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Investigation of Compost and Vermicompost of Water Hyacinth as Growing Media for Lily (*Longiflorum* × *Asiatic*)

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ABSTRACT

Water hyacinth (*Eichornia crassipes*) is one of the ten most invasive weed species in the world that is spread over most of the tropical and subtropical regions. Due to the environmental and economic concerns associated with spreading of the water hyacinth, control its distribution is important issue. Water hyacinth can be used for composting and vermicomposting. In the present study, compost or vermicompost of water hyacinth was used as growing media for growing of lily plants (*Longiflorum* × *Asiatic* cv. 'Nashville'). To do so, an experiment was conducted in a completely randomized design with nine treatments and four replications. Treatments included peat moss + perlite (2:1 v/v) as control and 25%, 50%, 75% and 100% of water hyacinth compost or vermicompost substitute for peat moss in control treatment. According to the obtained results, the tallest plants were observed in the control (55.50 cm) and 25% compost (55.25 cm) treatments. No significant difference was observed among 50, 75 and 100% compost and 25% vermicompost treatments. The highest number of open buds (3.50) was seen in 25% vermicompost. Results also showed that using 75% compost and 50% vermicompost increased nitrogen content of the leaf. Highest total phenol with 6.9 mg quer/g FW was recorded in 75% and 100% vermicompost. The maximum vase life (six days) was obtained in flowers grown in 25% vermicompost. In conclusion, water hyacinth compost or lower vermicompost percentages could be a substitute for peat as the growing media for lily plants.

Introduction

Water hyacinth (*Eichornia crassipes*, Pontederiaceae), is a monocotyledonous plant with thick leaves and purple flowers. This plant is one of the ten most important species of the invasive aquatic plant in the world (Parson and Cuthberson, 2001; Gettys, 2014). Water hyacinth can grow up to 600-900 tons of fresh biomass (35-45 tons of dry biomass) per hectare in a temperate climate. This plant can be controlled by chemical, biological and mechanical treatments. One of the disadvantages of chemical control is its negative effect on ecosystem. The biological control method used fungal pathogens, snails, insects or some species of fish, but did not achieve the desired control of this weed.

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Composting and vermicomposting are promising techniques for controlling the water hyacinth, which reduces the use of chemical fertilizers and the aggressive growth of this plant (Prasad et al., 2013). Vermicompost is a humic substance that has effects similar to growth regulators. It contains humic, folic and other organic acids produced by microorganisms to stimulate plant growth (Gonzalez, 2010; Talukdar, 2018). Vermicompost, in addition to being a rich source of micronutrients, can help obtaining micronutrients such as iron and zinc in plants and improves plant growth and yield (Gonzalez, 2010).

In many studies compost and vermicompost have been used as soil modifiers, mulch and growing media. For example, the use of compost made from sewage sludge as a soil-modified material increases microbial activity, soil fertility and plant growth (Alvarenga et al., 2016). It has been shown that application of compost from poultry manure as mulch reduced insects, fungal diseases and weeds in apple (*Malus domestica* Borkh.) orchard (Brown and Tworkoski, 2004). In a study, compost and vermicompost of green waste were evaluated as a growing medium for geranium (*Pelargonium zonale* L.) and calendula (*Calendula officinalis* L.). It has been shown that green waste vermicompost can be used instead of peat for growing these plants (Gong et al., 2018). Oriental beech (*Fagus orientalis* Lipsky.) seedlings treated with vermicompost had better growth (Atik, 2013). In another study on European borage (*Borago officinalis*) the maximum chlorophyll content was detected in the third harvest when 10 t/ha vermicompost and mycorrhiza were applied (Shahbazi et al., 2019).

