Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 6, No. 6, p. 179-186, 2015
http://www.innspub.net

INNSPUB
RESEARCH PAPER

OPEN ACCESS

Different growing substrates affect Periwinkle's (*Catharanthus roseus* L.) growth and flowering

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Article published on June 08, 2015

Key words: Periwinkle (*Catharanthus roseus* L.), Growing media, Vegetative Growth, Flower quality.

Abstract

Periwinkle (*Catharanthus roseus* L.) is one of the important ornamental and medicinal plants, due to the presence of the blue tint flowers and the indispensable anti-cancer drugs, vincristine and vinblastine. Therefore, the production of this plant has been emphasized. Nutritional management and application of organic and inorganic materials as substrates can play an important role in increasing the productivity and quality of this plant. Therefore, the effects of different organic materials as growing media including: rotted manure spent mushroom compost (SMC), vermicompost, and garden soli as control on the vegetative growth, yield and flower quality of Periwinkle were considered. The organic materials were in four levels (15, 30, 40 and 50 %). Analysis of variance showed that the effects of different treatments on studied properties are significant ($p<0.001$). The maximum of plant height (37.83 cm), fresh weight of shoot (116.55 g), number of flower (42.67) and diameter of flower (45.67 mm) were obtained in vermicompost 50%. Moreover, maximum of dry weight of shoot (32.91 g) was observed in SMC 40%. The results showed that the application of vermicompost 50% resulted in significant increases in concentration of N. The maximum of number of leaf were obtained in vermicompost 50%. The application of organic fertilizers resulted in significant increases in concentration of P and K compared to control. In conclusion, the results showed that vermicompost was found to be suitable for production of Periwinkle. This organic matter can be an alternative substrate in growing media.

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Introduction

Periwinkle (*Catharanthus roseus L.*) is one of the important ornamental and medicinal plants, due to the presence of the blue tint flowers and the indispensable anti-cancer drugs, vincristine and vinblastine (Sepehri *et al.,* 2013). It is identified with the scientific names of *Catharanthus roseus*, *Vinca rosea* and *Lochnera rosea* (Omidbeigi, 2000).

Periwinkle is a bushy perennial plant; it reaches 0.30-1.20 m in length and is mainly adapted to tropical and subtropical regions. It is also cultured in temperate regions as an annual plant. It reportedly originates from tropical regions such as: Indonesia, south India and Madagascar Island (Zargari, 2000). The management of soil organic matter (SOM) by application of composted organic waste is the key for sustainable agriculture (Nyamangara *et al.,* 2003). For fertilization of the soils, the organic fertilizers can serve as alternative practice to chemical fertilizers (Naeem *et al.,* 2006). The application of earthworms for composting organic matter is called Vermitech. The compost provided through the using of earthworms has been called vermicompost (Ismail, 2005). The concentration mineral elements in vermicompost extremely depend on the parent material. It commonly contains higher levels of most of the nutrition elements than the input material (Buchanan *et al.,* 1988; Edwards and Bohlen, 1996).

The positive effects of vermicompost on the growth and yield of peppers (Arancon *et al.,* 2005) wheat (Edwards-Jones and Jones, 2007), Chinese cabbage (Wang *et al*., 2010) and maize (Doan *et al*., 2013) have been referred. Doan *et al.* (2013) observed greater chlorophyll (maize) in control compared to the compost and vermicompost treatments. Wang *et al.* (2010) in experiments using manure vermicompost to growth and yield of Chinese cabbage found that the content of vitamin C were far greater in vermicompost compared to soil treatment. Application of vermicompost as an organic fertilizer improved the soil productivity and increased the growth of plant (Zaller and Kopke, 2004). Nonetheless, the effects of organic fertilization on quantities and qualities traits of periwinkle are not yet available in the literature. Therefore, the aim of this study was to investigate the influence of vermicompost, Spent Mushroom Compost (SMC), rotted manure on some properties of periwinkle.

Materials and methods

To study the effect of different of organic fertilizers on growth and yield of periwinkle, this experiment was carried out as randomized completely block design with 13 treatments and 3 replications. Treatments were as fallowing: rotted manure fertilizer, spent mushroom compost (SMC), vermicompost and a non-treatment as control (garden soil). These organic fertilizers were applied in four levels (15, 30, 40 and 50 %). During growth period, irrigation rate, humidity and temperature were similar. Average temperature of day and night were 29 °C and 17 °C, respectively during growth period.

