Available online at www.worldscientificnews.com

World Scientific News

WSN 61(2) (2017) 86-97 EISSN 2392-2192

Ornamental swiss chard (*Beta vulgaris* var. *cicla*) response to daminozide and flurprimidol

Agnieszka Zawadzińska*, **Piotr Salachna**, **Rafał Piechocki**

Department of Horticulture, Faculty of Environmental Management and Agriculture, West Pomeranian University of Technology, Szczecin, Poland

*E-mail address: agnieszka.zawadzinska@zut.edu.pl

ABSTRACT

The ornamental swiss chard (*Beta vulgaris* var. *cicla*) has the potential to produce ornamental potted plants becaused of the highly decorative foliage, characterized by intens color of leaves with large, ribbed blades and wide, grooved stalks arranged in a rosette. Depending on the cultivar, swiss chard may grow up to 60 cm in height. However to obtain compacts and attractive plants it is necessary to use plant growth regulation (PGRs). The aim of the study was to identify the most effective regulator and the method of its application to reduce the size and improve the habit of ornamental swiss chard grown in pots. In two years experiments two growth retardants were used, i.e. daminozide at 4250 $mg \cdot dm^{-3}$ and flurprimidol at 15 $mg \cdot dm^{-3}$. The retardants were applied four times at an interval of 10 days by spraying the plants with 20-25 ml of the solution on plants or drenching them with 150 ml of the solution per pot. Control plants were not treated with the retardants. Both the habit and proportions of potted swiss chard may be effectively controlled by drenching it four times with flurpirimidol at a dose of 2.25 mg/pot. Daminozide was not effective in controlling swiss chard habit, irrespective of the application method. Non negative effects or phytotoxicities were found in any drench or spray treatments of daminozide and flurprimidol.

***Keywords*:** chard, drenching, spraying, 4-(2,2-dimethylhydrazinyl)-4-oxobutanoic acid, 2-methyl-1-pyrimidin-5-yl-1-[4-(trifluoromethoxy)phenyl]propan-1-ol

1. INTRODUCTION

Ornamental swiss chard (*Beta vulgaris* var. *cicla*) belonging to Chenopodiaceae family. Its wild forms are native to the Canary Islands, the Mediterranean region and South-East Asia [25]. Swiss chard is cultivated for its leaves with large, ribbed blades and wide, grooved stalks arranged in a rosette. It has been cultivated in Europe for 300 years as a plant with valuable biological and taste properties [7]. The underground parts are fleshy roots that distinguish this species from beetroot [18]. Due to its decorative qualities, it is often grown as an ornamental plant in flower beds in the cities, and home and botanical gardens. Swiss chard may be also grown in containers together with other ornamental plants and vegetables with decorative leaves and fruits. Commercially available varieties include those with red and green blades with prominent ribbing and white, bright pink, yellow or red stalks [7,18,36].

Depending on the variety, swiss chard may grow up to 60 cm in height [26]. This means its size needs to be restricted for potted cultures to facilitate plant transport and sale and to improve plant habit and plant to pot ratio [8,11]. The use of growth retardants (PGRs) is the most reliable and widely used approach in ornamental gardening providing commercial material of desired characteristics [4,5,8,15,16,23,24,32].

The retardants inhibit shoot elongation by blocking the synthesis of gibberellins [27,28]. Their effectiveness depends on many factors, such as the type and dose of an active substance, application method, growing conditions, fertilization or plant spacing, and different species or even variations may respond in a different way [34,35,37-40].

Little information on ornamental swiss chard culture has been available and there are no quantitative data on the effects of plant growth regulators (PGRs) on growth, habit and decorative value of ornamental swiss chard.

The aim of the study was to identify the most effective retardant and the method of its application to reduce the size and improve the habit of ornamental swiss chard grown in pots.

2. MATERIALS AND METHODS

The study was conducted for two growing seasons in a greenhouse and a plastic tunnel belonging to the West Pomeranian University of Technology in Szczecin (53°25’ N, 14°32’ E; 25 m a. s. l.).

The seeds of ‘Bright Lights’ swiss chard (Vilmorin Garden Sp. z o. o.) were sown in greenhouse into pots filled with TS1 substrate (Table 1) in the third decade of March 2013 and 2014. After four weeks, selected seedlings with white ribbed leaves were transferred into square (8×8 cm) plastic pots filled with the same substrate.

