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Original scientific paper

LENGTH OF VEGETATION PERIOD AS PARAMETER OF COMMON OAK (QUERCUS ROBUR L.) PHENOLOGICAL VARIABILITY

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Paper presents results for length of vegetation period as factor in common oak's (*Quercus robur* L.) phenological variability. Trees in two common oaks populations on two locations in area of Belgrade were researched. Average length of vegetation period on site Ada Ciganlija is 166 days, while in location Bojčinska šuma is 179 days. Regarding that populations are in similar environmental and habitual conditions, differences in results should be treated as consequence of common oaks intra-specific variability and genetic structure of population. Significant differences in three consecutive years of observation are confirmed.

Key words: Quercus robur L., vegetation period, population and individual variability

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INTRODUCTION

Phenological researches provide useful information about ecology, distribution and evolution of plant species, competition with other species, population and individual variability etc (PERIĆ *et al.,* 2006; MYKING and SKROPPA, 2007). Intra-specific phenological variability trough adaptation to environmental conditions has influence on population survival (FIGUEIREDO GOULART *et al*., 2005). A question imposes, what kind of consequences on plants development has annual temperature change, and recently noted early beginning of vegetation period (VISSER and HOLLEMAN, 2001). Conclusions on development course and duration of some phenophases can be based solely on observation of larger number of individuals, considering that each individual caries only part of information about changeability of one population or specie.

Individual variability in terms of beginning of some phenophases occurrence, or their duration length, expressed through genetic factors interaction and environmental factors enable determination of plant resistance to herbivore (KLAPER *et a*l., 2001). Phenological variability of common oaks is well known and numerous studies deal with its connection to development of caterpillar herbivore (WESOŁOWSKI and ROWINSKI, 2008). Individuals that start leafing earlier suffer more from defoliators, due to existence of clear synchronization between phenophases and development of defoliators (VAN DONGEN *et al.,* 1997). There are significantly less data about the connection between phenology and sensitivity of oaks to frosting. Plants that start leafing earlier in spring are more sensitive to frost from those starting later. Furthermore, it is more probable that the plants which continue growing in fall will suffer more from early fall frost than those that finished their growth. Moreover, same authors argue that south origin plants have tendency to grow leafs earlier and be damaged from frost in spring, while origins with shorter vegetation period that finish growth in fall avoid frosts. Spring frosts are more damaging to plants than winter. Also research results are supportive on selection of walnuts and hazels according to resistance on low temperatures and pathogens in relation to vegetation period length (GOLOŠIN *et al*., 2005; CEROVIĆ *et al*., 2007; ČUKANOVIĆ *et al*., 2011). Analysis results for common oaks' early leafing and late leafing growth confirmed significant advantage of late leafing common oak in respect of analyzed growth traits (STAMENKOVIĆ *et al.,* 1995). Some trees have earlier start over the years, others have extremely late, and in between is possible to determine numerous overlapses. Features of early and late beginning of some phenophases are considerably under genetic control and they are useful for assortment of starting material in process of forest trees breeding. Selection based on phonological traits is justified (SCHILLER *et al.,* 2005), although one should not neglect that decreasing of individual variability can be restraining factor of population's resistance and stability (TIKKANEN and JULKUNEN-TITTO, 2003). While establishing seeding plantations it is important uniformity of flowering period between individuals, because good potential of mutual pollination guaranties production of more quality genetic seeds (FRANJIĆ *et al*., 2011).

Phenological character (beginning, end and length of some phenophases and length of vegetation period) are used in determination systemic of oaks and their inter specie hybrids (BREZNIKAR and HORVAT-MAROLT, 1998).

The aim of this study was patterns definition of common oaks' phenological characteristics inside and among locations. Research included follow up of phenological changes on study locations "Ada Ciganlija" and "Bojčinska šuma" in three consecutive years (2004, 2005, 2006). In that context we searched answers to following questions:

- is there a difference in values of tested phenological characters inside and among study locations for each of analyzed years;
- are they different in phenological characteristics patterns among themselves, and
- which is percentage phenological pattern of analyzed populations in respect to presence percentage of trees with different length of vegetation period.

