

The influence of meteorological factors on growth and vegetation process of *Perilla frutescens* (L.) Britton in Lithuania

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Key words: *Perilla frutescens* (L.) Britton, growth, phenology, phases of vegetation period, climatic conditions of Lithuania.

Summary. The results of a study on the dependence of growth and vegetation process of *Perilla frutescens* (L.) Britton upon meteorological factors are presented in the article. The investigations were conducted at Kaunas Botanical Garden of Vytautas Magnus University during vegetation periods in 2001–2005. The object of investigations was *Perilla frutescens* (L.) Britton, a medicinal annual herbaceous plant of Lamiaceae Lindl. family, native of Eastern Asia, which passes the whole development cycle under climatic conditions of Central Lithuania. The duration of vegetation period of *Perilla frutescens* on the average is 167 days. The earliest beginning of vegetation and optimal climatic conditions for growth are when hydrothermic coefficient reaches 1.60–1.80 (conditions of excessive humidity). Optimal climatic conditions for massive flowering and seed maturation are observed when hydrothermic coefficient decreases to 1.20 – then massive flowering starts 10 days earlier and lasts 25 days longer. A strong correlation was found between massive flowering and hydrothermic coefficient ($r^2=0.9408$). Using mathematical-statistical methods, the consistent patterns of growth and vegetation process of *Perilla frutescens* (L.) Britton were determined, specifying the time for raw material preparation what determines its quality and quantity.

Introduction

Perilla frutescens (L.) Britton (*P. frutescens*) is an annual herbaceous medicinal plant of Lamiaceae Lindl. family, native of Eastern Asia, which possesses immunomodulatory properties. In 1990, its raw material (leaves and fruits) was included into the Pharmacopoeia of The People's Republic of China (1). *P. frutescens* raw material and preparations are used for treatment of various diseases (2, 3). Leaves and seeds are used as a spice (4). During the last decades various experiments that confirmed the variety of pharmacological effects – antimicrobial (2, 5), antioxidative (2, 6, 7), immunostimulating (2, 8), anti-inflammatory (9), desensitizing (10) – were carried out in China, Japan, Korea, the USA, Turkey, Russia, the Ukraine, and some other European countries.

Anatomical–morphological characteristics of *P. frutescens* were investigated by experimental studies in Lithuania (11). The biochemical properties of the plant were investigated, and maximal quantity of antioxidants accumulated during flowering period was identified. Investigation also characterized a new chemotype of isoegamaketone (7, 12). Immunomodulatory properties, which are the basis for development

of food supplements and functional ingredients, were also investigated (8, 13).

This plant has been cultivated in the collection and exposition of medicinal plants at Kaunas Botanical Garden of Vytautas Magnus University since 1998. The dependence of growth and vegetation process of *P. frutescens* on meteorological factors has not been investigated yet.

After the performed analysis of the influence of meteorological factors on growth and vegetation process of *P. frutescens*, the time for preparation of the raw material can be predicted.

The aim of this study was to investigate and determine the consistent patterns of growth and vegetation process of *P. frutescens* and the dependence of growth parameters (height, projectional cover) on meteorological factors (ambient air temperature, precipitation, and hydrothermic coefficient) during the vegetation period.

Materials and methods

The object of investigation was *Perilla frutescens* (L.) Britton, an annual herbaceous medicinal plant of Lamiaceae Lindl. family, native of Eastern Asia.

Investigation was carried out in the collection of medicinal plants and in 345 m² trial area at Kaunas Botanical Garden of Vytautas Magnus University, Kaunas, Middle Lithuania.

According to climatic zones, it is a part of the central lowlands of Lithuania, where the average yearly temperature is +6.7°C, the annual cumulative temperature >10°C is 2100 to 2300°C, the average minimal monthly temperature in winter is –24 to –26°C, and annual precipitation level is 500–750 mm (14).

The sum of average circadian temperatures and amount of precipitation during the periods of experiment in 2001–2005 were taken from agrometeorological bulletins (15). The calculated hydrothermic coefficient (16) varied during the experiment: in 2002, it was the lowest; the highest, in 2004; and of average value, in 2003. During 2001–2005, the sum of ambient air temperatures and average precipitation levels varied.

