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Influence of Foliar Fertilizers on Growth and Development of *Petunia hybrida* in Winter-Spring 2015-2016 in Thua Thien Hue

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Abstract: The experiment was conducted in winter-spring 2015-2016 in Thua Thien Hue to identify different foliar fertilizer for *Petunia hybrida* having good growth and development, beautiful colors and long lifetime under local conditions. The experiment included four treatments with three kinds of forliar fertilizers—Dau Trau MK 30-10-5, gibberellin 25-10-10 and abscisic acid. The control treatment (T_0) used sterilized water without foliar fertilizer. The results showed that all the foliar fertilizers influenced well on growth and development of *Petunia hybrida*. Dau Trau MK 30-10-5 helped *Petunia hybrida* have high quality and high value/cost ratio than the others.

Key words: Foliar fertilizer, *Petunia hybrida*, growth, Thua Thien Hue.

1. Introduction

Petunia hybrida or *Petunia*, which originated from South America [1], is a genus in the Solanaceae family and Petunioideae subfamily [2]. *Petunia hybrida* is variable in shape, colors and very popular in the world [3]. It is cultivated as potting and bedding flower to decorate the landscape. There were many researches conducted on this plant to find suitable fertilizer levels in order to achieve good growth as well as high quality of flowers. Hoda and Mona [4] studied the effect of bio and chemical fertilizers on growth and flowering of *Petunia hybrida* plants. The effect of fertilizer concentration on growth and flowering of subirrigated petunias and begonias was published by James and Van Lersel [5]. Fain et al. [6] reported the results of whole tree substrate and fertilizer rate in production of greenhouse-grown Petunia (*Petunia hybrida* Vilm.) and Marigold (*Tagetes patula* L.). Today, most *Petunia hybrida* are hybrid, so this flower becomes easier to grow in different soil types and temperature ranges, and does not require much maintenance. In Vietnam, there are so many kinds of flowers, and each flower has a special color, meaning and beauty. Of those, *Petunia hybrida* is one of flowers that was first introduced and grown in Southern provinces of Vietnam. However, the flower has high price, supply resources are not stable and lifetime of flower is decreased when changing living conditions. Thus, research on influence of fertilizers on growth, development and lifetime of *Petunia hybrida* in the garden at production stage is necessary. Nguyen et al. [7] studied the effect of organic and inorganic fertilizers on growth and quality of potted *Begonia* and *Petunia hybrida*.

Thua Thien Hue has typical climatic conditions of the central region, so it greatly affects on the growth and products of flowers, specially the color of flowers is always brighter than those planted in different

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provinces. Currently, in Thua Thien Hue, the demand of flowers is increasing and the floriculturists also have developed new flower varieties. Therefore, *Petunia hybrida* is a potential flower to develop in Thua Thien Hue. However, the development of *Petunia hybrida* has also limitations of technical and adaptability because of hot and humid climate conditions. The published domestic studies about effect of different fertilizers on this ornamental plant are not much. Saqib et al. [8] indicated that foliar feeding of nutrients has important role in root absorption promotion of the same nutrient or other nutrients due to improving root growth and enhancing nutrient uptake. The researches by Alexander and Schroeder [9], Fageria et al. [10] and Kannan [11] showed great potential of foliar fertilizer as a mean to reduce soil and groundwater contamination. Therefore, the purpose of this study was to evaluate the influence of foliar fertilizers under local conditions for growth, development, colors and lifetime of *Petunia hybrida*.

2. Materials and Methods

2.1 Weather Conditions during This Experiment

The field experiment was conducted during winter-spring season from November 2015 to April 2016 in an open field at Agronomy Faculty, University of Agriculture and Forestry, Hue University. The weather condition during experiment is presented in Table 1. In December, mean temperature was 21.8 °C, with high humidity (93%) and high number of rainy days (19 d), which were suitable for seedlings. From January to March, the temperature was always low and the humidity ranged from 91% to 93% that were favourable for growth and development of *Petunia hybrida* as well as flowering stage. However, the change of the temperature in April with the highest temperature during experiment (27.3 °C) and the highest of total sunny hours (142 h) led obstacle of flowering process.

