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The effect of calcium carbonate and top dressing with Peters Professional Special on the growth and flowering of *Helleborus lividus* Aiton

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ABSTRACT

For two years (2006 − 2007), seedlings and young plants of *Helleborus lividus* Aiton were grown in containers with a peat substrate, which was deacidified with calcium carbonate at the following doses: 2.5, 5.0, 7.5 and 10.0 g dm^{-3}. The plants were divided into two groups in each variant of $CaCO_3$ dosage, one fertilized with a solution of a lower (0.1%) and the other with a higher (0.3%) concentration of Peters Professional PL Special (15:11:29). *Helleborus lividus* growth in the first year of cultivation depended on the calcium carbonate dose. Taller plants, with a higher number of leaves, were produced using calcium carbonate at a dose of $CaCO_3$ 2.5-5.0 g dm^{-3}. In the second year of cultivation good quality plants – taller, with higher numbers of leaves and shoots, were produced when grown in a substrate with 2.5-7.5 g $CaCO_3$ per dm^3. The application of solutions of various

concentrations in top dressing did not have an effect on the growth of *Helleborus lividus* in the first year of cultivation, while in the second year taller plants, with more leaves as well as flowers and buds, were produced when applying a 0.3% fertilizer solution.

INTRODUCTION

In winter and early spring hellebores are some of the most decorative flowering plants. They are grown in gardens and – especially in Western Europe – they are popular pot plants or grown for cut flowers. Flowering Christmas rose (*Helleborus niger* Lam.), sold in pots, is an excellent example in this respect (Piskornik 2003, Trier 2004). Other hellebore species are also gaining in popularity, due to their ornamental inflorescences and winter-hard leaves. *Helleborus lividus* has exceptionally decorative leaves. Its trifoliate leaves, arranged in rosettes, are dark green with silvery spots. Additionally, from February to April the plant forms ornamental, low green-brownish inflorescences.

Plants from the genus *Helleborus* are found throughout the world and are grown in different positions. To date cultivation recommendations have been prepared in detail only for the most popular species, i.e. Christmas rose, *Helleborus orientalis* Lam. and garden hellebore (Pogroszewska 1995, 1996, Piskornik et al. 1999, Szczepaniak et al. 2008). The optimal range of soil pH reported for these plants in literature sources is rather wide, from 5.7 to 7.0 (Ganslmeier and Henseler 1985, Reimherr 1998).

The aim of the study was to assess the effect of a dose of calcium carbonate used to deacidify highmoor peat and the concentration of nutrient solution used in top dressing on the growth and flowering of *Helleborus lividus* in the first and second year of growing.

MATERIAL AND METHODS

Experiments with *Helleborus lividus* at different growth stages were conducted at the Marcelin Experimental Station of the Poznań University of Life Sciences. Seedlings were grown in pallets for two months (31 March – 28 May 2006), after which the plants were transplanted to 1.0 dm^3 pots, in which they were grown from 28 May 2006 to 27 March 2007. In the second year plants were grown in 2.1 dm^3 pots (27 March 2007 – 23 April 2008). Each time Klasmann high moor peat of pH 3.91 was used as a substrate, to which 0.5 g of Peters Professional PL Special (15:11:29) per dm^3 and calcium carbonate ($CaCO_3$) at varied doses (2.5, 5.0, 7.5, and 10.0 g dm^{-3}) were added. After substrate liming, pH was 5.28, 6.80, 7.09 and 7.24, respectively.

Seedlings were supplied by Syngenta Seeds in pallets with 264 openings of 2 cm^3 and on average one-leaf stage, which were transplanted to multi-pots, with openings of 110 cm^3. They were grown in a greenhouse. In seedling growing there were 48 replications of one plant each for each liming level. Seedling growth was assessed after two months (28 May 2006), taking into consideration the height of the plants and the number of leaves. Their growth was determined based on the difference in the number of leaves (28 May vs. 31 March.). Results were analyzed statistically using one-way analysis of variance with the Newman Keuls test at the significance level $p = 0.05$.

