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RESEARCH CONCERNING THE INFLUENCE OF CLIMATE ON EVOLUTION OF PHENOLOGICAL STAGES IN SWEET CHERRY TREE

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Abstract

Carrying out the phenological stages of vegetation and fructification in sweet cherry cultivars is determined by the cumulative action of rainfall registered and daily average temperatures exceeding 5°C, value considered as biological limit of this species. Research was conducted during 2011-2014 at six Romanian cultivars 'Cetăţuia', 'Cătălina', 'Maria', 'Andreias', 'Margonia' and 'George' and three introduced sweet cherry cultivars 'Van' (Canada), 'Bigarreau Burlat' (France) and 'Bigarreau Dönissen' (Germany). Were recorded number of days, active thermal balance (°C) and rainfall quantity (mm) on periods between phenological stages: from swelling buds to blooming, flowering period, from end of flowering to ripening of fruits and from ripening of fruits to leaves fall. The number of days recorded in periods between phenological stages from swelling buds to start of blooming was between 20-26 days, the active thermal balance ranged between 192 to 269 °C and rainfall quantity ranged between 41 mm to 63 mm. In the blossom period number of days ranged between 8-12 days, with the active thermal balance ranged between 97°C to 151°C and rainfall quantity ranged between 6.5mm to 30 mm. The number of days from swelling buds to start of blooming, from the end of blossom to fruit maturity and from ripening of fruits to leaves fall is positive correlated with the active thermal balance. The number of days from swelling buds to start of blooming and from ripening fruit to leaves fall is positive correlated with the rainfall quantity registered.

Key words: *Prunus avium* L.*, temperature, rainfall, cultivars, blooming.*

INTRODUCTION

Sweet cherry is an important specie in Romania and occupies an area of 7,760 ha (Coman and Chitu, 2014) with the great extension in the following years by new plantations established.
The period between phenological stage of swelling buds and fruit maturation is very short for sweet cherry cultivars compared with other tree species, excepting strawberry (Budan and Grădinariu, 2000). Global climate change are subject to the recent research on plants having great influence in the development of phenological stages (Ansari and Davarynejad, 2008; Balaci et al., 2008; Chmielewski et al., 2004; Inouye et al, 2003). The previous research showed that phenological stages carrying the sweet cherry are determined by the cumulative action of daily average temperatures that exceed the value of 5°C (Sîrbu et al., 2013; Istrate, 2007). Average daily temperature has a direct influence in flowering plants (Radicevic et al., 2011; Tooke and Battey, 2010; Roversi & Ughini, 1996). Temperature is very important during ripening fruit, but from the end of flowering to strengthen of the kernel, the influence of these climatic parameter is low (Budan and Grădinariu, 2000). Sparks et al. (2000), shows that climate change affects the starting time of flowering but Darbyshire et al. (2012) show that every Celsius degree increased of temperature advancing phenophases with 4 to 7 days. Also, rainfall in the period of fruit maturity induced fruit cracking in sweet cherries and can cause heavy losses in yields and returns (Meland et al., 2014).
This paper aims to determine the number of days of active heat balance and rainfall necessary to conduct phenological stages at different sweet cherry cultivars in terms of climate change and establish correlations between the studied parameters.

MATERIALS AND METHODS

In this study during 2011-2014, six Romanian sweet cherry cultivars: 'Cetăţuia', 'Cătălina', 'Maria', 'Andreiaș', 'Margonia' and 'George' and three introduced sweet cherry cultivars

'Van' (Canada), 'Bigarreau Burlat' (France) and 'Bigarreau Dönissen' (Germany) were evaluated. All cultivars were cultivated on *P. mahaleb* L. seedlings rootstock.

Three trees presented each cultivar and were planted at spacing of 4 x 5 m, with free palmette crown shape with support system. The orchard was located on a medium sandy clay loam with medium (6%) humus content.

Herbicide spraying were mantained along trees rows and grass was cut three times during summer in alleyways. No irrigation, rainfall, frost or birds protection system provided.

