UDC (UDK) UDK 633*174.7:582.475

***Milić ČUROVIĆ and Velibor SPALEVIĆ*[1]**

DEVELOPMENT OF SPRUCE TREES IN MIXED FORESTS OF SPRUCE, FIR AND BEECH (*PICEETO-ABIETI-FAGETUM*) ON MT. LJUBIŠNJA

SUMMARY

Felling of four trees from the experimental fields (OP1-OP4) that have been set up near the village of Vrba (Vukodol site), which is on a limestone base, and two trees from experimental fields in the vicinity of the mining village of Sula, situated on basic eruptives, with later analysis of these trees, gave us important conclusions about the basic characteristics of spruce growth in these forest communities. This gave an insight into the relations and impact of habitat characteristics on the development of spruce trees in mixed stands of beech, fir and spruce from Mt. Ljubišnja.

The given results are a contribution to the understanding of complex systems such as these forest communities. To meet the growth and achievable dimensions of spruce trees from stands like those that have been studied on Mt. Ljubišnja, while observing a high level of conservation, undoubtedly provides a contribution to the creation of forest management goals in these and similar forest communities.

Analysed spruce trees have shown a somewhat shorter period of slow growth compared to fir trees in the same communities. The results confirmed that spruce over 150 years old can have good height and volume increment. Therefore, if healthy conditions and the market value for stronger varieties are in favour of longer rotations, the very biology of this species and its late culmination growth would certainly justify a commitment.

Key words: spruce, stem analysis, increment, Ljubišnja

INTRODUCTION

With a view to providing an environmental platform for contemporary forest planning and management, it is necessary to make a study of the developmental characteristics of stems of autochthonous tree species in addition to the environmental, structural and production properties of stands.

Tri-dominant forests of beech, fir and spruce (*Piceeto-Abieti-Fagetum* s. lat.) are of great significance for science, as well as the practice. Taking into account the importance of mixed forests of beech, fir and spruce, they should be protected from further deterioration in future. The forest eco-systems of Mt. Ljubišnja are typical representatives of massifs rich in high mountainous, mixed

[1] Milić ČUROVIĆ, PhD, (corresponding author: curovic@t-com.me);
Velibor SPALEVIĆ, PhD, Biotechnical Faculty, Mihaila Lalića 1, 81 000 Podgorica

deciduous-coniferous forests. For that reason, these forests were selected for the groundwork of this research. These are high quality forests with highly valued timber volume (Čurović et al. 2011) in which all three edificators achieve large stem dimensions, both in height and width, and most of them live to an old age.

The stability of these stands, according to Hartman (1999), is reflected in the ability of beech to act like alabaster and fill in the gaps that result from the death of certain trees, and in the extraordinary ability of fir to persist in shade, interposing itself among the shoots of the beech. Fir trees can stay in a latent state for up to 330 years (Banković et al. 1994). On the basis of 230 trees felled in selection stands in Serbia, Pantić et al. (2011) stated that the duration of the vegetative time for fir trees on Mt. Goč was up to 330 years, while the stagnation stage on Mt. Tara was up to 185 years. It is clear from the structure found through irregular selection that it is supported by fir and beech, while its presence makes possible more rational utilization of the habitat's production (spatial) potential. Alongside the dynamic monitoring of the spruce growth process, it was also interesting to observe the changes.

Studying of the pattern of stem development, as well as observing the stands in general, reveals, first of all, the biological features of certain tree species and their productive capacity. Such studies, in addition to their theoretical importance, also have significant practical importance: they are an important component in determining the most favourable management practices (Banković and Pantić 2006).

MATERIALS AND METHODS

Eight permanent experimental plots were set up, of which four are on sites with limestone and four are on sites with silicate soils. Four experimental plots (OP1-OP4) were set up in the vicinity of the village Vrba (Vukodol site), which is on limestone soil, and the other four (OP5-OP8) were set up in the vicinity of the miners' settlement, Šula, where basic eruptives occur as parent substrate. In these sites (Vukodol and Šula) a pedological profile was opened, in order to obtain more exact data on soils.

