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ANALYSIS OF GRAPEVINE PHENOLOGY IN THE REGION OF SREMSKI KARLOVCI

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Abstract: A comprehensive analysis of phenological timing and growth intervals for eight red and thirteen white wine grape cultivars in the region of Sremski Karlovci was performed using a long-term (1986–2011) data set. Four phenological stages of grapevine were examined: beginning of budburst, beginning of flowering, beginning of veraison and harvest. The phenological stages studied exhibited a 30 to 51 day variation between the earliest and latest years for red cultivars and 29 to 49 day variation for white cultivars. The beginning of flowering exhibited the least, while harvest showed the highest inter-annual variation. The difference between red and white cultivars was the greatest for harvest – the mean harvest date averaged over all red cultivars was 24 September and over all white cultivars 14 September. The beginning of flowering to the beginning of veraison interval showed the smallest and budburst to harvest interval the greatest year-to-year variability. The beginning of budburst to harvest period for the cultivars examined averaged 165 days for red and 156 days for white cultivars, with the mean interval range of 58 days for red and 55 days for white cultivars. In addition, it was found that a variability of the onset and duration of phenological phases was greater between years for a single cultivar than among cultivars within individual years, meaning that climatic factors are more important than genetic characteristics of cultivars for phenological timing.

Key words: grapevine, budburst, flowering, veraison, harvest, Serbia.

Introduction

Phenology is the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces, and interrelation between

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phases of the same or different species (Leith, 1974). Phenology variables are indicated as some of the most sensitive data to climate conditions and therefore were proposed by the European Environmental Agency as climate difference and global change indicators (Menzel, 2003). Besides climate change studies, phenology can contribute to viticulture in many ways (Ruml and Vulić, 2005). The phenological studies are important in determining the vine cultivars suitability for a given climate regime (Tesic et al., 2002a, 2002b), timely application of viticultural and chemical practices (Matthews and Anderson, 1987; Keller, 2010) and in estimating crop yields (Clingeleffer et al., 1997).

Grapevine (*Vitis vinifera* L.) is a phenologically distinct crop with the most important phenological stages being bud break, flowering, fruit set, veraison, harvest and leaf fall (Jones and Davis, 2000). The rate of development depends on grapevine cultivar, climatic conditions and topography. The timing of these developmental stages is related to the ability of the vine to produce, with early and fully expressed phenological events usually resulting in larger yields (Mullins et al., 1992). Additionally, the pace by which vines go through their stages has been related to vintage quality with shorter intervals and early harvests generally resulting in higher quality (Jones and Davis, 2000).

The aim of this study was to examine phenological dynamics for a number of wine grape cultivars in the region of Sremski Karlovci, the wine capital of the Srem viticultural region, one of the oldest vine growing areas in Europe.

Material and Methods

Phenological data were collected at the experimental station of the Faculty of Agriculture in Novi Sad (45°10' N, 20°10' E, 110 m a.s.l.). The station is situated in Sremski Karlovci on Mt. Fruška Gora's slopes. The climate is mid-latitude moderate continental (Koeppen's Cfw) with mean annual air temperature of 12.3°C and mean annual precipitation of 650 mm. Soil type is pararedzina on loess. For conducting this study, a group of eight red and thirteen white wine grape cultivars (both Serbian and internationally recognized ones) was selected from ampelographic collection. The collection was established in 1979 and all cultivars were represented by 20 vines, planted with a spacing of 3 x 1 m and grown with Simple Guyot system.

Four phenological stages of grapevine were examined for the period 1986–2011: beginning of budburst (the date when green shoot tips became just visible); beginning of flowering (the date when first flower hoods were detached from the receptacle); beginning of veraison (the date when berries begin to develop variety-specific colour); harvest. Harvest date was not precisely defined in phenological sense. It mainly depended upon winery requests and some other constraints such as current weather conditions, disease outbreaks, etc.

