COMPARATIVE INFLUENCE OF MYCORRHIZA AND PHOSPHORUS ON THE GROWTH OF *BOMBAX COSTATUM* PELLEGR & VUILLET FROM DIFFERENT PROVENANCES

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ABSTRACT

Arbuscular mycorrhiza has a potential to colonize plant roots towards increasing plant uptake of phosphorous and other nutrients for plant growth. This study investigated comparative influence of Mycorrhiza and Phosphorus on the growth of *Bombax costatum* seeds from different provenances with a view to improving the growth of the species was investigated. *B. costatum* seeds were collected from four provenances (Aponmu, Oluwa, Ibadan and Oyo). Seeds from each provenance were sown and at the two-leaf stage after germination, seedlings from each source were transplanted into polythene pots containing mycorrhiza inoculum soil. The inoculation was done at rate of 20 g of mycorrhiza to 2 kg of potting soil. The single super phosphate fertilizer was applied at 0 mg/l (control), 25 mg/l, 50 mg/l, 75 mg/l and 100 mg/l. Seedling height (cm), collar diameter (cm), number of leaves and leaf area (cm^2) were assessed fortnightly for 12 weeks. The experimental design was 2 x 4 x 5 factorial arranged in Completely Randomized Design and replicated four times. Data were subjected to analysis of variance (ANOVA). Results show that there were significant differences ($p<0.05$) among mycorrhiza inoculum, phosphate fertilizer and provenances on the growth of *B. costatum*. The treatment with 75 mg/l phosphorus fertilizer had the highest height and leaf area of 20.0 cm and 110.7 cm^2 while the lowest values 14.4 cm and 88.8 cm^2 were observed for the treatment with 0 mg/l. Growth of *B. costatum* was enhanced by mycorrhiza inoculum and application of phosphate fertilizer.

Keywords: Inoculation, Provenances, Mycorrhiza, Phosphate fertilizer, Growth variables

Introduction

Mycorrhiza is a symbiotic association between the roots of higher plants and soil fungi. The most commonly occurring forms are the Vesicular-Arbuscular Mycorrhiza (VAM) (Arias, 1991). Ghosh *et al*. (2019) reported that about 90% of total plants form symbiotic associations with Arbuscular Mycorrhiza. The fungi species belong to the family Endogonaceae and are distributed worldwide such as *Alomas fasculatum* and *Glomus mosseae* (Rhodes, 1980). Karl & Johannes (1997) reported that they are obligatory symbiotic which means that they require the presence of host plants to reproduce. They can however survive for several years in the soil in the form of resting spores. A mycorrhiza fungus does not need a specific host plant nor do host plants require a particular mycorrhiza species (Vivekanandan & Fixen, 1991; Jung *et al*. 2003).

The importance of mycorrhiza symbiosis for the uptake of phosphorus by various species of plant was demonstrated by Raju *et al*. (1990) and Arias (1991) in which the inoculation of the host plants with a chosen strain of mycorrhiza produced increased yield, even under natural condition. In addition, the ability of mycorrhiza fungi to improve the growth of their host plants even when they grow on soils relatively poor in mineral elements has already been shown for certain plants (Yukiyoshi *et al*. 2018; Haro *et al*. 2021). Likewise, Sieverding (1991) showed that plants infected with mycorrhiza were better supplied with nutrient; they produce more dry matter than non-infected plants. Abdul-Nasr (1994) observed that mycorrhiza inoculation increased vegetative growth parameters in *Tagets erecta* and *Zinna elegans* compared with control flowering herbaceous plants of the. Mycorrhiza treated Teak seedlings survived better and exhibited significantly greater growth (Vijaya *et al*. 1996).

