EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH AND FLOWER QUALITY OF POTTED BEGONIA AND PETUNIA

Nguyen Thi Ngoc[1*], Vu Ngoc Thang[2], Dong Huy Gioi[3], Li-HuaTang[4], Ya-Ning Chang[1*]

[1]The State Key Laboratory of Bioreactor Engineering, East China University of Science and Technology, China; [2]Faculty of Agronomy, Vietnam National University of Agriculture
[3]Faculty of Biotechnology, Vietnam National University of Agriculture
[4]Institute of Chemical Technology, East China University of Science and Technology, China

Email[*]: ngoc.ecust@gmail.com/changyn@ecust.edu.cn

Received date: 12.06.2015 Accepted date: 02.12.2015

ABSTRACT

The objective of this study was to evaluate the effect of organic and inorganic fertilizers on growth and quality of potted flowers. Three types of fertilizer (composite organic fertilizer (COF), composite inorganic fertilizer (CIF), and foliar spray of multi-nutrients (FSMN) were used for two flower species, Begonia (*Begonia semperflorens*) and Petunia (*Petunia hybrid* Vilm). The results showed that application of fertilizers enhanced the growth, physiology, and quality of both flower species. The growth characteristics and quality of both flower species in COF treatment were higher than those in other fertilizer treatments. Specifically, treatment of COF stimulated growth of lateral branch, number of leaves, leaf chlorophyll value and photosynthetic rate of both species. In addition, the highest flower diameters, number of flowers/plants, and flower longevity were observed in COF treatment. Days to first flowering of both species in COF treatment were also shorter than those in other treatments.

Keywords: Growth, inorganic fertilizer, organic, quality, potted flowers.

Ảnh hưởng của phân bón hữu cơ và vô cơ đến sinh trưởng và chất lượng của cây hoa Thu Hải Đường và Dạ Yến Thảo trồng chậu

TÓM TẮT

Nghiên cứu được tiến hành nhằm đánh giá ảnh hưởng của phân bón vô cơ và hữu cơ đến sinh trưởng và chất lượng của hoa trồng trong chậu. Ba loại phân bón bao gồm phân hữu cơ (COF), vô cơ (CIF) và dung dịch dinh dưỡng tổng hợp (FSMN) đã được bố trí thí nghiệm trên 2 loại hoa trồng chậu (Thu Hải Đường - *Begonia semperflorens* và Dạ Yến Thảo - *Petunia hybrid* Vilm). Kết quả nghiên cứu cho thấy, xử lý phân bón giúp tăng sinh trưởng, quang hợp và chất lượng của hai loại hoa trồng chậu. Trong đó, phân bón COF có ảnh hưởng tốt nhất đối với các chỉ tiêu sinh trưởng và chất lượng hoa chậu so với các phân bón còn lại. Đặc biệt COF kích thích sự phân nhánh, tăng số lá, tăng hàm lượng diệp lục và hiệu suất quang hợp của 2 loài hoa trồng chậu. Giá trị cao nhất về đường kính thân, số hoa/cây, độ bền của hoa đều được quan sát ở công thức phân bón COF. Ngoài ra, Thu hải đường và Dạ yến thảo đều nở hoa sớm nhất trong công thức phân bón COF so với các công thức phân bón còn lại trong thí nghiệm.

Từ khóa: Chất lượng, dạ yến thảo, phân bón, sinh trưởng, thu hải đường.

1. INTRODUCTION

Fertilizer is considered as one of fundamental factor in agricultural production. Over 100 years after its inception, fertilizer industry has produced various types of fertilizers with varied nutritional ingredients (Gaskell et al., 2000; Isherwood, 1998; Luo et al., 2011; Kumar et al., 2013). Many studies have proved that fertilizers brought great

benefits to agricultural production in terms of crop productivity. Fertilizers increased growth parameters on many kinds of crops such as plant height, lateral stem, leaf area, leaf chlorophyll, and root system… (Chapagain and Wiesman, 2004; Wang et al., 2007; Dursun et al., 2009; Najm et al., 2010; Zafar et al., 2011; Aminifard et al., 2012).

