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The influence of vermicompost on the growth and productivity of cymbidiums

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ABSTRACT
The effects of cattle manure vermicompost on the growth and productivity of cymbidium (*Cymbidium* sp.) plants were evaluated under shade conditions. Cymbidium was grown in a container medium including 50% pumice, 30% charcoal, 10% vermiculite and 10% peat moss, which was basic plant growth medium substituted with 10%, 20%, 30% and 40% (by volume) vermicompost. The control consisted of container medium alone without vermicompost. Plants were supplied regularly with a complete mineral nutrient solution. The greatest vegetative growth resulted from substitution of container medium with 30% and 40% vermicompost, and the lowest growth was in the potting mixtures containing 0% vermicompost. Most flower buds and inflorescences occurred in the potting mixture containing 30% and 40% vermicompost, and the greatest length of inflorescences was observed in 30% vermicompost. Cymbidium grown in a container medium substituted with 30% and 40% had the most and greatest number of flowers. Some of the cymbidium growth and productivity enhancement, resulting from substitution of container medium with vermicompost, may be explained by nutritional factors; however, other factors, such as plant- growth-regulators and humates, might have also been involved since all plants were supplied regularly with all required nutrients.

Keywords: *Cymbidium, Flowering, Humates, Nutritional factors, Vermicompost.*

INTRODUCTION
Utilization of earthworms to break down organic wastes is gaining increasing popularity in different parts of the world. During ingestion, the earthworms fragment the waste substrate, accelerate the rate of decomposition of organic matter, and alter the physical and chemical properties of the material, leading to an effect similar to composting in which the unstable organic matter is oxidized and stabilized aerobically. The final product, named vermicompost, which is obtained as a result of such transformations, is very different from the original waste material, mainly because of the increased decomposition and humification. Compared to their parent materials, vermicomposts have less soluble salts, greater cation exchange capacity, and increased total humic acid contents (Atiyeh *et al*. 2002).

Humic acid (HA) has beneficial effects on nutrient uptake by plants, and was particularly important for the transport and availability of micronutrients (Nikbakht *et al.* 2008). Nikbakht *et al.* (2008) suggested that humic acid application in gerbera was not significant on K accumulation in scapes (peduncles). The effect of HA applications on Mg content of leaf and scape samples was highly significant and increased Ca accumulation in the leaf. Hypotheses which account for the stimulatory effects of HA are numerous, the most convincing of which is a direct action on the plant, which is hormonal in nature, together with an indirect action on the metabolism of microorganisms and the dynamics of uptake of soil nutrients, substrate physical conditions through positive effects on seed germination, seedling growth, root growth and shoot development (Atiyeh *et al.* 2002, Nikbakht *et al.* 2008). They contain nutrients in forms that are taken up by the plants readily, such as nitrates, exchangeable phosphorus, and soluble potassium, calcium, and magnesium (Atiyeh *et al.* 2002).

In recent years, vermicompost effects were investigated by researchers, and influences of type and concentration of vermicompost were reported on diverse plant species (Table 1). Smith *et al.* (1999) found that the exchangeable calcium and base saturation of the soils were increased in 200 mm of surface soil by the application of vermicompost, and it was more effective than compost in increasing exchangeable Ca values although the compost contained significantly more Ca than the vermicompost. Vermicomposts are finely divided peat-like materials with high porosity, good aeration, drainage, water holding capacity and very high microbial activity, which make them excellent as soil amendments or conditioners and as plant growth media (Arancon *et al.* 2008). Singh et al. (2008) reported higher fruit yield of strawberry plants in vermicompost treatment than those receiving inorganic fertilizer only. Based on these physical, chemical and biological characteristics, vermicomposts have considerable comme-rcial potential in the horticultural industry as container media for growing vegetable and bedding ornamental plants.

The objective of this experiment was to compare the growth and flowering characteristics of cymbidium orchid (*Cymbidium* sp.) plants, grown in the basic plant growth medium (BPGM) substituted with a range of different concentrations of cattle manure vermicompost under greenhouse conditions. To eliminate nutrient limitations on growth, the cymbidium plants in all of the potting mixtures were watered daily with a complete plant nutrient solution.

Table 1. Effects of type and concentrations of vermicompost (VC) on the various plant species.

