Arch. Biol. Sci., Belgrade, 65 (4), 1609-1617, 2013 DOI:10.2298/ABS1304609R

ECOLOGICAL AND MORPHOLOGICAL CHARACTERISTICS OF PYRAMIDAL FIR (*ABIES ALBA* VAR. *PYRAMIDALIS*) IN THE LOCALITY OF OGORIJEVAC (THE PESTER PLATEAU)

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Abstract – The paper presents environmental conditions and morphological characteristics of pyramidal fir (*Abies alba* var. *pyramidalis*) in the locality of Ogorijevac in southwestern Serbia. Pyramidal fir trees grow in three localities in Europe, but only as individual trees. A site of pyramidal fir (*Abies alba* var. *pyramidalis*) in the locality of Ogorijevac near the town of Sjenica in Serbia was first studied by Tošić in 1963, who described some characteristics of the locality in which the pyramidal fir occurs and some morphological characteristics of the trees. This paper provides a detailed description of the parent rock, soil, climate characteristics of the locality and morphological characteristics of the trees.

Key words – Abies alba var. *pyramidalis;* morphological characteristics; Ogorijevac; ecological characteristics

INTRODUCTION

Silver fir (*Abies alba* Mill.) is less variable in comparison to some other conifers. According to its growth habit, there are three groups of varieties: (1) pyramidal, columnar or conical; (2) pendulous or weeping, and (3) dwarfish. The pyramidal variant has been found in three localities in Europe, but only individually. The pyramidal fir site in Ogorijevac, near the village Kladnica (near Sjenica) in Serbia was first described by Tošić (Tošić, 1963). Its main characteristic is a pyramidal habit that is formed in the process of morphogenesis during its growth and development. This pyramidal habit, which occurs in a number of species of different system groups of trees, is developed in different ways. In pyramidal fir, this feature of habit develops from the characteristics of the shoots. A comparative analysis of the shoots and needles of silver and pyramidal fir shows that they have both common and differential characteristics. These findings form a basis for further studies of genetic, ontogenetic and physiological-ecological processes that lead to the occurrence of different growth habits.

Pyramidal firs form mixed, uneven-aged stands with silver fir and beech. Unlike other European sites, where it occurs only individually, there are six mature individual trees of different age in this locality. Among the numerous individuals of its progeny, some tend to form a pyramidal habit. Pyramidal firs breed with silver fir. Most of the new growth, which is between silver and pyramidal fir, has the characteristics of silver fir. Only a portion of the progeny has a narrow angle of branching.

Morphological characteristics of pyramidal fir (Abies alba var. pyramidalis)

Pyramidal fir is a canopy tree and it can be as tall as silver fir. It is difficult to determine the age with

Table 1. Morphological characteristics of silver and pyramidal fir

Silver fir	Pyramidal fir
wide conical habit	narrow pyramidal habit
oval tip	elongated cylindrical tip
horizontal branching	ascending branching, with a vertical tendency
two rows of horizontally-arranged needles	radially-arranged, ascending needles arranged all over the twig
needles flattened in cross-section with a concave central vein	needles elliptic in cross-section with a convex central vein
broad, fan-shaped seed wings	narrow and elongated seed wings

the naked eye because many of the branches have a very narrow angle of branching, especially near the top, where they stick closely to the stem. Pyramidal fir forms a narrow, pyramidal or conical habit with a very sharp tip similar to cypress. Its branches are thick and leave the main stem at a very narrow angle from a very young age (about 20-30°). They grow both from nodes and from internodes.

Self-pruning is characteristic of pyramidal firs that grow in a dense forest canopy, although dead branches can persist for a long time before they fall off.

The tip of pyramidal fir does not have a terminal bud. Mature trees have an elongated, cylindrical tip, with many small ascending lateral branches that stick closely to the central shoot. At a young age, the tip is characteristically narrow due to the strong height increment.

Pyramidal fir has a very distinctive vertical tendency. Its mode of growth is similar to the growth of cypress and juniper, but it also has common characteristics with the related species, fir and spruce (Table 1.).

RESEARCH AIM AND METHOD OF WORK

The research was aimed at defining the main ecological characteristics of the sites in which pyramidal fir (*Abies alba* var. *pyramidalis*) occurs in groups of trees, and to determine a means of better protection and wider distribution of this variant of fir, through planting stock production and reforestation.

