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Full Length Research Paper

Vermicompost induced changes in growth and development of *Lilium* Asiatic hybrid var. Navona

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Organic agriculture minimizes the negative effects of agricultural activities. The present study was carried out in the factorial experiment on the basis of Complete Randomized Design (CRD) with 4 treatments and 3 replications. The vermicompost used was prepared using bovine manure and the earthworm (*Eisenia foetida*). Applied vermicompost levels were V_0 = 0%, V_1 = 10%, V_2 = 20%, V_3 = 30%. The obtained results from the present research indicated that applied vermicompost especially, at 30% level had significantly improving effects on the accumulation of macro nutrients, Ca and K, and micronutrients, Zn and Fe in both stems and root tissues. Applied vermicompost resulted in better growth and development of vermicompost treated plants as they had higher number of leaves, leaf dry mass, fresh stem and dry weight, stem height and diameter, root number and length. Observed increased contents of gibberellic acid in root tissues resulted from the application of vermicompost. Vermicompost treatments at suitable levels of 20 and 30% had stimulating effects on the number of flowers and their diameters and reducing effects on time of flowering. The result of the present study showed that the use of vermicompost, particularly, with a 30% content had favorable results on the growth and development of the *Lilium asiatic* hybrid var. Navona.

Key words: Biofertilizer, flowering, Gibberellins, humic acid, ornamental plant.

INTRODUCTION

Nowadays, according to the importance of environmental issues, more attention is being paid to the substituting of chemical fertilizers with biological ones (Hu and Barker, 1998). Using the biological fertilizers such as vermicomposts increases the quality and sustainability, in addition to preserving of the environment (Kader et al., 2002). Vermicomposts are produced through interactions between earthworms and micro-organisms in the breakdown of organic wastes (Edwards et al., 2010). Depending on the origin, vermicomposts differ in chemical composition (Handreck, 1986). Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, and water-holding capacity (Edwards and Burrows, 1988). Vermicomposts are usually more stable than their parent materials with increased availability of nutrients and improved physio-chemical and microbiological properties (Edwards and Burrows, 1988; Albanell et al., 1988; Orozco et al., 1996; Atiyeh, 2000). Vermicomposts have the same reported benefits as conventional composts such as a source of organic matter, increased moisture-holding capacity, and enhanced nutrient uptake and plant hormone-like activity (Tomati et al., 1988; Galli et al., 1990; Atiyeh et al., 2002; Bachman and Metzger, 2008). Vermicompost is a sustainable source of macro- and micro-nutrients and have a considerable potential for improving plant growth significantly when used as components of horticultural soils or container media (Sahni et al., 2008). Vermicompost is formed from pits with lots of pores with high potential of airing, draining, and water retention which prepares an optimum condition in soil (Atiyeh et al., 2001b). Vermicompost in potting media has no detrimental

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but rather a stimulatory effect on the emergence and root growth of seedlings and has thus, a considerable potential for substituting peat in horticultural potting substrates (Zaller, 2007a, b). Replacing part of the ground soil by different amounts of vermicomposts with different origins leads to increased germination, growth and flowering in laboratory and greenhouse condition in a vast variety of ornamental plants and vegetables such as marigold (Atiyeh et al., 2001a), tomato (Atiyeh et al., 2001b) and pepper (Arancon et al., 2004).

Lilium belongs to the Liliaceae family. Lilies are of special economic importance because they possess big, beautiful and attractive flowers. This plant is known as one of the important bulbous products and has possessed the 7^{th} position among the cut flowers of the world (Varshney et al., 2000).

Despite the proposed enhancing effects of vermicompost, it is stated that high level of it could have inhibiting effect on the plant growth and development, this could be probably due to plant stress by its high soluble salt concentration (Wang et al., 2010). The results of some studies indicated that the application of some levels of vermicompost did not result in significantly increased plant growth and linear relationship between applied vermicompost levels and growth and development of treated plants have not been observed. Atiyeh et al. (2000) reported that lower concentrations of vermin-composts (<50%) into potting mixtures produced greater tomato plant growth and yield effects than the higher concentrations.

High rates of vermicompost substitution may cause adverse effects on plant growth and yield (Arancon et al., 2004). Greater proportions of vermicomposts substituted in growth media have not improved plant growth as much as smaller proportions (Atiyeh et al., 1999, 2000, 2001, 2002). Crop plants are sensitive to the negative effects of vermicompost at early stages of development (Ievinsh, 2011). Vermicompost substitution inhibited seed germination and seedling growth with almost linear decrease of growth with an increasing concentration of vermicopost in the substrate (Ievinsh, 2011). It is suggested that, vermicompost must be applied cautiously for practical purposes of plant propagation (Ievinsh, 2011). Therefore, the determination of considerable growth inducing levels of vermicompost for reducing costs of agriculture is essential. The purpose of this study was to examine the possible impacts of different levels of vermicompost on the growth, developmental and physiological characteristics of *Lilium asiatic* hybrid var. Navona, an important ornamental plant used to obtain the best and economic level of vermicompost for better growth and development.

Table 1. Characteristics of the applied soil before the experiment.

Measured indexes	
Soil tissue	**Loam**
pH	7.5
EC	2.4 dS m^{-1}
N	0.08 (%)
P	75 mgL^{-1}
K	413.2 mgL^{-1}
Fe	10.32 mgL^{-1}
Zn	18.9 mgL^{-1}
Cu	0.98 mgL^{-1}
Mn	2 mgL^{-1}
B	1.04 mgL^{-1}

Table 2. Measured characteristics of the used vermicompost.

Measured indexes	
Soil tissue	**Loam**
pH	7
EC	3.7 dS m^{-1}
Total N	1.84%
P	0.57%
K	0.87%
Ca	8.87%
Fe	950 mgL^{-1}
Zn	348 mgL^{-1}
Mn	325 mgL^{-1}

MATERIALS AND METHODS

The bulb of *L. asiatic* hybrid var. Navona had been purchased through a reliable importer. The choice of genus was done according to the color, market and number of produced flowers on a branch cultivated in Iran. The pot experiment was carried out in a Complete Randomized Design (CRD) with four treatments and three replications. The impact of bovine manure vermicompost at 4 levels (V0 = as a control plants, V_1 = 10%, V_2 = 20%, V_3 = 30%) were studied.

In order to produce the vermicompost, 30 × 50 × 100 cm boxes were prepared and some 25 cm diameter holes were made on them and the bottoms covered with metal net boxer. The boxes were filled with raw material including bovine manure and about 500 g of earthworms (*E. foetida*) and the optimum condition, regarding heat and humidity was met and continued for 4 months and the needed vermicompost for the study was also prepared. The analysis results of the prepared vermicompost were indicated in Table 2.

The experimental design was a complete randomized one with four treatments and three replications. Plants were grouped in 4 treatments including V_0 = as a control plants, V_1 = 10%, V_2 = 20% and V_3 = 30%. Before planting physical and chemical characteristics of vermicompost, soil and used water were examined (Tables 1, 2 and 3).

Nine bulbs with an interval of 15 cm were planted in each pot (40 * 25 * 60). Plants were grown in natural light and at an average temperature of 21.5°C. Plants were harvested after the period of growth and flowering (about 3.5 months). Growth indexes such as height and diameter of stem, diameter of flower, dry and fresh

Table 3. Characteristics of the used water.

