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INFLUENCE OF FOLIAR FERTILIZERS ON GROWTH AND DEVELOPMENT OF *TORENIA FOURNIERI* LINDEN IN THUA THIEN HUE PROVINCE

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Abstract: The experiment was conducted in Winter–Spring 2016–2017 in Thua Thien Hue to identify a suitable foliar fertilizer for *Torenia fournieri* Linden that had a good growth and development, beautiful colour and long lifetime under local conditions. The experiment consisted of four treatments with three foliar fertilizers: Dau Trau MK 30-10-5, Gibberellin 25-10-10, and HVP. The control used sterilized water without the fertilizer. All the foliar fertilizers well influenced the growth and development of *Torenia fournieri* Linden. In which, the treatment with Dau Trau MK 30-10-5 displayed a good growth with high quality: highest plant height (45.73 cm), number of leaves (136), and plant diameter (34.90 cm); large flower diameter (2.94 cm), and lifetime of flower (6.60 days–the longest). This treatment also had the highest value/cost ratio (15.25).

Keywords: foliar fertilizer, Torenia fournieri Linden, growth, Thua Thien Hue

1 Introduction

Torenia (*Torenia fournieri* Linden), originated from Southeast Asia, Madagascar and Africa (Gilman and Howe, 1999; Whistker, 2002; Yamazaki, 1985), belongs to the Scrophulariaceae family. *Torenia fournieri* Linden is a herbaceous tropical plant, variable in colours and used as potting and bedding plant in the landscape decoration (Kellum, 2008; Pham et al., 2010). Yamazaki (1985) reported that there are 50 Torenia species. Of these, 20 species are from Cambodia, Laos and Vietnam, and 19 species are from Thailand. There are a number of researchers studying this plant to find effective methods to achieve good growth as well as high flower quality. Pham et al. (2010) studied the effect of some culture techniques on the growth and development of potted Torenia (*Torenia fournieri* Linden). The effect of potassium silicate on the growth of Torenia under the salt stress was studied by Jo et al. (2011). *Torenia fournieri* was also mentioned in the report of the influence of chlormequat and flurprimidol application on

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the vegetative growth of some ornamental container plants (Babelewski and Pancerz, 2014). Today, *Torenia fournieri* Linden is widely cultivated in the North and South of Vietnam for ornamental purposes. Besides, flower growing is one of the traditional professions and brings high profits to growers.

Thua Thien Hue has typical climatic conditions of the central region that greatly affect the growth and production of flowers. Specifically, the flowers always have a brighter colour than those planted elsewhere in the country. Currently, in Thua Thien Hue, the demand for flowers is increasing, and the floriculturists also have developed new flower varieties. Therefore, *Torenia fournieri* Linden is a potential flower to develop in Thua Thien Hue. However, the development of *Torenia fournieri* Linden also has certain limitations concerning planting techniques and adaptability due to hot and humid climate. There are a few studies concerning the effect of different fertilizers on this ornamental plant. Saqib et al. (2006) indicated that foliar feeding of nutrients has an important role in root absorption promotion of the same nutrient or other nutrients due to improving root growth and enhancing nutrient uptake. Alexander and Schroeder (1987), Fageria et al. (2009), and Kannan (2010) showed a great potential of foliar fertilizer as a means to reduce soil and groundwater contamination. Therefore, the purpose of this study was to evaluate the influence of foliar fertilizers under local conditions for the growth, development, colours and flower lifetime of *Torenia fournieri* Linden.

2 Materials and methods

2.1 Materials

A purple *Torenia fournieri* Linden variety collected from Da Nang green Tree Company was used in this study. Three foliar fertilizers, namely Dau Trau MK 30-10-5, Gibberellin 25-10-10, and HVP were applied on the growth and development periods of *Torenia fournieri* Linden (Table 1). The fertilizers were administered from the 21st day after transplanting (DAT) till the wilting of the first flower, and periodically sprayed every 7–10 days. The components of the fertilizers are presented in Tables 2–4.

