University of West Hungary
Faculty of Forestry

PhD Thesis

Economic study of the cultivation and utilization of *Miscanthus sinensis* 'Tatai' "energy reed"

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1. AIMS

We presently exhaust the Earth's resources in order to meet the ever rising human demand and desires and due to globalisation and population rise. The world's energy requirements are impossible to meet today by relying only on fossil fuel. The dramatic decrease of stocks of fossil fuel, air pollution caused by burning fossil fuel are becoming of primary concern, and these issues should be addressed by an increased share of eco-friendly sources of energy in the system of energy consumption. Today and in the future, the renewable energy sector poses the greatest challenges and business opportunities, including the renewal and development of biomass-based energy production. Increasing the security of supply, environmental protection and the need for economic recovery all point in this direction. In its efforts, the European Union (EU) prefers the use of clean and renewable sources of energy. The rate of production of renewable energy is a high-level priority for the energy strategy in Hungary, and the use of fossil fuels must be significantly reduced to achieve this goal. Biomass can be considered the most important energy source in Hungary. To achieve the goals of energy policies of the Community, an ever increasing number of power plants of different capacities in the EU develop new blocks burning energy crops, and this is expected to generate an increased demand for the sources of energy of cultivated biomass, including herbaceous plants used for energy production. To widen the range of raw materials used at biomass plants, the *Miscanthus sinensis* 'Tatai' (MsT) "energy reed" variety bred in Hungary creates a genuine opportunity.

The aim of this thesis is:

- to review the energy policies of the EU and Hungary governing the use of biomass, the international and Hungarian literature in this research topic, to properly delimit the body of research and to assist in the selection of proper research tools and methods,
- to analyse the large-scale industrial breeding technologies of MsT "energy reed",
- to devise the optimum planting technology of MsT and to determine the optimum distance between rows and between plants,
- to analyse the growth properties of MsT "energy reed" and to devise the administration and operation practices of plantations with consideration of expenses,
- to compare the characteristics of the plant under extreme weather conditions with the results published in the international literature,
- to devise the proper, cost-effective harvesting technology of MsT,
- to analyse the economics of the cultivation and utilization of the plant and to create the net present value calculation of the investment of establishing an MsT plantation for use by domestic biomass power plants,
- to make a sensitivity study to determine the transport margin distance of MsT and its energy efficiency.

2. MATERIAL AND METHODS

The author has performed theoretical, experimental, laboratory, data collection and field work in this research project. The field experiments have been practical endeavours mostly, performed by the author in Komárom-Esztergom county at Tata and Ács, in Győr-Moson-Sopron county in the area of Nagyszentjános, on MsT "energy reed" plantations of 2, 3 and 4 years of age at 5 different locations on a total surface area of 50 ha owned by the Komárom-Esztergom Megyei Parképítő és Kertészeti Zrt. (Parképítő Zrt.) and on the premises of Parképítő Zrt. at Tata, with the assistance of the company staff. There were laboratory and greenhouse experiments performed in 2009-2010 at Sopron, at the University of West Hungary (NYME), Faculty of Forestry, EMKI Energetics Department and the NYME Cooperation Centre (and of its Partners), and at Tata, in a greenhouse of Parképítő Zrt.

2.1 METHODS USED IN FIELD EXPERIMENTS

2.1.1 Breeding

For devising the breeding technology of MsT, the author relied on foreign scientific literature, experiments and domestic experience. In a practical research study, the "rootstock separation method" was tested at the greenhouses of Parképítő Zrt. at Tata in 2009 and 2010 and at Ács in 2010. In this experiment, 3-year-old MsT roots were removed from the soil using Hitachi machinery, and split. The rhizomes thus prepared were planted. In a laboratory study, MsT stalks were cut into 10-15 cm long sections. These were put into water tanks, and the sprouted plants were used in a field experiment.

2.1.2 Determining soil preparation and planting technology, optimum distance between rows and plants

The author studied the foreign and domestic scientific literature to determine the soil preparation applied before planting MsT. The soil preparation techniques used before sowing cereals grown in the field in Hungary were used as examples. The soil was prepared using a Kühne M40 4-furrow, suspended, deep plough, pulled by a John Deere 8320 machinery. There have been experiments in planting *Miscanthus* both in Hungary and abroad. For selecting the method, the author relied on the results of domestic experiments and the recommendations of farmers at Ács. A potato planting machine was used for planting pulled by an MTZ-820 tractor.

