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CURRENT PROPAGATION OPTIONS FOR *MISCANTHUS GIGANTEUS* IN THE REPUBLIC OF SERBIA

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Abstract

The key RS government's strategy for energy development is to expand the supply of home grown biomass and facilitate the development and competitiveness of a sustainable supply chain. Analysis of the potential supply chain suggests that this can partially be achieved by growing agroenergy crops. *Miscanthus giganteus* was chosen because of the potentially high productivity and cultivation on degraded soil.

This study aims to present the knowledge by which plant propagules (propagation) of *Miscanthus giganteus*, for the biomass supply chain, can be produced at minimum cost. Because *Miscanthus giganteus* is sterile, it can only be propagated by vegetative division.

The method of field experiments followed the potential of production of viable rhizomes on soils with variable fertility. Monitoring was done on 6 parameters of the rhizome growth and planting survival rate. The results indicate that the production of viable rhizomes is affected mainly by age of mother plants and biotic effects of the weed vegetation. A much smaller effect is shown through size of rhizomes and nursery fertilization.

The work reported here focuses on the available knowledge regarding the potential routes by which Miscanthus material could be mass produced for high density planting established to maximize yields. Vegetative clonal plant propagation is required to deliver uniform crops. Rhizome production and division is slow, but currently does not limit increase in production because the Serbian industry uptake is currently small.

At present the establishment rate of Miscanthus is slow and this appears to be limited by economics; evidence suggests that the cost of plant propagules is one factor that prevents widespread planting.

Key words: agroenergy crops, Miscanthus giganteus, ecoremediation

Introduction

Miscanthus giganteus is a highly productive plant species, which has been cultivated in Europe
for 20 years as energy crop. The remarkable adaptability of miscanthus to diferent environments
makes this novel crop suitable for establishment and distribution under a range of European and
North American climatic conditions (Lewandowski et al., 2000). It produces no seed, so it must be established vegetative by planting divided rhizome (rootstock) pieces. This process results in high establishment costs relative to crops established from seed.

There are two methods of propagation that are currently used for *Miscanthus* plants - rhizome division and micropropagation. The sterility of *M*. x *giganteus* necessitates vegetative propagation by either rhizome division or in vitro cultures. This results in very high costs for planting, making *Miscanthus* production economically non-viable. Furthermore, using a single clone carries a considerable risk of attack from pests and diseases (Clifton- Brown et al., 2002).

Rhizome division is more used method because it is less expensive and generally produces more vigorous plants. To produce new planting material, two or three-year-old plants are split whilst dormant, using a rotary cultivator and the rhizome pieces collected for replanting.

A 30-40 fold increase in plants can be achieved this way over a period of 2-3 years, depending on soil conditions. Rhizome pieces must have at least 2-3 ‘buds’ and must be kept moist before re-planting. This is best achieved by keeping rhizomes under cold-storage conditions, (<4°C) (possibly for up to a year) but they will remain viable in the field for a short period of time, if stored in a heap and covered with moist soil.

This study aims to present the knowledge by which plant propagules of *Miscanthus giganteus*, for the biomass supply chain, can be produced in Republic of Serbia under agro-ecological conditions of fertile and degraded soils.

Material and methods

Field experiments were established at following locations: 1. Sadzak (wetland); 2. Vrsac (fertile soil, chernozem - control field); and 3. RB Kolubara (landfil tailings). Plant material, rhizomes of *Miscanthus giganteus* (with a length of 10 cm and with 3 - 6 nodes), was purchased from commercial supplier and manually planted on agro-technically prepared land (plowing was conducted in the fall of the year before the planting and discing just before the planting). Investigated plates were:

A - without agrotecnical measures;

B - agrotecnical measures applied: watering during the 1st vegeataion period, once just afer planting and 4 times later; fertilization (N:P:K=15:15:15 150 kg/ha just before planting) and mechanical weed control 3 times per year.

At the locations Sadzak and Vrsac there has been a monitoring of the potential of rhizome production from 3, 2 and 1 year-old plants, (planting period in 2010, 2011 and 2012), and on humogley only 2 and 1 year-old (planting period in 2011 and 2012). Planting density was 5 rhizomes per m^2 and in every experiment there was a total of 40 plants and the presented results are arithmetic averages of 40 calculations. Measuring was done in the first part of April 2013.

A part, 50 rhizomes produced in this way were planted again at the same locations. Digging out, cutting and planting of rhizomes was done by hand. Rhizomes that have had sprouts within the 30 day period were considered to be viable.

In the second experiment, there was separate monitoring of the influence of irrigation, fertilization and weed on rhizome production from the 1st to the 3rd year on the experimental field Sadzak. Rhizomes that had 2, 4 or 6 sprouts were planted in April 2012. In the beginning of April 2013, rhizomes were dug out and cuttings, with 3-5 sprouts, were made for further planting. Other conditions were as in the previous experiment.

