

# Effect of length and thermal time of the growing season on blueberry production

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**Abstract.** Highbush blueberry is one of the most popular fruit-bearing culture in the world. But its cultivation is associated with a number of peculiarities, which must be considered when setting up plantations in a given region. To ensure large stable harvests cultivars require sufficient heat sum and time for successful formation of flower buds, which provide the next year’s harvest of berries. Initiation and formation of flower buds begins during crop maturation and ends with the growing season. According to our observation data, blueberry cultivars require no less than 100 days and a heat sum of no less than 900°C (of temperatures above 0°C) during this period to successfully initiate flower buds. Failing to meet this mark leads to a significant (2,0-2,5 times) drop in yield. When setting up industrial plantations it is important to consider these circumstances and to select the cultivars, maturation times of which allow the plants to successfully form the number of flower buds, which provide a consistent high yield and profitability of the grown culture in the given region.

## 1 Introduction

The most important economically viable trait of any type of fruit bearing crop is its productivity – a complex trait, which characterizes the genotype’s resilience to hostile climate conditions and diseases. Productivity is the deciding factor of a successful introduction, and thus an important goal in this process is to determine the ability of plant cultivars to produce high quality harvest.

As the result of many years of monitoring the productivity of different cultivars of highbush blueberry [1, 2] it has been determined that cultivars are characterized by genetically determined fruiting periodicity [3]. But, in addition to genetic traits, harvest size is affected by a wide variety of factors, in particular by the climate conditions of the region where the plant is grown. Some of these factors, such as, for example, the amount of moisture the plants receive, are controllable and can be adjusted in accordance with the needs of a plant. Others, such as the beginning and the end of the growing season, its length, thermal time, are impossible to manage artificially when growing the plant in open soil. Therefore they often provide the key influence on the productivity of the cultivated plants. Blueberry productivity is largely characterized by the plants’ ability to initiate flower buds, inflorescences in the year, preceding the fruiting, flowering strength and mass yield of the fruits [4]. And, as productivity of blueberry cultivars depends on how favorable

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the circumstances of for initiation and formation of flower buds were during the previous season, the conditions of the previous year play the chief role, rather than those of the current year. And they may affect cultivars of different maturation times in different fashions.

The aim of our research was to determine the effect of the length and thermal time of a growing season, as well as the length and thermal time of the period from mass crop maturity until the end of the growing season on formation of harvest and productivity of blueberry cultivars of different ripening periods.

## **2 Materials and methods**

The research was conducted form years 2011 to 2019 on Gantsevichi experimental base of the Central Botanical Garden NAS of Belarus, situated in Gantsevichi district, Brest region. The object of the research were 8 cultivars of highbush blueberry of different ripening periods. early ripening – Bluetta, Duke, Patriot; mid-ripening: Bluecrop, Denise Blue; late ripening: Coville, Darrow, Elizabeth, and 2 cultivars of half-high blueberry: Northcountry and Northblue.

Climate characteristics of a given research year were calculated based on the monitoring data provided by Gantsevichi weather station. Phenological monitoring was conducted according to the methodology of I.D. Yurkevich et al. [5]. The research of fruiting peculiarities was conducted according to the methodology of S.Ye. Korovin et al. [6]. Harvest evaluation was done by multiple weightings as the fruits ripened, by weighing and summing up the masses of the harvested fruit on each experimental bush, after which average values were calculated for each cultivar.

Statistical processing of the data was conducted on a personal computer using the «Microsoft Excel 2019» application.

## **3 Results and discussion**

As the research data has shown, the dates of the beginning and end of the frost-free period noticeably varied during the monitoring years (table 1). At the same time, variation of such metrics as the length of the frost-free period and the number of days with temperatures above +10°C was not notable (table 1) and did not affect the formation of harvest and productivity of cultivated blueberry in any significant way. The length of the growing season during the monitoring years was within normal values at 230-260 days, and the number of days with temperature above +10°C was 135-168 days. A similar situation could be seen with thermal time, both for individual months as well as for the entire growing season (table 2). In general, the thermal time of a growing season also was within normal values at 3100-3460°C. Nonetheless, the yield of the blueberry cultivars during the research period greatly varied, and, at the same time, depended neither on the length of the growing season of the year preceding the fruiting, nor on its thermal time. Frosts during the flowering period of blueberry, as well as extreme winter conditions a long thaw followed by an abrupt temperature drop made some adjustments in certain years of the research (2011, 2014), but in other years these factors did not affect anything.

