out at a depth of 30-35 cm with the formation of ridges in the height of 14-18 cm at the transition of the average daily temperature through 0o S. This method provided for reduction of wires by 84% of the total number, and the damaged plants in the first year of vegetation did not exceed 4%.

To control weeds until the emergence of stairs, after 8-9 days after planting, the area was harvested by light harrows. After the appearance of the stairs, a two-time, and if necessary, three-way inter-row cultivation at a depth of

8-10 cm is carried out. with the simultaneous filling of the weeds in rows and planting. In the second year of the vegetation of the Miscanthus there was no need for measures to control weeds – since the plants of the miscanthus themselves could compete with the stairs of weeds.

Compliance with the necessary agrotechnical requirements in the first year of cultivating the culture, especially the implementation of effective agro measures to combat the wires and weeds, ensures the acquisition of high yields of biomass of miscanthus in subsequent years.

An important factor that ensures high productivity of the miskanthus is the nutrient regime of the soil, which is formed in the dried peatlands so that these soils are well-supplied with nitrogen due to the high content of organic matter (60-80%). Dynamics of providing mobile phosphorus for normal growth and development of plants is also sufficient due to vivianite layers in the peat field [4].

The content of nitrates in the soil in the springtime was high and was within the range of 274-365 mg / 1000 g of soil. The provision of soil with mobile phosphorus was also sufficient and fluctuated within the range of from 56.7 to 90.5 mg per 1000 g of soil.

It is known that peat soils are very poor in potassium and the main source of its replenishment is the introduction of mineral fertilizers. The content of potassium in the soil at the beginning of the vegetation of plants of the miscanthus was: on a variant without fertilizers – 104.5-131.6 mg / 1000 g of soil, which corresponded to insufficient supply; variant K60 – 202–253 mg / 1000 g of soil and variant K120 258.0–309.0 mg / 1000 g of soil, which corresponded to medium and high availability. The density of the micacentus did not have a significant effect on the dynamics of nutrients. The introduction of potassium fertilizers had a direct impact on the dynamics of linear growth of the miskanthus and the accumulation of dry matter crop.

The results of studying the influence of the investigated factors on the productivity of the miscanthus are presented in Table 1. It was determined that the determining factors in increasing the productivity of the miskanthus in the third year of vegetation were, the density of rhizomes and the introduction of mineral fertilizers with increased density.

1. The yield of the miscanthus and the energy output for 3 years of research (t / ha) 2016–2018 gg

Density of planting	Fertilizers	Yields by years of research. (green mass)				Yields by years of research. (dry substance)				Output energy in the amount of 3 years GJ / ha
landingins pring		2016	2017	2018	in total for 3 years	2016	2017	2018	in total for 3 years	
25 thousand hectares	0	5,1	40,2	50,8	96,1	1,4	17,3	19,0	37,6	640
	K_{60}	6,4	52,6	63,1	122,1	2,3	23,7	26,1	52,1	886
	K_{120}	6,8	55,3	74,1	136,2	2.4	24.1	27,4	54,0	917
20 thousand hectares	0	4,2	37,5	44,1	85,8	1,3	16,3	18,2	35,8	609
	K_{60}	5,1	47,5	59,2	111,8	2,0	21,4	23,1	46,5	791
	K_{120}	5,9	48,3	59,9	114,1	2,3	23,3	26,4	52,0	884
15 thousand hectares	0	3,9	31,4	42,0	77,3	1,3	14,3	16,6	32,2	547
	K_{60}	4,6	40,4	57,6	102,6	1,5	18,4	24,9	44,9	762
	K_{120}	5,2	41,3	73,8	120,3	1,5	21,1	26,5	49,1	835
10 thousand hectares	0	3,6	26,2	40,2	70,0	1,2	13,7	16,4	30,8	524
	K_{60}	4,4	37,9	61,5	103,8	1,4	19,3	23,7	44,5	756
	K_{120}	4,7	38,4	56,0	99,1	1,5	20,0	24,9	46,7	790

20t / ha made by herbicide	K_{60}	4,2	37,3	68,3	109,8	1,5	18,0	23,3	42,8	727
landing in autumn 25 tons / ha	K_{60}	7,3	51,8	67,9	127,0	3,1	24,4	27,1	54,6	928
HIP05		Goodbye – 2,06 According to the landing scheme – 1,78 Overall - 3.56				For fertilizers – 0,85 According to the landing scheme – 0.72 Total – 1.46				

the standing of the plants of the miskanthus, the yield of biomass also increases. So, for the density of plants standing 10 tons per ha, the output of the dry biomass when introduced to the K60 was:

23.7 t / ha or 403 GJ / ha, 25 t / ha or 26.1 t / ha or 444 GJ / ha, and during autumn planting the yield of solid biofuels and energy was 27.1 t / ha and 461 GJ / Ha. At the same time, in the third year of vegetation, as evidenced from the data given, a notable difference between the autumn and spring plantings was practically not observed.