MATERIALS AND METHODS

Analyzed specie

Common oak (*Quercus robur* L.) belongs by number of species to rich and significant genera *Quercus*, family *Fagaceae*, spread over the area of Europe. In Serbia largest surfaces under common oak forests are in valleys of larger rivers: Sava, Danube and Morava. Ecologically, specie is adapted to forest continental and forest-steppe climate, as well as Mediterranean and sub-mediteranean on south of area. However, in relation to soil common oak is not so flexible. Common oak demands deep and fertile soil under influence of underground waters and occasional floods. Large inter specie variability is consequence of waste specie area as well as appearance of spontaneous hybridization with chestnut-oak (*Quercus petraea* L.), which makes determination more difficult. Based on phenological variability divided on "early" (*Q. robur* var. *praecox* Čern.) and "late" (*Quercus robur* var. *tardiflora* Čern) common oak. Common oak is one of most appreciated wooden forest specie whose surfaces in last century significantly decreased (YAKOVLEV and KLEINSCHMIDT, 2002; THOMAS *et al.*, 2003; BALBOA-MURIAS *et a*l., 2006; KUTNAR, 2006; KOVAČEVIĆ and ORLOVIĆ, 2007; HELAMA *et al.,* 2009). Has large commercial influence in forestry, ecology, medicine, pharmacy etc. (RAKIĆ *et al*., 2007).

Locations

Research of population and individual phenological variability of common oak was conducted in two populations on two locations in the area of Belgrade. Populations are in habitats appropriate for common oak, of mixed structure, mixed age, outgrowing and seeding origin. Habitat and environmental conditions in which analyzed populations are developed are presented in Table 1.

Length of vegetation period

Length of vegetation period length during three consecutive years (2004, 2005, 2006) as observations of leafing beginning and leaf fall beginning, were done. Observations were done on 29 separated trees in location "Ada Ciganlija" and 29 trees in location "Bojčinska šuma". Vegetation period represents number of days from beginning of spring leafing phenophase until beginning of leaf fall phenophase. It is determined by difference in calendar number of days which marks beginning leaf fall and number of days that marks beginning of leafing w (HEMERY *et al.*, 2005). In patterns analisys of phenological population characteristics, was used distribution on three levels where each represents number of days, that is length of vegetation; 1. level: 130 – 150 days, 2. level: 151 – 170 days, 3. level: 171 – 200 days. Population's phenological characteristics pattern is presented with percentage participation of trees, which during three years of observation didn't change group or did for 1, that is 2 levels, in total amount of trees from analyzed populations.

Table 1 Primary ecological characteristics of the analyzed populations of common oak (Quercus robur L.) on the sites "Ada Ciganlija and "Bojčinska šuma"

Study sites	Position	Altitude (m)	Association	Age (y)	Are (ha)
Ada Ciganlija	44° 48´ N 20° 24´ I	70-76	*Fraxino angustifoliae-Quercetum roboris* Jov. and Tom. 1979.	60	1.0
Bojčinska šuma	44° 43´ N 20° 10´ I	77-78	*Carpino-quercetum roboris* Rauš 1969.	120	66.7

Average annual temperature (°C)			Average annual precipitation (mm)			Geological substrates	Soil substrate	*Rain Factor (L)
2004	2005	2006	2004	2005	2006			
12.5	11.9	12.8	832.2	832.2	749.3	Sandy sediment	Fluvisol calcaric	65 Humid
12.5	11.9	12.8	832.2	832.2	749.3	Loessial clay	Planosol dystric	65 Humid

Note: Weather information and soil substrate are from Republic Hydrometeorological Service of Serbia
*Rain factor and classification of climatic areas by Lang; $L = h_{g,n}/t_{g,n}$,
$0 < L \leq 20$ desert, arid; $20 < L \leq 40$ semi-desert, arid; $40 < L \leq 60$ steppes and savannas, humid;
$60 < L \leq 100$ low forest, humid;
$100 < L \leq 160$ high forest, humid; $L > 106$ steppes and tundra, perhumid (Unkašević et al., 2002)

Statistical data processing

Basic parameters of descriptive statistic were gained using PROC MEANS procedures: medium value ($\bar{x}$), standard deviation (S), coefficient of variation (CV %) and their errors (SE $\bar{x}$, SEs, SEcv). Analyses were done separately by locations and years as presented in appendix. With purpose of getting more detail data on differences between medium values of phenology traits in different locations were applied SCHEFFE'S test of multiple comparison using MEANS options from GLM procedure. Transformation of primary data did not provide normal distribution of data that would satisfy primary condition of parameter analysis, therefore non-parametric analysis of sample comparison MANN-WHITEY U - Test was done.

