RESEARCH CONCERNING THE INFLUENCE OF CURRENT CLIMATE CHANGES OVER THE PHENOLOGICAL STAGES AT SWEET CHERRY TREE (*PRUNUS AVIUM* L.)

CERCETĂRI PRIVIND INFLUENȚA SCHIMBĂRILOR CLIMATICE ACTUALE ASUPRA STADIILOR FENOLOGICE LA CIREŞ (*PRUNUS AVIUM* L.)

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Abstract. *Carrying out the phenological stages of vegetation and fructification in sweet cherry is determined by the cumulative action of daily average temperatures exceeding 5°C, value considered as biological limit of sweet cherry cultivars. In climate conditions from last few years, was observed some changes about value of the sum degree of active temperature necessary onset the phenological stages of sweet cherry tree compared with the same period in '50. The research was conducted during 2009-2012 by 20 sweet cherry cultivars with different fruit maturation period, existing in the sweet cherry germplasm fund from Fruit Growing Research Station Iaşi, Romania. This paper aims to determine the active thermal balance needed to carry out the fruiting phenophases and comparing the results with data cited in the literature.*
Key words*: temperature, phenology, cultivars, flowering, fruiting, sweet cherry tree*

Rezumat. *Desfăşurarea fenofazelor de vegetaţie şi fructificare la cireş este determinată de acţiunea cumulată a temperaturilor medii zilnice ce depăşesc valoarea de 5°C, considerată prag biologic la specia cireş. În condiţiile climatice din ultimii ani, s-a observat o schimbare a sumei gradelor de temperatură activă necesară declanşării stadiilor fenologice la cireş, comparativ cu aceleaşi date din perioada anilor '50. Cercetările au fost efectuate pe perioada 2009-2012, la 20 soiuri de cireş cu perioada de maturare a fructului diferită, existente în colecţia naţională de cireş din cadrul Staţiunii de Cercetare-Dezvoltare pentru Pomicultură, Iaşi. Lucrarea are ca obiectiv determinarea bilanţului termic activ necesar desfăşurării fenofazelor de fructificare şi compararea rezultatelor cu datele citate în literatură.*
Cuvinte cheie: *temperatură, fenologie, soiuri, înflorire, fructificare, cireş.*

INTRODUCTION

The sweet cherry tree is a species with economic importance due to nutritional, technological and commercial aspects of the fruits (Budan and Grădinariu, 2000). The period between the beginning of the growing and maturing fruit phenophases is very short at sweet cherry tree compared to other fruit tree species, being surpassed only by the strawberry. Previous research have shown that the start of vegetation and fruiting phenophases in sweet cherry tree are

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determined by the action of daily average temperatures that exceed the value of 5°C (Istrate, 2007) and have a direct influence on plant flowering (Roversi and Ughini, 2008; Radicevic et al., 2011).

The importance of air temperature is low during the flowering sweet cherry tree until the stengthening of the stone and it increases during the fruit ripening (Budan and Grădinariu, 2000). Kolesnikov (1959) cited by Budan and Grădinariu, 2000 noted that the heat during the blooming and ripening of the fruits is different and it depends on the cultivar. Zacharias and Zacharias (1986) shows that different cultivars of sweet cherry recorded a period of 43 and 65 days from the start of flowering until the harvest maturity, requiring between 660.1°C and 1105.3°C active temperature. Drăgoi and Chitu (1995) studied the influence of meteorological parameters on phenological dynamics using statistical methods to 163 plum genotypes. Global climate change affects indications used by plants to start flowering (Sparks et al., 2000) bringing the phenophases to advance with 4-7 days per degree Celsius of high temperature (Darbyshire et al., 2012).

This paper aims to determining the active thermal balance necessary to fruiting phenophases of sweet cherry cultivars in terms of climate change and comparing the results with data from literature.