Phenological data were determined through the Fleckinger system (Fleckinger, 1960): B_1 - the bud swelling: the bud rounds delicate and gains a green light at the top; F_1 – start of blooming: the flowers are open for 5%; G - the end of the flowering: the petal of flowers have fallen for 90%. The data of the fruit ripening was established in the time of marketing quality traits (colour, the content of dry matter) specific to each cultivar.

The climatic data were recorded with the AgroExpert system by the station located on the perimeter of the experimental plot of the Research Station for Fruit Growing, Iaşi - Romania. The active thermal balance (Σt°a) is provided by the sum of average daily temperature degree, which exceeds the biological limit characteristic to the sweet cherry tree, considered to be 5°C (Istrate, 2007).

$$\Sigma t°a = \Sigma T \text{ atd} - BL, \text{ in which:}$$

ΣT atd = sum of average temperature of days between two subsequent phenological stages;

BL = the biological limit of fruit tree species.

The statistical analysis was performed with the XLSTAT programme (ProAcademic, 2011, Addinsoft). The differences between cultivars were determined by the Duncan's test ($p \leq 0.05$). The Pearson correlation coefficient has been calculated between the variables measured ($p \leq 0.05$).

RESULTS AND DISCUSSIONS

For studied sweet cherry cultivars, the number days during the swelling buds to start of blooming ranged between 20 ('Cetăţuia') and 26 ('Margonia') (Table 1).

Table 1. Number of ffdays, active themal balance and rainfall quantity registered during the swelling buds to start of blooming at sweet cherry cultivars (2011-2014).

Cultivar	Number days[1]			Active themal balance (°C)			Rainfall quantity (mm)		
	Av	Min	Max	Av	Min	Max	Av	Min	Max
Cetăţuia	20[b2]	11	26	191.6[b]	114.6	242.8	43.9[ab]	7.6	85.4
Cătălina	22[b]	12	28	197.7[b]	123.2	245.7	44.9[ab]	7.6	85.4
Bigarreau Burlat	22[b]	14	28	208.5[b]	148.7	253	46.0[ab]	7.6	85.4
Maria	22[b]	14	29	217.4[b]	151.4	261.2	47.4[ab]	7.6	85.4
Van	21[b]	15	23	204.7[b]	166.2	225.8	46.3[ab]	4.6	85.4
Andreias	21[b]	15	26	213.9[b]	160	261.6	41.3[b]	9.2	85.4
Bigarreau Dönissen	22[b]	17	27	222.4[ab]	183.3	255.05	48.9[a]	7.6	85.4
Margonia	26[a]	21	33	269.1[a]	233.2	309.1	62.9[a]	33.4	85.4
George	21[b]	15	26	214.2[b]	171.1	254.8	41.9[b]	9.2	85.4
LSD $_{0.05}$	3.1			25.6			20.8		

[1] Av - average; Min - minimum; Max – maximum;

[2] - Different letters after the number corresponds with statistically significant differences for P 5% - Duncan test.

Also, 'Bigarreau Burlat' is a control cultivar for other cultivars as start of blossom, according with other studies (Kazantzis et al., 2011), but 'Cetăţuia' was earlier.

Minimum days for this phenological stage was 11 ('Cetăţuia') and maximum was 33 ('Margonia'). The active termal balance as average on period 2011-2014 ranged between 191.6°C ('Cetăţuia') and 269.1°C ('Margonia'). Except 'Margonia' all others sweet cherry cultivars have not differed statistically significant among them as active termal balance during the swelling buds to start of blooming.

Rainfall quantity ranged between 41.3 mm ('Andreias') and 62.9 mm ('Margonia') but significant statistical differences registered just 'Andreias' and 'George' (table 1). For period 2011-2014, the minimum values was 4.6 mm at 'Van' but the maximum value was the same for all studied cultivars as 85.4 mm.