China's fertilizer production and consumption was rank number one in the world.The latest data in 2012 (FAO) showed that total amount of fertilizers used in 2012 was 240,711,000 tons which accounted for the largest proportion (37.1%) of fertilizers in East Asia (mostly in China), followed by America (23.7%). In China, there are many policies from the goverment to support the development of new fertilizers, technology and market. Fertilizer improvement is always a key issue in the agricultural production of this country (Xia and Hu 2011; Wang and Yang 2012). Begonia and Petunia are two popular flowers in China (Zhang et al., 2009; Ding et al., 2011; Zhang et al., 2012), which are commonly used for decorative purposes in the cities, parks, highways, streets, residential quarters and balcony (Zhang et al., 2012). Begonia and Petunia not only have great impact on the emotional health of the human, but also offer the potential for high economic profits for flower industry (Fain et al., 2008; Liu et al., 2011). The objective of this study was to evaluate the effect of organic and inorganic fertilizers on growth and flower quality of two flower species, Begonia (*Begonia semperflorens*) and Petunia (*Petunia hybrid* Vilm).

2. MATERIALS AND METHODS

2.1. Plant materials and fertilizers

Seedlings of Begonia (*Begonia semperflorens*) and Petunia (*Petunia hybrid* Vilm) were provided by Shanghai Kangdeng (Kangnan) Horticulture Co. Ltd (Fig. 1). Three unfolded true leaf seedlings were transferred to plastic pots (with top and bottom diameters of 13cm and 9.5cm, respectively and f 11cm high with 8 bottom perforation of 0.9 cm of diameter) filled with 0.8 $kg \cdot pot^{-1}$ of compound soil. The compound soil was a mixture of common soil, decayed grass and perlite with the proportion of 50%: 30%: 20%, respectively. The physico-chemical properties of common soil are given in Table 1. After planting, seedlings were watered immediately to 70-80% of field capacity.

Three types of fertilizers, viz. composite organic fertilizer (COF), composite inorganic fertilizer (CIF) and foliar spray of multi-nutrient solution (FSMN) were used in this study. Composite organic fertilizer (COF) is a new liquid fertilizer of East China University of Science and Technology, Institute of Chemical Technology. It is derived from cotton stalks obtained by a new technology of cotton stalk pulping with potassium hydroxide and ammonia liquor. The resulting liquid can be directly used as organic fertilizers after addition

Fig. 1. Begonia and Petunia used in pot experiment

Table 1. The physico-chemical properties of soil used in this study

Parameters	Physico-chemical properties
pH	6.33
Water-soluble salts (EC) ($mS \cdot cm^{-1}$)	1.21
volume-weight ($g \cdot cm^{-3}$)	1.13
Aeration porosity (%)	40.46
Organic matter ($g \cdot kg^{-1}$)	10.80
Total N ($g \cdot kg^{-1}$)	2.32
Total P ($g \cdot kg^{-1}$)	2.70
Total K ($g \cdot kg^{-1}$)	2.31

Table 2. The physico-chemical properties of organic fertilizer (COF)

Parameter*	Physico-chemical property
pH	7.15
Density (g.mL-1)	1.20
Solid content (%)	0.19
Organic matter (%)	8.43
N (%)	5.00
P2O5 (%)	5.00
K2O (%)	5.41

*Note: * The percentage organic matter, total nitrogen (N), total phosphorus (P), total potassium (K) were calculated from their relative contents in 100 g dry samples.*

of some elements. Physico-chemical properties of COF are presented in Table 2. Composite inorganic fertilizer (CIF) is a granular fertilizer ($N\text{-}P_2O_5\text{-}K_2O$ = 15-15-15) containing humic and trace elements. This is produced by Stanley Fertilizer Co., Ltd. Foliar multi-nutrient solution (FSMN) with $N\text{-}P_2O_5\text{-}K_2O$ = 2.5-2.5-2.75 and trace elements is produced by Shanghai Huazhiduyuan Arts and Technology Co., Ltd.

