

TECHNOLOGY FOR TWO SWITCHGRASS MORPHOTYPES GROWING IN THE CONDITIONS OF UKRAINE'S FOREST STEPPE ZONE

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ТЕХНОЛОГІЯ ВИРОЩУВАННЯ ДВОХ МОРФОТИПІВ СВІТЧГРАСУ В УМОВАХ ЛІСОСТЕПОВОЇ ЗОНИ УКРАЇНИ

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ABSTRACT

Different quality adaptive reactions of the "Cave-in-rock" and "Morozko" varieties were found in terms of productivity parameters depending on the method of sowing seeds, the presence of a marker crop and the conditions of vegetation periods. The highest yield of switchgrass for both varieties was for the second and third terms of sowing (first and second decades of May). The method of sowing switchgrass seeds with a row spacing of 45 cm with white mustard as marker crop must be used for effective weed control. Ukrainian variety "Morozko" is a more adapted variety for the conditions of the forest-Steppe of Ukraine.

РЕЗЮМЕ

Різні якісні адаптивні реакції сортів "Cave-in-rock" та "Морозко" виявлено за показниками продуктивності залежно від способу посіву насіння, наявності маркерної культури та періодів вегетації. Найбільша врожайність світчграсу обох сортів була на другий і третій терміни посіву (перша і друга декади травня). Для ефективної боротьби з бур'янами необхідно використовувати спосіб посіву насіння світчграсу з міжряддям 45 см з використанням білої гірчиці у якості маркерної культури. Український сорт "Морозко" є більш пристосованим сортом для умов Лісостепу України.

INTRODUCTION

The soil and climatic conditions in the main regions of Ukraine are favourable for energy crops cultivation with high level of biomass energy accumulation (Kvak et al., 2018). Switchgrass is a perennial plant similar to a shrub grass, which is propagated by both seeds and rhizomes. This crop uses C4 carbon fixation and has a high capacity to utilize nitrogen and water (Zhang et al., 2017). The advantages of Switchgrass are: little need for the use of pesticides, promoting the preservation of natural conditions and improving the quality of the soil (Rushing et al, 2013). The crop is resistant to diseases and pests, has a low cost and low risks of cultivation, requires little investment, gives high yields of biomass even on low-productive lands (Smeets et al, 2009). Switchgrass requires minimal management, and has a large potential to sequester carbon underground (Hartman et al, 2011). In the last decade, Switchgrass has been considered to be a "model biofuel" crop because of its ability to produce large quantities of biomass on marginal soils (Scaglione et al, 2015). Numerous cultivars of switchgrass (*Panicum virgatum* L.) have been assessed in terms of yield potential and adaptability in diverse environments, in different countries. Upland ('Cave-in-Rock' and 'Shelter') and lowland ('Alamo' and 'Kanlow') cultivars were harvested for 3 year under one- or two-cut management at eight sites in the USA (Fike et al, 2006; Cherney et al., 2018). Upland cultivars yielded more on average with two harvests rather than one. Lowland varieties grow better in deep moist soils, while upland varieties tend to be better adapted to thinner soils and drier sites (Parrish and Fike, 2005). The highest yield, obtained with Cave-in-Rock during the third year, was 9.2 t/ha (Marra et al., 2013). Cave-in-Rock and Nebraska 28 had the highest photosynthesis rate. At the same time Nebraska 28 and Pathfinder varieties shown strong drought tolerance (Ma et al, 2011).

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General opinion is that Cave-in-Rock variety and other upland cultivars with a high chromosome ploidy might be optimal choices for biomass plants. Field experiments with two US varieties from the Elsberry Plant Materials Centre conducted in Ukraine last decade gave possibility to select locally adapted Switchgrass varieties (Kulik, 2016). Yield of variety Cave-in-Rock in the fifth vegetation year with row-spacing of 45 cm was higher on 1.0 t/ha (10.0%) comparatively with width of 30 cm. Sanburst variety had increase of yield according to row-spacing on 1.2 t/ha (9.4%) and 0.1 t/ha (0.8%). The greatest difficulty in switchgrass growing technology is the increased sensitivity of plants to the conditions of life support in the first year of vegetation. The highest switchgrass yield of dry biomass and the energy output was provided in our earlier conducted field experiments in options with marker crop sowing and the inter-row space width of 30 and 45 cm (Gumentyk and Kharytonov, 2018). The main goal of this research was to develop a technology for two switchgrass varieties growing by establishing the optimal terms and methods of sowing and caring for plants during the first year of vegetation.

