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AIR TEMPERATURE INFLUENCE ON SEASONAL DEVELOPMENT OF COMMON MAPLE SEEDLINGS

The article presents the results of the 3 years of phenological development observations of maple sprouts, depending on the date of seeds sowing. Experimental autumn and spring sowings of maple seeds in the nursery sowing department are selected as objects. Seedlings, grown with the autumn sowing of winged seeds are 7–10 days ahead in the development of the spring sowing seedlings. It is also found out that the seasonal development is closely associated with the effective daily average air temperatures indices (≥+5°C).

Introduction. Life activity of plants is characterized by passing through phenological phases or development stages. Morphologically the phenological stage display is expressed in emergence of certain organs – buds, leaves, flowers, fruits, etc. on a plant. Calendar terms and duration of these phases depend not only on biological peculiarities of the species, but also largely on a complex of external conditions, in particular climatic ones [1–4]. It is necessary to consider determination of the phenological stages duration and also calendar terms of their starting date, for example, at forest sowing and planting, taking care of forest plantations [5, p. 40]. In references there is information that the beginning or finishing of a phenological phase mainly depends on the air temperature [1, 6].

The seed breeding method of the common maple by autumn and spring seeds sowing is mainly used in the republic[7]. Hence, the seasonal seedlings development will differ depending on the seeds sowing time. We consider that this issue is insufficiently mastered and there isn't enough information about it in the references. We studied the peculiarities of maple seedlings seasonal development, depending on the seeds sowing time and we found out the phenological phases dependencies on the air temperature.

Main part. Phenological observations over the development of hypocotyl and epicotyl plant parts were carried out on the record sowing lines according to the method of N.E. Bulygin [8]. Experimental autumn and spring sowings of common maple seeds in the nursery sowing department of the BSTU branch of «Negoreloe forestry experimental station» were selected as objects.

Detection of regular connections between the development phases beginning and the environmental conditions was carried out on the basis of daily average air temperatures above +0, +5, +10°C and effective temperatures (≥ +5°C) at the moment of the beginning and termination of the phenological stage [6; 9, p. 30]. The weather data from the meteorological station near Stolbtsy was used for this purposee [10].

Emergence over the soil surface of cotyledon growing tips, carried out by hypocotyl, indicates the beginning of seasonal development of the hypocotyledonary part of the common maple (Figure *a*, *b)*.

On the basis of 3 years of observations it was found out that emergence of the first maple sprouts at autumn seeds sowing took place during the third ten-day period of March with discrepancy of 3–5 days according to the years of registration. More exact, up to one day, prediction of the first sprouts emergence is possible when reaching the total of effective air temperatures from 2,9 to 3,4°C (Table 1).

Sprouts cotyledons expansion, i. e. their isolation on a hypocotyl, comes in 2 days after the sprouts emergence (Figure *c, d)*.

a

b

c

d

Phenological phases of seasonal development of the hypocotyledonary plant part:
a, *b* – emergence of the first sprouts;
c, *d* – expansion of cotyledons

Table 1

Phenological phases of seasonal developmentof the hypocotyledonary plant partat the autumn seeds sowing

Phenological phase	Year of observations	Date	The total of daily average temperatures			
			>0°C	>+5°C	>+10°C	effective
Emergence of sprouts	2009	30.III	42.6	12.9	–	2.9
	2010	25.III	37.5	13.4	–	3.4
	2011	28.III	50.9	18.1	–	3.1
Cotyledons expansion	2009	01.IV	52.4	18.0	–	3.0
	2010	27.III	53.6	29.5	–	9.5
	2011	30.III	57.6	18.1	–	3.1
Cotyledons fall	2009	26.V	622.6	573.3	366.1	303.3
	2010	21.V	664.2	631.9	402.5	346.9
	2011	25.V	640.8	579.8	413.1	314.8

The specified phase begins at accumulation of the total of the daily average air temperatures above +0°C from 52.4 to 53.6°C that makes 1–2 days of weather in this period. Yellowing and the subsequent cotyledons fall on seedlings were registered during the third ten-day period of April. Beginning difference of the specified phase according to the years of registration makes up to 5 days. The total of stored effective air temperatures (≥+5°C), the magnitude of which is within the limits of 303.3–346.9°C signals the most precisely about the approach of the cotyledons fall phase.