From 28 May 2006 the plants were grown in pots in a hotbed frame equipped with a hothouse mat and a mulching mat. During winter, from November to April 2006/2007 and 2007/2008, plants were grown in an unheated plastic tunnel. Within each liming level the plants were divided into two groups, one fertilized with a solution with a lower (0.1%) and the other with a higher (0.3%) concentration of Peters Professional PL Special (15:11:29), at 100 ml per pot. Fertilization was started a month after transplantation and was repeated every 15 days till the end of August. Towards the end of vegetation, substrate acidity was determined. In 2006 for the fertilization variant with a 0.1% solution for increasing $CaCO_3$ doses, pH was 5.47, 5.30, 6.90 and 6.91, while in 2007 it was 5.96, 6.66, 7.41 and 7.64, whereas at the fertilization variant with a 0.3% solution in 2006 it was 5.42, 5.36, 6.81 and 6.54, while in 2007 it was 6.31, 6.66, 6.96 and 7.54, respectively. Plants were measured (the number of leaves and plant height) every two months, starting from August 2006 and June 2007. Results of plant measurements were analyzed using two-way analysis of variance with the Newman Keuls test at the significance level $p = 0.05$. Within one combination (the $CaCO_3$ dose used on the substrate × fertilizer solution concentration for top dressing) there were 24 replications with one plant. The flowering of plants was evaluated in the spring of 2008. The diameter of flowers and the length of peduncles were measured at the beginning of flowering. Flowers, buds and inflorescences were counted during anthesis. The analysis of flowering was conducted on the 10 plants within a combination (10 replications) that were the first to begin flowering. Dates of the onset of flowering and anthesis were calculated using the weighted means methods, while the other measurements were analyzed by the two-way analysis of variance with the Duncan test at the significance level $p = 0.05$.

RESULTS AND DISCUSSION

Helleborus lividus is found in the wild in Majorca, where it grows in small clusters on stream banks and in olive groves (Rice and Strangman 2001). Schmiemann (2005) pointed to the fact that due to its limited cold resistance and tolerance to

elevated substrate moisture content this species is suitable first of all for pot growing, although recommendations for this type of cultivation have not been presented to date. Grantzau (2000) reported that in the production of perennials as cut flowers, the kind of substrate is more important than its optimal acidity.

Table 1. Seedling growth of *Helleborus lividus* depending on the $CaCO_3$ dose introduced to the substrate

Dose of $CaCO_3$ (g dm^{-3})	Increment of leaf number	Height of plant (cm)
2.5	2.5 a*	4.9 c
5.0	2.2 a	4.1 b
7.5	2.3 a	4.1 b
10.0	2.2 a	3.6 a

*Means followed by the same letters do not differ at p = 0.05

Table 2. Height of *Helleborus lividus* in the first year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing (cm)

Dose of $CaCO_3$ (g dm^{-3})	Date of measurement					
	28 August 2006			28 October 2006		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3	
2.5	9.0 a*	9.0 a	9.0 B	9.0 b	9.0 b	9.0 C
5.0	9.0 a	8.7 a	8.8 AB	8.5 ab	8.7 ab	8.6 BC
7.5	8.4 a	8.1 a	8.3 A	7.7 a	8.0 ab	7.8 A
10.0	8.2 a	8.8 a	8.5 AB	7.9 ab	8.6 ab	8.2 AB
Mean	8.6 *a*	8.6 *a*		8.3 *a*	8.6 *a*	

*Explanations: see Table 1

Table 3. The number of leaves in *Helleborus lividus* in the first year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing

Dose of $CaCO_3$ (g dm^{-3})	Date of measurement					
	28 August 2006			28 October 2006		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3	
2.5	6.6 a*	6.3 a	6.5 A	8.2 b	7.5 ab	7.8 B
5.0	6.3 a	6.3 a	6.3 A	7.2 ab	7.9 b	7.5 B
7.5	6.0 a	6.0 a	6.0 A	6.5 a	7.3 ab	6.9 A
10.0	6.2 a	5.7 a	6.0 A	6.5 a	7.1 ab	6.8 A
Mean	6.3 *a*	6.1 *a*		7.1 *a*	7.4 *a*	

*Explanations: see Table 1

In our study peat substrate was used and a wide range of $CaCO_3$ doses (from 2.5 to 10.0 g dm^{-3}) was applied. The tallest plants (4.9 cm) were produced using calcium carbonate at 2.5 g dm^{-3}, while the lowest (3.6 cm) at a dose of 10.0 g dm^{-3} (Table 1). Plants grown in a substrate with doses of 5.0 and 7.5 g dm^{-3} reached an identical height of 4.1 cm. Within 70 days of seedling the number of leaves grown increased on average by 2.2-2.5, which did not depend on the calcium carbonate dose introduced to the substrate. Similarly, Szczepaniak et al. (2008), in their study on *Helleborus orientalis,* found a significant reduction of plant height after the application of $CaCO_3$ at 10.0 g dm^{-3}, and doses 2.5-10.0 g $CaCO_3$ per dm^{-3} did not have an effect on the increase in the number of leaves.