Analysis of soil and organic fertilizers

Physical characteristics of soil and organic fertilizers including water holding capacity (Verdonck and Gabriels, 1992), bulk density, particle density and porosity (Baruah and Barthakur, 1997) were measured before planting. Soil pH was measured in the soil saturation paste and electrical conductivity (EC) in saturated extracts. pH and EC in vermicompost were determined in water extracts (1:5 v/v) (ADAS, 1988). The soil organic matter (the Walkley and Black method), total nitrogen (the Kejldahl method), available K (with ammonium acetate) available P (the Olsen's method) and cation exchange capacity (CEC) with NH_4OAc method were determined via procedures described in Baruah and Barthakur (1997). Available Fe, Zn, Cu and Mn were extracted using DTPA (Lindsay and Norvell, 1978). Some physical and chemical properties of different growing substrate are listed in Table 1 and Table 2, respectively.

The some properties of periwinkle such as plant height, number of leaf, number of lateral shoot, number of flower, diameter of flower, fresh and dry weight of shoot and root, chlorophyll a chlorophyll b and total chlorophyll, total nitrogen, potassium and phosphor were determined at the after the plant harvest.

Measurement of total N, K and P:

Total N (Kjeldahl method), K (flame photometry method) and P (spectrophotometrically method) was determined after wet digestion (Isaac and Kerber, 1971).

Measurement of chlorophyll (a, b and total) content

Chlorophyll content was determined in 80% acetone extract. Total chlorophyll as well as chlorophyll a and b concentrations were calculated according to Arnon (1949).

Statistical analyses

Experimental data normality was verified, and then data were submitted to analysis of variance, using SAS 9.1 software package for Windows. Means were compared using Least Significant Difference (LSD) test at $p<0.05$.

Results and discussion

Plant height

The analysis of variance showed that the effect of organic fertilizers on plant height of periwinkle was significant at $p<0.001$. The obtained data in (Table 3) showed that plant height of periwinkle was significantly affected organic treatments. The results showed that plant height in 30, 40 and 50% vermicompost and SMC in levels of 30 and 40% was significantly greater than that in soil (control). The maximum of plant height (37.83 cm) were obtained in vermicompost 50% (Table 3). This was mainly due to the great concentration of nutrient elements, especially nitrogen, potassium and phosphor in vermicompost. This finding is in according with Ahmad *et al.* (2012) who showed that leaf area, flower stalk length was lower in plants grown in garden soil (control) than that in soil + silt + sand + mushroom compost.

Table 1. Some physical properties of garden soil and organic fertilizers.

Parameters	Units	Garden Soil	Vermicompost	Manure fertilizer	Spent mushroom compost
Porosity	(%)	22	58	68	66
Water holding capacity	(%)	46	66	85	75
Particle density	(g cm^{-3})	1.47	1.31	2.2	2.02
Bulk density	(g cm^{-3})	1.12	0.56	0.66	0.75

Table 2. Some chemical properties of experimental field soil and vermicompost.

Parameters	Units	Garden Soil	Vermicompost	Manure fertilizer	Spent mushroom compost
pH	(–)	8.27	8.04	7.99	8.50
EC	(dS/m)	9.38	2.53	41.92	6.08
CEC	(cmol+/kg)	5.4	13.04	42.9	27.9
OM	(%)	2.0	69.0	25.0	30.0
N	(%)	0.20	1.6	0.53	0.43
P	(mg/kg)	61.6	195.0	145.0	242.5
K	(mg/kg)	866.3	8056.9	2552.4	30887.7
Zn	(mg/kg)	1.48	9.15	11.95	27.75
Cu	(mg/kg)	3.52	1.3	2.15	3.59
Mn	(mg/kg)	14.6	1.75	15.55	26.65
Fe	(mg/kg)	6.42	6.1	41.85	48.85

Note: EC: electrical conductivity, CEC: cation exchange capacity, OM: organic matter.

Number of leaf

The results showed that the effect of treatments on number of leaf of periwinkle was significant at $p<0.001$ The results showed that number of leaf in organic fertilizers was greater than that in soil (control), however, in some cases, there were no significant differences between applied treatments and control. The maximum of number of leaf were obtained in vermicompost 50% (Table 3). The application of vermicompost as a biofertilizer improved the soil productivity and consequently increased the growth and yield of plant (Zaller and Kopke, 2004).