MATERIALS AND METHODS

Studies of switchgrass cultivation was carried out at the Borschiv experimental field station in Ternopil region for the 2013-2016 period. This area is represented by gray forest soils. The climate of the district is moderate-continental with insignificant amplitudes of temperature fluctuations, characterized by short mild winters, warm humid summers and sufficient precipitation. The period with an average daily temperature of more than 10°C lasted 160-165 days. The amount of precipitation during the growing season was 370...420 mm. Weather conditions prevailing in the region during 2013-2016 years are shown in Fig. 1 and 2.

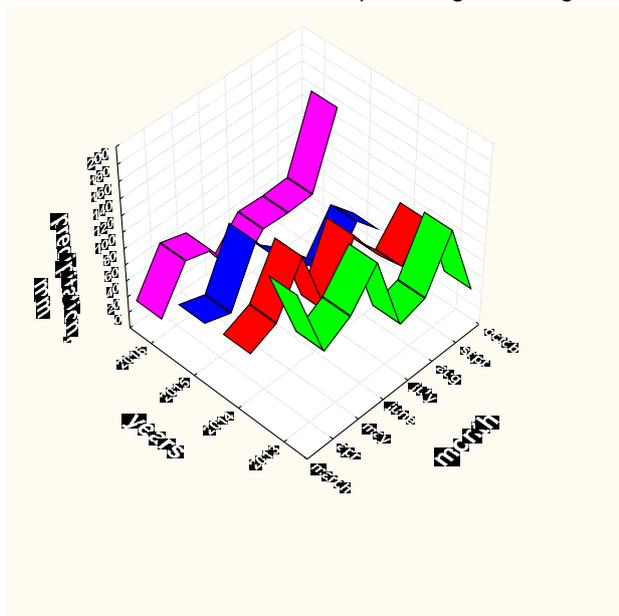


Fig. 1 - The precipitation during the vegetation periods of 2013-2016, [mm]

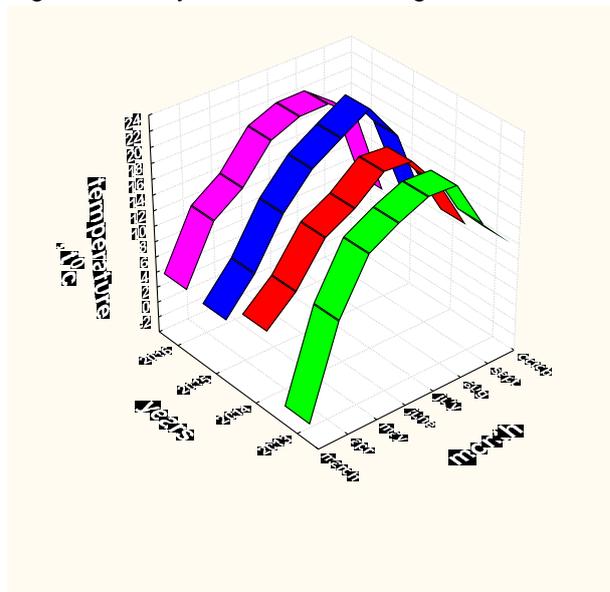


Fig. 2 - The temperature regime during the growing periods of 2013-2016, [°C]

Temperature regimes during the vegetation periods of 2013-2016 were characterized as weighted average without extreme emissions. The year 2016 was the driest during the active vegetation period. The vegetation periods of 2013 and 2014 were the most optimal in terms of moisture content. 2015 was characterized by a lack of moisture in the second half of the growing season. Several factors were taken into account in the field experiment with switchgrass including planting dates (III decade of April, I – II decade of May and III decade of June), method of sowing switchgrass seeds (with and without marker plant), width of inter-row spacing (30 and 45 cm) and two varieties (Cave-in-rock and Morozko) testing. White mustard was used as marker crop. The total area of the experiments was 0.90 ha, four-fold repetition. Switchgrass sowing period was chosen, waiting for the soil temperature at a depth of 10 cm to exceed 10°C. The germination of switchgrass seeds in the forest-Steppe of Ukraine occurred at a temperature of +6-8°C. High level of germination was observed when the soil was heated to +15°C. It was established that the crop can be sown until the end of May in the conditions of Forest-Steppe zone of Ukraine. In our earlier conducted research, the largest switchgrass yield was obtained when a seed sowing was made in the first decade of May (Gumentyk and Kharytonov, 2018).

