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EFFICIENCY OF HERBICIDES IN THE TECHNOLOGY OF CULTURATION OF *Miscanthus giganteus*

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Abstract

Among the elements of Miscanthus giganteus cultivation technology, the most important link is the protection of plants from weeds. Weed component control is necessary in the most critical periods of plant development. For Miscanthus giganteus, mainly plots are allocated on low-fertility previously uncultivated lands with high weediness. In this regard, it became necessary to study the methods of weed control in the Miscanthus giganteus agrocenosis and their effect on the yield of plantations in the second year of life. Research to examine the aftereffect of herbicides on the formation of the productivity of Miscanthus giganteus was carried out in 2016-2018 on the experimental site of Penza State Agrarian University (Russia) on light gray forest sandy loamy soil. The most favorable weather conditions were in 2016. With optimal thermal conditions and sufficient precipitation, by the end of the growing season, the plants reached a height of 239.0-300.0 cm with the number of stems 12.0-22.0 pcs/plant. The maximum yield of Miscanthus giganteus dry mass of 11.35 t/ha was obtained by applying the herbicide based on metsulfuron-methyl against the background of glyphosate. The return of frosts in May 2017 to minus 1.8°C led to the death of regrown plants and the number of stems after overwintering decreased to 4-8 pcs/m^2, against 18-38 pcs/m in 2016. The highest stem density of 24 pcs/m^2 on average over three years was noted in the agrocenosis, where in the year of laying the plantation of Miscanthus giganteus, against the background of glyphosate-containing herbicide, they were treated with preparations based on metsulfuron-methyl and 2.4D + florasulam.

Key words*: Miscanthus giganteus, weed vegetation, herbicides.*

INTRODUCTION

Improvement of crop cultivation technologies and their adaptation, in relation to the soil and climatic features of the land use area, is the most important task in the development of modern farming systems. Among the elements of cultivation technology, the most important link is plant protection from weeds. Depending on the weather conditions and the location of the crop on the territory, the species composition of weeds varies significantly over the years. These changes are associated with the biological characteristics of weeds, the strategy for combating them, the predominant range of herbicides used, the method of tillage, the weed control system throughout the crop rotation, and the general crop culture. (Atkinson, 2009; Xuea et al., 2015; Winkler et al., 2020)

Weed damage is extensive and varied. In agrocenosis, they enter into a competitive relationship with cultivated plants for the use of moisture, nutrients, light and other life factors. As a result, weeds worsen the conditions for their growth and development (Lewandowski, 1998; Gushina et al., 2021).

Weakly competes with weeds and a new technical plant - *Miscanthus giganteus*, especially in the first two years of cultivation. Weed component control is necessary in the most critical periods of plant development (Chuansheng et al., 2021). For *Miscanthus giganteus* mainly areas are allocated on low-fertility previously uncultivated lands with high weediness. Ways to control weeds in plantings of *Miscanthus giganteus* have been little studied, since today this crop occupies small areas. In this regard, it became necessary to study the methods of weed control in the *Miscanthus giganteus* agrocenosis and their effect on the yield of plantations of the second year of life.

MATERIALS AND METHODS

Herbicide after-effect researches on agrotechnical and chemical measures to combat

the weed component in the *Miscanthus giganteus* agrocenosis were carried out in 2016-2018, humus content in the arable horizon - 2.7% (State Standard (SS) 26213-91), alkaline hydrolysable nitrogen - 102.8 mg/kg (according to Kornfield), mobile phosphorus and exchangeable potassium - 188 and 110 mg/kg, respectively (SS 26204-91), pH_{Cl} - 5.7 (SS 26483-75).

Experiment scheme:

1. Absolute control (control 1);
2. Production control (control 2 - two inter-row treatments);
3. Treatment with glyphosate-containing herbicide (Tornado 500 4 l/ha);
4. Herbicide treatment based on 2.4 D + florasulam (Ballerina 0.6 l/ha);
5. Treatment with metsulfuron-methyl herbicide (Magnum 0.01 kg/ha);
6. Treatment with herbicide Tornado 500 (4 l/ha) + treatment with Balerina herbicide (0.6 l/ha);
7. Treatment with Tornado 500 herbicide (4 l/ha) + treatment with Magnum herbicide (0.01 kg/ha).

The repetition is fourfold, the placement of plots is systematic.

Systemic herbicides Magnum and Ballerina were applied in the phase of two to four leaves in annual weeds and rosettes in perennials with a water consumption rate of 300 l/ha using a knapsack sprayer.