Number of lateral shoot

The results showed that the effect of treatments on number of lateral shoot of periwinkle was significant at $p<0.001$. The results showed that the application of organic fertilizers resulted in significant increases in number of lateral shoot (Table3).

Table 3. The effects of different fertilizer treatments on the some properties of periwinkle.

Treatment	Plant height (cm)	Number of leaf	Number of lateral shoots	Number of flower	Diameter of flower (mm)
Garden soil (control)	25.87 d	27.27 g	5.67 h	9.67 f	29.30 ef
Manure fertilizer 15%	25.07 d	34.23 ef	6.00 gh	13.00 ef	30.56 edf
Manure fertilizer 30%	28.10 cd	39.53 b-e	8.67 c-f	24.00 c	30.50 edf
Manure fertilizer 40%	28.93 cd	41.07 bcd	11.00 ab	33.33 b	31.23 cde
Manure fertilizer 50%	25.87 d	34.77 def	7.67 efg	20.00 cd	27.10 f
SMC 15%	28.20 cd	35.20 def	8.00 def	16.67 de	33.83 bcd
SMC 30%	30.93 bc	37.83 c-f	7.33 fgh	16.67 de	34.27 bcd
SMC 40%	33.67 b	44.80 b	11.00 ab	33.67 b	33.60 bcd
SMC 50%	25.77 d	32.53 fg	7.33 fgh	19.67 cd	34.53 bc
Vermicompost 15%	25.57 d	45.83 b	9.33 b-e	31.67 b	34.00 bcd
Vermicompost 30%	34.00 ab	43.47 bc	10.00 bc	16.33 de	34.03 bcd
Vermicompost 40%	30.63 bc	37.90 c-f	9.67 bcd	31.67 b	35.50 b
Vermicompost 50%	37.83 a	54.25 a	12.67 a	42.67 a	45.67 a
$LSD_{0.05}$	4.02	6.80	1.90	4.36	3.77

SMC: spent mushroom compost. In each column, the values followed by at least one common character are not statistically ($p<0.05$) different, according to the Least Significant Difference (LSD) test.

Number of flower

The number of flower was influenced by the organic fertilizer treatments. The application of organic fertilizer resulted in significant increases in number of flower. The maximum of number of flower (42.67) were obtained in vermicompost 50% (Table 3 and Fig. 1.). This may be due to high various nutrients like P and K. Similar trends have also been reported by Caballero *et al.* (2009) who observed maximum available potassium in spent mushroom compost while comparing various substrates for gerbera production. The improved quality attributes and similar growth indices with the substrates containing vermicompost and spent mushroom compost are consistent with previous findings. Ahmad *et al.* (2012) also demonstrated that soil + silt + sand + coconut coir + mushroom compost produced best flower quality followed by soil + silt, soil + sand, soil + silt + sand and silt + sand with 7.03, 6.50, 6.33 and 6.03, respectively. They found that control (garden soil) turned out into poor quality flowers.

Diameter of flower

The analysis of variance showed that the effect of organic fertilizers on diameter of flower of periwinkle was significant at $p<0.001$. The application of vermicompost and SMC significantly increased diameter of flower ($p<0.05$, Table 4 and Fig. 2.). The maximum of diameter of flower (45.67 mm) were obtained in vermicompost 50%. However, there were no significant differences between manure fertilizer and soil treatment in diameter of flower (Table 4 and Fig. 2.). In another study, two horticultural by-products viz., coconut coir and spent mushroom compost were tested by Ahmad *et al.* (2012) for their suitability as growing media for cut flower production.

They indicated that the plants grown in soil + silt produced maximum flower diameter followed by soil + sand, soil + silt + sand + coconut coir+ mushroom compost, silt + sand and soil + silt + sand. The garden soil produced minimum flower diameter followed by soil + silt + sand + mushroom compost and soil + silt + sand + coconut coir.

Fresh weight of shoot

The results showed that the effect of treatments on fresh weight of shoot was significant at $p<0.001$. Statistical analysis revealed that in most cases, the application of organic fertilizers resulted in significant increases in fresh weight of shoot compared to control (Table 4). The maximum of fresh weight of shoot (116.55 g) were obtained in vermicompost 50% (Table 4). Similar effects of vermicompost on the growth and yield of peppers (Arancon *et al.,* 2005) and wheat (Edwards-Jones and Jones, 2007) have been referred.