In the experimental area, *P. frutescens* was planted by sprouts with three leaves in rows 50 cm apart; the distance among the rows was 70 cm. The experimental areas were arranged according to a modified method (17). The phenological observations were performed during various periods of vegetation: beginning of vegetation, intense growth, preflowering, flowering (initiation, massive), seed ripening, and end of vegetation (18).

The dependence of the process of *P. frutescens* vegetation on meteorological factors was evaluated by correlation and regression analysis; 95% confidence intervals were calculated. Statistical analysis

of the data was performed using programs Microsoft Excel and SPSS 9.0. In this study, a linear regression model has been analyzed. For the suitability of each regression model, determination coefficient r^2 and p-value obtained by checking hypothesis on nonlinear regression were used. The strength of a linear relationship between variables was measured by Pearson's correlation coefficient r (19, 20).

Results and discussion

The growth dynamics of P. frutescens during the vegetation period. Under climatic conditions of Lithuania, the duration of *P. frutescens* vegetation on the average is 167 days (maximal 177, minimal 160); 95–100% of plants pass through whole developmental cycle (21).

The seasonal development rhythms of the plant match with the length of vegetation period and reflect seasonal and periodic climatic conditions (22).

The phenological observations show that the beginning of vegetation period of *P. frutescens* starts on the 125–146th days of the year (May), and intense growth is in progress during the 157–220th days (June–July). During the 173–230th days of the year (June–mid-August) before the beginning of flowering, an increase in height and projectional cover was observed; these parameters stabilize during the 230–250th days of the year (mid-August–September) – from massive flowering till the period of full seed ripening (Fig. 1 and 2).

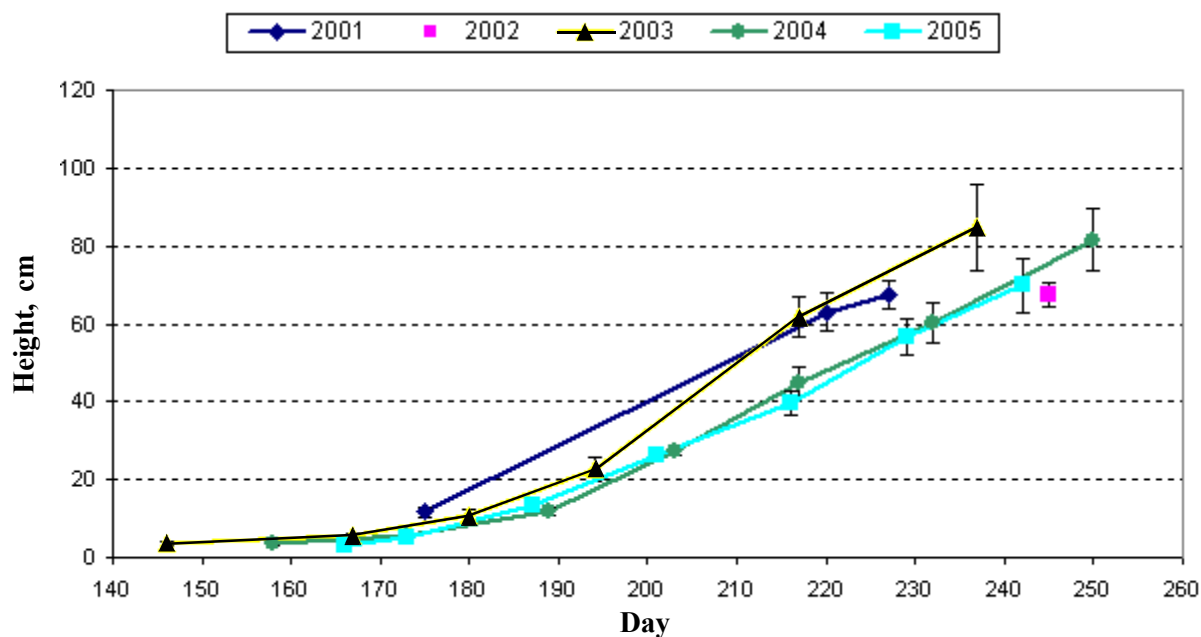


Fig. 1. Changes in height of aboveground parts of *Perilla frutescens* (L.) Britton during the vegetation period (May–October, 2001–2005)