RESULTS

Vegetation period length in population on site "Ada Ciganlija" was on average for three years of observation 166 days with minimum of 134 and maximum of 187 day, while on site "Bojčinska šuma" 179 days, with minimum of 149 and maximum of 193 days. On average trees on site "Bojčinska šuma" started earlier and finished later vegetation in comparison to trees on site "Ada Ciganlija". According to test results difference of medium values (SCHEFFE'S test), on average for three years of observation, analyzed on site "Ada Ciganlija" and "Bojčinska šuma" are significantly different. Vegetation period on location "Bojčinska šuma" is considerably longer (Table 2).

Table 2. Basic statistical parameters for lenght of vegetation period duration in locations „Ada Ciganlija" and "Bojčinska šuma" for three years of observation .

Study sites	Year	min	max	$\bar{X}$ ± SEx	S ± SEs	CV(%) ± SEcv
Ada Ciganlija	2004	134	181	158.28±2.1632	11.6493±1.5296	7.3601±0.9664
	2005	158	187	170.90±1.9798	10.6615±1.3999	6.2386±0.8192
	2006	158	193	169.21±1.7238	9.2828±1.2189	5.4861±0.7204
	$\bar{X}$			166.13^{a}		
Bojčinska šuma	2004	173	188	183.34±0.9394	5.0588±0.6642	2.7592±0.3623
	2005	162	187	178.69±1.4989	8.0716±1.0589	4.5171±0.5931
	2006	149	193	175.59±2.3307	12.5514±1.6481	7.1483±0.9386
	$\bar{X}$			179.21^{b}		

According to MANN-WHITEY U.- Test results of no-parametric analysis duration of vegetation period on locations "Ada Ciganlija", "Bojčinska šuma" were considerably different for year 2004 and year 2005, while for year 2006 differences are not highly significant (Table 3).

Additionally, differences exist between years of observations on one location. On location "Ada Ciganlija" vegetation period was the longest in second observation year (2005), somewhat shorter in third (2006) and shortest in first observation year (2004). According to F-test results on location "Ada Ciganlija" differences between observation years are statistically justified. First observation year in comparison to second and third had considerably shorter vegetation period as consequence of significantly earlier beginning of leaf falling in that year (Figure 1). There are also statistically justified differences between observation years on location "Bojčinska šuma", as confirmed by results of F-test. Considerably longer vegetation period in year 2004 in comparison to years 2005 and 2006 on this site is consequence of significantly earlier beginning of leafing (Figure 2). Individual differences regarding length of vegetation period duration are very expressed on both locations. That supports differences between shortest and longest vegetation length during one year inside one location. On site "Ada Ciganlija" this difference for three observation years was from 4 – 7 weeks and on site "Bojčinska šuma" 2 – 6 weeks. Opposite to that, discrepancies between observation years, for vegetation duration length with the same tree was from 1 – 2 weeks. Indicating that annual influence exists but also that genetic influence on vegetation period length is more important. Variability among trees was higher on site "Ada Ciganlija" (Figure 3, Figure 4).

Table 3. Mann-Whitney U - Test non-parametric analyses for length of vegetation period duration on study sites "Ada Ciganlija" and " Bojčinska šuma" for three years of observation

Variable	Valid N AC	Valid N BS	Rank Sum AC	Rank Sum Bs	p-level
			Year 2004.		
Vegetation lenght	29	29	453.000	1258.000	0.000000
			Year 2005.		
Vegetation lenght	29	29	667.500	1043.500	0.002992
			Year 2006.		
Vegetation lenght	29	29	714.5000	996.5000	0.027041

Percentage pattern of analyzed phenological features inside location was similar in all three observation years, and different between locations. Meaning that on location "Bojčinska šuma" 65.6 % of trees for three years of observation did not change level, that is their length of vegetation period duration didn't significantly changed from year to year, 31.0 % of trees transferred in one lower or higher level and only 3.4 % of trees changed group for two levels. Population on location "Ada Ciganlija" has reversed structure; 34.5 % of trees didn't shift level, 62.1 % of trees changed group for one level and also 3.4 % of trees changed group for two levels (Figure 5, Figure 6).

