Natural Resources for Human Health

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Received 06 November 2021
Revised 03 December 2021
Accepted 06 December 2021
Available online 06 January 2022

Edited by Prabhukarthikeyan SR

KEYWORDS:
Morphological traits
biomass
Bombax ceiba
compost
organic fertilizer
forestry

Natr Resour Human Health 2022; 2 (2): 222-227
https://doi.org/10.53365/nrfhh/144578
eISSN: 2583-1194

Effect of different compost concentrations on the growth yield of *Bombax Ceiba* (Simal)

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ABSTRACT: *Bombax ceiba* is an important agroforestry tree species widely distributed throughout the world. It has been extensively grown and planted for eras in hot and dry regions and high humidity zones of southern Asia. The main objective of this research was to evaluate the growth response of *B. ceiba* in response to different compost treatments. Different morphological traits (plant height, stem height, root length) and biomass (shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and root/shoot ratio) were measured. Two experiments (pot experiment = seedlings) and (field experiment = saplings) were conducted simultaneously. Different compost treatments: (T_0) = (Compost 0% + Soil 0%), (T_1) = (Compost 25% + Soil 75%), (T_2) = (Compost 50% + Soil 50%), (T_3) = (Compost 75% + Soil 25%), (T_4) = (Compost 100% + Soil 0%) were applied in the growing media. Results demonstrated that plant growth increased with the increment in compost application. In the pot experiment, *B. ceiba* exhibited its better growth under 75% of compost application, whereas in the field experiment, 100% compost was helpful for the best production of *B. ceiba*. Overall, positive effects of compost were observed for the growth of *B. ceiba*. The plant growth was increased greatly in response to the better content of organic fertilizer, and it was determined that compost enhances soil fertility. It should be implemented as organic fertilizer in agroforestry operations for optimizing plant growth and yield.

1. INTRODUCTION

Bombax ceiba belongs to the Bombacaceae family and is commonly known as Simal. It is an important multipurpose tree used for agroforestry, providing food, fodder, fuel, and fiber (Mane & Vedamurthy, 2020; Neupane, 2000). Specifically, it is used in various indigenous systems of medicine in India, China and Southeast Asian countries and its roots and flowers are used for curing a maximum number of ailments (Asif et al., 2020). Economically, *B. ceiba* is valuable due to its rapid growth and volume production. Its wood is soft, whitish elastic, durable and suited for the match, plywood industries as well as used for making planking ceilings, canoes, shingles, toys, scabbards, coffins, well curbs, packing cases, brush-handles, and artifact production (Aziz et al., 2016; Chaturvedi & Pandey, 2004).

B. ceiba is a major agroforest tree species due to its clear bole and self-pruning habit of branches. It is widely used in the silvi-pastoral system of agroforestry to meet livestock feed requirements (Singh et al., 2021). In agroforestry systems, farmers may prefer tree species with deep and less dense roots and do not compete strongly with agricultural crops for water and nutrients. *B. ceiba* is useful for the reclamation of wastelands and mine spoils (Ahirwal & Maiti, 2021; Tejwani,

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1994), so it can also be utilized to improve the barren soil and gain economic benefits simultaneously.

Compost is the term used to describe the decomposed organic material used as natural, synthetic manure. It's usual in forestry and agriculture to utilize compost as a soil-improving tool (Duong, 2013). Compost's humus-like elements have an adhesive and flexible texture that is beneficial for growing plants (Silva & Gouveia, 2020). Different microorganisms are active during degradation and improve the composting process (Daldoum & Ameeri, 2013). Organic matter, such as compost, positively affects soil biodiversity by attracting new species of bacteria and fungi. The biological decomposition of organic matter produces compost fertilizer, whereas the adverse effects of compost on seedlings are exceedingly rare (Luo, 2020).

