The Pharma Innovation Journal 2023; 12(6): 1806-1809

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 1806-1809

www.thepharmajournal.com
Received: 16-04-2023
Accepted: 20-05-2023

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Effect of vermicompost and mycorrhizal consortia on the growth of casuarina seedlings towards the production of quality wood logs

M Kiruba and B Sivakumar

Abstract
A study was conducted to assess the efficacy of different vermicompost on the growth of *Casuarina equisetifolia* seedlings in the nursery. In order to find out the efficient waste management technology, the selected waste materials were subjected to vermicomposting processes. The microbially enriched vermicompost was used as potting mixture for raising seedlings. The vermicompost was much darker and had been processed into homogenous manure. The advantage of composing with the conventional process took a long time compared to vermicomposting. As far as earthworm biomass production is considered, vermicompost derived from albizia and teak leaf waste favored the plant growth parameters with respect to shoot length, root length, diameter and total dry weight of seedlings. Besides, the inoculated VAM persisted in the rhizosphere and their count increased at the time of harvest. The maximum nodule number was observed up to 75 days after planting (DAP) in seedlings applied with simaruba vermicompost and mycorrhizal consortia. The maximum population of VAM was observed in the roots of casuarina seedlings applied with simaruba vermicompost and mycorrhizal consortia. Thus, studies on the biocomposting process revealed that nutrient-rich, stable and mature compost could be produced from various substrates by employing earthworms. From the nursery experiment, it is learned that quality casuarina seedlings could be produced utilizing coffee and teak vermicomposts and mycorrhizal consortia.

Keywords: Vermicompost, VAM fungi, *Casuarina*, seedling growth

Introduction

The tree species *Casuarina equisetifolia* L. belongs to the family Casuarinaceae is primarily found in Southeast India's coastline (Mascarenhas and Jayakumar 2008) [12]. According to estimates, 500,000 ha of casuarina trees have been planted in the states of Andhra Pradesh, Orissa, Tamil Nadu, and the Union Territory of Puducherry, making India the largest casuarina-growing nation in the world (Nicodemus 2009) [14]. It is one of the trees that frequently grows close to the coast, is tolerant of salt spray, and in light to thick textured soil (Balasubramanian 2001) [1]. It is also a crucial species for preventing erosion, particularly on coasts, sand dunes, and poor inland soils, where it thrives thanks to its capacity to fix nitrogen. Further, vermicompost is being sold commercially as a potting mix for various horticultural and decorative plants, as well as for growing root stocks and forest trees (Khare *et al.* 2018) [10]. The vermicompost gives plants the vital nutrients they need and facilitates rapid nutrient absorption and production of quality wood logs. The composting method emerges as the most widely applicable process for handling diverse wastes in the entire area of waste recycling. To reduce the environmental impact and the need for organic manure for intensive farming, organic wastes are composted in an appropriate way based on their physico-chemical nature. Composting is a method for transforming a wide range of organic materials from sources of plant, animal, and industrial waste into a stable, useful eco-friendly product. A lot of waste materials such as tree litter, coffee and tea waste, vegetable waste, etc. are available in and around Nilgiri hills of Tamil Nadu. The degradable organic matter from these wastes when dumped in the open undergoes either aerobic or anaerobic degradation. These un-engineered dumpsites permit fine organic matter to become mixed with percolating water to form leachate. The potential of the leachate to pollute adjoining water and soil is high. The environmentally friendly 'vermicomposting technology' can very well be adopted for converting these wastes into wealth. 'Vermicomposting' is a kindred process to composting, featuring the addition of certain species of earthworms to enhance the process of waste conversion and to produce a better end product.

Vermicomposting differs from conventional composting in several ways. Chiefly, vermicomposting is a mesophilic process and the process is considered faster than normal composting. Since the material passes through the earthworm gut and undergoes a significant but not yet fully understood transformation; hence, the resulting earthworm castings are abundant in microbial activity, plant growth regulator and fortified with pest repeller attributes as well. Considerable work has been carried out on vermicomposting of various organic materials and it has been established that epigeic forms of earthworms can hasten the composting process to a significant extent, with the production of a better quality of composts as compared with those prepared through traditional methods. The viability of using earthworms as a treatment or management technique for numerous organic wastes has been investigated by the number of workers (Hand 1988; Logsdan 1994; Singh and Sharma 2002) [6, 17]. Similarly, numerous industrial wastes have been vermicomposted and turned into nutrient-rich manure (Sundaravadivel *et al*. 1995) [20]. But there is a dearth of information regarding the vermicomposting of wastes viz., tree litters, coffee, tea processing wastes, pungam and simaruba shell, vegetable wastes, etc. hence study has been conducted to evaluate the efficacy of vermicompost and mycorrhizal consortia on growth and development of casuarinas seedlings under nursery conditions.