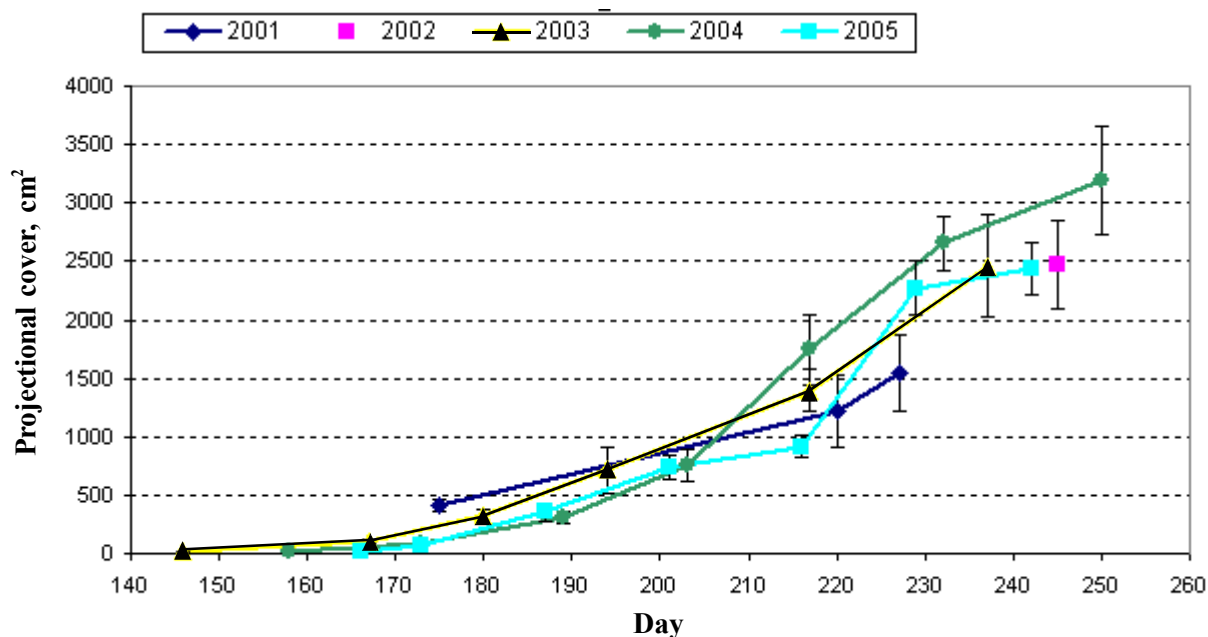


Fig. 2. Changes in projectional cover of aboveground parts of *Perilla frutescens* (L.) Britton during the vegetation period (May–October, 2001–2005)

The defined consistent patterns in the changes of growth parameters (height and projectional cover) during the vegetation period provide the basis for predicting the time for preparation of raw material of better quality and quantity.

The influence of meteorological factors on P. frutescens vegetation cycle. *P. frutescens* is a typical short-day plant that flowers when the night length is longer than a certain length (23), i.e. in Lithuania, the plant starts flowering when the night length reaches 10 hours (end of August). In Egypt, *P. frutescens* flowers at the same night length in July (24).

In Lithuania, the initiation of vegetation of *P. frutescens* begins in the late springtime – during the 135–150th days of the year (end of May). This plant species has a particularly short preflowering period of 5–6 days during the 216–229th days of the year (mid-August); massive flowering lasts during the 229–250th days (August–September). Massive flowering on the average lasts 13 days: maximum 25, minimum 6 days; seeds ripen during the 250–278th days (August–September).

