ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

# Introduction And Adaptation Of Giant Miscanthus To The Conditions Of The Forest-Steppe Of The Middle Volga Region.

**VA Gushchina*, AA Volodkin, ND Agapkin, and NI Ostroborodova.**

Federal State Budget Educational Establishment of Higher Education, Penza State Agrarian University, 30, Botanicheskaya St, Penza, Russian Federation, 440014

**ABSTRACT**

When introducing giant miscanthus in the forest-steppe of the Middle Volga region, the main risks are associated with its reduced winter hardiness and rather high demand for moisture supply. Therefore, in order to create highly productive and ecologically stable agrophytocenoses of giant miscanthus, its agrobiological features were studied taking into account the agroclimatic resources of the region. With reference to local climatic conditions, the peculiarities of plant growth were revealed and, first of all, the conformity of the culture to local humidity conditions was determined. The year of planting (2013) was characterized as excessively moistened, when the hydrothermal coefficient (HTC) from May to September was 1.3, with a sum of active temperatures of 2643 ° C. The favorable conditions of the vegetation period allowed the miscanthus to form a powerful tops with a height of 180-190 cm and a yield of 14.0 t / ha. The winter period was characterized by both low temperatures below freezing and positive ones with insufficient snow cover. However, this did not lead to the death of plants and after successful wintering, the yield of the plantation of the second year of life increased by 2.1 times, of the third year – by 2.6 times in relation to the first year. Due to the far-spreading rhizogenous root system of the miscanthus, the rows of plants were joined, the row spacing decreased by a factor of 2. With sufficient moisture in 2016, on average, each plant formed 35 stems with a height of 207–230 cm. Intensively developing growth processes this year allowed to generate the wet weight yield of 40t / ha. Despite the night frosts in mid-May and the later spring growth of the miscanthus in 2017, the yield of the tops was at the level of the previous year. Thus, the introduction of giant miscanthus in the zone of unstable moistening is possible. This will allow agricultural enterprises to expand the cultural flora of the region with a new bioenergetic plant, which can become an alternative to natural gas and wood for home heating when used as fuel pellets. Проверь пожалуйста правильно ли переведено

**Keywords:** introduction of plants, giant miscanthus, growing conditions, yield, unstable hydration

**Corresponding author*

ISSN: 0975-8585

## INTRODUCTION

Most of the EU countries actively develop production of energy from renewable sources, which also comprise biomass according to Article 2 of Directive 2001/77 / EC of the European Parliament and of the Council of 27 September 2001 [1]. Development of bio-energetics is also a pressing issue in Russia.

Today we have an experience of creating complex enterprises that besides producing energy (both thermal and electrical) also grow necessary biomass which is characterized by high content of cellulose, significant emission of thermal energy and annual reproduction [2, 3, 4].

Environmentally friendly and inexhaustible source of energy of vegetable origin is biomass of giant miscanthus of perennial plant from grass family (Miscanthus x giganteus) [5, 6]. It can grow on slopes, hills, in cloughs, on not productive and degraded soils, not being a competitor to food crops for fertile soils, but being a competitor to wood if it comes to biomass growth [7]. High yield is provided by increased efficiency of photosynthesis. It allows to accumulate a significant quantity of organic substance due to thermolability of key ferments – Rubisco and Pyruvate, phosphate dikinase, i.e. ferments activity in miscanthus doesn't fall even at lowered temperatures, as in most of the plants from group C4. At single planting of miscanthus with rhizomes during 20-25 years it is possible to obtain 8 t of cellulose per one hectare if compared with single obtaining of 40 tons of cellulose per one hectare of wood of age between 70-100 years [8, 9, 10].

Risk of bad overwintering in the first year after establishing and increased requirements for moisture provision are factors that restrict cultivation of miscanthus in the zone of not sufficient moisturizing [11, 12]. That is why in order to introduce valuable energy culture of giant miscanthus into production it is necessary to study the peculiarities of high-productive invasive plant agrocoenosis adapted to the conditions of growth in the period of use and first of all during the first year of life [13, 14].

## MATERIALS AND METHODS

In the context of the evaluation of miscanthus cultivation potential in the Middle Volga region on light grey forest soil sabulous according to grain-size, culture plantation was put on the 6th of May, 2013.

Tilth top soil is characterized with the following agrotechnical factors: humus content – 2.7%, easy hydrolysable nitrogen content – 102 mg/kg, labile phosphorus and exchangeable potassium content is 188 and 110 mg/kg of soil respectively, pH is 5.7. Forecrop were spring sown cereal. After the gathering, the stubble field was unhusked on the depth of 7-10 cm and in a week it was plowed up on the depth of 22-25 cm. In the early spring, harrowing was conducted with the help of toothed harrows. Determination of soil moisture in tilth top soil was conducted by weight method [15], it made up 25.4% against oven-dry mass, i.e. there were optimal conditions for planting, even for the late cultures. Phenological observations, determination of plant population and registration of biological yield were conducted according to the method of State variety testing of agricultural crops [16].

