Growth and blossoming of Lilium under various organic fertilizers

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Abstract

The present research was conducted to mitigate the environmental contamination and with the aim of evaluating the possible impacts of the application of sugarcane bagasse sewage sludge-based compost (BSC), vermicompost, and fish compost on different aspects of physiology, growth, and development of *Lilliumlongiflorum* var Ceb-Dazzle. The bulbs were planted in four different prepared soil mixtures with two levels (0% or 10%) of organic fertilizers including vermicompost, BSC, and fish compost. In contrast to vermicompost, the application of fish fertilizer delayed the germination reactions. BSC and particularly vermicompost had desirable promoting effects on leaf and root system, as opposed to fish compost.Increased proline, soluble carbohydrate, K, and Ca contents were observed in vermicompost and BSC treated samples. In contrast to the fish compost, the application of BSC and especially vermicompost had an improving impact on the blossoming time, qualities of flowers, and the postharvest life of cut flowers. In comparison with fish compost and BSC, vermicompost was the most effective fertilizer to promote growth and development of *Lilliumlongiflorum.* According to the obtained results, it seems that the horticulture utilization of BSC at this level at least does not have detrimental impacts on plant growth,whereas the application of fish compost, especially the one originated from the sea, may result inundesirable inhibiting effects most probably due to the high electrical conductivity (EC) and toxic metals or products.

Keywords: *Lilliumlongiflorum*; environmental contamination; ornamental; organic wastes

Abbreviations:
BSC: sugarcane bagasses sewage sludge-based compost; EC: electrical conductivity

Mousavi, S. M. and **Z. Oraghi Ardebili.** 2014. 'Growth and blossoming of Lilium under various organic fertilizers '. *Iranian Journal of Plant Physiology* 5 (1), 1235-1242.

Introduction

Organic materials are an essential factor for keeping fertility in the soil-plant system (López-Mosquera et al., 2011). Organic agriculture facilitates the recycling of nutrients and minimizes the negative effects caused by the different agricultural activities (López-Mosquera et al., 2011; Oraghi Ardebili et al., 2012; Ladan Moghadam et al., 2012). With respect to the significance of environmental issues, more efforts have been devoted to substitute chemical

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Received: June, 2014
Accepted: October, 2014

fertilizers with biological ones (Hu and Barker, 1998).

Sugarcane is applied in industry worldwide for ethanol and sugar production (Rezende et al., 2011), and bagasse is remained as a byproduct (Betancur et al., 2010) which is thrown away as a waste or burned (Pauly and Keegstra, 2008; Betancur et al., 2010; Rezende et al., 2011). It may be necessary to identify alternative ways like agricultural utilization to minimize the environmental impacts and recycle these sugarcane residues (Jayasinghe, 2012). The use of sugarcane bagasse as a low cost support material during the rooting stage of strawberry has been recommended (Mohan et al., 2005). Jayasinghe (2012) evaluating the effect of the sugarcane bagasse sewage sludge-based compost (BSC) on lettuce (*Lactuca sativa* L.) stated that BSC-based media is a promising alternative to peat for plant cultivation.On the other hand, composts may act as limiting factors in horticultural practices mainly because of the presence of hazardous components like heavy metals, poor physical properties, phytotoxicity or high electrical conductivity (EC) (Jayasinghe, 2012).

Large amounts of waste are resulted from the fishing trade, in fish markets and processing industries (López-Mosquera et al., 2011) and these byproducts may have potentially valuable application in agriculture (López-Mosquera et al., 2011).

The application of the biological fertilizers, alternative way for the preservation of the environment, like vermicompost has considerable effects on plant growth and development (Kader et al., 2002). Vermicomposts differ in chemical composition depending on the origin (Handreck, 1986) and are produced via the interactions between special earthworms and microorganisms from the processing of organic wastes and possess high porosity, aeration, drainage, and waterholding capacity (Edwards et al., 2010). It has been stated that vermicomposts cause improved availability of nutrients as well as modified physicochemical and microbiological properties of soil (Orozco et al., 1996; Atiyeh, 2000). Vermicomposting is known as an eco-friendly method for degrading organic wastes and its product, i.e. vermicompost, possesses growth promoting substances, thereby improving plant growth and enhancing the fertility, water holding capacity, and microbial populations of the soil (Bhat and Limaye, 2012).

Finding suitable ways for effective utilization of industrial wastes has considerable economic importance (Kumar et al., 2010).In line with the attempts to mitigate the environmental contamination, this study attempted to find the most effective compost for growing *Lilium* which belongs to the Liliaceae family and is of economic significance because of its attractive flowers. More specifically, the study was conducted with the aim of evaluating the possible impacts of sugarcane bagasse sewage sludge-based compost (BSC), vermicompost, and fish compost on different aspects of physiology, growth, and development of *Lilliumlongiflorum* var Ceb-Dazzle.

