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Effect of Application of Vermicasts as Layering Media for an Ornamental Plant, *Codiaeum variegatum* (L.) Bl.

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ABSTRACT

In this paper, the effect of vermicasts (VC) on the growth performances of an ornamental plant, *Codiaeum variegatum* (L.) Bl. var. *pictum* (Lodd.) Muell. Arg. in layering experiments was studied in comparison with peat moss. The vermicasts were collected from the vermibeds of *Lampito mauritii* Kinb. and of *Perionyx ceylanensis* Mich. cultured in three kinds of organic substrates i.e., leaf litter of *Polyalthia longifolia* (LP), *Pennisetum typhoides* cobs (PT) and a weed *Rottboellia exaltata* (RE) in combination with cowdung (1:1). The vermicasts recovered from each vermibed were used alone and in combination with peat moss (PM; 1:1) as layering media for *C. variegatum* and the results were compared with PM. Root initiation, root length, total number of roots developed, fresh and dry weight of the roots were higher in the layering experiments with VC and VC + PM than that of PM which served as control. All these parameters showed significant differences between VC and PM (control). Vermicasts either alone or in combination with PM were able to initiate earlier rooting and development of roots better than in the layering experiments conducted only with PM. The enhanced root initiation and development in this study can be partially explained by the elevated levels of NPK contents in the vermicasts. The variation within VC + PM and VC on the growth parameters in layerings of *C. variegatum* were also observed, which might be due to the difference in vermicasts obtained from different vermibed substrates. The results of the present study show that PM can be substituted with vermicasts in layering media for the ornamental plant, *C. variegatum*.

Keywords: croton, earthworm, peat moss, plant growth, vermicomposting
Abbreviations: LT, layering treatment; **NPK**, nitrogen, phosphorus and potassium; **PM**, peat moss; **VC**, vermicast

INTRODUCTION

The application of organic resources to soil is essential for the maintenance of soil fertility status and crop productivity in agricultural systems. Biofertilizers, farm yard manure, compost, poultry manure, green waste compost and vermicompost are applied to soil, or at least together with chemical fertilizers, to obtain higher yield and to achieve sustainability in agriculture through organic farming (Kannan *et al.* 2005; Behera *et al.* 2007). Earthworms have long been recognized as soil conditioners (Syers and Springett 1984). The end product of vermicomposting utilizing earthworms is a finely ground vermicompost with nutrients in available form along with growth promoters and microorganisms and its application both at laboratory and field levels have proven to bring about better crop growth and yield. A field trial conducted by Parthasarathi *et al.* (2008) using vermicompost, vermicompost + chemical fertilizer and chemical fertilizer alone in three different types of soils, clay loam, sandy loam and red loam soil evidently showed that the soil which received vermicompost increased the pore space, reduced particle and bulk density, increased water holding capacity, cation exchange capacity, reduced pH and electrical conductivity, increased organic carbon content, available NPK and microbial population and activity along with the enhanced yield and quality (protein and sugar content in seed) of black gram, *Vigna mungo*.

Another field trial conducted by Karmegam and Daniel (2008) using vermicomposts, chemical fertilizer and combination of vermicompost + chemical fertilizer with *Lablab purpureus* (L.) Sweet. showed that the leaf area index, total chlorophyll content of leaves, dry matter production, number of primary branches per plant, day of first flower appearance, length of fruits, dry weight of 100 seeds, yield (fruit) per plant, yield per plot and yield per hectare were significantly higher in the plots which received vermicompost, chemical fertilizer and vermicompost + chemical fertilizer mixture than in the control plots ($P < 0.05$). The highest fruit yield (fresh weight) of 109 tonnes ha^{-1} was recorded in the treatment which received 2.5 tonnes of vermicompost [prepared with *Rottboellia exaltata* + cowdung, (1:1) using *Perionyx ceylanensis*] + ½ dose of recommended NPK ha^{-1}, while it was 61.9 tonnes ha^{-1} in control plots without vermicompost and/or chemical fertilizer. The available soil nutrients (NPK) were higher in the plots which received vermicompost than in the plots that received chemical fertilizer and those that received chemical fertilizer + vermicompost mixture. Recent reports also reveal the use of vermiwash (prepared with cold or heat stimulated earthworm secretions) and vermicompost extracts [aqueous extracts prepared by mixing vermicompost with tap water at a ratio of 1:2 (v/v)] as foliar sprays (Zaller 2006; Zambare *et al.* 2008).