Soil characteristics were determined by taking a soil profile at the same place in the forest community at which phytocoenological recordings were taken. Soil types were determined according to the classification of soil by Škorić et al. (1985).

Standard laboratory methods were used for determining the properties of the soil samples. Soil texture was determined by International pipette B method with the soil textural triangle after Ferre being used for fine-textured soil classes. The sum of absorbed alkaline cations and hydrolytic acidity values were determined according to Kapenn and the acidity of the soil dissolved in water and KCl by applying the electrometric method. The total sum of humus was determined by the method of Tjurin. The total content of nitrogen was determined by Macro-Kjeldahl method. Easily accessible forms of phosphorus and potassium were determined by Al-method.

Forest vegetation was studied by applying the principles of the French-Swiss Braun-Blanquet method (Braun-Blanquet, 1928, 1921).

Five phytocoenological recordings were taken as the basis for the study of vegetation. They included the most important stand characteristics, floristic composition and structure, and site conditions. The spectrum of flora elements (participation of groups of flora elements and individual flora elements expressed as percentage) was done for each community according to the systematization of plant-geographical elements after Gajić (1980, 1984). The biological spectrum (percentage of separate life forms) of plants was done after Kojić et al. (1997), on the ba-

Table 2. Chemical characteristics of luvisol

Horizont and depth cm		Adsorptive complex					pH		Total		Accessible	
		T	S	T-S	V	Y1	H_2O	KCl	humus	N	P_2O_5	K_2O
		ekv m.mol NaOH			%	ccm			%	%	mg/100g	
A	3-18	27.18	5.52	21.66	20.32	33.32	3.7	2.8	4.69	0.60	2.0	4.96
E	18-30	16.40	2.08	14.32	12.69	22.03	4.0	2.9	1.44		2.0	3.28
Bt	30-70	25.51	3.86	21.65	15.13	33.10	4.0	3.5	1.02		2.0	2.42

Table 3. Texture of fine luvisol

Horizont and depth cm		Coarse sand	Fine sand	Silt	Clay	Total sand	Total clay	Textural class
		%	%	%	%	%	%	
A	3-18	20.03	52.77	14.7	12.5	72.8	27.2	sandy loam
E	18-30	24.77	41.93	17.0	16.3	66.7	33.3	sandy loam
Bg	30-70	26.31	41.69	12.4	19.6	68.0	32.0	sandy loam

sis of Raunkiaer's plant life form system (Raunkiaer, 1934).

RESULTS AND DISCUSSION

Tomić (1992) states that the climatoregional (oroclimatogenic) belt of beech-fir forests, which occurs in Illyric province where it is quite distinct and covers a large area, is significantly smaller in Serbia. The greatest number of beech and fir communities in Serbia were identified and described by Jovanović (1959).

Range of distribution and location in the research area.

The conditions on the Pester plateau have been more favourable for spruce than for fir. Therefore, beech and fir forests can nowadays be found only in three localities: on Gutavica above the village Uglo in the Vakuf reserve, in the mixed forests on the territory of Bare, and in the mixed forests in Ogorijevac. According to Krstić (1956), there is still a high proportion of spruce in the mixed forests. On the other hand, fir has not managed to keep a satisfactory proportion due to constant forest pastures, since fir is more susceptible to grazing and trampling. The fir could not endure the harsh conditions of the Pester plateau and it can now be found only in small groups. It cannot survive in exposed, windy positions. The forests of beech and fir continued to grow only in almost inaccessible canyons and cliffs of the streams and rivers in the territory of Bare. As soon as we find some reasonably accessible and flattened positions, we find degraded forests of beech and fir, with aspen and birch starting to colonize them. Judging by the local topographic names, there are two other sites of fir with beech. One is the drainage basin of the Jelovska River, between Rasan and Krnja Jela on silicate parent rock, and the other is in Jelovac above the village of Žabren. Our research deals with mixed beech and fir forests that survived in the localities towards Bare, which are possibly remnants of once developed mixed forests of broadleaves and conifers. The beech and fir forest covers a larger area only on the slopes of Mt. Javor, in the locality of Ogorijevac, where it occurs in a well-preserved state. Slightly poorer stands of beech and fir occur in the locality of Jasikovac, towards Bare, spreading up to the valley of the Dubočica River and its smaller tributaries and mountain brooks. The beech and fir forest here does not make one complex, but rather a mosaic arrangement with other forest communities.