The planting was conducted with rhizomes according to the scheme 100x50 cm into the moist soil on the depth of 8-10 ca according to the method of Dospekhov B.A. (1986)[15].

## THE EXPERIMENTAL PART

Giant miscanthus imposes special requirements to the conditions of moisturizing. For its normal growth and development according to the studies of Shumnyi V.K. [17] and Blum Ya.B. about 700 mm of precipitation is needed per year, especially at the initial stages of ontogeny.[ 18]

During the month after the planting in 2013, there was only 28 mm of precipitation with an average annual rate of 43.4 mm. Hydrothermic coefficient in May made up 0.52 (table) according to Selyaninov G.T [19]. Nevertheless, it didn't affect seedling emergence registered on the 27th of May, since plastic substances of planting material were used. Precipitations of the second half of June (77 mm at a rate of 26.7 mm) promoted a good development of shoots and on the 3rd of July, each rhizome of the main mass of plants developed 4-8 stems.

Further favorable conditions for intensive growth of the miscanthus were formed and by the end of the growing season plants reached a height of 180-190 cm, with leaves accounting for 38%. Top light green leaves with a smooth surface, stem leaves of emerald green color with fuzzy leaf blade and clear-cut white stripe along the leaf vein. Linear leaves, located on two opposite sides of the stem, have jagged edges and end with a sharp tip.

**Table 1: Hydrothermic coefficient of giant miscanthus vegetation period**

| Month | Years | | | | |
|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 |
| May | 0.52 | 1.08 | 0.25 | 1.80 | 0.64 |
| June | 1.40 | 0.98 | 1.14 | 0.43 | 1.15 |
| July | 0.79 | 0.60 | 1.40 | 1.64 | 1.41 |
| August | 1.15 | 0.51 | 0.14 | 0.36 | 0.19 |
| September | 3.20 | 1.17 | 0.15 | 2.10 | 3.20 |
| Average | 1.41 | 0.87 | 0.62 | 1.27 | 1.32 |
| Variation coefficient, %, $C_V$ | 74.4 | 34.0 | 98.3 | 64.0 | 87.4 |

After the first frosts in October the leafs lost turgor and grew weak, at this the 9-11 mm thick and 80-88 cm height erect stems were well-shaped, they consisted of internodes with the length of 12-14 cm divided by thickened stem nodes, moreover, three shortened internodes were in the soil. Number of well-developed stems of the plant didn't exceed 11 pieces with the total mass of 335 g. At a density of plant stand of 46 pcs./$m^2$ the yield of top mass in autumn made up 14.0 t/ha.

The yield of the top mass depends on the development of the underground organs, which, in the case of miscanthus, are rhizomes. Rhizome is a modified sprout, containing stocks of plastic substances. Buds are formed on them, giving new underground shoots and additional roots each year, using the nutrients stored in it. New shoots are also formed after the top part of the plant dies out under the influence of unfavorable conditions. After the old parts of the rhizome die out, the underground shoots arising on it are separated, thus vegetative reproduction occurs [20].

By the end of vegetation period (the first decade of October 2013), the main root in the soil on the depth of 5-20 cm created a thin net. 7-10 buds-pips occurred on them and were visible on the soil surface. Underground sprouts were well-developed which could be seen from their mass of 1.07 kg/plant. In average each plant developed up to 57 well-formed rhizomes with length from 4 to 18 cm. Number of small buds on them with size from 0.5 to 3.0 cm was 154 pieces.

Thus, in the conditions of the redundant moistening at HTC – 1.3 and sum of active temperatures 2643.5 °C during the period of miscanthus vegetation, the plants with developed tip mass have high productivity of main roots and their correlation is close to 1:3. Meanwhile, agricultural measures against non-competitive weed were conducted on the plantation.

Pets and diseases were not found on the plants, which means that warm moist summer and cold autumn with redundant moistening didn't affect the phytopathologic state of miscanthus and before wintering the plants were well-developed. Annual precipitation of 664 mm met the biological requirements for the culture.

But in winter a partial death of the plant may occur, as each plant is seen as a self-regulated system, development of which depends on the weather conditions, strength of the root system and quantity of accumulated plastic substances.

