POLISH SOCIETY FOR HORTICULTURAL SCIENCE

Folia Hort. 27/1 (2015): 79-83

DOI: 10.1515/fhort-2015-0017

FOLIA HORTICULTURAE

Published by the Polish Society for Horticultural Science since 1989

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Influence of substrate pH on the growth and flowering of *Mandevilla* Lindl. Sundaville® 'Pretty Red'

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ABSTRACT

Sundaville is the brand name of a new collection of cultivars of the genus *Mandevilla* (syn. *Dipladenia*), with the potential to become a leading vine in the world horticultural market. The research was carried out in order to analyse the growth of Sundaville 'Pretty Red' at different values of substrate pH (4.0, 4.7, 5.3 and 5.5). The study shows that flowers appeared after more than six months irrespective of soil conditions. Plants cultivated at pH 4.0 had the longest leaves, but at the highest substrate pH the widest leaf laminae were observed. Regardless of the substrate pH, the diameter of a single flower remained the same. Plants cultivated at a pH lower than 5.0 produced more flower buds and more flowers in comparison with the plants exposed to the higher pH. Moreover, pH < 5.0 positively affected the number of stems. The soil pH did not only affect the growth, but also the health of the plants. The lowest pH level (4.0) caused adverse changes to the leaves.

Key words: *Dipladenia*, morphological features, substrate acidity

INTRODUCTION

Sundaville is a registered and protected trademark of an ever-growing group of interspecific hybrid varieties of the genus *Mandevilla*, family *Apocynaceae* (Simões et al. 2007). *Mandevilla* has been a popular tropical flowering vine for summer sales in the Mediterranean area (Berberich et al. 2006). This is a completely new group of varieties obtained by crossing, which has become valuable because of the attractive large velvety flowers, a long flowering time and a wide range of applications. The group was developed by breeders at Suntory Flowers Ltd. in Japan, and has been present on the European market since 2003. Sundaville cultivation technology is developed mostly internally and independently by licensed producers, who take into account individual factors of the production. This can be seen in the use of growth substrates with a wide pH range. A properly selected value of soil pH determines the efficient use of nutrients by plants and any errors made at this stage have a profound impact on the subsequent quality of the plants (Baligar et al. 2001). The objective of this research was to determine how the substrate pH influences the vegetative growth and flowering of Sundaville 'Pretty Red'.

MATERIAL AND METHODS

The experiment was conducted in Oświęcim-Zaborze, Poland. Rooted cuttings of Sundaville 'Pretty Red' were imported from the company Isaacson (Israel) and planted in a greenhouse on 6 September 2008 in 12 cm pots (0.75 dm^3) filled with a peat base substrate prepared from high-

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moor peat and a special compound fertilizer – PG MIX (N-NO_3 5.5%, N-NH_4 8.5%, P_2O_5 16%, K_2O 18%, MgO 0.8%, B 0.03%, Cu 0.15%, Fe 0.08%, Mn 0.16%, Mo 0.2%, Zn 0.04%), 1.5 kg of fertilizer per 1 m^3 of peat. The substrate pH levels were modified to 4.0 and 4.7, 5.3 and 5.5 by adding calcium carbonate. During cultivation, substrate pH was measured with the use of a pH Meter on average every two weeks in order to maintain the target pH range. When the substrate pH increased above the target pH range, a diluted nitric acid (HNO_3) solution was applied with fertilizer. In cases when the substrate pH dropped below the target pH range, the lime solution was applied on the medium surface. One month after plant potting, the same top dressing was applied on average every week within each experimental group, using the fertilizers Yara-Kristalon and Peters Professional (at 1 g l^{-1}), alternatively. The fertilizers were diluted in water with EC of 0.6 mS cm^{-1} and pH of 6.9.

Each treatment was replicated four times, with 30 plants in each replication. There were 42 plants arranged in an area of 1 m^2. The plants were cultivated in the greenhouse under natural light conditions and the temperature was programmed for 18/16°C (day/night) but during hot weather, in the spring months, the day temperature reached as high as 28°C. Two weeks after planting, plants were pinched above the second node and then the treatment was repeated on 5 November above the second node.

The measurements were made when the plants reached 20-30 cm in height. The growth of the Sundaville plants was evaluated, taking into consideration the following features: the height (cm) – measured from the surface of the substrate to the tip of the shoot, the number of shoots per plant, inter-node length (cm), leaf length (cm) and width (cm) – measured on a randomly selected stem of each plant, the number of flower buds and open flowers per plant, and flower diameter (cm) – when the first flower on a single plant was fully open. The percentage of flowering plants was calculated every week from 20 March to 11 May 2009. To determine the shades of the leaf colour, the Royal Horticultural Society (RHS) Colour Chart was used.