Number of days for entire blossom time as average during 2011-2014 ranged between 8 ('Van' and 'George') to 12 ('Cătălina') (Table 2). The minimum value was 4 at 'Cetăţuia' and 'Andreiaş' but the maximum value was at 'Cătălina' with 16 days. Active thermal balance ranged between 97.3ºC ('Cetăţuia') and 145.7 ('Margonia') but significant statistical differences registered only 'Cetăţuia' and 'Van'. Minimum value was at 'Cetăţuia' with 46.2ºC but the maximum value was 174.7ºC at 'Bigarreau Dönissen' (Table 2).

Table 2. Number of days, active themal balance and rainfall quantity registered during the blossom time at sweet cherry cultivars (2011-2014).

Cultivar	Number days[1]			Active themal balance (°C)			Rainfall quantity (mm)		
	Av	Min	Max	Av	Min	Max	Av	Min	Max
Cetăţuia	9^{ab2}	4	15	97.3^{b}	46.2	131.3	28.2^{ab}	0	66.6
Cătălina	12^{a}	8	16	151.0^{a}	147.8	153.4	29.8^{a}	0	67.8
Bigarreau Burlat	9^{ab}	5	15	105.9^{ab}	68.3	155.1	29.3^{ab}	0	72.6
Maria	9^{ab}	8	11	119.1^{ab}	94.6	147.8	26.4^{ab}	0	67.8
Van	8^{b}	5	11	99.9^{b}	82.2	125	25.4^{ab}	0	67.8
Andreias	10^{ab}	4	12	123.9^{ab}	80.2	161.3	28.7^{ab}	0	71.2
Bigarreau Dönissen	11^{ab}	6	15	143.2^{ab}	114.5	174.7	27.6^{ab}	2.6	72.6
Margonia	9^{ab}	6	13	145.7^{ab}	114.5	174.1	6.5^{c}	0	14.8
George	8^{b}	5	9	107.2^{ab}	65.1	166.4	23.5^{abc}	0	65.0
$LSD_{0.05}$	3.3			48.1			15.9		

[1] Av - average; Min - minimum; Max – maximum;

[2] - Different letters after the number corresponds with statistically significant differences for P 5% - Duncan test.

For studied sweet cherry cultivars, the rainfall quantity registered values between 6.5 mm to 29.8 mm as an average for 2011-2014 period with a minimum as 0 mm to 72.6 mm. Number of days recorded from the end of blossom to fruit maturity at the studied sweet cherry cultivars ranged between 32 ('Cătălina') to 67 ('George') with a minimum value at 'Cătălina' with 26 days and a maximum value at 'George' with 81 days. These results are according with other studies for sweet cherry cultivars (Sîrbu et al., 2011) which show that from the blossom to fruit ripening are needed 70 - 98 days.

Also, for this stage the studied cultivars required an active thermal balance ranged between 539.2ºC ('Cătălina') to 1,226.1ºC ('George') with a minimum value to 'Cetăţuia' with 485ºC and a maximum value at 'George' with 1,381.6ºC (Table 3).

Number of days registered from the ripening fruit to leaves fall at the studied sweet cherry cultivars ranged between 112 ('George') to 152 ('Cetăţuia') with a minimum value at 'Maria' with 99 days and a maximum value at 'Cetăţuia' with 157 days (Table 4).

Table 3. Number of days, active themal balance and rainfall quantity registered during the end of blossom to fruit maturity at sweet cherry cultivars (2011-2014).