Results and Discussion

The phenological characteristics over the period 1986–2011 for the eight red wine grape cultivars are shown in Tables 1 and 3 and for thirteen white wine grape cultivars in Tables 2 and 4.

Table 1. Descriptive statistics of phenological stages for selected red grapevine cultivars for the period 1986–2011 in Sremski Karlovci, Serbia.

Phenological stage	Statistics (date or days)	Portugizer	Pinot Noir	Cabernet Sauvignon	Gamay	Merlot	Probus	Limberger	Prokupac	Average
Beginning of budburst	Mean	10-Apr	9-Apr	18-Apr	8-Apr	14-Apr	16-Apr	8-Apr	10-Apr	12-Apr
	SD	9.7	10.5	6.7	10.0	8.3	8.4	10.3	10.6	9.4
	Max	28-Apr	29-Apr	1-May	28-Apr	29-Apr	30-Apr	27-Apr	30-Apr	29-Apr
	Min	22-Mar	20-Mar	6-Apr	21-Mar	3-Apr	26-Mar	20-Mar	19-Mar	25-Mar
	Range	37	40	25	38	26	35	38	42	35
Beginning of flowering	Mean	28-May	28-May	31-May	27-May	29-May	2-Jun	28-May	31-May	29-May
	SD	8.3	7.8	7.6	7.8	8.1	7.8	8.0	7.1	7.8
	Max	14-Jun	13-Jun	16-Jun	13-Jun	16-Jun	18-Jun	13-Jun	15-Jun	15-Jun
	Min	15-May	15-May	17-May	15-May	16-May	19-May	15-May	18-May	16-May
	Range	30	29	30	29	31	30	29	28	30
Beginning of veraison	Mean	19-Jul	22-Jul	31-Jul	23-Jul	31-Jul	3-Aug	24-Jul	30-Jul	27-Jul
	SD	10.0	9.7	8.5	8.6	10.5	8.5	10.1	8.6	9.3
	Max	13-Aug	12-Aug	17-Aug	12-Aug	20-Aug	21-Aug	16-Aug	15-Aug	16-Aug
	Min	1-Jul	5-Jul	13-Jul	8-Jul	7-Jul	15-Jul	7-Jul	15-Jul	9-Jul
	Range	43	38	35	35	44	37	40	31	38
Harvest	Mean	13-Sep	18-Sep	28-Sep	21-Sep	27-Sep	28-Sep	24-Sep	28-Sep	24-Sep
	SD	10.7	15.7	12.1	12.9	13.4	13.1	14.6	12.2	13.1
	Max	10-Oct	18-Oct	18-Oct	13-Oct	18-Oct	23-Oct	18-Oct	15-Oct	17-Oct
	Min	26-Aug	24-Aug	2-Sep	24-Aug	30-Aug	30-Aug	24-Aug	30-Aug	27-Aug
	Range	49	59	46	50	49	54	55	46	51

An overall average date of the beginning of budburst for red wine grape cultivars was 12 April (Table 1). White wine grape cultivars tended to bud break two days earlier with average date 10 April (Table 2). The mean date of the beginning of budburst ranged over 35 days for red cultivars and over 36 days for white cultivars. The earliest occurrence of budburst averaged over all cultivars was 25 March for red and 23 March for white cultivars, while the latest date averaged over all cultivars was 29 April for red and 28 April for white cultivars. The red cultivars with the earliest beginning of budburst were Gamay and Limberger with an average date of 8 April, while the white cultivars with the earliest beginning of budburst were Chardonnay, Bouvier and Petra with an average date of 7 April. The cultivars with the latest beginning of budburst on average were Cabernet Sauvignon (18 April) among red cultivars and Beli Medenac, Bagrina and Riesling Italico (13 April) among white cultivars. In terms of year-to-year variability in the

beginning of budburst, among red cultivars Cabernet Sauvignon exhibited the lowest variability (SD=6.7 days), while Prokupac had the greatest variability (SD=10.6 days) and the greatest budburst range (42 days). The white cultivar with the lowest year-to-year variability in the beginning of budburst was Riesling Italico (SD=7.5 days) and the cultivar with the greatest variability was Chardonnay (SD=10.7 days) with the greatest budburst range (42 days).

