ACTA SCIENTIARUM POLONORUM

**Acta Sci. Pol. Hortorum Cultus, 17(3) 2018, 137–146**

www.acta.media.pl ISSN 1644-0692 e-ISSN 2545-1405 DOI: 10.24326/asphc.2018.3.14

ORIGINAL PAPER

Accepted: 19.12.2017

# IMPACT OF GROWING CONDITIONS AND FOLIAR NUTRITION ON GROWTH AND DEVELOPMENT OF SPANISH BLUEBELL (*Hyacinthoides hispanica* (Mill.) Rothm.)

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**ABSTRACT**

*Hyacinthoides hispanica* (Mill.) Rothm. is a valuable bulbous ornamental plant grown in parks and gardens. It comes from the Iberian Peninsula, hence its cultivation under Polish conditions may be inefficient. The purpose of the study was to determine the effect of growing conditions and foliar feeding using phosphorous fertilizer on the growth and decorative qualities of *H. hispanica*. It was found that the pine bark layer effectively protected the plants from freezing, which had a beneficial effect on their growth and flowering characteristics. Flowering of plants grown without the mulch was minimal, which clearly indicates that mulching of the soil under *H. hispanica* can be necessary. Plants grown using the mulch produced more and longer leaves, and also formed more inflorescences and fruits as well as longer inflorescence stems. The addition of peat to the soil did not favour the growth and decorative qualities of *H. hispanica*, while foliar nutrition with phosphorous had a positive effect. In addition, the decorative values of *H. hispanica* were influenced by the interaction of soil mulching with bark and foliar feeding. Plants grown in this combination had more inflorescences, which were higher, composed of more flowers in the inflorescence and reached a greater diameter than non-fertilized ones. Tested cultivars of *H. hispanica* differed in their features of growth and flowering.

**Key words:** mulching, pine bark, phosphorus, flowering, decorative value

## INTRODUCTION

Spanish bluebell (*Hyacinthoides hispanica* (Mill.) Rothm. from *Asparagaceae* family was quite recently classified as *Scilla* L. and known as the squill (*Scilla campanulata* Aiton.) [Grundmann et al. 2010; Chase et al. 2016]. It origins from the Iberian Peninsula. It has been cultivated for a long time in gardens as an ornamental bulbous plant. In England, it poses a threat to the native flora, because it crosses with *Hyacinthoides non-scripta* (L.) Chouard ex Rothm. [Stace 2010].

*H. hispanica* is a typical spring geophyte of deciduous forest. It forms bright bulbs without cover (about 10–12 cm in circumference), from which dark green, equally narrow leaves of 20–30 cm length and about 2.5 cm width, arise in spring, and immediately after that inflorescence shoots appear. The clustered inflorescences consist of about 15 campanulate flowers of about 2 cm in length that are blue, while in the cultivated forms also pink or white. The fruit is a three-compartment poly sac [Ietswaart et al. 1983,

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Grabowska et al. 1987, Grabowska and Kubala 2010]. The leaves are dry at the beginning of summer. If the winter is mild, the plants start their vegetation very early, if spring is frosty, their flowering is delayed [Łuczaj 2007]. Natural habitat of *H. hispanica* are forests, shady areas, scrubs, slopes, where it grows on limestone soils [Ortiz 2011]. Dense bluebell populations are often associated with well-drained loamy soil [Knight 1964 after Ebuele et. al 2016]. According to Łuczaj [2007], it is best solution to plant it in semi-shaded areas, on forest clearings, near forest roads and in scrubs e.g. eagle ferns. In the park or garden, plants blooming in spring are impressive under the trees or shrubs. They can be planted in flowerbeds, rock and naturalistic gardens. It is usually advisable to grow *H. hispanica* on fertile, moderately moist, permeable, and humus abundant soils. It is tolerant to soil reactions, but some suggest that the soil is slightly acidic [Grabowska and Kubala 2010].

In the production of ornamental plants, special attention is paid to phosphorus fertilization, because it influences better flowering, flower quality, and longer shelf life. Presence of phosphorus in the early stages of plant growth ensures proper root growth, and hence drought resistance and nutrient deficiencies at later stages [Koc and Skwierawski 2008, Michałojć and Konopińska 2009]. A prolong phosphorus deficiency in the soil can lead to delays in flowering, worse fruiting, and ultimately to the death of plants [Ciereszko 2003, Bezak-Mazur and Stoińska 2013]. The ability of *H. non-scripta* to take up phosphorus from the soil is greatly enhanced by the presence of arbuscular mycorrhizae in its roots [Begon et al. 2006]. The purpose of the study was to determine the effect of growing conditions and foliar nutrition using phosphorous fertilizer on growth and development of *H. hispanica*.