Peat has been widely used for many years as the main component in soilless culture. However, excessive mining would cause rapid depletion of peatland and environmental deterioration, resulting in reduced availability and increased prices for peat products (Forens et al., 2012). Increasing costs and reducing the availability of peat moss have led to the utilization of compost as an alternative substrate. Few studies have been done on the use of compost and vermicompost of water hyacinth for ornamental plants so far. It has been shown that water hyacinth compost increased the number of flowers in marigold (*Tagects erecta* L.) compared with other organic and inorganic substances (Paul and Bhattacharya 2012). Studies have shown that water hyacinth compost can be used as an organic fertilizer to improve soil fertility and increase product yield. Water hyacinth compost is reported to enhance the growth and yield of tomato (Mashavira et al., 2015). Sridevi et al. (2016) reported that water hyacinth compost improves growth and yield of peanut (*Arachis hypogaea* L.).

Lily (genus *Lilium* L.) is one of the most beautiful cut and pot flowers that ranked 4th in the global flower trade (Raj, 2014). The genus consists of approximately 100 species that range from the Sierra Nevada and Rocky Mountains to eastern North America through Europe and the Middle East to the Caucasus Mountains and Eastern Asia (Pelkonen and Pirttila, 2012). Therefore, the purpose of this study was to investigate compost and vermicompost from water hyacinth as the growth media for lily flower.

Material and Methods

Plant material

LA *Lilium* hybrid (*Longiflorum*×*Asiatic* cv. 'Nashville') bulbs was obtained from an Iranian company (Saee Gol, Tehran, Iran). Pre-chilled bulbs with uniform circumference (15 cm) were planted in plastic pots (20 cm length, 15 cm diameter) on 15 November 2018 in the greenhouse of Sari Agricultural Sciences and Natural Resources University. The average night and day temperature in the greenhouse during the experiment were 17±1°C and 22±1°C, respectively. The relative humidity was 75–80%. Nine growing media were used containing: Peat moss + perlite (2:1 v/v) as control (Al-Ajlouni et al., 2017) and 25%, 50%, 75% and 100% of compost or vermicompost substitute for peat moss.

Preparation of compost and vermicompost

To prepare water hyacinth compost, the water hyacinth was collected from a river in Sari, Mazandaran, Iran. Water hyacinth leaves were exposed to direct sunlight for 8 h to wither then chopped to fine pieces and eventually was spread in five-centimeter thickness. One centimeter thickness of animal manure was added on top of the water hyacinth leaves and then a layer of ash and lime was respectively added. This step was repeated until the height of the layer reached to one meter, finally the top layer was covered with dry leaves of native trees and black polyethylene sheets. The mass was mixed up every 15 days to get better result (uniform decomposition). Finally, after three months, the compost was prepared (Kafel et al., 2009). To prepare the vermicompost, the water hyacinth was crushed into small pieces and dried for eight h under sunlight to reduce its water content into half. Then it was combined with a ratio of 6:1 with cow manure, and then 300 adult and immature worms (*Eisenia foetida*) were added. Within four months, vermicompost was prepared (Gajalakshmi et al., 2001). Some properties of compost and vermicompost are presented in Table 1.

Table 1. Some properties of compost, vermicompost, and peat moss used for growing of *Lilium* cv. 'Nashville'

Growing media	pH	EC ds/m	Ca mg/kg	K mg/kg	P mg/kg	C (%)
compost	7.97	2.41	2998	2381	117.89	40.14
vermicompost	7.89	3.11	3139	1897	117.71	34.51
Peat moss	6.92	0.58	4597	325	51.91	36.76