Sowing with marker crop - white mustard, which comes before the main crop and sprouts very quickly, was used to speed up the first row-to-row processing before the emergence of switchgrass seedlings. Marker crop makes it possible to carry out the first inter-row processing before the emergence of seedlings. Seeding rate of marker crop (white mustard) - 1-2 kg/ha. Depth of seeding-1-1.5 cm. Inter-row cultivation was carried out to establish the optimal timing of soil treatment in various phases of plant growth and development of weed control methods. These agrotechnical operations were carried out during the entire vegetation period until the parts of plants closed over the soil surface. The soil was treated as close to the plant as possible to minimize the protective zone and reduce the cost of weeding and loosening the soil in the rows of crops. Cultivator with claws - blades in combination with needle discs, loosens the soil near the plants and cleans the soil from the shoots of annual weeds by 60-70% was used for inter-row tillage. The average width of the protective zone after the passage of the cultivator was 5-6 cm. Ripping needle discs with bent to one side pointed teeth had a diameter of 350 and 450 mm. During the movement of such discs in the aisles and protective zones, the teeth are buried in the ground up to 4-9 cm, loosen it and destroy weeds. The quality of inter-row processing depends on the straightness of the lines. The width of the cultivator working zone should coincide with the seeder width. The working bodies must completely cut the weeds in the rows, not bring the wet soil layer to the surface, not damage the plants more than 1-2%, not deviate from the specified depth by more than 15%.

RESULTS AND DISCUSSIONS

It was established that the terms and methods of switchgrass sowing had a significant impact on seed germination (Table.1).

Table 1

The boundaries of changing the friction angle of the soil on the steel

Variety	Terms of sowing			
	I term (III decade of April)	II term (I decade of May)	III term (II decade of May)	IV term (I decade of June)
Cave-in-rock	42	73	68	60
Morozko	47	75	71	65
LSD ₉₅	4.0			

The first and second decades of May were the best for sowing. The number of seedlings of switchgrass plants was 75 ... 71 units/line meter for Morozko variety and 73...68 units/line meter - for Cave-in-Rock variety. The lowest number of seedlings was in the third decade of April and the first decade of June - 47 and 65 units/line meter varieties Morozko and Cave-in-Rock. This is due to the low temperature of the soil at the time of sowing. This is also due to the varietal features of the switchgrass. The data on switchgrass plants standing density at the end of the growing season are shown in table 2.

Table 2

Table 2. Density of switchgrass plants standing at the end of the growing season, depending on the timing of sowing and varietal characteristics, mln. unit /ha, (2013-2016).

Variety	Terms of sowing			
	I term (III decade of April)	II term (I decade of May)	III term (II decade of May)	IV (I decade of June)
Cave-in-Rock	3.9	6.7	6.3	3.9
Morozko	3.4	5.2	4.1	3.7
LSD ₉₅	0.1			

The density of standing switchgrass plants at the end of the growing season was the highest (6.7 mln. units/ha) - for the second term of sowing Cave-in-Rock variety and the smallest (3.4 mln. units/ha) - for the first period of sowing the Morozko variety. It was found that the switchgrass sowing timing had a significant impact on the yield and energy output (table 3). The highest average yield of 16.5 t/ha of switchgrass biomass for both varieties was for the second and third terms of sowing, the lowest-11.0 t/ha - for the fourth term. This is due to the fact that during the first period of switchgrass sowing, the soil temperature has didn't rise to a favourable level for seed germination.

Low reserves of productive moisture led to a decrease in field germination and, as a result, the crop decreased. Accordingly, the energy yield was in the range from 176.0 to 268.8 GJ / ha depending on the sowing period.