Table 1. List of foliar fertilizers used

Name of foliar fertilizers	Usage
Dau Trau MK 30-10-5	10 g for 8–10 litres of water
Gibberellin 25-10-10	20 g for 16–20 litres of water
HVP	10 g for 8–10 litres of water

Table 2. Components of Dau Trau MK 30-10-5 foliar fertilizer

Components	Concentration
N_{total}	30 %
$P_2O_{5effective}$	10 %
$K_2O_{effective}$	5 %
CaO	0.05 %
MgO	0.05 %
Zn	500 ppm
B	100 ppm
Cu	500 ppm
Humidity	2 %

Table 3. Components of Gibberellin 25-10-10 foliar fertilizer

Components	Percentage (%)
N_{total}	25
P_2O_{5total}	10
K_2O_{total}	10

Table 4. Components of HVP foliar fertilizer

Components	Concentration
Organic matter	15–20 %
N–P–K	3–3–2 %
Mg	0.1 %
Ca	0.2 %
Fe	1000 ppm
Cu	800 ppm
Zn	700 ppm
Mn	450 ppm
B	250 ppm

2.2 Methods

Experimental treatment and design

The field experiment was conducted during the Winter–Spring season from October 2016 to January 2017 at the Agronomy Faculty of University of Agriculture and Forestry, Hue University. The experiment was laid out in a random complete block design with three replicates and four treatments (Table 5). Each plot contained five plants. *Torenia fournieri* Linden was planted in flower pots with a diameter of 15 × 12 cm that contained a mixture of fluvisols and compost with a ratio of 1:1, treated with *Trichoderma* spp. The compost was made from manure and husk.

Table 5. Experimental treatments

Treatments	Fertilizers
I (Control)	Water
II	Dau Trau MK 30-10-5
III	Gibberellin 25-10-10
IV	HVP

Agronomy characteristic collection

The quantitative and qualitative parameters were observed. The time from transplanting to the appearance of the first bud, first flower, and the first flower to wilt. The ability of growth was measured from the plant height, number of leaves, and plant diameter. The ability of development was evaluated on the number of flower buds, number of flowers and percentage of effective flowers. The flower quality was estimated with the flower diameter, lifetime, and colour.

The economic efficiency was calculated according to Eqs. (1) and (2):

$$I = R - E \quad (1)$$

where I is the income; R is the total revenue, i.e. the money obtained from a pot; and E is the expenditure, i.e. the expenses of unused fertilizer (expenses increased due to fertilizer application).

$$\text{Value-cost ratio (VCR)} = \frac{\text{value products increased by fertilizing}}{\text{expenses increased due to fertilizer application}} \quad (2)$$

Analysis method

The raw data were synthesized using Excel 2010, while the differences in the mean values of the ability of growth, and flower parameters among the treatments were compared using Statistix 10.0. The flower parameters were the number of flower buds, number of flowers, flower diameter, and flower lifetime.

3 Results and discussion

3.1 Length of development periods

Table 6 showed the length of the development periods of *Torenia fournieri* Linden. The time from transplanting to the first bud ranged from 23 to 31 days. Treatment II showed the earliest budding time at 23 days, followed by treatment III at 24 days and treatment IV at 25 days. The control (I) had the longest budding time at 31 days.

The time from transplanting to the first flower of all treatments using foliar fertilizers was shorter than that in treatment I (38 DAT). The first flower appeared earliest in treatment II at 30 DAT, followed by treatment III and IV at 32 DAT and 33 DAT, respectively. The flowers in treatment II also had the longest life (8 days) and the shortest time was recorded in treatment IV and I (5 days).

Table 6. Influence of foliar fertilizers on development periods of *Torenia fournieri* Linden

Treatments	Time from transplanting to... (days)		
	First bud	First flower	First flower to wilt
I	31	38	43
II	23	30	38
III	24	32	38
IV	25	33	38

3.2 Plant Height

The plant height was controlled by genetics, but it was also influenced by environmental factors such as temperature, sunlight, soil nutrition, and other cultivation techniques. The plant height is one of the morphological indicators to assess the growth, development and yield. The influence of foliar fertilizers on the plant height is presented in Table 7.

Seven days after transplanting, the plant height ranged from 5.53 cm (control) to 7.66 cm (treatment II). From 21 to 35 DAT, the plant height of *Torenia fournieri* Linden increased quickly due to the fertilizers, and treatment II gave the highest plant height. From 42 to 49 DAT, the plant height in all treatments increased slowly because the trees achieved a certain height and allocated the nutrient to form flowers. At 49 DAT, the highest plant height was recorded in treatment II (45.73 cm), followed by treatment IV (39.93 cm), treatment III (39.86 cm) and the control (35.06 cm). In general, *Torenia fournieri* Linden treated with the foliar fertilizers was higher than that of the control.

