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First year development of poplar clones in biomass short rotation coppiced experimental cultures

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Abstract. Poplar and willows are the main fast growing tree species used for biomass production in short rotation coppiced (SRC) cultures. The main characteristics for biomass production (plant survival, basal diameter and height increment) after first growing season are presented. Four Italian clones - AF2, AF6, AF8 and Monviso (Alasia New Clones) and two controls - Turcoaia and Sacrău 79' (ICAS, România) have been tested in five experimental cultures, in different locations. Italian energetic clones have adapted very well to the pedoclimatic conditions of South-Eastern Romania, being more competitive than control clones in terms of biomass production and resistance to leaf diseases. AF8 and Monviso have registered the most active growth.
Keywords: poplar clones, biomass, height increment, basal diameter

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Introduction

Fossil fuels crisis felt since the seventh decade of last century triggered complex actions to find alternative energy resources, especially renewable. Specialists attention has been focus also on the vegetal resources (from agriculture and forestry), witch were considered virtually inexhaustible.

In order to promote and to extend these renewable energy sources, several common actions started at European level since 2005 (Biomass Action Plan 2005).

For their very active growth, especially in the juvenile stage for the ease of reproduction and the vegetative regeneration, for the possible adoption of super-intensive cultivation technology, and for the wide range of uses of biomass products, poplars (*Populus* spp.) and willows (*Salix* spp.) are the most used fast growing tree species in short rotation coppiced (SRC - of hereafter) cultures for biomass productions. Efforts of genetics in selection and inbreeding programs of the poplars clones, as well as by improving culture technology (Baratto et al. 2008), had remarkable results in woody biomass production with high energetic value.

In order to obtain the maximum amount of biomass in certain site conditions, SRC cultures several new or already in use poplar clones have been tested for their fast growing abilities in juvenile phase, in different countries and environmental conditions (Mau and Impens 1989, Tharakan et al. 1998, Trnka et al. 2008).

In Romania, research on the production and use of wood biomass for energetically purposes started in 1980 (Muşat 1983), achieving in time significant results on the productive capacity of different poplar clones, evidence of eco-pedological indicators of the sites suitable for energetic cultures, soil preparation techniques, installation, maintenance and harvesting of crops, the influence of density, irrigation and fertilization on growth capacity of tested species and clones (Benea 1989).

Former similar projects from national research programs (CEEX, PN), have sought to: (i) identify the possibilities of using degraded land, unsuitable for agriculture, for short rotation coppiced (SRC) cultures and use of biomass as alternative energy sources (Turcu 2006), (ii) develop technologies to replace gaseous fuels through a combination of forest biomass and coal (Lăzăroiu 2008).

The new project "*Research on the cultivation and energetically use of fast growing poplar clones in short production cycles*" includes three research units (ICAS, INL, IPA), one university (UPB), a co-financing partner (RNP Romsilva) and an Italian scientific consultant (Alas New Clones). Its objectives are to test, during 2008-2011, poplar biomass production in SRC cultures (2-5 years) and to use biomass to produce bio ethanol (Fara et al. 2009). In this project five experimental plantations in different ecological zones of Romania, using energetic poplar clones have been installed.

This paper aims to highlight the forest-cultural performance (survival - adaptation, biometric increment) of poplar clones after the first growing season.

Material and methods

The experimental plots have been planted in different zones (tab. 1, fig. 1) in the spring of 2008 (Nufăru) and 2009 (Boianu, Urleasca, Râseşti, Zăval), using six clones: four Italians (AF2, AF6, AF8, and Monviso), selected for energetic biomass (www.alasiafranco.it/biomassa), tested for the first time in Romania, and two controls - the most productive in Danube zone (Sacrău 79) and a new promising clone (Turcoaia).

Each variant was disposed in randomized blocks with three repetitions. Each repetition includes all 6 clones, with 18-28 cuttings/clone. Cuttings of 30 cm length and 15-25 mm diameter have been used. Cuttings have been planted after autumn land ploughing and spring land harrowing, leaving 5-10 cm above the ground with minimum three viable buds, unlike the planting instructions used in present wich specifies that the cuttings should be introduced entirely in the soil (Filat et al. 2009). Between the starting of the growing season (April) and the end of August, 3-4 soil mobilization (mechanized between rows and handy on plant rows) have been done in order to destroy weeds soil loosening. In the same time, depending on the rainfall, crops have been irrigated once or twice a month.