Material and Methods

The bulbs of *Lilliumlongiflorum* var Ceb-Dazzle, vermicompost (prepared using cow manure and the earthworm (*Eiseniafoetida*)), sugarcane bagasse sewage sludge-based compost (BSC), and fish compost (fish wastes originated from sea) were purchased from the reliable commercial companies. The physical and chemical characteristics of theapplied vermicompost, BSC, and fish compost were examined (Table 1). The bulbs were planted (two in each pot) in four differently prepared soil mixtures with organic fertilizers(0% or 10% of

Table 1
Details of various chemical characteristics of the applied vermicompost, sugarcane bagasse sewage sludge-based compost (BSC), and fish compost

The analyzed parameter	P %	K %	N %	Fe (mgL^{-1})	Zn (mgL^{-1})	Cu (mgL^{-1})	Mn (mgL^{-1})	Mg (mgL^{-1})	B (mgL^{-1})
vermicompost	0.48	0.49	1.7	8021	146.75	62.4	275.75	1.26	55.8
BSC	0.08	0.18	-	4242.1	56.9	28.45	57.7	0.111	9.15
Fish compost	0.6	4.6	5.23	4167.9	1002	14.05	84.85	86.16	0.651

vermicompost, BSC, or fish compost) and grouped in four treatments including control (C), sugarcane bagasse sewage sludge-based compost

Table 2
The effects of the applied organic fertilizers including vermicompost, BSC, and fish compost on some parameters related to the germination, growth, and development in vegetative stage.

Treatment	The germination time (Day)	The number of roots	The leaf fresh mass (g)	The number of leaves	The leaf area (Cm^2)	The leaf length (Cm)
C	10.33^{a}	50^{c}	0.24^{c}	77.66^{b}	7.09^{b}	7.6^{ab}
BSC	16.33^{ab}	62.66^{b}	0.3^{b}	78.66^{b}	7.8^{ab}	7.0667^{b}
V	9.66^{a}	77^{a}	0.36^{a}	87.66^{a}	8.9^{a}	8.2^{a}
F	28.33^{b}	25^{d}	0.061^{d}	61.66^{c}	1.9^{c}	3.66^{c}

*Mean values (n = 3); values followed by different letters are significantly different at P < 0.05 according to Duncan's multiple range test.

Table 3
The effects of the applied organic fertilizers including vermicompost, BSC, and fish compost on the compatible solute contents (proline and soluble carbohydrates)

Treatments	root proline contents($\mu g g^{-1}$fw)	leaf proline contents ($\mu g g^{-1}$fw)	root soluble sugar ($mg g^{-1}$fw)	leaf soluble sugars ($mg g^{-1}$fw)
C	144.11^{b}	26.68^{b}	28.16^{bc}	44.1^{b}
BSC	178.42^{b}	98.15^{a}	29.03^{b}	50.13^{a}
V	168.34^{b}	57.746^{ab}	37.2267^{a}	45.98^{ab}
F	363.19^{a}	40.9^{ab}	23.13^{c}	38.0467^{c}

*Mean values (n = 3); values followed by different letters are significantly different at P < 0.05 according to Duncan's multiple range test.

(BSC), vermicompost (V),and fish compost (F) with the growth conditions including mean temperature of 14-15° C and relative humidity of 80 - 85%in a greenhouse located in Pakdasht, Tehran.

Some parameters related to the growth and development in the plant vegetative stage including the numbers of roots and leaves as well asleaf area and fresh weight were measured.

The induced changes by the applied treatments in the plant reproductive stage were evaluated based on the parameters like petal fresh and dry mass, the number of flowers, flower diameter, and the postharvest longevity of cut flowers in distilled water.

Proline contents in the leaf and root tissues were determined according to the method of Bates et al. (1973). Briefly, leaf fresh tissues were weighed and abraded in a mortar with 10 mL sulfasalicylic acid (3%) and the resulting homogenates were centrifuged. Then, 2 mL of the supernatant with 2mL of glacial acetic acid and 2mL of ninhydrin reagent were added and incubated for one hour at 100°C. The reaction was stopped by placing the test tubes on ice. The samples were rigorously mixed with 4 mLtoluene. The absorption of toluene phase was measured at 520 nm using spectrophotometer. The proline concentrations were calculated using a standard curve based proline as standard and expressed in $\mu g g^{-1}$fw.

The extractions of soluble carbohydrates of fresh leaf tissues were done using ethanol 80% (v/v) and total soluble carbohydrate contents were determined according to the method described by Kochert (1978). Glucose was used as a standard.

Ash solution was prepared by the wet ash method. Measurementof K and Ca contents were done by flame photometer and atomic absorption spectroscopy.