Lovlock *et al*. (1997) showed that another way of managing natural mycorrhiza is to inoculate plants with mycorrhiza rich earth. Inoculating plant with earth from the root area of known microtropic plants can prove very effective when such earth together with spores and infected pieces of root is placed in the planting holes, nursery pot or seed beds of other microtropic plants. The inoculation material should however, always be from a different plant family, so that injurious agents are not carried over at the same time. Matsubara *et al*. (1995) reported that mycorrhiza infection promoted leaf emergence and also increase the number of main roots of welsh onion seedlings. Saggin *et al*. (1992) reported that non-mycorrhiza coffee seedlings transplanted into soil untreated with mycorrhiza fungi showed severe nutrient deficiencies whereas seedlings transplanted into mycorrhiza treated soil became mycorrhiza infected and showed increased growth at 60 days after transplanting. Kaizzi *et al*. (2017) reported that soils in sub-Saharan Africa (SSA) are degraded with low nutrient availability. The findings emphasize that the rate of soil fertility decline depends on soil erosion, nutrient removal in harvests, the rate at which nutrients are returned to the soil using both (inorganic) fertilizer and organic manures, and the rate of mineralization of soil mineral and organic matter nutrients. Therefore, soil mycorrhization increased seedling growth in four-fold. Even at low initial mycorhiza colonization rates, some mycorrhiza species still stimulated seedling growth (Kaizzi *et al*. 2017). Mycorrhiza infection is known to enhance the growth of plant through improved phosphorus nutrition in low phosphorus soils (Osonubi *et al*. 1991). Phosphorus concentrations are particularly low in many tropical soils (Costa *et al.* 1992). This may impose limitations on growth since the rate of photosynthesis is strongly influenced by phosphorus concentration.

Chang (1996) discovered that arbuscular mycorrhiza enhances seedlings growth and reduces the phosphorus requirements of four horticultural crops (asparagus, gerbera, melon and strawberry). Ba & Guissou (1996) reported that *Faidherbia albida* seedlings grew poorly without mycorrhiza colonization and without rock phosphate applications.

The *B. costatum* commonly known as the red kapok tree in the family Malvaceae is indigenous to West Africa with myriad of socio-economical potentials (Ojo & Asinwa, 2021). Its ethno botanical values for food and medicine, source of pulpwood, and timber cannot be underestimated (Assogba *et al*. 2018; Ojo & Asinwa, 2021). However, despite the numerous potentials of *B. costatum*, it has been listed as one of the threatened species probably because of its slow growth and poor regeneration (Assogba *et al*. 2018). This study therefore investigated comparative influence of Mycorrhiza and Phosphorus on the growth of *Bombax costatum* seedlings from different provenances with a view to improving the growth of the species.

Experimental

Bombax costatum seeds were procured from four provenances in South Western Nigeria. This is because the species is predominant in the region of the country. The selected provenances included: Aponmu (latitude 7º 23' and 7º 19'N and longitude 5º 10' and 5º 05'E), Oluwa (latitude 7º 44' and 7º 48'N and longitude 3º 91' and 3º 63'E) in Ondo State, Ibadan (latitude 7º 18' and 7º 25'N and longitude 3º 42' and 3º 29'E), and Oyo (latitude 3° 55' N and 4° 42' N and longitude 3º 53' and 3º 47'E) in Oyo State.

Two hundred and fifty seeds from each provenance were sown in germination trays filled with washed and sterilized river sand. At the two-leaf stage after germination, seedlings from each source were transplanted into polythene pots containing mycorrhiza inoculum soil. The inoculation was done at 20 g of mycorrhiza to 2 kg of potting soil to have 1% mixture (Osonubi *et al*. 1991). The Vesicular – Arbuscular Mycorrhiza inoculum consists of a mixture of soil, spores and root fragments collected from the Forestry Research Institute of Nigeria (FRIN) Arboretum where *Pinus* species were grown. The following quantities of single super phosphate fertilizer were applied; 0 mg/l (control), 25 mg/l, 50 mg/l, 75 mg/l and 100 mg/l.

The experimental design was 2 x 4 x 5 factorial arranged in completely randomized design and replicated 4 times. Growth variables assessment commenced two weeks after mycorrhiza and fertilizer application. Seedling height (cm), collar diameter (cm), number of leaves and leaf area (cm^2) were assessed fortnightly for 12 weeks. The seedlings from different were separated into root, stems and leaves for biomass assessment. The plant samples were oven dried at 80°C for 24 hours after taking the fresh weights of the parts (leaf, stem and root). The samples were allowed to cool in desiccators before weighing on electronic balance according to their provenances. Data on growth parameters of *B. costatum* seedlings were subjected to analysis of variance and where significant, the LSD test was used to separate the means at 5% probability level.