Table 2. Descriptive statistics of phenological stages for selected white grapevine cultivars for the period 1986–2011 in Sremski Karlovci, Serbia.

Phenological stage	Statistics (date or days)	Chardonnay	Bouvier	Ezerjo	Petra	Pinot Blanc	Neoplanta	Kreaca	Muscat Ottonel	Riesling 239 20 Gm	Pinot Gris	Beli Medenac	Bagrina	Riesling Italico	Average
Beginning of budburst	Mean	7-Apr	7-Apr	8-Apr	7-Apr	9-Apr	11-Apr	11-Apr	11-Apr	12-Apr	12-Apr	13-Apr	13-Apr	13-Apr	10-Apr
	SD	10.7	10.1	9.3	10.2	10.0	10.2	9.4	8.0	9.3	9.2	9.1	7.8	7.5	9.3
	Max	26-Apr	27-Apr	26-Apr	27-Apr	26-Apr	27-Apr	30-Apr	26-Apr	29-Apr	30-Apr	1-May	30-Apr	29-Apr	28-Apr
	Min	15-Mar	20-Mar	21-Mar	18-Mar	18-Mar	23-Mar	26-Mar	27-Mar	21-Mar	27-Mar	22-Mar	1-Apr	27-Mar	23-Mar
	Range	42	38	36	40	39	35	35	30	39	34	40	29	33	36
Beginning of flowering	Mean	26-May	28-May	28-May	28-May	27-May	31-May	31-May	30-May	29-May	27-May	31-May	2-Jun	30-May	29-May
	SD	8.3	7.7	7.6	7.6	8.7	8.0	7.9	7.8	7.4	7.5	8.2	8.8	6.6	7.8
	Max	12-Jun	12-Jun	13-Jun	13-Jun	15-Jun	17-Jun	16-Jun	16-Jun	14-Jun	12-Jun	16-Jun	20-Jun	11-Jun	14-Jun
	Min	15-May	15-May	16-May	16-May	15-May	17-May	17-May	17-May	17-May	16-May	16-May	18-May	18-May	16-May
	Range	28	28	28	28	31	31	30	30	28	27	31	33	24	29
Beginning of veraison	Mean	24-Jul	13-Jul	22-Jul	30-Jul	27-Jul	30-Jul	29-Jul	22-Jul	30-Jul	23-Jul	23-Jul	30-Jul	22-Jul	26-Jul
	SD	8.9	8.5	8.8	10.9	9.1	9.2	10.2	8.1	10.2	8.2	8.4	9.7	8.0	9.1
	Max	9-Aug	30-Jul	5-Aug	28-Aug	16-Aug	16-Aug	15-Aug	17-Aug	17-Aug	9-Aug	9-Aug	20-Aug	17-Aug	13-Aug
	Min	9-Jul	30-Jun	3-Jul	10-Jul	11-Jul	12-Jul	6-Jul	8-Jul	9-Jul	9-Jul	8-Jul	10-Jul	18-Jul	9-Jul
	Range	31	30	33	49	36	35	40	30	39	31	32	41	30	35
Harvest	Mean	11-Sep	6-Sep	11-Sep	17-Sep	14-Sep	11-Sep	18-Sep	6-Sep	17-Sep	12-Sep	10-Sep	20-Sep	26-Sep	14-Sep
	SD	12.8	10.5	12.5	13.4	12.8	11.1	11.6	11.8	12.4	12.6	11.9	14.3	11.9	12.3
	Max	4-Oct	30-Sep	30-Sep	23-Oct	11-Oct	4-Oct	4-Oct	4-Oct	11-Oct	1-Oct	1-Oct	14-Oct	27-Oct	8-Oct
	Min	19-Aug	15-Aug	20-Aug	20-Aug	20-Aug	21-Aug	24-Aug	15-Aug	20-Aug	17-Aug	16-Aug	26-Aug	1-Sep	20-Aug
	Range	46	46	41	64	52	44	41	50	52	45	46	49	56	49