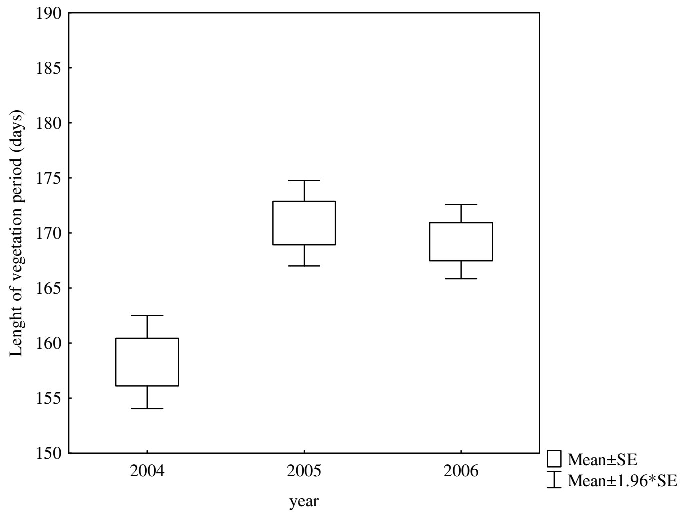

Figure 1. Lenght of vegetation period ((# day) as parameter of common oak's (*Quercus robur* L.) phenological variability, on Ada ciganlija location for three years of observation . F-test results of differences between years $F_{(2,84)} = 12.1699$, $p = 0.00002$.

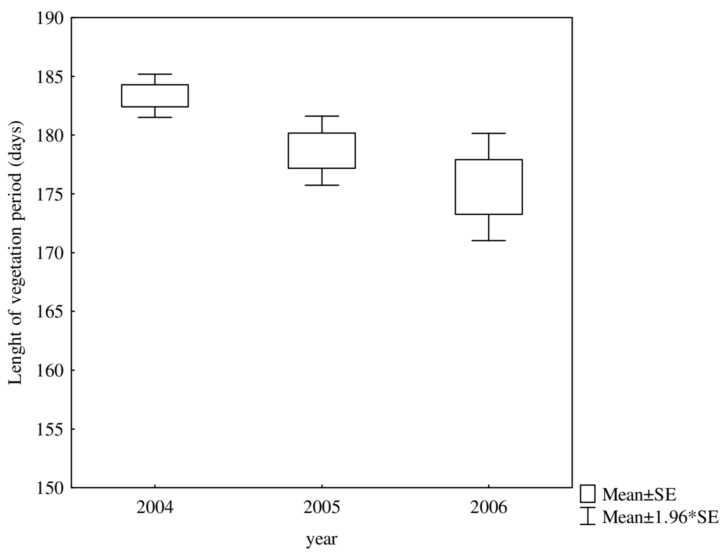

Figure 2. Lenght of vegetation period (# day) as parameter of common oak's (*Quercus robur* L.) phenological variability, on Bojčinska šuma location for three years of observation . F-test results of differences between years $F_{(2,84)} = 5.3437$, $p = 0.0065$.

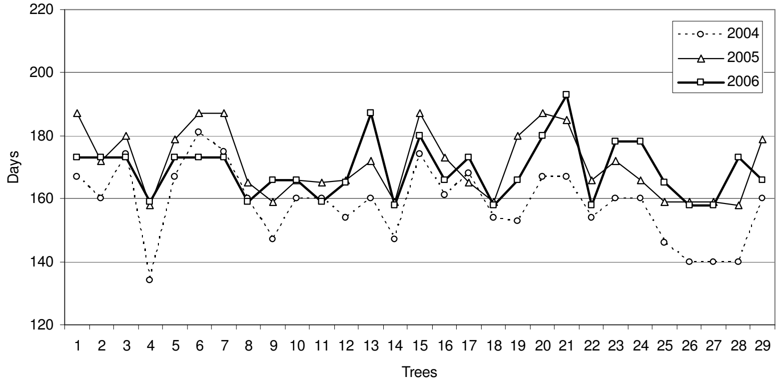

Figure 3. Individual variability of of vegetation period lenght (days) on Ada Ciganlija location in three years of observation.