## MATERIAL AND METHODS

The field experiment was carried out in 2010–2012 at the Experimental Station Felin belonging to The University of Life Sciences in Lublin (Poland, 22°56'E, 51°23'N), on grey brown podzolic soil (AP) developed from loess formations covering the cretaceous marls with a granulometric composition corresponding to medium dusty loam (BN-78/9180-11). The experimental plant species was Spanish bluebell *Hyacinthoides hispanica* (Mill.) Rothm. The following factors were taken into account in the experiment: 1. Cultivar: 'White City', 'Excelsior', 'Queen of the Pinks'; 2. Soil mulching: a) without mulching, b) pine bark mulch; 3. Soil types: a) local soil (without peat addition), b) soil with peat addition (to improve the soil structure); 4. Foliar nutrition: a) with no fertilization, b) foliar nutrition using Fostar fertilizer. The control consisted of plants grown on local soil without mulching and without foliar fertilization.

In September 2010, half of the field was covered with garden acidic peat (pH 3.5–4.5) in such a quantity that the topsoil layer (0–20 cm) contained an average of 22.2% peat (by volume). Then the entire surface of the field was dug and raked. *H. hispanica* bulbs with a circumference of 8–9 cm were planted to the ground on September 23$^{rd}$, 2010 at a spacing of 20 × 20 cm to a depth of 8 cm [Grabowska et al. 1987]. Before planting, the bulbs were dressed in Topsin M 500 SC. The experiment was based on a completely randomized sub-blocks pattern in 3 replicates. A replicate was a plot of 1.20 m$^2$, on which 24 plants were grown. Surface of the soil in half of the experiment was covered with pine bark, which was replenished each year. Every year in spring (March 20$^{th}$), fertilization with ammonium nitrate 60 kg N·ha$^{-1}$ was applied, and the soil was covered with a pine bark of a thickness about 6 cm according to the experimental scheme. Fostar liquid fertilizer (5.0% m·m$^{-1}$ N; 35.0% m·m$^{-1}$ $P_2O_5$) from Intermag was used for the foliar nutrition. The sprayings were made on four dates at weekly intervals from April 30$^{th}$ to May 21$^{st}$. Throughout the entire experiment, nursing works were performed to remove the weeds. No plant protection products or herbicides were used. During the vegetation period, observations were made to determine the dates of major phenological phases. Growth and development of leaves, flowers and fruits have been observed up to the end of vegetation. Regular biometric measurements were made (every 2 weeks) as well. The weather conditions during the vegetation of *H. hispanica* in 2010–2012 are shown in Table 1.

**Table 1.** Mean monthly air temperatures and amount of precipitation in ES Felin during the experiment in 2010–2012

| | Year | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
| Temperature (°C) | 2010 | | | | | | | | 20.2 | 12.5 | 5.6 | 6.4 | –4.7 |
| | 2011 | –0.9 | –4.5 | 2.4 | 10.2 | 14.3 | 18.6 | 18.4 | 18.8 | 15.2 | 8.0 | 2.4 | 1.9 |
| | 2012 | –1.9 | –7.4 | 4.4 | 9.5 | 15.0 | 17.3 | 21.4 | | | | | |
| | mean for 1951–2005 | –3.5 | –2.7 | 1.1 | 7.4 | 13.0 | 16.2 | 17.8 | 17.1 | 12.6 | 7.8 | 2.5 | –1.4 |
| Amount of precipitation (mm) | 2010 | | | | 24.5 | 156.7 | 65.6 | 101.0 | 132.8 | 119.0 | 11.2 | 46.8 | 32.4 |
| | 2011 | 24.8 | 25.2 | 8.1 | 29.9 | 42.2 | 67.8 | 189.0 | 65.3 | 5.4 | 28.5 | 1.0 | 34.5 |
| | 2012 | 33.6 | 22.1 | 28.6 | 34.0 | 56.3 | 62.8 | 52.3 | | | | | |
| | mean for 1951–2005 | 22.7 | 25.6 | 26.3 | 40.2 | 57.7 | 65.7 | 83.5 | 68.6 | 51.6 | 40.1 | 38.1 | 31.5 |