In the first year of pot cultivation of *Helleborus lividus*, irrespective of fertilizer concentration applied in top dressing, the dose of calcium carbonate introduced to the substrate had an effect on plant height (Table 2). At both measurement dates the tallest plants were obtained in high moor peat deacidified with a dose of $CaCO_3$ – 2.5 g dm^{-3}, but their height did not differ significantly from that of plants grown at a doubled dose of calcium carbonate. The lowest plants were produced when introducing calcium carbonate to the substrate at a dose of 7.5 g dm^{-3}. However Ganslmeier and Henseler (1985) recommended the dose of $CaCO_3$ – 4-7 g dm^{-3} in forcing of *Helleborus niger*. Top dressing with a fertilizer solution at a concentration of 0.1% or 0.3% did not have a significant effect on the height and the number of leaves in *Helleborus lividus* in the first year of growth (Tables 2 and 3). In contrast, Szczepaniak et al. (2008) showed that *Helleborus orientalis* formed more leaves and plants were significantly taller when an increased concentration of fertilizer solution was used in top dressing. In measurements taken in October significantly higher numbers of leaves (Table 3) were reported in *Helleborus lividus* grown in a substrate with 2.5 and 5.0 g doses of $CaCO_3$ than it was the case for 7.5 and 10.0 g $CaCO_3$. For growing one-year-old seedlings of *Helleborus* × *hybridus,* Kraus and Warren (2002) recommend a pine bark substrate with dolomite in the amount of 1.8 g dm^{-3}, but fertigation with a solution of NPK containing nitrogen in the amount of 160 mg dm^{-3}.

In the second year of cultivation the effect of applied $CaCO_3$ doses on the height of *Helleborus lividus* was most marked in October (Table 4). The difference between the tallest plants grown in the substrate with a dose of 2.5 g, and the lowest at a dose of 10.0 g, was 2.4 cm. Statistical analysis showed a significant difference between plants grown at these doses, as well as doses of 5.0 and 7.5 g $CaCO_3$. Irrespective of the calcium carbonate dose used, starting from August significantly taller plants were produced after fertilization with a solution of a higher concentration (0.3%). Similar dependencies were indicated by the results of studies on *Helleborus orientalis* (Szczepaniak et al. 2008).

Table 4. Height of *Helleborus lividus* in the second year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing (cm)

Dose of $CaCO_3$ (g dm^{-3})	Date of measurement								
	21 June 2007			13 August 2007			16 October 2007		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3		0.1	0.3	
2.5	13.5 d*	10.2 b	11.7 B	11.8 b	10.7 ab	11.3 A	11.5 bc	11.8 c	11.7 C
5.0	11.4 bc	13.0 cd	12.2 B	9.5 a	11.5 b	10.5 A	9.5 a	11.5 bc	10.5 B
7.5	10.1 b	11.6 bc	10.8 A	10.8 ab	11.7 b	11.2 A	9.9 ab	10.8 abc	10.3 B
10.0	8.7 a	11.4 bc	10.1 A	10.1 ab	11.0 ab	10.5 A	9.0 a	9.6 a	9.3 A
Mean	10.9 *a*	11.5 *a*		10.5 *a*	11.2 *b*		10.0 *a*	10.9 *b*	

*Explanations: see Table 1

The application of calcium carbonate at the highest dose of $CaCO_3$ – 10.0 g dm^3 resulted in a significant reduction of the number of leaves and shoots in *Helleborus lividus* (Tables 5 and 6). Irrespective of the dose of calcium carbonate, only in October the number of leaves was significantly higher when the concentration of fertilizer solution in the top dressing was 0.3%. In *Helleborus orientalis* such a response was found as early as June (Szczepaniak et al. 2008). The highest number of leaves and shoots in *Helleborus lividus* was found in plants growing on a substrate with a dose of $CaCO_3$ – 2.5 g dm^{-3} and top-dressed with a 0.3% fertilizer solution. However, Treder (2001), comparing an influence of Peters Professional (15:11:29) doses – 0.8 i 1.6 g dm^{-3} on the growth of lilies, stated that there was a favourable effect of the higher dose of fertilizer only in relation to the fresh matter of stems.