Considering that all researched cultivars grow on the same plot, in the same environment, it follows that all biotic and abiotic regional growth factors affect them in the exact same way. Nonetheless, the results provided in table 3 show that early- and mid-ripening cultivars of highbush blueberry and early ripening cultivars of half-high blueberry display the highest and most consistent productivity in our environment, unlike the late ripening cultivars.

Annual productivity of late ripening cultivars of blueberry was 2,0-2,5 times lower, than in early- and mid-ripening cultivars (table 3). Because of that it has been decided to analyze the effect of the length and thermal time of the period from mass crop maturity until the end of the growing season on blueberry productivity, as initiation of flower buds of the next year’s harvest takes place precisely at this time.

**Table 1.** The length of the growing season during the monitoring years.

Values	Length of the frost-free period by year								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Surpassing 0°C	26.03	11.03	1.04	1.03	2.03	6.03	1.03	30.03	5.03
End of the frost-free period	15.11	26.10	25.11	22.10	23.11	8.11	22.11	16.11	21.11
Length, days	232	230	238	336	268	248	267	224	254
Days with t > +10°C	147	155	150	159	151	137	144	168	135

**Table 2.** Thermal time of the growing season during the monitoring years.

Monitoring year	Heat sum of temperatures above 0°C by month									Season sum
	March	April	May	June	July	August	September	October	November	
2011	13	276	430	564	601	546	421	191	75	3117
2012	106	267	449	492	640	546	400	237	131	3268
2013	0	222	499	557	568	557	361	271	146	3180
2014	187	266	468	489	635	589	397	226	104	3362
2015	144	236	404	509	563	618	451	201	132	3259
2016	85	275	454	552	611	564	414	177	22	3153
2017	156	196	409	502	542	573	404	240	86	3107
2018	8	343	518	542	636	616	464	252	87	3466
2019	143	260	430	622	539	563	388	306	159	3409

**Table 3.** Blueberry productivity during the monitoring years.

Cultivar	Productivity of blueberry cultivars, kg per shrub, by year								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Bluetta	2.8	5.6	5.5	0.6	4.6	1.8	4.4	1.0	2.3
Duke	1.1	5.7	6.8	1.8	3.7	1.7	1.5	3.2	4.0
Patriot	3.0	6.4	5.2	0.7	6.9	3.3	4.7	3.6	5.8
Bluecrop	0.7	3.9	4.4	1.5	3.1	0.2	4.4	2.8	3.2
Denise Blue	2.5	7.9	4.0	3.1	4.2	1.5	8.4	1.9	3.9
Coville	0.9	2.1	2.0	1.1	1.7	0.3	2.6	0.3	0.5
Darrow	1.3	1.6	2.2	0.8	1.3	1.4	2.7	0.4	1.1
Elizabeth	1.6	0.7	3.6	0.7	3.0	0.6	2.3	0.3	1.0
Northblue	7.9	2.6	4.5	0.1	8.5	4.4	1.9	5.1	7.2
Northcountry	8.0	4.9	7.3	0.3	5.6	2.9	5.2	4.3	5.8

Mass crop maturity in early- and mid-ripening cultivars of highbush blueberry, as well as cultivars of half-high blueberry in our environment happens, as a rule, in July and the first half of August, and these months are the warmest ones of the entire growing season (table 4). Mass crop maturity in late ripening cultivars happens in September, in rare cases it occurs in August. Therefore, in late cultivars the warmest months of the season take place during fruit formation period and the beginning of fruit ripening. As a result, late cultivars have a shorter period to initiate flower buds for the next year’s harvest and receive

much less heat to undergo this process. As calculation of the length of the time period from mass crop maturity to the end of the growing season has shown, along with the calculation of the heat sum of positive temperatures during this period, the difference in these values in early and late cultivars is 1.5-2.0 times (tables 5, 6). In particular, the length of the period from mass crop maturity until the end of the growing season in early ripening cultivars during the monitoring years was 99 to 133 days, in mid-ripening ones – 95 to 127 days, and in late ripening ones – 62-102 days (table 5). Thermal time of this period also varied significantly was 1166°-1640°C for early ripening cultivars, 977-1664°C for mid-ripening ones and only 816-1146°C for late ripening ones (table 6).