**Table 2.** Contents of phosphorus, potassium, magnesium and nitrogen in the soil along with the soil acidity depending on experimental factors during *H. hispanica* vegetation in 2010–2012

| Experimental factors | | Soil acidity | P | K | Mg | N |
|---|---|---|---|---|---|---|
| Substrate / foliar nutrition | Mulching | $pH_{KCl}$ | ($mg \cdot 100g^{-1}$) | ($mg \cdot 100g^{-1}$) | ($mg \cdot 100g^{-1}$) | ($mg \cdot dm^{-3}$) |
| 23.09.2010 (bulb planting) | | | | | | |
| Local soil | | 6.94 | 22.5 | 9.6 | 4.4 | 26 |
| Soil + peat | | 5.90 | 17.2 | 8.4 | 2.8 | 18 |
| 19.05.2011 | | | | | | |
| Local soil | without mulch | 6.96 | 16.5 | 8.7 | 4.3 | 64 |
| | pine bark mulch | 6.65 | 16.3 | 8.6 | 4.4 | 65 |
| Soil + peat | without mulch | 5.92 | 12.8 | 7.5 | 2.8 | 63 |
| | pine bark mulch | 6.06 | 13.0 | 7.7 | 3.0 | 60 |
| 27.04.2012 | | | | | | |
| | without mulch | 6.52 | 13.9 | 4.6 | 3.4 | 63 |
| | pine bark mulch | 6.30 | 22.8 | 9.4 | 5.0 | 60 |
| 12.07.2012 (end of vegetation) | | | | | | |
| Without nutrition | without mulch | 6.7 | 14.6 | 5.8 | 3.5 | 28 |
| Fostar | | 6.6 | 14.6 | 4.0 | 3.9 | 30 |
| Mean | | 6.7 | 14.6 | 4.9 | 3.7 | 29 |
| Without nutrition | pine bark mulch | 6.5 | 22.3 | 6.9 | 4.6 | 30 |
| Fostar | | 6.6 | 22.6 | 7.6 | 5.1 | 33 |
| Mean | | 6.6 | 22.4 | 7.2 | 4.9 | 32 |
| Without nutrition | mean | 6.6 | 18.5 | 6.3 | 4.1 | 29 |
| Fostar | | 6.6 | 18.6 | 5.8 | 4.5 | 32 |
| Mean | | 6.6 | 18.6 | 6.1 | 4.3 | 31 |

**Chemical analyses of soil.** Soil samples were collected from the 0–20 cm layer. First time – during bulb planting on September 23rd, 2010 (one average sample from each substrate), the second time – at full flowering stage (May 19th, 2011) from individual combinations. In 2012, soil samples were taken twice: for the first time in spring – 1 week after application of ammonium nitrate (April 27th, 2012), the second time – after the end of plant vegetation, from individual combinations of the experiment (July 12th, 2012). Soil samples were dried and then subjected to chemical analysis after sieving. The pH of the soil (pH in KCl) as well as potassium, phosphorus, magnesium and nitrogen contents were determined; P and K – Egner-Riehm method, magnesium – ASA technique, $N\text{-}NH_4$ i $N\text{-}NO_3$ – Bremner method (modified by Starck) [Ostrowska et al. 1991].

Contents of macronutrients (P, K, Mg and N) along with the soil acidity during *H. hispanica* vegetation depending on experimental factors have been shown in Table 2.

Achieved results were statistically processed using variance analysis (ANOVA). The difference significance was determined by means of Tukey test at $p = 0.05$.

## RESULTS AND DISCUSSION

The beginning of *H. hispanica* vegetation in the first year of vegetation (2011) took place on March 18th and the end on June 29th, while the full flowering on May 12th (vegetation lasted 103 days). In the second year, plants mulched with pine bark began vegetation on March 5th, while the full flowering was recorded on May 18th, hence vegetation lasted 124 days and ended on July 6th (tab. 3). Also Laskowska [1996] reported that *H. hispanica* flowers at the turn of April and May, whereas in opinion of Grabowska and Kubala [2010], *H. hispanica* flowering begins a bit later – late in May and June. The flowering period varies from 4–5 weeks [Żuraw 2011]. In 2012, the mulching of the pine bark had clear effects on the vegetation of plants. On non-mulched plots, plants later resumed their vegetation, flowered later, but they finished the vegetation earlier than those with pine bark mulching (tab. 3).

