Experimental Short Rotation Crops in Croatia

Davorin Kajba and Sasa Bogdan

Faculty of Forestry, University of Zagreb, 10 000 Zagreb, Croatia

1. INTRODUCTION

Late 1980s and early 1990s mark the outset of research on biomass production of fast-growing hardwoods in short rotations in Croatia. The experimental cultures that were established include the clones of arborescent willows (*Salix* spp.), the eastern cottonwood (*Populus deltoides* Marshall), and Canadian poplar (*Populus* ×*canadensis* Moench); the half-sib families of black alder (*Alnus glutinosa* (L.) Gaertn.) and silver birch (*Betula pendula* Roth); as well as the clones and seedlings of the species *Alnus subcordata* C. A. Mey. and *Alnus rubra* Bong.

2. DISCUSSION

Clone testings of arborescent willows have proved their genetic differentiation in terms of fresh and dry biomass production. In its second vegetative year, for example, the clone 'V 221' (trispecies hybrid *S. alba* × *S. fragilis* × *S. caprea*) yielded a larger amount of biomass than did the white willow clones. Biomass usability is comparatively low in very young plants, whose underground part forms a significant amount of its biomass. This ratio can be improved by growing a larger number of stump shoots. It has been generally agreed that the number of the shoots per hectare in short rotation cultures should fall within the range of 20000 to 25000. Due to their larger nutritional needs, hybrids between white willow (*Salix alba* L.) and crack willow (*S. fragilis* L.) have proved to grow well only in fertile soils. Extremely poor soils can sustain only white willow clones, whose lower need for nutrients, especially nitrogen, enables this species an easy adaptation to these kinds of soil (Komlenovic and Krstinic, 1969, 1987; Komlenovic *et al*., 1996).

The largest biomass production was reported for the 4/5-year-old hybrid clone 'V 221' (*Salix* ×*savensis* Trinajstic et Krstinic) grown in alluvial soil. The trees, planted 1.2 × 0.4 m apart (with a total of 41 660 shoots/ha, considering the survival), yielded 130 tons of dry biomass per hectare. Although this experimental area provided a poor nitrogen supply, the results have considerably exceeded other reports on biomass production of willow clones at that age (Kajba *et al*., 1998).

The arborescent willow clone cultures aged 2/3 years were planted at a density of 9615 or 19231 plants per hectare. Their average dry biomass production fell within the range of 2.0 to 3.9 t/ha. The largest output was achieved by the clones 'V0240' and 'V052' – hybrids between the white willow (*Salix alba*) and its variety, *Salix alba* var. *calva* – as well as by the white willow clone 'B44'. In view of the fact that the experiments were carried out in an environment that was unfavorable for the willow, it is clear that the clones have demonstrated a capacity for specific adaptation to low—production sites (Bogdan, 2002).

Average dry biomass output in the poplar clones, with a planting density of 10204 plants per hectare, fell within the range 1.0 to 11.5 t/ha, depending on their age (1/2 and 2/3 years). Whereas the eastern cottonwood clones 'S 1-8', 'S 6-36' i '710' yielded a significantly larger output than the Canadian poplar clones, especially at the age of 2/3 years, the eastern cottonwood clones '618' i '457' reached a significantly lower biomass production in comparison to the Canadian poplar clones. The investigated poplar clones have demonstrated statistically significant differences in mean dry biomass output; this indicates a genetical variability for biomass production in both taxons (Bogdan 2002).

The willow clones, aged 16 years, planted at a density of 625 trees per hectare, were grown in a mixed culture with the black alder (*Alnus glutinosa* (L.) Gaertn.). Their average dry biomass production reached 32.8 t/ha. In view of the average production of black alder in the culture, the selected white willow clones obviously have superior capacities for dry biomass production (Bogdan, 2002).

In the three experimental cultures with the clones and seedlings of three species of the genus *Alnus* L. (Kajba and Krstinic, 1998), the best results in biomass production were achieved by the clones and seedlings of the allochthonous species *A. subcordata*, as compared to the native *A. glutinosa*. The poorest results were recorded for another non-native species, *A rubra*. Interclonal variability, discovered in the most productive species, *A. subcordata*, raises a possibility of selecting superior genotypes and effecting further output increase, along with the successful routine vegetative propagation by cuttings. Successive autovegetative propagation may be used to eliminate negative geotropism and improve the plant's quality. In the experiments conducted on pseudogley and organic-gley soil types, high survival rates were reported for *A. subcordata* and *A. glutinosa*, whereas *A. rubra* proved unsuitable for these types of sites.

The following results have been obtained from research in biomass production in the experimental pure cultures of black alder, mixed cultures of black alder and willow, and silver birch cultures. Average dry biomass production of black alder half-sib families fell within the range from 27.4 to 105.9 t/ha, depending on the locality, planting density, silvicultural treatment and the plant's age (12-16 years). In terms of different conditions in the experimental cultures, the largest dry biomass output was achieved by black alder aged 14 years, grown in pure culture, with the planting density of 1667 trees per hectare. The black alder families have shown a statistically significant genotype × environment interaction (GEI); this points to a capacity of some of the families for adaptation to the specific environmental factors present in this study. Two families ('B18' i 'B21') reached an above-average biomass production under various growing conditions and in different localities; this in turn indicates phenotype stability, as well as a good general combining ability (GCA) of their parent plants.

Average dry biomass production of silver birch half-sib families, fell within the range from 3.8 to 43.0 t/ha, depending on the locality and the age. A statistically significant genotype × environment interaction has been recorded for the families grown in two different localities.

The above rewiev of the array of hardwood species studied in our research points to the conclusion that the greatest potential for dry biomass production in short rotations is to be found in the existing clones of the arborescent willows and the eastern cottonwood (Table 1). A number of clones capable of starting initial production cultures are currently available; however, in order for biomass production in short rotations to be recognized as a useful and cost-effective form of providing energy supplies, a lot of work remains to be done in many areas, not least in the area of plant improvement.

Table 1. Dry biomass production of some of the clones or families in the experimental short crops cultures in Croatia

Species	Clone/ Family	Age (yrs)	Number of trees/ ha	Soil type	Dry biomass production (t/ ha)
Salix alba	107/65/6	1/2	56249	Fluvisol	9,1
Salix alba	V 052	2/3	9615	Amfigley	6,4
Salix ×savensis	V 221	2/3	53749	Fluvisol	39,8
Salix ×savensis	V 221	4/5	41660	Fluvisol	130,2
Salix alba	V 093	14	625	Pseudogley	65,2
Salix alba	V 093	16	625	Organic-gley	57,8
Populus×canadensis	M1	1/2	10204	Alluvial	1,7
Populus deltoides	S 1-8	2/3	10204	Alluvial	17,8
Alnus glutinosa	B21	14	1667	Pseudogley	47,0
Alnus glutinosa	B7	14	1667	Pseudogley	105,9
Alnus glutinosa	B18	16	1250	Organic-gley	40,1
Alnus glutinosa	B17	16	2000	Organic-gley	35,2
Betula pendula	S 2403	13	1667	Pseudogley	43,0

3. REFERENCES

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