Measured indexes	
Soil tissue	**Loam**
pH	7.5
EC	0.045 dS m^{-1}
SAR	0.3 $meqL^{-1}$
LR	0.4 meq L^{-1}
Mg	41 mgL^{-1}
Ca	720 mqL^{-1}
So_4	52.836 mgL^{-1}
Cl	14.2 mg L^{-1}
HCo_3^{-1}	164 mg L^{-1}
$CO3^{-2}$	0 mg L^{-1}

SAR: Sodium absorbation rate; LR: Leaching requirement.

weight of stem, number of flowers and some other physiological characteristics including amount of Fe, Zn, Ca and K of stem and root, and gibberellins (GA) content of root were measured at the end of the growth period.

Ash solution was prepared by wet ash method. Determination by atomic absorption spectroscopy, Varian specter-AA200 was used to measure the elements, Fe, Zn, Ca and K. Finally, the concentration of each element was measured per each gram of dry mass.

Gibberellic acid (GA) concentration was measured as previously described by Shengjie et al. (2008). A solid-phase extraction (SPE) pre-treatment method was used to concentrate and purify hormones from plant samples. 1 g of fresh tissue was put in the solution of methanol, water and acetic acid with a proportion of (30: 70: 1) and the solution was homogenized by homogenizer. The supernatant was separated with centrifuge and after being placed in SPE column C18, the solution of ethanol, water, acetic acid with the proportion of (80: 20: 1) was used. This solution was dried, resolved in methanol and used for the determination of GA content. The separation was carried out on a C_{18} reversed-phase column, using methanol/water containing 0.2% formic acid (50: 50, v/v) as the isocratic mobile phase at the flow-rate of 1.0 ml min^{-1}.

Analysis of variance was performed on all data sets. Duncan test with a probability of 0.05 was used to show significant differences between treatments. All data are presented as mean±SE.

RESULTS

The applied vermicompost especially, at 30% level had significantly improving effects on the accumulation of macro-nutrients, Ca and K in root and stem tissues (Figures 1 and 2). The effect of application of vermicompost on Fe and Zn content of stem tissues was significant (Figures 3 and 4) where the highest amounts of them were detected at 30% level of applied treatments. Applied vermicompost especially, at 20 and 30% had significantly enhancing effects on the Fe and Zn contents of root tissues (Figures 3 and 4).

The application of vermicompost especially, at 20 and 30% treatments resulted in significantly increased root number and length as they shown in Figures 5 and 6.

Application of vermicompost resulted in improved GA contents of root tissues with the highest observed amount at 30% treatment (Figure 7).

Based on our results, the effect of vermicompost on the stem height, diameter and dry weight was significant (Figures 8, 9 and 10). The highest amounts of them were found at 30% vermicompost treatment.

All used levels of veremicompost at 10, 20 and 30% respectively, had significantly enhancing effects on the number of leaves (Figure 11). The applied treatments of 20 and 30% respectively, had significantly increasing effects on leaf dry mass (Figure 12).

The stimulating effect of applied vermicompost on the number of flower was observed only at 30% level of significance (Figure 14). The results indicated that impact of vermicompost on flower diameter was significant (Figure 13). Flower diameter in V_2 and V_3 treatment groups was significantly increased (Figure 13). The time of flowering was significantly reduced by the application of 30% vermicompost (Figure 15).

DISCUSSION

The obtained results from the present research indicated that the applied vermicompost especially, at 30% level of significance had significantly improving effects on the accumulation of macro nutrients, Ca and K, and micronutrients, Zn and Fe in both stem and root tissues. It could result from vermicompost containing humic acid and minerals in suitable and available forms and vermicompost-induced changes in root system and metabolism.

It is recorded that compared to conventional composts, vermicompost was 40 to 60% richer in humic compounds (Dominguez et al., 1997). Humic acid increases nutrient accumulation in conditions of limited nutrient availability (David et al., 1994). Treatment with humic acids derived from vermicompost enhanced growth of tomato and cucumber (Atiyeh et al., 2002). Treatments with vermin-compost showed increased accumulation of N, P, K, S, Mn and Fe in chickpea seedlings (Sahni et al., 2008). Vermicomposts contain nutrients in forms that are readily taken up by the plants such as nitrates, exchange-able phosphorus and soluble potassium, calcium, and magnesium (Edwards and Burrows, 1988; Orozco et al., 1996; Atiyeh, 2001). The high nitrate content of the mature vermicompost (Atiyeh, 2001) and presence of available forms of minerals led to enhanced growth of tomato plants in vermicompost derived from pig wastes (Atiyeh et al., 1999).

At the present research, the application of vermin-compost resulted in induced morphological changes of root and increased GA content of root tissues. The observed changes in root system could be as a result of induced hormonal changes, especially, GA, the hormone-like activities of vermicompost and improved nutrition. In addition to GA effect on root system, it could affect

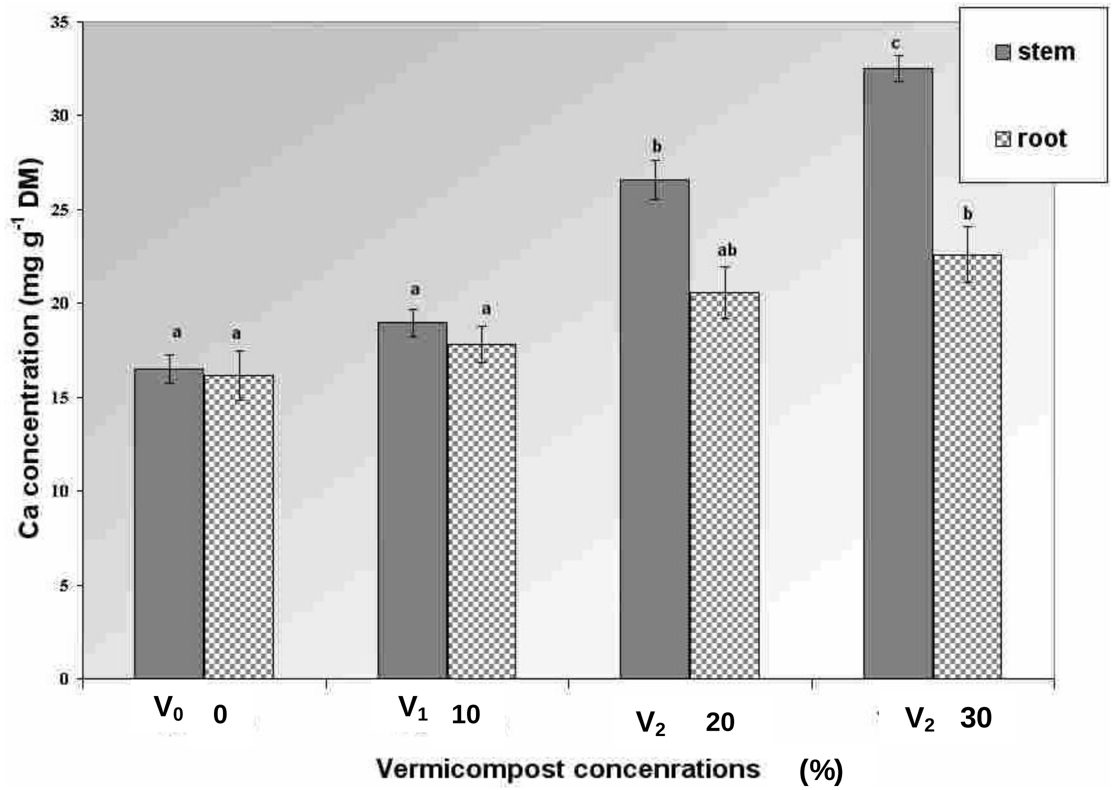

Figure 1. The effect of different levels of vermicompost on the Ca content of stem and root tissues ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