During the growing season, several culture features have been noticed: plant survival (the ratio between the number of viable plants found growing in the end of the season and number of cuttings planted), biometrical characteristics (height and diameter increment) and susceptibility to foliar diseases

Plant height was measured at the beginning of each month, from June to October, and the diameter was measured at 10 cm above the ground at end of vegetation (first decade of October).

Evaluation of the resistance to foliar diseas-

Table 1 Location and the main site characteristics of experimental plots for biomass production

No	Name	Geographic location		Altitude (m)	Relief	Climate and soil characteristics
		Latitude	Longitude			
1	Boianu	+44°11'35"	+27°18'25"	9	river meadow (Danube Holm)	Silvo-steppe continental climate; T = 11,1°C; P = 530 mm; fluvisol*, pH = 8,2
2	Urleasca	+45°08'55"	+27°37'28"	19	plain (Bărăgan Plain)	Steppe continental climate; T = 11,0°C; P = 440 mm; chernozem*, pH = 7,8
3	Râşeşti	+46°44'47"	+28°10'07"	21	river meadow (Prut Holm)	Steppe continental climate; T = 9,5°C; P = 517 mm; fluvisol*, pH = 7,5
4	Zăval	+43°50'00"	+23°52'52"	36	river meadow (Jiu Holm)	Silvo-steppe continental climate; with slight Mediterranean influence; T = 12°C; P = 500 mm; fluvisol*, pH = 7,2
5	Nufăru	+45°09'07"	+28°54'32"	2	river meadow (Danube Delta)	Steppe continental climate; with slight maritime (Black Sea) influence; T = 11,2°C; P = 400 mm; fluvisol*, pH = 7,7

Note: T – average annual temperature, P – average annual rainfall, pH – soil reaction in water, *WRB-SR-1998