For determining the optimum distance between rows and plants, the author analysed the distances used in international practice, and then plantations of a surface area of 1, 2, 5 and 7 ha were created with different values for the distance between rows and plants. The author calculated the optimum distances and the number of plants to be planted on an area of 1 ha based on the harvesting yield after 1, 2 and 3 years.

2.1.3 Estimation of yield

To estimate the yield of plantations of different ages and thus at a different level of development, in March / April, prior to harvesting, the author randomly sampled and cut all MsT rootstock on 3 x 10 m^2 areas for each hectare of plantation using a chainsaw. The weight of the harvested plants was measured after drying to 0 % moisture level. The average value for one rootstock was calculated based on the data, and the resulting value was multiplied in function of the plant coverage of the stock by a value in the range of 8.100-9.500 (81-95 % coverage). The author estimated the annual dry matter yield in the above process.

3.2.1.4 Flooding, extreme drought

Due to the unusually high amount of precipitation in the period of 05-06/2010, the author could observe the reaction of the 3 year old, 0.27 ha Mst plantation to long-term immersion to water. The rate of survival of plants was determined by counting the plants. The resistance to drought of plants was tested at the 3 year old 7 ha plantation of Parképítő Zrt. at Pusztaszer in the period of 07-08/2012. 50-60% of the average precipitation of a long period has fallen in the region in this timeframe. The author tested the drought-resistance of the plant by surveying the plantation 4 times and taking samples at randomly assigned plots of 10-10 m^2 for each hectare of the plantation. The author compared the samples and the development rate of plants on the plantation with the development rate of plantations of Parképítő Zrt. at Ács receiving an average rate of precipitation in 2012 and with data on drought resistance of *Miscanthus* species in the international scientific literature.

2.1.5 Harvesting technology

The basic criteria for the MsT harvesting technology was that the “energy reed” harvested from MsT plantations should be provided in a form ready-made for burning by biomass power plants, i.e. to meet the requirements of end-users on form, quality and handling of raw materials used as fuel. Data was collected in the research project to gather information about technologies developed and used for harvesting *Miscanthus sinensis* and *Miscanthus x giganteus* “energy reed” species in different European countries.

The plants were cut using an RZ-2 Z119/Z010 stem crusher pulled by an MTZ-820 tractor. A Class Liner 390 hay rake with propeller shaft was used for windrowing, driven by a Massey Ferguson 5435 machinery. A Krone BigPack HDP high-pressure baling machine was used for preparing rectangular bales pulled by a 270 horsepower (200 kW) John Deere tractor. Round bales were prepared with a Krone F155 round baler, driven and pulled by a Belarus 820.2 tractor. The bales were collected and loaded on trucks using Hitachi, Bobcat and Manitou machines of Parképítő Zrt. The work processes were performed by using leased machinery.

2.2 METHODS USED IN OTHER EXPERIMENTS

2.2.1 Economic analysis

In the economic analysis of MsT cultivation and use, the candidate created 3 groups of the costs connected to plant cultivation. Group (1) comprises costs connected to the reproduction, nursing of propagating material, establishment, weed control and winding-up the plantation at the end of its lifecycle. Group (2) comprises costs of activities connected to maintaining the plantations. Group (3) comprises costs connected to harvesting MsT and transporting it to the end-users (power plants). The author compared the costs in the 3 different groups with the purchase price paid by power plants and available subsidies, which make up group 4 of revenues. The candidate made a net present value (NPV) calculation.

2.2.2 Transport margin distance

Together with the study on the costs of harvesting technologies devised for MsT, the author analysed the logistical costs incurred for transporting the “energy reed” to the biomass power plants, and he compared these costs with the current purchase price paid by power plants. The price per transport km, the transport distance by road from the location of cultivation of the biomass to the end user, and the amount of fuel stock which can be transported by a 24 t carrying capacity truck in one round were the data parameters used, and the author calculated the transport distance, in case of which the MsT bales can still be transported economically to the end user based on the variation of the above data and analysis of supplier costs based on different distance values and quantities.

2.2.3 Energy efficiency

In the analysis of energy efficiency of MsT, the candidate compared the amount of energy of the “energy reed” recovered after burning by power plants to the total amount energy required for its production, that is, the total value of energy required for biomass planting, harvesting, logistics and own consumption. In this study, the author distinguished the different operations, and calculated the energy input of these operations based on the primary energy carriers. He documented the amount of diesel fuel consumption of machinery and he determined the total calorific value (MJ) of the processes. Data was collected in the research project to acquire information about the energy flux of technologies developed and used for harvesting *Miscanthus sinensis* and *Miscanthus x giganteus* energy reed species in different European countries.