The mean date of the beginning of flowering was 29 May for both red and white cultivars and ranged from 16 May to 15 June for red cultivars (Table 1) and from 16 May to 14 June for white cultivars (Table 2). The earliest flowering of red cultivars on average was recorded for Gamay (27 May), while the latest one on average was observed in Probus (2 June). Chardonnay (26 May) was the earliest and Bagrina (2 June) the latest flowering white cultivar. Prokupac, which showed the greatest variability in the beginning of budburst, exhibited the least year-to-year variation in the beginning of flowering (SD=7.1 days) among red cultivars and Riesling Italico (SD=6.6 days) among white cultivars. Portugizer with SD=8.3 days was the red cultivar and Bagrina with SD=8.8 days was the white cultivar with the highest year-to-year variation.

The mean date of beginning of veraison was 27 July for red (Table 1) and 26 July for white wine grape cultivars (Table 2). Mean veraison dates showed a 38-day variation for red and 35-day variation for white cultivars. Among red cultivars, the earliest beginning of veraison on average was observed in Portugizer (19 July) and the latest in Probus (3 August). Bouvier was a white cultivar with the earliest beginning of veraison on average (13 July) and Petra, Neoplanta and Bagrina white cultivars with the latest date on average (30 July). Red cultivars Cabernet Sauvignon and Probus had the lowest year-to-year variation in the beginning of veraison (SD=8.5 days), while Merlot had the highest year-to-year variation (SD=10.5 days). Riesling Italico exhibited the lowest year-to-year variation (SD=8.0 days), whilst Petra had the highest year-to-year variation in the beginning of veraison (SD=10.9 days) among white cultivars.

The difference between red and white wine grape cultivars was more pronounced for harvest than for any other phenological events studied. The mean harvest date averaged over all red cultivars was 24 September (Table 1), and the mean harvest date averaged over all white cultivars was 14 September (Table 2). The earliest mean harvest date was 27 August for red and 20 August for white cultivars. The latest mean harvest date was 17 October for red and 8 October for white wine grape cultivars. The earliest mean harvest date was observed in Portugizer (13 September) among red cultivars and in Bouvier and Muscat Ottonel (6 September) among white cultivars. The latest mean harvest date was observed in Cabernet Sauvignon, Probus and Prokupac (28 September) among red cultivars and in Riesling Italico (26 September) among white cultivars. The red cultivar with the lowest year-to-year variability in the harvest date was Portugizer (SD=10.7 days) and the cultivar with the greatest variability was Pinot Noir (SD=15.7 days), which also has the greatest range between the earliest and the latest years (59 days). Among white cultivars, Bouvier showed the lowest (SD=10.5 days) and Bagrina (SD=14.3 days) the highest harvest date variability. The white cultivar with the greatest harvest range was Petra (64 days).

The length of periods between events (Tables 3 and 4) is often more important than the dates of phenological events (Tables 1 and 2). Short periods are linked with optimum climate conditions and a rapid physiological growth and differentiation, while long periods between events indicate less favourable climate conditions and a delay in growth and maturation (Jones and Davis, 2000).

Table 3. Descriptive statistics of phenological phases for selected red grapevine cultivars for the period 1986–2011 in Sremski Karlovci, Serbia.

