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Influence of Different Leaf Litter Vermicompost Substitution on the Growth of *Eucalyptus* Hybrid (*Eucalyptus camaldulensis* Dehn x *E. tereticornis* Sm)

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ABSTRACT

Due to environmental problems caused by improper waste management like burning of leaf litter and intensive use of chemical fertilizers, scientists around the world are seeking for management alternatives. The aim of this study was to see the effect of different vermicompost treatments [prepared from leaf litters of eucalyptus, parthenium, poplar, sal and pine needles, individually mixed with municipal solid waste (MSW) in 1:1 ratio (v/v)] and control (nursery soil) on the growth of *Eucalyptus* hybrid. For this, nursery soil and vermicomposts were mixed in three different proportions 1:1, 1:2 and 1:3. The results showed that vermicompost substitution significantly increased seedling germination and plant morphology (height, number of leaves, number of branches, total leaf area, root length and number of lateral roots) as compared to control. But with increased vermicompost concentration (1:3), a decrease in plant growth was noticed. Most of the growth parameters responded better with PiLMSWV in 1:2 ratio. Maximum root length and number of lateral roots were achieved in PoLMSWV (1:2).

Keywords: biodegradation, *Eisenia foetida*, municipal solid waste, plant growth parameters, soil amendment
Abbreviations: ANOVA, analysis of variance; **DM**, dry matter; **EuLMSWV**, eucalyptus leaf litter + municipal solid waste vermicompost; **FRI**, forest research institute; **GLM**, general linear model; **MSW**, municipal solid waste; **ParLMSWV**, parthenium leaf litter + municipal solid waste vermicompost; **PiLMSWV**, pine leaf litter + municipal solid waste vermicompost; **PoLMSWV**, poplar leaf litter + municipal solid waste vermicompost; **SrLMSWV**, *Shorea robusta* leaf litter + municipal solid waste vermicompost; **SPSS**, statistical package for social sciences

INTRODUCTION

Disposing-off the considerable quantity of leaf litter produced by trees growing in the forests, along the roads, rail lines, in the backyard, etc. has always been a problem. Improper management of such wastes (burning of leaf litters and uncared dumping in public places) and intensive use of synthetic fertilizers and chemical pesticides since the Green Revolution some five decades ago has deteriorated the health of the environment to a large extent. In the rural areas, residents generally collect and use leaf litter as biomass fuel for cooking. In India, approximately 5 lakh women and children die due to indoor air pollution caused by using solid biomass as cooking. In the cities, leaf litters are burnt which causes several health problems, especially respiratory like asthma and heart diseases (Sannigrahi 2009). The conversion of a negative waste into beneficial material is an important aspect of resource recycling and environmental cleaning (Tripathi and Bhardwaj 2004). Leaf litters are a potential energy resource if properly and biologically converted to organic matter. In this regard vermicomposting is an easy and effective way to recycle leaf litter along with bioconversion of organic waste materials into nutritious compost by earthworm activity (Mall *et al*. 2005). It is the best alternative of the present day's environmental degradation to make proper use of the available unutilized organic biodegradable wastes in order to convert them into compost within a short period. Vermicomposting of organic waste and their application in the fields could decrease the use of chemical fertilizers and eventually replace it. Due to increasing awareness, farmers are now returning to natural methods of cultivation san chemicals.

Several studies have been carried out and reported which prove that vermicompost could be used as an excellent soil amendment for main fields and nursery beds. Gajalakshmi and Abbasi (2004) and Gajalakshmi *et al*. (2005) have reported vermicomposting of neem and mango leaves respectively. The ability of some species of earthworms to consume and breakdown a wide range of organic residues especially crop residues is well known (Karmegam and Daniel 2009; Patnaik and Reddy 2010). Nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium present in vermicompost are mostly in plant-available forms (Orozco *et al.* 1996). It is now scientifically proved that vermicompost can influence the growth and productivity of plants significantly.

The main objectives of the present study were to access the effects of the application of different ratios of different vermicompost treatments (prepared from leaf litter mixed with municipal solid waste) and nursery media on germination and different growth parameters of *Eucalyptus hybrid*, namely plant height (cm), number of leaves per plant, number of branches per plant, root length (cm), number of lateral roots and total leaf area (cm^2).

MATERIALS AND METHODS

The leaf litters of *Eucalyptus* hybrid, *Pinus roxburghii*, *Parthenium hysterophorus*, *Populus deltoides* and *Shorea robusta* were selected for this study and were collected from Forest Research Institute (FRI) campus. The leaf litters of each species were first composted by individually mixing them with equal amounts (v/v) of municipal solid waste (MSW) and then moistened with cow-dung slurry (following Gajalakshmi *et al.* 2001). Organic wastes (leaf litter + MSW) were composted thermophilically for 47-82 days (depending on the leaf litter) with manual turning every 3rd

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Table 1 Effect of different treatment mixtures on germination percentage and growth parameters of *Eucalyptus* hybrid.