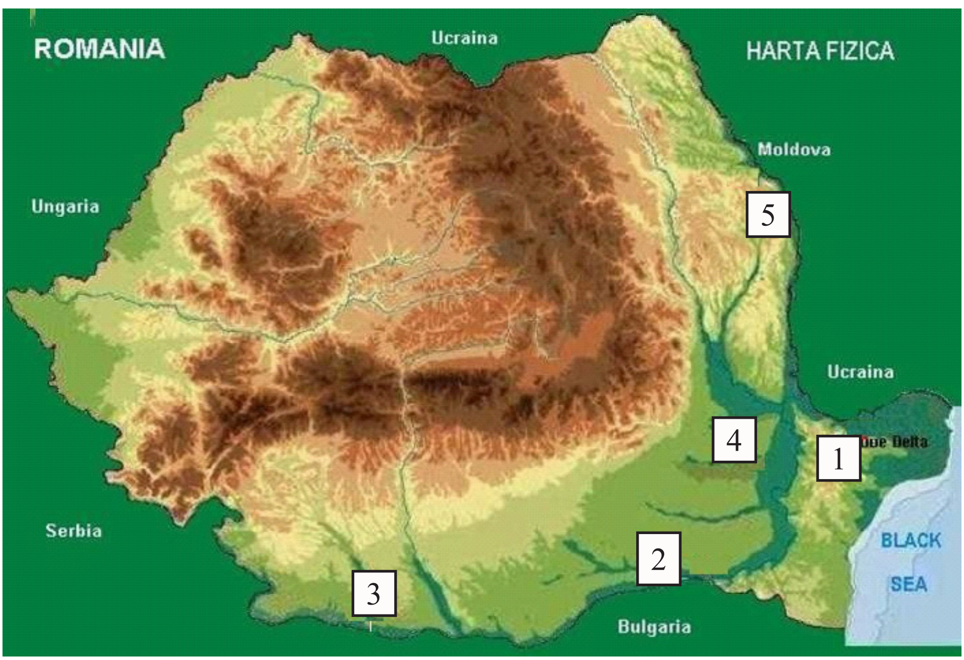

Figure 1 Location of the poplar biomass experimental cultures

es have been made in Nufăru plot, where infection level with *Melampsora* spp. is high due to former artificial infections. Uredial stage of disease (first decade of October) have been noticed, using the following intensity scale: 0 (immune) - no infection, 1 (very poor) - some uredospors/plant, 2 (weak) - some uredospors /leaf, 3 (moderate) - many uredospors on most leaves (threshold level of sensitivity), 4 (strong) - leaves are covered with uredospors, most leaves are browning, 5 (very strong) - total defoliation (Chira et al. 2004). Disease inventory includes transects through each variant (all plants/variant) and repetition.

Results

Significant differences of plant survival, height and diameter have been calculated among the clones (variants). Site conditions and culture techniques have produce large variation among plantations (tab. 2-3, fig. 2-4).

The best adaptation, in terms of plant survival, have had the control clone Turcoaia, followed by Italians AF6 and Monviso, but all three have significantly varied with locations (very good in 3 of 5 tests). On the opposite, AF8 and the local Sacrău 79 have constantly (in 4 of 5 plantations) recorded the lowest rate of survival (tab. 2, fig. 2).

Height increase, achieved during the first vegetation season, was sustained in all clones, from June until late September. In Urleasca culture, at the beginning of July, height of all variants were close, between 55 cm and 65 cm, but starting with August differences between clones were significant (Figure 5). In Boianu culture, where clones have registered very good growing performances, the highest increment rate in all variants was in August. In the beginning of September, the best clones have reached 248.6 cm height (AF8) and 245.6 cm (Monviso). It is interesting to be mentioned that in September plants have also recorded important growing rates (Figure 6). Similar to Urleasca plantation, in Zăval culture in the end of the vegetation season (during September) height increment was low, best performing being Monviso and AF2 (Figure 7).

In terms of biometric features, the six variants have grouped in four clusters. The best growth capacity had constantly AF8 and Monviso. The other Italian energetic clones AF6 and AF2 had also better performance comparing to local variants (AF2 having the best performance in the most succesful test of Nufăru). In all the experimental plantations, the controls had the lowest biometric features and Sacrau 79, the most productive clone in Romania, has recorded the worst height and diameter increment (Table 3).

Resistance to natural infections of *Melampsora* ssp. and *Marssonina brunea* varied significantly among the clones in Nufăru trial.

Table 2 Standardized index of plant survival

	Boianu	Urleasca	Râşeşti	Zăval	Nufăru	Average
AF2	-1.63	-1.20	-0.80	-0.55	0.65	-0.71
AF6	0.82	0.00	0.74	0.63	0.00	0.44
AF8	0.82	1.20	0.68	-0.16	-1.94	0.12
Monviso	0.82	-0.60	0.03	0.63	0.65	0.30
Turcoaia	-0.41	1.20	0.93	1.09	0.00	0.56
Sacrau 79	-0.41	-0.60	-1.58	-1.64	0.65	-0.72
Average (values - %)	98.33	98.00	81.50	82.00	98.00	91.57
s (of values)	0.82	1.67	15.55	12.79	1.55	

Note: standardized index: IPS = (x’-x’’)/s, x’- clone average, x’’- culture average, s - standard deviation.

Table 3 Standardized index of the biometric characteristics

	Boianu	Urleasca	Râşeşti	Zăval	Nufăru	Average
AF8	**0.89**	**0.71**	**1.01**	**0.72**	0.29	**0.73**
Monviso	**1.48**	**0.62**	0.05	**0.67**	**0.67**	**0.70**
AF6	-0.02	0.32	**0.46**	0.44	0.17	**0.28**
AF2	-0.68	0.09	0.30	0.14	**1.15**	**0.20**
Turcoaia	-0.70	0.23	0.07	-0.04	-1.52	**-0.39**
Sacrau 79	-0.98	-1.97	-1.90	-1.94	-0.76	**-1.51**
Height (average) (cm)	**261.57**	**200.95**	**134.00**	**195.32**	**303.98**	**219.16**
Height (standard deviation)	32.13	20.74	12.26	19.48	24.28	**21.78**
Diameter (average) (mm)	**27.08**	**19.88**	**13.40**	**18.82**	**24.87**	**20.81**
Diameter (standard deviation)	3.85	3.24	2.00	1.52	2.94	**2.71**

Note: standardized index: $I = (x' - x'')/s$, $I(H+D) = (IH+ID)/2$, H - height, D - DBH, x'- clone average, x''- culture average, s - standard deviation.