2.2 Experiment Design

A violet *Petunia hybrida* variety used in this study was collected from Da Nang green tree company. The three foliar fertilizers (Dau Trau MK 30-10-5, gibberellin 25-10-10 and abscisic acid) were applied on growth and development periods of *Petunia hybrida* (Table 2). The control treatment (T_0) used sterilized water without foliar fertilizer. Fertilizers were used from 21 days after transplanting (DAT) to flower wilted, and periodically sprayed every 7-10 d. Components of the three foliar fertilizers are presented in Tables 3-5.

The experiment was laid out in a random complete block design (RCBD) with three replications and four treatments (Table 6). Each replication contained five plants. *Petunia hybrida* was planted in flowerpots with a diameter of 15 cm × 12 cm containing mixture of semi-sandy soil and compost with a ratio of 1:1, which treated with *Trichoderma* spp..

2.3 Agronomy Characteristic

Quantitative and qualitative parameters were observed. Time of development periods was recorded

Table 1 Meteorological conditions recorded in winter-spring season 2015-2016.

Month	Temperature (°C)			Humidity (%)		Rainfall		Total sunny hour (h)
	T_{mean}	T_{max}	T_{min}	H_{mean}	H_{min}	NRD (d)	R_{mean} (mm)	
November	25.4	28.7	23.0	92	64	6	374.3	43
December	21.8	31.0	15.0	93	67	19	313.1	105
January	20.9	23.9	18.8	93	66	19	124.1	49
February	18.3	22.1	15.6	91	38	18	86.4	61
March	22.4	26.8	19.5	91	57	24.8	24.8	121
April	27.3	34.2	23.6	86	43	7	26.2	142

T: temperature; H: humidity; R: rain; NRD: number of rainy days.

Source: Center for Hydrometeorology Forecast of Thua Thien Hue Province.

Table 2 Three foliar fertilizers used.

Name of foliar fertilizers	Dose
Dau Trau MK 30-10-5	10 g for 8-10 L water
Gibberellin 25-10-10	20 g for 16-20 L water
Abscisic acid (ABA)	10 g for 8-10 L water

Table 3 Components of Dau Trau MK 30-10-5 foliar fertilizer.

Components	Concentration
Total N	30%
Effective P_2O_5	10%
Effective K_2O	5%
CaO	0.05%
MgO	0.05%
Zn	500 ppm
B	100 ppm
Cu	500 ppm
Humidity	2%

Table 4 Components of gibberellin 25-10-10 foliar fertilizer.

Components	Percentage (%)
N	25
P_2O_5	10
K_2O	10

Table 5 Components of abscisic acid (ABA).

Components	Percentage (%)
N	5
P_2O_5	30
K_2O_5	30
ANA	0.4
BNA	0.1

ANA: alpha naphthalene acetic acid; BNA: beta naphtoxy acetic acid.

Table 6 Experimental treatments.

Treatments	Formulation
T_0 (control)	Water
T_1	Dau Trau MK 30-10-5
T_2	Gibberellin 25-10-10
T_3	ABA

from transplanting to appearing the 1st flower-bud, the 1st flower flowering and the 1st flower wilted. Ability of growth, including plant height, number of leaves and plant diameter, was measured from 7 DAT to 98 DAT. Flowering progress started from 10 weeks to 17 weeks after transplanting (WAT). Ability of development was counted including number of flower buds, number of flowers and percentage of effective flowers (%). Flower quality was formed by flower diameter, lifetime of flowers and flower color. Of those, the flower diameter was the widest of flower, the lifetime of flowers was recorded from flower flowering to flower wilted and the flower color was observed by sensory method.

The economic efficiency was calculated as the following Eqs. (1) and (2):

$$\text{Income} = \text{total revenue} - \text{total expenditure} \quad (1)$$

where, total revenue: money that florist obtained from a pot; total expenditure = expenses of unused fertilizer (expenses increased due to fertilizer application).

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

2.4 Analysis Method

Data were calculated by Excel 2007 and analyzed by statistical software Statistix 9.0.