3. RESULTS AND EVALUATION

The author monitored the development of plots planted with propagating material produced using the method of cutting into rhizomes for 2 years. The plant coverage exceeded 90% in the second year after planting. Strong propagating material can be produced using this method, which is inexpensive if using the large-scale industrial roll-out of this solution, and this can be a real benefit as compared to more expensive breeding technologies based on micro-breeding.

The seedlings produced by cutting the stem can be planted in the field in 2 months after propagation, and the author investigated their growth at Kópháza and Ács. The plants grew to a height of 120 cm after 3-4 months, their stems were well developed, strong and of a fresh green colour. Propagating material is produced in a lengthy process using this method. Large-scale industrial use of this method is presently not feasible and not recommended.

For planting MsT, in experiments to determine the optimum distance between rows and between plants, the candidate found that, planting 10.000 MsT plants or 12.000 rhizomes is optimum for 1 ha of arable land, in a grid of 1 m x 1 m or ~ 1 m x 0.8 m respectively. Using a higher number of plants and a more dense planting grid is not justified, because the plant stock closes in after year 3-4, and it is physically incapable of getting thicker and denser due to the lack of space. Having a distance between rows of 1.5-2 m and a distance between plants of 1-2m is not recommended, because it causes an unreasonable low space utilisation and it also lets weeds flourish. Planting MsT propagating material is ideal if the soil temperature is above 10 °C at the planting depth. A 4-person potato planting machine was used for planting, pulled by an MTZ-820 machine. Based on the experiments, the author concluded that in the warm summer period (after May) and in late autumn (after October) planting MsT plants or rhizomes is not recommended due to the possible drought or frost damage.

The results of yield estimations of MsT plantations differed significantly from the data of foreign scientific literature concerning the dry-matter content of biomass harvested from a 1 ha *Miscanthus* plantation and they also differed from the actual quantities harvested due to the lack of homogeneity of different plantations. The difference between the estimated and actual yield was up to 600% in case of the 2 ha plot in Nagyszentjános in 2010. The yield forecast based on counting the rootstock does not give reliable data on the actual biomass yield in the respective year.

As a result of devising the MsT harvesting technologies, the harvesting procedure of the "energy reed" consists of the following work processes: crushing the plant, windrowing the crushed reed spread on the field and baling, followed by logistical operations, that is removing the tied-up bales from the field and loading them on trucks, and then transporting the bales to the end-user of the biomass. For harvesting, the plant stems were crushed using an RZ-2 Z119/010 stem crusher driven by an MTZ-820 machinery. A Class Liner 390 hay rake with propeller shaft was used for windrowing driven by a Massey Ferguson 5435 machinery. Rectangular and round bales of MsT were prepared. Domestic power plants using biomass fuel prefer rectangular bales (these are significantly more simple to handle, transport and reposition as compared to round bales) and using the Krone BigPack 1290 HDP high-pressure baler driven by a 270 horsepower (200 kW) John Deere tractor proved a good solution. The harvesting method developed at Tata was determined based on the requirements of the end-user power plants concerning the form, quality and handling of fuel stock and the types of machinery available in domestic agricultural practices. With the above solution, a wellfunctioning solution was created for burning the biomass produced at domestic plantations of "energy reed" in the boilers of different power plants.

MsT can handle flooding / persistent immersion in water well, if its leaves can reach above the water level. There are high chances for the survival of the plant in these conditions. If the water level exceeds the height of the plant in the field and the plant is therefore completely immersed in water, the chances of survival decrease drastically and this condition can even lead to the destruction of the entire plant stock. Abnormally dry weather has a serious adverse effect on the growth of MsT shoots which start growing in spring. The growth of the "energy reed" slows down significantly. In the weather condition without any rain experienced at Pusztaszer, the growth and development of MsT plants decreased to approximately 45% of the rate experienced under normal conditions.

The profit generated by the sale of the plant is highly sensitive to the weight of the bales, to the transport distance, to the purchase price and to the yield per 1 hectare arable land. The results of the net present value calculation based on diverse sets of conditions support the conclusion that the cultivation and use of MsT "energy reed" can be profitable under the investigated conditions, and therefore funding MsT plantations can be a profitable business endeavour. The initial high investment costs can be recovered after harvesting in the 6th year and from this moment, the plant generates revenue to the farmer for 14-19 years with maintenance works at very low costs. The net present value of the cash flow of the investment increases significantly with the weight of MsT bales, the purchase price and with the yield harvested on 1 ha cultivated land and with the decrease of the transport distance.