Codiaeum variegatum (L.) Bl. var. *pictum* (Lodd.) Muell. Arg., family Euphorbiaceae (**Fig. 1A**), one of the many brightly-foliaged crotons, native to southern India, Sri Lanka and Malaya, that are widely grown as house plants. *C. variegatum* var. *pictum* is widely cultivated as a house plant for its very brightly colored foliage and is easily distinguished by its very narrow, yellow-spotted leaves (**Fig. 1B**). Crotons are usually propagated from air layering or cuttings (Gilman 1999) and the suggested cultural and propagation medium for crotons is peat moss in combination with sand or perlite (Stamps and Osborne 2003). The use of peat moss (PM) in horticulture is well known; however, harvesting of peat results in the destruction of natural eco-

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Fig. 1 ***Codiaeum variegatum*** **(L.) Bl. var.** ***pictum*** **(Lodd.) Muell. Arg.** (**A**) A dense variegated foliage; (**B**) Enlarged view of very narrow, golden yellow spotted leaves.

Fig. 2 Earthworm species used in the study and their casts. (**A**) *L. mauritii*; (**B**) *P. ceylanensis*; (**C**) Vermicasts of *L. mauritii*; (**D**) Vermicasts of *P. ceylanensis*. Divisions in scale indicate cm.

systems and at a global level, concern is being given to replace PM with suitable amendments like vermicompost (Robertson 1993; Zaller 2007a). Keeping these needs in mind, the present study was conducted to assess the effect of vermicasts, recovered from two different earthworm species *Lampito mauritii* Kinb. and *Perionyx ceylanensis* Mich. grown in three different organic substrates, on the root growth of an ornamental plant *Codiaeum variegatum* in layering experiments in comparison with PM.

MATERIALS AND METHODS

The vermicastings or vermicasts (VC) were collected from the vermibeds of *Lampito mauritii* Kinb. (**Fig. 2A**) and of *Perionyx ceylanensis* Mich. (**Fig. 2B**) which were separately mass cultured (in cement tanks 1 m × 1 m × 0.75 m in size) in three kinds of organic substrates i.e., leaf litter of *Polyalthia longifolia* (PL), *Pennisetum typhoides* cobs (PT) and a weed *Rottboellia exaltata* (RE), each in combination with cowdung (1:1). The pellet like vermicasts (excretory pellets) found on the surface of vermibeds were carefully brushed aside and collected in separate containers and used for the study. Each experiment consisted of six replicates. The vermicasts and PM were subjected to NPK analysis using standard procedures (Tandon 1993). In the present study, leaf litter of *P. longifolia*, *P. typhoides* cobs and a weed *R. exaltata* have been used as vermibed substrates due to their availability in large quantities. The plant, *R. exaltata* grows vigourously in road sides and waste lands as a weed during November-April and is avoided by cattles due to the presence of sharp hairs on the leaf surface.

Layering experiments were conducted with an ornamental plant, *Codiaeum variegatum* (L.) Bl. var. *pictum* (Lodd.) Muell. Arg., using PM (control), VC (**Fig. 2C, 2D**) and PM + VC mixed in a 1:1 ratio. *C. variegatum* branches of 1.5-2 years old and 2 cm girth were uniformly selected for layering. The leaves on the selected branches, 8-10 cm were removed above and below the point where the cut was to be made. One cm of the outer layer of the bark was carefully removed by making two circular cuts and wrapped with a transparent polyethylene sheet (6 × 12 inch.) containing 10 g of layering medium as shown in **Table 1** and **Fig. 3A**. Both ends of the polyethylene sheet were tied tightly to minimize the evaporation of moisture.

Initiation of rooting was observed from the beginning of the experiment until all the experimental sets developed roots (**Fig.**

Table 1 Layering experimental design (45 day trial in *Codiaeum variegatum*, an ornamental plant) PM: peat moss, VC: vermicasts.