Monviso and AF6 were relatively immune to *Melampsora* spp., showing a strong genetic resistance to rust. AF2 was also resistant to rust, while controls and AF8 were moderate susceptible to this disease, but all these four variants had very sensitive individuals (fig. 8-9). AF2 and AF 8 were virtually immune to *Marssonina brunea* leaf spot, the other variants being relatively resistant to moderate sensitive to leaf spot (Figure 10).

Discussion

In Romania, only 10 poplar species/cultivars/clones and 10 willow species/cultivars/clones are homologated and admitted to be used in wood production cultures. *P.* x *canadensis* I-214 and Sacrău 79 together represent nearly 80% of all plantations (Filat et al. 2009).

In recent Romanian studies, after the first vegetation season the best results have had Sacrău 79 (basal diameter of 20.5 mm and total height of 197.9 cm) and I-214 (17.5 mm/ 90.3 cm) (Filat and Chira 2004). In other experiment, in the same location, after first year of vegetation, height was 224.4 cm on Turcoaia, 219.1 cm on I-214 and 240.5 cm on Robusta RO-16 (Filat 2008).

In SRC experimental plantation established on alluvial and humofluvisol soils in the Middle Danube Basin - Serbia, after first year of vegetation, one of the oldest and widely used poplar clone I-214 has recorded medium high of 300.0 cm and basal diameter (at 10 cm above ground) of 2.0 cm and cv. Robusta has registered 192.3 cm high and 1.38 cm in diameter (Klasnja et al. 2006).

In this context, energetic experimental plantations have showed very good biomass potential, especially in good site conditions and management (Nufăru: over 3 m height on Italian clones, comparing to 261.9 on Turcoaia and 293.4 cm on Sacrău 79). Maximum heights above 3 m have been recorded on all variants in Nufăru plot and on five variants in Boianu and Zăval tests, which confirms the great biomass productive capacity of the tested clones. The peak heights of 4.7 m - Monviso and 4.2 m - Sacrău 79 and AF2 (Nufăru) and 4.3 m - AF8 (Boianu) have been noticed.

The differences among experimental plantations are generally based on water supply and soil characteristics, the culture operations being similar. Danube meadows (including Delta) are generally more productive than interior river meadows (Prut and Jiu), which water level has large fluctuations. The worst conditions are in Prut valley (Râşeşti test), its water balance being strongly influenced by the management of hydro-electric power station of Stânca-Costeşti.