Treatments	Germination %	Height (cm)	No. of leaves	No. of branches	Total leaf area (cm2)	Root length (cm)	No. of lateral roots
Control	96.4 ± 2.19	99.3 ± 11.84	56.9 ± 13.12	2.4±1.98	1043.3 ± 624.92	44 ± 10.17	7.4 ± 1.52
EuLMSWV							
1:1	94 ± 1.41	93.6 ± 10.09	51.4 ± 3.27	3 ± 3.26	993.38 ± 387.20	37.4 ± 2.70	6.8 ± 1.30
1:2	94 ± 1.41	105.9 ± 21.25	58.2 ± 20.14	3.5 ± 1.96	1380.736 ± 540.58	40.8 ± 6.70	8.2 ± 1.92
1:3	96 ± 1.41	98.7 ± 13.01	55.9 ± 16.25	2.5 ± 2.36	1058.68 ± 317.67	38.6 ± 5.59	7.6 ± 1.14
PiLMSWV							
1:1	98 ± 1.22	115.4 ± 9.18	66.7 ± 10.25	4.6 ± 2.31	1577.96 ± 195.36	34.2 ± 6.18	7 ± 1.22
1:2	99.33 ± 3.04	136.9 ± 8.15	73.8 ± 23.72	6.6 ± 2.75	1854.32 ± 235.18	46.8 ± 5.63	8.6 ± 1.14
1:3	99.67 ± 2.34	122.7 ± 12.36	72.4 ± 15.68	5.3 ± 2.64	1618.75 ± 233.79	39.7 ± 4.75	8.2 ± 1.09
ParLMSWV							
1:1	96.67 ± 2.27	102.9 ± 2.83	57.5 ± 26.09	3.9 ± 1.59	1279.1 ± 288.23	34.6 ± 4.39	7.4 ± 1.52
1:2	98 ± 1.22	117.4 ± 14.73	65.3 ± 10.71	4.8 ± 3.29	1585.48 ± 217.48	49.2 ± 9.78	9 ± 1.58
1:3	98 ± 1.22	113.1 ± 15.90	62.8 ± 19.89	4.3 ± 2.58	1363.08 ± 589.55	42.8 ± 6.61	8.2 ± 1.64
PoLMSWV							
1:1	98 ± 1.22	106.6 ± 7.03	63 ± 6.81	4.1 ± 2.76	1225.4 ± 517.82	45 ± 3.94	8.4 ± 1.14
1:2	97.67 ± 1.27	119.3 ± 18.94	66.9 ± 11.25	5.7 ± 3.23	1627.8 ± 455.08	51.6 ± 4.50	9.9 ± 4.01
1:3	99.67 ± 3.12	108 ± 13.19	66.1 ± 6.41	4.6 ± 2.31	1499.5 ± 498.71	49.4 ± 4.39	9 ± 3.46
SaLMSWV							
1:1	93 ± 4.41	90 ± 8.21	45.8 ± 10.51	1.7 ± 1.49	562.32 ± 149.68	41.3 ± 4.27	8.1 ± 1.59
1:2	92 ± 3.46	98.7 ± 13.01	56.9 ± 18.66	1.9 ± 1.37	916.11 ± 112.38	48.7 ± 10.59	9.3 ± 4.02
1:3	94 ± 2.44	93.6 ± 10.09	54.3 ± 10.59	2.7 ± 2.1	822.96 ± 125.57	46 ± 4.53	8.6 ± 1.14
CD	38.27	21.88	23.34	2.219	542.3	10.154	1.544
Significance	***	**	**	**	***	**	**

The values are mean of five replicates ± standard deviation. **, ***, significant at 0.01, 0.001 probability levels, respectively.
Eucalyptus leaf litter + Municipal solid waste vermicompost - EuLMSWV; Pine leaf litter + Municipal solid waste vermicompost- PiLMSWV; Parthenium leaf litter + Municipal solid waste vermicompost - ParLMSWV; Poplar leaf litter + Municipal solid waste vermicompost – PoLMSWV; *Shorea robusta* leaf litter + Municipal solid waste vermicompost – SrLMSWV

day initially and later turned in accordance with temperature evolution and water was added to maintain moisture content near 60% (Aalok and Tripathi 2010).