The experimental was based on a completely randomized design. Analysis of variance was performed on all data using SPSS software. Duncan test with probability of 0.05 was applied to assess any significant differences between treatments.

Table 4
The effects of the applied organic fertilizers including vermicompost, BSC, and fish compost on K and Ca contents in root and leaf tissues

Treatments	leaf Ca contents ($mgg^{-1}dw$)	root Ca contents ($mgg^{-1}dw$)	leaf K contents ($mgg^{-1}dw$)	root K contents ($mgg^{-1}dw$)
C	4.8^{ab}	5.58^{b}	40.36^{b}	26.2^{b}
B	4.156^{b}	6.68^{a}	43.8^{ab}	37^{a}
V	5.09^{a}	6.47^{a}	46.13^{a}	35.73^{a}
F	1.52^{c}	3.83^{c}	35.066^{c}	17.8667^{c}

*Mean values (n = 3); values followed by different letters are significantly different at P < 0.05 according to Duncan's multiple range test.

Table 5
The effects of the applied organic fertilizers including vermicompost, BSC, and fish compost on some characteristics related to the reproductive stage
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Treatment	number of flowers	blossoming time (Day)	petal fresh weight (g $petal^{-1}$)	petal dry weight ($gpetal^{-1}$)	flower diameter (Cm)	longevity of cut flowers (day)
C	4.66^{a}	84^{a}	6.74^{b}	0.65^{b}	16.067^{c}	7.66^{c}
BSC	5.3^{a}	82.33^{b}	7.54^{ab}	0.7^{b}	17.2^{b}	13.33^{b}
V	4.66^{a}	80.66^{c}	9.31^{a}	0.916^{a}	18.066^{a}	15.33^{a}
F	---	----	---	---	---	-----

*Mean values (n = 3); values followed by different letters are significantly different at P < 0.05 according to Duncan's multiple range test.

Results

The germination process was significantly delayed by the used of fish fertilizer while the observed changes between three other treatment groups were not significant (Table 2). In contrast to fish fertilizer, the application of BSC and especially vermicompost had enhancing effects on the number of roots (Table 2). As it is shown in Table 2, the leaf system was favorably affected by the applied BSC and vermicompost fertilizers but adversely by the fish compost.

Appraisal of the changes induced by the treatments on the organic osmolyte, proline, revealed that the highest amounts of proline contents in root tissues were found in F group whereas the observed differences between the other groups were not significant. In comparison with the control, leaf proline contents in BSC treatment group was significantly more than the othertreatments whereas the increased amounts found in V and F groups were not significant (Table 3).

Application of vermicompost and BSC resulted in the increased soluble sugars in leaf tissues (Table 3). The highest amounts of soluble carbohydrates in root tissues were found in V treatment group, as opposed to F treatment (Table 4). In contrast to the F treatment group, the highest amounts of Ca and K in leaf and root tissues were found in plants treated with V and BSC (Table 4).

In the reproductive stage, the flowering process was significantly inhibited by the usage of fish fertilizer (Table 5). However, the blossoming time was accelerated by the utilization of BSC and especially vermicompost treatments (Table 5).

Supplementation of vermicompost and BSC did not increase the number of produced blossoms in each plant whereas they significantly modified the quality of flowers as reflected by the significantly higher petal fresh and dry mass, flower diameters as well as the promoted vase life of cut flowers (Table 5).

Discussion

The evaluation of the possible impacts of the applied organic fertilizers on different aspects of plant physiology, growth, and development were done based on the various measured parameters in two main stages including vegetative and reproductive. The obtained results indicated that the application of fish fertilizer had the delaying effects on the germination reactions, most probably due to the high EC and/or the presence of toxic elements such as heavy metals. The presence of enhancing factors like humic acid in vermicompost and/or modified microbial population may be involved in germination response. The recorded results reflected that in contrast to the fish fertilizer, BSC and particularly vermicompost had the desirable promoting effects on the leaf and root systems. The increased osmolyte contents, proline and soluble carbohydrates, observed in vermicompost and BSC-treated samples could be attributed to the higher EC, photosynthesis and/or modified metabolism.It is well documented that proline and soluble carbohydrates act as compatible solute. The common physiological reaction of plants to the high EC conditions is osmotic adjustment regulated by the accumulation of free amino acids, proline (a source of nitrogen), and soluble sugars.Assessment of the applied treatments on the plant nutrition showed that the utilization of vermicompost or BSC resulted in improvements in nutrient contents (Ca and k) in leaf and root tissues which are important factors in plant metabolism and postharvest life of cut flowers. In reproductive stage, in spite of the ineffective impacts of the used level of vermicompost and BSC on the numbers of produced flowers on each plant, the blossoming time, qualities of flowers, and postharvest life of cut flowers were significantly modified by the supplementations of vermicompost and BSC fertilizers as indicated by the accelerated blossoming, the higher petal fresh and dry weight, the increased flower diameter, and the promoted longevity of cut flowers.