Results and Discussion

Variations were observed in the growth performance of seedlings subjected to phosphorus and mycorrhiza application. Table 1 shows values of the response of phosphorus and mycorrhiza on the growth parameters of *B. costatum*. The highest value for height (20 cm) was observed under the treatment with 75 mg/l phosphorus fertilizer, while the lowest height (14.4 cm) was observed for seedlings with no phosphorus. The height value (21.2 cm) recorded for seedling with mycorrhiza application was higher than the value (14.8 cm) recorded for seedlings without mycorrhiza application. The highest value for diameter growth (0.5 cm) was observed under the treatment with 75 mg/l phosphorus fertilizer and mycorrhiza while the lowest value (0.3 cm) was obtained for seedlings without phosphorus fertilizer and mycorrhiza. The highest value for the number of leaves (7.5) was observe under the treatment with 75 mg/l phosphorus fertilizer, while the lowest value of 6.1 was observed for seedlings without phosphorus fertilizer. The higher number of leaves of 7.8 was obtained in seedlings with mycorrhiza, while the lower value of 6.3 was obtained in seedlings with no mycorrhiza application. Phosphorus is one of the most limiting macronutrients affecting plant growth (Nwoboshi, 2000). An adequate supply of nutrients is needed for the satisfactory growth of tree seedlings (Wightman, 1999). With inadequate phosphorus, root systems are poorly developed and the seedling displays signs of general growth disturbance. The supply of nutrients in sufficient amount may be hampered by erosion and leaching and also by its immobile nature (Duffy & Casells, 1999). The best seedling performance which was recorded when 75 mg/l of single super phosphate was applied with respect to height, diameter, number of leaves, leaf area and dry weights shows that the quantity of fertilizer applied had a significant effect on the growth parameters. This is in contrary to the observation of Awodola & Abubakar (1996) for *Sclerocarya birreai* that the quantity of phosphate fertilizers applied to seedlings is an important factor affecting seedling growth.

The highest value for leaf area (110.7 cm^2) was obtained among seedlings treated with 75 mg/l phosphorus fertilizer, while the lowest value of 88.8 cm^2 was obtained in seedlings without it. The highest value of 112.2 cm^2 was observed in seedlings treated with mycorrhiza, while the lower value of 93.0 cm^2 was obtained in seedling without it. The highest value for leaf dry weight (6.1 g) was observed under the treatment with 75 mg/l phosphorus fertilizer, while the lowest value (4.8 g) was observed for seedlings with no phosphorus. The higher leaf dry weight of 6.2 g was observed for seedlings treatment with mycorrhiza, while the lower value of 4.9 g was obtained in seedlings without it. Seedlings under the treatment with 50 mg/l and 75 mg/l phosphorus fertilizer had the highest value for stem dry weight of 4.4 g, while the lowest value of 3.6 g was obtained among seedlings without phosphorus fertilizer. The higher value of 4.7 g was observed for seedlings treated with mycorrhiza, while the lower value of 3.6 g was observed with treatment with no mycorrhiza. The highest value for root dry weight of 3.1 g was obtained among seedlings with 75 mg/l and 100 mg/l phosphorus fertilizer, while the lowest value of 2.5 was obtained for seedlings with no phosphorus fertilizer. The highest value of 3.3 g was obtained among seedlings treated with mycorrhiza, while the lower value of 2.5 g was observed for seedlings with no mycorrhiza. There were significant differences among the treatments of phosphorus fertilizer and mycorrhiza on the growth parameters of *Bombax costatum*.

The result of this study confirms the positive contribution of phosphorus fertilizer application to growth of *B. costatum* seedlings. It was observed that growth parameters of *B. costatum* seedlings increases with increasing application of phosphorus up to 75% application; but there was negative effect recorded at 100% application of phosphorus fertilizer to *B. costatum* seedlings. The effect of the phosphate fertilizer on the growth of *B. costatum* seedlings is in agreement with the work of Aluko (1989) on *Terminalia ivorensis*. The poor result obtained in the control experiment could be linked to effects if nutrient deficiency. This has earlier been confirmed by Fredeen *et al*. (1996). Phosphorus deficient plants exhibited retarded growth. This is because the nutrient is one of the most limiting soil macro-nutrient due to its immobilization in soils (Ojo, 2019). The result has therefore indicated the importance of phosphorus to seedling growth.