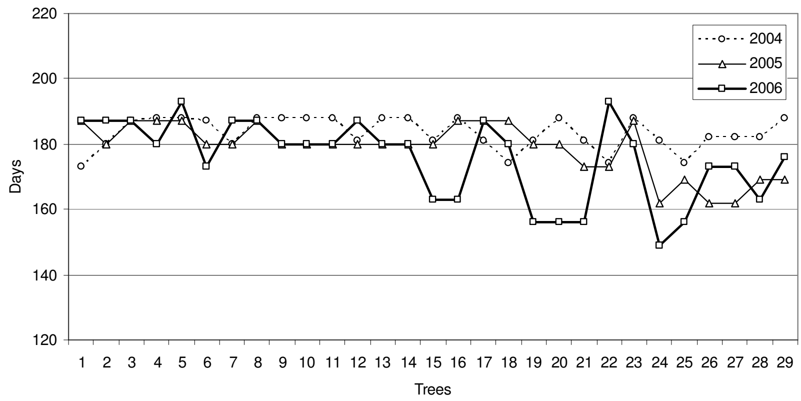

Figure 4. Individual variability of vegetation period length (days) on Bojčinska šuma location in three years of observation.

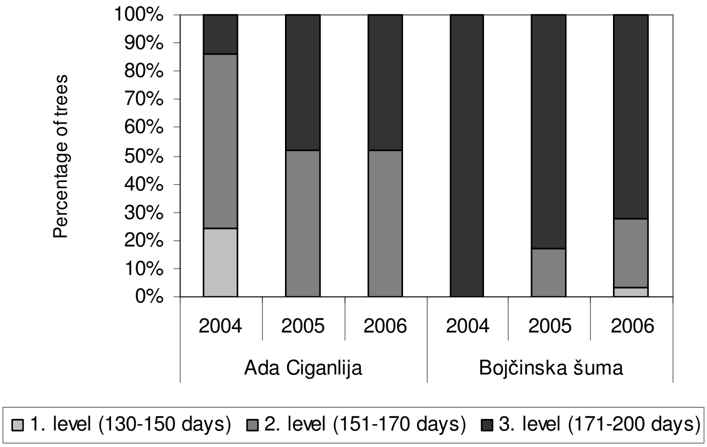

Figure 5. Pattern of phenological variability (%) parameter of common oak's (*Quercus robur* L.) on both location AdaCiganlija and Bojčinska šuma, in three year of observation.

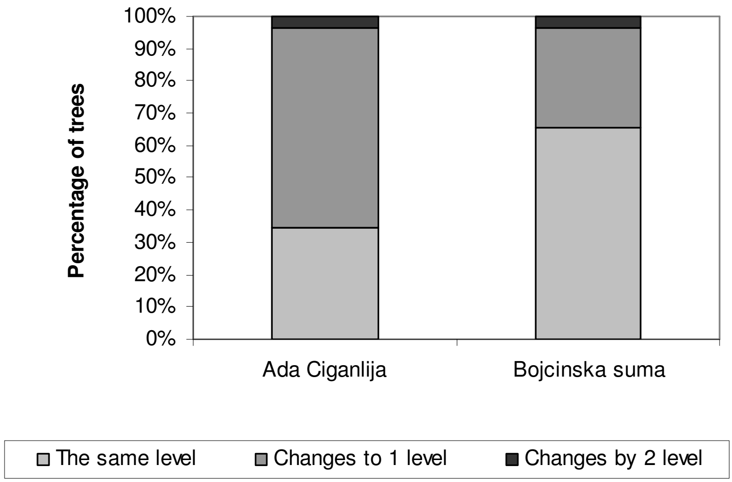

Figure 6. Pattern of phenological variability (%) in relation of vegetation length period on both locations Ada Ciganlija and Bojčinska šuma.