Sources of vermicompost	Plant species	Influences	References
Cattle manure	*Petunia* sp.	Number of germinated seeds was increased in 90% VC as compared with less than 40% VC	Arancon *et al.* (2008)
Food waste	*Petunia* sp.	Number of germinated seeds was higher than 0% VC in 50 to 100% VC	Arancon *et al.* (2008)
Paper waste	*Petunia* sp.	Number of germinated seeds was increased when was added VC to planting beds	Arancon *et al.* (2008)
Cattle manure	*Petunia* sp.	Shoot and root dry weights were more in 40% VC as compared with lower and higher concentrations	Arancon *et al.* (2008)
Food waste	*Petunia* sp.	Shoot and root dry weights were more in 40% VC as compared with lower and higher concentrations	Arancon *et al.* (2008)
Paper waste	*Petunia* sp.	Shoot and root dry weights were more in 30% VC as compared with lower and higher concentrations	Arancon *et al.* (2008)
Pig manure	*Tagetes patula*	Shoot weight, total number of flower were higher in 40% VC than 10-50% and 0-30% VC	Atiyeh *et al*. (2002)
	Lycopersicon esculentum Mill.	Shoot length, shoot dry weight and number of leaves were increased with 25-100% VC as compared with 0-10% VC when it used no fertilizer	Atiyeh *et al.* (2001)

Table 1 Continued:

	'Queen Sophia' French marigold	Shoot and root dry weight and leaf area was more in 10% as compared with 0 and 20%	Bachman and Metzger (2008)
	'Rutgers' tomato	Shoot and root dry weight and leaf area was more in 20% as compared with 0 and 10%	Bachman and Metzger (2008)
	'California Wonder' pepper	Shoot and root dry weight and leaf area was more in 0% as compared with 10 and 20%	Bachman and Metzger (2008)
	'Imperial' cornflower	The addition of VC (10 and 20%) to beds didn't have any effect as compared with controls	Bachman and Metzger (2008)
Sheep manure	*Zea mays*	The VC increased the mycrrrohization of maize roots in 5% but inhibited it in 10%	Gutiérrez-Miceli *et al.* (2008)
Vegetable waste and cow dung	*Fragaria* X *ananassa* Duch.	More concentrations of VC as compared with inorganic nutrients decreased days to flowering and increased number of fruits/plant individual berry weight and total fruit yield.	Singh *et al.* (2008)
Water hyacinth	*Crossandra Crassipes* Mart. Solms.	All of growth factors (e.g. plant height, root length, harvest index, length of the inflorescence were higher in plants were treated with VC as compared with compost and control	Gajalakshmi and Abbasi (2002)

MATERIALS AND METHODS

The experimental design used was a completely randomized design (CRD) with 5 treatments replicated six times. The basic plant growth medium was 50% pumice, 30% charcoal, 10% vermiculite, and 10% peat moss by volume that was mixed completely. Thirty grown cymbidium orchid (*Cymbidium* sp.) plants were planted into the plastic pots that had small holes in their bottom and sides containing either 100% (control), 90, 80, 70 or 60% basic plant growth medium substituted with 0, 10, 20, 30 or 40% (by volume) cattle manure vermicomposts. The cattle manure vermicompost was provided by Behparvar Taksir (Tehran, Iran) and consisted of separated cattle solids processed by earthworms (*Eisenia fetida*) in indoor beds. The basic chemical properties of the cattle manure vermicompost was analyzed by the mentioned company and was taken from its catalog and are summarized in Table 2.

Table 2. Chemical properties of the cattle manure vermicompost

	Cattle manure vermicompost
Electrical conductivity (ds m^{-1})	9.5
pH	7.6
Organic C (%)	29.41
Total N (%)	1.83
P (%)	0.66
K (%)	0.85
Ca (%)	2.8
C/N	16
Mg (%)	2.5
Cu (mg/kg)	23
Zn (mg/kg)	92
Fe (mg/kg)	5825
Mn (mg/kg)	424.3

Plants were watered daily with tap water and fertilized with 200 mg N l^{-1} (20N-10P-20K) to provide all BPGM/vermicompost mixtures and the control with all the necessary nutrients. The plant growth experiment was conducted in a greenhouse of the Floriculture and Landscape Association (Baharestan-E-Moj, Anzali Port, Guilan Province, Islamic Republic of Iran). Observations on leaf area (cm^2) were recorded on six plants from each replicate at 0, 2, 4 or 6 and 6 weeks after first measurement, and these were terminated when plants reached the flowering stage. First measurement was two weeks after vermicompost treatment. For recording leaf area, five full grown young leaves were removed from each plant and passed through leaf area meter (Sing *et al.* 2008).