In the analysed experiment, plants formed rosettes, that in May consisted on average of 15.4 to 22.3 leaves (mean 18.7) with a length from 16.2 to 29.1 cm (mean 28.7 cm) (fig. 1). Grabowska et al. [1987] reported that leaves of *H. hispanica* had from 20 to 30 cm of length, which was confirmed by own study. According to Ortiz [2011] *H. hispanica* forms 2–4(–8) leaves per bulb, (10)12–36(50) cm long. The single plant produced a maximum of 1.06 to 2.25 (average 1.46) inflorescences (fig. 2). The height of inflorescences varied to reach a maximum value of 24.8 cm (May 19th), on average. As Grabowska and Kubala [2010] reported, inflorescences of this species

**Table 3.** Dates of phenological phases of *H. hispanica* in 2011–2012

| The phenological phases | 2011 | 2012 | |
|---|---|---|---|
| | | mulching | without mulch |
| Appearance of the first leaves (beginning of vegetation) | 18.03.2011 | 5.03.2012 | 23.03.2012 |
| Production of wide spread rosette | 08.04.2011 | 16.04.2012 | |
| Appearance of inflorescence shoots | 27.04.2011 | 27.04.2012 | 5.05.2012 |
| Beginning of flowering | 05.05.2011 | 9.05.2012 | 12.05.2012 |
| Full flowering | 12.05.2011 | 18.05.2012 | 23.05.2012 |
| Beginning of the fruit set | 19.05.2011 | 1.06.2012 | 4.06.2012 |
| Green multiple fruits | 26.05.2011 | 8.06.2012 | 10.06.2012 |
| Drying of multiple fruits and beginning of leaf rosette drying | 10.06.2011 | 27.06.2012 | |
| End of vegetation | 29.06.2011 | 6.07.2012 | 2.07.2012 |