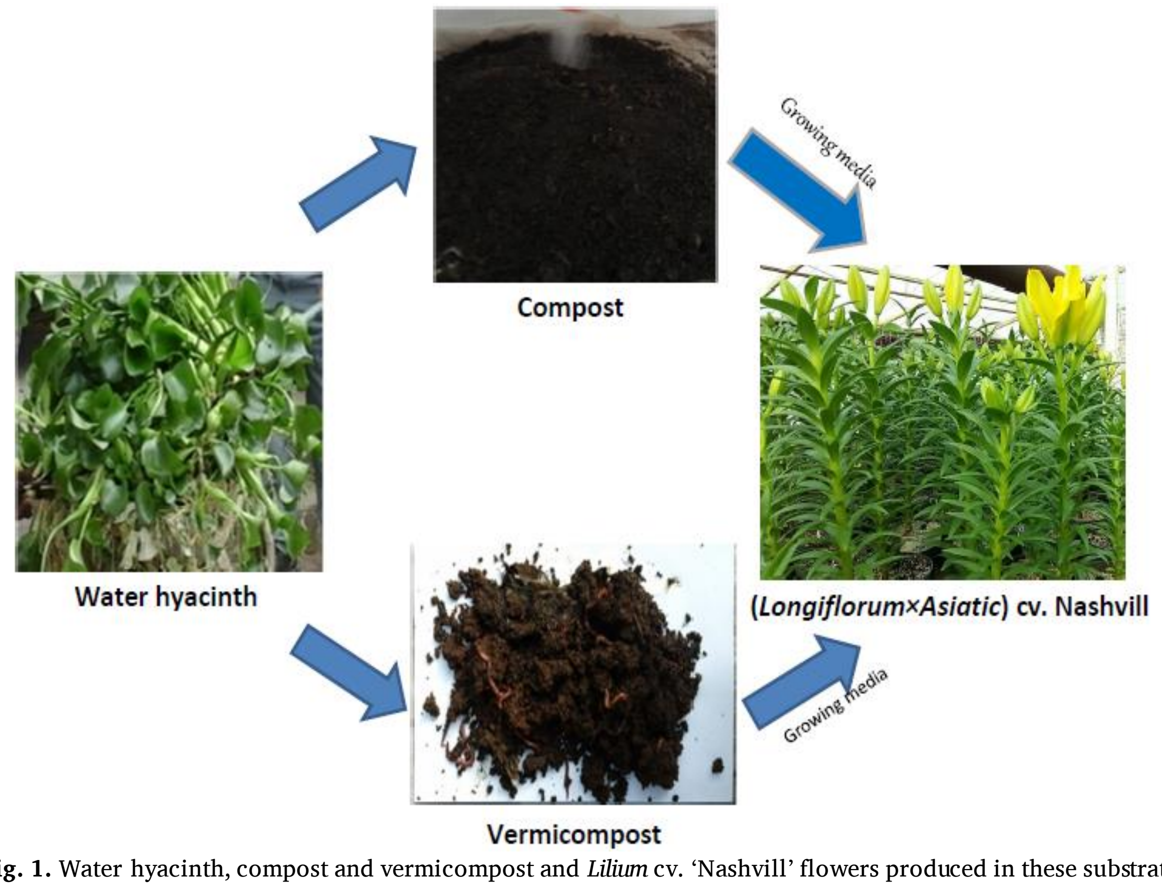

Fig. 1. Water hyacinth, compost and vermicompost and *Lilium* cv. 'Nashvill' flowers produced in these substrates.

Measurements

In the present study, root dry weight, root fresh weight, vase life, chlorophyll content (Arnon 1967), total phenol (Slinkard and Singleton, 1977), number of open buds, plant length and leaf elements were evaluated. To study the vase life, (when the color of the first bud was changed), the flower stem was harvested and placed in distilled water. Flower senescence was evaluated daily and defined when at least 50% of the flowers per pot were senesced (John Elgar et al. 1999). The phosphorus content of leaves was measured according to Chapman and Pratt, (1961). Calcium, magnesium, potassium and nitrogen were measured according to Wahing et al. (1989). Figure 1 shows water hyacinth compost and vermicompost and lily flowers produced in these substrates.

Statistical analysis

This experiment was conducted in a completely randomized design with nine treatments and four replications. Data were statistically analyzed using SAS software (Version 9.1). Mean comparisons were performed using the least significant difference (LSD).

Results

Plant height

The effect of growing media on plant height was significant. The tallest plants were observed in the control and 25% compost treatments. No significant difference was observed among the treatments with 50, 75 and 100% compost and 25% vermicompost. The shortest plants were found in 75% or 100% vermicompost (Table 2).