Dry weight of shoot

The results showed that the effect of treatments on dry weight of shoot was significant at $p<0.001$. Results indicated that that in most cases, the application of organic fertilizers resulted in significant increases in dry weight of shoot compared to control (Table 4). The result also showed that dry weight of shoot was far greater in vermicompost compared to other organic fertilizers (Table 4). Moreover, maximum of dry weight of shoot (32.91 g) was observed in SMC 40% and vermicompost 50%. Caballero *et al.* (2009) found that composted peat mixed with spent mushroom compost provided the largest amounts of dry matter of gerbera. Also, the application of vermicompost as a biofertilizer improved the soil productivity and increased the growth and yield of plant (Zaller and Kopke, 2004; Edwards *et al.,* 2004).

Fresh weight of root

The analysis of variance showed that the effect of treatments on fresh weight of root was significant at $p<0.01$. The results showed that the application of organic fertilizers (with the exception of SMC 15% and vermicompost 50%) resulted in significant increases in fresh weight of root (Table 4), however, in some cases, there were no significant differences between applied treatments and control.

Dry weight of root

The results showed that the effect of treatments on dry weight of root was significant at $p<0.001$. The results showed that the application of organic fertilizers resulted in significant increases in dry weight of root (Table 4), however, in some cases, there were no significant differences between applied treatments and control.

Total Nitrogen (N)

The analysis of variance indicated that the effect of treatments on total N was significant at $p<0.001$. The results showed that the application of vermicompost 50% as organic fertilizers resulted in significant increases in concentration of N (Table 5).

Total Phosphorous (P)

The analysis of variance indicated that the effect of treatments on the concentration of P was significant at $p<0.001$. The results showed that the application of organic fertilizers (with the exception of rotted manure 50%, SMC 15% and vermicompost 40%) resulted in significant increases in concentration of P (Table 5), however, in some cases, there were no significant differences between applied treatments and control. Kalantari *et al.* (2010) found that application of vermicompost increased the concentrations of P, K, Ca, Mg in the shoot of corn.

Total Potassium (K)

The analysis of variance indicated that the effect of treatments on the concentration of K was significant at $p<0.01$. The results showed that the application of organic fertilizers resulted in significant increases in concentration of K (Table 5), however, in some cases, there were no significant differences between applied treatments and control. In a field experiment, Stamatiadis *et al.* (1999) reported that differences between treatments (control, compost and ammonium nitrate application) in leaf nutrients (N, P, K, Ca, Mg, Zn, Fe) for broccoli were insignificant.

Chlorophyll a, b and total chlorophyll

The analysis of variance indicated that the effect of treatments on content of chlorophyll was significant at $p<0.001$. The application of organic fertilizers resulted in significant increases in values of chlorophyll a, b and total chlorophyll. The maximum of values of chlorophyll a was observed in rotted manure 15% and vermicompost 50% (Table 5). However, the maximum of values of chlorophyll b and total chlorophyll was observed in rotted manure 15% (Table 5). In contrast with findings obtained in this work, Doan *et al.* (2013) observed greater chlorophyll (maize) in control compared to the compost and vermicompost treatments.

Table 4. The effects of different fertilizer treatments on weight of shoot and root.

Treatment	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)
Garden soil (control)	50.53 f	10.41 e	16.14 cde	3.11 h
Manure fertilizer 15%	68.13 cd	12.48 de	18.04 b-e	5.33 def
Manure fertilizer 30%	111.54 a	11.93 de	19.17 b-e	5.87 cde
Manure fertilizer 40%	66.70 cd	14.22 cd	18.08 b-e	4.25 e-h
Manure fertilizer 50%	52.25 f	10.78 de	21.34 ab	5.23 def
SMC 15%	54.86 ef	12.47 de	14.72 e	3.45 gh
SMC 30%	75.90 c	17.58 bc	16.71 b-e	7.91 ab
SMC 40%	111.91 a	32.91 a	25.21 a	7.56 abc
SMC 50%	62.39 de	11.22 de	18.76 b-e	3.77 fgh
Vermicompost 15%	99.30 b	18.89 b	20.63 abc	8.03 ab
Vermicompost 30%	113.32 a	18.63 b	24.61 a	6.87 bcd
Vermicompost 40%	71.79 cd	18.94 b	19.72 bcd	5.15 efg
Vermicompost 50%	116.55 a	29.48 a	15.57 de	8.88 a
$LSD_{0.05}$	9.76	3.54	4.80	1.71

SMC: spent mushroom compost. In each column, the values followed by at least one common character are not statistically ($p<0.05$) different, according to the Least Significant Difference (LSD) test.