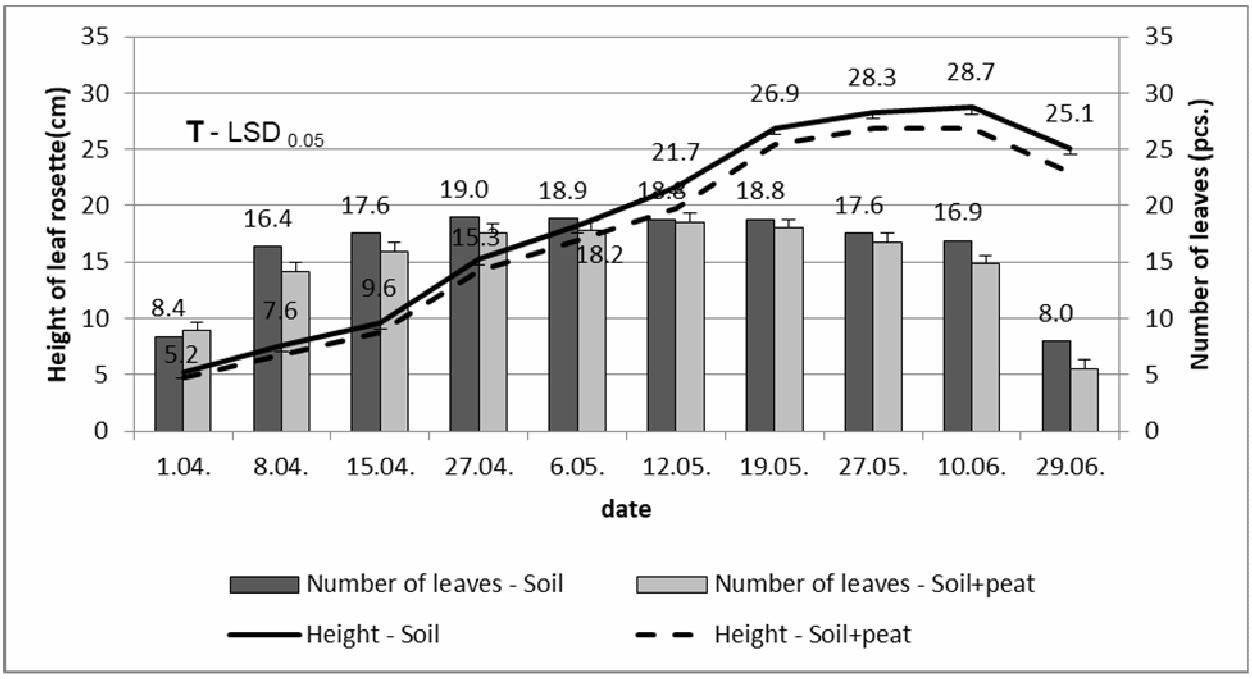


**Fig. 1.** Effect of peat addition to the soil on growth characteristics of *H. hispanica*

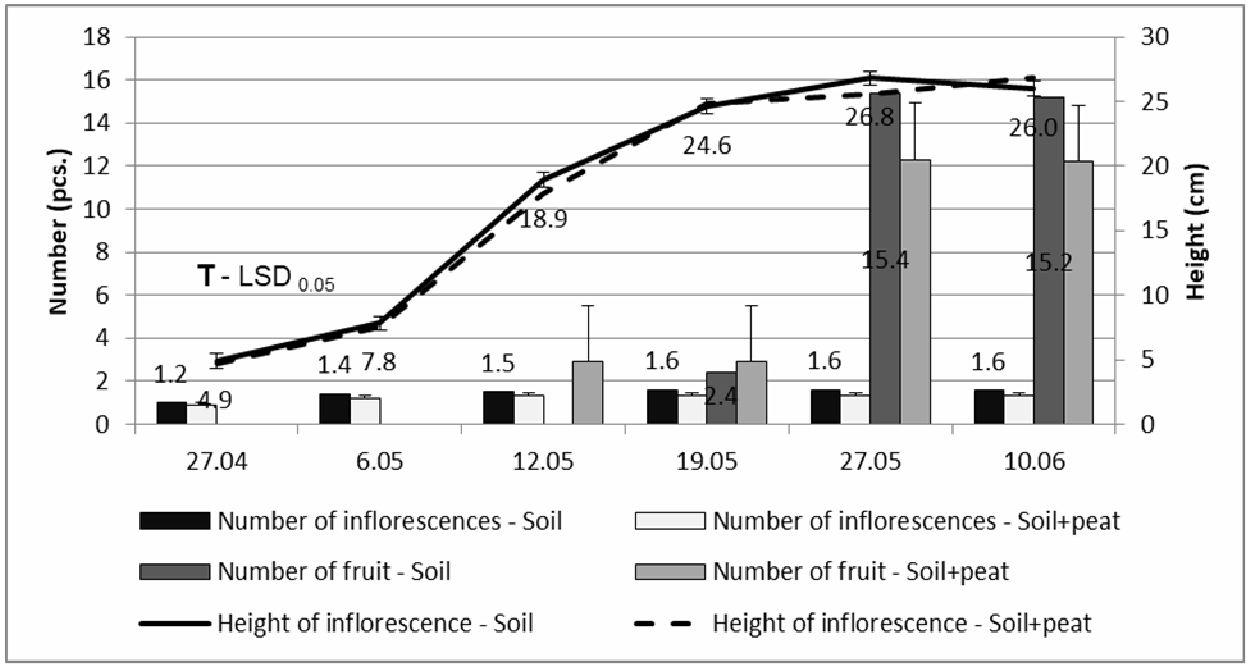


**Fig. 2.** Effect of peat addition to the soil on generative traits of *H. hispanica*

grow up to 30–40 cm in height and several inflorescences arise from large bulbs. Ietswaart et al. [1983] found that *H. hispanica* forms 4–8 leaves per bulb, 20–50 cm long, however in their study, the leaf length of *H. hispanica* was 12–20 cm (mean 15), stem length 14–33 cm (mean 22), while flower number per stem 7 (5–10). In opinion of Grabowska and Kubala [2010], *H. hispanica* prefers permeable, slightly acidic, mineral-humus substrate. Meanwhile, in the experiment, plants growing in the loess soil without the addition of peat formed more leaves and were slightly longer than those grown in the peat-enriched soil (fig. 1). Influence of the substrate type on the height of inflorescences on the individual measurement dates was ambiguous, while plants growing in the soil with added peat produced slightly less inflorescences (1.3 pcs.) and significantly less fruits (12.2 pcs.) (fig. 2). No positive reaction of plants to peat can be explained by a decrease in soil pH to 5.90 as well as lower phosphorus and potassium contents than in local soil (tab. 2). Many authors considers *H. hispanica* a tolerant to soil pH [Laskowska 1996], but plants absorbed far more phosphorus from peat-free soil than from substrate with peat addition, which had a beneficial effect on flowering and fruit formation. Negative reaction of *H. hispanica* to peat was confirmed by Ortiz [2011].