3. Results and Discussion

3.1 Time of Development Periods

Time from transplanting to appearing the first bud ranged from 66 d to 78 d. Treatment T_1 showed the earliest time for budding with 66 d, followed by treatment T_2 with 72 d and T_3 with 73 d. The control treatment had the latest time for budding with 78 d (Table 7).

Time from transplanting to the first flower of all treatments with application of foliar fertilizers was shorter than those in the control T_0 (84 DAT). The first flower appeared the earliest in the treatment T_1 with 70 DAT, followed by treatments T_2 and T_3 with 77 DAT. Time from transplanting to the first flower wilted in the treatment T_0 was the longest with 89 d. However, the interval time between the first flower flowering and the first flower wilted in treatment T_1 was shorter than the remained treatments.

Table 7 Influence of foliar fertilizers on development periods of *Petunia hybrida*.

Treatments	Time (DAT) from transplanting to		
	Appearing the 1st flower-bud	The 1st flower flowering	The 1st flower wilted
T_0	78	84	89
T_1	66	70	78
T_2	72	77	84
T_3	73	77	83

Table 8 Influence of foliar fertilizers on plant height of *Petunia hybrida.*

DAT	Plant height (cm)				$LSD_{0.05}$
	T_0	T_1	T_2	T_3	
7	9.37^{a}	11.23^{a}	9.40^{a}	9.23^{a}	2.45
14	11.23^{a}	13.47^{a}	13.70^{a}	12.93^{a}	2.71
21	14.07^{c}	18.20^{ab}	20.93^{a}	18.03^{b}	2.87
28	15.20^{b}	20.87^{a}	23.67^{a}	21.27^{a}	5.03
35	17.13^{b}	22.07^{ab}	25.00^{a}	22.87^{a}	5.09
42	19.70^{b}	23.23^{ab}	26.27^{a}	24.13^{ab}	5.37
49	20.67^{b}	24.23^{ab}	27.80^{a}	24.87^{ab}	5.24
56	23.53^{a}	27.77^{a}	29.17^{a}	26.80^{a}	6.34
63	25.90^{b}	31.60^{a}	30.80^{ab}	28.57^{ab}	5.08
70	27.53^{b}	34.07^{a}	32.17^{ab}	31.76^{ab}	5.15
77	28.73^{b}	35.43^{a}	33.67^{a}	32.87^{ab}	4.88
84	31.43^{a}	35.83^{a}	35.03^{a}	33.47^{a}	4.79
91	31.90^{a}	36.03^{a}	35.23^{a}	33.60^{a}	4.67
98	32.03^{a}	36.20^{a}	35.33^{a}	33.73^{a}	4.70

$^{a-c}$ Different letters in each column indicate different means at $\alpha = 0.05$.

3.2 Plant Height

Plant height is controlled by genetics, but also influenced by environmental factors, such as temperature, sunlight, soil nutrition and other cultivation techniques. Plant height is one of the morphological indicators to assess the growth, development and yield. On the other hand, it also reflects ability of organic accumulation of the plant. Progress of plant height influenced by foliar fertilizers is presented in Table 8.

At 7 DAT and 14 DAT, plant height in all treatments had no significant difference, because foliar fertilizers had not been used in this time. In the next periods, plant height of *Petunia hybrida* increased quickly, due to that application foliar fertilizers affected on plant height. At 21 DAT, plants in the treatment T_2 presented the highest height with 20.93 cm, followed by treatment T_1 (18.20 cm) and T_3 (18.03 cm). The shortest plants were observed in the control treatment (T_0) with 14.07 cm. The plant height in the treatment T_2 maintained the tallest until 56 DAT.

At 63 DAT and 70 DAT, plant height increased rapidly in the treatment T_1 to 31.60 cm and 34.07 cm, respectively. From 84 DAT to 98 DAT, plant height in all treatment growing slowly, because trees had achieved a certain height and focused on nutrient to form flowers. Plant height ranged from 32.03 cm to 36.20 cm.

In summary, the growth rate of the plant height for *Petunia hybrida* in all treatments which used the foliar fertilizers was higher than those in the contol treatment T_0.