In order to assess the influence of meteorological factors on the growth and vegetation of *P. frutescens*, the relationship between massive flowering, full seed maturity and precipitation level, sum of air temperatures, and hydrothermic coefficient was determined during the vegetation periods in 2001–2005. The earliest beginning of vegetation and optimal climatic conditions for growth were when HTC was 1.60–1.80 (conditions of excessive humidity). The beginning of

vegetation starts later when HTC reaches 0.8 (conditions of inadequate humidity). Fig. 3 shows a strong correlation between the beginning of vegetation period and HTC ($r^2=0.945$). Massive flowering directly depends on precipitation level ($r^2=0.875$, $r=0.935$; $p=0.06$) and the sums of air temperatures ($r^2=0.8903$, $r=0.943$; $p=0.05$). Massive flowering of *P. frutescens* starts at the earliest (about 10 days earlier) when HTC reaches 1.20 and at the latest when HTC increases up to 1.80. Fig. 4 shows a strong correlation between these parameters – the period of massive flowering and hydrothermic coefficient ($r^2=0.9408$, $r=0.978$; $p=0.04$).

The seeds of *P. frutescens* ripen during September and October. The beginning and duration of seed ripening depend on the sum of air temperatures ($r^2=0.8657$, $r=-0.930$; $p=0.07$).

The performed correlation analysis and established dependences of vegetation process of *P. frutescens* on meteorological factors enable to predict the most suitable time for the harvesting of plants, thus pre-determining the quality of raw material.

Conclusions

1. An experimental investigation was carried out on a medicinal herb *Perilla frutescens* (L.) Britton. at Kaunas Botanical Garden of Vytautas Magnus University during 2001–2005. It was shown that under climatic conditions of Middle Lithuania, this introduced plant passes through whole developmental cycle successfully with maximum duration of vegetation of 177 days and minimal, of 160 days.

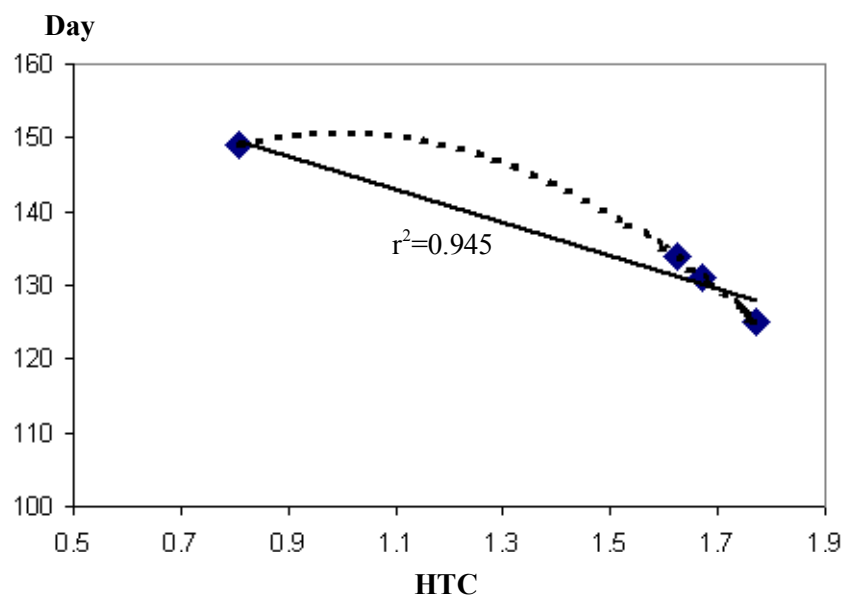


Fig. 3. Association between the beginning of vegetation period of *Perilla frutescens* (L.) Britton and hydrothermic coefficient (HTC)

