Preliminary Research On Short Cycle Poplar Clones For Bioenergy Production

*Laurentiu FARA, lfara@renerg.pub.ro , Polytechnic University of Bucharest (UPB)
Mihai FILAT, filatmihai@yahoo.com , Forest Research and Arrangement Institute (ICAS)
Danut CHIRA chira@rdsbv.ro, Forest Research and Management Institute (ICAS)
Silvian FARA, sfara@ipa.ro , Research and Design Institute for Automation (IPA)
Cornelia NUTESCU, cornelia.nutescu@inl.ro, National Institute for Wood (INL)

Abstract

The paper is dedicated to preliminary research results obtained within a national project concerning the introduction of specialized short cycle poplar clones plantations for biomass production for heating and obtaining of bioethanol. The results are very encouraging, the poplars displaying very good adaptive qualities in paedoclimatic conditions in the Danube Delta area, as well as an excellent growth rate in the first year of the experiment. The paper discusses the main aspects to be considered in the next stages of the project to characterize the combustion process of wood biomass based on poplar clones cultures, as well as the characteristics of bioethanol obtained from these cultures.

Keywords: poplar clones, short rotation, bioenergy, bioethanol

Introduction

Various studies have shown that short-cycle energy plantations may represent a valuable source of biomass with multiple uses. The performance of these products is linked, in many cases, to the quality of the vegetal varieties employed, which, in its turn, is determined by the adaptability to paedoclimatic conditions and by the technology used (Laureysens et al., 2004).

Three Romanian research institutes (ICAS, IPA, INL) and one Romanian university (UPB) together with a scientific consultant from Italy (Alasia New Clones) have assessed the possibilities of introducing specialized poplar plantations in the energy industry, having considered the fact that the wood of rapidly-growing species, with a high capacity of vegetative multiplication, has become of foremost importance, due to its becoming accessible for various uses. This approach was considered for a research national project to be developed in the period 2008-2011 (PLEN Research National Project Proposal, 2008). The project mainly entails the completion of the growing stage under different local conditions, specific to the eco-regions in our country, of certain rapidly-growing clones of poplars, with a production cycle of two, and five years respectively. On the basis of numerous analyses and assessments, clones with superior technological characteristics will be created and their optimal uses will be determined. The initial phase of this research will focus on the technique of growing high bio-accumulation capacity currently existing in Romania or imported, in various experiments located on forest or farm land. Six locations are considered for poplar clone cultures of two to five years rotation. Meanwhile, the physical-mechanical properties for each tested clone will be closely analyzed, then pursuing the vegetative multiplication of efficient species (more productive or with superior energy properties).

Poplar and willow plantations are generally the only solution to value Danube artificial holms. A group of ten hybrid poplar clones has shown good production and resistance for this site. National Forest Administration (ROMSILVA) generally used only two clones (I 214 and

Sacrau 79), which have the highest productivity (wood for veneer or cellulose) in Danube holms and delta (Clonaru, 1967; Ocskay 1971; Iliescu et al., 1993; Filat and Chira, 2004).
Hybrid poplars are more and more used in renewable energy plantations, in short rotations (2-5 years) (Benea et al., 1986). Romanian forest administration is interested to find the most efficient poplar clones for biomass production in Danube meadows, river sides and other proper site conditions, as well as to test the methods and harvesting technology for these special bio energy plantations.

At the same time an important objective of this research will be to characterize the combustion process and bioethanol obtained on this basis (Fara et al., 2008).

Method

Four Italian poplar clones, specially selected for their high bioenergy production have been tested for the first time in Romania. Two clones, already in use in the Danube area, have also been included in the first experiment (Table 1).

Table 1: Types of poplar clones present in Nufaru test plot

No.	Clone	Source
1	AF 2	Alasia New Clones – Italy
2	AF 6	Alasia New Clones – Italy
3	AF 8	Alasia New Clones – Italy
4	Monviso	Alasia New Clones – Italy
5	Turcoaia	Forest Research and Management Institute – Romania
6	Sacrau 79	Forest Research and Management Institute – Romania

The first test began in the spring of 2008, in the proximity of the Danube Delta (Nufaru Nursery, Tulcea Forest District), which is an area protected against flooding. Like on any other former lake (swamp) bottom, soil texture is heavy (silty-clayey to clayey till 90-120 cm depth) and phreatic water level varies between 1.5 and 2.0 m depth during vegetation, in normal seasons.

The experimental plot has random blocks, each consisting of three repetitions with 18-28 plants per unit parcel and three density variants:

- 5555 plants/ha (1.5 m between rows x 1.2 m between plants);
- 6666 plants/ha (1.5 m x 1.0 m);
- 9523 plants/ha (1.5 m x 0.7 m).