Data of leaf area is mean of 30 leaves in each treatment. Number of backbulbs (backbulbs of cymbidium orchid termed to the green bulbs on the surface of pot substrate) was recorded at the end of the flowering period. Data were analyzed statistically by one-way ANOVA in MSTATC software with the "vermicompost concentration" as the main factor. For each measured parameter, the means were separated statistically using Tukey's test. Significance was defined as $P \leq 0.05$, unless indicated otherwise.

RESULTS

Leaf area for the 30% and 40% vermicompost was significantly (Fig. 1, $P \leq 0.05$) greater than the control (BPGM) in the first stage of measurement (0^{th} week). Leaf area was greater in the 30% and 40% vermicompost compared to the control and 10% vermicompost, respectively, and was not significantly different from the treatment with 20% vermicompost in the second week of measurement (Fig. 1). In the fourth week, significantly greater leaf area was in the 30% and 10% vermicompost groups that was significantly different (Fig. 1, $P \leq 0.05$) from the 20%, control and 40% groups. Leaf area for the 10%, control (BPGM) and 20% vermicompost was significantly (Fig. 1, $P \leq 0.05$) greater than both the 40% and 30% vermicompost groups in the sixth week.

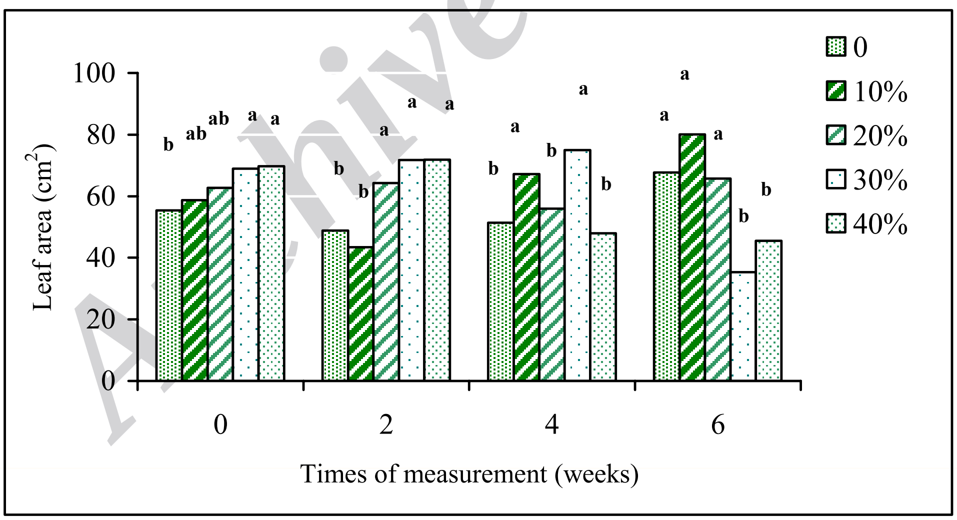

Fig 1. Average leaf area of cymbidium orchid in the basic plant growth medium substituted with different concentrations (0, 10, 20 30 and 40%) of cattle manure vermicompost, 0, 2, 4 and 6 weeks after first measurement. Columns with the same letter are not significantly by Tukey's test at $P \leq 0.05$ in each time of measurement.

Number of backbulbs was greater in the 30% vermicompost compared to the control (BPGM), 40%, 10% and 20% vermicompost groups (Table 3, $P \leq 0.01$). Substituting BPGM with cattle manure vermicompost not only improved the growth of cymbidium plants, but it also significantly increased number of inflorescence, length of the inflorescence and number of flower buds per inflorescence produced (Table 3,

$P \leq 0.01$). The greatest number of inflorescences and number of flower buds per inflorescence were recorded in the potting mixtures containing 40% cattle manure vermicompost 60% BPGM and the greatest length of the inflorescence were observed in the potting mixtures containing 30% cattle manure vermicompost 70% BPGM. Cymbidiums grown in 30% and 40% cattle manure vermicompost produced significantly greater and larger flowers ($P \leq 0.01$) although, there was no significant different between the 30% and 40% cattle manure vermicompost groups (Table 3).