Cultivar	Number days[1]			Active themal balance (°C)			Rainfall quantity (mm)		
	Av	Min	Max	Av	Min	Max	Av	Min	Max
Cetăţuia	33[c]	28	38	541.3[c]	485	586.6	67.7[b]	41	104
Cătălina	32[c]	26	41	539.2[c]	489	600.3	75.9[b]	54.6	101.4
Bigarreau Burlat	36[c]	31	41	602.3[c]	554.9	667.4	89.8[b]	54.6	113.8
Maria	52[b]	42	60	911.5[b]	763.9	1027.6	114.6[b]	72	148.2
Van	54[b]	45	58	955.1[b]	770.5	1092.5	120.8[b]	62.2	182.8
Andreias	50[b]	44	57	897.7[b]	804.7	1006.2	113.1[b]	63.4	150.8
Bigarreau Dönissen	56[b]	47	65	1006.6[b]	845.4	1074.7	123.6[ab]	56	192.8
Margonia	52[b]	47	59	930.5[b]	845.4	1002.5	313.5[a]	56	892.8
George	67[a]	49	81	1226.1[a]	858.7	1381.6	167.4[ab]	62.2	345.6
$LSD_{0.05}$	8.2			155.1			190.9		

[1] Av - average; Min - minimum; Max – maximum;
[2] - Different letters after the number corresponds with statistically significant differences for P 5% - Duncan test.

Table 4. Number days, active themal balance and rainfall quantity registered during the ripening fruit to leaves fall at sweet cherry cultivars (2011-2014).

Cultivar	Number days[1]			Active themal balance (°C)			Rainfall quantity (mm)		
	Av	Min	Max	Av	Min	Max	Av	Min	Max
Cetăţuia	152[a2]	146	157	2,767.2[a]	2,537.3	3,031.8	271.7[a]	177.0	415.4
Cătălina	149[a]	146	152	2,701.9[a]	2,537.3	3,031.8	261.8[ab]	177.0	415.4
Bigarreau Burlat	146[a]	142	150	2,654.9[a]	2,466.1	2,983.9	240.6[ab]	139.8	406.0
Maria	120[bcd]	99	132	2,338.2[b]	2,248.9	2,514.0	223.2[abc]	131.8	368.6
Van	126[bc]	115	138	2,300.8[b]	2,058.6	2,432.0	215.6[bc]	123.2	336.6
Andreias	128[b]	119	132	2,337.5[b]	2,262.4	2,497.8	223.3[abc]	132.0	368.6
Bigarreau Dönissen	121[bcd]	116	133	2,209.0[b]	1,946	2,433.3	210.8[bc]	131.8	324.0
Margonia	114[cd]	102	121	2,229.9[b]	1,934.6	2,528.4	210.9[bc]	132.0	324.0
George	112[d]	102	134	2,021.9[c]	1,670.1	2,343.8	170.8[c]	129.2	240.2
$LSD_{0.05}$	11.3			153.2			49.6		

[1] Av - average; Min - minimum; Max – maximum;
[2] - Different letters after the number corresponds with statistically significant differences for P 5% - Duncan test.

Also, for this stage the studied cultivars required an active thermal balance ranged between 2,021.9ºC (‘George’) to 2,767.2ºC (‘Cetăţuia’) with a minimum value to ‘George’ with 1,670.1ºC and maximum value at ‘Cetăţuia’ and ‘Cătălina’ with 3,031.8ºC. Correlating the number of days with the active thermal balance (Table 5) we observed distict significant positive correlation in the period between swelling buds to start of blooming (r=0.9139), in the period between end of blossom to fruit maturity (r=0.9995) and between ripening fruit to leaves fall (r= 0.9730).

Table 5. Correlation coefficient (r) between number days and active thermal balance and number days and rainfall quantity

Period	Number of days - active thermal balance[1]	Number of days – rainfall quantity
I - Swelling buds -start of blooming	0.9139**	0.9353**
II - Blossom time	0.7702*	0.3137^{ns}
III - End of blossom - fruit maturity	0.9995**	0.4961^{ns}
IV - Ripening fruit - leaves fall	0.9730**	0.9158**

[1]-*-significant correlation; **- distinct significant correlation; [ns]-non-significant correlation.