2. The yield of dry mass of the miscanthus, depending on the depth of wrapping and the mass of rhizomes, t / ha, 2018

Deadline for planting	Depth of wrapping of rhizomes, see			Weight of rhizomes, g		
	4-6	6-8	10-12	20-30	30-50	50-70
I-autumn 3 decades November	,,--,,	,,--,,	26,41	,,--,,	25,00	,,--,,
II- Spring 2 decades April	25,60	26,74	25,00	25,86	26.36	27,37

Yield of dry hybrids of mosquitoes in the dry season increased by an increase in the height of the stand and on varieties without fertilizing. So, for the density of plants standing 10 thousand pieces / ha, the dry weight yield from 1 ha in the third year of vegetation was 16.4 tons per hectare and 25 tons per hectare for stand density 0 t / ha (Table 1).

The introduction of potassium fertilizers significantly increased the yield of the miscanthus. According to the landing schemes of 20 tons / ha in the case of non-fertilizers, the yield was 18.2 tons / ha, while the K60 – 23.1 tons / ha and K120 – 26.4 tons / ha of dry matter. Increment of the crop from the introduction of potash Fertilizer was noted on the remaining variants of the experiment.

According to the norms of K60 and K120, the yield of dry matter increased by the density of the planting of 25 ppm / ha by 7.2 and 8.5 t / ha; for landing 20 thousand tons / ha at 4.8 and 8,1 tons / ha; 15 ths. St / ha – 8.3 and 9,9t / ha; and 10 tons / ha 7.3 – 8.5 tons / ha; comparable to non-fertilizer control. On average, the yield was increased on variants with the addition of K60 at 27.1 – 29.4%, and on variants K120 respectively 30.6 – 34.1%.

The highest yield of the miscanthus in the amount of three years was obtained on the variant of autumn landing for the landing scheme of 25 ths / ha, when it was made with the addition of K60 – 54.6 tons / ha of dry matter or 929 GJ / ha of energy, respectively, at spring planting, these indicators were at the level – 52.1 t / ha of dry matter and 886 GJ /

ha of energy, according to the landing plan of 20 tons / ha respectively – 46.5 tons / ha and 791 GJ / ha; 15 tons / ha – 44.9 t / ha and 762 g / ha / ha and with the least condensation of 10 tons / ha dry biomass yields 44.5 t / ha and 756 gJ / ha energy (Table 1).

One of the important factors affecting the yield of the miscanthus is the mass of rhizomes whose increase leads to an increase in the yield of plants, both the first and second years of cultivation. So, for the masses of rhizomes 20-30g, the productivity of the dry superstrong mass of the miscanthus amounted to an average of 2.3 tons per hectare in the first year of vegetation, and a second to 19.6 tons / ha, and a mass of 50-70g, respectively, – 3.3t / ha and 23.4t /Ha.

In 2018, in the third year of growing the miscanthus, the effect of the mass of rhizomes on yield was less noticeable than in the first two years of its cultivation, and it comprised 20-30 g – 25.9 t / ha for the masses of rhizomes, and for the masses 50-70 g – 27, 4t / ha (Table 2).

The influence of the depth of the rhizomes on the yield of the miscanthus in the current year, as in the previous two years, was insignificant. On the other hand, as shown by previous studies with strong late freshener frosts on the soil surface of 5 – 70 S in the 2nd and 3rd decades of April, the effectiveness of the wrapping of rhizomes was 10–12 cm, as the negative effect of freezing on the stairs of the miskanthus at such depth was minimal.

The calculations of economic efficiency were carried out on the basis of the compilation of the technological map and at tariffs and prices as of December, Costs for the production of the miscanthus in the area of 1g, depending on the elements of cultivation technology, were taken in the amount of three years.

The cost of money together for the three years of growing the miscanthus amounted to a maximum landing density of 25 thousand tons / ha, with the introduction of K60 – 29046 UAH / ha and, respectively, with a minimum 10 thousand / ha – 23547 UAH / ha, which is primarily due to the high costs of planting material.