MsT has a transport margin distance of 250 km by road (one way) based on 400 kg bales, 12 t/ha biomass yield and HUF 270/km transport fee. The author concluded that the transport margin distance of 250 km for MsT is highly sensitive to the variation of the price per transport km, the weight of the bales prepared and the purchase price of the biomass at the power plant. The transport reach can be extended using several methods, and their development and implementation depend mostly on external market conditions.

If using the "energy reed" by a power plant at a boiler energy efficiency of 85 % (in the 5-20 MW_{th} capacity range) and with heat loss of 10 % caused by the pipe distance, 163.404 MJ thermal energy can be generated by burning the biomass produced from 1 ha "energy reed" plantation. Based on the E_{inp}/E_{out} ratio, MsT has an energy efficiency of 1 to 55, with the following conditions: 400 kg bales, 12 t/ha biomass yield, HUF 270/km transport fee and 120 km transport distance. With these conditions, 55 times the energy required for producing the plant can be recovered by burning it. The author could not find any publication with similar results in the international literature. The energetic efficiency of MsT was influenced significantly by the quantity of biomass harvested from the plantations (t/ha) and the transport distance (km). Using less machinery based on combined harvesting technologies causes a reduction of diesel fuel, and this can reduce the amount of energy input into the entire process.

4. NEW SCIENTIFIC RESULTS (THESES)

1. Strong propagating material can be produced by removing the 3 year old MsT rootstock at the appropriate development stage and separating the rhizomes and this propagating material can be planted in the field in 1-2 days after removal. The plantation produced using this method can have a very high budding rate of over 85 %. Using the method of cutting up rhizomes and by its large-scale industrial roll-out, inexpensive propagating material can be created, and this can be a real benefit as compared to more expensive breeding technologies based on micro-breeding despite the fact that *Miscanthus* propagating material is presently produced most efficiently by micro-breeding in in-vitro culture systems (integration of biotechnological systems). Based on experience in the first 2 years from plantation of plants, we can state that the development rate, strength and establishment of the plantation created from plants is higher than that of plantations of rhizomes, this difference, however, ceases from year 3-4 with the closure of the plant stock.

2. We can state that planting 10.000 MsT plants or 12.000 rhizomes is recommended for 1 ha arable land in a planting grid of 1 m x 1 m or ~ 1 m x 0.8 m respectively. Using a higher number of plants and a more dense planting grid is not justified, because the plant stock closes in after year 3-4, and it is physically incapable of getting thicker and denser due to the lack of space. Having a distance between rows of 1.5-2 m and a distance between plants of 1-2 m is not recommended, because it causes an unreasonable low space utilisation and it also lets weeds flourish. A method of splitting rootstock was devised to supplement the dead roots in MsT plantations. A low number of good quality propagating material can be generated with the rootstock splitting method. The resulting half-roots should be used to replenish plant stocks in plantations, where there is only a small number of plants missing, i.e. the plantation has a high rate of living plants of over 90 %. A sprouting rate of 94 % can be achieved using this method.

3. On the flood resistance of MsT, we can conclude that MsT can handle flooding / persistent immersion in water well, if its leaves can reach above the water level. In these conditions, there is a high chance of survival of the “energy reed” even in case of immersion for 1-2 months. If the water level exceeds the height of the plant in the field and the plant is therefore completely immersed in water, the chances of survival decrease drastically and this condition can even lead to the destruction of the entire plant stock. Based on observations on the drought resistance of the plant, we can state that abnormally dry weather and low level precipitation of 200-250 mm falling by the end of summer (January-August) have a serious adverse effect on the growth of MsT shoots which start growing in spring. In these conditions, the growth and development of MsT can decrease to 45% of the rate found under average conditions.

4. Given a lifecycle of 20 years of the plant, 120 km transport distance and 400 kg rectangular bales, HUF 270/km transport fee and HUF 15.000/t purchase price, the results of net present value calculation prove that it can be economically viable to invest in the creation of an MsT plantation and cultivation of the plant, i.e. cultivation and use of the MsT “energy reed” can be a profitable business venture under the conditions analysed in the thesis. The net present value of the cash flow of the investment creating the plantations increases significantly with the weight of MsT bales, the purchase price and with the yield harvested from 1 ha cultivated land and with the decrease of the transport distance.