The main criteria for selection of stands where the permanent experimental plots were set up was that they had to be among the best stands for a specific environmental unit (homogeneous, and with optimal inventory size and structure) and that all of them, under all separate environmental units, were at approximately the same developmental stage (Jović et al. 1991). In the process of selecting the experimental plots, care was taken to ensure that the conditions of homogeneity of habitat and stand circumstances were met.

For the purpose of analysing the developmental features of individual stems, one medium dominant tree of each of the species represented was felled from each of the permanent experimental plots. Since there are no spruces in the upper storey of experimental plots 6 and 8, there was no point in felling trees of small dimensions and age for the purpose of the analysis. Six spruce trees were

felled in total. The age of the spruce trees analysed ranged from 171 – 250 years. An exception is a tree from OP 5, which was 65 years old.

Round cross cuttings (tree cookies) were analysed, taken at heights of

0.30 m, 1.30m, and 5.30m, and then at every 2 meters to the top of the stem. The data obtained were processed with support from specialised data processing programs adjusted to "Apple Macintosh" personal computers at the Department for Increment, Faculty of Forestry, Technical University Munich (TUM), in Munich.

The analysis establishes the dimension and the volume of the stem at the end of certain life stages. The recommendation of Husch (1963) was accepted, according to which forming and marking of ten-year periods in cross sections are done from the periphery towards the centre. In that way, the oldest (central) period at the cross section remains largely incomplete.

Image 1. Samples for analysis of a spruce stem

Although applicability of this method was disputed in the United States because, according to Meyer (1953), analysis of one or several stems is not enough to establish with adequate confidence the patterns of increment of a stand, and hence it is not possible to make development forecasts; this has been the most frequently used method, and the one still applied in European forestry science and practice, where it is considered the most accurate method for determining the development and increment of volume and its elements during the whole lifetime of a tree.

RESULTS AND DISCUSSION

Stem analysis is a procedure used in order to establish stem growth in the past by directly measuring accumulated height and width increments (Husch 1963). Felling of four trees from the experimental plots (OP1-OP4) in the

vicinity of the village of Vrba (Vukodol site), which is on limestone soil, and of two trees from the experimental plots in the vicinity of the mining settlement, Šula, where basic eruptive occurs as the parent substrate, and subsequently analysing the development of these stems, resulted in important conclusions on the homogeneity of conditions for the growth of dendrofloral elements and their correlation depending on habitat conditions.

The analyses of physical properties of soil showed that sandy loam is present at the Vukodol site (samples M1 and M2), while the first layer at the Šula site (sample M3) was clay loam by texture, and the second (sample M4) was light loamy soil (Table 1).

Table. 1. Physical properties of soil

No. prof	Site (location)	Sample	Depth (cm)	Granulometric composition in %						Hygro scopic humidity
				2.00-0.25	0.25-0.02	0.02-0.002	< 0.002	Total sand	silt + loam	
1	Vukodol	M 1	0-5	32.56	39.84	17.50	9.80	72.70	27.30	4.57
		M 2	6-60	31.52	37.02	19.25	11.91	68.85	31.15	2.05
2	Šula	M 3	0-5	0.74	32.06	44.50	22.70	32.80	67.20	3.15
		M4	6-60	0.19	26.01	33.65	40.15	26.20	73.80	2.82

Image 2. Pedological profile in Vukodol

Lines of spruce height development at the Vukodol sites (Chart No. 1) have an S shape in experimental plots 2 and 3 (spruce 2 and 3), while height development lines of spruce 1 and 4 have a clear-growing flow over the first 60

years, followed by a continuous, mildly pronounced upward trend. It takes 150 to 200 years to reach the dominant height values (>30 m).