Emergence of the first maple sprouts at spring seeds sowing is observed during the third ten-day period of April, with insignificant difference of time (2 days). The given phase begins when the total of the effective air temperatures (≥+5°C) reaches the value from 102.9 to 108.6°C (Table 2). Cotyledons expansion on sprouts begins one day later after their emergence. The most exact temperature index indicating the approach of the specified phase (up to one day), is the daily average air temperature above +0°C, at accumulation of the total of air temperatures above +0°C to the phase beginning within the limits of 299.6–309.6°C. Seedlings cotyledons fall was observed during the first ten-day period of June. It is possible to predict the approach of the cotyledons fall phase ±3 day in advance according to accumulation of the total of the daily average air temperatures above +10°C – 491.2–539.9°C.

Thus, seasonal development of the maple seedlings hypocotyledonary part is most closely connected with the index of the effective air temperatures (≥+5°C). The first sprouts emergence at autumn seeds sowing is observed when reaching the total of the effective air temperatures from 2.9 to 3.4°C, and at spring sowing – 102.9–108.6°C.

Seasonal development of the seedlings epicotyl part begins with the gemma expansion. Morphologically the given phase shows itself in the gemma length increase and isolation on its surface of primary leaves protuberances.

At autumn sowing of winged seeds the common maple seedlings gemma expansion is observed during the second half of April or in 15–20 days from the cotyledons emergence moment (Table 3). It is possible to consider the total of the stored daily average air temperatures above +0°C, equal to the phase beginning to 185.6–187.5°C as the predictive index. The sprout length increase between cotyledons and the first real leaves indicates the linear growth phase beginning of the primary sprout. The sprout length increase begins in 6-10 days after the gemma expansion and terminates at the end of August.

Table 2

Phenological phases of seasonal development of the hypocotyledonary plant part at the spring seeds sowing

Phenological phase	Year of observations	Date	The total of daily average temperatures			
			>0°C	>+5°C	>+10°C	effective
Emergence of sprouts	2009	28.IV	282.2	232.9	77.7	102.9
	2010	26.IV	300.9	268.6	74.5	108.6
	2011	28.IV	294.3	233.3	117.8	103.3
Cotyledons expansion	2009	29.IV	299.6	250.3	95.1	115.3
	2010	27.IV	309.6	277.3	74.5	112.3
	2011	29.IV	309.0	248.0	132.5	113.0
Cotyledons fall	2009	04.VI	756.5	707.2	491.2	392.2
	2010	31.V	802.3	770.0	532.1	435.0
	2011	01.VI	767.6	706.6	539.9	406.6

Table 3

Phenological phases of seasonal development of the epicotyl plant part at the autumn seeds sowing

Phenological phase	Year of observations	Date	The total of daily average temperatures			
			>0°C	>+5°C	>+10°C	effective
Gemma expansion	2009	17.IV	185.6	143.1	34.2	58.1
	2010	12.IV	187.5	163.4	22.0	63.4
	2011	20.IV	187.7	126.7	11.2	36.7
Linear growth beginning of the primary sprout	2009	26.IV	251.1	201.8	46.6	81.8
	2010	20.IV	265.3	241.2	74.5	101.2
	2011	26.IV	263.6	202.6	87.1	82.6
Frondescence of the primary sprout	2009	28.IV	282.2	232.9	77.7	102.9
	2010	24.IV	287.1	254.8	74.5	104.8
	2011	28.IV	294.3	233.3	117.8	103.3
Linear growth termination of the primary sprout	2009	27.VIII	2210.7	2161.4	1936.1	1426.4
	2010	29.VIII	2659.8	2627.5	2389.6	1842.5
Isolation of the terminal bud of reproduction	2009	11.IX	2447.1	2397.8	2172.5	1587.8
	2010	08.IX	2774.8	2742.5	2495.9	1907.5

More exact determination of the sprout growth beginning (up to 2 days) is possible when reaching the total of the effective air temperatures(≥+5°C) from 81.8 to 101.2°C. With isolation and unfolding of the first entire leaves on the sprout the frondescence phase begins. The given phase beginning is observed during the third ten-day period of April, or in 3–5 days after the linear growth phase beginning of the seedlings primary sprout. Accumulation of the total of the effective air temperatures (≥+5°C) to the phase beginning within the limits of 102.9–104.8°C indicates the most exactly its approach.