Phenological phase	Statistics (days)	Portugizer	Pinot Noir	Cabernet Sauvignon	Gamay	Merlot	Probus	Limberger	Prokupac	Average
Budburst to flowering	Mean	48	48	43	49	45	48	50	51	48
	SD	10.6	10.8	6.7	10.0	8.7	8.7	11.4	9.9	9.6
	Max	65	69	53	68	66	66	71	66	66
	Min	28	29	28	32	30	30	29	34	30
	Range	37	40	25	36	36	36	42	32	36
Budburst to veraison	Mean	100	103	105	106	108	109	107	111	106
	SD	12.7	12.3	9.7	11.2	11.3	11.1	13.6	11.2	11.6
	Max	126	128	127	127	129	128	131	131	128
	Min	71	77	79	83	75	79	77	88	79
	Range	55	51	48	44	54	49	54	43	49
Budburst to harvest	Mean	156	162	163	166	166	166	169	171	165
	SD	15.1	16.3	12.0	14.2	13.8	14.8	17.5	13.2	14.6
	Max	187	189	180	188	184	192	196	194	189
	Min	130	123	134	134	134	130	131	134	131
	Range	57	66	46	54	50	62	65	60	58
Flowering to veraison	Mean	53	55	62	57	63	62	57	60	59
	SD	6.3	6.2	5.8	4.1	6.2	6.1	4.5	5.3	5.6
	Max	67	66	76	66	74	73	64	71	70
	Min	40	42	50	48	45	49	48	50	47
	Range	27	24	26	18	29	24	16	21	23
Flowering to harvest	Mean	108	114	120	117	121	118	119	120	117
	SD	9.0	10.8	8.8	9.0	9.7	9.9	10.5	10.4	9.8
	Max	125	138	134	134	138	135	136	140	135
	Min	95	90	106	100	104	96	101	96	99
	Range	30	48	28	34	34	39	35	44	37
Veraison to harvest	Mean	56	59	58	59	58	56	62	60	59
	SD	9.6	9.5	8.2	8.7	10.1	9.2	10.1	8.2	9.2
	Max	79	84	74	75	75	71	83	76	77
	Min	43	45	44	41	38	41	42	46	43
	Range	36	39	30	34	37	30	41	30	35

The beginning of budburst to the beginning of flowering interval averaged 48 days for red cultivars (Table 3) and 49 days for white cultivars (Table 4). The mean interval range was 35 days for red and 36 days for white cultivars. Cabernet Sauvignon had the shortest (43 days) and Prokupac (51 days) the longest average interval from budburst to flowering among red cultivars. Among white cultivars, Pinot Gris (45 days) had the shortest, whilst Bouvier, Petra and Neoplanta (51 days) had the longest average budburst to flowering interval. Cabernet Sauvignon had the lowest year-to-year variability (SD=6.7 days) and the least interval range (25 days), while Limberger exhibited both the highest variability (SD=11.4 days) and the greatest range (42 days) among red cultivars. The white cultivar Riesling Italico showed the lowest year-to-year variability (SD=7.6 days) and the least interval range (26 days). Kreaca was white cultivar with the highest variability (SD=10.7 days), while Chardonnay and Pinot Blanc were white cultivars with the greatest range of the budburst to flowering interval (38 days).

The beginning of budburst to the beginning of veraison interval was on average 106 days for red and 107 days for white cultivars. The mean interval range was 49 days for red and 45 days for white cultivars. Portugizer had the shortest (100 days) and Prokupac (111 days) the longest average interval from budburst to veraison among red cultivars. Among white cultivars, Bouvier (97 days) had the shortest and Petra (115 days) the longest average budburst to veraison interval. Among red cultivars, Cabernet Sauvignon (SD=9.7 days) exhibited the lowest and Limberger (SD=13.6 days) the greatest year-to-year variability. The red cultivar with the least interval range was Prokupac (43 days), and with the greatest range was Portugizer (55 days). The white cultivar Riesling Italico showed the lowest year-to-year variability (SD=8.9 days) and the least interval range (30 days). Kreaca (SD=13.4 days) showed the highest variability in the interval from budburst to veraison, while Petra (57 days) exhibited the greatest range among white cultivars.