The soil mulching using pine bark had a positive effect on the growth and flowering of *H. hispanica* in the first year of vegetation (tab. 4). In growing with the use of mulching, *H. hispanica* produced more leaves, which were longer. In 2011, the beneficial effect of mulching on leaf length was marked on May 18$^{th}$, while in 2012, it was significant since April 16$^{th}$. In 2012, the pine bark layer effectively protected the plants from freezing (tab. 1), which had a positive effect on their growth and flowering characteristics, and consequently on their decorative effect (tab. 5). When analysing the growth of bluebell grown with or without pine bark mulching, significant differences have occurred since the beginning of vegetation. The conditions that the mulch has provided in winter have affected the characteristics of *H. hispanica* growth and development in the second growing year. Weak development, and above all flowering, can be explained by freezing of non-mulched plants (tab. 1). Organic mulch protects the soil from negative effects of low temperatures, which determines the growing effects [Laskowska and Słowińska-Jurkiewicz 1996]. Hetman [1996] reports that roots of bulbous plants may be damaged by soil movements caused by several freezing and thawing of the soil during winter. Laskowska and Słowińska-Jurkiewicz [1996] showed that soil mulching using composted pine bark positively affected the soil structure in winter. Study performed by Waźbińska et al. [2003] revealed that wintering of *H. hispanica* grown without soil mulching was 34.8–69.3%. These authors, however, do not recommend cultivation of this species under Olsztyn conditions.

**Table 4.** Effect of soil mulching using pine bark on growth characteristics of *H. hispanica* in subsequent study years

| Mulch | Date | | | | | | | | $LSD_{0.05}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16.04 | | 27.04 | | 7.05 | | 18.05 | | | | |
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | for: | 2011 | 2012 |
| | Height of leaf rosette (cm) | | | | | | | | | | |
| Without bark | 8.9 | 4.9 | 14.4 | 8.6 | 17.3 | 12.6 | 23.5 | 13.2 | *A | 2.07 | 0.72 |
| Pine bark | 10.3 | 6.7 | 16.2 | 12.6 | 19.2 | 18.1 | 30.3 | 19.1 | B | 0.57 | 0.39 |
| Mean | 9.6 | 5.8 | 15.3 | 10.6 | 18.2 | 15.4 | 26.9 | 16.2 | A × B | 3.11 | 1.21 |
| | Number of leaves (pcs. per 1 plant) | | | | | | | | | | |
| Without bark | 16.1 | 81.4 | 17.9 | 97.3 | 17.7 | 97.7 | 17.4 | 97.7 | *A | 2.88 | 15.64 |
| Pine bark | 19.0 | 89.9 | 20.0 | 106.0 | 20.0 | 105.9 | 20.2 | 108.2 | B | 0.80 | 8.44 |
| Mean | 17.6 | 85.6 | 19 | 101.6 | 18.9 | 101.8 | 18.8 | 102.9 | A × B | n.s. | n.s. |

*A – date; B – mulch; n.s. – no significant differences

In the second year of vegetation, *H. hispanica* produced an average of 102.9 leaves and 1.5 inflorescences · plant$^{-1}$ (tab. 4). The positive effect of mulching with pine bark resulted in larger leaf rosette height, higher number of leaves, and decorative value. The flowering of plants grown without mulching in both years of study was weaker and in the second year, the plants practically did not flower, which clearly indicates the validity of soil mulching in the cultivation of this species (tab. 5). A similar relationship was observed by Laskowska [1992], who grew *Scilla sibirica* Hav., for which length of the inflorescence of plants growing in soil with bark mulching was 18.1 cm, whereas without mulching 14.6 cm. In the case of *Allium ursinum* L., the positive response to soil mulching with pine bark was similar [Błażewicz-Woźniak et al. 2011]. Mulching had positive effects on the length of inflorescence stem, the flower stalk, and the inflorescence diameter, as well as the number of flowers per inflorescence and per plant. The average length of garlic inflorescence in mulched objects was 274.1 mm, while in the non-mulching cultivation 212.7 mm. Publications of many authors indicate the positive impact of mulching using pine bark on the growth and development of ornamental plants. Kocira and Laskowska [2006] found that applying bark and peat mulch positively influenced on the length of *Acidanthera bicolor* Hochst. inflorescence stems. Mulching the soil with pine bark positively influenced on the number of flowers in the *Iris germanica* 'Gold Fackel' inflorescence [Krzymińska and Lisiecka 2004]. In studies performed by Błażewicz-Woźniak et al. [2012], the pine bark mulching had a beneficial influence on almost all growth and flowering characteristics of scarlet sage. The plants growing on mulched soil were higher, had more leaves and branches, as well as their inflorescences were longer and had more whorls than plants growing without mulching. Meanwhile experiments by Hetman and Pogroszewska [1997] reveal that applying the bark and sawdust mulching for growing the *Liatris spicata* (L.) Willd., more inflorescence stems were obtained from plants grown without mulch. Wróblewska et al. [2012] reported that pine bark positively determined the diameter of *Eupatorium purpureum* L., whereas negatively influenced on *Silene chalcedonica* (L.) E. Krause diameter and number of shoots.