Table 3. Effects of the application of cattle manure vermicompost on the growth and development of cymbidium plants.

Vermicompost treatment%	Inflorescence no.	Length of inflorescence(cm)	No. flowers/ inflorescence	Flower diameter (cm)	Backbulb no.
Control [y]	0.70 b	0.70 c	0.70 b	0.70 b	1.49 b
10	0.70 b	0.70 c	0.70 b	0.70 b	1.38 b
20	0.70 b	0.70 c	0.70 b	0.70 b	1.33 b
30	1.44 a	7.85 a	3.71 a	9.39 a	2.22 a
40	1.58 a	5.83 b	3.85 a	9.32 a	1.44 b

Means within the column with the same letter are not significantly different by Tukey's test at $P \leq 0.01$.

[y] Control represents 100% BPGM (Basic Plant Growth Medium)

DISCUSSION

The plants grown in 30% and 40% vermicompost finished the vegetative phase very fast (data not presented) and reached the procreative phase sooner, therefore, these concentrations produced smaller leaf area in the sixth week (Fig. 1). On the other hand the control (BPGM), 10% and 20% vermicompost groups were in the vegetative phase in the sixth week, and they produced greater leaf area (Fig. 1). Similar results have been reported for other crops. Atiyeh *et al.* (2002) reported that if the container medium contained only a relatively small concentration (40%) of pig manure vermicompost, growth and productivity of marigold plants improved significantly compared to those grown in the commercial medium, Metro-Mix360, and 40% vermicompost accelerated the early growth of marigolds. Atiyeh *et al.* (2001) reported greater growth of tomato seedlings treated with fertilizer in potting mixtures substituted with 25% and 50% pig manure vermicompost (depending on the plant growth stage), probably as a result of combined improved physical conditions and nutritional factors.

Arancon *et al.* (2008) showed that substitutions of 20, 30 and 40% of food waste vermicomposts into MM360 produced significantly more petunias flowers than substitution of the other amounts of food waste vermicompost/ MM360, and petunias grown in a mixture of 40% paper waste vermicompost and 60% MM360 produced significantly more flowers than those from food waste substituted at other rates. They suggested that all these increases in flower production were independent of nutrient availability. The increased rates of plant growth parameters like leaf area and number of backbulbs of cymbidiums could not have been associated with greater nutrient availability because, in all treatments, the plants received all the required nutrients from regular applications of nutrient solution. Some possible factors that improved the growth and flowering of cymbidiums could include vermicompost producing improvements in the physical structure of the growth medium such as aeration and drainage. It could also have been due to biological effects such as increases in beneficial enzymatic actives, increased population of beneficial microorganisms, or the presence of biologically active plant growth- influencing substances such as plant growth regulators or plant hormones in the vermicompost (Atiyeh *et al.* 2001, Singh *et al.* 2008) and humic acids (Nikbakht *et al.* 2008). Vetal *et al.* (2003) found that the performance of Lilium in respect to growth, earliness, quality and quantity of flowers and root development was better in organic mixtures than soil based ones of which with the mixture of agropeat+vermicompost and soilrite+ vermicompost produced the best results.

As demonstrated scientifically, microbes like fungi, bacteria, yeasts, actinomycetes, algae etc., are capable of producing auxins, gibberellins etc., in appreciable quantity during vermicomposting, which affects plant growth appreciably (Singh *et al.* 2008). Gajalakshmi and Abbasi (2002) showed that the pots containing soil amended with water hyacinth vermicompost had crossandra plants achieving significantly better height, larger number of leaves, more favorable shoot: root ratio, greater biomass per unit time and larger length of inflorescence. In terms of root length, quicker onset of flowering and harvest index, the treated plants on an average performed better than the controls. Plant growth hormones can become adsorbed onto the complex structure of humic acids that are produced very rapidly in vermicompost and may have acted in conjunction with them to influence plant growth since humates have also been shown to increase plant growth (Bachman & Metzger 2008). Gutie´rrez-Miceli *et al.* (2008) found that growth in maize plants amended with vermicompost derived from sheep manure was significantly affected, and the number of leaves, wet weight of plant, stem height and stem diameter increased in peat moss amended with vermicompost. In this situation plant growth hormones that are adsorbed onto humates would persist in soil and would be released slowly from humates and have much more effects on plant growth over a considerably longer period. Humus or humates are believed to stimulate plant nutrient uptake and metabolism, have an influence on protein synthesis, and show hormone-like activity (Bachman & Metzger 2008).