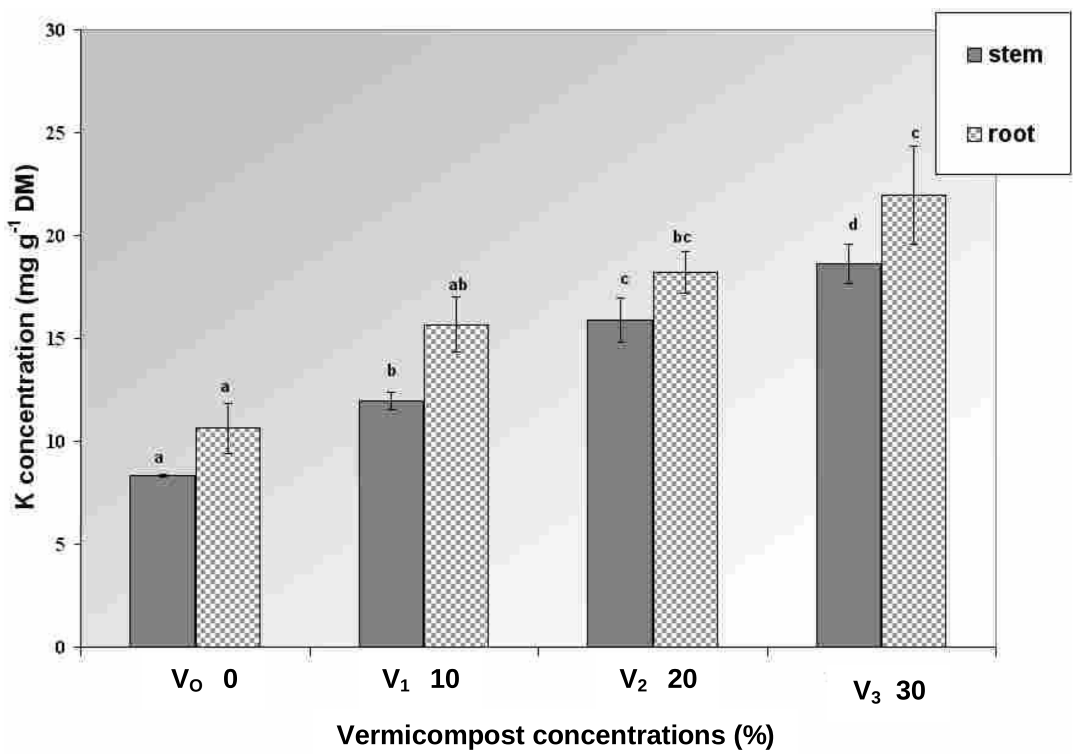

Figure 2. The effect of different levels of vermicompost on the K content of stem and root tissues ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

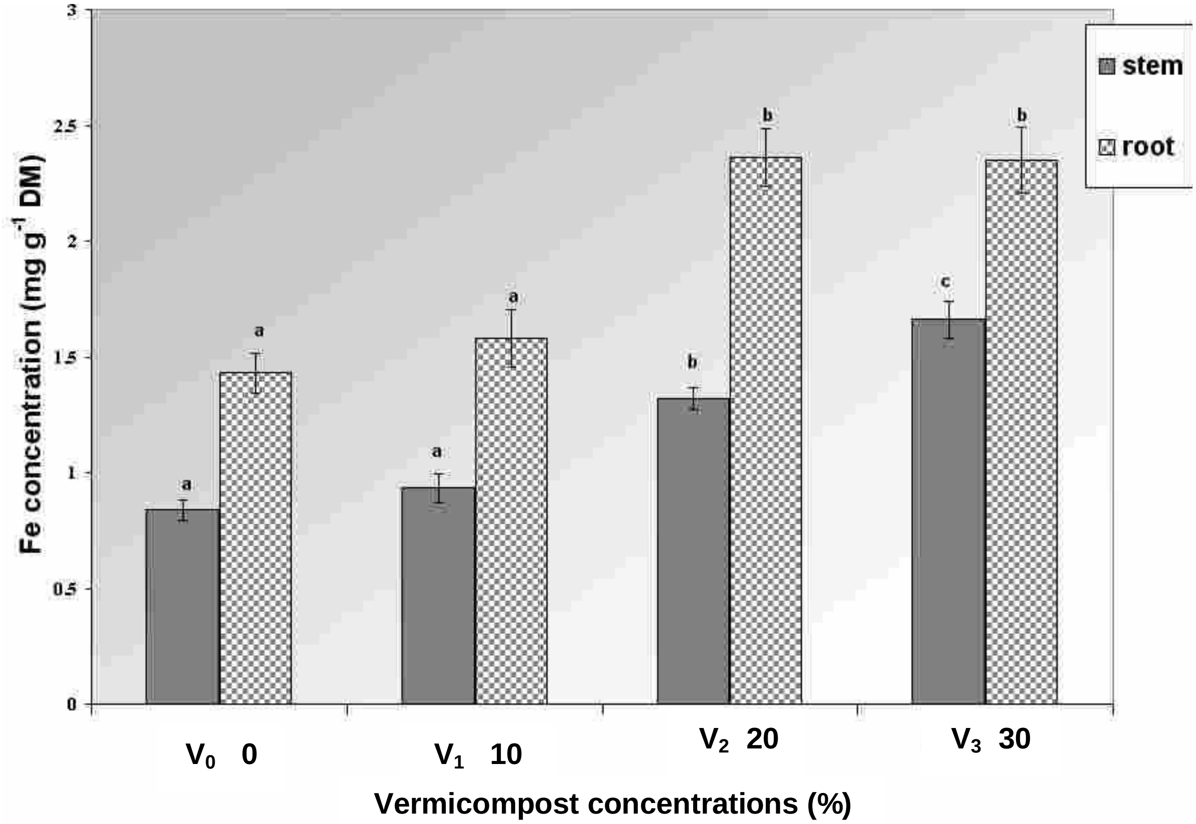

Figure 3. The effect of different levels of vermicompost on the Fe content of stem and root tissues ($\bar{X}$ ± SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