Table 3

Productivity of dry switchgrass biomass and energy output in the third year of vegetation depending on the sowing period and varietal characteristics

Variety	Terms of sowing								Average	
	I term (III decade of April)		II term (I decade of May)		III term (II decade of May)		IV (I decade of June)			
	Yield, t/ha	Energy uptake, [GJ/ha]	Yield, [t/ha]	Energy uptake, [GJ/ha]	Yield, [t/ha]	Energy uptake, [GJ/ha]	Yield, [t/ha]	Energy uptake, [GJ/ha]	Yield, [t/ha]	Energy uptake, [GJ/ha]
Cave-in-Rock	14.0	224.0	16.7	267.2	16.8	268.8	9.0	144.0	14.1	225.6
Morozko	14.3	228.8	16.3	260.8	16.1	257.6	13.0	208.0	14.9	238.4
Average	14.2	227.2	16.5	264.0	16.5	264.0	11.0	176.0	14.5	232.0
LSD ₉₅									1.6	

The most productive variety in the first year of vegetation was Morozko with an average yield of 14.9 t/ha. Different quality adaptive reactions of "Cave-in-rock" and "Morozko" varieties were identified by productivity parameters depending on the method of sowing seeds, the presence of marker crop and terms of vegetation periods (Fig. 3 and 4).

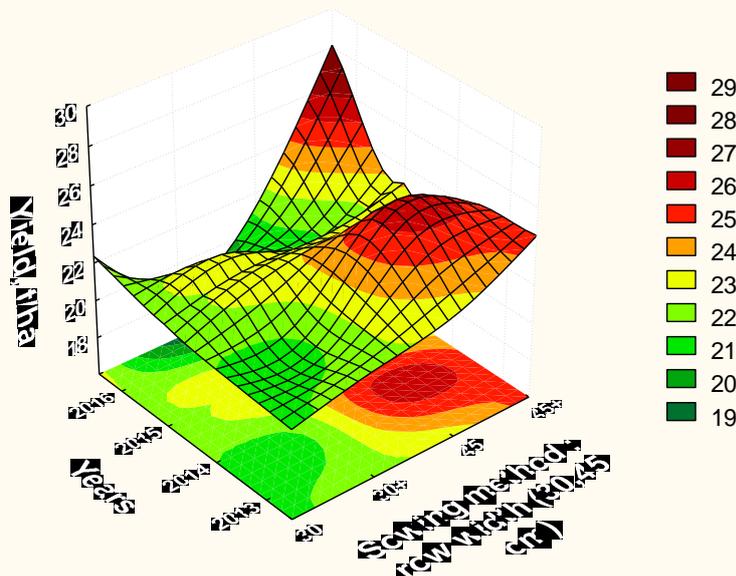


Fig. 3 - Productivity of the "Cave-in-rock" variety biomass, depending on the sowing seeds, the presence of a marker crop and the terms of vegetation periods

In particular, it can be noted, that the adaptive reactions of the "Cave-in-rock" variety concern the method of sowing seeds, the presence of a marker crop and the conditions of vegetation periods. The adaptive reactions of the variety "Morozko" were flexible regarding the parametric levels of productivity relative to the method of sowing seeds, the presence of a marker crop in the conditions of extreme manifestations of 2016 in the growing season. It indicates a wider and optimized rate of adaptive reactions at "Morozko" variety.