MATERIAL AND METHOD

For experimentation, 20 sweet cherry cultivars were studied in period 2009-2012, which were in existence at the national collection of the experimental polygon, which can be found at the Fruit Growing Research Station, Iaşi - Romania. The studied sweet cherry cultivars were different periods of the fruit ripening: early (*Rivan, Muncheberge Frühe, Cetățuia, Catalina, Bigarreau Burlat, Scorospelka* and *Bigarreau Moreau*), medium (*Van, Maria Golia, Bucium, Ludovic, Bing* and *Cociu*) and late period (*Bigarreau Drogan, Germersdorf, Margo* and *George*). 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 - the beginning of the flowering: the flowers are open for 5%. The date of the fruit ripening was established in the time of marketing quality traits (color, 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 polygon of the Fruit Growing Research Station, Iaşi - Romania.

The active thermal balance (Σt°a) is provided by the sum of average daily temperature grades, which exceeds the biological limit characteristic to the sweet cherry tree, considered to be 5°C (Istrate, 2007).

Σt°a = ΣT atd – BL, 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 interpretation of experimental data. The statistical analysis was performed with the Microsoft Excel programme. The difference between cultivars was determined by the Duncan test ($p \leq 0.05$) and the Pearson correlation coefficient has been calculated between the variables measured ($p \leq 0.05$).

RESULTS AND DISCUSSIONS

During 2009-2012 it has been observed a great variability of the number of days and the sum of active degrees of temperature between the vegetation stages according to the sweet cherry tree cultivar and climatic year. Therefore, the period from the swelling of the buds until the beginning blossoming, the studied cultivars showed large variations in vegetation period and the active thermal balance (table 1).

Table 1

Active thermal balance necessary during the vegetation period between the swelling bud to beginning blossom of the sweet cherry cultivars (2009-2012)

Cultivar	Duration of the vegetation between the swelling of the buds to the beginning of blossom (B_1-F_1)								Average	
	2009		2010		2011		2012			
	Nr. days	∑ t°a	Nr. days	∑ t°a	Nr. days	∑ t°a	Nr. days	∑ t°a	Nr. days	∑ t°a
Rivan	29	166,7	14	133,6	32	236,7	13	114,6	22^{cde}	$170,4^{cdef}$
Muncheberge fruhe	28	171,3	15	149,8	27	179	12	98,9	21^{e}	$149,8^{f}$
Cetățuia	25	126,3	14	137,8	29	219,0	14	124,9	21^{e}	$152,0^{f}$
Cătălina	28	171,3	14	144,4	28	227,3	15	133,5	21^{de}	$169,1^{def}$
Bigarreau Burlat	28	171,3	17	169,1	31	251,7	15	129,1	23^{bcde}	$180,3^{cdef}$
Scorospelka	27	180,3	13	124,3	28	203,2	16	140,1	21^{e}	$162,0^{ef}$
Bigarreau Moreau	32	218,7	15	145	33	260,1	17	148,7	24^{abcd}	$193,1^{bcde}$
Van	31	207,8	13	126,4	29	213,8	17	151,4	23^{bcde}	$174,9^{cdef}$
Maria	29	180,3	15	144,4	30	247,7	17	161,7	23^{bcde}	$183,5^{bcdef}$
Golia	30	207,8	15	145	25	194,8	18	176,5	22^{cde}	$181,0^{bcdef}$
Bucium	33	218,7	14	137,4	29	237,8	16	156,5	23^{bcde}	$187,6^{bcde}$
Ludovic	33	218,7	13	126,4	30	250,2	21	197,8	24^{abcd}	$198,3^{bcd}$
Bing	31	189,3	12	119,7	31	242,1	15	134,9	22^{cde}	$171,5^{cdef}$
Cociu	33	218,7	14	135,7	30	246,3	18	185,1	24^{abcde}	$196,5^{bcde}$
Bigarreau Drogan	33	229,4	12	166,1	32	260,1	20	188,2	24^{abcd}	$211,0^{ab}$
Germersdorf	34	218,7	18	178,4	30	242,1	20	183,3	26^{ab}	$205,6^{abc}$
Margo	35	242,2	18	178,4	32	272,9	24	243,5	27^{a}	$234,3^{a}$
George	30	198,8	18	177,4	28	227,1	18	181,4	24^{bcde}	$196,2^{bcde}$
Marina	31	198,8	15	145	26	217,7	17	171,3	22^{cde}	$183,2^{bcdef}$
Anda	32	162,8	16	157,3	30	245,6	23	225,2	25^{abc}	$197,7^{bcd}$
LSD 5%									3	29,3