TABLE 1

Values for Effect of Phosphorus and Mycorrhiza on Growth Parameters of Bombax costatum

Treatments	Height (cm)	Diameter (cm)	Number of leaves	Leaf area (cm^2)	Leaf dry weight (g)	Stem dry weight (g)	Root dry weight (g)
Phosphorus (mg/l)							
0	14.4c	0.3c	6.1c	88.8c	4.8d	3.6c	2.5c
25	16.7b	0.4b	6.8b	99.2b	5.2c	4.0b	2.7c
50	19.2a	0.4b	7.4ab	105.2ab	5.7b	4.3b	3.0ab
75	20.0a	0.5a	7.5a	110.7a	6.1a	4.4a	3.1a
100	19.8a	0.4b	7.4a	109.2a	6.0a	4.4a	3.1a
LSD	2.1	0.2	0.6	9.0	0.1	0.1	0.1
Mycorrhiza							
-Mycorrhiza	14.8a	0.3a	6.3a	93.0a	4.9a	3.6a	2.5a
+Mycorrhiza	21.2b	0.5b	7.8b	112.2b	6.2b	4.7b	3.3b
LSD	1.3	0.1	0.4	5.7	0.1	0.1	0.1

Means with the same letter along a column are not significantly different from each other.

The response of *B. costatum* seedlings to mycorrhiza application in each provenance is shown in Table 2. Seedlings from Ibadan provenance treated with mycorrhiza had the highest number of leaves of 8.5 while those from Oluwa provenance with no mycorrhiza application had the least value of 5.7. Seedlings from Oyo provenance treated with mycorrhiza had the highest leaf area of 131.8 cm^2, while those from Ibadan provenance with no mycorrhiza had the least value of 77.5cm^2. There were significant differences in mycorrhiza application on the number of leaves and leaf areas. Likewise, the highest stem dry weight of 6.2 g was observed among seedlings from Ibadan provenance with mycorrhiza application, while the lowest value of 2.5 g was observed among seedlings from Oluwa provenance with no mycorrhiza. The highest root dry weight of 3.6 g was observed among seedlings from Ibadan provenance under treatment with mycorrhiza application, while the lowest root dry weight of 2.3 g was observed among seedlings from Oluwa provenance with no mycorrhiza. There were significant differences of mycorrhiza application on stem dry weight and root dry weight. Mycorrhiza can improve plant growth and increase nutrient uptake (Haghighi *et al*. 2016). The potential benefits of the symbiotic interactions between the fungi and root of seedlings are well known particularly in increasing growth and balanced nutrition (Lovelock *et al*. 1997). Ghosh *et al*. (2019) reported that Ambuscular Mycorrhiza are tolerant to a wide range of ecological conditions that is soil pH, temperature, nutrient gradients and so on, so they are active in most ecosystems including riverbanks, seashores, disturbed or polluted areas. In order to reduce unnecessary amounts of fertilization, mycorrhiza is very important. This will contribute to reducing pollution of the soil by excess fertilizer application. Since phosphorus sources are getting limited and the production of fertilizer is expensive, it is logical to use land adaptation mechanisms such as mycorrhiza symbiosis. The results from this study showed that *B. costatum* seedlings are mycorrhiza dependent. This is explained by the various positive responses of the seedlings growth parameters to mycorrhiza inoculation. Haro *et al*. (2021) reported that inoculation of mycorrhizal improved the growth of *Sclerocarya birrea*. This could be associated to a better distribution of the absorbing surface nutrients as suggested by Votsatka (2005).

TABLE 2

Values for Interaction Effect of Mycorrhiza and Provenances on Growth Parameters of Bombax Costatum

Mycorrhiza	Provenance	Number of leaves	Leaf area (cm2)	Stem dry weight (g)	Root dry weight (g)
-Mycorrhiza	Oluwa	5.7d	88e	2.5f	2.3d
-Mycorrhiza	Ibadan	6.0c	77.5f	5.3b	2.8c
-Mycorrhiza	Oyo	6.7bc	117.2c	3.4e	2.6c
-Mycorrhiza	Aponmu	6.7bc	91.2d	3.1e	2.4d
+Mycorrhiza	Oluwa	6.6bc	102.9cd	3.9d	3.4b
+Mycorrhiza	Ibadan	8.5a	88.6e	6.2a	3.6a
+Mycorrhiza	Oyo	8.2a	131.8a	4.7c	3.3b
+Mycorrhiza	Aponmu	7.9b	123.6b	4.0d	2.8c
LSD		0.8	11.3	0.1	0.2

Means with the same letter along a column are not significantly different from each other.