We based on the contents N.P.K of composite fertilizer CIF ($N\text{-}P_2O_5\text{-}K_2O$ = 15-15-15 (%)) and FSMN ($N\text{-}P_2O_5\text{-}K_2O$ = 2.5-2.5-2.75 %) to adjust the N.P.K contents of COF (Table 2). By this way, we ensured similar total amount of N, P and K used in each treatment.

2.2. Experimental design

Experiments included four treatments and five replications arranged in completely randomized design:

Treatment 1: Without fertilization, irrigation by water only (control).

Treatment 2: root irrigation with COF using concentration of 0.5%, 100 mL/plant/time, once a week.

Treatment 3: Foliar spray root irrigation with FSMN using concentration of 1%, 100 mL/plant/time, once a week (according to recommendation of producer).

Treatment 4: Root irrigation with CIF using 2g of CIF/pot for four applicationsg (7 days after transfer to pots, the first bud appearance, 20 days and 40 days after flowering).

2.3. Data collection and analysis

The growth characteristics (plant height, number of lateral stems, height lateral stem, leaf number, leaf length, and leaf width) were measured weekly. Leaf chlorophyll value was measured by using a chlorophyll meter (Minolta, SPAD-502, Japan). Forty days after treatment, stomatal conductance, photosynthetic rate, and transpiration rate were assessed at 4^{th} leaf from the top of 5 plants of each treatment in greenhouse with P-

Photosynthesis System Yaxin-1102 (Beijing Yaxinliyi Science and Technology Co., Ltd.). Data were collected between 11.00 am to 13.00 pm at humidity of 45%. The numbers of days to first flowering (days) and flower longevity were recorded daily for each treatment. Flower diameters and number of flowers/plants were also recorded for analysis of quality characteristics.

For the statistical analysis of growth and physiology parameters, 5 plants per treatment from each replication were randomly selected. Analysis of variance (ANOVA) was performed with the toolpak VBA Excel 2010 for Windows and mean comparisons were done using the least significant difference (LSD) test at $P < 0.05$ and/or $P < 0.01$.

3. RESULTS AND DISCUSSIONS

3.1. Effect of organic and inorganic fertilizers on growth characteristics of potted flowers

Effect of organic and inorganic fertilizers on growth characteristics of Begonia and Petunia flowers are presented in Table 3 and Fig. 2. The growth characteristics of Begonia and Petunia flowers in three fertilizer treatments were better than the control (non- fertilization). In the Begonia experiment, there was no significant difference in growth parameters between FSMN and CIF treatment, but lower than that of COF application (P < 0.05%). COF treatment increased the number of leaves (29.73% and 20.80% higher than in the treatments of FSMN and CIF, respectively). COF also significantly increased plant height, lateral branch length and leaf size of Begonia (Table 3).

In the Petunia experiment: There were significant differences in growth indicators within three fertilizer treatments. The highest growth parameters were observed in COF treatment. COF treatment increased by 12.95 - 16.74 % of plant height, 37.10 - 41.67% of number of lateral stem, 19.66 - 28.10% of height of lateral stem, 21.58 - 25.68% of number of leaves, about 16 - 18% of leaf size compared to FSMN and CIF 3). For both flower species, the effects of composite organic fertilizers were better than inorganic fertilizers. We assumed that the nutrients contained in in COF were easily absorbed, or that organic ingredients can help retain nutrients and increase the absorption by plant roots.