On 26th May 2013 and 28th May 2014 the plants were transferred into pots of 16 cm diameter and 2 dm^3 capacity filled with peat substrate (Table 1). The substrate was supplemented with nutrients in the form of Yara Mila Complex fertilizer at a dose of 2.5 $g \cdot dm^{-3}$ (Yara International ASA, Norway) that contained 12% N, 11% P_2O_5, 18% K_2O, 2.7% MgO, 8% S, 0.015% B, 0.2% Fe, 0.02% Mn and 0.02% Zn. The pots were placed in the plastic tunnel on nursery mats.

In the first week of June 2013 and 2014 two growth retardants (Table 2) were used, i.e. daminozide (IUPAC chemical name: 4-(2,2-dimethylhydrazinyl)-4-oxobutanoic acid) at 4250 $mg \cdot dm^{-3}$ (commercial preparation B-Nine 85 SG, Chemtura, Netherlands) and flurprimidol

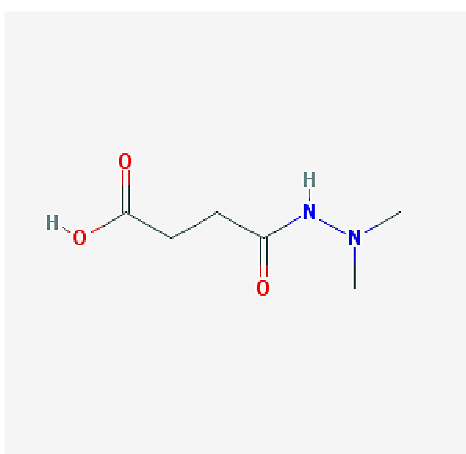
(IUPAC chemical name: 2-methyl-1-pyrimidin-5-yl-1-[4-(trifluoromethoxy)phenyl]propan-1-ol) at 15 mg·dm^{-3} (Topflor 015 SL, SePRO Corporation, USA).

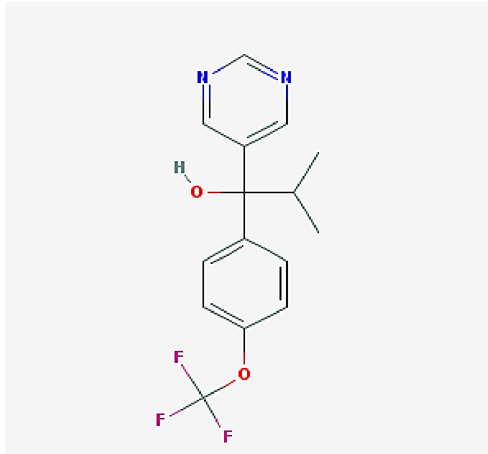
Table 1. Chemical composition of media used to potted ornamental swiss chard cultivation.

Media	pH_{H2O}	$N\text{-}NO_3$	P	K	Ca	Mg	Cl	EC mS·cm^{-1}
		mg·dm^{-3}						
TS1 Kronen Poland	5.6	181	131	402	1646	172	18	1.18
Peat substrate* Nowy Chwalim Poland	6.6	9	37	19	3403	95	15	0.24

*peat chemical composition before addition of fertilizer

Table 2. Chemical name, 2D structure and molecular formula of daminozide and flurprimidol. (source: www.pubchem.ncbi.nlm.nih.gov)

Chemical name	2D Structure	Molecular formula
Daminozide		$C_6H_{12}N_2O_3$

Flurprimidol		$C_{15}H_{15}F_3N_2O_2$

The retardants were applied four times at an interval of 10 days by spraying the plants with 20-25 ml of the solution per plant or drenching them with 150 ml of the solution per pot.

The substrate of each plant was supplemented with four doses of 2.25 mg of flurprimidol per pot or 638 mg of daminozide per pot. Control plants were not treated with the retardants. Four repetitions, each including four plants, were prepared. Each year the experiment included 80 plants. The plants were grown under natural photoperiod. Air temperature and relative humidity during the study were recorded with Testo 175-h2 device with a sensor placed at the plant level (Table 3, Table 4).

Table 3. The air temperature (°C) during the experiment in plastic tunel.

Temperature	Month					
	May		June		July	
	2013	2014	2013	2014	2013	2014
Minimum	10.9	6.9	14.2	13.3	16.1	17.6
Maximum	26.0	25.0	27.5	27.3	31.0	32.5

Table 4. The relative humidity (RH %) during the experiment in plastic tunel.