Wintering conditions for miscanthus plants (2013-2014) were difficult. In December the snowfall was 1.5 less than needed at the temperature minus 3.8 °C. Winter months of 2014 were characterized by sharp temperature fluctuating. In the first decade of January daily mean temperature didn't go lower than minus 1.9 °C, quantity of precipitations was 15 mm. But on the 11$^{th}$ of January the temperature went above zero (+1.2°C) and during the day there fell 9 mm of rain. In the absence of a snow cover on the 20th of January, a sharp temperature drop to minus 25.3 °C was noted. Daily mean temperature in the third decade made up minus 21.3 °C and precipitation quantity was twice as bigger than long-term average annual quantity. The lowest temperature minus 31.7°C established in the last days of January and held up during the first three days in February. On the 5th of February the temperature rose to minus1.9°C, precipitation level was 37% bugger than long-term annual level. Sharp temperature fluctuations and precipitations characterized the following two decades of February. Similar conditions were noted in March, but it didn't reduce the winter hardiness and in April thaw the plants were neither drenched nor rotten. In the second year of its life after the wintering miscanthus continued its ontogenesis, the renewal organs, in this case, are represented by wintering buds and root shoots. At daily mean temperature of 10.0°C miscanthus regrowth started in the third decade of April, the full regrowth happened on the 5th of May. Moistness arrival and consumption equilibrium in May (HTC - 1.08) made it possible for miscanthus to develop well. In a month after the spring regrowth, the plants reached the height of 110 cm, i.e. the daily growth made up 3.6 cm.

Vegetation period in 2014 was characterized by the increased temperatures and not sufficient level of precipitations. But plants that were well-formed during the first year proved to be resistant to arid conditions of summer months (HTC-0.7) next year. By the harvesting, at the end of September, the plants were 220 cm high, without forming generative organs but they have formed the yield of top mass of 29 t/ha and powerful root system that colonized soil space in rows. Row space colonization didn't happen, but weed was not able to compete with miscanthus.

Temperature in November 2014 was lower than rate by 8.6 °C but during the winter months, it was higher than long-term annual temperature by 1.5 – 6.6 °C. Precipitation level correspondingly was 2.3 times lower, in winter precipitation level exceeded the rate by 25 mm. A fairly thick snow cover, established on the miscanthus plantation due to the remaining stems, increased the frost resistance of the rhizomes. Melting of snow took longer, so the regrowth of plants in 2015 was 7 days later than in the previous one.

Despite the arid conditions during the vegetation period (HTC-0.62), miscanthus used autumn-winter moisture reserves and precipitation for two summer months for successful development. This allowed it to reach a height of 385 cm by harvesting. With a stand density of 122 shoots per square meter, powerful stems with a diameter of 1.5 cm at the base did not lie down. A well-developed root system formed a dense network extending deep into the soil, which allowed to use moisture reserves located there. Therefore, the absence of precipitation in August and September (HTC-0.14) did not reduce the yield of the top mass, which made up 36 t/ha.

In the fourth year of life, i.e. 2016 intensive growth of miscanthus was registered under the conditions of sufficient moistening (HTC-1,27). The height of the plants was 320 cm, and the shoot without the tip of the leaves had a length of 242 cm, and their number per square meter increased to 140 pieces, the yield of the top mass was up to 40 t/ha. On the stems of this year one-two rhizomes were formed, more than 5 cm long, on the stems of the previous year, the number of which was determined from stubble, 2-3 rhizomes were formed with length less than 5 cm.

Due to the lowered daily mean temperatures of the spring months, the regrowth of the miscanthus in 2017 was delayed until the 15th of May, so night frosts that occurred two days before the appearance of plants did not damage them. The low temperatures of June (15.9 °C versus the norm of 18.4 °C) did not reduce the intensity of plant development, since shoots of old-growth plantations of miscanthus are less sensitive to lower temperatures at which the photosynthetic processes proceeded as actively as at optimal temperatures [5]. In July, when the HTC was 1.41, the plants reached a height of 250 cm. The drought in August did not affect the productivity of the miscanthus, which was 41 t/ha, which is the level of 2016. The precipitations of September (126.5 mm vs. 51 mm) did not prolong the activity of the lower leaves; they were obscured by the upper, more developed ones. In total during four years (2014-2017) the productivity of one hectare of miscanthus was 146.4 tons, which corresponds to 51.2 tons per hectare of dry mass or 27.4 tons of cellulose.

## CONCLUSIONS

Thus, for the good development of miscanthus during the vegetation period of plant's first year, not less than 170 mm of precipitation with a sum of active temperatures of 2600 ° C is necessary. Starting from the third year of growth in conditions of unstable moistening on low0fertile soils it is able to form stable top mass yield of 36-41 t/ha annually by the end of vegetation. The research will be continued for determination of miscanthus useful period, but it can be assumed that its cultivation in the Middle Volga region is possible. This will allow agricultural enterprises to expand the cultural flora of the region with a lightly renewable bioenergetic plant.

## REFERENCES


[1] Directive 2001/77 / EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the domestic electricity market (in Russian).