Table 3. Effect of organic and inorganic fertilizers on growth characteristics of potted Begonia and Petunia

Plant	Treatment	Plant height (cm)	No. of branches	Length of lateral branch (cm)	No. of leaves	Leaf length (cm)	Leaf width(cm)
Begonia	Control	13.77±0.84	4.0±0.88	3.06±0.12	13.35±0.24	4.72±0.33	3.64± 0.37
	COF	16.34±0.19	9.6±0.68	6.84±0.24	18.76±0.37	5.01±0.11	4.15±0.13
	FSMN	15.62±0.21	7.5±0.68	5.58±0.38	15.68±0.48	4.80±0.27	3.75±0.74
	CIF	15.87±0.20	7.4±0.68	5.45±0.26	15.53±0.41	4.82±0.31	3.90±0.21
	CV%	*1.52*	*2.49*	*2.17*	*2.18*	*1.09*	*1.34*
	LSD 0.01%	*0.67*	*1.09*	*0.40*	*0.57*	*0.40*	*0.64*
Petunia	Control	18.22±0.41	4.5±0.68	8.12±0.21	26.65±0.57	3.54±0.21	1.36±0.15
	COF	25.04±0.48	8.5±0.88	13.45±0.47	39.15±0.64	4.21±0.18	1.61±0.14
	FSMN	22.17±0.42	6.0±0.88	11.24±0.53	32.20±0.72	3.55±0.28	1.38±0.21
	CIF	21.45±0.36	6.2±0.55	10.50±0.43	31.15±0.91	3.59±0.15	1.41±0.16
	CV%	*1.66*	*2.10*	*2.83*	*2.54*	*0.96*	*1.25*
	LSD 0.01%	*0.62*	*1.13*	*0.64*	*1.07*	*0.28*	*0.17*

Note: Values are means ± standard deviation of measures, n = 5.