30 cm long and 15 - 25 mm in diameter cuttings, with minimum three viable buds, have been planted in spring after autumn soil ploughing (strong winter frost improves ploughed soil physical features). Till now Romanian practical guides advised that the cuttings should be planted completely covered by soil, but in this experiment the first 5 cm of cutting remains above the soil. Planting space has been adapted both to equipment size (used to prepare the soil surface and to control the weeds) and to ensure the proper culture density.

In the first vegetation season, plant survival, growth rate and sensitivity to foliar disease have been recorded. Plant survival has been measured based on mortality rate of cuttings (spring) and plants (end of the first season).

Clone resistance to foliar diseases has been evaluated in autumn. Intensity scale (Colin, 1999): 0 (immune) – no infections; 1 (very low) – some uredosorus/plant; 2 (low) – some uredosorus /leaf; 3 (moderate) – many uredosorus on majority of leaf (sensitivity level); 4 (high) – leaf covered by uredosorus, many leaves are browning; 5 (very high) – generally dead leaves.

Results

Plant survival in the first year has been very good with no significant difference between clones being recorded (Fig. 1). Cuttings mortality has varied between 0% (AF2 in density variant 1, Monviso, Sacrau 79 and Turcoaia in density variant 2) and 9% (AF8 in density variant 2). All the plants (100%) have survived in the vegetation season, the six clones proving to be well adapted to the particular Danube site condition and culture methodology (soil preparation before and after planting, irrigation) (Table 2).

The height graphic in the first vegetation season (Fig. 2) shows a high increment rate, from June to end of September, on all variants, but it also shows that the new energetic Italian clones have better results than local ones.

Table 2: Clone survival and biometric characteristics after one year in nursery biomass experimental plot of Nufaru, 2008

Clone	Number of cuttings	Cutting survival (%)	Plant survival (%)	Height (cm)		Diameter (mm)	
				Max.	Med.	Max.	Med.
Variant 1 – 5555 plants/ha (1.5 x 1.2 m)							
AF 2	72	100	100	355	**300**	43	**27**
Monviso	72	99	100	360	277	40	23
AF 6	72	99	100	365	281	33	23
AF 8	72	90	100	**370**	281	**48**	24
Sacrau 79	72	99	100	330	263	30	20
Turcoaia	72	97	100	290	216	25	19
Average V1		**97.33**	**100.00**	**345.00**	**269.67**	**36.50**	**22.67**
Variant 2 – 6666 plants/ha (1.5 x 1.0 m)							
AF 2	66	98	100	360	**313**	**38**	**28**
Monviso	66	100	100	**400**	**313**	**38**	26
AF 6	66	98	100	**400**	295	37	25
AF 8	66	91	100	370	288	35	23
Sacrau 79	66	100	100	365	282	34	21
Turcoaia	66	100	100	300	244	27	20
Average V2		**97.83**	**100.00**	**365.83**	**289.17**	**34.83**	**23.83**
Variant 3 – 9523 plants/ha (1.5 x 0.7 m)							
AF 2	84	99	100	420	371	**43**	**31**
Monviso	84	100	100	**470**	**384**	42	30
AF 6	84	99	100	415	336	38	29
AF 8	84	98	100	125	367	42	30
Sacrau 79	84	100	100	425	335	42	24
Turcoaia	84	98	100	395	326	35	24
Average V3		**99.00**	**100.00**	**375.00**	**353.17**	**40.33**	**28.00**
Average V1,V2,V3		***98.06***	***100.00***	***361.94***	***304.00***	***37.22***	***24.83***

Italian energetic clones have proved higher productivity in all variants, in contrast to local (control) ones (Fig. 3, Table 2). AF2 and Monviso have been the best of variants, but the differences from AF8 and AF6 have been insignificant.

Clone resistance / sensitivity to foliar disease (rusts - *Mellampsora* ssp. and black spot disease - *Marssonina brunnea*) have varied as follows (Table 3):
- Monviso and AF6 are immune to rusts and relative resistant to black spot;
- AF2 and AF 8 are relative resistant to rusts and almost immune to black spot;
- local clones have similar moderate sensitivity to rusts.

Table 3: Poplar clone resistance to rusts (Mellampsora ssp.) and black spot (Marssonina brunnea)

Clone	***Mellampsora* ssp.**				***Marssonina brunnea***	
	S	**I**	**Med.**	**Max.**	**Med.**	**Max.**
AF 2	1.5	2	1.5	3.5	0	0
AF 6	0	0	0	0	2.2	3.5
AF 8	2	2.5	2.5	3	0	0
Monviso	0	0	0	0	2.2	2.5
Turcoaia	3	2	2.5	3.5	?	?
Sacrau 79	3	3.5	3	3.5	?	?
Intensity scale: 0: immune, 1: resistant, 2: relative resistant, 3: moderate sensitivity, 4: sensitivity, 5: very sensitivity; S: intensity value in superior part of shouts; I: intensity value in inferior part of shouts; Med.: average, Max.: maximum value on plant						

Bioenergy and bioethanol

Romania benefits from an important potential of wood biomass and wastes which could be developed by promoting the poplar clones with short cycles of production.