Results and discussion

Miscanthus biomass yield can be limited by poor rhizome establishment and this is linked to rhizome age and storage conditions prior to planting. To avoid poor establishment, best practice recommends field planting directly after rhizome division. Operations avoiding rhizome storage, and utilizing favourable climatic conditions at planting, may be climatologically and logistically challenging when large areas are planted at high rhizome densities (Davies MJ, et al., 2011).

Our aim is to evaluate impacts of nursery age and soil typeto produce and maintain rhizome viability when planted under conditions of fertile (Vrsac) and degraded soil (Sadzak and Kolubara).
Monitored locations are different primarily by soil characteristics (humogley in Sadzak, deposol in RB Kolubara, chernozem in Vrsac). The results from a rhizome establishment bioassay showed high viability.
Biometric characteristics shown in the Table 1 are for field experiment in which there were no agricultural measures applied, and Table 2. for the field experiment in which there was fertilization directly before planting, watering right after the planting and two more times during the first summer and mechanically removing weed three times during the first year of development and once during the second year.
At all three locations, the biggest production of rhizomes was from three years old nursery, and the lowest from the one from the last year, including agrotechnical measures. In the experiment without agrotechnical measures the biggest development of biomass above ground and underground was recorded in Vrsac which was expected considering soil fertility. Namely, at that location, measured content of humus was 1.71% which is significantly more than at other locations (Sadzak 0.60% and Kolubara 0.64%). With the application of agrotechnical measures parameters of Miscanthus development at the experimental field Sadzak are getting close to the values of the experimental field in Vrsac, especially for rhizomes produced from three year plants (Table 2). The results of the experiment in Kolubara show that the Miscanthus development is significantly limited without agrotechnical measures even though the canopy survives in these extreme conditions. With irrigation, fertilization and weed removing, results are becoming comparable with the ones acquired in other locations. All three locations show that rhizomes are mostly viable from over 50% of rhizomes from the nursery at Kolubara to almost 95% for rhizomes produced from three year nursery at Sadzak with measures.

Table 1.*Without agrotechnical measures*

	SADZAK			VRSAC			KOLUBARA	
	III	II	I	III	II	I	II	I
Tillering (nu)	54	36	16	58	38	18	24	8
Clump diameter (cm)	46	40	28	52	34	26	36	24
Whole lenght of rhizome	330	160	110	460	240	90	80	50
Number of rhizomecutings	52	40	24	68	56	32	30	14
Rhizomes survived (%)	88	85	72	90	88	76	66	52

Table 2. *With agricultural measures*

	SADZAK			VRSAC			KOLUBARA	
	III	II	I	III	II	I	II	I
Tillering (nu)	70	52	20	60	38	32	48	24
Clump diameter (cm)	60	54	36	66	50	42	46	30
Whole lenght of rhizome	580	340	220	600	350	180	280	160
Number of rhizome cutings	75	56	32	68	52	30	42	28
rhizomes survived (%)	94	88	80	92	90	86	82	70

Acquired results show that on degraded, swamp soil, as the Sadzak location, yields of viable rhizomes can be almost as the ones on fertile soil (Vrsac). Similar results were also achieved for biomass yield (Dražic, G. et al., 2012) and the possible reason is that the conditions on this site are similar to the natural conditions in which Miscanthus grows (Ji-Hoon Chung et al., 2012), and the raise in temperatures is good for this agroenergetic crop. In a different experiment, monitoring was done on the influence of rhizome size, irrigation, fertilization and weed control on a production of new rhizomes. The production of rhizomes was mostly influenced by the competition with weed not considering the size of primer cutting (Table 3). On the other hand, Primer cuttings that had only two buds produced clumbs with significantly smaller rhizomes that the ones with 4 and 6 buds. Survival of the rhizomes planted in 2012 also depends on the age of nursery and on conditions of development from which the weed vegetation is considered to be the most important negative factor. Similar results were achieved for development of biomass above ground (Dražic, G. et al., 2010).