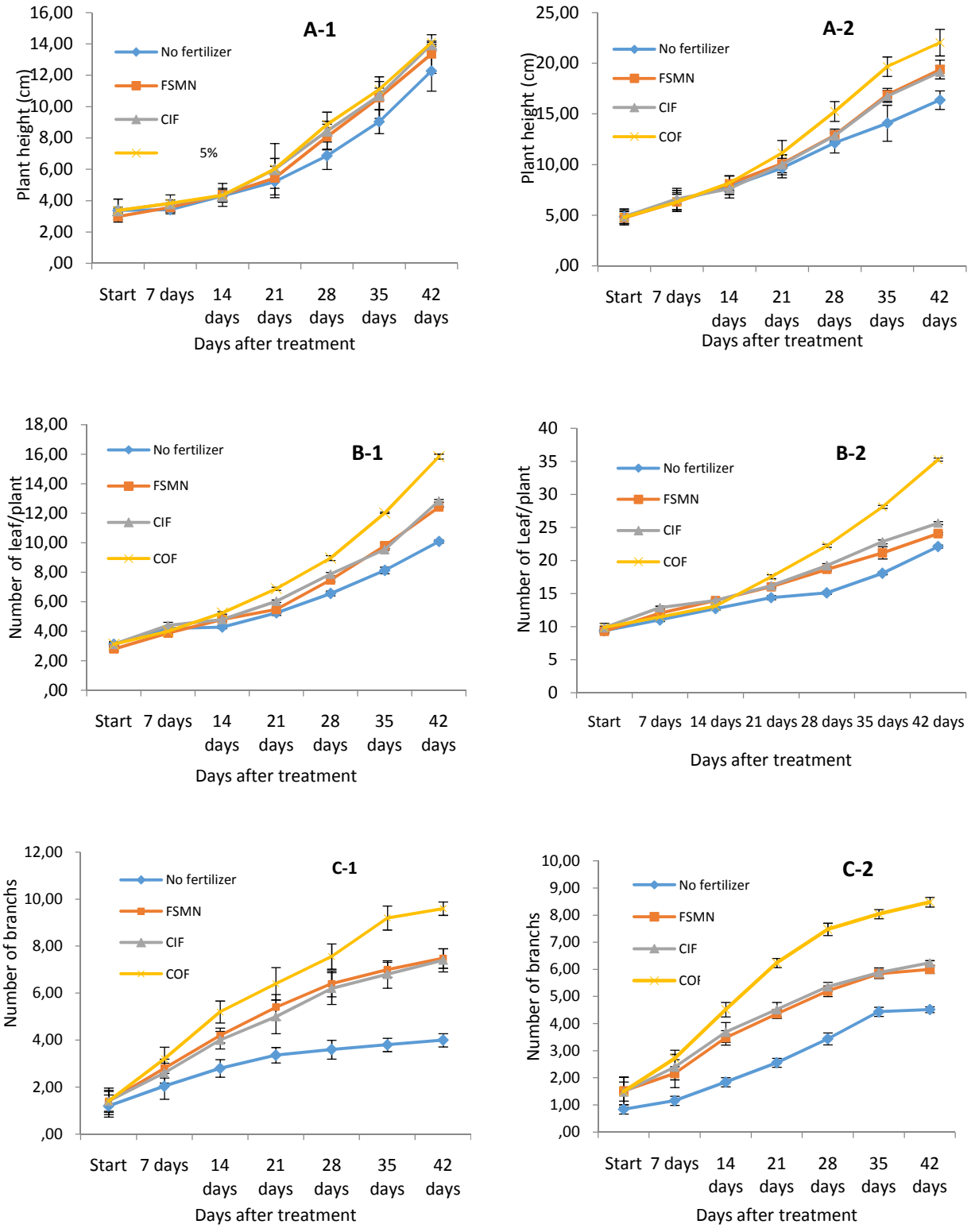

Fig. 2. Effect of organic and inorganic fertilizers on plant height (A), number of leaves (B) and number of branches (C) of Begonia (1) and Petunia (2)

Note: Vertical bars represent ± SD of mean, n = 5

There was variation of plant height, number of leaves and number of branches during the growth of Begonia and Petunia (Fig. 2). There was similar trend on plant height and number of leaves of both flower species in three fertilizer treatments in first two weeks after fertilization. This result agreed with the results reported by James and Iersel (2001) and Zhang et al. (2012) which showed that there were no significant differences in the effect of nutrition on plants in the early growth stages. However, plant height and number of leaves of two flower speciesshowed significant differences at the third week after fertilization. Plant height and number of leaves in treatments of COF developed greater than those in other fertilizer treatments. Especially, the number of branches in the COF increased steadily during growth and development of potted Begonia and potted Petunia. These results indicate that COF (processed from cotton stalks) was more effective than "soybean-based liquid" on growth of flowers grown in green house (Nelson et al. 2010).

3.2. Effect of organic and inorganic fertilizers on physiology characteristics of potted flowers

Many scientists have studied the relationship between fertilizers' effectiveness and physiologcal characteristics of plants. They concluded that the physiological characteristics such as photosynthesis, respiration, transpiration rate etc. are the important indicators of plants; they particularly affected on yield and quality of agricultural product (Lu 2011, Yang et al 2012).

Variance analysis of physiological characteristics are given in Table 4. The results showed that physiological indicators of both flower species in all fertilizer treatments were better than those in the control (non-fertilization) ($P < 0.01$). Treatment of COF increased chlorophyll value of Petunia leaf (13.19%) and Begonia (6.34%) in comparison with two treatments of FSMN and CIF. COF treatment increased 9.65 - 17.92 % of photosynthetic rate while FSMN and CIF

Table 4. Effect of organic and inorganic fertilizers on physiological characteristics of potted Begonia and potted Petunia

Plant	Treatment	Leaf chlorophyll value (SPAD)	Photosynthetic rate ($\mu mol \cdot m^{-2} \cdot s^{-1}$)	Transpiration rate ($mmol \cdot m^{-2} \cdot s^{-1}$)	Stomatal conductance ($mmol \cdot m^{-2} \cdot s^{-1}$)
Begonia	Control	31.88 ± 1.55	10.38 ± 0.25	1.64 ± 0.09	189.4 ± 2.86
	COF	35.54 ± 1.06	12.24 ± 0.21	1.74 ± 0.08	194.2 ± 2.67
	FSMN	33.94 ± 1.19	11.31 ± 0.24	1.69 ± 0.06	190.2 ± 3.00
	CIF	33.42 ± 1.26	11.26 ± 0.22	1.69 ± 0.08	190.6 ± 2.88
	CV%	*2.02*	*1.18*	*1.99*	*1.66*
	LSD 0.05%	*1.38*	*0.24*	*0.08*	*3.08*
	LSD 0.01%	*NS*	*0.35*	*0.12*	*NS*
Petunia	Control	31.84 ± 1.77	13.78 ± 0.26	1.73 ± 0.05	201.6 ± 2.07
	COF	37.42 ± 1.96	15.11 ± 0.22	1.92 ± 0.07	233.5 ± 1.65
	FSMN	33.74 ± 1.36	14.62 ± 0.28	1.86 ± 0.07	224.5 ± 1.50
	CIF	33.06 ± 1.23	14.67 ± 0.33	1.89 ± 0.05	231.4 ± 1.33
	CV%	*2.06*	*1.86*	*1.32*	*2.18*
	LSD 0.05%	*1.83*	*0.34*	*0.06*	*1.72*
	LSD 0.01%	*2.39*	*0.41*	*0.09*	*2.37*