The effect of foliar nutrition using Fostar agent on the growth and flowering of three *H. hispanica* cultivars is shown in Table 6. Due to the poor growth and lack of flowering of plants grown without mulching in 2012, the results are averaged and presented only for pine bark mulching cultivation. On the basis of the obtained results, it was found that plants had an average of 12.4 flowers per inflorescence; the inflorescence diameter reached 3.5 cm, produced 8.1 fruits per stem, and number of seeds produced by one plant was 42.0. Studies carried out by Ietswaart et al. [1983] revealed that *H. hispanica* produced from 5 to 10 (mean 7) flowers per stem, and depending on the population, number of fruits per plant amounted from 1 to 6, while number of seeds per plant from 6 to 57. Plants fertilized with Fostar were higher, produced more inflorescences, and had longer stems. Their inflorescences were larger in diameter and consisted of more flowers and more seeds. Hossain and Ryu [2009] have shown a positive impact of foliar application of phosphorus on the number of leaves at *Diospyros discolor*. Experiments performed by Wach and Błażewicz-Woźniak [2012] indicated that foliar nutrition with phosphorus (Insol Fos fertilizer) had positive effects on yields of *Vaccinium corymbosum*.

Tested cultivars differed in their growth and development features. Regardless of the experimental factors, *H. hispanica* 'Excelsior' produced the largest number of leaves, its inflorescences were the highest and had a large diameter, while the number of inflorescences, number of flowers per inflorescence, and number of fruits and seeds were the smallest. 'Queen of the Pinks' produced the shortest rosettes and with the smallest number of leaves, but it had the largest number of flowers per inflorescence. 'White City' and 'Queen of the Pinks' were similar in terms of the number of inflorescences, their height, and number of seeds produced. The highest number of seeds was produced by 'Queen of the Pinks' fertilized with Fostar (average 74.6 pcs.·plant$^{-1}$). Of the non-fertilized plants, the highest number of seeds was recorded for 'White City' (average 32.0 pcs.·plant$^{-1}$).

**Table 5.** Effect of soil mulching using pine bark on flowering characteristics of *H. hispanica* in subsequent study years

| Mulch | Date | | | | $LSD_{0.05}$ | | |
|---|---|---|---|---|---|---|---|
| | 8.05 | | 18.05 | | | | |
| | 2011 | 2012 | 2011 | 2012 | for: | 2011 | 2012 |
| | Height of inflorescence (cm) | | | | | | |
| Without bark | 6.7 | – | 22.0 | – | *A | 2.07 | 1.43 |
| Pine bark | 8.8 | 9.4 | 27.2 | 15.5 | B | 0.5 | – |
| Mean | 7.8 | | 24.6 | | A × B | 3.2 | – |
| | Number of inflorescences (pcs. per 1 plant) | | | | | | |
| Without bark | 1.36 | 0.00 | 1.46 | 0.00 | *A | 0.26 | n.s. |
| Pine bark | 1.46 | 1.10 | 1.75 | 1.50 | B | 0.10 | 0.30 |
| Mean | 1.41 | 0.55 | 1.61 | 0.75 | A × B | 0.57 | n.s. |
| Mulch | Date | | | | $LSD_{0.05}$ | | |
| | 10.06 | | 28.06 | | | | |
| | 2011 | 2012 | 2011 | 2012 | for: | 2011 | 2012 |
| | Number of fruit (pcs. per 1 plant) | | | | | | |
| Without bark | 10.10 | 0.00 | 11.50 | 0.00 | *A | 1.57 | n.s. |
| Pine bark | 14.20 | 7.20 | 12.60 | 7.90 | B | 0.84 | 1.19 |
| Mean | 12.15 | 3.60 | 12.05 | 3.95 | A × B | 2.62 | n.s. |