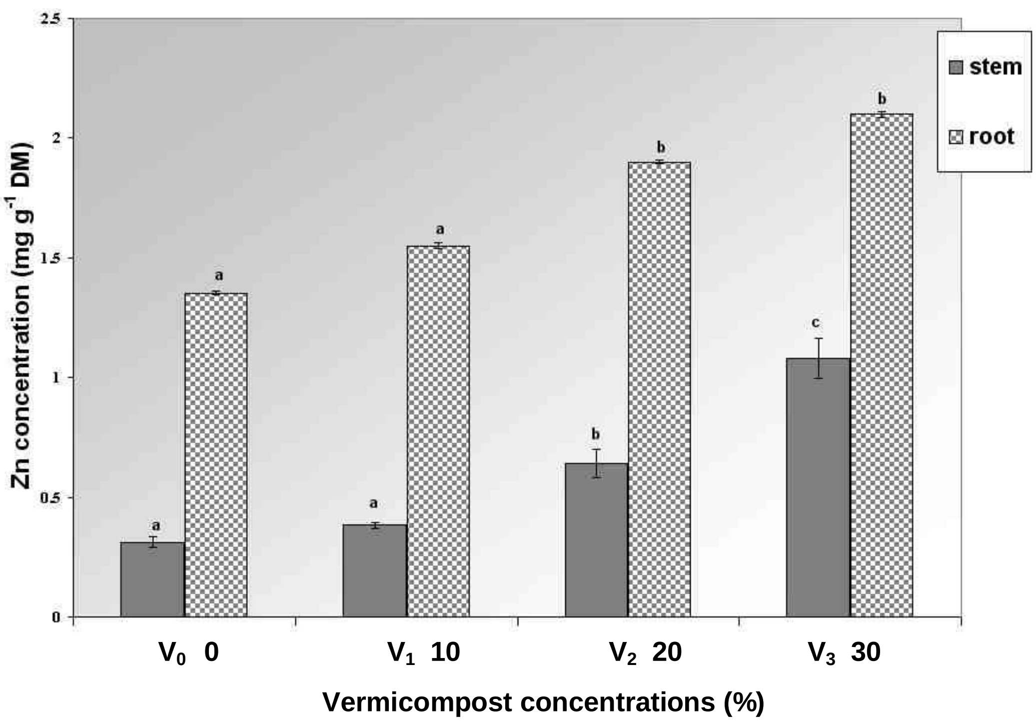

Figure 4. The effect of different levels of vermicompost on the Zn content of stem and root tissues ($\bar{X}$ ± SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

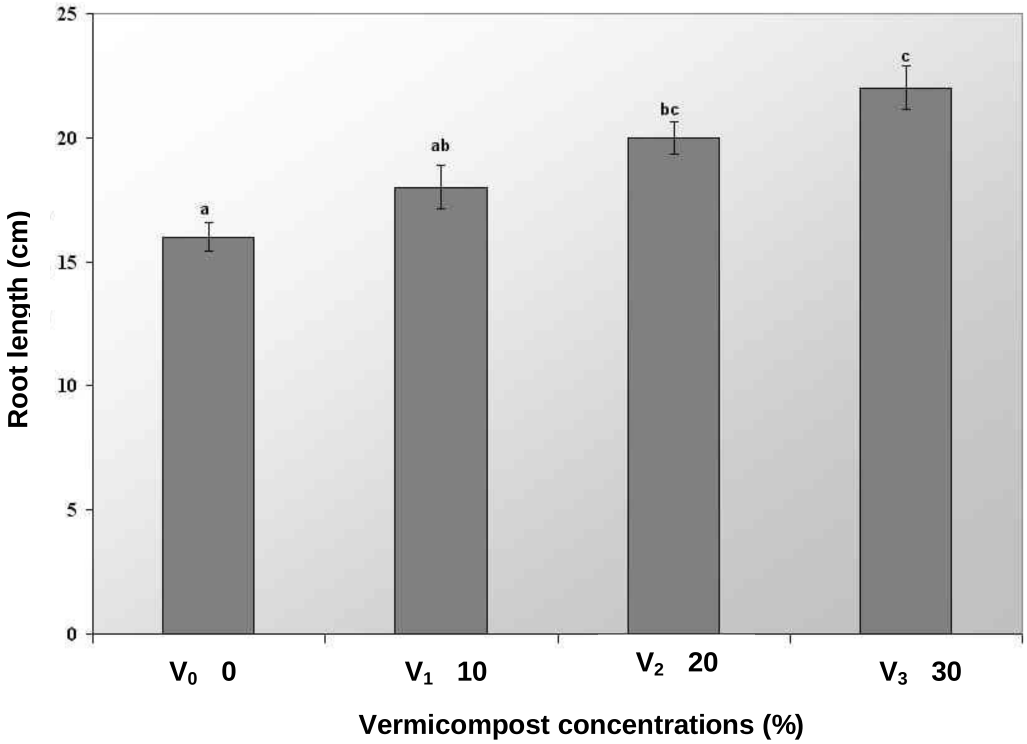

Figure 5. The effect of different levels of vermicompost on the root length ($\bar{X}$ ± SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

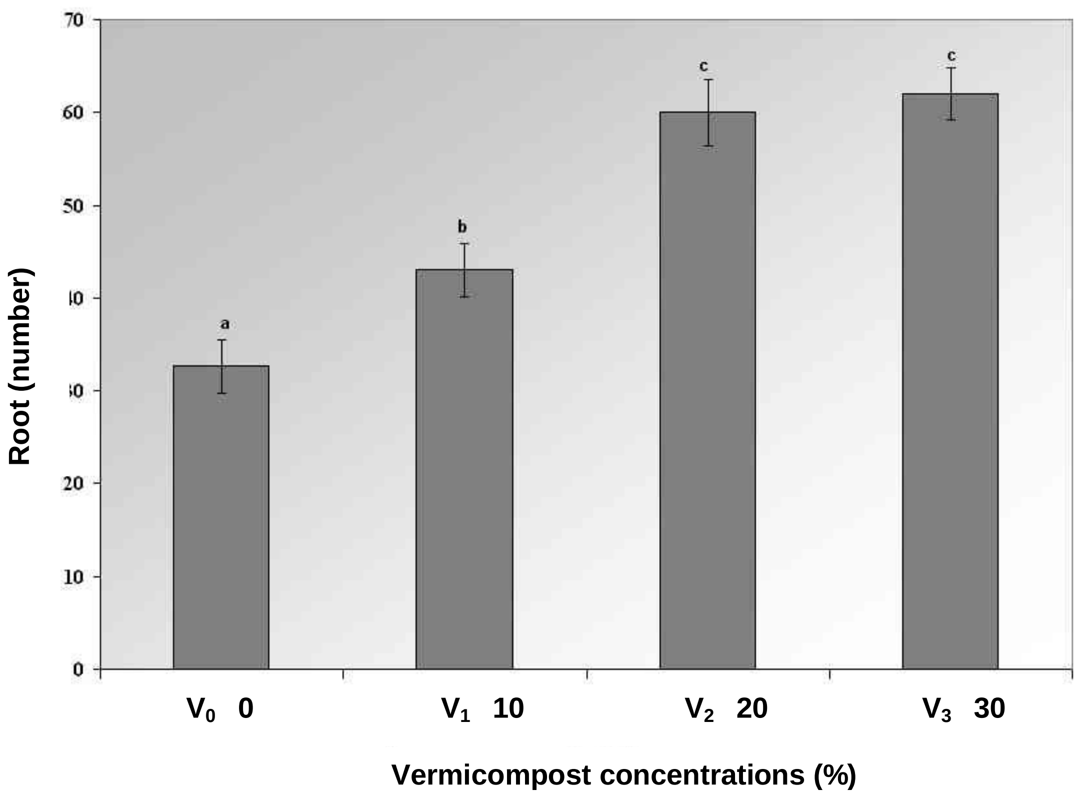

Figure 6. The effect of different levels of vermicompost on the number of root ($\bar{X}$ ± SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