Table 4. Association *Abieti-Fagetum moesiacae* Jovanović 1953

Recording ref. number	1	2	3	4	5	Degree of presence
Date	24. 6. 96					
Locality	Ogorijevac					
Size s.s. (m^2)	900					
Aspect	Northern					
Slope (^{0})	20	15	22	22	27	
Altitude (m)	1140	1147	1155	1140	1155	
Parent rock	quartz conglomerates and sandstone					
Soil type	luvisol					
OVERSTOREY						
Canopy closure	0.9	0.8	0.8	0.8	0.9	
Height-mean (m)	24	26	26	26	26	
Diameter-mean (cm)	33	35	35	35	35	
Distance (m)	4	4	4	4	4	
Abies alba	4.4	4.3	4.4	4.4	4.4	V
Fagus moesiaca	2.2	2.2	2.1	2.2	2.2	V
Betula pendula	+.1		+.1	+.1	+.1	IV
Populus tremula	1.1	1.1	1.1	1.1	1.1	IV
Acer pseudoplatanus				1.1		I
SHRUB LAYER						
Canopy closure	0.3	0.3	0.3	0.3	0.3	
Height (m)	1.5	1.5	1.5	1.5	1.5	
Abies alba	2.3	2.3	2.3	2.3	2.3	V
Corylus avellana	+.1	1.1	+.1	+.1	+.1	V
Fagus moesiaca	1.2	1.1	1.2	1.2	1.2	V
Evonymus europaeus						II
Sorbus aucuparia	+.1		+.1	+.1	+.1	IV
Betula pendula	+.1	+.1	+.1	+.1	+.1	III
Crataegus monogyna		+1				II
Daphne laureola			+.1		+.1	I
Lonicera nigra	+.1	+.1	+.1		+.1	III
Populus tremula	+.1	+.1	+.1	+.1	+.1	III
Rosa pendulina				+.1		I
Rosa vosagiaca			+.1			I
Sorbus austriacus			+.1			I
GROUND LAYER						
Cover	0.4	0.3	0.4	0.3	0.4	
Anemone nemorosa	1.1	1.1	1.2	1.1	1.1	V
Aremonia agrimonoides	+.1	+.1	+.1	+.1	+.1	V
Glechoma hirsuta	+.1	+.1	+.1	+.2	+.1	V
Polygonatum verticyllatum	+.1	+.1		+.1	+.1	IV

Table 4. *Continued*

Recording ref. number	1	2	3	4	5	
Prenanthes purpurea	+.1	+.1	+.1	+.1	+.1	V
Rubus hirtus						II
Vaccinium myrtillus	3.3	3.2	3.2	3.2	3.3	V
Athyrium filix-femina	+.1		+.1	+.1	+.1	III
Brachypodium silvaticum	+.1	+.1	+.1	+.1		III
Carex silvatica		+.1			1.1	II
Galium silvaticum		+.1			1.1	II
Gentiana asclepiadea		+.1			+.1	II
Platanthera bifolia		+.1			+.1	II
Polystichum aculeatum	+.1			+.1	+.1	III
Solidago virgaurea						II
Abies alba	2.2	2.1	2.1	2.2	2.1	V
Fagus moesiaca	1.1	1.1	+.1	+.1	1.1	V
Sorbus aucuparia	+.1	+.1	+.1	+.1	+.1	V
Corylus avellana		+.1	+.1			III
Daphne laureola		+.1				I
Populus tremula	+.1					I
Aegopodium podagraria	+.1					I
Ajuga reptans	+.1					I
Anemone ranunculoides	1.1					I
Angelica sylvestris	+.1					I
Asperula odorata	1.1					I
Calamagrostis arundinacea	1.2					I
Campanula persicifolia		+.1				I
Carex hirta		+.1				I
Cephalanthera rubra				+.1		I
Dactylorhiza maculata		+.1				I
Danaa cornubiens		+.1				I
Festuca vallesiaca			+.1			I
Fragaria vesca					+.1	I
Hypericum maculatum			+.1			I
Hypericum montanum	+.1					I
Knautia drimea			+.1			I
Lapsana communis				+.1		I
Luzula luzuloides		1.1				I
Luzula pilosa					+.1	I
Melampyrum pratense			+.1			I
Moehringia trinervia			+.1			I
Mycelis muralis				+.1		I
Orchis pallens				+.1		I