An analysis of the possibilities of using steam boilers with low parameters in order to produce the steams for turbines with counter pressure of low and reduced power, will be developed in the next stages of the PLEN project. Certified information regarding the quality of this type of biomass will be developed on research laboratory scale in order to characterize this specific combustion process.

The existing experience in the world, as well as in Romania, regarding the central power plants that use sawdust, pellets or wood chips could be very useful in the future stages of our project to develop a market study on utilization of wood biomass based on poplar clones.

By processing of wood biomass, bioethanol could be obtained, which would have to be tested to certify its alternative fuel qualities. The main tests will include the qualities regarding the mixture miscibility and specific and vaporization heat levels, self-ignition capacity, the value of its cetanic figure, specific additives to be incorporated in bioethanol in order to improve its delay to self-ignition process.

The production costs of such type of biofuel have to be analyzed before its implementation in the Romanian market.

Taking into account that wood biomass, from which bioethanol is going to be produced, will be obtained by cutting down large areas of forests (even if the growth and harvesting cycle is much faster than that of regular poplar species), a study must be made regarding the efficiency of this culture, more specifically the ratio between the volume of fuel obtained and the volume of wood biomass used to obtain it, relation in which all the costs of bioethanol production will have to be considered. For this purpose, the bioethanol production process should be optimized in regards with production costs, in order to be used on a large scale.

Conclusions

The preliminary research of energetic poplar clones in the experimental plot of Danube Delta has shown the following features in the first year:

- very high adaptive capacity of Alasia New Clones to special paedoclimatic conditions present in the Danube Delta area;
- growth rate was excellent in all Italian and local clones, even in the first year of the experiment;
- Italian new clones Monviso and AF6 are immune to rusts; respectively AF2 and AF 8 are almost immune to black spot;
- Italian energetic clones are more efficient in biomass production comparing with controls.

The results obtained in this project could be useful for other countries where the poplar clones could be introduced. The analysis to be developed regarding the combustion process of this type of biomass as well as the characterization of bioethanol, will be extremely useful in the market study to be developed at the end of the PLEN Project.

References

Benea, V., 1986: Selection of poplar and willow clones to produce energetic biomass in special plantations. Dezvoltarea cercetarii ştiintifice din Silvicultură, 50 ani de la crearea ICAS (1933-1983) (*in Romanian*).

Chira, D., Filat, M., Chira, F., Colin, J., Mantale, C., 2004: Research on the poplar resistance to rusts (*Melampsora* spp.). Revista de Silvicultură şi Cinegetică, 19-20: 41-45.

Clonaru, Al., 1967: Poplar and willow culture in Danube holms. Ed. Agro-Silvică. *(in Romanian)*

Fara, L., Bitir-Istrate, I., Racovitza, A., Moraru A., Comaneci D., 2008: Technical Report of the PLEN Project, PUB Partner, Stage 1, December 2008 (*in Romanian*).

Fara, L., Fara, S., Chira, D., Nutescu, C., Filat, M., "Research concerning cultivation and energy utilization of rapid growing poplar clones for short production cycles" (PLEN) Project Proposal, February 2008

Filat, M., Chira, D., 2004: Introduction of new poplar and willow species / clones with high productive potential and resistance. Anale ICAS, Seria I, 47: 83-99 (*in Romanian*).

Iliescu, M., Benea, V., Nicolae, C., 1993: Technical regulation for poplar and willow cultivation. ICAS Bucureşti, 81-94 (*in Romanian*).

Laureysens, I., Bogaert, J., Blust, R., Ceulemans, R., 2004: Biomass production of 17 poplar clones in a short-rotation coppice culture on a waste disposal site and its relation to soil characteristics. Forest Ecology and Management 187: 295–309.

Ocskay, S., 1971: Research on breeding of poplar and willow with economic interest. ICSPS, Seria I (*in Romanian*).

Pinon, J., Valadon, A., 1997: Comportement des cultivars de peupliers commercialisables dans l'Union européenne vis-à-vis de quelques parasites majeurs. Ann. Sci. For., Elsevier/INRA, 54 : 19-38 (*in Romanian*).