The compost obtained was then subjected to vermicomposting using the epigeic species *Eisenia foetida.* The methodology followed for vermicomposting was as per Gajalakshmi *et al*. (2001). The compost and vermicompost produced were analyzed for different physico-chemical nutrients (Aalok and Tripathi 2010). For the nursery experiments, treatment mixtures were prepared by thoroughly mixing nursery soil and five different vermicompost in three different ratios (1:1, 1:2 and 1:3) and nursery soil was set as control. Seeds of *E.* hybrid were collected from the local nursery. 50 seeds were sown in plastic trays filled with the treatment mixture. Out of the 50 seeds germinated, 5 seedlings (replicates) were transplanted into polybag of size 0.73 liters (approx.) filled with the treatment mixture after 30 days of sowing. An individual plant was considered as a replicate. The nursery study was carried out for a period of six months (from December, 2006 to May, 2007). The detail of the treatments prepared is as follows:
Nursery soil (control)
Nursery soil + EuLMSWV - 1:1, 1:2 and 1:3
Nursery soil + PiLMSWV - 1:1, 1:2 and 1:3
Nursery soil + PoLMSWV - 1:1, 1:2 and 1:3
Nursery soil + PaLMSWV - 1:1, 1:2 and 1:3
Nursery soil + SrLMSWV - 1:1, 1:2 and 1:3
(EuLMSWV - eucalyptus leaf litter + municipal solid waste vermicompost; ParLMSWV - parthenium leaf litter + municipal solid waste vermicompost; PiLMSWV - pine leaf litter + municipal solid waste vermicompost; PoLMSWV - poplar leaf litter + municipal solid waste vermicompost; SrLMSWV - *Shorea robusta* leaf litter + municipal solid waste vermicompost).

Observations recorded

Various morphological observations were recorded at monthly intervals on the development of seedlings followed by true leaves. The parameters analyzed were germination percent (GP), plant height (cm), number of leaves per plant, number of branches per plant, root length (cm), number of lateral roots and total leaf area (cm^2).

Statistical analysis

The experiment was a completely randomized design with 5 replicates of each treatment. The experimental data was expressed as mean ± Standard Deviation. Two-way ANOVA was used to analyze the significant ($P \leq 0.05$) difference between the treatments and among ratios using General Linear Model (GLM) procedure of SPSS v. 11 [FRI, Dehradun] statistical software for windows.

RESULTS

The seeds of *E.* hybrid were sown in the month of December and germination was noticed after four weeks. The data recorded for different growth parameters are presented in **Table 1**. Application of vermicompost significantly increased the plant growth. The results indicated that under identical laboratory conditions the plants grown in the media containing soil amended with different vermicompost had better height, larger number of leaves and branches per plant, root length, number of lateral roots and total leaf area.

Germination percent

Higher germination of seedlings was recorded in the treatments (leaf litter vermicomposts) as compared to the control. Maximum germination was noticed in the treatment PiLMSWV and minimum in SrLMSWV (**Fig. 1A**). It was noted that the germination of eucalyptus seedlings increased with increasing vermicompost concentration, i.e., in 1:3 ratio (**Table 1**). Significant differences ($P < 0.001$) were seen between the treatments, between the ratios and in the interactions between the treatments and ratios.

Growth parameters

Most of the growth parameters (mean height, number of leaves, number of branches and total leaf area) responded well with the treatment PiLMSWV and the least effective treatment was SrLMSWV (**Fig. 1B-D**). Regarding increment of root length and number of lateral roots, the treatment PoLMSWV was best suited (**Fig. 1E**). Here an opposite trend to that germination was noted, i.e., the plant growth and morphology decreased with increasing vermi-