Table 3. *The number of survived rhizomes*

	1st year			3rd year		
	**2 buds	4 buds	6 buds	2 buds	4 buds	6 buds
*Control	12	24	25	20	52	56
Watering	18	25	25	36	61	68
Fertilizing	14	26	28	40	60	66
Weed control	20	33	35	58	72	80

* without any agricultural measures
** number of buds on rhizomes at planting

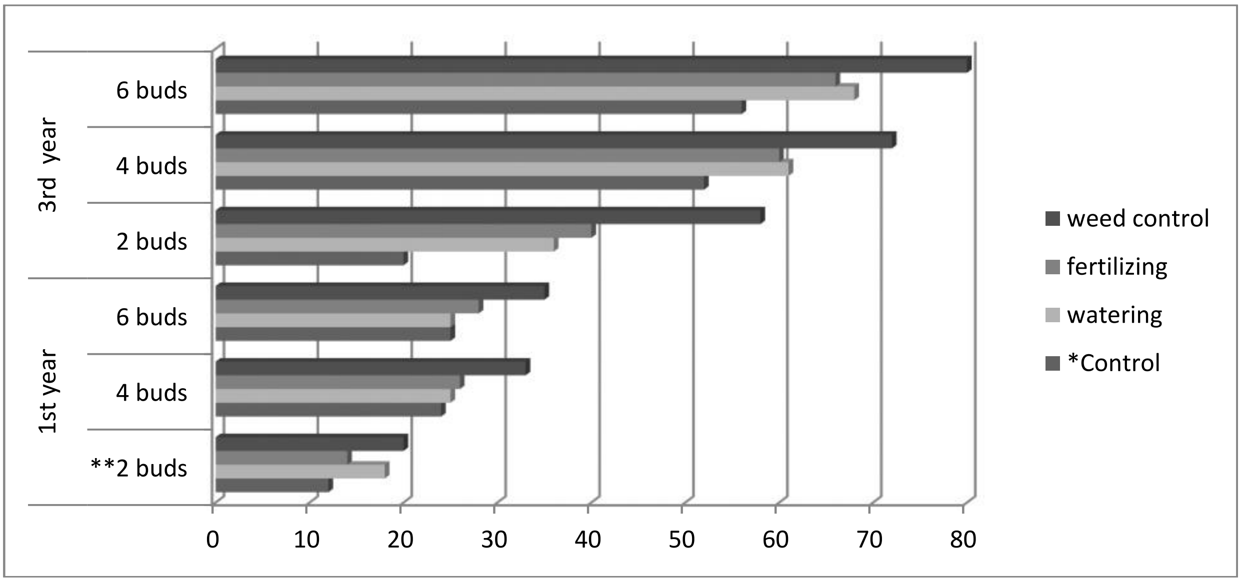

Chart 1. *The number of rhizome cuttings*

Table 4. Survived rhizomes (2012/2013) %

	1st year			3rd year		
	**2 buds	4 buds	6 buds	2 buds	4 buds	6 buds
*Control	32	54	55	64	85	84
Watering	38	55	56	56	90	92
Fertilizing	42	26	78	50	90	92
Weed control	44	78	82	68	94	98

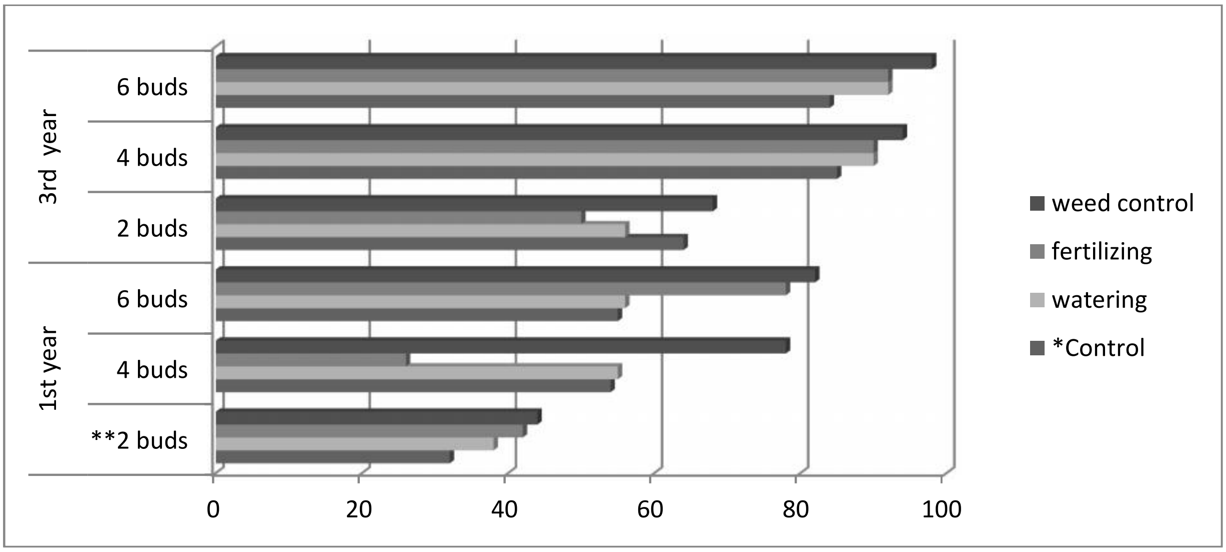

Chart 2. *Survived rhizomes (2012/2013) in %*

At all three locations the competition with weed significantly decreases rhizome yield. Similar results are achieved for biomass above ground (Milovanovic, J. et al., 2012). A large amount of weed (especially at Sadzak and Kolubara sites) is a consequence of the lack of weed control with total pesticide in the year before planting: in Sadzak, before Miscanthus, the soil was used for agricultural purposes with corn and in Kolubara it was a landfill and razastrto before planting. The results achieved at the experimental field Kolubara, even though they refer to only two vegetation show that, even in the bad conditions like these, Miscanthus development is possible, which opens possibilities for further researches for increasing production of underground as well as aboveground parts of the plant.