Layering treatment	Earthworm used	Vermibed material (1:1)	Layering media		
			PM	VC	PM + VC (1:1, fresh wt.)
LT1	*L. mauritii*	Leaf litter of *P. longifolia* + cowdung	+	+	+
LT2	*L. mauritii*	*P. typhoides* cobs + cowdung	+	+	+
LT3	*L. mauritii*	*R. exaltata* + cowdung	+	+	+
LT4	*P. ceylanensis*	Leaf litter of *P. longifolia* + cowdung	+	+	+
LT5	*P. ceylanensis*	*P. typhoides* cobs + cowdung	+	+	+
LT6	*P. ceylanensis*	*R. exaltata* + cowdung	+	+	+

Fig. 3 Layering experiments with *C. variegatum*. (**A**) Layerings made with PM, VC and PM + VC using polythene sheets on the branches of *C. variegatum*; (**B**) Roots of *C. variegatum* developed in LT1 (45 days).

3B). The polyethylene cover was unwrapped; layering material was carefully removed and observed for the emergence of roots. For observing the root initiation, a separate set of experiment with six replicates were carried out by adopting the above described layering method. This was done to avoid damage and disturbance while handling. Hence, the final experimental sets were left undisturbed until termination of the experiment. After 45 days, the experiment was terminated, the polyethylene sheets were removed. The roots were carefully removed, counted, washed with distilled water, blotted on Whatman no. 1 filter paper and the fresh weight and the length of the roots were recorded for each experimental set-up. After that the roots were dried in a hot air oven at 80°C and the dry weight of the roots was measured. The results were subjected to a Student's *t*-test using Microcal Origin (ver. 3.1) at the probability levels of $P < 0.05$, $P < 0.01$ and $P < 0.001$. Each rooting material was experimented with six replicates and the mean values obtained for PM (A) was compared with VC+PM (1:1, B) mixture and with VC (C). The comparison of mean values of VC+PM (B) and VC (C) was also made.

RESULTS

NPK content in vermicasts recovered from different vermibed substrates

The NPK contents in vermicasts of *L. mauritii* and *P. ceylanensis* were found to be higher than that of PM used in the study (**Fig. 4**). The total N content in vermicasts recovered from the vermibed LT1 showed a higher value (1.68%) followed by LT4 (1.48%), LT2 (1.37%), LT5 (1.05%), LT3 (0.99%), LT6 (0.93%) and PM (0.86%). The total P and K contents of 1.21 and 0.65% were recorded in the vermicasts obtained from the vermibeds of LT1 and LT3, respectively which were higher than that of the casts recovered from the remaining vermibeds.

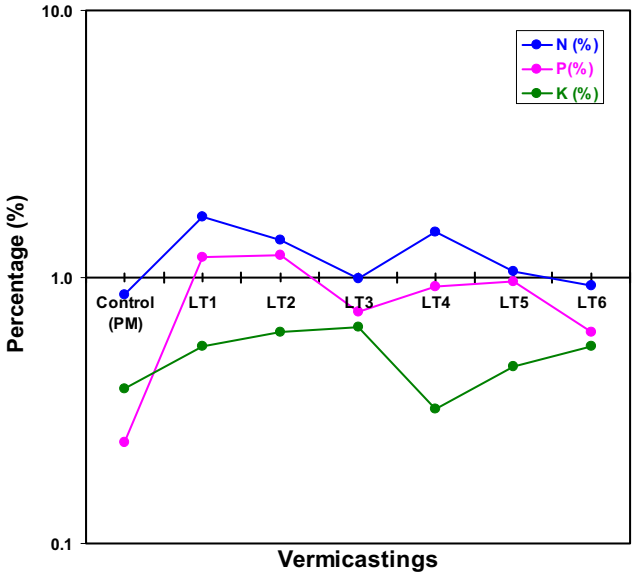

Fig. 4 Total NPK contents in vermicasts of *L. mauritii* and *P. ceylanensis* collected from different vermibed substrates in comparison with peat moss. (PM, control).

Root initiation

Rooting initiation was much earlier in the VC than in PM (control) and in the PM + VC mixture. There was a significant difference in root initiation between the control and the experimental setups (VC and VC + PM mixture) and between VC and the VC + PM mixture (**Table 2**).