CONCLUSIONS

The climate change from recent years have influenced the duration of the phenological phases of different sweet cherry cultivars.
The number of days with the rainfall quantity was distict significant positive correlated in the period between swelling buds to start of blooming (r=0.9353) and between ripening of fruits to leaves fall (r=0.9158). The action of daily average temperatures determines different blooming periods in different year conditions.
The number of days from swelling buds to start of blooming, from end of blossom to fruit maturity and from ripening fruit to leaves fall are positive correlated with the active thermal balance.
The number of days from swelling buds to the start of blooming and from ripening of fruits to leaves fall are positive correlated with the the rainfall quantity registered.

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REFERENCES

Ansari M., Davarynejad G., 2008. The Flower Phenology of Sour Cherry Cultivars. American-Eurasian J. Agric. & Environ. Sci., 4 (1): 117-124.

Balaci R. A., Zagrai I., Platon I., Zagrai L., Festila A., 2008. The Evaluation of Produductive and Qualitative Potential of Some Sweet Cherry Varieties in the Pedoclimatic Conditions of Bistrita Area. Bulletin UASVM, Horticulture 65 (1), 502-507.

Budan S., Grădinariu G., 2000. Cireşul, Edit. 'Ion Ionescu de la Brad', Iaşi.

Chmielewski F.-M., Müller A., Bruns E., 2004. Climate changes and trends in phenology of fruit trees and field crops in Germany, 1961–2000. Agricultural and Forest Meteorology 121, 69–78.

Coman M.,Chiţu E., 2014. Zonarea speciilor pomicole în funcţie de condiţiile pedoclimatice si socio-economice ale României. Editura Invel Mutimedia, Piteşti.

Darbyshire R., Webb L., Goodwin I., Barlow E. W. R., 2012. Evaluation of recent trends in Australian pome fruit spring phenology, Int. J. Biometeorol., 57 (3), 409-421.

Inouye D. W., Saavedra F., Lee-Yang W., 2003. Environmental Influences on the Phenology and Abundance of Flowering by Androsace Septentrionalis (Primulaceae), American Journal of Botany, 90 (6): 905–910.

Istrate M., 2007. Pomicultură generală, Edit. Ion Ionescu de la Brad, Iaşi.

Kazantzis, K., Chatzicharissis, I., Papachatzis, A., Sotiropoulos, T., Kalorizou, H., Koutinas N., 2011. Evaluation of Sweet Cherry Cultivars Introduced in Greece. Lucr. st. Univ. Craiova, XVI (LII), 293-296.

Meland M., Kaiser C., Christensen Mark J., 2014. Physical and Chemical Methods to Avoid Fruit Cracking in Cherry, AgroLife Scientific Journal ,3 (1), 177-183.

Radicevic S., Cerovic R., Maric S., Dordevic M., 2011. Flowering time and incompatibility groups – cultivar combination in commercial sweet cherry (Prunus avium L.) orchard, Genetika, 43 (2), 397-406.

Roversi A., Ughini V., 1996. Influence of weather conditions of the flowering period on sweet cherry fruit set, Proc. Intl. Cherry Symp., Eds. Hampson C.R., Anderson R.L., Perry R.L., Webster A.D., Acta Hort. 410, 427 - 441.

Sîrbu S., Beceanu D., Niculaua M., Anghel R. M., Iurea E., 2011. Fruit's physico-chemical characteristics of two bitter cherry cultivars. Lucr. st. USAMV Iaşi, Seria Horticultură, 54 (1), 531-536.

Sîrbu S., Iurea E., Corneanu M., 2013. Research concerning the influence of current climate changes over the phenological stages at sweet cherry tree (Prunus avium L.), Lucr. st. USAMV Iaşi, Seria Horticultură, 56 (2), 201-207.

Sparks T.H., Jeffree E.P., Jeffree C.E., 2000. An examination of the relationship between flowering times and temperature at the national scale using long-term phenological records from the UK, International Journal of Biometeorology, 44, 82–87.

Tooke F., Battey N.H., 2010. Temperate flowering phenology. Journal of Experimental Botany, 61 (11), 2853–2862.


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