All data was performed using the STATISTICA software. The results were analysed with the ANOVA test by testing the differences in the distributions of measurement results among the experimental groups. In addition, linear correlation was calculated between the measured morphological features of the plants and the pH of the substrate in which they were grown. Taking into consideration the features of the tested plants, a cluster analysis was carried out using the hierarchical approach. A test probability at a level of $p \leq 0.05$ was considered significant, and at $p \leq 0.01$ highly significant.

RESULTS AND DISCUSSION

The data presented in Table 1 indicate that shorter plants were obtained at pH 4.0 than in other objects (no significant correlation with pH of substrate). The largest number of shoots was obtained from the plants grown in substrates with a pH < 5.0, and the lowest in the group of plants grown in the substrate with a pH of 5.3 (the number of shoots and leaf length were significantly but negatively low correlated with the test factor). The positive effect of low substrate pH on the number of stems may be evidence that 'Pretty Red' is a low pH-tolerant cultivar. Tang et al. (2001) claim that the poor plant growth of a pH-sensitive genotype is mainly the result of decreased root growth due to aluminium toxicity in an acidic soil. In our study, the shortest internodes were produced by the plants grown in the substrate with the lowest pH (4.0), while the longest was found in the groups grown at a pH > 5.0; there was a significant positive correlation between inter-node length and leaf width with substrate pH (Tab. 1).

The number of flower buds also varied and depended on the substrate pH (Tab. 1). Higher values of this feature were observed in plants from the groups grown in substrates with a pH < 5.0, while both groups of plants grown at a pH > 5.0 were characterized by a smaller number of flower buds. Although this significant division of the results differentiates the four experimental groups into those grown at a pH < 5.0 and those grown at a pH > 5.0, there is, however, a clearly visible downward trend in the number of buds with an increasing pH of the substrate. A single plant grown at a substrate pH < 5.0 produced about ten flower buds. According to Plaza et al. (2009), plants of *Dipladenia sanderi* 'Scarlet Pimpernel' have eight buds at their marketable stage. The results of the measurements concerning the number of flowers, as in the case of the flower buds, showed that the differences among the investigated objects depended on the cultivation conditions of either pH < 5.0 or pH > 5.0. In the cultivation of rose, Schmitzer and Štampar (2010) obtained significantly more flowers on the plants potted in a substrate with pH 4.7 compared with those potted

Table 1. Effect of substrate pH on the morphological features of Sundaville 'Pretty Red'

Feature	Substrate pH				Mean	Correlation
	4.0	4.7	5.3	5.5		
Plant height	21.5 a*	27.5 c	26.3 b	26.4 b	25.5	0.41
Number of shoots	4.9 b	4.7 b	4.3 a	4.6 a	4.6	-0.12**
Inter-node length	2.7 a	3.6 b	3.9 c	3.9 c	3.5	0.67**
Number of flower buds	11.2 b	9.7 b	6.1 a	4.9 a	8.0	-0.58**
Number of flowers	3.8 b	3.2 b	1.7 a	2.1 a	3.0	-0.54**
Flower diameter	9.0 a	9.2 a	9.1 a	9.0 a	9.1	0.00
Leaf length	6.9 c	6.2 a	6.5 b	6.3 ab	6.5	-0.26**
Leaf width	2.9 a	3.2 b	3.3 c	3.5 d	3.2	0.49**

*Values marked with the same letter do not differ significantly at p = 0.05
**Values marked with asterisks are significant at p = 0.05

in an acid (3.3) or alkaline (7.3) substrate. This demonstrates that plants differ in the optimum pH range over which their flowering and growing reach the optimum level. Regardless of the substrate pH, the diameter of a single 'Pretty Red' flower remained the same – about 9.0 cm (Tab. 1). Deneke et al. (1992) report that 'Alice du Pont' (*Mandevilla*) achieves a flower diameter of 8.0-9.4 cm, but this feature may decrease when the application rate of the retardant increases.