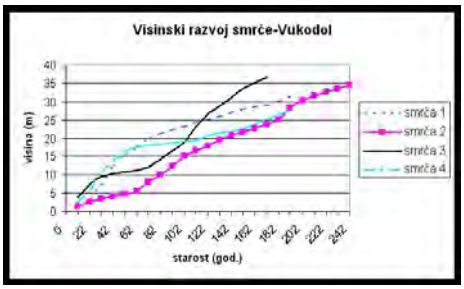

Chart 1 Height development - Vukodol

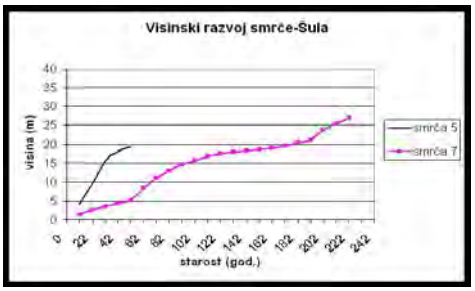

Chart 2 Height development - Šula

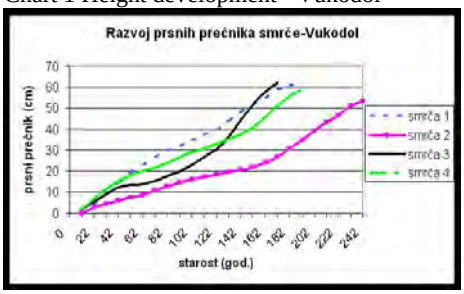

Chart 3 Breast diameters development- Vukodol

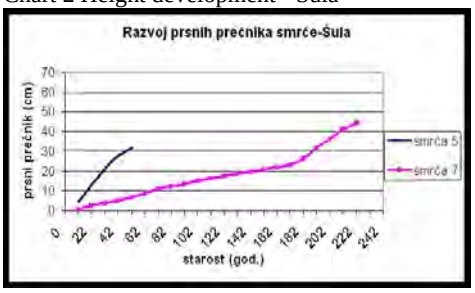

Chart 4 Breast diameters development - Šula

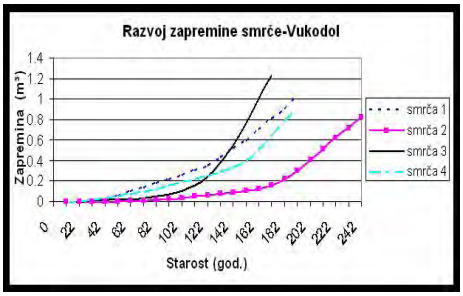

Chart 5. Volume development - Vukodol

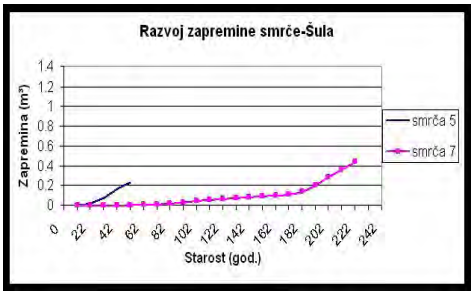

Chart 6. Volume development - Šula

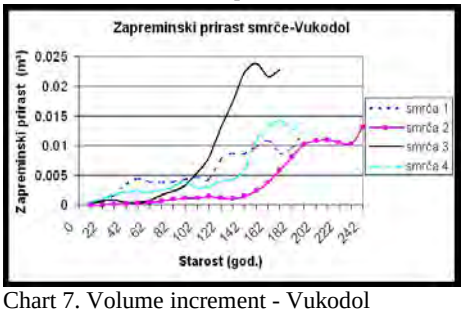

Chart 7. Volume increment - Vukodol

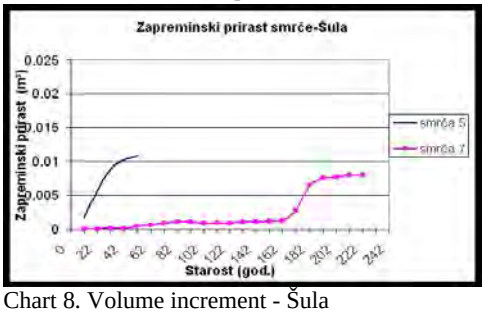

Chart 8. Volume increment - Šula

Lines of spruce height development at the Šula site vary (Chart No. 2). From experimental plot 5, the line's flow shows a pronounced growing trend up to the 40th year, then the height growth is reduced. The spruce from experimental plot 7 shows unequal growth in height in specific time sequences. Slowed growth is characteristic of the first 60 years, accelerated growth for the following 60, then slow growth up to the 200th year, followed by a significant height growth again. It takes 60 – 180 years to reach the height of 20 m.

Breast diameter development lines of spruces 3 and 4 from the Vukodol site (Chart No. 3) have an S-shaped form with a pronounced upward trend during the first 50 years, a mild upward trend until year 130 (spruce 3), and about year 150 (spruce 4), and a new swing following this period. The breast diameter development line of spruce 1 has quite a balanced upward trend, while in spruce 2 the diameter development line has a more pronounced upward trend following a balanced continuous growth over the first 170 years. It took 150 to 230 years for analysed spruce stems from the Vukodol site to reach a breast diameter (without bark) of 50 cm.

From the Šula site, breast diameter development lines of spruce vary (Chart No. 4). In the spruce from experimental plot 5 the said line has a pronounced upward trend, while spruce 7 is characterised by uneven diameter growth in certain time sequences. In spruce 7, the diameter development line has a slightly more pronounced upward trend following the balanced continuous growth over the first 170 years.