Table 2. Comparison of morphological traits of *Lilium* cv. 'Nashvill' under different levels of compost and vermicompost

Growing media	Plant height (cm)	number of open buds	Vase life (Day)	Root fresh weight (mg)	Root dry weight (mg)
T0	55.50a	3.00ab	5.50a	6.99ab	1.64a
T1	55.25a	3.25ab	5.50a	8.08a	1.31ab
T2	53.25ab	3.25ab	5.75a	5.99a-c	1.02a-d
T3	53.25ab	2.50bc	5.25a	7.70ab	1.18a-c
T4	53.25.ab	2.50bc	5.00a	4.39b-d	0.69b-e
T5	54.75a	3.50a	6.00a	7.91ab	1.20a-c
T6	49.25bc	3.00ab	4.75b	4.65a-d	0.61c-e
T7	45.00c	1.75c	4.75b	2.43d	0.24e
T8	46.25c	0.75d	2.00c	3.04cd	0.45de
Significance	**	**	**	*	**
CV (%)	7.26	21.60	20.95	24.73	19.10

The means with similar letter in each column are not significantly different (LSD 0.05)

T0 (control), T1, T2, T3, and T4 (25, 50, 75, and 100% compost), T5, T6, T7, and T8 (25, 50, 75, and 100% vermicompost)

Number of opened buds

The highest number of open buds by 16.66% increase compared to the control was found in 25% vermicompost. There was no significant difference between 25% vermicompost with control, 25%, and 50% compost and 50% vermicompost. The lowest number of opened buds was gained in 100% vermicompost (Table 2).

Vase life

The longest vase life by 9% extension compared to the control treatment was obtained in flowers of plants that were grown in 25% vermicompost, while the shortest vase life by 42.85% decrease compared to the control was observed in 100% vermicompost (Table 2).

Root dry weight and root fresh weight

Different levels of compost and vermicompost had a significant effect on fresh and dry weight of roots. The highest root fresh weight was observed in 25% compost. But this treatment showed no significant difference with control, 50%, and 75% compost or 25% and 50% vermicompost. The lowest fresh weight was found in 75% and 100% vermicompost (Table 2).

Number of leaves

According to the obtained results, the effect of media on leaf number was significant. The highest leaf number was observed in 100% compost. However, there was no significant difference between the treatments with other compost levels and the 25% vermicompost and control treatments (Table 3).

Table 3. Comparison of morphological traits of *Lilium* cv. 'Nashvill' under different levels of compost and vermicompost

Growing media	Number of leaves	Number of buds	Number of bulblets
T0	79.50a	4.00a	3.50e
T1	68.50a	4.00a	7.50ab
T2	67.25ab	4.25a	8.00a
T3	80.25a	4.50a	8.25a
T4	81.50a	3.50b	8.00a
T5	68.75ab	3.50b	8.00a
T6	68.25bc	3.00ab	7.75ab
T7	65.00c	2.75c	5.75c
T8	65.25c	2.00d	4.50d
Significance	**	**	**
CV (%)	11.18	8.60	10.92

The means with similar letter in each column are not significantly different (LSD 0.05)
T0 (control), T1, T2, T3, and T4 (25, 50, 75, and 100% compost), T5, T6, T7, and T8 (25, 50, 75, and 100% vermicompost)

Number of buds

The highest number of buds was observed in the control, 25, 50 and 75% compost. The lowest number of buds was detected in 100% vermicompost (Table 3).

Number of bulblets

The results revealed that the effect of growing media on the number of bulblets was significant. Compost-based media and media with a low percentage of vermicompost (25 and 50%) produced the highest number of bulblets (Table 3).

Foliar element concentrations

Mineral elements in the leaf of the lily plants were significantly affected by growth media. The highest nitrogen content was found in 75% compost (18% increase compared to the control) and 50% vermicompost (19% increase compared to the control). The lowest nitrogen content was measured in vermicompost 75%. The highest phosphorus level was detected in the control and 25% compost. The highest potassium content was measured in 25% vermicompost and its lowest content was detected in 100% vermicompost. The highest concentrations of magnesium were found in the leaves of plants grown in 75% or 100% compost (Table 4). The maximum level of calcium was detected in 25% vermicompost. There was a positive linear relationship between the concentration of calcium and vase life of flowers. As the amount of calcium was increased, vase life was prolonged (Fig. 2).