Roşu, C., Daia, M., 2003: Specificul condiţiilor fizico-geografice (cu deosebire al celor hidrologice) din zona dig – mal a Luncii Dunării şi unele măsuri de gospodărire durabilă a pădurilor. Revista Pădurilor 2 (*in Romanian*).

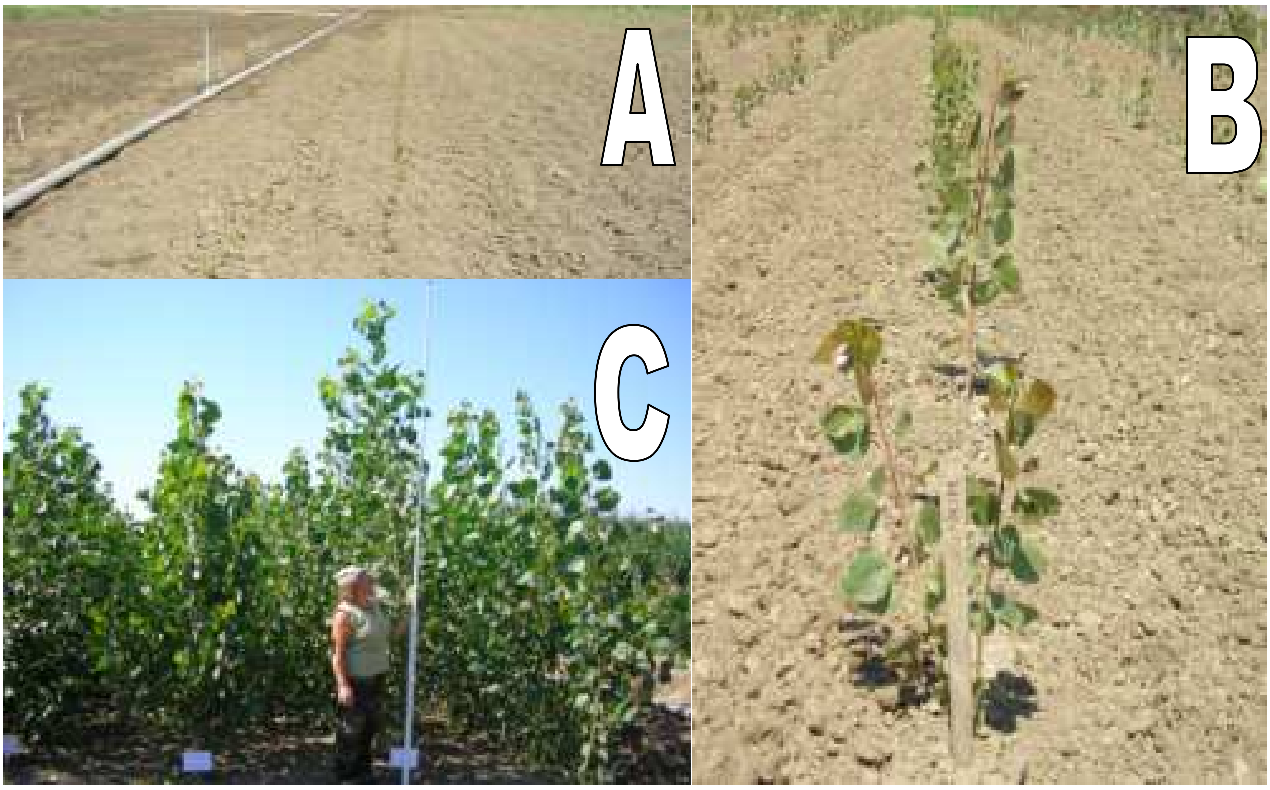

Fig. 1: (A) poplar culture from Nufaru test plot, Danube Delta, in different stages of growth: April (A), June (B) and September(C)

***Fig. 2:** Height increment in the first year in dens variant - 9523 plants/ha*

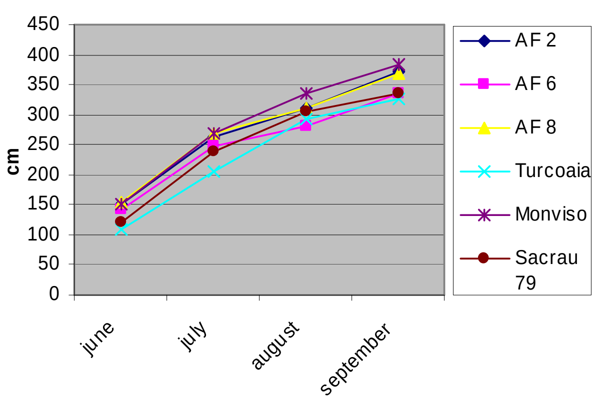

***Fig. 3:** Height increment comparing to control after one season*