One of the more important intervals is the length of the growing season (here defined as a period from the beginning of budburst to harvest). Growing season length averaged 165 days for red cultivars (Table 3) and 156 days for white cultivars (Table 4). The mean interval range was 58 days for red and 55 days for white cultivars. Portugizer (156 days) exhibited the shortest average growing season length among red cultivars and Muscat Ottonel (149 days) among white cultivars. Prokupac (171 days) had the longest average growing season among red cultivars and Riesling Italico (166 days) among white cultivars. The red cultivar with the lowest year-to-year variability (SD=12.0) and the least interval range (46 days) was Cabernet Sauvignon. The interval from budburst to harvest has the highest standard deviation among all studied phenological phases (SD=14.6 days for red cultivars and SD=13.4 days for white cultivars). Limberger was the red cultivar with the greatest year-to-year variability (SD=17.5 days), while Pinot Noir

had the greatest interval range (66 days). The white cultivar with the lowest year-to-year variability (SD=12.0) and the least interval range (45 days) was Beli Medenac, while Petra was the white cultivar with the greatest year-to-year variability (SD=14.9 days) and the greatest interval range (74 days).

Table 4. Descriptive statistics of phenological phases for selected white grapevine cultivars for the period 1986–2011 in Sremski Karlovci, Serbia.

Phenological phase	Statistics (days)	Chardonnay	Bouvier	Ezerjo	Petra	Pinot Blanc	Neoplanta	Kreaca	Muscat Ottonel	Riesling 239 20 Gm	Pinot Gris	Beli Medenac	Bagrina	Riesling Italico	Average
Budburst to flowering	Mean	49	51	49	51	48	51	50	49	47	45	48	50	47	49
	SD	10.2	10.3	10.0	10.1	10.5	9.6	10.7	9.6	9.7	9.9	9.4	9.7	7.6	9.8
	Max	69	67	69	68	69	66	68	65	67	63	65	68	60	66
	Min	31	31	33	33	31	34	31	30	32	29	29	31	34	31
	Range	38	36	36	35	38	32	37	35	35	34	36	37	26	35
Budburst to veraison	Mean	108	97	105	115	109	110	109	103	109	102	104	107	110	107
	SD	10.6	11.9	13.2	13.1	10.3	11.5	13.4	9.8	11.8	11.1	11.4	11.8	8.9	11.5
	Max	129	117	130	142	128	131	127	119	127	120	129	129	126	127
	Min	88	76	77	85	90	88	75	81	80	78	79	79	96	82
	Range	41	41	53	57	38	43	52	38	47	42	50	50	30	45
Budburst to harvest	Mean	157	152	155	163	158	153	160	149	159	152	150	159	166	156
	SD	12.6	13.1	14.2	14.9	14.3	13.0	13.1	13.6	13.5	13.8	11.8	13.3	12.3	13.4
	Max	179	180	175	198	186	179	180	175	182	172	172	179	194	181
	Min	129	132	126	124	127	131	124	120	122	116	127	123	141	126
	Range	50	48	49	74	59	48	56	55	60	56	45	56	53	55
Flowering to veraison	Mean	59	46	56	64	60	60	60	54	62	57	56	58	63	58
	SD	5.3	3.5	5.9	6.4	5.3	5.2	6.9	3.7	6.0	4.4	5.3	5.3	4.3	5.2
	Max	70	53	73	76	71	72	69	64	73	67	65	69	70	69
	Min	46	39	42	52	48	49	43	48	47	49	47	48	55	47
	Range	24	14	31	24	23	23	26	16	26	18	18	21	15	21
Flowering to harvest	Mean	108	102	106	113	110	103	110	100	111	107	102	110	119	108
	SD	8.1	7.0	9.5	9.4	8.8	7.6	8.6	7.3	8.0	8.6	8.0	10.8	10.9	8.7
	Max	124	119	126	132	123	119	131	113	124	123	120	138	151	126
	Min	94	86	87	91	93	86	92	87	89	87	87	92	100	90
	Range	30	33	39	41	30	33	39	26	35	36	33	46	51	36
Veraison to harvest	Mean	49	55	50	49	49	43	51	46	50	50	46	52	56	50
	SD	7.5	6.0	9.8	8.8	6.9	7.0	8.3	6.4	7.1	7.4	7.6	11.2	9.9	8.0
	Max	65	68	65	69	60	56	66	59	63	66	63	78	83	66
	Min	34	43	25	31	35	26	37	37	34	37	35	38	41	35
	Range	31	25	40	38	25	30	29	22	29	29	28	40	42	31