Total Chlorophyll and phenol

The highest total chlorophyll content (11.1 mg/g FW) was detected in control treatment. The lowest chlorophyll content (1.8 mg/g FW) was found in 100% vermicompost (Fig. 3). Total phenol was increased by 75% and 100% vermicompost treatments. The lowest amount of phenol was found in 50% and 75% compost and 25% vermicompost (Fig. 4).

Table 4. Comparison of leave nutrient concentration of *Lilium* cv. 'Nashvill' under different levels of compost and vermicompost.

Growing media	N%	P%	K%	Mg%	Ca%
T0	2.66bc	0.34a	1.43d	0.45ab	0.92a
T1	2.41c	0.33a	1.66c	0.35b	0.73ab
T2	2.50bc	0.19b	1.70bc	0.46ab	0.71ab
T3	3.14a	0.19b	.1.70bc	0.53a	0.52bc
T4	2.59bc	0.19b	1.69bc	0.48a	0.50bc
T5	2.43bc	0.22b	1.82a	0.44ab	0.85a
T6	3.17a	0.23b	1.75ab	0.41ab	0.52bc
T7	2.36c	0.20b	1.70bc	0.34b	0.51bc
T8	2.31c	0.19b	1.63c	0.35b	0.34c
Significance	**	*	**	*	**
CV (%)	10.04	27.79	3.35	19.08	27.07

The means with similar letter in each column are not significantly different (LSD 0.05)

T0 (control), T1, T2, T3, and T4 (25, 50, 75, and 100% compost), T5, T6, T7, and T8 (25, 50, 75, and 100% vermicompost)

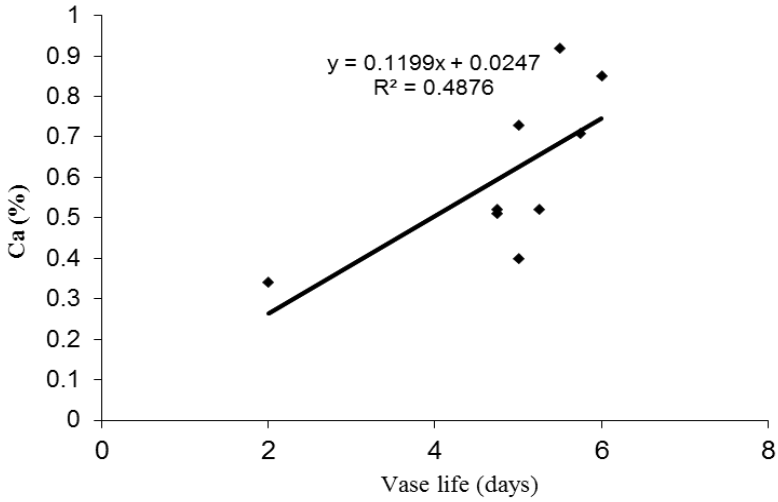

Fig. 2. Relationship between calcium and vase life in *Lilium* cv. 'Nashvill'.