Relative humidity	Month					
	May		June		July	
	2013	2014	2013	2014	2013	2014
Minimum	41.7	46.3	46.6	45.3	43.1	41.7
Maximum	87.8	98.5	92.4	98.5	92.4	99.3

Morphological measurements were performed in the second week of July 2013 and 2014. They included plant height (from the base to the top of the blade), plant width (most outermost leaves), height plant to width plant ratio (H:W ratio), number of leaves, and leaf greenness index measured with a hand device Yara N-Tester (Yara, Norway). Five Yara N-tester readings were collected from at least six leaves within each pot. This device is equipped with two light emitting diodes and one silicon photodiode that functions to measure light transmittance through green plant tissues at the red (650 nm) and near-infrared (960 nm) wavelengths within a 6 mm^2 area [14]. Yara N-Tester calculates a running average of thirty readings to evaluate leaf greenness value that correlates with leaf content of chlorophyll and nitrogen and leaf greenness index read from chlorophyll meter SPAD-502 [2,12-13,22].

Plant ornamental value was assessed using a five-score bonitation scale that accounted for plant habit, plant to pot ratio, foliage, and leaf greenness. Bonitation assessment was performed by three independent people. Maximum score of 5 was given to the plants with the greatest decorative value, and those without any ornamental value were scored 1.

The results for each year were processed by analysis of variance for univariate experiments and the significance of differences between mean values was evaluated with Tukey's test at a significance level of $P \leq 0.05$.

3. RESULTS AND DISSCUSION

Vegetables with ornamental leaves and fruits are nowadays used as an interesting supplement to balcony and bedding plant assortment [11]. Plants with high growth potential need to be treated with growth inhibitors that improve their habit. Studies conducted in ornamental pepper (*Capsicum annuum*) and ornamental cabbage (*Brassica orelaceae* L. var. *acephala*) showed that the required habit and better plant quality may be achieved by using growth inhibitors, such as paclobutrazol, chloromequat, daminozide and trinexapac-ethyl [10,19,21].

In our study, the growth of ornamental swiss chard was restricted by two retardants, flurprimidol and daminozide that belong to different groups of chemicals. Both agents significantly reduced swiss chard height (Table 5). Stronger effects were observed for flurprimidol, as the growth of plants drenched with its solution was restricted by 46.5% in the first year and by 43.1% in the second year, as compared with control (Fig. 1).

Table 5. The height and width of potted ornamental swiss chard treated with daminozide and flurprimidol.

Treatment	Height of plant (cm)		Width of plant (cm)	
	2013	2014	2013	2014
Control	49.5 a*	54.5 a	77.0 a	66.5 a
Daminozide spraying	47.5 ab	44.5 c	74.5 a	70.0 a
Daminozide drenching	45.0 b	45.0 c	71.8 ab	73.8 a

Flurprimidol spraying	46.0 b	48.0 b	63.3 b	71.5 a
Flurprimidol drenching	26.5 c	31.0 d	48.8 c	46.8 b

*Means marked with the same letter in column do not differ significantly according to the Tukey test at $P \leq 0.05$

Spraying the plants with daminozide and flurprimidol was less effective and inhibited plant growth by respectively 4.0% and 6.9% in the first year, and much stronger – by 18.3% and 11.9% in the second year. Clearly compact plants with reduced width were obtained in the first year after drenching and spraying the plants with flurprimidol.

Plant width was smaller than in control by 36.6% and 17.8%, respectively. In 2014, drenching with flurprimidol reduced plant width by 19.7 cm, i.e. by 29.6% as compared with control. Flurprimidol belongs to the retardants that are absorbed via both the stem and the root system and act as monooxygenase inhibitors catalyzing the transition of ent-kaurene to ent-kaurenoic acid at the early stage of gibberellin synthesis [27].