Applied $CaCO_3$ doses had an effect only on the number of inflorescences, while their quality did not depend on this factor (Table 7). The biggest number of inflorescences was formed by plants grown on a substrate with an addition of $CaCO_3$ in the amount of 2.5 g dm^{-3}, although their number did not differ significantly from that of plants grown at a dose of $CaCO_3$ – 5.0 g dm^{-3}. The fertilizer concentration used in top dressing did not have an effect on the number of inflorescences or the diameter of flowers. Significantly longer peduncles were found in plants fertilized with a solution of a lower concentration (0.1%), while significantly higher numbers of flowers and buds were recorded in plants top-dressed with a solution of a higher concentration (0.3%). The application of a 0.3% fertilizer solution in *Helleborus orientalis* resulted not only in an increase in the number of flowers and buds, but also in the number of inflorescences and the diameter of flowers (Szczepaniak et al. 2008). In classifying perennials cultivated as cut flowers, Grantzau (2000) included hellebore among plants with the smallest needs for nitrogen fertilization; however, Sander (1991) recognized it as a species with medium requirements towards nitrogen content in substrate. Different $CaCO_3$ doses did not have an effect on the beginning of flowering in *Helleborus lividus*. Plants top-dressed with a fertilizer solution at a lower concentration of 0.1% flowered by over 20 days later in comparison to plants top-dressed with a 0.3% solution (Table 8).

One of the commercial substrates available in recent years is also a substrate for hellebores, with pH 6.1-6.4 (Springer 2005). This study concludes that *Helleborus lividus* grows well when substrate pH in the first year of cultivation is 5.30-5.47, and 5.96-7.41 in the second year.

Table 5. The number of leaves in *Helleborus lividus* in the second year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing

Dose of $CaCO_3$ (g dm^{-3})	Date of measurement								
	21 June 2007			13 August 2007			16 October 2007		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3		0.1	0.3	
2.5	12.9 b*	13.4 b	13.2 B	12.9 abc	14.5 c	13.8 B	14.0 ab	18.2 c	16.1 B
5.0	12.1 b	12.0 b	12.0 B	12.0 abc	13.2 abc	12.6 B	13.0 ab	13.4 bc	14.2 B
7.5	12.2 b	11.6 b	11.9 B	14.0 bc	13.8 bc	13.9 B	13.7 ab	15.2 bc	14.5 B
10.0	9.4 a	8.3 a	8.9 A	10.3 a	10.9 ab	10.6 A	11.0 a	12.8 ab	11.9 A
Mean	11.6 *a*	11.3 *a*		12.3 *a*	13.2 *a*		12.9 *a*	15.4 *b*	

*Explanations: see Table 1

Table 6. The number of shoots in *Helleborus lividus* in the second year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing

Dose of $CaCO_3$ (g dm^{-3})	Date of measurement								
	21 June 2007			13 August 2007			16 October 2007		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3		0.1	0.3	
2.5	2.7 b*	2.7 b	2.7 B	2.8 abc	3.2 c	3.0 B	2.8 abc	3.2 c	3.0 B
5.0	2.3 ab	2.8 ab	2.5 B	2.7 abc	3.0 bc	2.8 B	2.7 abc	3.0 bc	2.8 B
7.5	2.4 ab	2.5 ab	2.4 B	2.5 abc	2.8 abc	2.6 B	2.5 abc	2.8 abc	2.6 B
10.0	2.0 ab	1.9 a	2.0 A	2.2 ab	2.1 a	2.1 A	2.2 ab	2.1 a	2.1 A
Mean	2.3 *a*	2.5 *a*		2.6 *a*	2.7 *a*		2.6 *a*	2.7 *a*	

*Explanations: see Table 1

Table 7. Evaluation of flowering of *Helleborus lividus* in the second year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing

Dose of $CaCO_3$ (g dm^{-3})	Number of inflorescences			Length on peduncle (cm)			Number of flowers and buds			Flower diameter (cm)		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3		0.1	0.3		0.1	0.3	
2.5	2.4 c*	2.1 abc	2.2 B	9.6 ab	9.8 ab	9.7 A	10.5 a	19.3 b	14.9 A	2.4 a	3.0 ab	2.7 A
5.0	1.6 ab	2.2 bc	1.9 AB	11.1 b	10.0 ab	10.6 A	8.6 a	20.3 b	14.5 A	2.9 ab	2.9 ab	2.9 A
7.5	1.6 ab	2.0 abc	1.8 A	11.0 b	9.3 ab	10.2 A	8.4 a	18.7 b	13.6 A	2.8 ab	2.9 ab	2.8 A
10.0	1.5 a	1.9 abc	1.7 A	10.9 b	7.9 a	9.4 A	7.7 a	18.1 b	12.9 A	3.3 b	2.4 a	2.9 A
Mean	1.8 *a*	2.1 *a*		10.7 *b*	9.2 *a*		8.8 *a*	19.1 *b*		2.8 *a*	2.8 *a*	

*Explanations: see Table 1

Table 8. Phenology of flowering of *Helleborus lividus* in the second year of pot cultivation depending on the $CaCO_3$ dose introduced to the substrate and the fertilizer solution concentration applied in the top dressing

Dose of $CaCO_3$ (g dm^{-3})	Date					
	Onset of flowering			Anthesis		
	Concentration of Peters Professional Special (%)		Mean	Concentration of Peters Professional Special (%)		Mean
	0.1	0.3		0.1	0.3	
2.5	21 March	28 February	10 March	8 April	9 March	24 March
5.0	21 March	25 February	9 March	26 March	3 March	15 March
7.5	20 March	29 February	10 March	26 March	3 March	15 March
10.0	24 March	28 February	12 March	26 March	13 March	20 March
Mean	22 March	28 February		29 March	7 March	

CONCLUSIONS

1. The growth of *Helleborus lividus* in the first year of pot cultivation depended on the dose of calcium carbonate. Taller plants with a larger number of leaves were produced when $CaCO_3$ was applied in the amount of 2.5-5.0 g dm^{-3}, i.e. at pH 5.3-5.5.
2. In the second year of cultivation good quality plants, i.e. taller, with a larger number of leaves and shoots, were produced when grown in a substrate with a dose of $CaCO_3$ 2.5-7.5 g dm^{-3}, i.e. at pH 6.0-7.4.
3. The application of solutions with different concentrations of Peters Professional Special in top dressing did not have an effect on the growth of *Helleborus lividus* in the first year of cultivation, while in the second year taller plants, with more leaves as well as flowers and buds, were produced after applying a 0.3% fertilizer solution.

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WPŁYW DAWKI WĘGLANU WAPNIA I NAWOŻENIA POGŁÓWNEGO PETERS PROFESSIONAL SPECIAL NA WZROST I KWITNIENIE CIEMIERNIKA BŁĘKITNAWEGO (*HELLEBORUS LIVIDUS* AITON.)

Streszczenie: Rozsadę i młode rośliny ciemiernika błękitnawego (*Helleborus lividus* Aiton.) uprawiano przez dwa lata (2006 – 2007) w pojemnikach, w podłożu torfowym, które odkwaszono węglanem wapnia w dawkach: 2,5; 5,0; 7,5; 10,0 g dm^{-3}. W obrębie każdej dawki $CaCO_3$ podzielono rośliny na 2 grupy, jedną nawożono roztworem o niższym (0,1%) a drugą o wyższym (0,3%) stężeniu nawozu Peters Professional PL Special (15:11:29). Wzrost ciemiernika błękitnawego w pierwszym roku uprawy zależał od dawki węglanu wapnia. Wyższe rośliny, z większą liczbą liści uzyskano stosując węglan wapnia w dawkach $CaCO_3$ – 2,5-5,0 g dm^{-3}. W drugim roku uprawy rośliny dobrej jakości – wyższe, z większą liczbą liści i pędów otrzymano przy uprawie w podłożu z dawkami $CaCO_3$ – 2,5-7,5 g dm^{-3}. Zastosowanie w nawożeniu pogłównym roztworów o różnym stężeniu nie miało wpływu na wzrost ciemiernika błękitnawego w pierwszym roku uprawy, a w drugim wyższe rośliny, z większą liczbą liści, a także obficiej kwitnące uzyskano po zastosowaniu roztworu nawozu o stężeniu 0,3%.

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