The increase in vermicompost concentration from 0 to 40% improved the production and quality of flower and flower diameter significantly. This response of plants to higher concentrations of vermicompost (30% and 40%) might be due to production of growth- promoting-substances in higher quantities by higher concentrations of vermicompost (30% and 40%) than lower concentrations (Singh *et al*. 2008). However, the significant growth of plants with vermicompost at 30% and 40% compared to the control, 10% and 20% indicate that these concentrations (30% and 40%) were enough for supplying the desirable amount of growth- promoting-substances for example gibberellins for higher growth and initiation and development of flower (Bachman & Metzger 2008). Similar results have been reported by Atiyeh *et al.* (2002). They suggested that substituting Metro-Mix360 with 30% and 40% pig manure vermicompost increased the total number of flower set by the plants and the flower diameter slightly compared to those plants grown in the Metro-Mix360 controls in marigold plants. And they reported that concentrations more than 40% (50-100%) significantly decreased shoot weight and height and total number of flower buds. Arancon *et al*. (2008) observed similar results in petunia plants that were treated with cattle manure vermicompost. It seems that when concentrations more than 40% were used for cymbidium plants, they exhibited adverse effects on the growth of the plants. This however calls for further research. Gajalakshmi and Abbasi (2004) showed more flower number per plant in brinjal (*Solanum melongena* Linn.) in the vermicompost treatments compared with the control plants.

So, it seems that plant- growth- influencing factors could include improvements in the physical structure of the container medium, increases in enzymatic activity and effect the number of beneficial microorganisms from the production of plant growth hormones or humic acids (Atiyeh *et al.* 2002, Bachman & Metzger 2008). This also requires further comprehensive investigation.

In conclusion, the cattle manure vermicompost used in this experimental offered potential as a component of soilless container medium. It could be used to increase the production of cymbidiums in the greenhouse when combined at a relatively small concentration (40% by volume) into the basic plant growth medium. Such substitutions would be economically desirable since acceleration of early growth of cut flowers is a requisite of the cut flowers industry, which allows the best use of expensive greenhouse space and energy, especially for cymbidium plants that are popular and valuable.

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اثر ورمی‌کمپوست روی رشد و گلدهی ارکیده سیمبیدیوم

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چکیده

اثرات ورمی‌کمپوست کود گاوی روی رشد و گلدهی گل‌های ارکیده سیمبیدیوم (*Cymbidium* sp.) که در شرایط تونل با پوشش تور پلاستیکی پرورش یافتند ارزیابی گردید. گل‌های ارکیده سیمبیدیوم در یک بستر گلدانی شامل ۵۰٪ پوکه معدنی، ۳۰٪ زغال چوب، ۱۰٪ ورمیکولیت و ۱۰٪ پیت ماس که به عنوان بستر پایه کشت محسوب می‌شد پرورش داده شدند. بستر گلدانی با درصدهای حجمی مختلف شامل ۱۰٪، ۲۰٪، ۳۰٪ و ۴۰٪ ورمی‌کمپوست جایگزین شد. بستر پایه بدون ورمی‌کمپوست به عنوان تیمار شاهد در نظر گرفته شد. گیاهان به طور منظم با محلول مواد غذایی کامل، کوددهی شدند. بیشترین رشد رویشی در تیمار ۳۰٪ و ۴۰٪ ورمی‌کمپوست و کمترین رشد در مخلوط گلدانی محتوی صفر درصد ورمی‌کمپوست حاصل شد. بیشترین تعداد جوانه گل و گل‌آذین در تیمار ۳۰٪ ورمی‌کمپوست مشاهده شد. گل‌های ارکیده سیمبیدیوم پرورش یافته در بستر گلدانی محتوی ۳۰٪ و ۴۰٪ ورمی-کمپوست بیشترین و بزرگترین گل‌ها را داشتند. علت افزایش رشد و گلدهی سیمبیدیوم را می‌توان به وسیله عوامل تغذیه‌ای تفسیر نمود. اما از آنجایی که همه گیاهان به طور منظم با مواد غذایی کامل تغذیه شدند، همچنین عوامل دیگر مانند تنظیم کننده‌های رشد گیاهی و مواد هومیک ممکن است دخالت داشته باشند.