Organic matter and nutrients are restored in the soil by compost application, which improves soil productiveness while also increasing the long-term viability of agricultural production. Organic matter is an essential key to a healthy soil since it contributes significantly to the soil's physical, chemical, and biological productivity, among other aspects (Trupiano et al., 2017). Recent research has suggested that the use of biochar in addition to organic or inorganic fertilizer may result in improved soil physical, chemical, and biological attributes and increase plant productivity. Certain composted elements constitute a sustainable supply of commonly available nutrients that could promote plant growth while simultaneously improving the soil's physicochemical qualities and microbiological properties (Scotti et al., 2015). There is evidence that the use of compost and biochar together has a beneficial synergistic impact on water-holding capacity in soil (Liu et al., 2012). Applying fully decomposed compost to the land has been proven to improve soil organic matter content, encourage natural soil development, improve soil nutrient uptake and modify soil microbial content and enzymes participating in nutrient activation (Bedada et al., 2014).

Different fertilizer application also has a great impact on the growth of *B. ceiba*. Nitrogen (N), phosphorus (P) and potassium (K) on the seedling's morphological growth of *B. ceiba* were observed significantly higher. However, N fertilizer has the greatest impact on *B. ceiba* seedling photosynthetic properties and growth, followed by K and P fertilizers, permitting a complete investigation (Zheng et al., 2016).

Despite improved approaches to overcome soil-related issues, waterlogging, salinity, and poor organic matter remain key difficulties in Pakistan agriculture, particularly in areas near arid zones and industrial cities. There is a critical requirement to cultivate multipurpose trees with a short rotation in certain circumstances. *B. ceiba* is a fast-growing agroforestry tree species, and we examined the growth of *B. ceiba* at various compost quantities in the current study. Field and pot trials were used to examine the differences in *B. ceiba*'s morphological features when grown in varied compost concentrations. Researchers and forward-thinking farmers will benefit from the *B. ceiba* maximal timber yield and revenue.

2. MATERIAL AND METHODS

2.1. Experimental Site

This experiment was conducted at the experimental area of the Department of Forestry and Range Management, University of Agriculture Faisalabad. The research area is located within latitudes 30.35^{o}N and 31.47^{o}N and longitudes 72.08^{o}E and 73^{o}E at altitudes of 130 to 150 m. Average low temperatures were 6 ^{o}C, and average high temperatures were 39 ^{o}C. Climatic conditions of the whole experimental duration are shown in Table 1. The information regarding soil physical and chemical properties is also added and shown in Table 2.

2.1.1 Preparation of Site

Initially, the leaf composts (leaves mix and organic materials) were added to the pots' soil. Following the soil preparation, we used a weighing machine to quantify the various amounts of compost that were placed in various levels based on the treatments. Leaf composts (leaves mix and organic materials) were collected from the Agronomy Farms and Forestry Research Area and applied in the pot and field growing media. Every few days, the field was tended, and irrigation was applied. In the field and pot trials of *Bombax ceiba* under various compost conditions, morphological traits and biomass were examined.

2.2. Experimental Design

In this study, five different treatments were applied in pot and field trials.

Treatment (T_0) - (Compost 0% + Soil 0%)
Treatment (T_1) - (Compost 25% + Soil 75%)
Treatment (T_2) - (Compost 50% +Soil 50%)
Treatment (T_3) - (Compost 75% + Soil 25%)
Treatment (T_4) - (Compost 100% + Soil 0%)

Five treatments with eight replications were used in pot and field experiments by making 40 plants for each trial. Irrigation was applied regularly.

2.3. Plant Morphology and Biomass Distribution

At the harvesting time, plant morphological traits, i.e., plant height, stem height and root length, were measured. Meanwhile, plant biomass, i.e., shoot fresh weight and root fresh weight, were measured with a weighing balance. After measuring fresh weights, all samples were dried in a drying oven (DGH-9202 series thermal electric thermostat drying oven) at 75 °C for 24 hours and measured dry weights on (electronic scale JJ3000B). Root-shoot ratios were also measured by dividing root dry mass with shoot dry mass.

