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THE NATURAL AND TECHNICAL RESOURCES OF BOTANICAL GARDEN OF PBAI IN BYDGOSZCZ AS A BASIS FOR RENEWABLE ENERGY EDUCATION

Włodzimierz MAJTKOWSKI, Gabriela MAJTKOWSKA

Botanical Garden of Plant Breeding & Acclimatization Institute, Jeździecka St. 5, 85-687 Bydgoszcz, Poland, e-mail: obihar@onet.pl

INTRODUCTION

Plant collections in The Botanical Garden of Plant Breeding and Acclimatization Institute (PBAI) in Bydgoszcz are closely connected with scientific activity, co-ordinated by The National Centre for Plant Genetic Resources of PBAI in Radzików near Warszawa. Since 1971 the main scientific activity has concentrated on the collection, evaluation and preservation of grass genetic resources. It is framed in ECP/GR (European Cooperative Programme for Crop Genetic Resources Networks) co-ordinated by IPGRI (International Plant Genetic Resources Institute) in Rome. Since 1994 genetic resources activities have been spread over species for energetic purposes. The above collection consists of popular plant species, usually cultivated for combustion purposes: *Salix* sp. (willow), *Sida hermaphrodita, Miscanthus giganteus* and other species of potential suitability for cultivation on large areas, i.e. *Silphium perfoliatum, Helianthus tuberosus, Reynoutria japonica*, perennial grasses as: *Andropogon gerardi* (big blustem), *Panicum virgatum* (switch grass), *Spartina pectinata* (praire cord grass). At the end of 2003 Botanical Garden of PBAI was granted from National Fund for Environmental Protection and Water Management to establish energy plant for biomass (wooden chips) combustion. Despite the obvious advantages of ecological (reduction of sulphur emission) and economic nature, on the basis of new energy plant it will be possible to measure quality parameters of biomass from different plant species. Owing to that new possibilities will emerge such as, for example, the project of didactic route explaining the way from plant (collection of energetic species) to final energy production.

COLLECTION OF PLANTS FOR ENERGETIC PURPOSES

I. Woody plants of short field rotation

The above term refers to the hard wood plantation, fast growing at the initial phases of plant development, capable of reproduction by seedlings or cuttings (i.e. willow *Salix* sp., poplar *Populus* sp. and eucalyptus *Eucalyptus* sp. – mainly in Mediterranean countries).

Willow (*Salix* sp.) – materials in collection originated from:

– University in Olsztyn – 21 clones (of energetic, wicker and medicinal purposes),
– Agrobränsle (Svalöv, Sweden) – 7 energetic varieties ((GUDRUN, KARIN, OLOF, SVEN, TORA, TORDIS, TORHILD).

New clones of basket willow (*Salix viminalis* L.) and its crosses from Olsztyn University, evaluated in experiments conducted on semi-hydrogenic soils, yielded 15 tons of dry matter /ha/year (Stolarski 2003). The energetic value of basket willow wood was affected by the production regime of plantation (Tab. 1).

II. Perennial dicotyledonous plants

Jerusalem artichoke (*Helianthus tuberosus* L.) – perennial plant originating from North America, from *Asteraceae* family. Stems reach 3 cm in diameter and grow to 2–4 m. Underground stolons have bulbs on the ends like potato. The advantages of artichoke are: high yields (stems – 10–20 t of d.m./ha/year and bulbs – up to 40 t/ha/year), low habitat requirements (Góral 1999). The energetic raw materials are: bulbs, for production of ethanol or biogas, and stems, for direct combustion or production of pellets and briquettes. The calorific value of artichoke biomass with 20% of mois-

Table 1. Yield and principal parameters of wood from willow plantation

Trait	The frequency of stem cutting		
	every year	once 2 years	once 3 years
Fresh wood yield (t/ha)	28,2	65,0	140,0
Wood moisture (%)	52,86	49,62	46,05
Dry matter yield (t/ha)	14,9	32,2	64,8
Total dry wood yield (t/ha/year)	14,9	16,1	21,6
Calorific value of d.m. (MJ/kg)	18,55	19,25	19,56
Yield energetic value (GJ/ha)	276,4	619,8	1267,5
Ash (%)	1,89	1,37	1,28

ture content equals 15 MJ/kg. Other ways the artichoke could be used are recultivation of post-industrial areas and protection of arable fields against wild animals.