Root length

Roots, after 45 days layering, were significantly ($P < 0.001$) higher record in VC than in PM. In the experiments with

Table 2 Rooting initiation in *C. variegatum* layering covered with peat moss (PM, control), vermicasts (VC) + peat moss mixture and vermicasts (days from the beginning).

Treatment	Root initiation in number of days		
	PM (Control)	VC + PM (1:1)	VC
	(A)	(B)	(C)
LT1	18.33 ± 1.37	15.83 ± 0.98**	12.83 ± 1.47***, b
LT2	18.33 ± 1.37	16.17 ± 1.33*	13.17 ± 1.17***, b
LT3	18.33 ± 1.37	16.67 ± 1.37^{NS}	13.83 ± 0.75***, b
LT4	18.17 ± 1.33	15.00 ± 0.89***	12.33 ± 1.21***, b
LT5	18. 17 ± 1.33	15.67 ± 1.03**	12.83 ± 1.17***, b
LT6	18. 17 ± 1.33	16.33 ± 1.51*	14.50 ± 1.05***, a

*, **, *** and ^{NS} indicates statistical significance of difference in mean values between the columns (A) and (B) and (A) and (C) at $P < 0.05$, $P < 0.01$, $P < 0.001$ and not significant respectively;
$^{a, b, c}$ and ^{NS} indicates statistical significance of difference in mean values between the columns (B) and (C) at $P < 0.05$, $P < 0.01$, $P < 0.001$ and Not significant respectively; Refer to **Table 1** for treatment details

Table 3 Root length of *C. variegatum* layering covered with peat moss (PM, control), vermicasts (VC) + peat moss mixture and vermicasts (45 days).

Treatment	Root length in cm		
	PM (Control)	VC + PM (1:1)	VC
	(A)	(B)	(C)
LT1	8.78 ± 0.75	13.87 ± 1.10***	15.05 ± 0.78***, NS
LT2	8.78 ± 0.75	12.98 ± 1.20***	14.50 ± 1.05***, a
LT3	8.78 ± 0.75	13.83 ± 0.90***	15.58 ± 1.40***, a
LT4	8.90 ± 0.85	13.50 ± 0.75***	14.62 ± 1.54***, NS
LT5	8.90 ± 0.85	13.60 ± 0.78***	15.18 ± 1.20***, a
LT6	8.90 ± 0.85	12.63 ± 0.43***	14.65 ± 0.53***, c

*** indicates statistical significance of difference in mean values between the columns (A) and (B) and (A) and (C) at $P < 0.001$;
$^{a, b, c}$ and ^{NS} indicates statistical significance of difference in mean values between the columns (B) and (C) at $P < 0.05$, $P < 0.01$, $P < 0.001$ and Not significant respectively; Refer to **Table 1** for treatment details

Table 4 Total number of roots developed in *C. variegatum* layering covered with peat moss (PM, control), vermicasts (VC) + peat moss mixture and vermicasts (45 days).

Treatment	Total number of roots (no./layering)		
	PM (Control)	VC + PM (1:1)	VC
	(A)	(B)	(C)
LT1	23.33 ± 1.37	29.67 ± 1.63***	31.17 ± 1.47***, NS
LT2	23.33 ± 1.37	27.33 ± 2.25**	29.83 ± 2.32***, NS
LT3	23.33 ± 1.37	26.33 ± 1.03**	29.17 ± 1.60***, b
LT4	23.17 ± 1.47	27.17 ± 1.47***	29.50 ± 1.52***, a
LT5	23.17 ± 1.47	26.83 ± 1.47**	28.00 ± 1.41***, NS
LT6	23.17 ± 1.47	27.00 ± 0.89***	28.17 ± 2.56**, NS

, * and NS indicates statistical significance of difference in mean values between the columns (A) and (B) and (A) and (C) at $P < 0.01$, $P < 0.001$ and Not significant respectively;
a, b, c and NS indicates statistical significance of difference in mean values between the columns (B) and (C) at $P < 0.05$, $P < 0.01$, $P < 0.001$ and Not significant respectively; Refer **Table 1** for treatment details

Table 5 Fresh weight of the roots developed in *C. variegatum* layering covered with peat moss (PM, control), vermicasts (VC) + peat moss mixture and vermicasts (45 days).