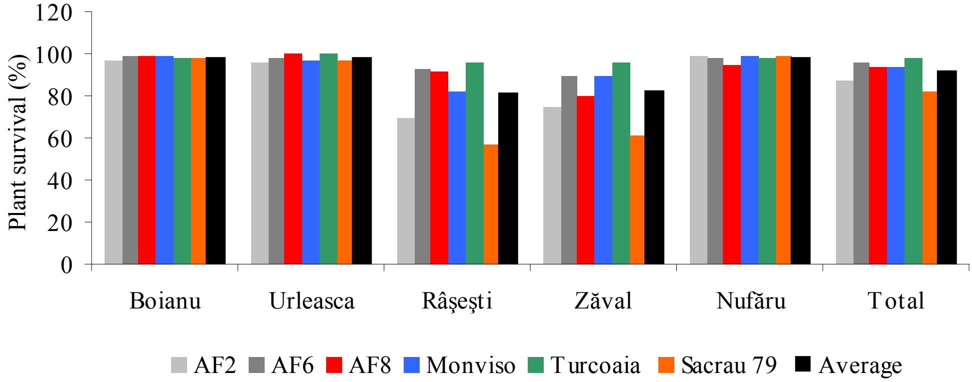

Figure 2 Survival rate in the first growing season

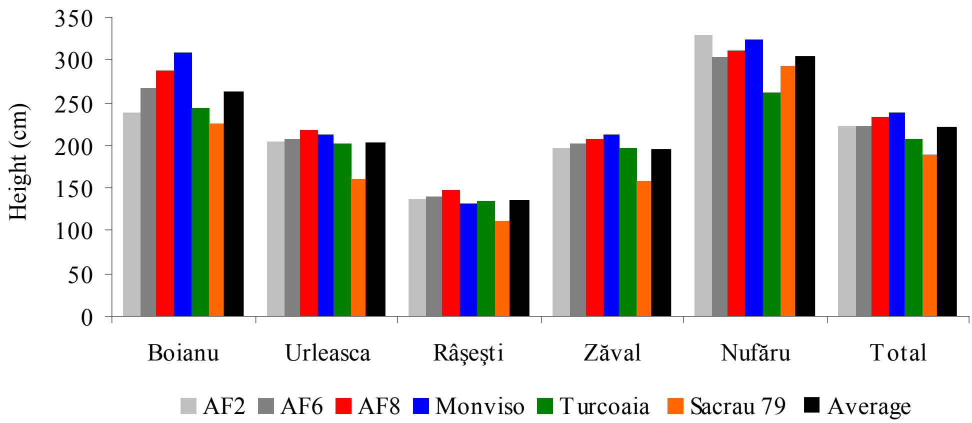

Figure 3 Height increment in the first growing season

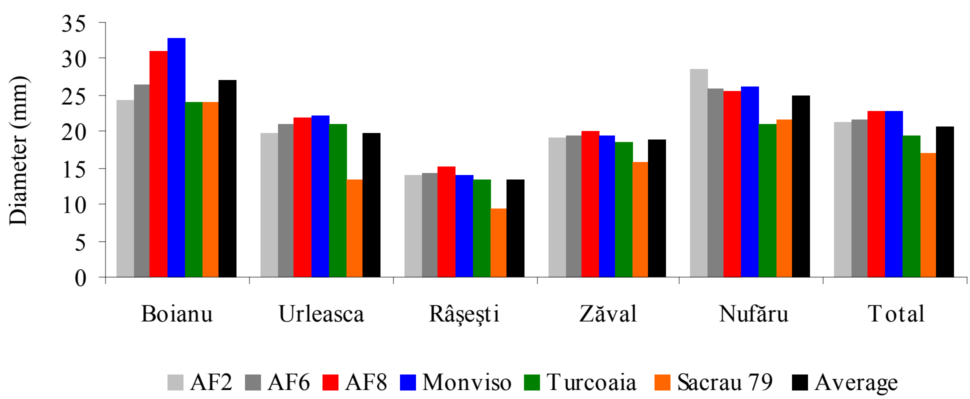

Figure 4 Diameter increment in the first growing season

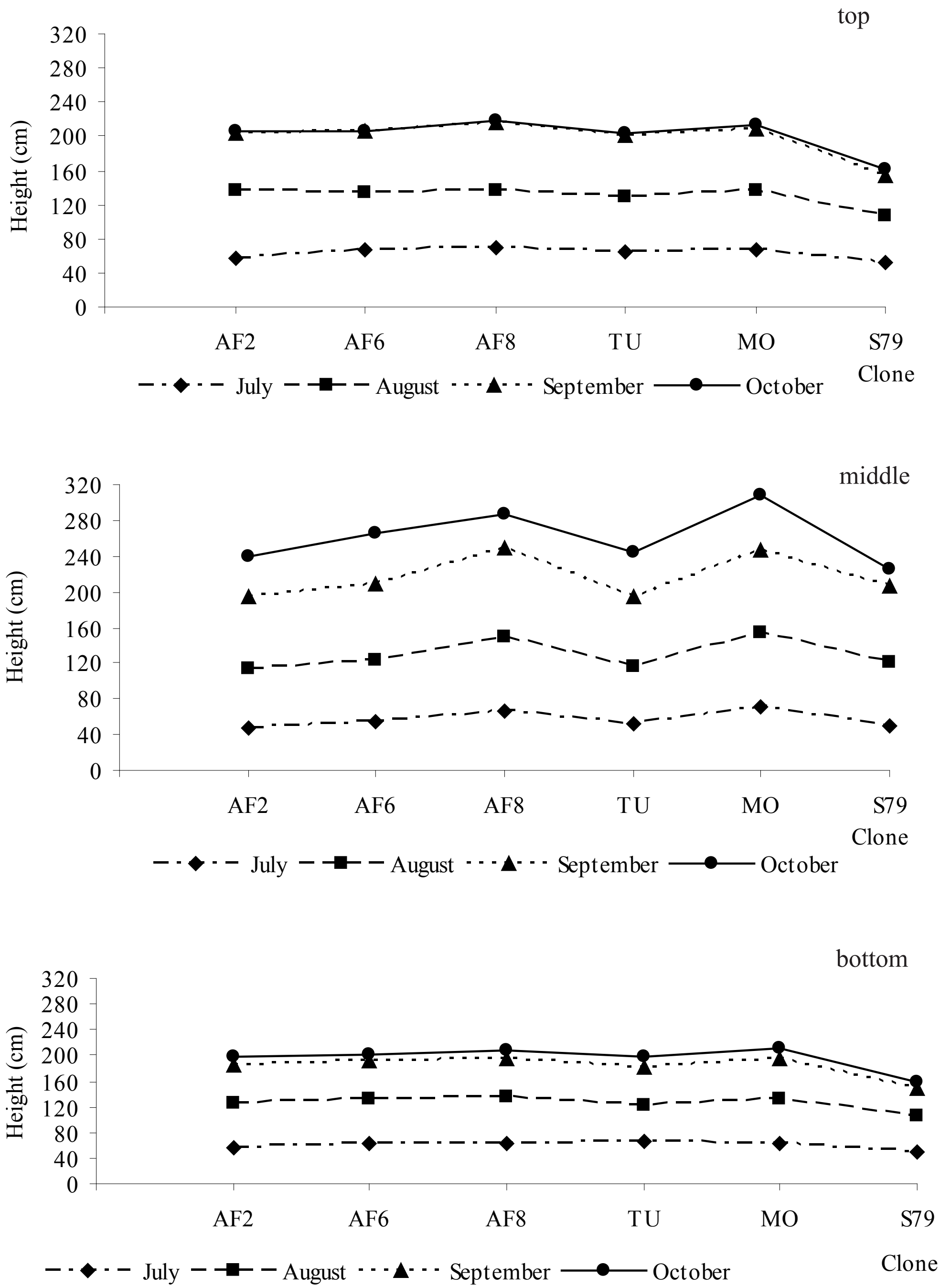

Figure 5-7 Height increment during vegetation season in the selected cultures - Urleasca (top), Boianu (middle, Zăval (bottom)

Figure 8 *Melampsora* leaf infections in Nufăru plot

Urleasca plot is settled down into silvo-steppe zone, where the soil troficity is very high but rainfall amount is very low and should be covered by additional irrigation. In 2009 the culture has suffered from injuries caused by hail fallen in mid-June.

The most active height increases have been noticed in July and August, the period with dry continental climate in Danube Field, so during this period additional irrigation are quite necessary in order to obtain proper biomass production. Also, soil mobilization and destroying weeds are recommended to limit evapo-transpiration.

In Nufăru collections, former inventories (2001-2003) have showed that Sacrău 79 was moderate, sensitive to relative resistant, both to *Melampsora* (average 2,4; amplitude 1,4-3,5) and *Marssonina* (2,4/2,0-3,7), while Turcoaia was resistant to rust (1,0/0-2,0) and relative resistant to leaf spot (1,9/1-3,0)(Chira et al. 2004). New Nufăru test has confirmed the general features of those clones. Italian energetic clones have proved a very good resistant to rust and leaf spot, Monviso and AF6 being relatively immune to *Melampsora,* respectively AF2 and AF 8 virtually immune to *Marssonina brunea*.