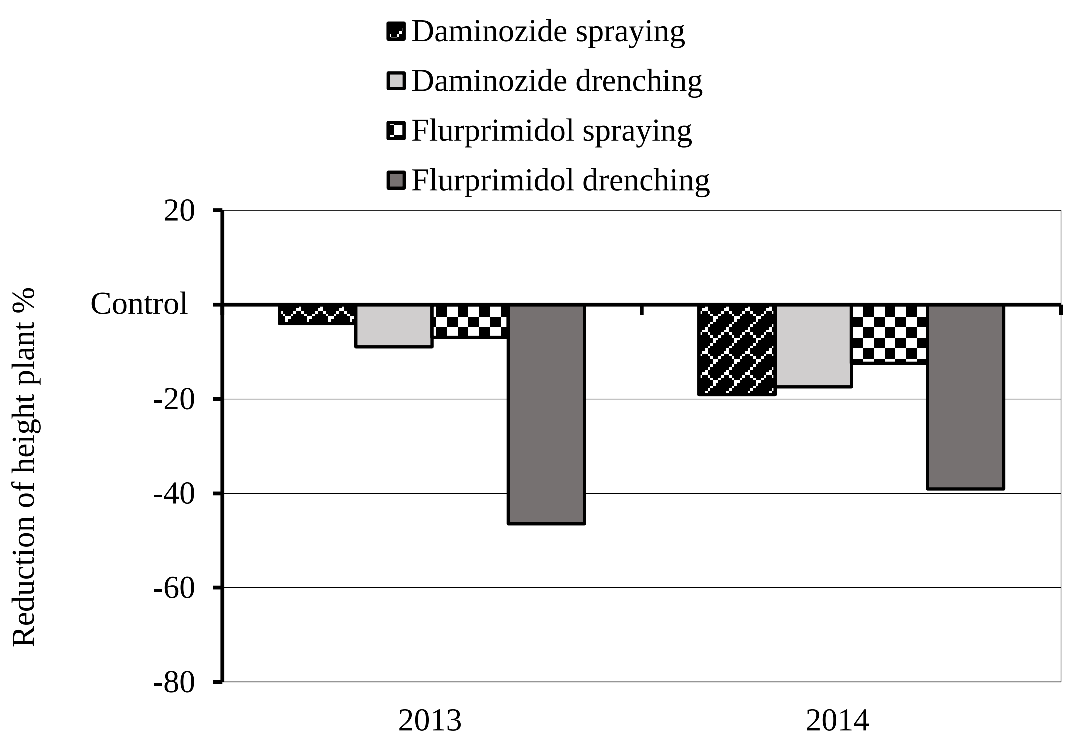


Fig. 1. Reduction of height of ornamental swiss chard treated with daminozide and flurprimidol in pot culture.

In this study soil application of flurprimidol at four doses of 2.25 mg/pot was more effective in reducing swiss chard growth and diameter than spraying. Moreover, flurprimidol was also more effective than daminozide. In other experiments flurprimidol used at a dose of

0.05 mg/pot reduced the height of *Ornithogalum dubium* and *O. thyrsoides* by 35% [17]. *Odontonema strictum* drenched with flurprimidol at a dose of 0.47 mg/pot was by 78% lower than control but when the dose was lowered to 0.24 mg/pot the plants were of better quality [29].

Flurprimidol used for soaking the bulbs of *Ornithogalum saundersiae* at a dose of 30 mg/l limited the length of the inflorescence stem by 52.5% and significantly reduced plant diameter [31]. When used at 20 mg·dm^{-3} for bulb soaking (*Gladiolus* sp.) and at 1-2 mg/pot, this retardant effectively inhibited plant growth but was also detrimental to plant quality [1]. Flurprimidol at 5-20 mg·dm^{-3} effectively restricted elongation in *Impatiens hawkeri* seedlings [6]. Contrary to this, daminozide used at 1250-5000 mg·dm^{-3} for spraying *I. hawkeri* seedlings did not affect plant elongation.

Rademacher [27] claimed that daminozide is a retardant absorbed mainly via leaves. It blocks gibberellin formation at later stages of their synthesis. Gibson et al. [11] suggested a few foliar applications of daminozide at 2500 mg·dm^{-3} were effective in dwarfing of swiss chard plants. In our study, foliar application of daminozide only slightly reduced swiss chard growth. No significant differences in plant height and width depending on the application method were noticed. However, a positive effect of daminozide on growth inhibition of ornamental cabbage was reported by Gibson and Whipker [10] and Mello et al. [19], who sprayed the plants two or three times with this retardant at a dose of 2500 mg·dm^{-3}. Daminozide effectiveness is significantly affected by plant condition that should be healthy, with correct turgor and no signs of water on the leaves before application. This is important, as the formulation is most efficiently absorbed under high air humidity, and low temperature and sun exposure [30].