Table 4. *Continued*

Recording ref. number	1	2	3	4	5	
Oxalis acetosella	+.1					I
Paris quadrifolia	+.1					I
Polypodium vulgare	+.1					I
Potentilla erecta				+.1		I
Ranunculus nemorosus				1.1		I
Rubus saxatilis				+.1		I
Stachys silvatica			1.1			I
Valeriana dentata		+.1				I
Veratrum nigrum					+.1	I
Veronica officinalis			+.1			I
Viola alba					+.1	I

Site characteristics

The altitude of the studied forests of beech and fir (*Abieti-Fagetum moesiacae*) in the locality of Ogorijevac ranges between 1 140 and 1 155 m (with a northern aspect). They developed on the parent rock composed of quartz conglomerates and sandstone. The soil is luvisol. Soil texture and chemical features are given in Tables 2 and 3.

The solum depth is 70 cm. The thickness of the humus accumulation horizon is 18 cm. Its textural class is sandy loam with high total content of sand and low content of clay. The content of clay increases with solum depth. Clay dispersion index is greater than 1.5, which classifies the soil into the group of luvisols, but there is no significant textural differentiation of profiles. The class remains the same in the illuvial horizon.

The chemical properties of the investigated profile are characterized by extremely high acidity. The reaction of the soil solution in water is 3.7 in the humus accumulation horizon, and 4.0 pH units in the eluvial and cambic horizons. Due to its light textural composition, the total adsorption capacity is low, as well as the sum of adsorbed base cations. According to the degree of base saturation, the soil belongs to the dystric soil class. This degree is the highest in the humus accumulation horizon. It decreases in the eluvial and then increases again in the illuvial horizon, which is typical of luvisol.

According to the total content of humus in the humus accumulation horizon, the soil is classified as very humic. The total content of nitrogen is high, which provides a quite favorable C/N ratio for nitrogen mineralization and its conversion to more accessible forms. The soil is poor in plant-accessible forms of phosphorus and potassium throughout the whole solum depth.

Floristic composition and structure

Floristic composition and structure of the community are presented in Table 4.

The phytocoenological table contains 61 plant species. There are 5 tree species in the overstory, 13 species of shrubs in the shrub layer and only 55 species that grow in the layer of ground flora. Individual phytocoenological recordings are poor in terms of the number of plant species, containing from 19 to 35 species, or 30 species on average. We can say that some recordings have a sufficient number of species, bearing in mind that this is a sciophilous community that is generally poor in plant species. The largest number of recordings has more than 30 species.

Table 5. Spectrum of life forms in the forest

Life forms (%)							
Phanero phytes	Nano phanero phytes	Woody Chamae phytes	Herbaceous Chamae phytes	Hemi crypto phytes	Geo phytes	Tero phytes	Terophytes / Chama ephytes
p	np	dc	zc	h	g	t	th
13.11	9.84	1.64	1.64	44.26	22.95	3.28	3.28
22.95		3.28					

Out of the total number of plant species (61), a great number of species occur only in one phytocoenological recordings (34).

Spectrum of life forms - biological spectrum

The biological spectrum of the association is shown in Table 5.

A significant presence of hemicryptophytes can be observed (44.26%). A high percentage of geophytes (22.95%) indicates favourable soil conditions (depth, moisture and structure) and favourable climate conditions due to increased heat (from the warm valley of the river Lim) and high relative humidity caused by the rivers and streams that flow through the beech and fir stands. There is a quite a significant presence of plants from the groups of phanerophytes and nanophanerophytes, amounting to 22.95%. Chamaephytes participate only with 3.28%. Therophytes and therophytes/chamaephytes participate with less than 3.28%, which is a usual ratio in forest communities with a thick stand canopy.

Spectrum of floral elements

The spectrum of floral elements of the community is shown in Table 6.

Central European floral elements account for as much as 36.06%, with a dominance of Central European and Subcentral European floral elements as individual area types. The percentage of Eurasian elements is typical of a community of beech and fir and amounts to 27.86. Circumpolar-cosmopolitan floral elements participate with 11.48%, while there is 4.92% of Sub-Mediterranean floral element in the strict sense. Mesophilic plant species (of Central European and sub-Atlantic floral element) account for 37.70%. Xerophilous plant species (Pontian and sub-Mediterranean) are represented by a mere 13.12%, while plant species of a wide ecological amplitude (Eurasian and cosmopolitan floral elements) have a large share of 39.34%. Frigoriphilic species participate with 9.84%.