Soil preparation included autumn plowing to a depth of 22-25 cm three weeks after the application of the herbicide Tornado 500 at the end of the second decade of August, harrowing with tooth harrows in the spring, and cultivation before planting. Planting of *Miscanthus giganteus* was carried out with rhizomes - rhizomes 8-10 cm long as early as possible to a depth of 10 cm according to the scheme 75 × 70 cm. Observations, records and analyzes were carried out according to generally accepted methods.

The weather conditions during the years of the research were different, which made it possible to give an objective assessment of the studied cultivation methods. Favorable for the development of plants was 2016, when the hydrothermal coefficient at the beginning of regrowth- cleaning was 1.17, which characterizes it as sufficiently moistened. During the growing season in 2017, 280 mm of precipitation fell with a sum of active temperatures of 2116.6°C. But, frosts in May to minus 1.8°C led to the death of regrown plants and the number of stems after overwintering decreased. In the dry year of 2018. However, during the period of intensive increase in the above-ground mass of precipitation, more than the norm fell at optimal positive temperatures.

RESULTS AND DISCUSSIONS

The success of the cultivation of wintering crops is determined not only by the weather conditions of the growing season, but also by the conditions prevailing in winter (Barksdale et al., 2020; Doronin et al., 2017). Overwintering of agricultural crops is also determined by the biological characteristics of plants and their condition during the period of cessation of the autumn vegetation. In the first year of wintering, they can be severely damaged by frost, resulting in their partial death (Jones, Walsh, 2001; Płazeka et al., 2011).

The early spring regrowth of *Miscanthus giganteus* plants in 2016 (April 14) was facilitated by the increased temperatures of the month and the period of the beginning of regrowth - harvesting was 165 days. 18 days later, the regrowth of culture was noted in 2017, full - on May 10, which affected the duration of the growing season, the length of which was 147 days. In 2018, the elevated temperature regime (16.6°C) and the lack of precipitation (27.8 mm) were extremely unfavorable for the initial growth of *Miscanthus giganteus*, so full regrowth was observed only on May 28. The duration of the period of the beginning of regrowth - harvesting was 125 days.

The problem of winter hardiness of *Miscanthus giganteus* occupies a special place in cultural studies. Favorable overwintering conditions for the plantation developed in 2016 and 2018, which had a positive effect on plant survival. In the initial period of growth, the number of *Miscanthus giganteus* stems of the second year of life was within 16-38 pcs/m^2, which is 1.3-3.0 times more than before leaving for winter. Their smallest number was noted in the absolute and production controls. With chemical methods of weed control, the stem per

square meter exceeded 34 pieces in 2016 and 20 pieces in 2018. This indicates a good overwintering of *Miscanthus giganteus*, whose survival rate in these years was 100%.

In mid-May 2017, the regrown plants suffered from frost, which led to the thinning of landings. As a result, the number of stems was 4-6 times less than before winter, and 4.5-8.5 times less than in the previous year, and their number in the experiment did not exceed 8 pieces/m^2. Plant survival decreased by 19-25%.

On average, over three years, the highest stem density after overwintering, 26 pcs/m^2, was noted in the variants with double herbicide treatment, the survival rate of plants varied from 73.0 to 75.0%.

The value of the yield of perennial crops largely depends on the density of the stem. Close crops significantly reduce unproductive moisture consumption due to good soil shading and do not leave an ecological niche for weeds.

As a result of three years of research, it was found that the studied agricultural practices, as well as the weather conditions of the growing season, influenced the formation of *Miscanthus giganteus*.

The productivity of agrocenosis is formed due to the main indicators of the crop structure, which include the height of the stems and their number. So, in 2016, due to the early spring growth of *Miscanthus giganteus*, the number of stems in early June increased to 9-19 pieces with a height of 120-140 cm (Figure 1). They were most developed in plantings with double herbicide treatment. On the plantation with the introduction of the herbicide Tornado 500, with well-developed 18 shoots, the height of the plants did not exceed 133 cm weight - up to 358-458 g. In the control variants, the height of the plants was 120-123 cm, the number of shoots was 9-10 pcs/plant. The mass of the above-ground part was within 168-658 g/plant.

In August, the height of plants increased by 116-147 cm compared to the previous determination in June 236 cm with developed 12 shoots. Mechanical weed control contributed to an increase in the number of stems up to 12 pcs with a height of 279 cm. The use of herbicide Tornado 500, compared with absolute control, led to an increase in plant height by 1.18 times, the number of stems - by 1.57 times, the use of systemic herbicides - 1.16-1.17 times and 1.67-1.75 times, respectively.

The greatest effect was noted on plantations where a double herbicide treatment was carried out. At the same time, the height of plants was 280-295 cm, the number of stems was 22 pcs, weight 2094- 2336 g/plant (Figure 1).