*A – date; B – mulch; n.s. – no significant differences

**Table 6.** Effect of foliar nutrition on growth and development characteristics of three *H. hispanica* cultivars

| Experimental factors | | Growth and development characteristics of *H. hispanica* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nutrition A | Cultivar B | Height (cm) | Number of leaves (pcs.) | Number of infloresc. (pcs. per 1 plant) | Height of inflo-resc. (cm) | Number of flower in infloresc. (pcs.) | Diameter of inflo-resc. (cm) | Number of fruit (pcs. per 1 stem) | Number of seeds (pcs. per 1 plant) |
| Without nutrition | *Wh.C | 20.5 | 105.8 | 1.6 | 14.3 | 9.7 | 2.1 | 6.5 | 32.0 |
| | Ex. | 19.3 | 129.6 | 0.5 | 18.1 | 8.4 | 3.5 | 4.2 | 15.8 |
| | QP | 17.6 | 89.1 | 1.3 | 14.0 | 11.8 | 3.0 | 5.4 | 18.6 |
| | Mean | 19.1 | 108.2 | 1.1 | 15.5 | 10.0 | 2.9 | 5.4 | 22.1 |
| Fostar | Wh.C | 22.2 | 94.8 | 5.1 | 19.6 | 14.7 | 3.5 | 14.0 | 65.5 |
| | Ex. | 24.0 | 129.1 | 3.4 | 28.1 | 13.1 | 4.4 | 7.1 | 45.5 |
| | QP | 20.5 | 88.5 | 5.8 | 22.1 | 16.7 | 4.4 | 11.4 | 74.6 |
| | Mean | 22.2 | 104.1 | 4.8 | 23.3 | 14.8 | 4.1 | 10.8 | 61.9 |
| Mean | Wh.C | 21.4 | 100.3 | 3.4 | 17.0 | 12.2 | 2.8 | 10.3 | 48.8 |
| | Ex. | 21.7 | 129.4 | 2.0 | 23.1 | 10.8 | 4.0 | 5.7 | 30.7 |
| | QP | 19.1 | 88.8 | 3.6 | 18.1 | 14.3 | 3.7 | 8.4 | 46.6 |
| | Mean | 20.7 | 106.2 | 3.0 | 19.4 | 12.4 | 3.5 | 8.1 | 42.0 |
| $LSD_{0.05}$ for: | A | 0.56 | n.s. | 0.3 | 1.43 | 1.19 | 0.27 | 0.27 | 2.36 |
| | B | 0.77 | 12.35 | 0.45 | 2.11 | 1.75 | 0.41 | 0.46 | 3.18 |
| | A × B | 2.31 | n.s. | n.s. | 3.66 | n.s. | n.s. | n.s. | 6.12 |

*Cultivars: Wh.C – 'White City', Ex. – 'Excelsior', QP – 'Queen of the Pinks'; n.s. – no significant differences

Taking into account the poor flowering of non-mulched plants in 2012, it can be said that mulching with pine bark combined with foliar nutrition using Fostar fertilizer positively influenced on growth, development and decorative value of *H. hispanica*.

## CONCLUSIONS

1. The pine bark layer effectively protected the plants against freezing, which had a beneficial effect on their growth and flowering characteristics and consequently on the decorative effect. Flowering of plants grown without mulching was minimal, which clearly indicates the need of soil mulching in *H. hispanica* cultivation.

2. Soil mulching using pine bark had a positive effect on all the growth, flowering features of *H. hispanica*. Plants grown on mulched soil produced more leaves and they were longer, and also formed more inflorescences and fruits as well as longer inflorescence stems.

3. Foliar application of Fostar had positive influence on almost all the growth, flowering and development features of bluebell. Treated plants were higher, produced more inflorescences and with longer stems. Their inflorescences were larger in diameter and consisted of more flowers and more seeds.

4. Decorative qualities of *H. hispanica* were positively influenced by the interaction of soil mulching with bark and foliar nutrition with Fostar fertilizer. Plants grown in this combination produced more inflorescences which were higher, composed of more flowers per inflorescence, and reached a greater diameter than non-fertilized ones.

5. Tested cultivars of *H. hispanica* differed in their growth and flowering features. 'Excelsior' reached the highest leaf rosette height, number of leaves, height and diameter of the inflorescence, while 'Queen of the Pinks' and 'White City' produced more inflorescences and flowers per inflorescence.

6. *H. hispanica* turned out to be an attractive plant with high decorative values in the springtime, suitable for growing in gardens and greenery, flowering already in the first year after planting and positively responding to soil mulching with pine bark and foliar nutrition.

## ACKNOWLEDGEMENTS

Research supported by the Ministry of Science and Higher Education of Poland as part of the statutory activities of the Department of Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin.

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