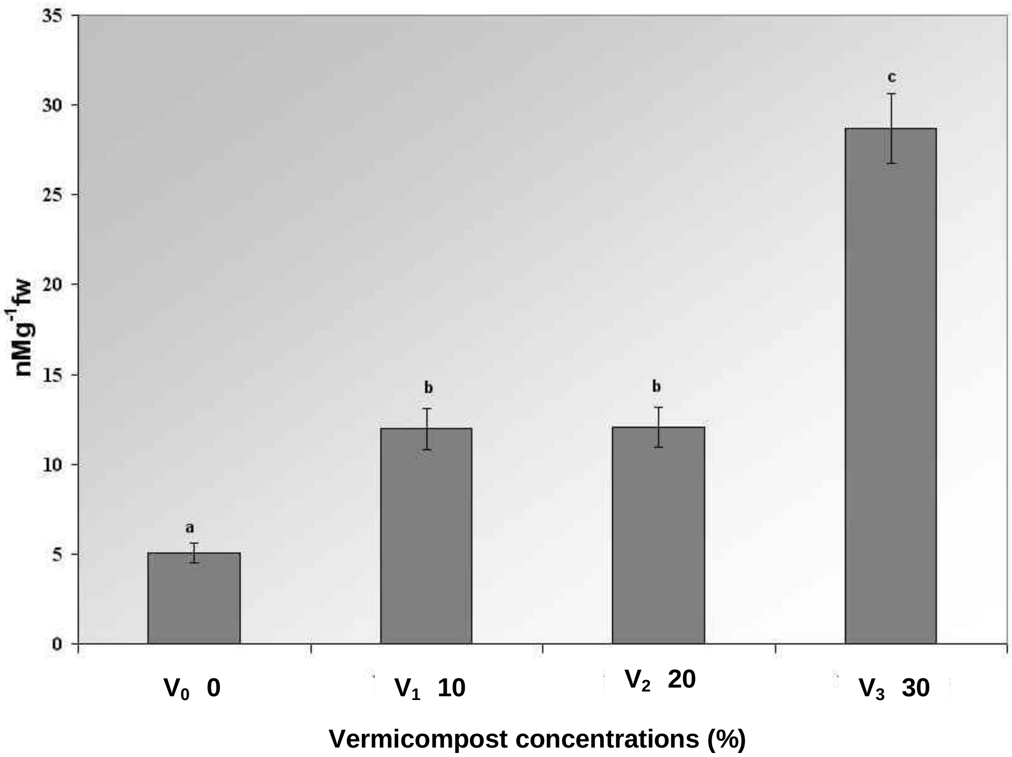

Figure 7. The effect of different levels of vermicompost on the GA content of root tissues ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

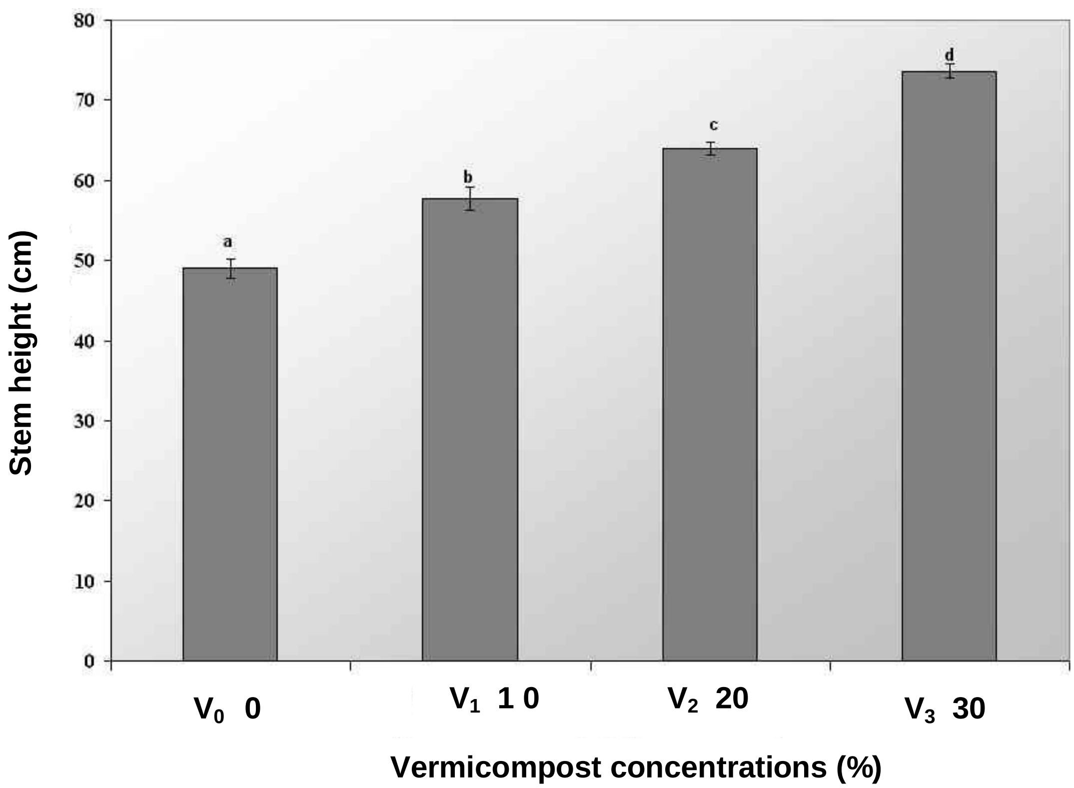

Figure 8. The effect of different levels of vermicompost on stem height ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

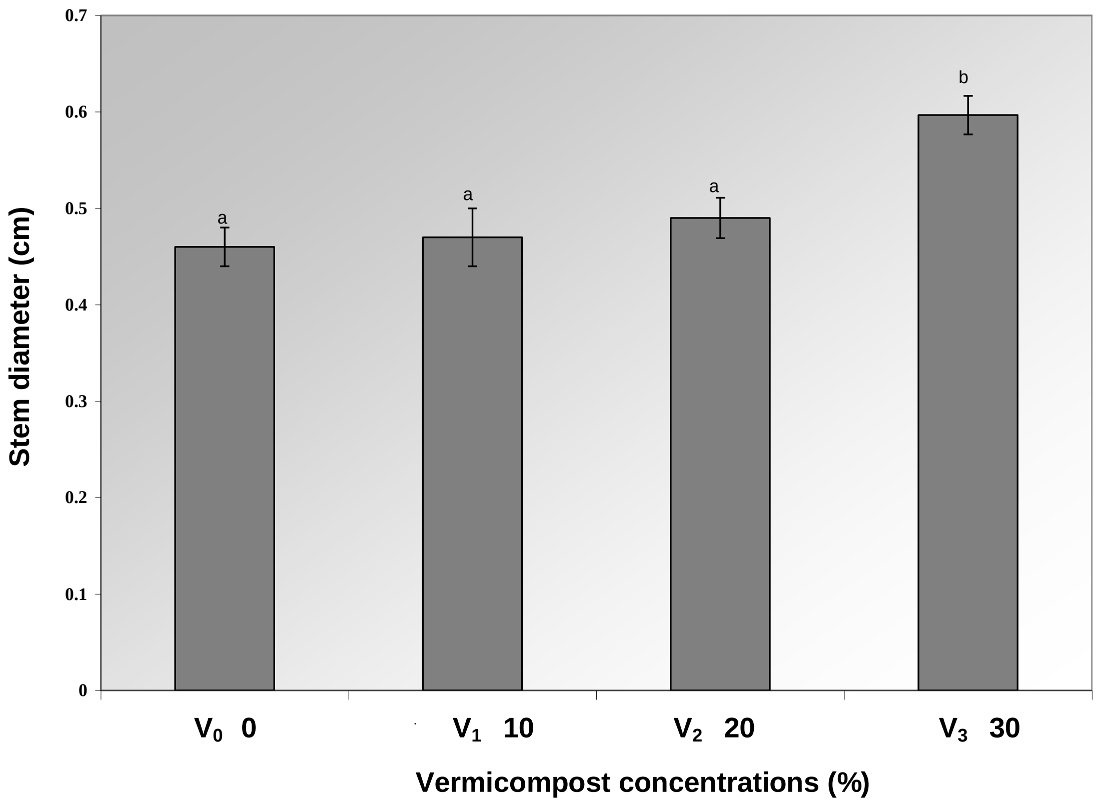

Figure 9. The effect of different levels of vermicompost on stem Diameter ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