The lines of volume development of spruce from Vukodol (Chart No. 5) are of an exponential form, with the X-axis as the asymptote and a more or less pronounced inflection point. Inflection points are more clearly expressed in spruce 2 and spruce 3 (in years 130 and 180, respectively), followed by a pronounced upward trend in curves of volume development of these trees. In spruces from experimental plots 1 and 4, following a vegetative period that lasted for 60 years the volume development curves have an upward trend which, in the case of spruce 4, had been of a lower intensity volume growth until year 160, when it became more pronounced.

The volume development lines of analysed spruce stems from the Šula site have an upward trend, too, which is particularly pronounced in the spruce from experimental plot 5 after year 30, and in spruce 7 after year 190 (Chart No. 6).

The growth in value of the current volume increment of analysed spruce stems from the Vukodol site (Chart No. 7) is the most pronounced in spruce 3 following year 100. The lines of the current volume increment of spruces 1 and 4 is characterised by an uneven upward trend. In spruce 2, this curve has a clearly pronounced upward trend after year 160 until year 200, followed by stagnation in values by year 240, and growing again in the last 10 years.

The line of the current volume increment of the spruce from experimental plot 5 (Chart No. 8) showed a pronounced upward trend over the first 50 years, followed by a somewhat lower growth intensity of this curve. The spruce from experimental plot 7 is characterised by low values of the volume increment by year 170, followed by a short increase in increment intensity (by 190) and then a period of stagnation of values for the current volume increment.

CONCLUSION

Some of the characteristics of analysed spruce stems are as follows:

The analysed spruce stems show a vegetative period somewhat shorter than that of fir. The lines of current volume increment of spruce from the Vukodol site are characterised by a similar flow. Several culmination points can be noted on the line of current volume increment, one of which is the most prominent and occurs between the years 150 and 210.

Due to absence of spruce trees in the overstory of experimental plots 6 and 8, only 2 stems were analysed from the Šula site, one of which (OP 5) shows quite rapid growth, while the development of the spruce stem from experimental plot 7 shows a growth flow similar to those from the Vukodol site.

The wavy flow of curves in the current volume increment can be explained by occasional deterioration of the canopy, releasing the trees in shade, and re-establishing of the full plant density by extension of the crowns of overstory trees.