The average values during the study ranged between 21 days (*Muncheberger Frühe, Catalina* and *Scorospelka*) and 27 days (*Margo*) and the active thermal balance of values were registered between 149.8°C (*Müncheberger Frühe*) and 234.3°C (*Margo*) (table 1).

For the period from the beginning of the blossoming (F_1) to the ripening of the fruit (mf) was required an average over the studying period which ranges from 40 days to 87 days for different sweet cherry cultivars.

Table 2

Active thermal balance necessary during the vegetation between the beginning blossom to ripening period of sweet cherry cultivars (2009-2012)

Cultivar	Duration of the vegetation between the beginning blossom to ripening period (F_1 – mf)								Average	
	2009		2010		2011		2012			
	Nr. days	∑ t°a	Nr. days	∑ t°a	Nr. days	∑ t°a	Nr. days	∑ t°a	Nr. days	∑ t°a
Rivan	54	779,0	49	685,9	30	429,5	40	655,4	43de	637,5^{e}
Muncheberge fruhe	45	635,9	43	577,0	34	458,3	38	608,8	40^{e}	570,0^{f}
Cetățuia	48	691,9	44	591,6	43	663,9	41	665,9	44de	653,3^{e}
Cătălina	54	785,5	56	816,3	46	724,8	41	665,9	49^{d}	748,1^{e}
Bigarreau Burlat	50	769,1	53	796,8	29	418,8	37	600,6	42de	646,3^{e}
Scorospelka	52	760,1	48	666,7	34	484,5	34	559,7	42de	617,8^{f}
Bigarreau Moreau	50	752,8	50	711,1	36	554,5	44	732,2	45de	687,7^{e}
Van	64	1025,8	61	921,9	56	925,8	61	1083,1	61^{c}	989,2^{cd}
Maria	65	1013,7	61	909,7	61	1037,3	64	1131,9	63^{c}	1020,9^{cd}
Golia	62	986,2	61	921,9	60	1005,3	55	946,9	60^{c}	965,1^{cd}
Bucium	61	975,3	61	935,8	57	971,8	56	958,2	59^{c}	960,3^{d}
Ludovic	56	1190,0	61	946,8	62	1065,1	58	1015,6	59^{c}	1054,4^{cd}
Bing	68	1085,5	70	1128,0	54	1155,5	63	1113,2	64^{c}	1120,6^{c}
Cociu	65	1056,1	60	1034,0	59	1003,7	56	970,5	60^{c}	1016,1^{cd}
Bigarreau Drogan	64	1045,4	72	1196,3	61	1069,7	61	1137,1	65^{c}	1112,1^{c}
Germersdorf	66	1080,1	64	1049,0	56	962,1	58	1051,2	61^{c}	1035,6^{cd}
Margo	68	1009,5	63	1031,2	55	949,4	56	1080,9	61^{c}	1017,8^{cd}
George	93	1636,4	97	1681,8	80	1398,3	76	1450,6	87^{a}	1541,8^{a}
Marina	85	1473,9	92	1539,3	71	1221,7	62	1148,6	78^{b}	1345,9^{b}
Anda	66	1067	68	1106,4	60	1108,4	60	1106,6	49^{c}	1097,1^{cd}
LSD 5%									6	121,5

The active thermal balance, during this period, ranged between 570.0°C (*Müncheberger Frühe*) and 1541.8°C (*George*) (table 2). Statistically speaking, there were significant differences in the thermal balance activity necessary during the period from the beginning of the blossom (F_1) and fruits maturation (mf) for *Marina* and *George*, in comparison with cultivars with ripening period in early or

medium season (table 2). *Bigarreau Drogan, Germersdorf, Margo* and *Anda* had late fruit maturation but not showed significant statistically differences in comparison with the sweet cherry cultivars with medium season maturation.