Note: Values are means ± standard deviation of measures (n = 5); NS = Not significant

Table 5. Effect of organic and inorganic fertilizers on quality characteristics of potted Begonia and potted Petunia

Plant	Treatment	Days to first flowering	Flower diameter (cm)	Flower longevity (day)	Number of flowers/plant
Begonia	Control	36.0 ± 0.88	2.13 ± 0.01	10.5 ± 0.84	11.7 ± 2.19
	COF	31.4 ± 0.68	2.14 ± 0.01	13.4 ± 0.69	18.3 ± 2.16
	FSMN	32.2 ± 0.56	2.14 ± 0.01	11.5 ± 0.77	16.6 ± 2.39
	CIF	32.4 ± 0.68	2.13 ± 0.01	11.2 ± 0.74	16.8 ± 2.33
	CV%	*1.88*	*0,97*	*2.02*	*2.83*
	LSD 0.01%	*0.94*	*0.01*	*1.82*	*1.42*
Petunia	Control	37.4 ± 1.42	7.78 ± 0.10	9.0 ± 0.48	7.6 ± 1.82
	COF	30.4 ± 0.68	8.61 ± 0.07	13.4 ± 0.50	12.4 ± 1.69
	FSMN	31.2 ± 0.56	8.14 ± 0.04	11.8 ± 0.45	10.2 ± 1.30
	CIF	35.4 ± 0.68	8.12 ± 0.05	11.2 ± 0.45	10.0 ± 1.94
	CV%	*2.00*	*1.16*	*2.33*	*2.42*
	LSD 0.01%	*1.34*	*0.10*	*1.12*	*2.07*

Note: Values are means ± standard deviation of measures, n = 5.

treatments only increased 6.46 - 8.96% when compared to the control. The transpiration rate and stomatal conductance were significantly higher in COF treatment than those in FSMN and CIF treatments ($p \leq 0.05$). This can be explained by positive effect of composite organic fertilizers on the physiological characteristics of plants compared to inorganic fertilizers.

3.3. Effect of organic and inorganic fertilizers on quality characteristics of potted flowers

Depending on the treatments, number of days to first flowering in Begonia and Petunia varied between 31 to 36 and from 30 to 38 days, respectively. The earliest flowering was observed in treatment with COF (31.4 days with Begonia and 30.4 days with Petunia), followed by treatments with FSMN and CIF (32 days with Begonia and 31 - 35 days with Petunia). The result showed that days to first flowering of Petunia were shorter by about 10 days than that reported by Gaur *el at* (2000) on the effects of inorganic fertilizers on the growth of potted flowers.

There was no significant difference in flower diameter between CIF treatment and the control (non-fertilization) in Begonia (2.13 ± 0.01 cm), but this was. smaller than that in treatments with FSMN and COF (2.14 ± 0.01 cm). Flower diameter of Petunia in three fertilizer treatments was significant different($p < 0.01$), being largest in COF treatment (8.61 ± 0.07 cm).This result shows that flower diameter increased when treated with COF, especially in the Petunia experiment. Flower diameter of Petunia in this study was larger than that reported by Kang and Iersel (2001), when they were applied the best experimental conditions in Petunia.