The habit of ornamental potted plants, which decides on their aesthetic value depends on their height to width ratio [20]. In the first year of the study, this ratio was the highest in the plants sprayed with fluropirimidol (0.73), and in the second year in the control plants (0.82) but it did not exceed 1.0 (Fig. 2). The ratio close to 1.0 indicates that plant habit is close to spherical. It was the lowest (0.54) in the plants drenched with fluropirimidol in the first year of the study. Too low H:W ratio is also not desirable, as the plant habit becomes flattened and the leaves do not have enough light. In swiss chard, the most exposed parts should be the decorative stems.

Swiss chard plants grown it pots produced in both study years on average 16.6-18.8 leaves (Table 6). Daminozide treatments in the first year did not affect swiss chard foliage irrespective of the application method. The plants both drenched and sprayed with flurprimidol produced by 3.5 and 4.5 leaves less, respectively. In the second year of the study, swiss chard plants treated with daminozide produced more leaves than the controls. Contrary to that, the plants drenched with flurpirimidol had significantly less leaves than the non-treated ones.

Measurements of leaf greenness index with Yara N-Tester device showed a significant effect of drenching with flurprimidol as compared with the control plants for both study years (Table 6). In the first year, the leaves of swiss chard plants drenched with flurpirimidol had significantly higher greenness index than the other plants, except for those sprayed with daminozide. In the second year, the plants drenched with flurpirimidol had more intense foliage colors than the plants in any other variants. Retardants may increase leaf color intensity by enhancing chlorophyll density per surface unit and the greater its production [3,34].

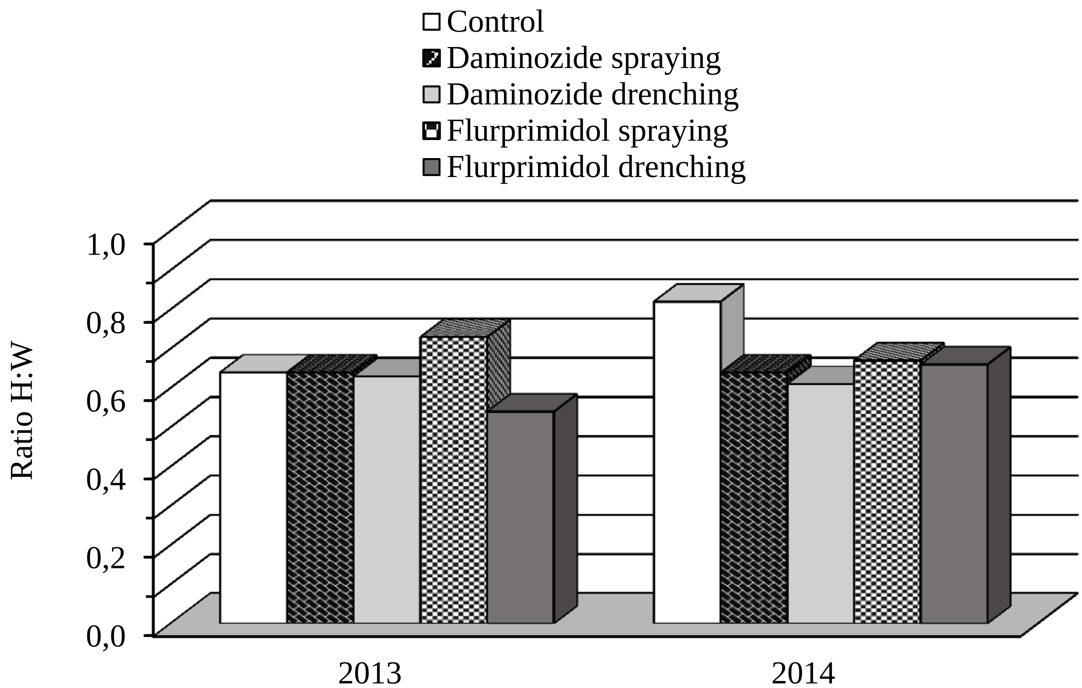


Fig. 2. Height (H) to width (W) ratio in potted ornamental swiss chard treated with daminozide and flurprimidol.