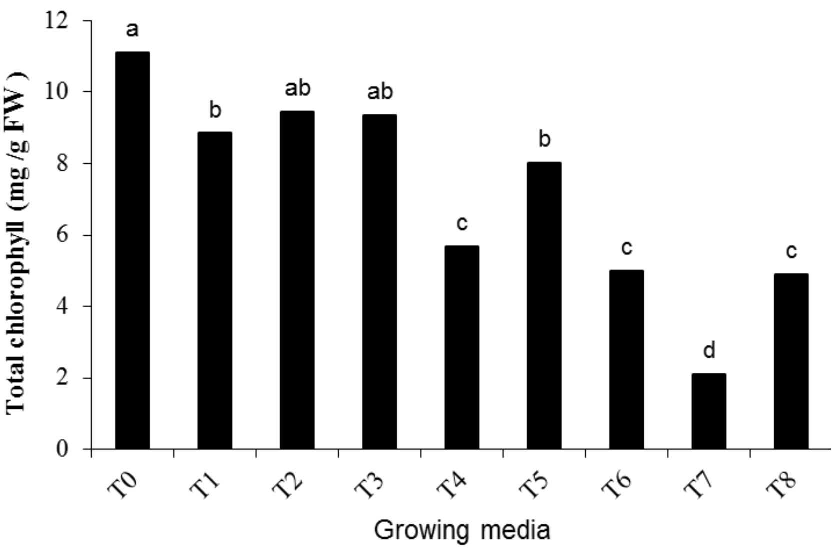

Fig. 3. Effect of compost and vermicompost on chlorophyll content in *Lilium* cv. 'Nashvill'. Columns with the same letters are not significantly different at the 5% probability level. T0 (control), T1, T2, T3, and T4 (25, 50, 75, and 100% compost), T5, T6, T7, and T8 (25, 50, 75, and 100% vermicompost).

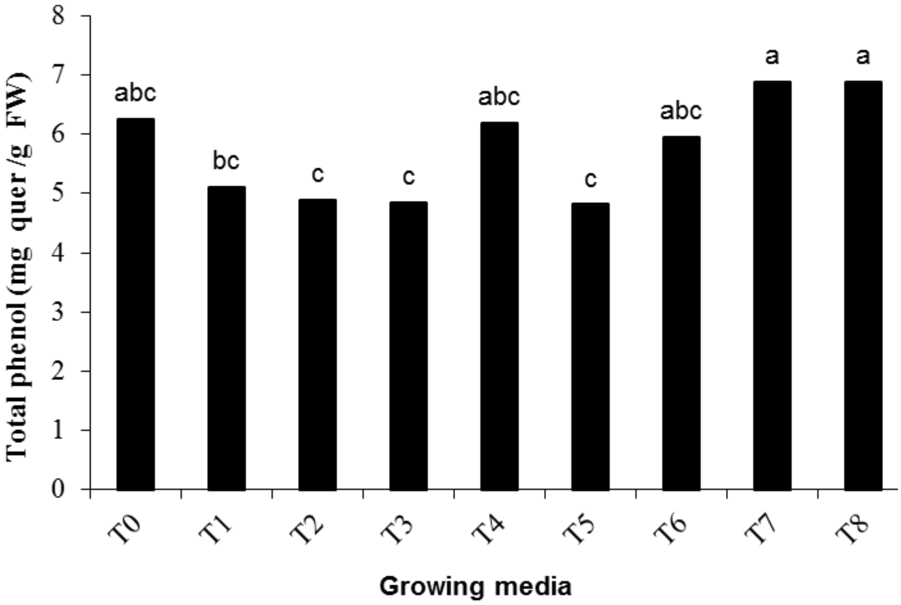

Fig. 4. Effect of compost and vermicompost on total phenol in *Lilium* cv. 'Nashvill'. Columns with the same letters are not significantly different at the 5% probability level. T0 (control), T1, T2, T3, and T4 (25, 50, 75, and 100% compost), T5, T6, T7, and T8 (25, 50, 75, and 100% vermicompost).

Discussion

In the present study, growth media significantly affected most of the lily plant characteristics. Growing media containing compost (at all levels) and 25% vermicompost had no significant effect on plant height compared to the height of control plants. Due to proper drainage, increased water retention, a quasi hormonal compound such as auxin and increased absorption of elements, compost and vermicompost improve the chemical and physical structures of the growing media. Due to increased plant growth, plant height increased by the compost and vermicompost (Edward and Burrows, 1988; Adediran et al., 2004). Also, high leaf nitrogen content was observed in most compost-containing substrates. This element plays a key role in vegetative growth. The concentrations of nitrogen and phosphorus in compost and vermicompost are usually 5 to 11 times higher than their levels in the soil, which are gradually delivered to the plant and increase the growth and flowering of plants (Edward and Burrows, 1988). Consistent with the present study, the application of water hyacinth compost positively influenced the growth attributes of the maize plants. Among the different treatments, water hyacinth compost prepared with EM was the best in most parameters including plant height, stem dry weight, root dry weight, and root dry weight (Osoro et al., 2014).