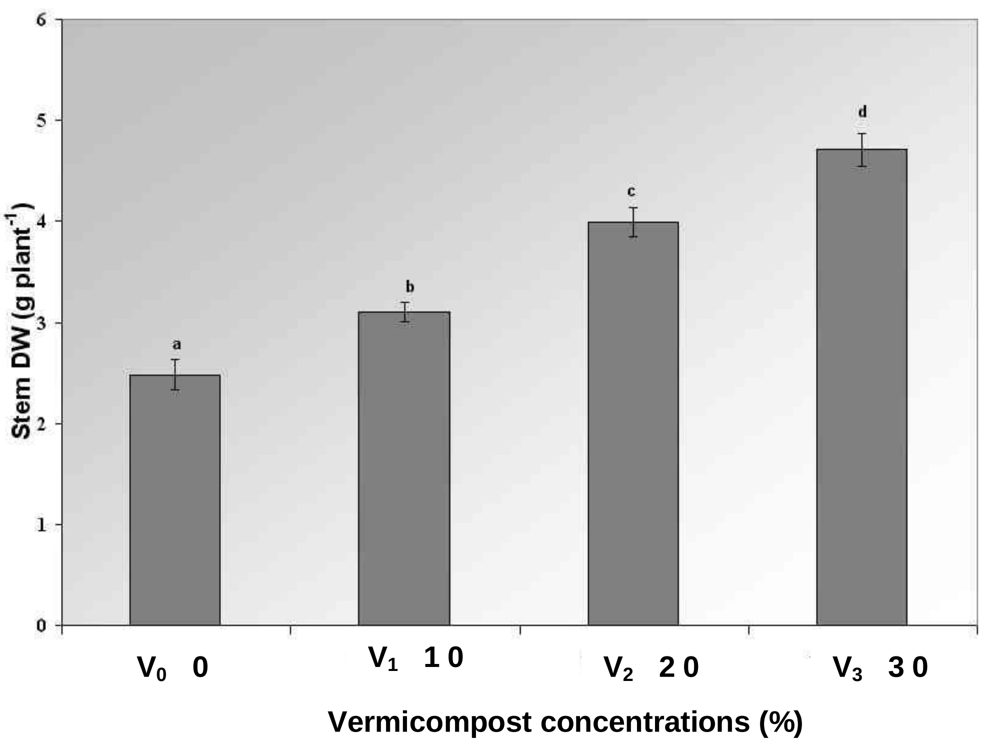

Figure10. The effect of different levels of vermicompost on stem dry mass ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

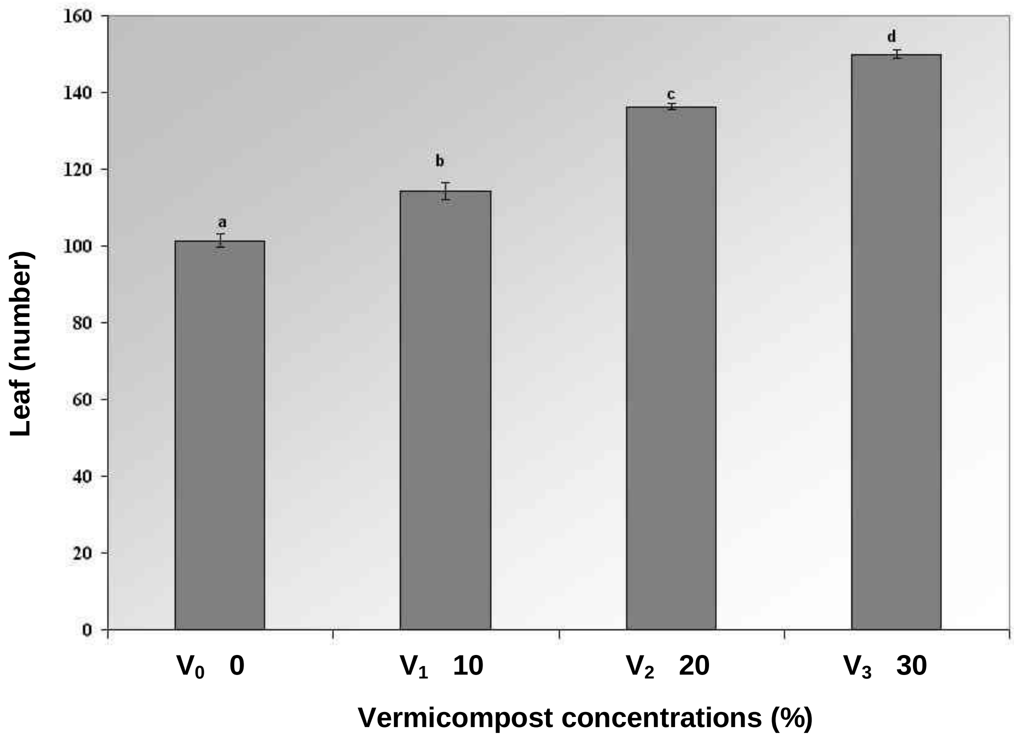

Figure 11. The effect of different levels of vermicompost on the number of leaves ($\bar{X}$ ±SE) in *Lilium* Navona*.* The vertical bars indicate standard errors of three replications.

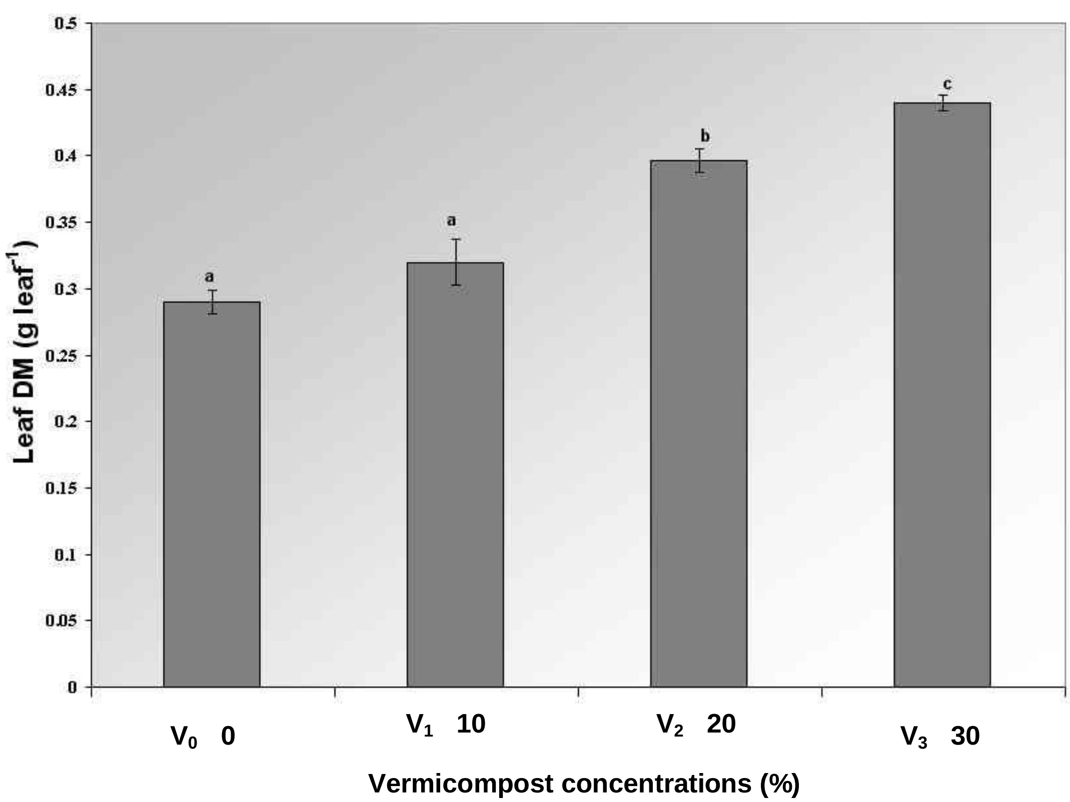

Figure 12. The effect of different levels of vermicompost on the leaf dry mass ($\bar{X}$ ±SE) in *Lilium* Navona*.* The vertical bars indicate standard errors of three replications.