During the establishing of Miscanthus plantation as a base for bioenergy production chain, the biggest cost is starting plantaza, i.e. acquiring of planting material (Dražic, G. et al., 2010).

The results presented here point out to a possibility of establishing a nursery on relatively small surfaces, from which viable rhizomes could be produced. With a simple calculation (for example for the Sadzak site from a three-year-old nursery from one till that developed from one rhizome, one can get 75 rhizomes, and as 5 rhizomes are planted on a $1m^2$ and the survival rate is 94% one can get 350 viable rhizome cuttings per m^2. If the density of planting Miscanthus is meant for biomass production, 1 rhizome/m^2, i.e. 10 000 rhizomes/ha, it means that less than $30m^2$ of nursery is enough for 1 ha of field. The price of establishing Miscanthus plantation is around 3000 €/ha of which the largest part is a price of the rhizomes of 0,18 €/unit. With this price, the field that lasts 20 years with the average biomass yield of 20 t/ha and production and distribution of biomass briketi for 130 €/t economic analysis show the Return on Capital Employed –ROCE in EUR =447,07 %; Working capital turnover - WCT = 9,82. If there was a nursery production these indicators would be much better.

The results of this research are completely the same as the latest publications: “A review of current propagation options for Miscanthus”[9]. At present the establishment rate of Miscanthusis slow and this appears limited by economics; evidence suggests that the cost of plant propagules is one factor that constrains widespread planting. New techniques are required that simultaneously reduce unit costs of propagules and increase the speed of their availability to aid this developing industry.

Conclusion

In agroecological conditions of the Republic of Serbia it is possible to produce viable rhizomes of Miscanthusgiganteus
Production rate depends on foil fertility and application of agrotechnical measures
It is possible to achieve results on degraded soil close to the ones on fertile soil
The production of planting material of Miscanthus in private nursery significantly reduces the cost of establishing a plantation and in that way the whole production chain becomes economically acceptable

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References

Atkinson, C.J. ,2009, Establishing perennial grass energy crops in the UK: A review of current propagation options for Miscanthus, Biomass and bioenergy 33, 752 – 759
Clifton- Brown, J.C., Lewandowski, I.,2002, Screening Miscanthus genotypes infield trials to optimise biomass yield and quality in southern Germany, European Journal ofAgronomy, Vol. 16(2), 2002, p. 97–110.
Davies MJ, et al.2011,Changes in duration of rhizome cold storage and manipulation of the growing environment to promote field establishment of Miscanthusgiganteus, Biomass and Bioenergy
Dražic, G., Đorđevic, A. Aranđelovic, M., Mitic, N., Babovic, N., 2012, Biomass production in cultivated wetland ecosystems, International Scientific Conference „Forest in Future-Sustainable Use, Risks and Challenges, Oktober 4-5 2012, Proceedings pp 1111-1115
Dražic, G.,Sekulic, S.,Milovanovic, J. Aleksic, J., 2010,Master plan plantaže energetskog useva Miscanthus x giganteus. Energija, ekonomija, ekologija, ISSN 03548651, UDK 620.9, br. 2. pp. 96-99.
Ji-Hoon Chung, Do-Soon Kim, 2012,Miscanthusas a Potential Bioenergy Crop in East Asia J. Crop Sci. Biotech. 2012 (June) 15 (2) :65 ~ 77
Dražic, G., Milovanovic, J., Ikanovic, J., Glamočlija, Đ.,(2010): Uticaj agroekoloških činilaca na produkciju biomase Miscanthus giganteus**,** Arhiv za poljoprivredne nauke, YU ISSN 0354 5695, UDC 63, vol 71, no 253, pp 81-85
Lewandowski, I., Clifton-Brown, J.C., Scurlock, J.M.O., Huisman, W.,2000,Miscanthus: European experience with a novel energy crop. In Biomass and Bioenergy,Vol. 19, 2000, p. 209-227
Milovanovic, J., Dražic, G., Ikanovic, J., Jurekova, Z., Rajkovic, S., 2012, Sustainable production of biomass through Miscanthusgiganteusplantantion development. Annals of Faculty Engineering Hunedoara International Journal of Engineering 10 (1) ISSN 1584-2665, pp 79-82.