The beginning of flowering to beginning of veraison interval averaged 59 days for red cultivars with a range of 23 days (Table 3). For white cultivars, the average length of interval was 58 days with a range of 21 days (Table 4). Portugizer (53 days) had the shortest and Merlot (63 days) the longest average interval from flowering to veraison among red cultivars. Among white cultivars, Bouvier (46 days) had the shortest and Petra (64 days) the longest average flowering to veraison interval. The flowering to veraison period had the lowest standard deviation among all studied phenological phases (SD=5.6 days for red cultivars and SD=5.2 days for white cultivars) indicating that it was the most consistent growth interval. The same finding was reported by Tomasi et al. (2011). The red cultivar Gamay (SD=4.1) and the white cultivar Bouvier (SD=3.5) showed the least year-to-year variability, while Portugizer (SD=6.3) and Kreaca (SD=6.9) exhibited the highest variability among red and white cultivars, respectively.

The beginning of flowering to harvest interval averaged 117 days for red cultivars (Table 3) and 108 days for white cultivars (Table 4). Portugizer (108 days) had the shortest and Merlot (121 days) the longest average interval from flowering to harvest among red cultivars. Among white cultivars, Bouvier and Beli Medenac (102 days) had the shortest and Petra (113 days) the longest average flowering to harvest interval. The red cultivar with the lowest year-to-year variability (SD=8.8) and the least interval range (28 days) was Cabernet Sauvignon, while Pinot Noir was the red cultivar with the greatest year-to-year variability (SD=10.8 days) and the greatest interval range (48 days). Bouvier was the white cultivar with the lowest year-to-year variability (SD=7.0 days), whilst Muscat Ottonel exhibited the least interval range (26 days). The white cultivar with the greatest year-to-year variability (SD=10.9) and the greatest interval range (51 days) was Riesling Italico.

The ripening phase (from the beginning of veraison to harvest) averaged 59 days for red and 50 days for white cultivars. The ripening phase was the shortest on average in Portugizer and Probus (56 days) among red cultivars and in Neoplanta (43 days) among white cultivars. The longest ripening phase was observed in Limberger (62 days) and Riesling Italico (56 days) among red and white cultivars, respectively. Among red cultivars, Cabernet Sauvignon and Prokupac (SD=8.2 days) showed the lowest, while Merlot and Limberger had the highest year-to-year variability in the veraison to harvest interval (SD=10.1 days). Cabernet Sauvignon, Probus and Prokupac were red cultivars with the smallest interval range (30 days), while Limberger was the red cultivar with the greatest range (41 days). The white cultivar with the lowest year-to-year variability (SD=6.0) was Bouvier, while Bagrina was the white cultivar with the greatest year-to-year variability (SD=11.2 days). Muscat Ottonel was the white cultivar with the least interval range (22 days) and Riesling Italico with the greatest interval range (42 days).

A variation among cultivars within individual years averaged over the period 1986–2011 is given in Table 5.

Table 5. Descriptive statistics of averaged variation of phenological stages and phases among selected grapevine cultivars within individual years for the period 1986–2011 in Sremski Karlovci, Serbia.