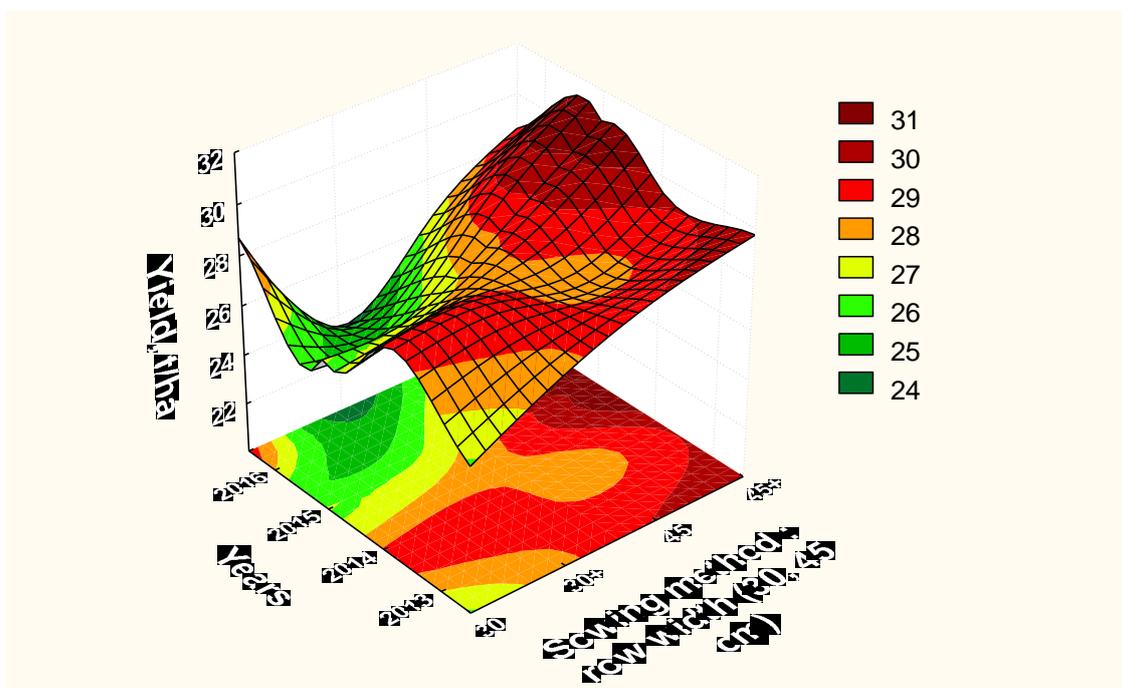


Fig. 4 - Morozko varieties' productivity of biomass depending on the method of sowing seeds, the presence of marker crop and terms of vegetation periods, t/h, 2013-2016

The results of accounting for the yield of Cave-in-Rock and Morozko varieties, depending on the method of sowing seeds, are shown in table 4.

Table 4

Switchgrass yield depending on width of inter row spacing, t/ha

Trials	Years				Average
	2013	2014	2015	2016	
«Cave-in-Rock»					
Width 30 cm	20.8	21.0	21.4	22.0	21.3
Width 30 cm with marker crop	21.4	21.5	22.2	20.4	21.4
Width 45 cm	23.8	25.2	22.4	21.0	23.1
Width 45 cm with marker crop	24.5	23.8	23.2	25.7	24.3
Morozko					
Width 30 cm	27.0	28.1	26.2	27.0	27.1
Width 30 cm with marker crop	28.1	28.3	26.3	24.3	26.8
Width 45 cm	28.4	27.7	28.3	27.4	28.0
Width 45 cm with marker crop	29.4	29.4	30.7	29.9	29.9
LSD ₉₅ – 1.08 t/ha					

High yield of switchgrass biomass 29.9 t/ha, in the first year of vegetation was observed in the variety Morozko with white mustard as marker crop and inter row spacing width of 45cm.

Conventional planting techniques managed in the field experiments in Virginia State of US showed that the best way to get the greatest yields is a choice for width of switchgrass stands from 18 to 25 cm (Parrish and Fike, 2005). In order to maximize biofuel production in other field experiments managed earlier in the same experimental station in Ukraine it was advisable to plant switchgrass in narrow rows to provide quicker canopy closure and weed control (Kulik, 2016). Variety Cave-in-Rock during the first three years and variety Sanburst during four years had the highest phytomass productivity with row - spacing width of 30 cm. However, switchgrass formed considerably high yield during the fifth and the sixth vegetation year with row-spacing width of 45 cm.

CONCLUSIONS

Different quality adaptive reactions of the "Cave-in-rock" and "Morozko" varieties were found in terms of productivity parameters depending on the method of sowing seeds, the presence of a marker crop and the conditions of vegetation periods. The highest yield of switchgrass for both varieties was for the second and third terms of sowing. In particular, it can be noted, that the adaptive reactions of the "Cave-in-rock" variety concern both methods of sowing seeds, the presence of a marker crop and the conditions of vegetation periods. The adaptive reactions of the variety "Morozko" were flexible regarding the parametric levels of productivity relative to the method of sowing seeds, the presence of a marker crop in the conditions of extreme manifestations of 2016 in the growing season. High yield of switchgrass biomass 29.9 t/ha, in the first year of vegetation was observed in the Morozko variety with white mustard as marker crop and inter row spacing width of 45cm. It indicates a wider and optimized rate of adaptive reactions at "Morozko" variety.

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