Materials and Methods

Effect of vermicompost and mycorrhizal consortia on growth of casuarinas seedlings

Nursery experiments were carried out to find out the effect of vermicompost on casuarinas. The polybag experiment had 12 treatments replicated thrice in a randomized block design. Thirty plants were maintained for each replication. The bags were filled with a nursery mixture of sand: red soil: FYM combination. The farmyard manure was replaced by the same quantum of compost, each containing 10 g of compost. The mycorrhizal consortia consisting of *Glomus mosseae*, *Gigaspora margarita* and *Acaulospora laevis* were used @ of 5g per polybag and seedlings were planted in the polybags. The growth parameters were recorded 15, 30, 45, 60 and 75 days after planting.

Treatments

T1 - VC1 (Teak litter vermicompost) + mycorrhizal consortia
T2 - VC2 (Albizia litter vermi compost) + mycorrhizal consortia
T3 - VC3 (Simaruba shell vermicompost) + mycorrhizal consortia
T4 - VC4 (Pungam shell vermicompost) + mycorrhizal consortia
T5 - VC5 (Coffee pulp vermicompost) + mycorrhizal consortia
T6 - Mycorrhizal consortia alone
T7 - VC1 (Teak litter vermicompost)
T8 - VC2 (Albizia litter vermicompot)
T9 - VC3 (Simaruba shell vermicompost)
T10 - VC4 (Pungam shell vermicompost)
T11 - VC5 (Coffee pulp vermicompost)
T12 - Control

Examination of mycorrhizal infection in roots

The extent of VAM infection was estimated by following the method of Philips and Hayman (1970) [16]. Plant roots were collected and washed carefully to remove adhering soil particles. The roots were cut into approximately two-centimeter segments. The Potassium hydroxide (10%) was used to digest the roots by autoclaving at 10 lbs for 15 min. After this, the solution was decanted and neutralized with one percent hydrochloric acid. The root pieces were then washed with tap water and stained with 0.008 percent tryphan blue in lactic acid: glycerol: distilled water (1:2:2 v/v) for 24 hours. The excess stain was removed by treating the root pieces with lactophenol. The mycorrhizal infection in the root pieces was observed using a binocular microscope (10 x).
The per cent mycorrhizal colonization was then calculated.

$$\text{Percent infection} = \frac{\text{Number of positive segments}}{\text{Total number of roots segments observed}} \times 100$$

Statistical analysis

The data obtained from various experiments were analysed statistically using the Factorial Randomized Block Design, as described by Gomez and Gomez (1984) [4].

Results and Discussion

Biometrical observation of casuarina seedlings

Treatments with various vermicompost and vermicompost + mycorrhizal consortia have positively influenced the growth of the seedlings. There was a significant increase in shoot fresh weight of casuarina seedlings due to the application of various vermicompost. Application of vermicomposted albizia litter registered a maximum shoot fresh weight of 10.99g. This was followed by vermicomposted teak litter + mycorrhizal consortia. The control treatment recorded the minimum shoot weight of 8.76 g and significant differences could be observed after 45 DAP onwards. The highest shoot dry weight of 3.68 g recorded by vermicomposted teak litter + mycorrhizal consortia, pungam vermicompost + mycorrhizal consortia (3.64 g) coffee vermicompost + mycorrhizal consortia (3.68 g). They were statistically on par with each other and were superior to control (2.8 g). Significant variations among the treatments were observed only from 30 DAP (Table 1). Vermicomposted teak litter + mycorrhizal consortia produced the maximum shoot length of (67.5cm) and was found to be statistically significant to all other treatments. The superiority of this treatment was evident as early as 30 days after planting and was consistent up to 75 DAP. The control recorded 45.20 cm (Table 1). Root length was also positively influenced by the treatments as evident from Table 1. The maximum root length was recorded in vermicomposted teak litter + mycorrhizal consortia followed by simaruba vermicompost + mycorrhizal consortia which is statistically on par with each other treatments. The influence of the treatments could be noticed even from 30 DAP. The maximum root length of 56.13 cm was recorded in 75 DAP.
The root fresh weight of casuarina was also influenced when subjected to the application of T_1 - teak vermicompost + mycorrhizal consortia and T_3 – simaruba vermicompost + mycorrhizal consortia. It could be seen that the T_1 and T_3 induced root fresh weight of 8.32 g. This was followed by T_5 - coffee vermicompost + mycorrhizal consortia. The maximum root fresh weight recorded at 75 DAP. Control recorded the lower value of 6.44 g. There was no significant difference among all other treatments. T_1 - teak vermicompost +