2.4. Statistical Analysis

The experiment used a completely randomized design (CRD) and performed a one-way ANOVA with the least significant test (Tukey's). Minitab-19 software was used for statistical analyses. The results were statistically examined at a significance level of $p < 0.05$. GraphPad Prism 8.02 (GraphPad

Table 1
Weather Condition of the Study Area

Month	Temperature			Relative Humidity	Rain-fall	Sun-shine
	Max (^{O}C)	Min (^{O}C)	Avg (^{O}C)	%	mm	Hours
April	37.7	20.9	29.3	30.6	28.3	9.2
May	41.1	26.0	33.5	29.8	10.1	10.4
June	39.8	27.3	32.8	38.9	41.6	9.38
July	38.5	38.9	33.7	70.0	117.2	7.0
August	38.1	28.6	33.4	68.9	66.1	7.9
Septem-ber	36.7	24.4	30.5	67.7	35.6	8.8
Octo-ber	35.0	19.2	27.1	68.2	22.2	7.6

Note: Data from Agricultural Meteorological Cell, University of Agriculture Faisalabad.

Table 2
Physical and Chemical Properties of Experimental Site

Parameters	Sand (%)	Silt (%)	Clay (%)	pH	EC (dSm^{-1})	TSS (ppm)	N (%)	P (ppm)	K (ppm)	OM (%)
0-20 cm	37	42	13	8.0	1.54	1176	0.068	3.6	280	1.43
20-40 cm	66	15.5	10.5	8.1	1.21	1236	0.04	9.4	250	0.87

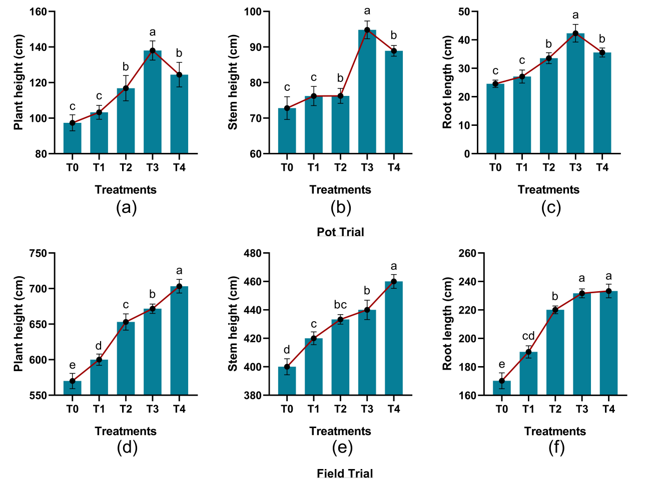

Figure 1. Plant height(cm), shoot length (cm), and root length (cm) of *Bombax ceiba* in response to five compost treatments in pot and field trials. Values are mean ± standard error (SE), and means followed by a different letter (s) are significantly different ($p < 0.05$) across different compost applications. **Note:** T_0 = (Compost 0% + Soil 0%), T_1 = (Compost 25% + Soil 75%), T_2 = (Compost 50% +Soil 50%), T_3 = (Compost 75% + Soil 25%), T_4 = (Compost 100% + Soil 0%)

Software, La Jolla, San Diego, CA, USA) was used to make graphs.

3. RESULTS AND DISCUSSION

3.1. Plant Morphological T raits

According to the analysis of variance, increment in plant height showed significant variations ($p < 0.01$) in response to different compost levels. Results indicated that the plant height of *B. ceiba* increased while adding 75% compost (T_3) into the growing media, and decline was found under zero compost application in pot trials. Simultaneously in the field trial, plant height gradually increased at 100% compost (T_4) level (Figure 1).

Greater shoot length was recorded (94.82 ± 2.5 cm) in response to 75% compost (T_3) level, and reduction (72.81 ± 3.2 cm) was observed at (T_0) level in the pot trial. In the field trial, a higher shoot length (460.0 ± 4.9 cm) was found under the (T_4) compost level and minimum (400.0 ± 5.6 cm) in (T_0) level. Similar root length results were observed as observed in shoot length under both pot and field trials (Figure 1).

Agroforestry is a well-known farming method that has the ability to strengthen soil fertility and nutrient cycling even while sustaining it (Wang & Cao, 2011). When *Bombax ceiba* seedlings were planted in different soil media with different ratios of (soil+sand+FYM), it showed better performance where maximum compost was applied (Khan et al., 2021). It was noticed that the plant growth (height), stem height and root length were higher after the application of compost, which is similar to the findings of (Gautam et al., 2017). The plants indicated better performance in both pots and field trials where compost quantity was maximum. Shoot, and root biomass increased under higher compost application related to the studies of Mostafa (2011). Farmyard manure helps produce more nutrients in the soil, which positively affects plant growth and development.