The distribution of the values of the length of the leaves in the test groups does not allow us to determine a general relationship, except that the plants grown in the substrate with the lowest pH were characterized by longer leaves in relation to the other objects (Tab. 1). Smith et al. (2004) claim that leaf length in petunia remains constant with the substrate's pH ranging from 4.4 to 7.0. Analysing the width of the leaves, highly significant differences were found within the test objects – an increase in the pH of the substrate in which the plants were grown resulted in a significant increase in the width of the leaves.

Taking into consideration the measured morphological features of Sundaville plants, a hierarchical cluster analysis was performed (flower diameter was not taken into consideration as it was the same in all treatments; the number of flowers was not showed on the figure as it was correlated with the number of buds). On the basis of that analysis, two clusters of the tested plants were distinguished. Cluster 1 was characterized by a greater height, inter-node length and leaf width. Cluster 2 was characterized by a greater number of shoots and flower buds and longer leaves (Fig. 1).

Following the conformity analysis, it was found that the plants grown in the substrate with pH 4.0 constituted the majority of cluster 2, while the other experimental groups formed a relatively homogeneous cluster 1 (Tab. 2). This means that the plants grown in the substrate with pH 4.0 clearly represent a different group in comparison with the remaining plants grown at a pH > 4.0.

Table 2. Distribution of the number of plants classified into different clusters depending on their classification into different experimental groups

Substrate pH	Cluster 1	Cluster 2
4.0	2	118
4.7	96	24
5.3	112	8
5.5	119	1
Total	329	151

The first to flower were plants grown in the substrates with a pH of 4.0 to 5.3, which began flowering on 20 March 2009 (Fig. 2). The plants planted in the substrate with the highest pH entered the flowering phase a week later. After two months of measurements, 65% of the plants cultivated at pH 4.0 were flowering. At the same time, only 25% of the plants from the substrate with pH 5.5 produced flowers. On average, regardless of the pH, the plants of Sundaville 'Pretty Red' needed about six and a half months from planting to begin flowering.

Leaf colour was determined using the RHS colour chart. It is a visual indicator of plant nutrition and health. Using a leaf colour chart (e.g. LCC) is a common practice among farmers to monitor the N status in rice plants (Houshmandfar and Kimaro 2011). The method has also been successfully used for maize (Islam et al. 2007) and cassava (Anand and Byju 2008). In our experiment, there was no clear difference in the colour of the leaves of the plants

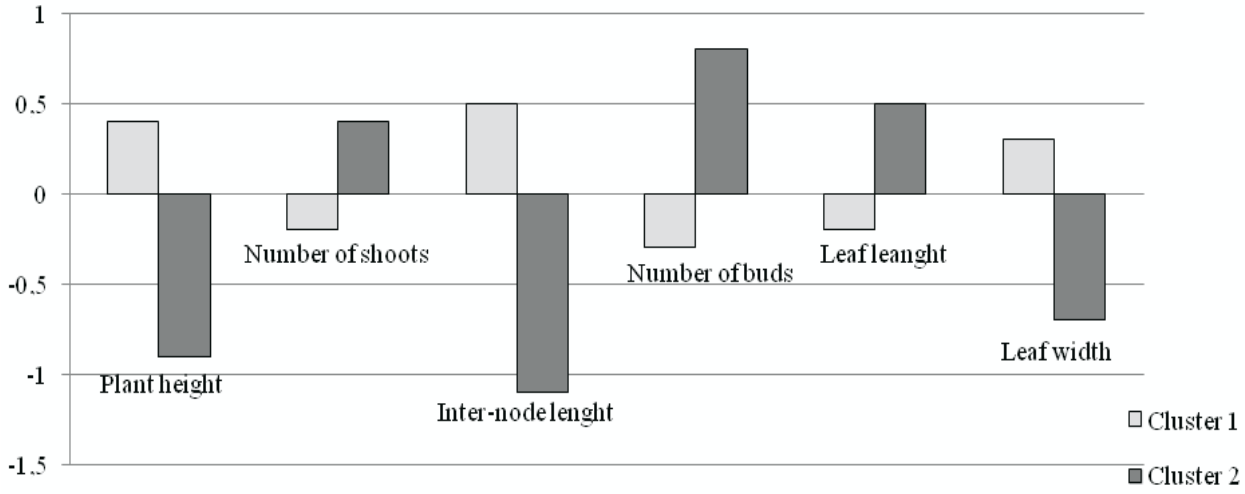

Figure 1. Standardized values of the plant features between the identified clusters