Phenological stage/phase	Red wine grape cultivars						White wine grape cultivars					
	SD (days)			Range (days)			SD (days)			Range (days)		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Beginning of budburst	4.2	10.2	0.7	12.3	29	2	2.4	5.8	0.6	7.3	18	2
Beginning of flowering	2.7	4.9	1.4	7.9	16	5	2.4	4.3	0.9	7.5	15	3
Beginning of veraison	5.8	8.6	3.1	16.8	29	10	4.2	6.4	0.8	12.8	21	2
Harvest	7.3	12.8	0.5	22.0	39	1	7.8	17.0	3.1	24.5	56	8
Budburst to flowering	4.2	10.7	1.2	11.5	35	4	3.2	6.5	1.2	10.1	19	4
Budburst to veraison	5.3	11.4	2.5	16.5	37	8	4.1	7.8	1.0	12.9	25	3
Budburst to harvest	7.7	12.4	2.2	24.2	40	7	7.9	16.8	2.5	24.9	56	7
Flowering to veraison	4.7	9.8	2.5	14.6	34	8	5.9	5.9	9.8	12.9	25	3
Flowering to harvest	6.8	12.3	1.5	21.6	41	5	7.9	17.0	2.8	25.0	55	9
Veraison to harvest	6.3	11.5	2.6	20.2	40	9	6.9	15.5	3.4	22.1	47	11

A variation in the onset of phenological stages was greater between years for a single cultivar (Tables 1 and 2) than among cultivars within individual years (Table 5), both in terms of standard deviation and range. The same held true for the duration of phenological phases (Tables 3, 4, and 5). These findings lead to a conclusion that ecological factors (temperature in the first place) have a stronger influence on phenological dynamics than genetic characteristics of cultivars. The beginning of flowering was the phenological event with the smallest and harvest was the event with the greatest variability among cultivars within individual years, whilst the biggest difference between red and white cultivars was displayed in a variation of budburst date (Table 5). The fact that in some extreme years the difference among cultivars was quite big (see maximum values of SD and range in Table 5), brings us to supposition that a wide diversity exists among wine grape cultivars in response to critical agro-meteorological variables.

Conclusion

The study presents an analysis of grapevine phenology timing for the region of Sremski Karlovci based on long-term data set. The mean dates of the onset of selected phenological stages and the duration of phenological phases were derived for a number of white and red wine grape cultivars. Additionally, inter-annual and cultivar variations in phenological timing were determined. Even though in general and on average, the variation of phenological timing was greater between years

than between cultivars, in climatologically extreme years, the difference among cultivars was considerable. Future research should focus on this diversity among cultivars in the sensitivity to climatic variables in order to offer adaptation options to climate change.

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ANALIZA FENOLOGIJE VINOVE LOZE U PODRUČJU SREMSKIH KARLOVACA

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R e z i m e

Urađena je detaljna fenološka analiza na osnovu višegodišnjih podataka za period 1986–2011. godine za osam crvenih i trinaest belih vinskih sorti vinove loze gajenjih na području Sremskih Karlovaca. Ispitivana su četiri fenološka događaja: otvaranje pupoljaka, početak cvetanja, početak šarka i berba. Amplituda između najranijeg i najkasnijeg nastupa proučavanih fenoloških događaja kretala se od 30 do 51 dan za crvene i od 29 do 49 dana za bele sorte. Najmanje variranje između godina pokazao je datum početka cvetanja, a najveće datum berbe. Najveća razlika između crvenih i belih sorti je utvrđena kod datuma berbe – srednji datum berbe bio je 24. septembar za crvene, a 14. septembar za bele sorte. Period od početka cvetanja do početka šarka je ispoljio najmanje, a period od otvaranja pupoljaka do berbe najveće variranje između godina. Prosečno trajanje perioda od otvaranja pupoljaka do berbe je bilo 165 dana za crvene i 156 dana za bele sorte. Po godinama, trajanje ove fenološke faze variralo je u proseku 58 dana za crvene i 55 dana za bele sorte. Takođe je ustanovljeno da na variranje nastupa i trajanja fenoloških faza veći uticaj imaju klimtski faktori nego genetske osobine sorti.

Ključne reči: vinova loza, otvaranje pupoljaka, cvetanje, šarak, berba, Srbija.

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