**Table 4.** Maximum temperatures by ten day periods of the second half of a growing season.

Monitoring year	Maximum temperatures by ten day periods of the second half of the season														
	July			August			September			October			November		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
2011	27.1	31.0	30.0	28.2	27.6	28.0	23.0	25.8	23.4	20.3	16.6	11.8	11.2	5.0	7.9
2012	33.6	28.2	27.3	33.0	28.3	27.9	24.0	25.6	26.9	20.9	18.2	16.2	11.7	10.0	8.9
2013	28.7	27.3	29.2	32.0	29.7	28.9	22.7	22.6	15.1	17.3	14.9	19.2	14.2	9.5	9.5
2014	28.9	29.1	33.8	35.5	32.4	23.3	25.5	24.8	18.7	21.8	21.7	14.0	18.2	10.0	-0.4
2015	33.5	27.6	30.5	34.8	34.0	31.5	34.4	27.7	25.8	21.2	12.7	11.5	11.7	13.7	6.0
2016	33.4	30.7	31.4	31.5	27.4	31.5	28.5	29.0	22.7	23.7	9.6	8.8	7.2	9.3	6.5
2017	26.1	28.3	31.2	32.3	33.1	24.8	25.0	26.5	20.6	13.8	20.2	10.7	12.7	7.2	5.2
2018	28.4	28.4	31.2	30.0	30.6	29.1	28.5	27.3	26.8	21.5	22.3	16.8	12.4	8.5	0.6
2019	33.7	27.0	29.1	25.5	30.3	31.5	29.5	26.7	18.9	23.0	23.1	22.0	17.0	15.5	7.3

**Table 5.** The length of the period from mass crop maturity until the end of the vegetation during the research.

Cultivar	Length of the period from mass crop maturity until the end of the vegetation, days.									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Bluetta	89	106	133	99	119	116	107	124	120	
Duke	113	103	133	99	111	116	107	118	119	
Patriot	118	98	128	95	100	106	102	123	111	
Bluecrop	113	77	116	95	100	106	97	117	103	
Denise Blue	107	71	107	85	103	99	89	108	101	
Coville	84	64	97	64	84	64	68	93	97	
Darrow	84	62	102	80	86	81	72	109	80	
Elizabeth	84	62	87	64	84	64	68	93	80	
Northblue	113	103	124	101	116	116	112	124	119	
Northcountry	113	98	124	101	116	117	110	124	122	

**Table 6.** Thermal time of the period from mass crop maturity until the end of the vegetation during the research.

Cultivar	Thermal time of the period from mass crop maturity until the end of the vegetation, heat sum of positive temperatures									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Bluetta	896	1490	1640	1557	1488	1469	1166	1812	1573	
Duke	1339	1436	1640	1557	1348	1469	1166	1686	1552	
Patriot	1518	1338	1537	1472	898	1308	1077	1794	1401	
Bluecrop	1339	908	1035	1472	898	1308	977	1664	1267	
Denise Blue	1217	820	848	1258	964	1177	832	1448	1401	
Coville	816	692	971	800	784	545	516	1146	1154	
Darrow	816	637	1055	1135	821	1036	589	1477	834	
Elizabeth	816	637	807	800	784	545	516	1146	834	
Northblue	1339	1436	1494	1597	1435	1469	1280	1867	1552	

Northcountry	1339	1338	1494	1597	1435	1488	1231	1867	1610
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Therefore, as Autumn months, when the process of flower bud initiation occurs in late ripening cultivars, have lower thermal times compared to the Summer (table 4), it negatively affects both the number of flower buds initiated during this period and the next year’s productivity of the cultivar.

## 4 Conclusion

According to the information above, it follows that the most important characteristic for the formation of the harvest in cultivated blueberry is the length and thermal time of the period required for the formation of flower buds, specifically the time period from mass crop maturation until the end of the growing season.

These characteristics must be considered when setting up blueberry plantations in areas with different lengths of the growing season and thermal times. Late crop maturity will negatively affect the yield of the cultivars. Therefore, it is necessary to select the cultivars, maturation times of which allow the plants to successfully form flower buds for the next year’s harvest to ensure high yield, or to employ modern technologies, which make it possible to extend the time period, required to completely undergo this process in such circumstances.

## References

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