The first year of the cultivation of the miscanthus was unprofitable, due to its low yield – 1,4–3,1 tons / ha of dry matter (Table 1) and high costs, first of all, for planting material, as well as basic soil cultivation and agro-measures in the fight against the wand and weeds.

The calculations showed that the expenses for the first year of vegetation amounted to 77.3–80.5% of all expenditures for three years or in monetary equivalent, for example, in the variant of landing 15 thousand tons / ha with the introduction of K60 at a total cost of 24210 UAH / ha in the first year was used 18714 UAH / ha.

Among the elements of the cultivation technology of the miscanthus, which had the greatest influence on its productivity, and hence on the economic efficiency were fertilizers and methods of landing. The introduction of potassium fertilizers K60 and K120 compared with the non-fertilizer option leads to a significant increase in yields, and therefore the economic indicators also increased. So, in non-fertilizer variants, the cost of dry biomass was 611-657 UAH / t, and when introduced K60 it fluctuated depending on the variant of cultivation in the range of 530 and 557 UAH / t, while the level of profitability of cultivated products in the first case was lower and was 26, 0–35.0% in the second with the introduction of potassium fertilizers it was at the level of 48.0–56.0%. The introduction of K120 in comparison with the K60, however, led to a slight increase in yields by 1.9-4.3 tons / ha of dry matter, but economic performance due to the high cost of fertilizers did not cover costs.

3. Economic efficiency of growing giant miscanthus for the production of solid biofuels depending on the elements of cultivation technology in three years of vegetation (2016-2018)

Densityofplanting landing in spring	Fertilizers	Entrance dry biomass t / ha	Cost dry biomass UAH / ha	Maternity ally money costs UAH / ha	Cost dry biomass UAH / t	Conditionally clean profit UAH / ha	Levelrent-linen-st %
25 thousand hectares	0	37,6	31061	24723	657	6338	26,0
	K_{60}	52,1	42990	29046	557	13944	48,0
	K_{120}	54,0	44525	31935	592	13590	42,5
20 thousand hectares	0	35,8	29559	22314	623	7245	32,5

	K_{60}	46,5	38387	25311	544	13076	51,72
	K_{120}	52,0	42883	28730	553	14153	49,3
15 thousand hectares	0	32,2	26978	20044	624	6934	34,6
	K_{60}	44,9	37018	24210	539	12808	52,9
	K_{120}	49,1	40549	26926	548	13593	50,5
10 thousand hectares	0	30,8	25435	18837	611	6598	35,0
	K_{60}	44,5	36704	23547	530	13157	56,0
	K_{120}	46,7	38511	25320	542	12991	51,3
20t / ha made by herbicide	K_{60}	42,8	35326	25964	606	9362	36,1
landing in autumn 25 thousand hectares	K_{60}	54,6	45070	31850	583	13220	41,5

So the profitability in the variant with the introduction of K60 was 48.0–56.0%, and in the variant K120 – 42.5–51.3% (Table 4).

The analysis of the economic efficiency of the production of the Miscanthus showed that, with different planting methods, the cost of cultivated products and the level of profitability were the same, while planting 25 thousand hectares per hectare, when K60 was introduced, the production cost was at the level of 557 UAH / t and the profitability was 48.0%, with landing 20 tons / ha respectively – 544 UAH / ha – 51,72% at landing 15 thousand / ha – 539 UAH / ha – 53,95% and when landing 10 thousand / ha these indicators were at 530 UAH / ha and 56.0% (Table 4).

Thus, as can be seen from the table, the economic growth rates of the miscanthus in the first three years were not high, which is due in the first place to significant costs in the first year of its cultivation and a low yield. However, in subsequent years, the cost of growing sharply reduced, they will be only in the introduction of fertilizers in spring and harvesting and transportation of grown products in the autumn-winter period. The costs will be (in 2018 prices) within the limits of 3740-4300 UAH / ha, and the yield is expected at the level of 25-28 t / ha of dry biomass.

Conclusions

The technology of cultivating giant miscanthus for energy purposes in carbonate peatlands of the Left Bank Forest-steppe, which consists in introducing mineral fertilizers in a dose of K60, is based on the planting of rhizomes at a density of 0.7 x 1.4 m (10 ths / ha) and their mass 50-70 g.

The use of agrotechnical in combination with the biological method of controlling the wire provides effective protection of plants of the miskanthus at the beginning of the creation of energy plantations.

The developed technology during the years of research provided the output of dry mass at the level of 44.5t / ha or 756GJ / ha of thermal energy, for 13157 UAH / ha of conditional net profit at a cost of 529.6 UAH / ha and profitability of 56%.

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