3.2. Biomass Distribution

3.2.1 Shoot Biomass

Statistical analysis found a significant difference in plant biomass (*$p < 0.05$*) in response to different compost applications. Results demonstrated that shoot (fresh and dry) weight exhibited higher in (T) treatment while it was observed greater in (T) treatment under pot and field trials, respectively. Meanwhile, lower shoot biomass was recorded under zero compost application (Figure 2).

3.2.2 Root Biomass

Significant variations ($p < 0.05$) observed in root biomass. In pot trials, root (fresh and dry) weight (18.00 ± 1.6; 9.01 ± 0.80 g) was found larger under (T_3) treatment, and it was lower in response to (T_0) compost treatment. On the other hand, root (fresh and dry) weight under field trial gradually increased towards the higher amount of compost (T_4) and the decline was recorded under zero compost application (Figure 3).

Considering soil quality as a fundamental standard, we can evaluate how well a soil's physical and chemical features can give plants the necessary nutrients (Neupane, 2000). Compost had a positive influence on the plant growth, as in our studies, shoot and root biomass was larger while adding a higher compost level (Bajracharya et al., 2016; Ścisłowska et al., 2015).

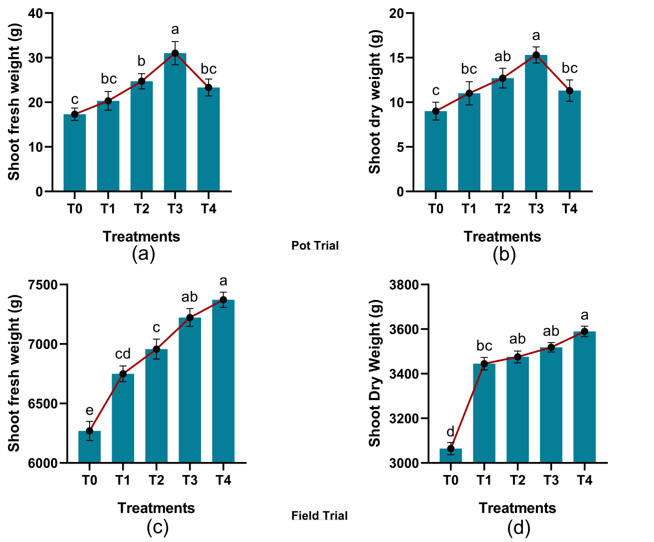

Figure 2. Shoot fresh weight (g), and shoot dry weight (g) of *Bombax ceiba* in response to five compost treatments in pot and field trials. Values are mean $\pm$ standard error (SE), and means followed by a different letter (s) are significantly different ($p < 0.05$) across different compost applications. **Note:** T_0 = (Compost 0% + Soil 0%), T_1 = (Compost 25% + Soil 75%), T_2 = (Compost 50% +Soil 50%), T_3 = (Compost 75% + Soil 25%), T_4 = (Compost 100% + Soil 0%)

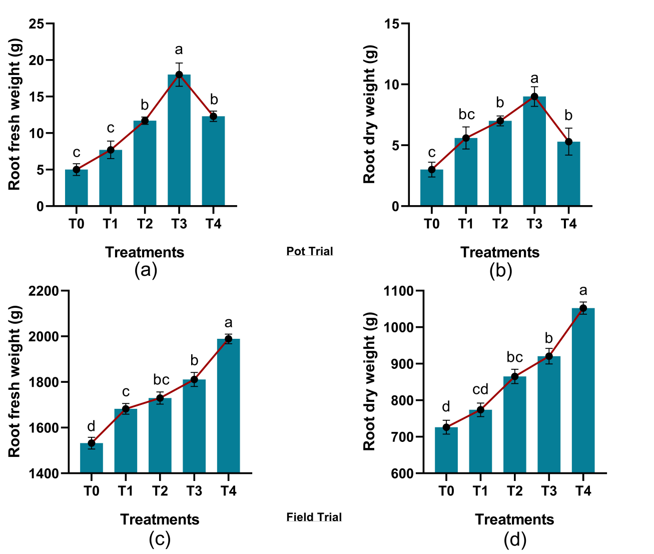

Figure 3. Root fresh weight(g), and root dry weight (g), of *Bombax ceiba* in response to five compost treatments in pot and field trials. Values are mean $\pm$ standard error (SE), and means followed by a different letter (s) are significantly different ($p < 0.05$) across different compost applications. **Note:** T_0 = (Compost 0% + Soil 0%), T_1 = (Compost 25% + Soil 75%), T_2 = (Compost 50% +Soil 50%), T_3 = (Compost 75% + Soil 25%), T_4 = (Compost 100% + Soil 0%)