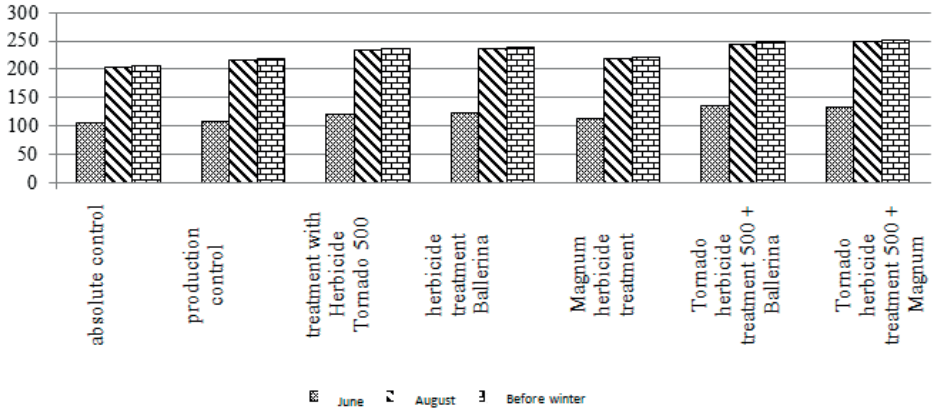


Figure 1. The height of *Miscanthus giganteus* second year of life (2016-2018), cm

Before leaving for winter, the height of the shoots increased by 3-6 cm and reached 300 cm, while their number did not change. The mass of the aerial part increased by 16-22 g and the largest (2112-2358 g) it was on the plantations where a double herbicidal treatment was carried out.

Spring frosts after the growth of *Miscanthus giganteus* in 2017 had a negative impact on its development. As a result, at the time of the first determination, compared with the previous year, the number of stems decreased by 4.5-8.5 times, the height of plants was 1.05-1.30 cm

less, and their weight did not exceed 115 g/plant.

At the end of August, the plants reached a height of 176-212 cm, the number of stems increased to 4-11 pieces, and their weight - up to 106-595 g. In plantings where care work was not carried out, the *Miscanthus giganteus* was weaker, the shoots had a height of 176 cm, and their number did not exceed four pieces. On the plantation treated only with Tornado 500, the number of shoots was 10 pieces 200 cm high. In the production control, the plant height reached 178 cm with well-developed 7 shoots. Herbicides of systemic action contributed to an increase in the number of stems up to 8...10 pieces, and their height up to 179-205 cm, weight 586-595 g.

Before harvesting, the growth of *Miscanthus giganteus* was insignificant 2-4 cm, the number of shoots did not change. The highest yield of wet weight (596-604 g) was obtained on plantations after double herbicide treatment. In absolute and production control, the wet weight was 116 and 289 g, respectively. The use of only Tornado 500 contributed to an increase in the mass of the aerial part up to 431 g, only systemic herbicides - up to 296-555 g/plant.

The optimal air temperature and precipitation in June 2018 evened out the development of plants of the second year of life, the height of which was 99-135 cm with the number of shoots 8-13 pcs/plant. The raw weight of the above-ground part of *Miscanthus giganteus* was 1.5-4.5 times more than in the same period of previous years. The use of herbicides Ballerina and Magnum against the background of Tornado 500 contributed to an increase in the number of shoots up to 13, plant height up to 132-135 cm, wet weight yield up to 238-240 g, which is 1.3-1.6 times higher than the absolute control.

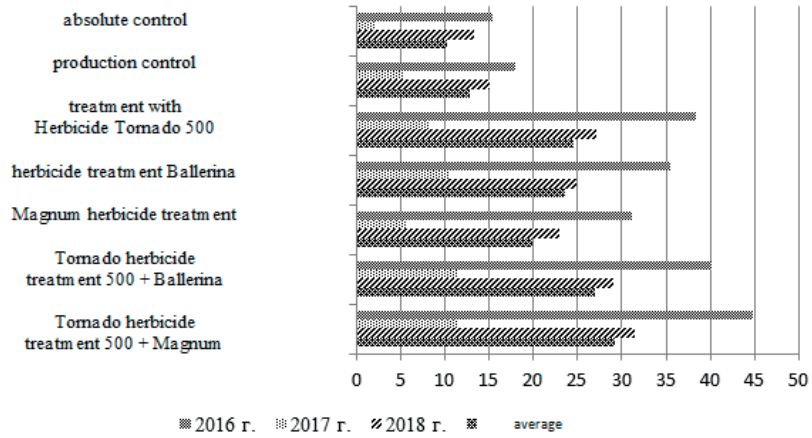
Slight increase in plant height in August (up to 195-240 cm) is associated with the biological characteristics of the culture and about severe rainfall deficit during this period. The number of shoots, in this case, amounted to 8-12 pcs/plant. The yield of raw mass in relation to the previous definition increased by 454-1159 g/plant.