The beech and fir forest in Ogorijevac belongs to the Central European type of community, which is indicated by the dominant role of Central European floral elements (36.06%).

Forest layers

The stand canopy closure degree in the tree layer ranges between 0.8 and 0.9, mean height from 24 to 26 (25.6 on average), mean diameter from 34 to 35, which are all significant values for the conditions and state of the forest on the Pester plateau. Besides fir (*Abies alba*) and beech (*Fagus moesiaca*), there is a significance presence of birch (*Betula pendula).* Aspen (*Populus tremula*) and sycamore maple (*Acer pseudoplatanus)* also occur. Fir outnumbers beech in these forests.

The shrub layer mostly includes *Abies alba, Fagus moesiaca* and *Corylus avellana*. On the territory of Ogorijevac, the fir canopy closure degree in the layer of trees is 4.4 and of beech 2.2. In the shrub layer, it amounts to 2.3 and 1.2, respectively. There is a significant presence of *Sorbus aucuparia* and *Euonymus europaeus*. *Betula pendula*, *Crataegus monogyna*, *Daphne laureola*, *Lonicera nigra*, *Populus tremula*,

Table 6 Spectrum of floral elements of the community

Group of floral elements	Floral elements	Participation in %	
1. Floral elements of the northern areas			
Boreal floral element	Subboreal-European-West Siberian	1.64	
	Subboreal-Circumpolar	4.92	
	Subboreal-Eurasian	1.64	
	Subboreal-Subeurasian	1.64	9.84
2. central-european floral elements			
Central-European and European	Central-European	14.75	
	Sub-Central-European	18.03	
	Alpine-Carpathian	3.28	36.06
3. Subatlantc floral elements			
Subatlantic and Atlantic	Subatlantic-Submediterranean	1.64	1.64
4. Submediterranean floral elements			
Submediterranean	Submediterranean	4.92	
Eastern-Submediterranean	Eastern-Submediterranean	1.64	
Balkan and Balkan-Apennine	Moesian	1.64	
			8.2
5. Pontian-central asian floral elements			
Pontian	Pontian-Eastern Submediterranean	1.64	
	Subpontian-submediterranean	3.28	4.92
6. Eurasian floral elements			
	Sub-South Siberian	6.56	
	Eurasian	14.75	
	Sub-Eurasian	6.56	27.86
8. Circumpolar and cosmopolitan floral elements			
	Circumpolar	4.92	
	Subcircumpolar	3.28	
	Cosmopolitan	3.28	11.48

Rosa pendulina and other species can be found as well.

Vaccinium myrtillus is widely distributed in all recordings of the ground layer. There is a significant presence of *Anemone nemorosa*, *Aremonia agrimonioides*, *Glechoma hirsuta*, *Polygonatum verticillatum*, *Prenanthes purpurea*. *Athyrium filix-femina*, *Brachypodium silvaticum*, *Carex silvatica*, *Galium silvaticum*, *Gentiana asclepiadea*, *Platanthera bifolia*, *Polystichum aculeatum*, and *Solidago virga aurea* can be found, but in smaller numbers. There are 34 plant species of ground flora per recording.

CONCLUSIONS

The site of pyramidal fir (*Abies alba* var. *pyramidalis*) in Ogorijevac in Serbia has very specific site and stand characteristics. A very deep type of soil (luvisol) was developed on the parent rock that is made of

quartz conglomerates. According to its textural characteristics, the soil is classified as sandy loam with high acidity.

The community has poor floristic composition. There is a small number of species, many of which are mesophilous (33%), which indicates moderately wet soil conditions. In terms of the biological spectrum, we can observe a weak presence of hemicryptophytes (36%) and a strong presence of geophytes (23%).

While the pyramidal fir stand is regenerated naturally, we should do more to protect this natural resource from adverse anthropogenic impacts. Pyramidal fir trees should be protected from branch lopping and the offspring should be protected from trampling, breaking or cutting.

It is possible to increase the area of pyramidal fir if we ensure a sufficient number of seedlings by producing seed planting material and planting pyramidal fir trees in forest nurseries. Modern planting stock production techniques should be applied because they provide good results even with the small amount of seed obtained from regular crops. There are large areas in this region whose site conditions allow for reforestation with pyramidal fir. The slopes of the Javor and Golija mountains are such places.

Acknowledgments - This paper was realized as part of the project "Studying climate change and its influence on the environment: impacts, adaptation and mitigation" (43007) which is financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2014.

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