The longevity of flowers and average number of flowers/plants are two important indicators of quality of potted flowers. In this study, the longevity of flowers was improved in all fertilizer application in comparison with the control, particularly COF treatment extended flower longevity by 3 days in Begonia t and 4 days in Petunia (Table 5).

The average number of flowers/plants was improved in three fertilizer treatments. Highest number of flowers was recorded in the COF treatment (18.3 ± 2.16 in Begonia and 12.4 ± 1.69 in Petunia). The results showed that, COF was the best for average number of

Fig. 3. Begonia and Petunia flowers 40days after planting (in COF treatment)

flowers/plants in experiments of Begonia and Petunia. Its effectiveness is equivalent to the effectiveness of "The common nutrient solution in garden of Japanese" in Begonia experiment (Zhou et al., 2013) and better than the nutritional formula of Klock-Moore and Broschat (2001) in Petunia experiment.

4. IN CONCLUSION

Although the composite fertilizer products were used in the equivalent rate, they have different effects on the growth and quality of plants. Composite organic fertilizer (COF) showed beneficial effect on growth and flower quality of both Begonia and Petunia. Flower plants in COF treatment were superior in stem growth, leaf development, leaf chlorophyll value, photosynthetic rate and especially in average number of flowers/plants and flower longevity compared to CIF, FSMN and control (without fertilization).

REFERENCES

Aminifard M. H., Aroiee H., Nemati H., Azizi M. and Khayyat M. (2012). Effect of nitrogen fertilizers on vegetative and reproductive growth of pepper plants underfield conditions. J. Plant Nutr, 35: 235-242.

Chapagain B. P. and Wiesman Z. (2004). Effect of Nutri-Vant-PeaK foliar spray on plant development, yield, and fruit quality in greenhouse tomatoes. Scientia Hort, 102: 177-188.

Ding X., Cheng J. M., Zhang W. J., Shen Z. G.(2011). Efficient cultivation techniques of Begonia. Journal of Heilongjiang Vocational Institute of Ecological Engineering (in Chinese), 24(5): 3-5.

Dursun A., Turan M., Ekinci M., Gunes A., Ataoglu N., Esringu A., and Yildirim E. (2009). Effects of boron fertilizer on tomato, pepper, and cucumber yields and chemical composition. Communications in Soil Science and Plant Analysis, 41: 1576-1593.

Fain G. B., Gilliam C. H., Sibley J. L., Boyer C. R., and Witcher A.L.(2008). Whole tree substrate and fertilizer rate in production of greenhouse-grown petunia *(Petunia hybrid* Vilm.) and marigold (*Tagetespatula* L.). HortScience, 43(3): 700-705.

Fain G. B., Gilliam C. H., Sibley J. L. and Boyer CR. (2008). Establishment of greenhouse-grown Tagetespatula and Petunia hybrid in 'Whole Tree' substrates. Acta Hort, 782: 387-393.

FAO. 2012. Current world fertilizer trends and outlook to 2016, pp. 16-24.

Gaskell M., Fouche B.,Koike S., LaniniT., Mitchell J., and Smith R. (2000). Organic vegetable production in California-Science and practice. HortTechnology, 10: 699-713.

Gaur A., Gaur A., Adholeya A. (2000). Growth and flowering in *Petunia hybrida*, *Callistephus chinensis* and *Impatiens balsamina* inoculated with mixed AM inocula or chemical fertilizers in a soil of low P fertility. Scientia Hortculturae, 84(2000): 151-162.

Isherwood K. (1998). The fertilizer industry's manufacturing processes and environmental issues. Technical report of United Nations environment programme, United Nations industrial development organization and international fertilizer industry association (UNEP-UNIDO-IFA). ISBN: 92-807-1640-9.

James E.C. and Iersel M.W. (2001). Ebb and flow production of Petunias and Begonias as affected by fertilizers with different phosphorus content. Hortscience, 36(2): 282-285.

James E. C. and Iersel, M.W.(2001). Fertilizer concentration affects growth and flowering of sub irrigated petunias and begonias. Hortscience, 36(1): 40-44.