Table 5. The effects of different fertilizer treatments on the some elements and chlorophyll of periwinkle.

Treatment	Total N (%)	P (%)	K (%)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)
Garden soil (control)	1.11 b	1.24 fg	1.26 d	0.26 f	0.53 cd	0.78 d
Manure fertilizer 15%	0.57 efg	1.51 ab	1.80 ab	0.66 a	0.83 a	1.49 a
Manure fertilizer 30%	1.01 b	1.34 c-f	1.50 bcd	0.36 d	0.48 de	0.84 cd
Manure fertilizer 40%	0.82 c	1.40 b-e	1.49 bcd	0.37 d	0.44 e	0.81 d
Manure fertilizer 50%	0.59 def	1.14 g	1.52 bcd	0.28 ef	0.65 b	0.93 c
SMC 15%	0.52 fg	0.75 i	1.52 bcd	0.33 de	0.50 de	0.83 cd
SMC 30%	0.78 c	1.31 def	2.12 a	0.53 bc	0.32 f	0.85 cd
SMC 40%	0.60 def	1.45 bcd	1.33 cd	0.34 de	0.43 e	0.76 d
SMC 50%	0.70 cde	1.48 bc	1.34 cd	0.50 bc	0.55 cd	1.05 b
Vermicompost 15%	0.83 c	1.26 efg	1.53 bcd	0.57 b	0.20 g	0.78 d
Vermicompost 30%	0.43 g	1.46 bcd	1.42 cd	0.46 c	0.59 bc	1.06 b
Vermicompost 40%	0.73 cd	0.91 h	1.67 bc	0.31 def	0.31 f	0.62 e
Vermicompost 50%	1.29 a	1.64 a	1.59 bcd	0.69 a	0.41 e	1.10 b
$LSD_{0.05}$	0.15	0.14	0.35	0.08	0.09	0.11

SMC: spent mushroom compost. In each column, the values followed by at least one common character are not statistically ($p<0.05$) different, according to the Least Significant Difference (LSD) test.

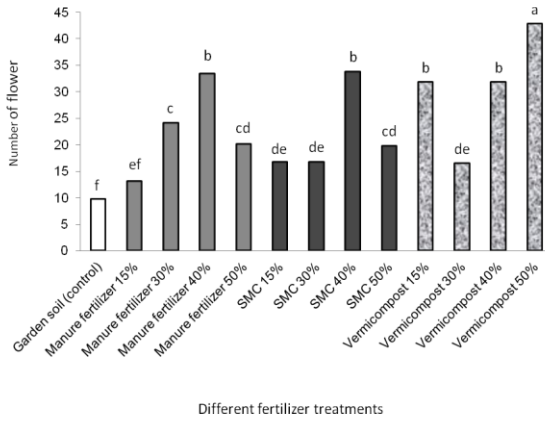

Fig. 1. The Effect of Different fertilizer treatments on number of flower.

The values followed by at least one common character are not statistically (p<0.05) different, according to the Least Significant Difference (LSD) test.

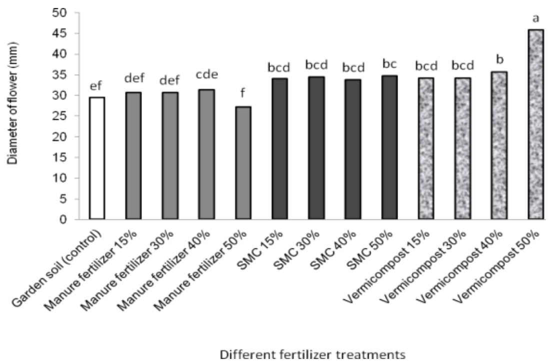

Fig. 2. The Effect of Different fertilizer treatments on diameter of flower (mm).

The values followed by at least one common character are not statistically (p<0.05) different, according to the Least Significant Difference (LSD) test.

Conclusions

The performance and suitability of different organic fertilizer for the culture of periwinkle were studied with employing 13 different organic fertilizers in a greenhouse experiment. Based on the results obtained in this study, vegetative growth, yield and flower quality of periwinkle was influenced by the organic fertilizer treatments and the application of organic fertilizer resulted in significant increases in these traits. In most cases, the maximum of quantities and qualities traits were obtained in vermicompost 50%. In conclusion the results showed that vermicompost 50 % was found to be suitable for production of periwinkle in a greenhouse conditions.

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