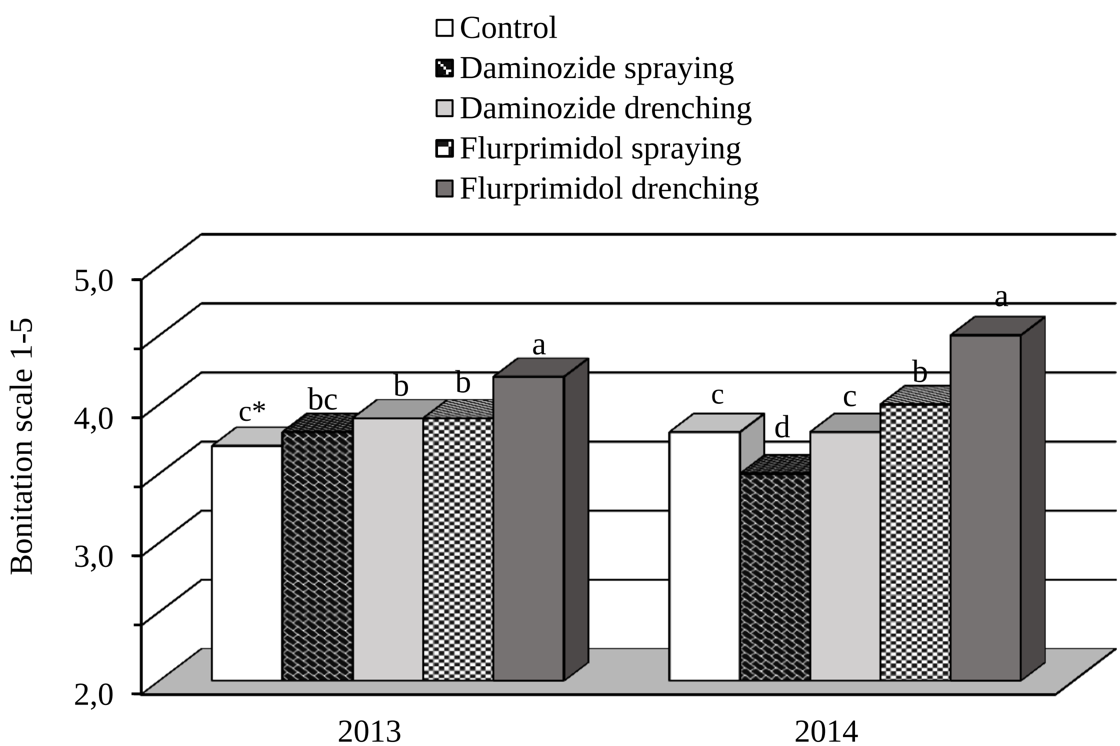
Table 6. Number of leaves per pot and greenness index of leaves (Yara N-Tester) of potted ornamental swiss chard treated with daminozide and flurprimidol.

Treatment	Number of leaves per plant		Greenness index of leaves Yara N-Tester	
	2013	2014	2013	2014
Control	20.5 a*	15.5 bc	596 c	504 c
Daminozide spraying	20.5 a	18.5 a	657 ab	530 bc
Daminozide drenching	19.5 a	18.0 a	581 c	558 b
Flurprimidol spraying	17.0 b	16.5 ab	622 bc	542 bc
Flurprimidol drenching	16.5 c	14.3 d	680 a	788 a

*Means marked with the same letter in column do not differ significantly according to the Tukey test at $P \leq 0.05$

Improved leaf greenness measured by hand chlorophyll meter was reported by Thohirah et al. [33] as a result of root application of paclobutrazol and flurprimidol in curcuma, by Zawadzińska et al. [37-40] as a result of spraying zonal pelargonium with flurprimidol, and by Salachna and Zawadzińska [31] who soaked the bulbs of *Ornithogalum saundersiae* in flurprimidol and drenched or sprayed its plants with this retardant.

The bonitation assessment revealed that the most decorative plants with the most proportional and compactness habit were obtained in both study years through drenching with flurprimidol (Fig. 3). Even though the plants in this variant produced less leaves than the control ones, they still had many of them and the blades were intensely green.



*Means marked with the same letter in column do not differ significantly according to the Tukey test at $P \leq 0.05$

Fig. 3. Decorative value (bonitation scale 1-5) of potted ornamental swiss chard treated with daminozide and flurprimidol.

4. CONCLUSIONS

- ✓ Both the habit and proportions of potted ornamental swiss chard may be effectively controlled by drenching it four times with flurprimidol at a dose of 2.25 mg/pot.
- ✓ Daminozide foliar spray and substrate drenching were ineffective in controlling potted ornamental swiss chard habit.
- ✓ Non negative effects or phytotoxicities were found in any drench or spray treatments of daminozide and flurprimidol in potted ornamental swiss chard.