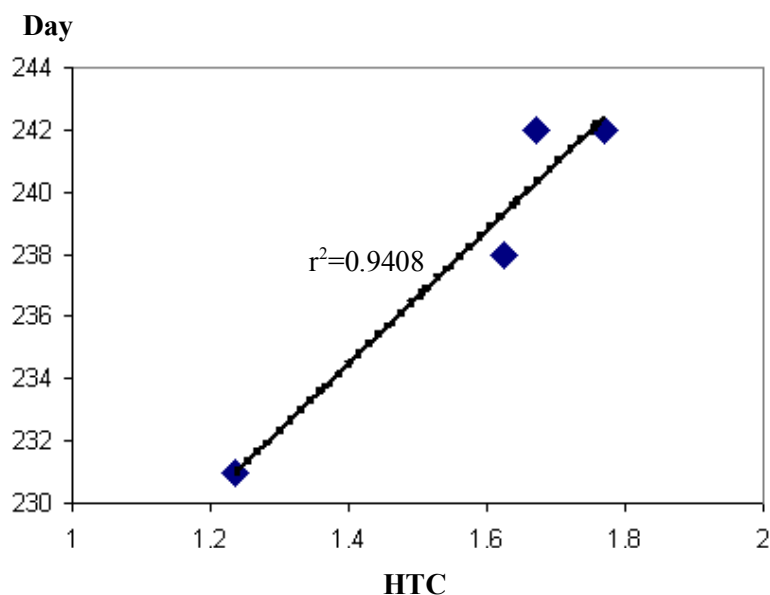


Fig. 4. Association between massive flowering of *Perilla frutescens* (L.) Britton and hydrothermic coefficient (HTC)

2. Excessive humidity conditions are optimal for the growth of this species. The vegetation starts at the earliest when hydrothermic coefficient reaches 1.60–1.80, that is during the 125–130th days of the year (in May). A strong correlation was found between the beginning of vegetation and hydrothermic coefficient ($r^2=0.945$).

3. At warmer and dryer climatic conditions, massive flowering and seed ripening begin earlier. When hydrothermic coefficient is 1.20, massive flowering starts 10 days earlier and lasts for 25 days longer. A strong correlation was found between massive flower-

ing and hydrothermic coefficient ($r^2=0.9408$).

4. The assessment of the dependence of growth and vegetation process of *P. frutescens* on meteorological factors (sum of air temperature, precipitation level, and hydrothermic coefficient) during the vegetation period enables to predict the optimal time for harvesting of raw material, predetermining its quantity and quality.

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Meteorologinių veiksnių įtaka *Perilla frutescens* (L.) Britton augimui ir vegetacijos eigai Lietuvoje

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Raktažodžiai: *Perilla frutescens* (L.) Britton, augimas, fenologija, vegetacijos tarpsniai, Lietuvos klimatinės sąlygos.

Santrauka. Straipsnyje pateikiami *Perilla frutescens* (L.) Britton augimo ir vegetacijos eigos priklausomumo nuo meteorologinių veiksnių tyrimo rezultatai. Tyrimai atlikti 2001–2005 metais augalų vegetacijos laikotarpiu Vytauto Didžiojo universiteto Kauno botanikos sode. Tyrimo objektas – *Perilla frutescens* (L.) Britton introdukuotas viename žolinis *Lamiaceae* Lindl. šeimos augalas, kilęs iš Rytų Azijos, kuris Lietuvos klimatinėmis sąlygomis pereina visą vystymosi ciklą. Vegetacijos vidutiniška trukmė – 167 dienos. Vegetacijos pradžioje augalų augimui yra optimalios perteklinio drėgnumo sąlygos, kai hidroterminis koeficientas – 1,60–1,80. Augalų žydėjimo ir sėklų brandos tarpsniais reikalingas optimaliai drėgnas periodas, kai hidroterminis koeficientas – 1,20, tada augalų masinis žydėjimas prasideda 10 dienų anksčiau ir trunka 25 dienas ilgiau. Nustatytas stiprus tarpusavio koreliacinis priklausomumas tarp masinio žydėjimo ir hidroterminio koeficiento ($r^2=0,9408$). Pritaikius matematinius ir statistinius metodus, nustatyti *Perilla frutescens* (L.) Britton antžeminės dalies (aukščio, santykinio projekcinio ploto) augimo ir vegetacijos eigos dėsningumai, patikslinant vaistinės augalinės žaliavos tinkamą ruošimo laiką, kuris lemia jos kiekybę ir kokybę.

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