Table 7. Influence of foliar fertilizers on plant height of *Torenia fournieri* Linden

Unit: cm

Days after transplanting	Treatments				$LSD_{0.05}$
	I	II	III	IV	
7	5.53[b]	7.66[a]	6.00[ab]	6.17[ab]	1.91
14	12.50[b]	16.00[a]	11.83[b]	12.00[b]	2.84
21	15.50[b]	18.83[a]	16.66[b]	15.83[b]	2.84
28	17.00[b]	22.50[a]	21.16[ab]	21.33[ab]	4.56
35	20.13[b]	29.63[a]	23.73[b]	24.50[b]	4.65
42	26.20[b]	37.73[a]	31.40[ab]	29.70[b]	6.72
49	35.06[b]	45.73[a]	39.86[ab]	39.93[ab]	6.14

[a, b] Different letters in each line indicate different means significantly at $\alpha = 0.05$

3.3 Number of leaves

The number of leaves of *Torenia fournieri* Linden is presented in Table 8. From 7 to 14 DAT, the number of leaves in all treatments was not significantly different because the root was still weak to absorb more nutrients and foliar fertilizers were not applied in this period. From 21 to 49 DAT, the number of leaves of *Torenia fournieri* Linden was dependent on the use of foliar fertilizers. A rapid increase of leaf numbers was observed in treatments II, III and IV. At 49 DAT, the highest number of leaves was observed in treatment II (136.00 leaves); treatment III and IV had 127.33 and 122.00 leaves, respectively; the control had only 108.00 leaves. The number of leaves of *Torenia fournieri* Linden was higher than that obtained by Nguyen et al. (2017) when they applied Dau Trau MK 30-10-5, Gibberellin 25-10-10 and Abscisic acid (ABA) on *Petunia hybrida* plant (29.07–34.93 leaves). The difference between the control and the treatments was statistically significant at $\alpha = 0.05$. Thus, the fertilizers acted well on *Torenia fournieri* Linden.

Table 8. Influence of foliar fertilizers on number of leaves of Torenia fournieri Linden

Unit: Leaves

Days after transplanting	Treatments				$LSD_{0.05}$
	I	II	III	IV	
7	15.33[a]	16.00[a]	15.33[a]	15.33[a]	1.15
14	24.67[a]	28.67[a]	26.00[a]	28.00[a]	4.21
21	36.00[b]	62.66[a]	52.66[ab]	47.33[ab]	26.47
28	46.00[b]	82.66[a]	76.00[ab]	67.33[ab]	36.39
35	58.00[b]	99.33[a]	88.00[ab]	85.33[ab]	30.23

42	97.67[b]	123.67[a]	106.67[ab]	110.00[ab]	21.63
49	108.00[b]	136.00[a]	127.33[ab]	122.00[ab]	26.92

[a, b] Different letters in each line indicate different means significantly at $\alpha = 0.05$

3.4 Plant Diameter

Plant diameter is a good indicator of the plant's morphological characteristics in terms of plant health because it is a measurement of growth through leaf production. A plant with a large diameter increases assimilation and photosynthesis. Table 9 shows the influence of foliar fertilizers on the plant diameter of *Torenia fournieri* Linden. At 7 DAT, the lowest plant diameter (6.53 cm) was found at the control treatment, and the highest was observed in treatment II (6.83 cm). At 14 DAT, the highest plant diameter was obtained in treatment II and III (9.67 cm); in treatment IV and I, it was 9.50 cm and 9.00 cm, respectively. There was no significant difference in the plant diameter among treatments from 7-14 DAT. From 21 to 35 DAT, the plant diameter of treatment II increased rapidly ranging from 16.80 cm to 24.57 cm. From 35 to 49 DAT, the plants absorbed more nutrients for the bud formation and flowering, and the plant diameter increased steadily. From 42 to 49 DAT, the difference between treatment II, III and the remaining treatments was statistically significant at $\alpha = 0.05$. In general, Dau Trau MK 30-10-5 was a more suitable foliar fertilizer for *Torenia fournieri* Linden than other foliar fertilizers.