Seasonal development end criterion of the seedlings epicotyl part at the autumn sowing of maple winged seeds is isolation of the terminal bud of reproduction. Morphologically the given phase expresses itself in emergence of a small green protuberance on the sprout top. The phase was registered on September, 11 (2009) and on September, 8 (2010). It is impossible to predict the approach of the specified phase, relying on the temperature indices, as the difference in the totals of the stored air temperatures according to the indices being studied turned out to be more than 300°C.

The sprouts gemma expansion at the common maple spring seeds sowing begins during the third ten-day period of April – the first ten-day period of May, or in 2–4 days after the first sprouts emergence. Approach of the sprouts gemma expansion phase is most closely connected to the effective air temperature (≥+5°C).

At accumulation of the total of the effective temperatures within the limits of 118.5–125.3°C the seasonal development phase under study was registered. The linear growth of the primary sprout begins in 3–4 days after the gemma expansion, and ends in the second half of August; it is earlier, than at the autumn seeds sowing. It is possible to predict the most exactly the approach of the specified phase according to accumulation of the total of the effective air temperatures within the limits of 129.1–154.8°C.

With isolation and unfolding of the first real entire leaves of the maple seedlings the frondescence phase is observed. Approach of the specified phase begins 3–5 days later after the primary sprouts entrance into the linear growth phase. The frondescence beginning is closely connected with the index of the effective air temperatures at accumulation of the total of which within the limits of 152.3–171.2°C the given phase is registered, and that corresponds to 1–2 days of May weather during the frondescence period (Table 4).

The seasonal development end of the common maple seedlings epicotyl part at the spring sowing of winged seeds was registered on September, 11 (2009) and on September, 8 (2010). The insignificant difference in calendar isolation terms of the terminal bud of reproduction according to the years of observations do not permit to relate it to the temperature indices being analyzed.

The difference in the totals of the stored air temperatures according to the indices under study by the phenological phase beginning turned out to be more than 300°C.

Conclusion. Making a summary of the stated above we come to a conclusion that the seedlings grown at the autumn sowing of winged seeds are 7–10 days ahead in their development of the seedlings at the spring seeds sowing.

These peculiarities should be taken into consideration in the planting stock cultivation process. Thus, seasonal development is most closely connected with the index of the effective daily average air temperatures (≥+5°C).

Table 4

Phenological phases of seasonal development of the epicotyl plant partat the spring seeds sowing

Phenological phase	Year ofobservations	Date	The total of daily average temperatures			
			>0°C	>+5°C	>+10°C	effective
Gemma expansion	2009	30.IV	314.6	265.3	110.1	125.3
	2010	29.IV	329.5	297.2	84.8	122.2
	2011	30.IV	319.5	258.5	143.0	118.5
Linear growth beginning of the primary sprout	2009	04.V	364.1	314.8	159.6	154.8
	2010	02.V	374.6	342.3	129.9	152.3
	2011	04.V	350.1	289.1	143.0	129.1
Frondescence of the primary sprout	2009	07.V	395.5	346.2	181.6	171.2
	2010	05.V	411.4	379.1	158.5	174.1
	2011	09.V	398.3	337.3	170.6	152.3
Linear growth termination of the primary sprout	2009	24.VIII	2159.3	2110.0	1884.7	1390.0
	2010	19.VIII	2494.9	2462.6	2224.7	1727.6
Isolation of the terminal bud of reproduction	2009	11.IX	2447.1	2397.8	2172.5	1587.8
	2010	08.IX	2774.8	2742.5	2495.9	1907.5

So, the first sprouts emergence at the autumn seeds sowing is observed when reaching the total of the effective daily average air temperatures from 2.9 to 3.4°C, and at the spring sowing – from 102.9 to 108.6°C.

The linear growth beginning of the primary sprout at the autumn seeds sowing is observed when reaching the total of the daily average air temperatures above +0°C from 81.8 to 101.2°C, and at the spring seeds sowing – 129.1–154.8°C. The primary sprout frondescence from the point of view of the sowing terms was registered accordingly at temperatures of 102.9–104.8°C and 152.3–174.1°C.

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