3.3 Number of Leaves

Number of leaves of *Petunia hybrida* is presented in Table 9. From 7 DAT to 21 DAT, the number of

leaves in all treatments was not significantly different, because the root was still weak to absorb more nutrients and this period foliar fertilizer had not been used.

From 21 DAT to 70 DAT, the number of leaves of *Petunia hybrida* was influenced by the use of foliar fertilizers. The treatment T_1 had the highest number of leaves and the lowest was observed in the control check (T_0).

From 70 DAT to 84 DAT, the number of leaves was significantly different among the treatments and increased rapidly. AT 84 DAT, the treatment T_1 still had the highest leaf number with 57.40 leaves, followed by treatment T_2 with 53.13 leaves, T_3 with 50.20 leaves and the control check (T_0) with 47.27 leaves.

From 84 DAT to 98 DAT, the number of leaves increased slowly, because the plant gained the maximum leaf number at this stage.

Thus, the number of leaves of *Petunia hybrida* showed significant difference at different stages, especially, the treatment T_1 with use of Dau Trau MK 30-10-5.

3.4 Plant Diameter

Plant diameter is a good indicator of the plant's morphological characteristics for studies of plant health, as it is a measurement of growth through leaf production. The large plant diameter will increase assimilation and photosynthesis.

Table 10 showed influence of foliar fertilizers on plant diameter of *Petunia hybrida*. From 7 DAT to 14 DAT, the treatment T_0 had the smallest plant diameter and the largest was obtained in the treatment T_1. At 7 DAT, it ranged from 8.80 cm (T_0) to 9.63 cm (T_1).

From 28 DAT to 35 DAT, the plant diameter of the treatment T_1 increased rapidly, ranging from 21.93 cm to 29.20 cm, respectively. After 70 DAT, the plant diameter ranged from 40.73 cm (T_0) to 48.27 cm (T_1).

From 70 DAT to 98 DAT, the plants absorbed more nutrients for flower-bud formation and flowering, so the plant diameter increased steadily and was significantly difference among treatments.

In general, *Petunia hybrida* was suitable for foliar fertilizer Dau Trau MK 30-10-5 than other foliar fertilizers.

3.5 Flowering Progress

Table 11 recorded the number of flowers of *Petunia hybrida*. There was no significant difference on number of flowers among treatments at 10 WAT. From 11 WAT to 14 WAT, the number of flowers showed significant difference between treatments.

Table 9 Influence of foliar fertilizers on number of leaves of *Petunia hybrida.*

Days after planting	Number of leaves				$LSD_{0.05}$
	T_0	T_1	T_2	T_3	
7	4.20^{b}	5.40^{a}	5.87^{a}	5.20^{a}	0.81
14	8.47^{a}	8.53^{a}	8.60^{a}	8.50^{a}	0.25
21	12.43^{a}	12.50^{a}	12.50^{a}	12.40^{a}	0.66
28	15.80^{c}	19.27^{a}	17.20^{b}	16.07^{c}	0.73
35	20.93^{c}	25.27^{a}	21.93^{b}	21.13^{bc}	0.81
42	25.27^{b}	30.00^{a}	26.27^{b}	25.40^{b}	1.12
49	29.07^{b}	34.93^{a}	30.53^{b}	29.33^{b}	1.56
56	32.33^{d}	39.60^{a}	35.67^{b}	33.33^{c}	0.86
63	36.60^{c}	43.53^{a}	40.93^{b}	38.13^{c}	1.80
70	41.07^{c}	48.00^{a}	45.47^{b}	42.07^{c}	2.34
77	44.27^{c}	52.20^{a}	49.73^{b}	46.60^{c}	2.16
84	47.27^{d}	57.40^{a}	53.13^{b}	50.20^{c}	2.32
91	49.73^{c}	59.07^{a}	55.67^{b}	52.27^{c}	2.75
98	51.53^{d}	60.33^{a}	57.47^{b}	54.53^{c}	2.16

$^{a-d}$ Different letters in each column indicate different means at $\alpha = 0.05$.

Table 10 Influence of foliar fertilizers on plant diameter of *Petunia hybrida*.