Cultivars with early fruit maturation (*Rivan, Muncheberger Frühe, Cătălina, Bigarreau Burlat, Scorospelka* and *Bigarreau Moreau*) registered significant statistically differences in comparison with sweet cherry cultivars with medium or late maturation season, both in number of days and the active thermal balance required for the period from the start of the blossoming (F_1) and fruit maturation (mf) (table 2).

From the data cited by Kolesnikov, 1959 cited by Budan & Grădinariu, 2000 it's considered necessary active temperature range of 460-670°C for the period from the beginning of blossom (F_1) to the fruit ripening (mf) for early sweet cherry cultivars. From research performed by us during 2009-2012 it was found that these limits have increased to 515-748°C, the difference being greater than 55-78°C. Also, the need for active temperature during the start of blossom (F_1) and the fruit maturation (mf) for the medium season cultivars was higher compared to the cited data from Kolesnikov, 1959, respectively 955-1085°C, with 135-145°C higher. Speaking about late maturing cultivars, registered limits were higher (1095-1281°C) with 45-131°C, compared with studies from the '50s. However, Zaharia & Zaharia, 1986, shows that *Van* requires an average of 65 days with 1068.3°C active thermal balance and *Bing* requires 63 days with 1002.1°C active thermal balance into Mehedinți County conditions, during the 1984-1985 years, but in failing to specify the biological limit considered for sweet cherry species. From the data recorded by us *Van* required an average of 61 days with a 989.2°C as active thermal balance, which were lower values, compared with the data cited. *Bing* took 64 days with 1120.6°C active thermal balance, higher values compared to the data cited by Zaharia & Zaharia, 1986.

By correlating the number of days from the period of the phenological phases from the swelling of the bud (B_1) to the beginning of the blossoming (F_1) and the period between the beginning of the blossoming (F_1) to fruit maturation (mf), it was observed that these variables are positively correlated (table 3), but there is some exceptions. Thereby, it was observed that in the years with low temperatures during February-March, when the starting of the phenological phases is long overdue, these variables were negatively correlated, but statistically insignificant.

Table 3

Correlations between the number of days and the sum of degrees of temperature over different phenological periods in sweet cherry tree

Year	Correlations between variables:	
	Number of days between: B_1-F_1 ÷ F_1 – mf	Sum of degrees of temperature between: B_1-F_1 ÷ F_1 – mf
2009	0,41 ^{ns}	0,41^{ns}
2010	0,24 ^{ns}	0,25^{ns}
2011	- 0,28 ^{ns}	0,21^{ns}
2012	0,54 **	0,64***
$P_{5\%}$= 0,44		

This means that, in the years with low temperature of the beginning of the springs, the period between the swelling of the buds (B_1) and the start of the blossoming (F_1) is greater and the period between the start of the blossoming (F_1) and the fruit maturation (mf) is reduced, compared to the normal years according to the climate conditions. Correlating the sum of degrees of active temperature degrees for these phenological intervals, it can be observed that it is positively correlated, which means that the large thermal balance from the swelling of the bud (B_1) until the beginning of the blossoming (F_1) implies an increase of the active thermal balance during the period from the beginning of the blossoming (F_1) to the fruit ripening (mf).

CONCLUSIONS

1. The climate change from recent years have influenced the duration of the phenological phases of different cultivars of sweet cherry tree.

2. Sweet cherry cultivars which have been studied, showed an increasing need for active temperature for the duration of phenophases, in comparison with the data cited in the 50's.

3. Phenological period of the same sweet cherry cultivars are variable, depending on the climate year conditions and the cultivation area.

4. In the years with cold springs, the beginning of the phenological phases is delayed and the phenophases between blossoming and fruit ripening succeed in a short time.

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