References

[1] I. Ahmad, B. E. Whipker, J. M. Dole, Flurprimidol preplant corm soaks or drenches affect potted gladiolus production. *Acta Horticulture* 1104 (2015) 103-108.

[2] L. M. Arregui, B. Lasa, A. Lafarga, I. Iraneta, E. Baroja, M. Quemada, Evaluation of chlorophyll meters as tools for N fertilization in winter wheat under humid Mediterranean conditions. *European Journal of Agronomy* 24 (2006) 140-148.

[3] A. M. Armitage, Z. P. Tu, H. M. Vines, The influence of chlormequat and daminozyde on net photosynthesis, transpiration and photorespiration of hybrid geranium. *HortScience* 19(5) (1984) 705-707.

[4] J. Barrett & C. Bartuska, Multiple Topflor drenches for baskets, *Greenhouse Product News* 5 (2010) 23-25.

[5] A. Barker, I. McCall, B. E. Whipker, Growth control of ‘Imperial Dark Blue’ plumbago with ethephon, flurprimidol, and paclobutrazol substrate drenches. *HortTechnology* 26(4) (2016) 493-496.

[6] C. J. Currey, N. J. Flax, K.J. Walters, Foliar sprays of flurprimidol, paclobutrazol, and uniconazole suppress height of seed-propagated New Guinea Impatiens. *HortTechnology* 26 (2016) 20-25.

[7] D. Drost, Swiss chard in the garden. Utah State University, Cooperative extension, (2010).

[8] P.M. Filios & W.B. Miller, Effects of flurprimidol, paclobutrazol and uniconazole drenches on *Eucomis comosa* growth, *Acta Horticulture* 1002 (2013) 439-443.

[9] M. P. N. Gent & R. J. McAvoy, Plant growth retardants in ornamental horticulture: A critical appraisal. (in: *Plant Growth Regulators in Agriculture and Horticulture. Their role and commercial uses*). Ed. M.S. Basra. Haworth Press, New York, (2000) 89-145.

[10] J. L. Gibson & B. E. Whipker, Ornamental cabbage and kale growth response to daminozide, paclobutrazol and uniconazole. *HortTechnology* 11(2) (2001) 226-230.

[11] J. L. Gibson, B. E. Whipker, R. A. Cloyd, R. Jones. Success with ornamental vegetables as floricultural crops. *NCSU Horticulture Information Leaflet* 508 (1999) 7.

[12] G. Gianquinto, M. Fecondini, M. Mezzetti, F. Orsini, Steering nitrogen fertilization by means of portable chlorophyll meter reduces nitrogen input and improves quality of fertigated cantaloupe (*Cucumis melo* L. var. *cantalupensis* Naud.). *Journal of the Science Food and Agriculture* 90 (2010) 482-493.

[13] G. Gianquinto, F. Orsini, P. Sambo, M. Paino D'Urzo, The use of diagnostic optical tools to assess nitrogen status and to guide fertilization of vegetables, *HortTechnology* 21(3) (2011) 287-292.

[14] M. Hughes, C. Lallo, V. Mlambo, P.G.A. Jennings, Calibration and validation of optical chlorophyll-measuring devices for use in predicting crude protein concentration in tropical grass herbage, *Grass and Forage Science* (2016) doi:10.1111/gfs.12219.

[15] A. Kapczyńska & M. Malik, Planting time and flurprimidol treatment influence the growth and flowering of *Lachenalia*. *HortTechnology* 26 (2016) 293-298.

[16] F. Larcher, A. Berruti, P. Gullino, V. Scariot, Reducing peat and growth regulator input in camellia pot cultivation. *Horticultural Science* (Prague) 38 (2011) 35-42.

[17] J. Lee, M. I. Gómez, W. B. Miller, Paclobutrazol and flurprimidol control stem elongation of potted star of Bethlehem. *HortTechnology* 25(4) (2015) 480-486.

[18] S. Mahr, Swiss chard. University of Wisconsin, Madison, *Wisconsin Master Gardener website*, 12.08.2012. (2012).

[19] S. C. Mello, R. T. Matsuzaki, R. Campagnol, C. F. Mattiuz, Effects of plant growth regulators in ornamental kale (*Brassica oleracea* var. *acephala*). *Acta Horticulture* 937 (2012) 245-251.

[20] M. Meijon, R. Rodriguez, M. J. Canal, I. Feito, Improvement of compactness and floral quality in azalea by means of application of plant growth regulators. *Scientia Horticulturae* 119 (2009) 169-176.