The results confirm that spruce can have a good height and volume increment even at ages above 150. Therefore, if healthy conditions and the market value for stronger varieties are in favour of longer rotations, the very biology of this species and the late increment culmination would certainly justify a commitment.

Knowing the flow of growth and attainable dimensions of concrete dendroflora elements, in this case in spruce, in forests as preserved as the stands in Mt. Ljubišnja would doubtlessly contribute to setting the objectives of forest management in this and similar forest communities.

REFERENCES

Banković S, Pantić D (2006): Dendrometrija, Sumarski fakultet, Univerzitet u Beogradu

Banković, S., Jović, D., Medarević, M. (1994): Vegetations stadium als Merkmal in der Entwicklung der Tannenstamme in Plenterbestanden auf Goc, „Oekologie und wadbau der weisstanne“ IUFRO Symposium 273-279

Čurović, M., Medarević, M., Pantić, D., Spalević, V. (2011): Major types of mixed forests of spruce, fir and beech in Montenegro; Austrian Journal of Forest Sciences; 128. Jahrgang, Heft 2, S. 93–111

Hartman, T. (1999): Hundred years of virgin forest conservation in Slovenia; Virgin forests and forest reserves in Central and East European countries: Proceedings of the COST E4 meeting in Ljubljana, Slovenia, Ljubljana, p.111-120

Husch, B. (1963): Forest Mensuration and statistics; The Ronald press company. New York.

Jović, D., Banković, S., Medarević, M.(1991): Proizvodne mogućnosti jele i bukve u najzastupljenijim tipovima šuma na planini Goč; Glasnik Šumarskog fakulteta; Br.73; Beograd.

Meyer H. A. (1953): Forest Mensuration; Pensylvania

Pantic D., Bankovic S., Medarevic., M., Obradovic Snezana (2011): Some characteristics of the stagnation stage in the development of silver fir (Abies alba Mill.) trees in selection forests in Serbia; TURKISH JOURNAL OF AGRICULTURE AND FORESTRY, vol. 35 br. 4, str. 367-378

Milić ČUROVIĆ and Velibor SPALEVIĆ

RAZVOJ STABALA SMRČE U MJEŠOVITIM ŠUMAMA SMRČE, JELE I BUKVE (*PICEETO-ABIETI-FAGETUM*) NA LJUBIŠNJI

SAŽETAK

Obaranjem četiri stabla sa oglednih polja (OP1-OP4) koja su postavljena u blizini sela Vrba (lokalitet Vukodol) na krečnjačkoj podlozi i i dva sa oglednih polja u blizini rudarskog naselja Šula kod kojih se kao matični supstrat javljaju bazični eruptive i kasnijom analizom razvoja ovih stabala došlo se do važnih zaključaka o osnovnim karakteristikama rasta smrče u ovim zajednicama. Ovim se dao uvid u odnos i uticaj staništa na razvojne karakteristike stabala smrče u mješovitim sastojinama bukve, jele i smrče na Ljubišnji.

Rezultati su dali još jedan doprinos shvatanju složenih sistema kakve su ove šumske zajednice. Upoznavanjem toka rasta i dostižnih dimenzija smrče u očuvanim šumama kakve su proučavane sastojine na Ljubišnji daju nesumnjiv doprinos kreiranju ciljeva gazdovanja šumama u ovim i sličnim šumskim zajednicama.

Analizirana stabla smrče su pokazala nešto kraći period usporenog rasta u odnosu na stabla jele u istim zajednicama. Rezultati su potvrdili da smrča i u starosti iznad 150. godine može imati dobar visinski i zapreminski prirast. Samim tim ukoliko zdravstveno stanje i tržišna vrijednost jačih sortimenata idu u prilog duže ophodnje, sama biologija ove vrste i kasna kulminacija prirasta svakako bi opravdale ovakvo opredjeljenje.

Ključne riječi: smrča, analiza stabla, prirast, Ljubišnja