mycorrhizal consortia, T_2 - albizia litter vermicompost + mycorrhizal consortia, T_3 – simaruba vermicompost + mycorrhizal consortia, T_4 - pungam vermicompost + mycorrhizal consortia, T_5 – coffee pulp vermicompost + mycorrhizal consortia, T_6 - mycorrhizal consortia only, T_8 - albizia litter vermicompost and T_{10}-pungam vermicompost were recorded higher (3.19 g) root dry weight followed by T_9 - simaruba vermicompost and T_{11} – coffee pulp vermicompost. T_9 and T_{11} were statistically on par with each other. Control recorded 2.49 g of root dry weight. Maximum root dry weight was registered at 75 DAP (Table 2). Total dry matter was greatest in teak vermicompost + mycorrhizal consortia (8.32 g) and simaruba vermicompost + mycorrhizal consortia (8.3 g). Both were statistically on par with each other. This could also be observed at 60 and 75 DAP. The total dry matter production progressively increased up to 75 DAP. The control recorded lowest value of (6.44 g). T_1 - teak litter vermicompost + mycorrhizal consortia, T_2 - albizia litter vermicompost + mycorrhizal consortia, T_6 - mycorrhizal consortia only and T_9 –simaruba vermicompost treatments were recorded highest collar diameter. These treatments were statistically on par with each other. This could also be observed at 60 and 75 DAP. The collar diameter progressively increased upto 75 DAP. The control recorded the lowest value of 0.51 g (Table 2).

The maximum number of needles of 89.7 per plant was produced when plants were treated with teak vermicompost+ mycorrhizal consortia, which is significantly superior to the rest. In case of 75 DAP number of needles per plant was more in teak vermicompost+ mycorrhizal consortia. The least number was found to be in control 72.0 g. In the present study, the maximum nodule number (10.0) was registered when subjected to T_3 - simaruba vermicompost + mycorrhizal consortia, T_4 - pungam vermicompost + mycorrhizal consortia followed by T_1 - teak vermicompost + mycorrhizal consortia (9.7). This treatment was significantly superior to the others. The maximum nodule number recorded at 75 DAP (Table 2).

A comparison of the mean value of all treatments of casuarina seedlings were registered significant values for VAM infection. The root samples from T_1 - teak vermicompost + mycorrhizal consortia, T_3 - simaruba vermicompost + mycorrhizal consortia and T_6 - mycorrhizal consortia were registered highest VAM infection (21.3%) and the degree of infection was lowest (11.66%) in casuarina seedlings due to T_4 - pungam vermicompst + mycorrhizal consortia, T_7 - teak vermicompost and T_8 - albizia vermicompost (Figure 1). They were statistically on par with each other.

This could be due to the richness of applied vermicompost with nutrients and indole acetic acid which is evidenced from the nutritional analyses of composts. There are reports that certain metabolites produced by earthworms could be responsible for plant growth (Gavrilov, 1962 and Nielson, 1965) [3, 15]. Wilson and Carlile (1989) reported better growth of tomatoes, lettuce and pepper in vermicomposted duck wastes than in unprocessed wastes. Domniguez *et al.* (1997) [2] also reported that vermicastings are rich in humus which contains essential plant nutrients, micronutrients, vitamins, beneficial microorganisms, antibiotics, enzymes etc., that are available for long term nutritional needs for plant growth. Karmegam *et al.* (1999) [9] reported that germination efficiency of green gram was greater in vermicompost medium. Hidalgo *et al.* (1999) [8] reported that 95 percentage germination was observed in cucumber when the seeds were sown with a soil mixture and vermicompost. Coffee pulp vermicompost recorded maximum value for all growth indices, like collar diameter, shoot length, root length, shoot dry weight, shoot fresh weight, percentage of seed germination, number of leaves, root fresh weight and root dry weight. Earthworm casting contain humic substances that could influence plant growth via physiological effects (Muscolo *et al*. 1999) [13]. Sivasubramanian (1999) [18] has reported that the introduction of the earthworm *Eudrilus eugeniae* alone and with cowdung and mulch effectively increase the vegetative growth of marigold and chrysanthemum through plant height, number of leaves, number of laterals produced and leaf area. Sivasubramanian and Ganesh Kumar (2000) [19] have reported that spraying vermiwash had a very positive effect on the plant height of vanilla. Harti *et al.* (2001) [7] reported that the worm extract contained hydroxy-indole carboxylic acid. The findings of current study are in confirmation with the findings of Gopi (2002) [5] who reported that application of vermicompost (1:1:1) as soil mixtures significantly increased the growth and biomass productivity of forest seedlings such as *Tectona grandis*, *Casuarina equisetifolia*, *Simarouba glauca*, *Pongamia pinnata* and *Delonix regia*. It is concluded that vermicompost obtained by composting teak litter and coffee pulp along with mycorrhizal consortia has significantly increased the growth and biomass of casuarina seedlings.