The presented results obviously showed that the plant vegetative and reproductive stages are affected by the applied treatments. It seems that the induced growth and development observed inBSC and especially V-treated samples were probably caused by the enhanced nutrition, modified microbial growth and reactions, and improved physical and chemical characteristics of the prepared mixture soil. In fact, these led to the promoted qualities of cut flowers, and thereby, extending the longevity of cut flowers which is of importance in horticulture.

Various levels of zinc (Zn) were observed in the applied fertilizers in the study (Tables 1). Zn is one of the most important microelements as well as heavy metals. It is possible that the levels of Zn in the vermicompost and BSC led to the changed metabolism, thereby affecting hormonal balance and stimulating processes like photosynthesis and protein synthesis, whereas its high levels in fish compost may be responsible for the inhibited growth and development of the plants. Zinc is a critical component for the activity of many enzymes as well as the synthesis of tryptophan, a precursor of indole acetic acid (IAA) (Fox and Guerimot, 1998; Ahmed et al., 2012). Involvement of Zn in different vital aspects of plant metabolism including DNA and RNA metabolism, cell division, and protein synthesis is documented by Ahmed et al.(2012). Zinc levels are assumed to affect the levels of endogenous gibberellins in *Zea mays*L. (Sekimoto et al., 1997).

The improved nutrient content was reported in treated lettuce plants resulting from the addition of sugarcane bagasse sewage sludge-based compost (BSC) to peat (Jayasinghe, 2012).Also, vermicompost significantly influenced germination time, flowering capacity, chlorophyll content, and dimensions of the leaves in the treated plants (Bhat and Limaye, 2012). The soils enriched with vermicompost may promote parameters related to the plant growth and productivity like leaf area, plant biomass, and yield (Arancon et al., 2005; Roy et al., 2010). Simultaneous treatmentsof mineral fertilizer and vermicompost have multiple beneficial effects on vegetative growth, biochemical properties, costs, and yield of onion crop and soil fertility (Srivastava et al., 2012). Vermicompost application as a fertilizer displays promoting effects on the plant growth and yield as much as inorganic fertilizers (Muscolo et al., 1999). In addition, soil enzymatic properties, dehydrogenase, b-glucosidase, urease, protease, and cellulose activities, significantly are all influenced by the vermicompost amendment (Marinari et al., 2007; Saha et al., 2008; Romero *et al*., 2010).

Vermicompost, in a similar way to compost, may modify the physicochemical and microbiological characteristics of the culture medium, by which influence plant growth (Sahniet al., 2008). The presence of humic substances, environmentally friendly materials, in the vermicompost may be responsible for restoring the physicochemical characteristics of soil, modifying plant physiology and improving plant growth and development (Arancon et al., 2008; Tejada et al., 2008; Calderín García et al., 2012). Humic substances can affect nutrient availability as well as chemical, biological, and physical soil properties (Khaled and Fawy, 2011). Humic substances via modifying cellular membranes, protein synthesis, enzyme activities, and photosynthesis as well as enhancing microbial growth may improve plant growth and development (Seyed Bagheri, 2010). The microscopic and spectroscopic analysis confirmed that the interaction of humic acid with the radicular system in rice plants led to the activated antioxidant enzymes, thereby reducing the contents of reactive oxygen species and modifying the gene expression (Calderín García et al., 2012). Replacing a portion of various soilswith different levels of vermicomposts from different origins have been resulted in the enhanced germination, growth, and flowering in various conditions in a variety of plants such as marigold (Atiyeh et al., 2001), pepper (Arancon et al., 2004; Aranconet al., 2005), *Lilium* (Ladan Moghadam et al., 2012), strawberries (Singhet al., 2008), onion (Srivastava et al., 2012), and lettuce (Papathanasiouet al., 2012). Utilization of vermicompost as a soil supplement should be promoted as an alternative way of fertilization reducing the risks that are connected with the consumption of leafy vegetables with high nitrate concentrations (Papathanasiou et al., 2012).

In conclusion, according to the obtained results it could be stated that the horticulture utilization of BSC at this level at least does not have detrimental impacts on plant growth and development and even might be promoting. Whereas the application of fish compost, especially originated ones from the sea, may result inthe undesirable inhibiting effects, most probably due to the high electrical conductivity (EC) and toxic metals or products. Based on our analysis, it is possible that the provided levels of Zn by the vermicompost and BSC led to the desirable modified metabolism, whereas its high levels in fish compost in combination with high EC and phytotoxicity of other heavy metals may be responsible for the inhibited growth and development.

Acknowledgements

This study was supported by the Islamic Azad University, Garmsar branch. Authors would like to thank Dr. A.R. Ladan Moghadam for his professional and warming helps.

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