Based on findings above can be concluded that on length of vegetation period duration year as a factor of variability has impact but also that genetic influence is more emphasized.

DISCUSSION

Literature resources on common oak's phenology in area of Serbia are very limited. Recent researches (BATOS, 2010; BATOS *et al*., 2010a; BATOS *et al*., 2010b) provide extensive analysis on common oak's features from area of Serbia, among others on phenological as well and implicate profound inter specie variability. Mentioned author gives data on earlier beginning and end of common oak's vegetation period compared to information 40-50 years ago (BUNUŠEVAC, 1961; JOVANOVIĆ and UVALIĆ-TOMIĆ, 1971), which can be treated as consenquence of obvious climate changes. Considering that there is no more information about common oak's phenology in area of Belgrade, and there are no more precise information on location nor in already stated above and definitely small number of analyzed samples, it is difficult to derive certain conclusions. According to JOVANOVIĆ and UVALIĆ-TOMIĆ (1971) earlier start of vegetation period is most commonly caused by higher temperatures, doesn't significantly affects lenght of duration for some individual phenophases and also does not lead toward disruption of phenological balance. Results of researches stated here confirm significant differences among years of observations which is consenquence of either earlier leafing start or leaf falling beginning. Annual influence can be significant factor in phenological alteration of oaks (VISSER and HOLLEMAN, 2001; PERIĆ *et al.,* 2006). On the other hand, there are studies in which year did not significantly affect phenological traits (KADOMATSU, 1997).

Analyzed locations are positioned in similar climatic conditions. Population in location "Bojčinska šuma" develops in climate with more humidity compared to soil type, but they have no impact on analyzed features. Inside population is noted same phenological pattern at certain trees which implicates the assumption about their common origin. Based on that conclusion can be derived that perceived differences between populations are result of excessive inter specie variability, that is phenological population pattern.

Phenological traits are till some extend under influence of genetic factors which is especially important for selection of more resistant forms. Annual temperature fluctuations can affect the beginning of some phenophases but total length of vegetation period duration does not change significantly and extreme individuals are the same from one year to another. Extreme forms have special meaning for creation of new species. BACILIERI *et al.* (1994) based on three years followup of common oak's flowering determined that 49 % of trees stays in group as the previous year („early", „late", intermediar), 45 % transferes into next group while only 6 % of trees changes group for two levels. Literature facts mentioned above as well as results stated here about levels of vegetation period duration length changes from one year to another emplifye genetic influence on common oak's phenology. Results stated in this study imply toward existence of individuals which from one year to another remain the same level in comparisson to vegetation period duration length. For exact selection of individuals who belong to determined level we believe that results should be confirmed by research longer than 3 years.

CONCLUSION

Analyzed locations are in similar climate conditions due to which phenological differences among them are more likely to be result of phenological population patterns, that is existance of “early” and “late” common oak forms. Confirmed significant differences between analyzed locations are consequence of inter specie common oak’s variability. Most influential factors on length of vegetation period duration were also years of observation. Results of phenological researches can find their application in creating reaction models for herbal organisms on micro and macro – changes in ecosystem, as well as in individual selection in reflection to resistance and growth features.

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TRAJANJE VEGETACIJE KAO PARAMETAR FENOLOŠKE VARIJABILNOSTI LUŽNJAKA (*QUERCUS ROBUR* L.)

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U radu su predstavljeni rezultati analize dužine trajanja vegetacije kao faktora fenološke varijabilnosti lužnjaka (*Quercus robur* L.). Istraživanja su obavljena na stablima u dve populacije lužnjaka na dva lokaliteta na području Beograda. Prosečno dužina trajanja vegetacije na lokalitetu Ada Ciganlija iznosi 166 dana a na lokalitetu Bojčinska šuma 179 dana. Obzirom da se populacije nalaze u sličnim sredinskim i stanišnim uslovima, dobijene razlike se mogu smatrati posledicom unutarvrsne varijabilnosti lužnjaka i genetičke strukture populacije. Potvrđene su značajne razlike između tri uzastopne godine osmatranja.

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