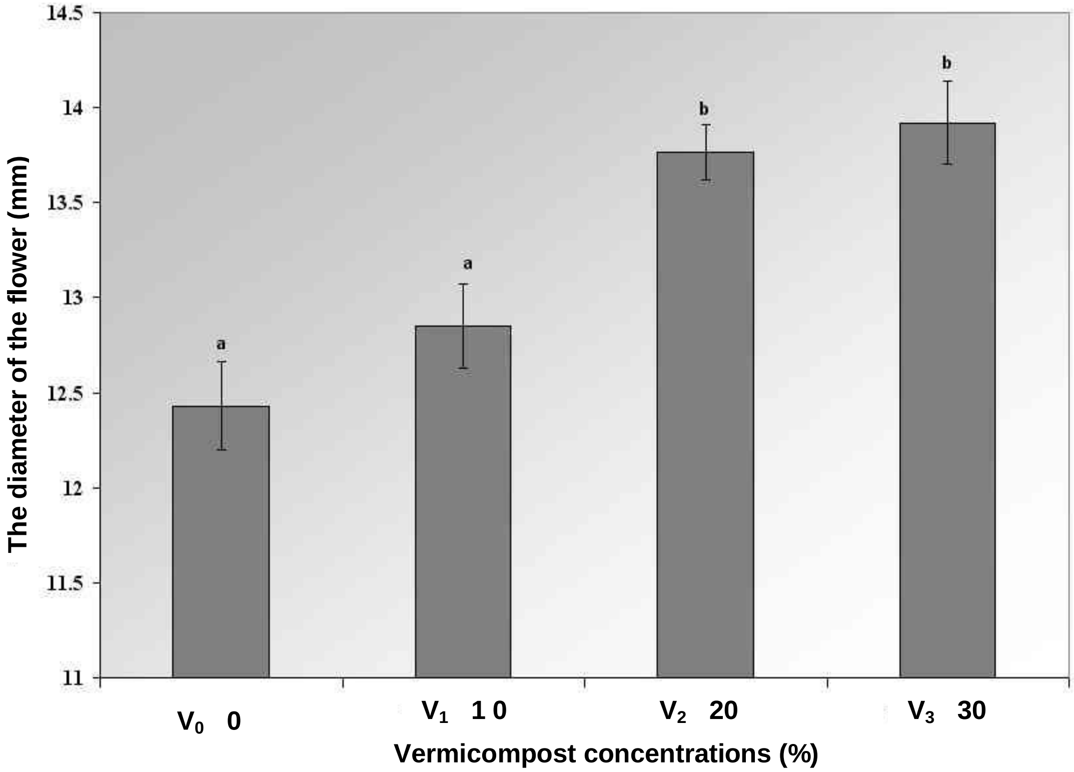

Figure 13. The effect of different levels of vermicompost on the flower diameter ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

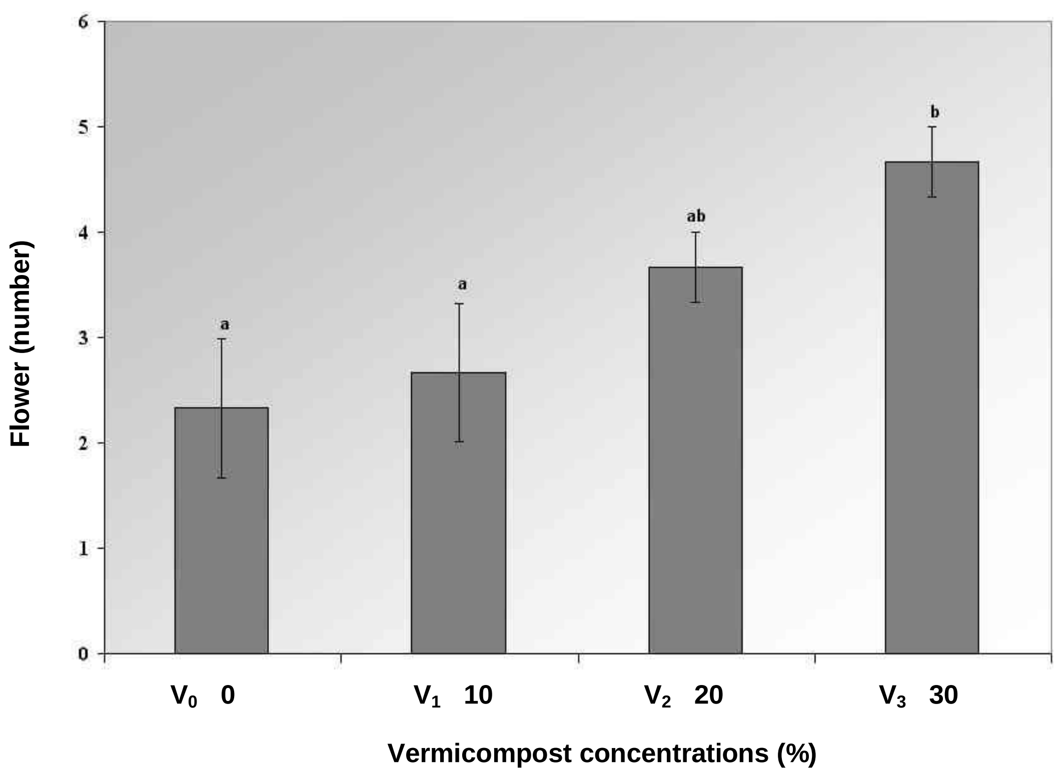

Figure 14. The effect of different levels of vermicompost on the number of flowers ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