Treatment	Fresh weight of the roots in g.		
	PM (Control)	VC + PM (1:1)	VC
	(A)	(B)	(C)
LT1	9.24 ± 0.54	11.75 ± 0.65***	12.34 ± 0.58***, NS
LT2	9.24 ± 0.54	10.82 ± 0.89**	11.81 ± 0.92***, NS
LT3	9.24 ± 0.54	10.43 ± 0.41**	11.55 ± 0.63***, b
LT4	9.17 ± 0.58	10.76 ± 0.58***	11.68 ± 0.60***, a
LT5	9.17 ± 0.58	10.63 ± 0.58**	11.09 ± 0.56***, NS
LT6	9.17 ± 0.58	10.69 ± 0.35***	11.15 ± 1.02**, NS

*, **, *** and NS indicates statistical significance of difference in mean values between the columns (A) and (B) and (A) and (C) at $P < 0.05$, $P < 0.01$, $P < 0.001$ and Not significant respectively;
a, b, c and NS indicates statistical significance of difference in mean values between the columns (B) and (C) at $p<0.05$, $p<0.01$, $p<0.001$ and Not significant respectively; Refer **Table 1** for treatment details

Table 6 Dry weight of the roots developed in *C. variegatum* layering covered with peat moss (PM, control), vermicasts (VC) + peat moss mixture and vermicasts (45 days).

Treatment	Dry weight of the roots in g.		
	PM (Control)	VC + PM (1:1)	VC
	(A)	(B)	(C)
LT1	0.83 ± 0.05	1.29 ± 0.07***	1.48 ± 0.07***, c
LT2	0.83 ± 0.05	1.19 ± 0.10***	1.42 ± 0.11***, b
LT3	0.83 ± 0.05	1.15 ± 0.05***	1.39 ± 0.08***, c
LT4	0.83 ± 0.05	1.18 ± 0.06***	1.40 ± 0.07***, c
LT5	0.83 ± 0.05	1.17 ± 0.06***	1.33 ± 0.07***, b
LT6	0.83 ± 0.05	1.18 ± 0.04***	1.34 ± 0.12***, a

*, **, *** and NS indicates statistical significance of difference in mean values between the columns (A) and (B) and (A) and (C) at p $P < 0.05$, $P < 0.01$, $P < 0.001$ and Not significant respectively;
a, b, c and NS indicates statistical significance of difference in mean values between the columns (B) and (C) at $P < 0.05$, $P < 0.01$, $P < 0.001$ and Not significant respectively; Refer **Table 1** for treatment details

VC and VC + PM, roots were significantly higher in the treatments with VC of *P. typhoides* cobs + cowdung and *R. exaltata* + cowdung except in the VC of leaf litter of *P. longifolia* + cowdung (**Table 3**).

Total number of roots

The total number of roots developed was more in the layering of *C. variegatum* covered with VC medium and the VC + PM mixture than in the control i.e., PM (**Table 4**). The total number of roots in the treatments LT3 and LT4 which received VC alone as layering material, were significantly higher ($P < 0.001$) from that of the respective treatments with VC + PM. Whilst, the treatments, LT1, LT2, LT5 and LT6 with VC were not significant to the respective treatments which received VC+PM combination.

Fresh weight of the roots

The fresh weight of the roots of the layering of *C. variegatum* covered with PM (control), VC + PM mixture and VC is given in **Table 5**. The fresh weight of the roots of the layering covered with VC and VC + PM mixture was higher than in the control. The layering treatments with VC, LT1, LT2, LT3, LT4, LT5 ($P < 0.001$) and LT6 ($P < 0.01$) were significantly different from control. A maximum fresh weight of roots (12.34 g per layering) was recorded in the treatment with VC of *L. mauritii* cultured in leaf litter of *P. longifolia* + cowdung (1:1) which was not statistically different from that of the fresh weight of roots recorded in the treatment with VC + PM mixture (11.75 g per layering).

Dry weight of the roots

The dry weight of the roots of *C. variegatum* developed in the layering covered with PM (control), VC + PM mixture and VC in 45 days layering experiment is given in **Table 6**. The dry weight of the roots of each layering was significantly higher in VC and VC + PM mixture than in the control ($P < 0.001$). The dry weight of roots recorded after 45 days of layering experiments with vermicast treatments were significantly higher than that observed in VC + PM mixture.