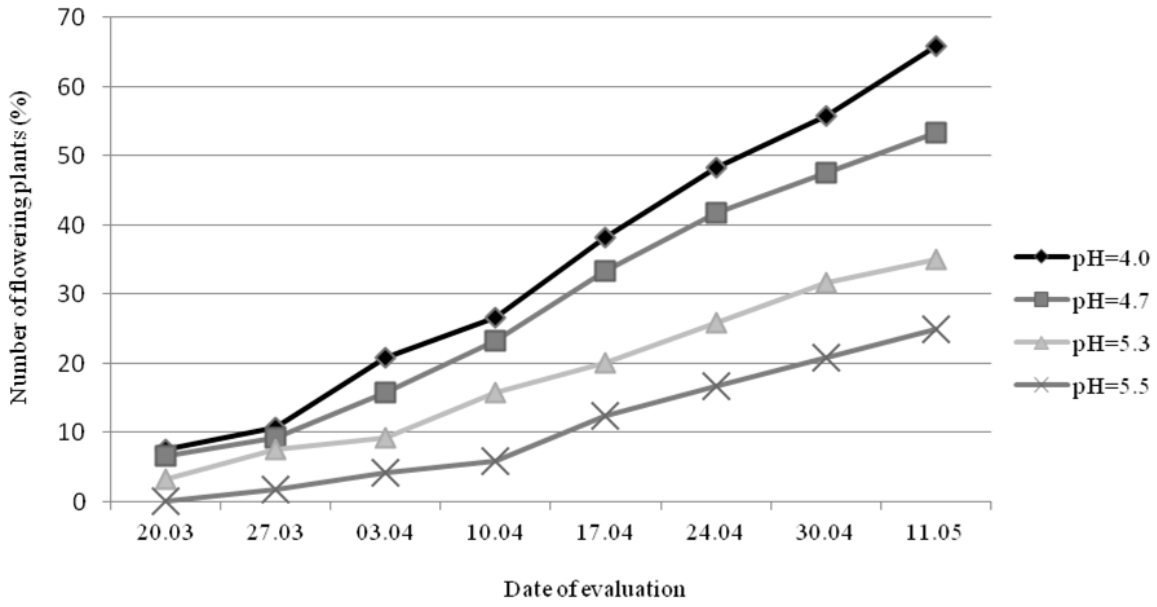

Figure 2. Effect of substrate pH on the dynamics of the flowering of Sundaville plants

grown in the substrates with different pH values in the initial phase of plant growth. Such differences emerged at a later stage. The plants grown in the substrate with pH 4.0 produced darker leaves (colour code: Green 139 A) than those grown in the substrate with a pH of 4.7 to 5.5 (colour code: Green 136 A). This tendency is in line with the report by Smith et al. (2004). They claim that increasing the level of substrate pH above 5.3 results in a decrease in the concentration of chlorophyll in the leaves of impatiens and petunia. In the presented work, when Sundaville plants were grown at pH 4.0, black necrotic spots were observed on the leaves. Floricultural crops should be assessed not only in terms of growth vigour but first of all in terms of appearance. Thus, a pH level of 4.0, despite good results in the number of flower buds and stems, seems to be too low in the cultivation of Sundaville plants because of the adverse symptoms on the leaves. Necrotic speckles on the leaves were also frequently observed by Jeong et al. (2010) on *Begonia albopicta* plants cultivated at a pH below 5.0. The relationship between soil pH and plant morphology has been discussed by Kessler (2004), who claims that ornamental plants cultivated at a pH below 5.0 cannot absorb the nutrients supplied with a fertilizer, which results in the yellowing of the leaf lamina. Acid soils (pH < 5) may be phytotoxic as a result of the toxicity of aluminium (a component of most mineral soils) (Čtvrtliková et

al. 2009). However, there are plants (*Limnanthes alba* 'Mermaid') that grow relatively well under a soil pH ranging from 3.8 to 7.3 (Jolliff and Seddigh 1993).

CONCLUSIONS

1. The shortest plants with the shortest inter-node length and narrowest leaves were obtained at pH 4.0.
2. The largest number of shoots, flower buds and flowers were obtained from plants grown in the substrate with a pH below 5.0.
3. Plants grown in a substrate with a pH 4.0 had the longest leaves but they had necrotic spots.

ACKNOWLEDGEMENTS

This study was supported by the Polish Ministry of Science and Higher Education, within the project DS no. 3500/KRO/2009-2010. We would like to thank Plantpol in Oświęcim-Zaborze (Poland) for making it possible to carry out the experiment.

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Received November 14, 2014; accepted February 22, 2015