It has been reported that the use of water hyacinth compost in *Colocasia esculenta* L. increased the height and number of leaves (Talkah, 2015). In a study on *Lilium* cv. 'Navona', vermicompost at 20 and 30% had stimulating effects on flower number and diameter (Moghadam et al., 2012). Decreasing plant height in 75% and 100% of vermicompost was probably due to undesirable drainage, reduced root growth, and finally reduced absorption of elements, especially nitrogen.

Chlorophyll synthesis in plants is directly related to the physiological activity of phosphorus, nitrogen and iron elements, so the availability of these elements improves chlorophyll formation in the leaves (Sonter et al., 2018). Nitrogen further increases the growth and leaf area index, which leads to an increase in chlorophyll and greater absorption of light and eventually the plant dry matter

(Ravi et al., 2008). In this study, the highest chlorophyll content was observed in control and 50% or 75% compost. The increased chlorophyll content in the present study might be associated with the supply of essential nutrients to the plants (Sonter et al., 2018). Consistent with the present study, it has been showed that the number of leaves, leaf length, chlorophyll a and chlorophyll b contents were increased in *Amaranthus* (Uma and Malathi, 2009).

Calcium is one of the most important factors that play an important role in flower longevity. Calcium ion reduces ethylene production (Torre et al., 1999). In the present study, there was a direct correlation between calcium content and vase life (Fig. 1). Minimum flower longevity and calcium content were observed in 100% vermicompost. In research on two AL hybrids cultivars 'Batistero' and 'Courier', the highest vase life was observed in sand + soil + FYM + vermicompost (2:2:2:1 v/v) (Rajera et al., 2017).

One of the advantages of using compost and vermicompost is the increased activity of microorganisms. One of the most important activities of these microorganisms is the conversion of ammonium nitrogen into nitrate, which has positive effects on the increase of diameter and root area. Also, compost contains high amounts of organic matter which could increase the moisture retention of the soil, improve dissolution of nutrients particularly phosphorus and soil structure hence better root growth and nutrient uptake (Osoro et al., 2014). In our study, most of the growing media increased the fresh and dry weights of root. In a study in lily plants, the number and length of roots were increased by application of 30% vermicompost (Huerta et al. 2010; Moghadam et al. 2012).

Vermicompost significantly increases the content of vitamins, phenols and flavonoids in plants. The use of organic fertilizers increases the availability of phenolic compounds due to increased access to nutrients, especially carbon and nitrogen (Huerta et al., 2010). In this study, the highest phenol content was observed in treatments with high vermicompost percentages. Consistent with our finding vermicompost application significantly changed total phenolic content in pepper plants. The highest phenolic content was obtained in 5 t/ha vermicompost (Aminifard and Bayat, 2016). Hu and Barker (2004) reported that the agricultural waste compost increased the amount of nitrogen, phosphorus, potassium, calcium and magnesium in tomato leaves. According to the present findings, the use of compost and low levels of vermicompost can be proposed as a suitable culture medium for *Lilium* cv. 'Nashville'.

Conclusion

The results of the present study revealed that compost and vermicompost from the water hyacinth can be used as growing media for lily plantation. There was no significant difference in most of the morphological traits between plants grown either in compost or in the peat. High percentages of vermicompost reduced the height of plants and decreased their number of buds. The water hyacinth as an organic fertilizer can be studied in other plant species as well. Due to the rapid growth of the water hyacinth in swamps and wetlands, its use for producing compost and vermicompost can be an effective approach for controlling the distribution of this aggressive weed.

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Conflict of interest

The authors declare that there is no conflict of interest.

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