Kang J. G., Iersel M.W., (2001). Interactions between temperature and fertilizer concentration affect growth of sub irrigated petunias. Journal of Plant Nutrition, 24: 753-765.

Klock-Moore K. A., Broschat T. K. (2001). Irrigation systems and fertilizer affect Petunia growth. Horttechnology, 11(3): 416-418.

Kumar M., Baishya L. K., Ghosh D. C., Ghosh M., Gupta V. K. and Verma M. R. (2013). Effects of organic manures, chemical fertilizers and bio-fertilizers on growth and productivity of rainfed potato in the eastern himalayas. Journal of Plant Nutrition, 36: 1065-1082.

Liu C.M., Wang H. C., Wang K., Chen Z.Y., Fan Z. E., Liu R.N. (2011). Current status and development strategy of flower production in China and on the World. Journal of Shaanxi Agricultural Sciences (in Chinese), **5**: 153-155.

Lu V. J. (2011). Plant physiology. China Forestry Press (in Chinese), pp. 28-41.

Luo Y., Chen X. F., Liu S., Xiang D. B., Li J., Shu G. M., Xia Y.L. (2011). Effects of micronutrient fertilizer application on yield and quality of Aconitum carmichaeli. China journal of Chinese materia medica, 36: 102-106.

Najm A. A., Haj SeyedHadiM. R., Fazeli F., TaghiDarzi M., Shamorady R. (2010). Effect of utilization of organic and inorganic nitrogen source on the potato shoots dry matter, leaf area index and plant height, during middle stage of growth. World Academy of Science, Engineering and Technology, 47: 900-903.

Nelson P. V., Pitchay D. S., Niedziela C. E. and Mingis N. C. (2010). Efficacy of soybean-base liquid fertilizer for greenhouse crops. Journal of Plant Nutrition, 33: 351-361.

Wang L. R. and Yang C.P. (2012). The new type of fertilizer is going to have a prosperous development. Journal of Market Modernization (in Chinese), 694: 163.

Wang Y. T., Huang S., Liu R. and Jin J. (2007). Effects of nitrogen application on flavor Composites of cherry tomato fruits. J. Plant Nutr. Soil Sci., 170: 461-468.

Xia X. F. and Hu H. (2011). Utilization present situation of fertilizers in China and new type of fertilizers. Technology & Development of Chemical Industry (in Chinese), 40: 45-48.

Xie K., Song X. H., Dong C. X., Xu Y.C. (2013). Effects of different organic fertilizers on tree growth and soil property in Huangguan pear orchard. Plant Nutrition and Fertilizer science (in Chinese), 19: 214-222.

Yang L. J., Qu H., Zhang Y. L., Li F.S. (2012). Effects of partial root-zone irrigation on physiology, fruit yield and quality and water use efficiency of tomato under different calcium levels. Agricultural Water Management, 104: 89-94.

Zafar M., Abbasi M. K., Khaliq A. and Rehman Z.(2011). Effect of combining organic materials with inorganic phosphorus sources on growth, yield, energy content and phosphorus uptake in maize at Rawalakot Azad Jammu and Kashmir, Pakistan. Archives of Applied Science Research, 3: 199-212.

Zhang W. J., Li X. K., Chen F., Lu J.W. (2012). Accumulation and distribution characteristics for nitrogen, phosphorus and potassium in different cultivars of Petunia hybrid Vlim. ScientiaHort, 141: 83-90.

Zhang W. J., Lu J. W., Jiang Z. P., Wang X.T. (2009). Effect of N, P, K fertilizer application and recommendation for Petunia Vilm. in pot experiments. Plant Nutr. Fertilizer Science, 15(5): 1147-1153.

Zhou J. B., Xu X. N., Zhang Y. T., Liang Y., Xi X.J. (2013). Effect of fournutrient solutions on growth and flowering indexes of begonia cuccullata “Super OlympiaSeries”. Journal of plant resources and environment, 22(1): 118-120.