The response of *B. costatum* seedlings to the combined effects of phosphorus and mycorrhiza on dry weights is presented in Table 3. The highest value for leaf dry weight of 7.0 g was obtained under the treatment with 75 m/l and mycorrhiza application, while the lowest value of 4.4 g was observed under the control experiment (seedlings without phosphorus fertilizer and mycorrhiza). The highest value for stem dry weight of 5.1 g was observed with seedlings under the treatment of 50 mg/l and 75 mg/l phosphorus with mycorrhiza application, while the lowest value of 3.1 g was obtained among seedlings under the control experiment. The highest value for root dry weight of 3.7 g was observed among seedlings under the treatment with 75 mg/l phosphorus and mycorrhiza application, while the lowest value of 2.3 g was obtained under the control experiment. There were significant differences in dry weights by the effects of phosphorus fertilizer and mycorrhiza application.

Raizada *et al*. (1998) observed improvement in the growth response of *Albizia lebbeck* seedlings when inoculated with mycorrhiza. The seedlings were found to be larger in dimension. Mycorrhiza inoculation is known to enhance the growth of plants through improved phosphorus nutrition in low phosphorus soils (Longman & Wilson, 1995). Aslan *et al*. (2005) recorded statistically significant differences between mycorrhiza inoculated and non-inoculated citrus trees. Mycorrhizae have been shown to have a key role to the health and nutrition of tree seedlings. Inoculation of *B.costatum* seedlings root by mycorrhiza increases growth through increased uptake of soil phosphorus. Akpinari, (2005) found that mycorrhiza inoculation significantly increased dry matter production, root infection and nutrient uptake of Citrus seedlings. Seedlings grew better and responded to the mycorrhiza inoculation. The requirement for phosphate fertilizer is also considerably lower with mycorrhiza inoculation than without (Duffy & Casells, 1999). Mycorrhiza inoculated *Acacia nilotica* seedlings also showed much better growth than non inoculated ones; with significant differences between control and inoculated seedlings (Kamal & Prasad, 2000). This was also observed for *B. costatum* seedlings. Variations in the dry weights of the species by the effects of interactions between mycorrhiza and phosphorus treatments as well as interactions between mycorrhiza and provenances are in conformity with the finding of Grove *et al*. (1995) for *Eucalyptus grandis*.

TABLE 3

Values for Interactive Effect of Phosphorus and Mycorrhiza on Dry Weights of Bombax costatum

Phosphorus(mg/l)	Mycorrhiza	Leaf dry weight (g)	Stem dry weight (g)	Root dry weight (g)
0	-Mycorrhiza	4.4f	3.1f	2.3e
25	-Mycorrhiza	4.6e	3.4e	2.3e
50	-Mycorrhiza	4.9d	3.6d	2.5de
75	-Mycorrhiza	5.1d	3.7d	2.5de
100	-Mycorrhiza	5.5c	4.0c	2.7d
0	+Mycorrhiza	5.1d	4.0c	2.7d
25	+Mycorrhiza	5.8c	4.7b	3.1c
50	+Mycorrhiza	6.6b	5.1a	3.5b
75	+Mycorrhiza	7.0a	5.1a	3.7a
100	+Mycorrhiza	6.5b	4.6b	3.4b
LSD		0.2	0.2	0.3

Means with the same letter along a column are not significantly different from each other.

Conclusion

There were significant differences among the treatments of phosphorus fertilizer and mycorrhiza on the growth parameters of *Bombax costatum* seedlings. Seedlings subjected to the application of different levels of Phosphorous fertilizer and mycorrhiza had a distinct influence on the growth variables of the species. The findings have implications for the ecological approach and it will require a thorough overview of the compatibility of the seedlings, mycorrhiza and nutrient status of the soil. Knowledge of the target environment where the seedlings will be eventually grown is important and amendment of growth media cannot be overemphasized. This may also be linked to the prevailing climate condition as well as prevailing environmental stresses.

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