Days after planting	Plant diameter (cm)				$LSD_{0.05}$
	T_0	T_1	T_2	T_3	
7	8.80^{b}	9.63^{a}	9.20^{ab}	8.93^{b}	0.68
14	11.83^{a}	13.00^{a}	12.67^{a}	12.37^{a}	1.31
21	15.77^{b}	17.30^{a}	16.70^{ab}	15.93^{b}	0.94
28	20.17^{a}	21.93^{a}	20.80^{a}	20.20^{a}	2.02
35	23.53^{c}	29.20^{a}	25.93^{b}	24.53^{bc}	1.88
42	26.83^{c}	33.23^{b}	30.23^{b}	27.60^{c}	2.34
49	30.60^{c}	39.20^{a}	34.93^{b}	31.53^{c}	1.48
56	33.27^{b}	41.60^{a}	38.07^{ab}	35.73^{ab}	3.73
63	36.77^{b}	44.80^{a}	40.40^{b}	39.40^{b}	1.51
70	40.73^{b}	48.27^{a}	44.87^{ab}	40.73^{b}	5.75
77	43.80^{b}	51.43^{a}	48.87^{ab}	46.13^{ab}	6.08
84	46.43^{b}	53.77^{a}	50.53^{ab}	47.80^{ab}	6.21
91	49.07^{b}	55.43^{ab}	52.13^{ab}	49.43^{b}	5.91
98	50.37^{b}	56.70^{a}	53.73^{ab}	51.40^{ab}	6.11

$^{a-c}$ Different letters in each column indicate different means at $\alpha = 0.05$.

Table 11 Flowering progress of *Petunia hybrida.*

Treatments	Number of flowers/plant at WAT							
	10	11	12	13	14	15	16	17
T_0	0.00^{a}	0.00^{b}	4.67^{b}	9.67^{c}	9.33^{c}	10.33^{c}	9.33^{c}	7.00^{d}
T_1	0.67^{a}	6.00^{a}	12.00^{a}	21.67^{a}	28.67^{a}	26.33^{a}	26.33^{a}	20.67^{a}
T_2	0.00^{a}	1.33^{ab}	8.67^{ab}	18.00^{ab}	21.33^{b}	19.67^{b}	21.00^{ab}	18.67^{c}
T_3	0.00^{a}	1.00^{ab}	7.33^{ab}	17.33^{b}	17.67^{b}	16.33^{b}	15.67^{b}	14.33^{c}
$LSD_{0.05}$	1.15	5.06	6.62	4.23	5.72	4.35	6.31	1.60

$^{a-d}$ Different letters in each column indicate different means at $\alpha = 0.05$.

At 14 WAT, number of flowers ranged from 9.33 (T_0) to 28.67 flowers (T_1). While treatment T_1 gained the highest number of flowers (28.67 flowers), followed by treatment T_2 (21.33 flowers) and treatment T_3 (17.67 flowers), treatment T_0 obtained the lowest number of flowers (9.33 flowers).

From 15 WAT to 17 WAT, the number of flowers in all treatments decreased steadily. The treatment T_1 still gained the highest number of flowers with 20.67 flowers. Whereas, the control check (T_0) had the lowest number of flowers with 7.00 flowers.

3.6 Percentage of Effective Flowers

The influence of foliar fertilizers on the number of flower-bud, number of flowers and percentage of effective flowers is presented in Table 12. The number of flower-bud is an important characteristic to evaluate flower quality. For *Petunia hybrida*, foliar fertilizer Dau Trau MK 30-10-5 (T_1) showed the best influence on the number of flower-bud (150.67 flower-buds), number of flowers (142.33 flowers) and the percentage of effective flowers (94.46%). Thus, treatment T_1 gained the highest percentage of effective flowers among the treatments, followed by treatment T_2 (91.32%) and T_3 (90.88%). The number of flower buds in this study was higher than that reported by Pham et al. [12] in Hanoi, Vietnam, where Atonik 1.8DD, Komix BEC 201 and Dau Trau 702 foliar fertilizer were applied to *Torenia fournieri* Linden and the number of flower buds ranged from 37.9 to 51.6.