[21] S. S. Mutlu & N. Kurtulan, Trinexapac-ethyl modifies plant architecture of ornamental pepper. *European Journal of Horticultural Science* 80 (2015) 280-287.

[22] K. Pacewicz & A. Gregorczyk, Comparision values of chlorophyll content by chlorophyll meter SPAD-502 and N-Tester. *Folia Pomeraniae Univesitatis Technologie Steinensis, Agricultura, Alimentaria, Piscaria, Zootechnica* 269(9) (2009) 49-46.

[23] B. Pennisi, Controlling growth in five species of herbaceous foliage plants, *University of Georgia, Extension Circular* 925 (2014). http://extension.uga.edu/publications/detail.cfm?number=C925

[24] A. Pobudkiewicz & J. Treder, Effects of flurprimidol and daminozide on growth and flowering of oriental lily 'Mona Lisa', *Scientia Horticulturae* 110 (2006) 328-333.

[25] Z. Podbielkowski, Rośliny użytkowe. WSiP, Warszawa. [in Polish] (1992).

[26] R. Pokluda & J. Kuben, Comparison of selected swiss chard (*Beta vulgaris* ssp. *cicla* L.) varieties. *Horticultural Science* (Prague) 29(3) (2002) 114-118.

[27] W. Rademacher, Growth retardants: effects on gibberellin biosynthesis and other metabolic pathways. *Annual Review of Plant Biology* 51 (2000) 501-531.

[28] W. Rademacher, Plant growth regulators: Backgrounds and uses in plant production, *Journal of Plant Growth Regulation* 34(4) (2015) 845-872.

[29] A. Rezazadeh, R. L. Harkess, G. Bi, Effect of plant growth regulators on growth and flowering of potted red firespike. *HortTechnology* 26 (2016) 6-11.

[30] E. Runkle, Successful use of the PGR daminozide. *Greenhouse Product News* 8 (2013) 62.

[31] P. Salachna & A. Zawadzińska, The effects of flurprimidol concentrations and application methods on *Ornithogalum saundersiae* Bak. grown as a pot plant. *African Journal of Agricultural Research* 28 (2013) 6625-6628.

[32] I. Sprząńczka & H. Laskowska, Evaluation of flurprimidol efficiency in pot cultivation of forced tulips. *Acta Scientiarum Polonorum, Hortorum Cultus* 12(2) (2013) 25-33.

[33] L. A. Thohirah, M. F. Ramlan, N. Kamalakshi, The effects of paclobutrazol and flurprimidol on the growth and flowering of *Curcuma roscoeana* and *Curcuma alismatifolia*. *Malaysian Applied Biology* 34(2) (2005) 1-5.

[34] B. E. Whipker, Additional benefits of PGRs. (in: Plant Growth Regulator Guide 2013). *GrowerTalks Magazine*. Ed. C. Beytes, Ball Publishing, West Chicago, IL. (2013) 6-7.

[35] B. E. Whipker, I. McCall, J. Gibson, T. Cavins, Using Topflor. Part I: Bedding and potted plants. *Greenhouse Product News* 13 (2003) 20-24.

[36] B. E. Van Wyk, Food plants of the world, identification, culinary uses and nutritional value. Briza Publication, Pretoria, South Africa (2005).

[37] A. Zawadzińska, P. Salachna, P. Żurawik, A. Dobrowolska, Controlling the growth and flowering of seed–propagated geranium (*Pelargonium* × *hortorum* L.H. Bailey) cultivated in two organic media. *Electronic Journal of Polish Agricultural Universities* 16(4) (2013) 1-10.

[38] A. Zawadzińska, Effect of foliar application of flurprimidol on the growth and flowering of *Pelargonium* × *hortorum* Bailey F1. *Folia Universitatis Agriculturae Stetinensis, Agricultura* 236(94) (2004) 251-256.

[39] A. Zawadzińska, A. Dobrowolska, D. Janicka, The influence of flurprimidol on the morfological traits, flowering and decorative value of *Pelargonium hortorum* 'Omega'. *Acta Agrobotanica* 59(1) (2006) 431-438.

[40] A. Zawadzinska, L. Startek, B. Płoszaj, Evaluation of flowering and decorative value of *Pelargonium hortorum* L.H. Bailey treated with flurprimidol. *Zeszyty Problemowe Postępów Nauk Rolniczych* 483 (2002) 311-319.

(Received 18 November 2016; accepted 30 November 2016)