The sensitivity analysis showed that the transport margin distance for MsT is sensitive to the variation of price per transport km, the weight of the bales prepared and the purchase price of biomass by the power plant. MsT has a transport margin distance of 250 km by road using 400 kg bales, HUF 270/km transport fee and HUF 15.000/t purchase price at the power plant. The transport reach can be extended using several methods and their development and implementation depend mostly on external market conditions.

When burning the biomass resulting from 1 ha MsT plantation in a power plant at a boiler energy efficiency of 85 % (in the 5-20 MW_{th} capacity range) and with heat loss of 10 % caused by the pipe distance, 163.404 MJ thermal energy can be generated. The energy used for harvesting the plant and the energy produced by the plant (E_{inp}/E_{out}), MsT has an energetic efficiency of 1 to 55, with the following conditions: 400 kg bales, 12 t/ha biomass yield, HUF 270/km transport fee and 120 km transport distance, that is 55 times the energy needed for producing the plant can be recovered by burning the plant in a power plant. The energetic efficiency of MsT was influenced significantly by the quantity of biomass harvested from the plantations (t/ha) and the transport distance (km).

5. PRACTICAL APPLICABILITY OF THE RESULTS

By removing from the soil and cutting up MsT rootstock, i.e. using the "rhizome separation" method, inexpensive propagating material can be created with the large-scale industrial roll-out of this solution, and this can be a real benefit as compared to more expensive breeding technologies based on micro-breeding.

MsT should be planted in the future in a grid of 1 m x 1 m using 10.000 plants per hectare or in a grid of ~ 1 m x 0.8 m using 12.000 rhizomes per hectare, because having a distance between rows of 1.5-2 m and a distance between plants of 1-2 m causes an unreasonable low space utilisation and it also lets weeds flourish.

Using the harvesting method of "energy reed" developed at Tata in 2009-2012, the biomass produced by domestic MsT plantations can be burnt in the boilers of different power plants, because the MsT bales resulting from this procedure comply with the requirements on quality, form and handling of the fuel stock burnt by end-users (power plants). The solution is not really modern in international comparison, however, using it in Hungary can create a smooth process of harvesting biomass from MsT plantations and it can generate profit.

MsT can be promoted and spread in Hungary because the initial high investment costs can be recovered after harvesting in the 6th year and from this moment, the plantation generates revenue to the farmer for 14-19 years with maintenance works at a very low cost. The profit generated by the sale of biomass can be increased with the application of a single-process, faster harvesting method and using more modern high-pressure (HDP II) baling machines. The high transport margin distance of the biomass also supports cultivation efforts of this plant, and this range can be extended with the increase of the bale weight and the latter results in a higher energetic efficiency of using MsT by power plants.

6. PUBLICATIONS

Publications in magazines, conference volumes

PINTÉR, CS.: Presentation of the harvesting method of the *Miscanthus sinensis* 'Tatai' "energy reed" bred in Hungary for use at biomass power plants. Acta Agraria Debreceniensis. Agrártudományi Közlemények, 2016/69.: p. 143-150. HU-ISSN 1587-1282. www.agr.unideb.hu/acta

PINTÉR, CS.: Economic study of the harvesting technology of the *Miscanthus sinensis* 'Tatai' "energy reed". Energy in daily life, Competition and Coference, Debrecen, 2015. Conference volume: pp. 73-81. ISBN: 978-615-5212-33-8.

MAROSVÖLGYI, B. – **PINTÉR, CS.:** Economic study of the harvesting of the *Miscanthus sinensis* 'Tatai' "energy reed". University of West Hungary, Faculty of Forestry, 5th Scientific Conference of the Faculty, Sopron, 2015. Conference volume: pp. 127-131.

PINTÉR, CS.: The energy reed of Tata. Hungarian Agriculture, Vol. 70, 15 April 2015: pp. 36-38.

PINTÉR, CS. – HORVÁTH, ZS. – MAROSVÖLGYI, B.: Cultivation and use of the domestic energy reed (*Miscanthus*). Environmental Research 2008-2012. Results of research study of the University of West Hungary, Research Centre Non-profit Ltd., Sopron, 2012. Closing volume: pp. 85-89.