[2] Bulatkin G.A., Mitenko G.V., Guryev I.D. Alternative energy: new biofuel resources from plant raw materials // Teoreticheskaya i prikladnaya ekologiya. - 2017. - No. 2. - P. 88-92 (in Russian).

[3] Bulatkin G.A. Producing second-generation biofuel from plant materials // Herald of the Russian Academy of Sciences. 2010. V. 80. № 3. P. 294–298.

[4] Parajuli R., Dalgaard T., Sperling K. Environmental performance of miscanthus as a fuel alternative for district heat production // Biomass and Bioenergy. 2015. T. 72. C. 104-116.

[5] Figala J., Vranová V., Rejšek K., Formánek P. Giant miscanthus (miscantus × giganteus greef et deu.) - a promising plant for soil remediation: a mini review // Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. 2015. T. 63. № 6. C. 2241-2246.

[6] Brosse N., Dufour A., Meng X., Sun Q., Ragauskas A. Miscanthus: a fast-growing crop for biofuels and chemicals production //Biofuels, Bioprod., Bioref. 2012. Vol. 6. No. 5. P. 580-598.

[7] Gushchina V.A., Volodkin A.A., Agapkin N.D. Giant Miscanthus - Introduced Technical Culture in the Middle Volga Region / V.A. Gushchina, A.A. Volodkin, N.D. Agapkin // Innovatsionnyye tekhnologii v APK: teoriya i praktika sbornik statey II Vserossiyskoy nauchno-prakticheskoy konferentsii. – Penza. 2014. - P. 49-51 (in Russian).

[8] Beale C.V., Morison J.I.L., Long S.P. Water use efficience of C4 perrenial grasses in a temperate climate //Agricultural and Forest Meteorology. 1999. 96. P. 103-115.

[9] Somerville C., Youngs H., Taylor C., Davis S.C., Long S.P. Feedstocks for lignocellulosic biofuels // Science. 2010. Vol. 329. P. 790-792.

[10] Cipriano P., Fernando A.L. Energy balance of the production and use of the Miscanthus for energy purposes, In Portugal // 20th European Biomass Conference and Exhibition. 18-22 June. Italy. 2012. P. 608 - 611.

[11] Gushchina V.A., Volodkin A.A., Ostroborodova N.I., Agapkin N.D., Letuchiy A.V. Peculiarities of growth and development of the giant miscanthus introducer (Miscanthus giganteus) in the conditions of the forest-steppe of the Middle Volga region // Agrarnyy nauchnyy zhurnal, 2018. - №1. - P. 10-13 (in Russian).

[12] Bulatkin G.A., Guriev I.D. Efficiency of cultivation of chinese silver grass (Miscanthus sinensis Anderss.) on gray forest soils of southern Moscow region territory, Russia // Italian Science Review. 2016. V. 1 (34). P. 151-155.

[13] Anderson E., Arundale R., Maughan M., Oladeinde A., Wycislo A., Voigt T., (2011). Growth and agronomy of Miscanthus x giganteus for biomass production. Biofuels 2: 167-183. DOI: 10.4155/bfs.10.80

[14] Christian D.G., Riche, A. B. and Yates, N, E. (2008). Growth, yield and mineral content of Miscanthus x giganteus grown as a biofuel for 14 successive harvests // Industrial Crops and Products 28. 320 - 327.

[15] Dospekhov B.A. Workshop on agriculture / B.A. Dospekhov [and others]. - M.: Agropromizdat, 1987. - 385 p (in Russian).

[16] The method of state variety testing of agricultural crops. Issue. 2: Cereals, cereals, legumes, corn and fodder crops / [Prep. M. A. Fedin et al.]. - M., 1989. – 194p. (in Russian).

[17] Shumniy V.K., Veprev S.G., Nechiporenko N.N. etc A new form of Chinese miscanthus (Miscanthus sinensis Anders.) as a promising source of cellulose-containing raw materials / V.K. Shumniy, S.G. Veprev, N.N. Nechiporenko etc. // Informatsionnyy Vestnik VOGiS. 2010., Vol. 14.-No. 1. P. 122-126 (in Russian).

[18] Blum Ya. B. The newest technologies of bioenergy conversion / Ya.B. Blum, G.G. Geletukha, I.P. Grigoryuk, etc. - Agrar Media Group, 2010. - 326 p.

[19] Selyaninov G.T. Towards the method of agricultural climatography / G.T. Selyaninov // Trudy po selskokhozyaystvennoy meteorologii. 1930. Issue. 2. P. 45-89 (in Russian).

[20] Pidlisnyuk V., Stefanovska T., Lewis E.E., Erickson L.E., Davis L.C. Miscanthus as a productive biofuel crop for phytoremediation // Critical Reviews in Plant Sciences. 2014. T. 33. № 1. C. 1-19.