Virginia-mallow (*Sida hermaphrodita* Rusby) – perennial species from *Malvaceae* family, orginating from south regions of North America. Previous research proved a possibility of virginia-mallow utilisation as pasture, medicinal, fibre or honey plant as well as for paper pulp production (Borkowska et al. 1994). During the last years this species has become interesting as energetic plant. It is quite suitable for perennial energetic plantations (up to 20 years of usage) for it produces strong tussocks with stems up to 3 m. Harvest takes place when vegetation season is over and natural stems have dried down. Total aboveground biomass yield (20–25% m.c.) could be 20–25 t/ha. The calorific value – 15 MJ/kg. The advantages of mallow are: suitability for cultivation on hydrogenic, alluvial and deluvial soils and easy propagation by seed or tussock fragmentation.

Cupplant (*Silphium perfoliatum* L.) – perennial species from *Asteraceae* family, originating from central regions of North America. It is accepted as a valuable honey, medicinal, pasture (high protein and carbohydrates content) and decorative plant. Due to its low nutrient requirements it is recommended as a pioneer species for recultivation of waste areas (Weryszko-Chmielewska et al. 1999). Stems of cupplant reach 2.5 m. Energetic plantation should be developed during autumn (X-XI) by seed sowing in rows of 1 m distance. After 3–4 years yields could reach ca. 19 t of d.m./ha.

Japanese and giant knotweed (*Reynoutria japonica* Houtt. and *R. sachalinensis* Nakai), both species are perennials from *Polygonaceae* family originating from East Asia. They were introduced to Europe in the first half of 19th century as decorative plants. They are planted for stabilisation of dunes and slopes (for instance in the Silesian region) and also as pasture plants for wild animals (in Czech Republic). They easily run wild due to long stolons (up to 5–6 m) or seeds and grow in dense clusters, hard to root out. In climatic conditions of Poland they begin to vegetate rather late – late April/early May. They grow very fast and reach 2–4 m of height. They finish vegetation with the first autumn frost (Majtkowski et al. 1996). Considering high growth dynamics and low environmental requirements this species should be paid more attention to geneticists and breeders.

III. Perennial C-4 grass species

Intensive production of biomass is typical for C_4 grass species. Such metabolism could be easily found in grass species from Asia (China, Japan) and North America. Differences in anatomical structure of assimilation organs are the effect of adaptation to effective CO_2 fixation in xerophytic conditions (reduced moisture, high temperature and insolation). What should be strongly emphasised is several times less ash content after C_4 grass (*Andropogon gerardi* Vitm., *Miscanthus sinensis* Anderss., *Panicum virgatum* L., *Spartina pectinata* Bosc. ex Link) straw combustion as compared to corn straw or other perennial C_3 grasses: *Phalaris arundinacea* L., *Phragmites australis* (Cav.) Trin. ex Steud. Straw from C_4 grasses is therefore of the same quality as biomass from wood plantation (Tab. 2).

Table 2. Comparision of ash content after C_4 and C_3 grass straw combustion

Species	Photosynthesis type	Ash content [% d.m.]
Spartina pectinata	C_4	1,6
Panicum virgatum	C_4	1,7
Andropogon gerardi	C_4	1,7
Miscanthus sinensis	C_4	2,0
Phalaris arundinacea	C_3	6,3
Phragmites communis	C_3	7,5
Triticum	C_3	11,1

Giant Chinese silver grass (*Miscanthus x giganteus* Greef et Deuter), is a large bunch grass, penetrating soil down to 2.5 m with strong roots. It produces thick, 200–350 cm long, stiff stems, filled with porous pith. The average yield from several-year-old plantation is above 20 t of biomass per ha (20% moisture). The calorific value of such material ranges from 14 to 17 MJ/kg. In Polish climatic conditions there are some critical moments concerning young seedlings, i.e. low temperature susceptibility in the first year of cultivation. Therefore it is recommended to protect new plantations against frost (i.e. by mulching). Due to high cellulose and lignin content miscant biomass is valuable raw material (mainly in Germany) in building staff production (i.e. isolation, light boards and floors, asbestos substitute), cellulose and paper industry (packages, technical paper, cardboard etc.) and agriculture (recyclable pots or pallets).

WOOD CHIPS-FIRED BOILER HOUSE (POWER – 450 KW) – EXPERIMENTAL AND EDUCATIONAL INSTALLATION

The modernisation of 27 years old coke-fired boiler house in The Botanical Garden of Plant Breeding and Acclimatization Institute in Bydgoszcz was finished in July of 2004. Two boilers (type ECA IV) produced in 1977 were replaced by two automatic wood-chips fired boilers (2 x 200 kW), produced by HDG Bavaria (Germany) and one hand loaded biomass-fired boiler (50 kW) which was equipped to measure calorific values of plants from collections. Mentioned modernisation was co-financed by PBAI and National Fund for Environmental Protection and Water Management in Warsaw. Boiler house will act as education place, to explain the complete way from plant collection to its energetic application.

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