HORVÁTH, ZS. – VÁGVÖLGYI, A. – **PINTÉR, CS.** – MAROSVÖLGYI, B.: Examination of the possibilities of *Miscanthus* 'Halmaji' energy reed reproductive material production. Hungarian Academy of Sciences, Department of Agriculture, Agricultural Mechanical Commission, Research and Development Council, No. 34., Gödöllő, 2010. Conference volume: pp. 25.

HORVÁTH ZS. – **PINTÉR CS.** – VÁGVÖLGYI A. – MAROSVÖLGYI B.: Examination of the flood resistance of miscanthus sinensis 'tatai'and 'halmaji' energy plant. IV. National Conference on Forestry Machinery. Scientific Council on the occasion of Dr. h.c. Dr. Jenő Kovács professor's 80th birthday, Sopron, 9-10 September 2010: p. 59-62.

HORVÁTH, ZS. – VÁGVÖLGYI, A. – **PINTÉR, CS.** – MAROSVÖLGYI, B.: Analysis of the production of new propagating material of the *Miscanthus* Halmaji energy reed. Agricultural Technology, Special Edition, Sustainable bioenergy production, "young researchers in biotechnology", Vol. LI, Gödöllő, January 2010: pp. 11-12.

HORVÁTH, ZS. – MAROSVÖLGYI, B. – **PINTÉR, CS.**: Analysis of the production of new propagating material of the *Miscanthus* and *Arundo* energy plants. University of West Hungary, Faculty of Forestry, Scientific Conference of the Faculty, Sopron, 2009. Conference volume: pp. 52-56.

PINTÉR, CS. – VÁGVÖLGYI, A. – HORVÁTH, ZS. – MAROSVÖLGYI, B.: Analysis of the production of new propagating material of the *Miscanthus sinensis* energy plant. Association for Forests of the Lowlands, Research Day, Scientific Results in Practices, Nyíradony-Gúthpuszta, 2009. Conference volume: pp. 89-93.

PINTÉR, CS. – VÁGVÖLGYI, A. – HORVÁTH, ZS. – MAROSVÖLGYI, B.: Analysis of the production of new propagating material of the Miscanthus sinensis energy plant. E-science, Green special volume: Focusing on biomass, 2009.: pp. II - 1-5.

Presentations

PINTÉR, CS.: The energetic efficiency of *Miscanthus sinensis* 'Tatai' "energy reed" bred in Hungary used at biomass power plants in Hungary. Energy in Daily Life, Scientific Competition, Debrecen, 12 March 2016, 12 Sl. (ppt.)

PINTÉR, CS.: Economic study of the harvesting technology of Miscanthus sinensis 'Tatai' "energy reed". Energy in Daily Life, Competition and Coference, Debrecen, 13 March 2015, 14 Sl. (ppt.)

PINTÉR, CS. – MAROSVÖLGYI, B.: Research and their results to increase sources of lignocellulose used as sources of energy. University of West Hungary, Research Centre Non-profit Ltd., Closing Conference, 2011, 17 Sl. (ppt.)

PINTÉR, CS.: Production experience of the *Miscanthus sinensis* 'Tatai' "energy reed" developed in collaboration with Parképítő Zrt. XIV. Biomass and Eco-energetics Conference, Sopron, 3-5 May 2010, 31 Sl. (ppt.)

PINTÉR, CS.: Production experience of the *Miscanthus sinensis* 'Tatai' "energy reed" developed in collaboration with Parképítő Zrt. *Miscanthus* cultivation and use, international R&D project, Tata, 11 December 2009, 31 Sl. (ppt.)

PINTÉR, CS.: Production experience of the *Miscanthus sinensis* 'Tatai' "energy reed" developed in collaboration with Parképítő Zrt. Pécs, MTA Conference, 13 October 2009, 31 Sl. (ppt.)

Posters

MAROSVÖLGYI, B. – **PINTÉR, CS.:** Economic study of the harvesting of *Miscanthus sinensis* 'Tatai' "energy reed". University of West Hungary, Faculty of Forestry, 5th Scientific Conference of the Faculty, Sopron, 2015. Poster

MAROSVÖLGYI, B. – **PINTÉR, CS.:** Energetic Utilisation of energy reed (*Miscanthus* Sp.). University of West Hungary, KKK, Sopron, 2010. Poster

MAROSVÖLGYI, B. – **PINTÉR, CS.:** Energetic Utilisation of energy reed (*Miscanthus* Sp.). Gyöngyös, 18 May 2010, 1. Poster