Table 1: Effect of application of vermicompost and mycorrhizal consortia on shoots of casuarina seedlings

Treatments	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Shoot dry weight (g)
T_1	67.50^{a}	56.13^{a}	10.57^{abc}	3.64^{a}
T_2	61.40^{b}	53.86^{abc}	10.24^{b-e}	3.34^{bc}
T_3	64.06^{b}	51.93^{bc}	10.80^{ab}	3.62^{ab}
T_4	63.30^{b}	54.00^{ab}	10.58^{abc}	3.64^{a}
T_5	60.73^{b}	53.86^{abc}	9.86^{de}	3.68^{a}
T_6	61.70^{b}	52.86^{bc}	10.39^{a-d}	3.56^{abc}
T_7	61.53^{b}	52.30^{bc}	10.82^{ab}	3.35^{bc}
T_8	63.23^{b}	52.20^{bc}	10.99^{a}	3.28^{c}
T_9	62.93^{b}	50.96^{c}	9.60^{e}	3.54^{abc}
T_{10}	61.90^{b}	52.03^{bc}	9.97^{cde}	3.58^{ab}
T_{11}	61.63^{b}	51.60^{bc}	10.62^{abc}	3.56^{abc}
T_{12}	45.20^{c}	43.40^{d}	8.76^{f}	2.80^{d}

In a column, means followed by a common letter are not significantly different at 5% level by DMRT

Table 2: Effect of application of vermicompost and mycorrhizal consortia on roots of casuarina seedlings

Treatments	Root fresh weight (g)	Root dry weight (g)	Dry matter (g)	Collar diameter (cm)	Needle number	Nodule number
T_1	8.32^{a}	3.19^{a}	6.83^{a}	0.56^{a}	99.3^{a}	9.7^{a}
T_2	8.07^{bc}	3.16^{a}	6.50^{b}	0.56^{a}	93.7^{ab}	7.7^{ab}
T_3	8.30^{a}	3.17^{a}	6.79^{a}	0.53^{ab}	93.3^{ab}	10.0^{a}
T_4	7.67^{ef}	3.16^{a}	6.80^{a}	0.54^{ab}	86.7^{cd}	10.0^{a}
T_5	8.12^{b}	3.16^{a}	6.84^{a}	0.54^{ab}	83.7^{cde}	8.3^{a}
T_6	7.89^{cd}	3.17^{a}	6.73^{a}	0.56^{a}	89.0^{bc}	8.7^{a}
T_7	7.28^{g}	2.51^{b}	5.86^{c}	0.54^{ab}	88.7^{bc}	5.3^{bc}
T_8	7.23^{g}	3.17^{a}	6.45^{b}	0.52^{ab}	82.0^{def}	3.7^{c}
T_9	7.83^{de}	2.83^{ab}	6.37^{b}	0.56^{a}	74.7^{g}	5.0^{c}
T_{10}	7.59^{f}	3.17^{a}	6.75^{a}	0.54^{ab}	77.7^{efg}	3.7^{c}
T_{11}	7.67^{ef}	2.83^{ab}	6.39^{b}	0.55^{ab}	76.3^{fg}	3.3^{c}
T_{12}	6.44^{h}	2.49^{b}	5.29^{c}	0.51^{b}	72.0^{g}	3.3^{c}

In a column, means followed by a common letter are not significantly different at 5% level by DMRT

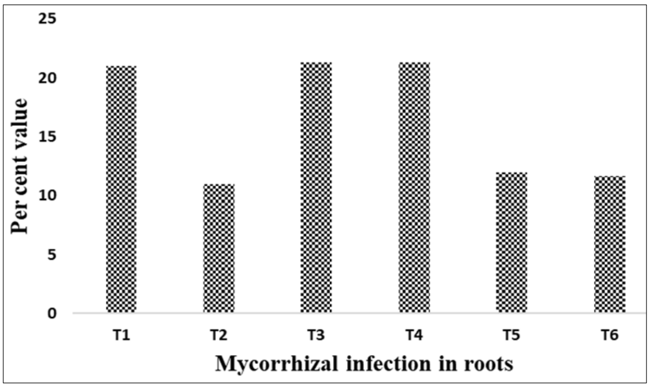

Fig 1: Effect of application of vermicompost and mycorrhizal consortia on mycorrhizal infection in roots of casuarina seedlings

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