3.7 Flower Quality

Flower quality is an important factor to increase

Table 12 Percentage of effective flowers.

Treatments	Number of flower-bud	Number of flowers	Percentage of effective flowers (%)
T_0	58.67[d]	50.33[c]	85.78
T_1	150.67[a]	142.33[a]	94.46
T_2	119.00[b]	108.67[b]	91.32
T_3	98.67[c]	89.67[c]	90.88
$LSD_{0.05}$	10.32	10.36	-

[a-d] Different letters in each column indicate different means at $\alpha = 0.05$.

Table 13 Influence of foliar fertilizers on flower quality of *Petunia hybrida.*

Treatments	Flower diameter (cm)	Lifetime of flowers (day)	Flower color
T_0	4.43[d]	3.78[d]	Violet
T_1	5.39[a]	7.03[a]	Violet
T_2	5.15[b]	5.43[b]	Violet
T_3	4.92[c]	4.67[c]	Violet
$LSD_{0.05}$	0.16	0.27	-

[a-d] Different letters in each column indicate different means at $\alpha = 0.05$.

Table 14 Economic efficiency of foliar fertilizers for *Petunia hybrida*.

Treatments	Economic efficiency (VND)					
	Total revenue	Total expenditure	Income	Value products increased by fertilizer	Production cost increased by fertilizer	Value-cost ratio
T_0	22,000	16,750	5,250	-	-	-
T_1	35,000	17,550	17,450	12,200	800	15.25
T_2	30,000	17,480	12,520	7,270	730	9.96
T_3	30,000	17,550	12,450	7,200	800	9.00

flower value. It is expressed by flower diameter, lifetime of flowers and flower color. The flower quality depends on many elements, such as weather conditions, techniques and variety.

Flower diameter of Petunia hybrida showed significant difference among treatments and ranged from 4.43 cm (T0) to 5.39 cm (T1). The flower diameter in the treatment T1, T2 and T3 was larger than those in the control check (T0) with 5.39, 5.15, 4.92 and 4.43 cm, respectively. These results were similar to the results obtained by Sardoei et al. [13] who conducted zinc sulphate and salicylic acid on Petunia hybrida plant with flower diameter in range of 4.54-5.13 cm.

The lifetime of flowers is also an important factor to increase the flower quality. It is based on many different elements, such as fertilizers and weather conditions. Table 13 shows that using foliar fertilizers helped flowers to have longer lifetime.

It is clear from Table 13 that *Petunia hybrida* in all treatments had same flower color (violet), because this research used same *Petunia hybrida* variety. Thus, foliar fertilizers used in this experiment did not affect flower color and treatment T_1 gained the best flower quality among the treatments.

3.8 Economic Efficiency

Table 14 shows the economic efficiency of treatments. It was found that economic efficiency in treatments with foliar fertilizers was higher than those in the control (T_0). The difference in investment cost among treatments was not very high only from 16,750 VND/plot (T_0) to 17,550 VND/plot (T_1, T_3).

The treatment T_1, T_2 and T_3 had higher investment cost than T_0. However, total revenue and value products increased by using fertilizer. The treatment

T_1 gained the highest total revenue with 35,000 VND/plot.

Value-cost ratio can be accepted by fertilizer investment, which is a factor reflecting the economic efficiency. The treatment T_1 had the highest index with 15.25, followed by treatment T_2 (9.96), and the control check (T_0) had the lowest. As a result, investment of foliar fertilizers for *Petunia hybrida* gave high value-cost ratio.

4. Conclusions

Foliar fertilizers used in the experiment well affected the growth and development of *Petunia hybrida*, compared with no use of fertilizer formula, especially Dau Trau MK 30-10-5 and gibberellin. The application of foliar fertilizers also achieved high economic efficiency for value of *Petunia hybrida*. In particular, using Dau Trau MK 30-10-5 obtained high value-cost ratio with 15.25. Thus, from transplanting to the first flower wilt of *Petunia hybrida*, Dau Trau MK 30-10-5 and gibberellin should be sprayed every 7 d.

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