Table 9. Influence of foliar fertilizers on plant diameter of Torenia fournieri Linden

Unit: cm

Days after transplanting	Treatments				$LSD_{0.05}$
	I	II	III	IV	
7	6.53[a]	6.83[a]	6.70[a]	6.57[a]	0.31
14	9.00[a]	9.67[a]	9.67[a]	9.50[a]	1.20
21	14.00[b]	16.80[a]	15.33[b]	15.33[b]	1.49
28	19.33[c]	21.50[a]	20.33[bc]	20.50[ab]	1.17
35	23.20[a]	24.57[a]	25.63[a]	25.00[a]	3.20
42	26.37[b]	30.53[a]	30.00[a]	28.87[ab]	2.54
49	28.03[c]	34.90[a]	33.97[a]	31.13[b]	2.38

[a, b, c] Different letters in each line indicate different means significantly at $\alpha = 0.05$

3.5 Flower parameters

The influence of foliar fertilizers on the number of flower buds, number of flowers and percentage of effective flowers is presented in Table 10. For *Torenia fournieri* Linden, Dau Trau MK 30-10-5 showed the largest influence on the number of flower buds (59.67 buds), and

number of flowers (52.67 flowers). Treatment IV provided the highest percentage of effective flowers of all the treatments (89.19 %), while treatment III and II gave this parameter at 88.56 % and 88.26 %, respectively.

Flower quality is an important factor to increase the flower value. It is expressed by the flower diameter, flower lifetime, and flower colour. The flower quality depends on many elements such as weather conditions, culture techniques, and varieties. The flower diameter of *Torenia fournieri* Linden ranged from 2.84 cm (treatment III, IV) to 2.94 cm (treatment II). Table 10 shows that the flowers had a longer lifetime when the foliar fertilizers were administered. The lifetime of flowers in treatment II, III and IV was longer than that in the control (6.60 days, 5.80 days and 5.80 days, respectively, compared with 5.40 days). The colour of *Torenia fournieri* Linden in all treatments did not change because the same *Torenia fournieri* Linden variety was used in this study. Thus, Dau Trau MK 30-10-5 (treatment II) gave the best *Torenia fournieri* Linden flower quality.

Table 10. Influence of foliar fertilizers on flower parameters of Torenia fournieri Linden

Treatments	Number of flower buds	Number of flowers	Percentage of effective flowers (%)	Flower diameter (cm)	Lifetime of flowers (days)	Flower colour
I	44.66^{b}	39.00^{b}	87.32	2.88^{a}	5.40^{b}	Purple
II	59.67^{a}	52.67^{a}	88.26	2.94^{a}	6.60^{a}	Purple
III	46.67^{b}	41.33^{b}	88.56	2.84^{a}	5.80^{b}	Purple
IV	**49.33^{b}**	44.00^{b}	89.19	2.84^{a}	5.80^{b}	Purple
$LSD_{0.05}$	8.54	7.73	–	0.22	0.51	–

$^{a, b}$ Different letters in each columns indicate different means significantly at $\alpha = 0.05$

3.6 Economic Efficiency

It was found that the economic efficiency of the treatments with foliar fertilizers was higher than that of the control (Table 11). The differences in the investment cost among treatments were not very high: 17,750 VND/ plot (treatment I) opposed to 18,550 VND/ plot (treatment II, IV). Treatment II, III and IV had a higher investment cost than treatment I. However, the total revenue and product value increased when using fertilizer. Treatment II gave the highest revenue at 35,000 VND/ plot.

The value-cost ratio can be counted from the fertilizer investment, which is a factor reflecting the economic efficiency. Treatment II had the highest value-cost ratio at 15.25 VND, followed by treatment III (9.96 VND), and the lowest was at treatment IV (9.00 VND). Thus, the foliar fertilizers gave a high value-cost ratio for *Torenia fournieri* Linden.

Table 11. Economic efficiency of foliar fertilizers for *Torenia fournieri* Linden

Treatments	Economic efficiency (VND)					
	Total revenue	Total expenditure	Income	Value products increased by fertilizer	Production cost increased by fertilizer	Value cost ratio
I	22,000	17,750	4,250	–	–	–
II	35,000	18,550	16,450	12,200	800	15.25
III	30,000	18,480	11,520	7,270	730	9.96
IV	30,000	18,550	11,450	7,200	800	9.00

4 Conclusions

The foliar fertilizers used in experiments, especially Dau Trau MK 30-10-5 and Gibberellin clearly influenced the growth and development of *Torenia fournieri* Linden. They also provided a high economic efficiency for *Torenia fournieri* Linden cutivation. In particular, Dau Trau MK 30-10-5 gave a high value-cost ratio at 15.25. The application of Dau Trau MK 30-10-5 and Gibberellin on *Torenia fournieri* Linden should be every 7–10 days from transplanting till the wilting of the first flower.

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