By harvesting, the plants reached a height of 199-245 cm, with a weight of 670-1578 g, shoot formation stopped. The highest rates of growth and development of *Miscanthus giganteus* plants were noted on plantations with double herbicide treatment.

On average over three years, overwintering conditions had a direct impact on the development of *Miscanthus giganteus*, but plants suffered most in 2017 from frosts that were observed during their mass growth. At the same time, depending on the methods of weed control, the greatest effect was obtained from the use of systemic herbicides Balerina and Magnum against the background of Tornado 500. An increase in the number of stems and their height is accompanied by a regular increase in the mass of the *Miscanthus giganteus* plant.

In the conditions of 2016, the yield of fresh mass in absolute control reached 15.41 t/ha, in the variants where weed control was carried out, it increased by 2.61-29.51 t/ha or 1.17-2.91 times (Figure 2). Favorable overwintering conditions and early regrowth of culture contributed to the formation of powerful plants. Compared to the absolute control, the yield of wet mass after inter-row treatment increased to 18.02 t/ha. An increase in the treatment of plantations with herbicides Magnum and Ballerina by 15.79-20.10 t/ha was noted. The highest yield 40.23-44.92 t/ha was obtained after a double herbicide treatment. In the version where only the herbicide Tornado 500 was used, the wet weight yield was 38.48 t/ha.

The spring frosts of 2017 had an impact on the development of *Miscanthus giganteus* plants. As a result, the yield of green mass was 3.28-6.97 times lower than in the previous year, and the lowest (2.21 t/ha) was noted on the plantation, where maintenance work was not provided. With inter-row processing, the yield of wet mass increased to 5.50 t/ha. The use of systemic herbicides contributed to an increase in yield by 2.55-4.78 times, and when plantations were treated with a continuous herbicide, by 3.71 times compared to absolute control. The greatest effect was noted when the herbicides Magnum and Ballerina were applied against the background of Tornado 500. On this agricultural background, the most powerful plants with a fresh weight of 11.35-11.50 t/ha were obtained.



NDS_{05}, t/ha: 2016 - 0.68, 2017 - 0.17, 2018 - 0.47.

Figure 2. Yield of wet mass of *Miscanthus giganteus* second growth year, t/ha

The yield of the above-ground mass of the *Miscanthus giganteus* second year of life in 2018 was 1.2-1.4 times less than in the favorable year 2016, but more by 9.56-20.21 t/ha than in the previous year. The maximum yield of wet weight 29.1-31.56 t/ha was obtained when herbicides Magnum and Ballerina were used in the year of planting against the background of Tornado 500, against 13.4 t/ha under absolute control.

The same trend can be traced in the collection of dry mass of plants. On average, over three years, its highest yield (9.71-11.35 t/ha) was obtained from plantations where a double herbicide treatment was carried out, the lowest 3.73 t/ha - from plots where maintenance work was not provided. The use of herbicides of systemic action contributed to an increase in the yield of dry matter in comparison with the absolute control by 1.92-2.28 times, and the use of the herbicide Tornado 500 - by 2.48 times.

Consequently, the methods of weed control in different ways allow *Miscanthus giganteus* to realize its biological capabilities. Thus, in 2017, overwintering conditions were less favorable for plants, which negatively affected the yield of the crop, the wet and dry weight of which, on average, according to the experiment, was 7.85 and 2.31 t/ha, respectively. In the first and third years of research, the conditions for the formation of yields were much better, therefore, on average, according to experience in 2016, the yield of green mass was 4.0 times higher, in 2018 - 3.0 times higher, and the dry mass yield was 19.56 and 8.37 t/ha, respectively.

CONCLUSIONS

In this way, the most favorable weather conditions were in 2016. With optimal thermal conditions and sufficient precipitation, by the end of the growing season, the plants reached a height of 239.0-300.0 cm with the number of stems 12.0-22.0 pcs/plant. The return of frosts in May 2017 to minus 1.8°C led to the death of regrown plants and the number of stems after overwintering decreased to 4-8 pcs/m^2, against 18-38 pcs/m^2 in 2016. The highest stem density of 24 pcs/m^2 on average over three years was noted in agrocenosis, where in the year of laying the *Miscanthus giganteus* plantation, systemic herbicides were treated against the background of Tornado 500. The maximum yield of wet and dry mass of *Miscanthus giganteus* was 29.28 and 11.35 t/ha respectively, obtained by applying the herbicide Magnum on the background of glyphosate.

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