3.2.3 Root/Shoot Ratio

Results indicated that the root-shoot ratio revealed greater (0.58 ± 0.03) in response to (T_3) treatment in pot trials, whereas it was higher (0.29 ± 0.008) in a field trial at (T_4) compost treatment. But in both trials, it was found minimum under the zero addition of compost in the growing media (Figure 4).

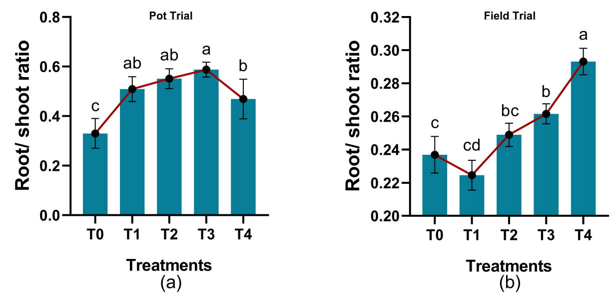

Figure 4. Root/shoot ratio of *Bombax ceiba* in response to five compost treatments in pot and field trials. Values are mean $\pm$ standard error (SE), and means followed by a different letter (s) are significantly different ($p < 0.05$) across different compost applications. **Note:** T_0 = (Compost 0% + Soil 0%), T_1 = (Compost 25% + Soil 75%), T_2 = (Compost 50% +Soil 50%), T_3 = (Compost 75% + Soil 25%), T_4 = (Compost 100% + Soil 0%)

Plant development and biomass production are critical indicators of a tree species' growth potential. A healthy tree has a maximum height and biomass productivity, while an unhealthy plant has inhibited growth, lower length, and biomass productivity. Compared to silt soil, composted modifications increased the biomass of the seedlings (Daldoum & Ameeri, 2013; Zhou et al., 2016).

The findings revealed a strong link between seedling growth and the various levels of organic fertilization. During a field experiment, 100% compost was added to soil led to a significant increase in plant morphological traits and biomass. At the same time, zero compost had no impact on plant development. The largest plant height, root-to-shoot ratio, and biomass output were found in pot trials using 75% compost. Overall, *B. ceiba* did better in the field trial when compost was applied at 100% and in the pot trial when compost was applied at 75%.

Using compost as crop fertilizer works to enhance the productivity of the soil. Completely prepared organic material compost is used rather than other soil media in plant nurseries for higher growth (Chu et al., 2017; Uddin et al., 2012).

4. CONCLUSION

Bombax ceiba showed better performance across different applications of compost. Plant morphological traits and biomass production found a positive correlation with the applied compost levels. Conclusively, the growth of *B. ceiba* executed well under pot trial in response to 75% compost, whereas 100% applied compost helped in the maximum increment of *B. ceiba* growth under field trial. Compost enhances soil fertility as a crop fertilizer in agricultural and forestry applications. The progressive foresters and agro-foresters are recommended that compost application will give best consequences to get a good yield from the simal tree. They can enhance their productivity on farmlands and also in pure tree plantations.

CONFLICTS OF INTEREST

The authors declare there is no conflict of interest.

ACKNOWLEDGMENTS

We are thankful to the Department of Forestry and Range Management, the University of Agriculture Faisalabad, for providing all the facilities. We would also like to thank the support of nursery staff for their help in site preparation and conducting experiments.

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AUTHOR CONTRIBUTIONS

IA, SN, MHUR - Research concept and design; SN - Collection and/or assembly of data; MHUR, THF, MK - Data analysis and interpretation; MHUR, ZS - Writing the article; IA, MA, MS - Critical revision of the article; IA - Final approval of the article.

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