Conclusion

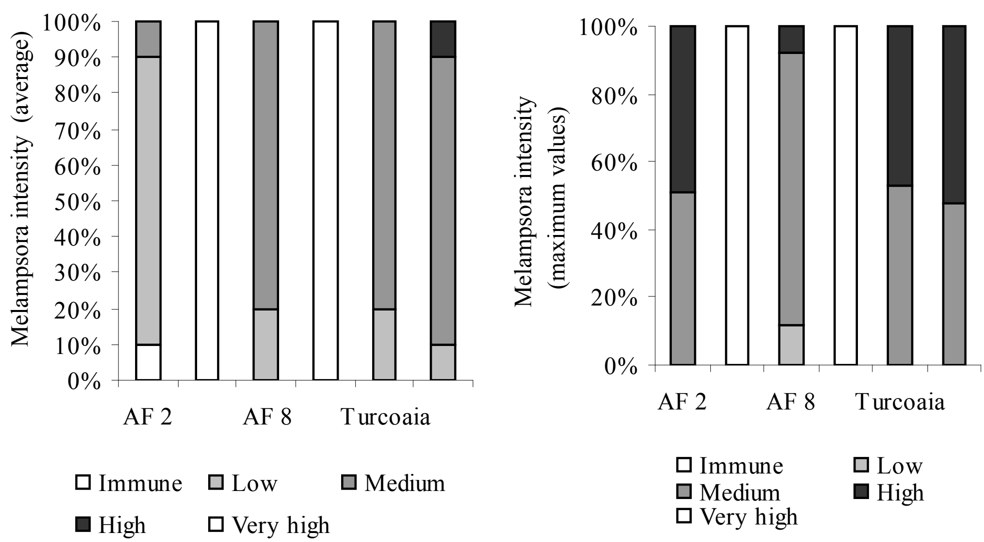

Figure 9 Clone resistance to *Melampsora* spp.

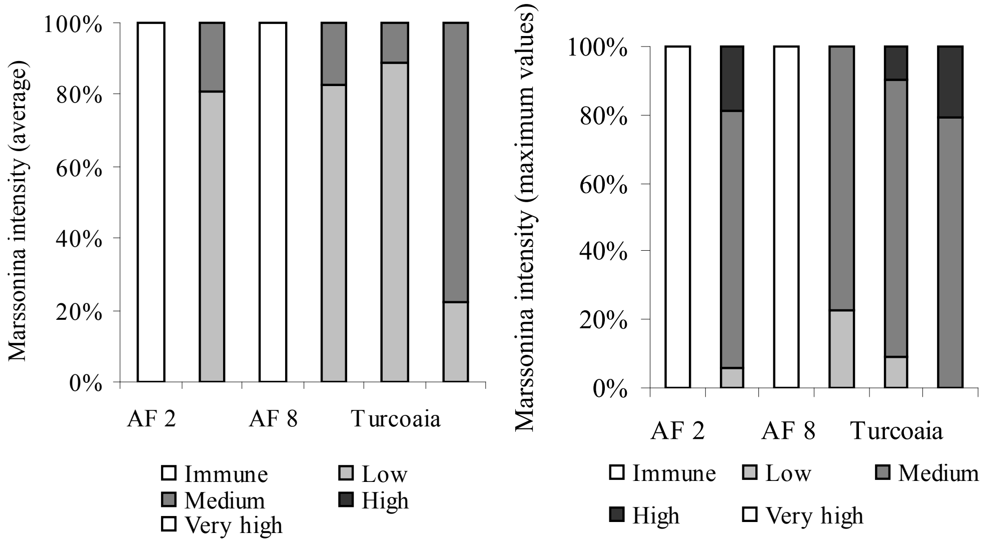

Figure 10 Clone resistance to *Marssonina brunea*

In the first vegetation season, the Italian energetic clones (AF2, AF6, AF8, Monviso) have adapted very well to the pedo-climatic conditions of South-Eastern Romania, being more competitive than control clones in terms of biomass production and resistance to leaf diseases. AF8 and Monviso have registered the most active growth. Danube Valley and Delta offer better conditions for the development of energetic clones in comparison with other locations in Romania.

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