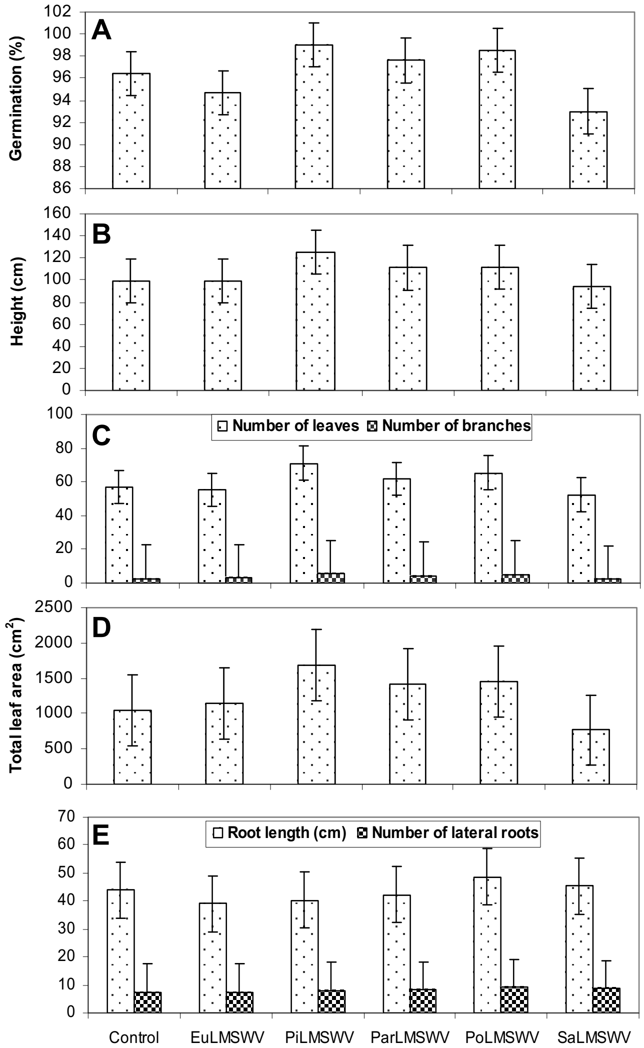

Fig. 1 A comparison of the effect of different treatments on the growth of *Eucalyptus* hybrid plant. (**A**) Germination (%) (**B**) height (cm) (**C**) number of leaves and number of branches (**D**) total leaf area (cm^2) (**E**) root length (cm) and number of lateral roots. Values represent means ± Standard Error (SE).

compost concentration (1:3 ratio). Higher growth was noted in a 1:2 ratio (**Table 1**). The growth of eucalyptus plant was significantly different ($P < 0.001$) with each treatment. Non-significant differences were seen between the ratios.

DISCUSSION

The results of this experiment show that it is possible to substitute leaf litter vermicompost as soil amendment in nurseries although substantially different effects were observed between these substrates in plant morphology and growth depending on the dose used. There are several greenhouse experiments to prove that vermicompost can have consistently positive effects on the growth and yields of plants (Edward and Burrow 1988). The effect of different types of vermicomposts as potting or soil amendments on plant growth and yield has been reported in many studies (Edwards *et al.* 2004; Hashemimajd *et al.* 2004; Tognetti *et al.* 2005; Garcia-Gomez *et al.* 2002; Perez-Murcia *et al.* 2006). Plant responses to the vermicompost treatment are highly dependent on the species, the source and the quantity of compost utilized. Vermicompost constitute a slow release source of nutrients that supply the plants with the nutrients when they are needed (Chaoui *et al.* 2003; Nevens and Reheul 2003). There are similar examples in the literature proving that compost and vermicompost are able to further enhance the growth of a wide range of plant species because of the supply of nutrients (Edwards *et al.* 2004; Grigatti *et al.* 2007). Furthermore, biologically active metabolites such as plant growth regulators (Tomati and Galli 1995; El Harti *et al.* 2001) and humates (Atiyeh *et al.* 2002; Canellas *et al.* 2002) have been discovered in vermicomposted materials.

Alagesan and Dheeba (2010) have reported that leaf litter vermicompost showed higher values for the growth parameters of *Abelmoschus esculentus* than the sugarcane trash. Application of vermicompost obtained from water hyacinth (*Eichhornia crassipes*) and neem leaf litter significantly enhanced growth and flowering of *Crossandra udulaefolia* (Gajalakshmi and Abassi 2002) and brinjal respectively (Gajalakshmi and Abassi 2004) as compared to untreated control plants. Vadiraj *et al.* (1998) reported enhanced growth and dry matter yield of cardamom (*Electtaria cardamomum*) seedlings in vermicomposted forest litter compared with that in other growth media tested.

The results similar to this study (i.e. decrease in seedling germination and plant growth with increase in vermicompost concentration) have already been reported in previous studies and it has been attributed to the change in the physical properties of the substrate (*i.e.* increase in bulk density and decrease in pore and readily available water) (Papafotiou *et al.* 2005), to the increase in salt content (García-Gómez *et al.* 2002; Castillo *et al.* 2004; Herrera *et al.* 2008) and to the presence of excessive nutrient levels (Hashemimajd *et al.* 2004).

Root morphology was also significantly improved through the increase in root length and number of lateral roots as compared to the control. These improvements in plant growth and morphology are basically due to enhancement of post-transplant success. Nutrient-rich environments and the presence of hormones like auxins improve root growth. This enables the plant to optimize the exploitation of the available resources which are in turn transformed into photoassimilates and transported again to the root consequently influencing plant growth and morphology in a systemic manner (Forde and Lorenzo 2001; López-Bucio *et al.* 2003).

CONCLUSION

The results of this study show that good quality vermicompost can be produced from the leaf litters of forest tree species. Such studies could prove to be helpful in dealing problems like uncared dumping and burning of leaf litter in public places. Due to increasing interest in organic farming, use of composted and vermicomposted organic waste as soil conditioner is on the rise. Thus vermicomposting of leaf litter holds promise to play a significant role both in cleaning the environment and building up of soil fertility for sustainable agriculture.

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