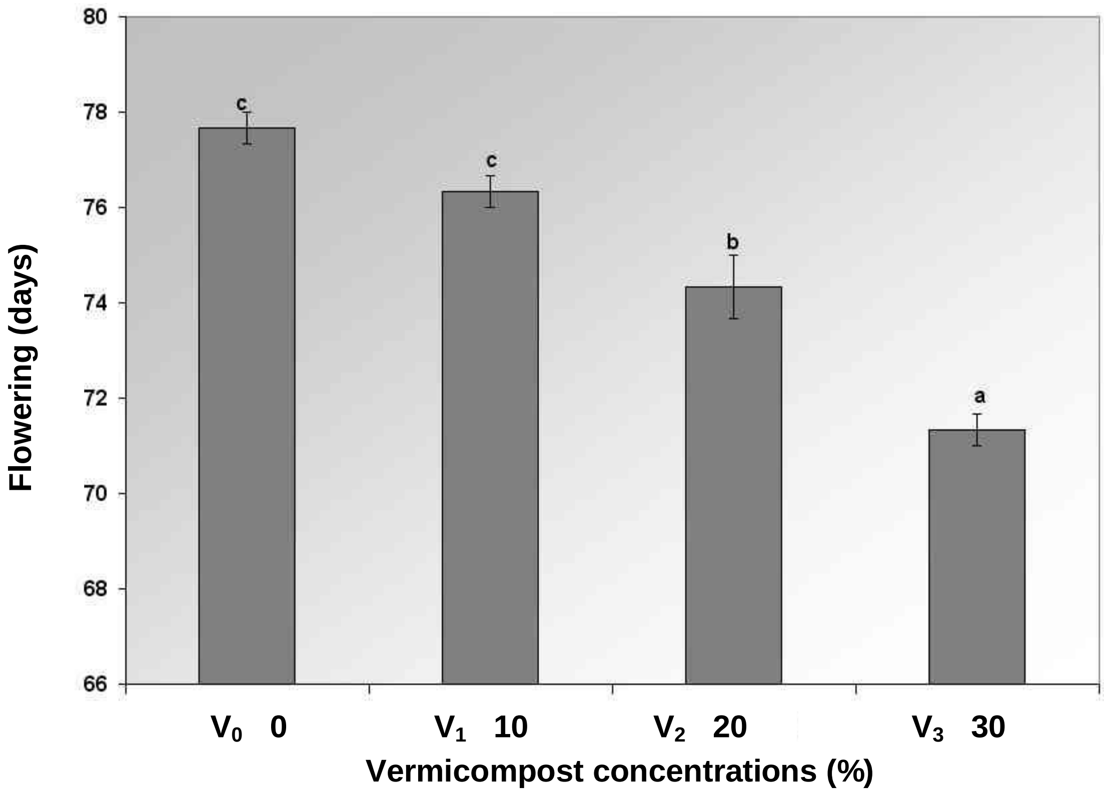

Figure 15. The effect of different levels of vermicompost on the time of flowering ($\bar{X}$ ±SE) in *Lilium* Navona. The vertical bars indicate standard errors of three replications.

growth and development of shoot tissues. The alteration in different aspect of cellular metabolisms including content of phytohormones could be arising from the different compounds present in the used vermicompost.

It is proposed that the humic acid present in vermicompost may affect biochemical processes in plants (Sahni et al., 2008). Applications of vermicompost significantly increased the contents of vitamin C, phenols and flavonoids of treated plants (Wang et al., 2010). The gibberellic acid (GA) is involved in many aspects of development throughout the life-cycle of higher plants. They also mediate certain environmental effects on plant development (Hedden, 1999). Gibberellins (GAs) are signaling molecules that regulate and integrate developmental processes during the entire life-cycle of higher plants, including shoot elongation and root development (Lange et al., 2005).There is growing evidence for the presence of root based GA biosynthesis from many plant species, including pumpkin, pea, Arabidopsis and rice (Lange et al., 2005). GA biosynthesis and signaling is limited to the root tip (Kaneko et al., 2003). One of the highest GA1 expressions was observed in root tips (Silverstone et al., 1997). Regulation of gibberellin (GA) biosynthesis by endogenous and environmental stimuli is an important factor in the control of plant morphogenesis (Hedden, 1999). It has been shown that GA promotes root growth in Arabidopsis (Lange et al., 2005). GA signaling may enable integration of aerial and root development (Gou et al., 2010). The hormone-like activities of vermicompost leads to increased rooting, root biomass, plant growth and development (Edwards, 1983, Satchell et al., 1984; Edwards et al., 1985; Tomati et al., 1988; Sainz et al., 1998; Bachman and Metzger, 2008). Vermicompost shows hormone-like activity and increased the number of roots, and consequently, improved nutrient uptake and plant growth and development (Alvarez and Grigera, 2005). Humic acids isolated from earthworm compost enhanced root elongation, lateral root emergence, and H+-ATPase activity of the plasma membrane of maize roots (Canellas et al., 2002).

The obtained results from the present research indicated that the application of the used vermicompost led to better growth and development of vermicompost treated plants as they were shown with higher number of leaves, leaf dry mass, fresh stem and dry mass, stem height and diameter, root number and length. The increased number of leaves induced by the applied vermicompost could lead to stimulated photosynthesis and increased leaf dry mass. Thus, the observed enhanced growth and development in vermicompost treated plants, especially, at 20 and 30% level of significance could result from the improved nutrition, stimulated rooting, induced changes of metabolic process and humic acid present in vermicompost.

The application of vermicompost increased plant leaf area, dry matter and total fruit yield in strawberries (Singh et al., 2008). Sheep-manure vermicompost as a soil supplement increased plant heights significantly (Gutiérrez-Miceli et al., 2007). Vermicompost treated plants had increased leaf area and biomass, especially, in the 10% vermicompost: soil mix (Warman and AngLopez, 2010). The enhancement of the marketable weight, leaf numbers and leaf areas by vermicompost treatments may be due to the plant growth regulators and humic acids present in the vermicompost (Wang et al., 2010).

Study on the effects of different levels of vermicompost on the time of flowering and flowers revealed that vermicompost treatments at suitable levels of 20 and 30% respectively, had improving effects on the number of flowers and their diameter and reducing effects on the time of flowering. More GA content, enhanced root system, stimulated development shown by increased number of leaves, improved photosynthesis which is concluded from more dry mass, and better nutritional status due to the applied vermicompost at optimal concentrations could lead to improved and accelerated flowering, as it was indicated by induced flower numbers and reduced time of flowering.

Incorporation of vermicompost of pig manure origin into germination media up to 20% v/v enhanced shoot and root mass, leaf area, and shoot: root ratios of both tomato and French marigold seedlings (Bachman and Metzger, 2008). Enhancement in plant growth was attributed to modifications in soil structure, access to water, increased availability of macro and micro nutrient elements, stimulation of microbial activity, augmentation of the activities of critical enzymes, or production of plant growth-promoting substances by micro-organisms (Atiyeh et al., 2001; Sahni et al., 2008). It is possible that vermicompost, in a similar way to compost, can affect plant growth by modifying the physio-chemical and microbiological characteristics of the plant growth medium (Sahni et al., 2008). Anwar et al. (2005) stated that vermicompost not only increases the availability of nutrient elements needed by plant, but also provides an optimum condition of growth and availability of nutrients by improving physical condition and functions of micro-organisms. The enhancement of plant growth by mature vermicompost may not only be nutritional but may also be due to its content of biologically-active plant growth influencing substances (Atiyeh et al., 1999; Arancon et al., 2004; Warman and AngLopez, 2010). Foliar application of vermicompost leachates improved the growth parameters like leaf area and dry weight of strawberry because of the presence of humic acid (Singh et al., 2010). The results of the current study matched with the results of vermicompost effects in red clover, barley (Krishnamoorthy and Vajrabhiah, 1986), tomato (Zaller, 2007a, b) and papaya (Shivaputra et al., 2004).

However, the best results of the applied vermicompost were found in V_3 group (30%), the observed differences between V_2 (20%) and V_3 (30%) treatment groups were not considerable. As It was proposed that high level of vermicompost have inhibiting effects on plant growth and development and the applied vermicompost has high EC, therefore, it does not seem that the application of 40% vermicompost would result in better economic results than that of the 30%. Thus, according to the findings of the present research, it can be stated that using vermicomposts up to 30% level, is optimum and economic to producing *Lilium* Navona. This level of vermicompost could be examined for organic planting.

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