DISCUSSION

The vermicasts are pellet like excretions of earthworms known to contain elevated levels of nutrients and harbour microorganisms than the surrounding soil or worm unworked organic material (Kang and Ojo 1996; Karmegam and Daniel 1999, 2000). The nutrient contents (NPK) in vermicasts recovered from different vermibeds in the present study were higher than that obtained for PM. Root initiation, root length, total number of roots developed, fresh and dry weight of the roots indicate that vermicast is a very good medium for *C. variegatum* layerage. All these parameters (**Tables 2-6**) have shown significant difference in their values between VC and PM (control). Vermicasts either alone or in combination with peat moss were able to initiate earlier rooting and development of roots better than in peat moss. The enhancement in root initiation and development in the present study can be explainable, partially, due to the elevated levels of NPK contents in the vermicasts. Plant propagation is strictly dependent on rhizogenesis and development of the complete organ from the callus which are controlled by phytohormones, i.e. plant growth regulating substances. These substances, particularly auxin, which is a strongly root-promoting substance is widely used in nurseries to stimulate plant growth. Application of earthworm casts to stem cuttings or to layers, have stimulated root initiation, root elongation and root biomass (Tomati *et al.* 1988, 1990; Tomati and Galli 1995). In the present study also the same result has been observed.

The vermicompost obtained from leaf litter of *P. longifolia*, *P. typhoides* cobs and a weed *R. exaltata* in combination with cow dung (1:1) using the earthworms *L. mauritii* and *P. ceylanensis* showed higher contents of nutrients than worm-unworked vermibed substrates and these vermicomposts when applied alone or in combination with chemical fertilizers, enhanced the growth and yield of hyacinth bean, *Lablab purpureus* (Karmegam and Daniel 2008, 2009). Studies conducted by Zaller (2007a, 2007b) on the use of vermicompost amendments on three different tomato varieties showed that the vermicompost could be an environmental friendly substitute for peat in potting media with similar or beneficial effects on seedling performance and fruit quality. Zaller also suggested that at least for tomatoes, variety-specific responses should be considered when giving recommendations on the optimum proportion of vermicompost amendment to horticultural potting substrate. The experiments conducted by Papafotiou *et al.* (2001) clearly showed that the production of ornamental plants, *Euphorbia pul-*

cherrima cv. 'Peterstar white', *C. variegatum* var. *pictum*, *Syngonium podophyllum* and *Ficus benjamina* from the rooted cuttings using cotton gin trash compost can replace up to 60% (by volume) of peat in a peat-perlite medium. The results of the present study also show that the peat moss can be substituted with vermicasts in layering media for the ornamental plant. Worm casts contain a mixture of hormone-like substances, known and unknown. Therefore, the complexity of the responses is as difficult to elucidate as the number of active components and the effects indeed which, like those of synthetic phytohormones, depend on dose, application time and plant species.

CONCLUSION

The results of the present study clearly show that the rooting initiation, root length, number of roots developed, fresh weight and dry weight of the roots of *C. variegatum* were higher in VC + PM and VC alone used as layering media than PM. The difference in enhanced growth parameters in VC + PM and VC were significant over PM. The enhancement could be attributed to the higher levels of major nutrients in VC. Also the differences, except few treatments, in parameters recorded for VC were significantly higher than that recorded for VC + PM. The slight variation within the VC + PM and VC is due to the difference in vermicasts obtained from different vermibed substrates. Zaller (2007a, 2007b) suggested that variety-specific responses should be considered when giving recommendations on the optimum proportion of vermicompost amendment to horticultural potting substrate. So the variation in the effect of vermicasts in the present investigation is due to the variation in nutrient contents as affected by the difference in vermibed substrates as well as different species of earthworms. In the current study, only external characteristics of the plant such as root growth and weight has been subjected to investigation. The complete understanding on the effect of vermicasts on other growth parameters of *C. variegatum* is required to be carried out. The results of the present study show that the peat moss can be substituted with vermicasts in layering media for the ornamental plant, *C. variegatum*.

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