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Effect of Organic Manure and Biofertilizers on Growth and Vigour of *Swietenia macrophylla* King. (Mahogany)

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Abstract

The present investigation was conducted at College of Forestry, Navsari Agricultural University, Navsari, Gujarat during July–February, 2018–19 aiming at adopting organic production, promoting forest nurseries for sustainable tree plantation, and exploring*Swietenia macrophylla* King for timber purposes. The experiment was designed by employing Completely Randomized Design comprising three replications to assess the growth and vigour of big-leaf mahogany seedlings amongst various organic manures (FYM, Vermicompost, Neem cake, and Poultry manure) in different combinations with red soil. Further, another aspect involved drenching of various biofertilizers (Azotobacter, Azosprillum, Acetobacter, PSB, Pseudomonas, and VAM) in early stages of the nursery in comparison to control (Red soil). Among different organic manure treatments, red soil+poultry manure (2:1) exhibited fair qualitative as well as quantitative responses in growth parameters however, the maximum seedling quality index was found in red soil + vermicompost (2:1) treatment. In case of biofertilizer application, highest growth and vigour were recorded in seedlings drenched with VAM @ 10 ml plant^{-1}. More sturdy and stable seedlings can be prepared using vermicompost and poultry manure as potting medium along with inoculation of VAM.

Keywords: Biofertilizers, growth, *Swietenia macrophylla*, vigour

1. Introduction

Rapid use of inorganic fertilizers may cause exhaustion of soil nutrients reserves which eventually leads to loss of productivity and fertility of soil. It is of utmost importance in this era to prioritize the use of organic and natural nutrient enhancers in order to save soil from further degradation. Adding organic manure induces life and promotes biological activities in soil. It has the potential to improve physical, chemical as well as biological activities in soil and thus increase its overall strength (Velis, 2021; Adekiya et al., 2020). Similarly, Biofertilizers consisting of bacteria, fungi, algae, etc. either alone or in combinations are known to increase plant growth by way of various biochemical activities in soil. Application of these microorganisms to seed, soil, or composting areas with the objective of increasing the number of such microorganisms and ascertaining certain microbial activities can increase the availability of nutrients in forms that can be easily assimilated by plants. (Sharma and Chaubey, 2015; Santoyo et al., 2021).When talking about timber-producing trees, *Swietenia macrophylla* King. commonly known as 'Big Leaf Mahogany' is one of the prominent members of the ton. It is a fast-growing and promising timber species belonging to Meliaceae family, it is capable of tolerating a wide range of environmental, climatic, and edaphic adversities. However, the tree is exotic and finds its persistent use as an avenue tree but it is gaining popularity as a timber species and numerous plantations are nowadays raised in order to meet the demand for wood in coming times.

It is common in recent times that discussions on climate change and its adverse effects on all living organisms are happening here and there. Owing to the multifarious benefits plants in general and trees in particular offer to humankind, their adaptability in diverse conditions along with added abatements to climatic adversities makes them a crucial and a potential solution for the present problem. The nation's forest cover currently spans 80.9 mha, with an average productivity of about 1.0 m^3 ha^{-1} year^{-1} (Anonymous, 2021), highlighting a significant disparity between demand and supply. This gap is exacerbated by factors such as land degradation, deforestation, population growth, and limited land availability.

Therefore, it is crucial to prioritize efforts to boost productivity by planting high-quality forest species seedlings.

Trees are propagated via various methodologies amongst which seed sowing is the most common. Nurseries are the nurture homes of plant species and are absolutely necessary to raise quality planting material. With the large-scale demand for quality forest plants and the poor availability of quality seeds, it is imperative that forest nurseries be managed professionally and efficiently to produce good and viable forest crop seedlings. The major problems among forest-based nurseries are poor growth and establishment of seedlings in the nursery as well as when planted outside.

In such cases, it is of utmost importance to develop strong saplings in order to withstand adverse conditions for years to come. A way out can be using proper organic media and biofertilizers in the nursery itself. Looking into this the present investigation was conducted with the backdrop of the dire need to adopt organic production involving organic manures and bio-fertilizers, promote forest nurseries for sustainable tree plantation, and explore *Swietenia macrophylla*for timber purposes in present times. In the new domain, fortified media is the key to unlock the hidden potential of soil microbes.

2. Materials and Methods

2.1. Study site

The investigation was performed under net house conditions at College of Forestry, NAU, Gujarat duringJuly-February 2018-19, to assess the effect of organic manure on seedling growth and vigor of *Swietenia macrophylla*. The mean minimum and maximum temperature during the course of experiment varied from 18.24°C to 36.4°C and maximum and minimum average morning relative humidity recorded was 95.96% and 81.53%.

2.2. *Influence of organic manure on seedling vigour of S. macrophylla*

Seeds were sown in different proportions and combinations of growing media. The various media were procured from the local market and mixed as per treatments viz.,T_1- Red soil; T_2: Red soil+Farm yard manure FYM (2:1); T_3: Red soil+ Vermicompost (2:1); T_4: Red soil+Neem cake (2:1); T_5: Red soil+Poultry manure (2:1); T_6: Red soil+FYM (4:1); T_7: Red soil+Vermicompost (4:1); T_8: Red soil+Neem cake (4:1) and T_9: Red soil+Poultry manure (4:1). The experiment was laid out in Completely Randomized Design (CRD) with 9 treatments and 3 repetitions in which 25 seedlings per treatment per repetition were taken for study.

2.3. *Influence of biofertilizer on seedling vigour of S. macrophylla*

In another aspect of assessing the effect of biofertilizer on seedling, seeds were sown in red soil. After the establishment of seedlings in polybags, the seedlings were drenched with biofertilizer viz.,T_1: Red soil; T_2: Azotobacter; T_3: Azosprillum; T_4: Acetobacter; T_5: PSB (Phosphate solubilizing bacteria); T_6: Pseudomonas; T_7: VAM (Vesicular Arbuscular Mycorrhiza) and T_8: NOVEL fertilizer (banana pseudostem based organic liquid fertilizer developed by Navsari Agricultural University, Navsari, Gujarat) at the rate of 10 ml plant^{-1}. It consisted of 8 treatments with 3 repetitions and 25 seedlings treatment^{-1} repetition^{-1}.

2.4. Data collection

Various parameters viz.,shoot length (cm), collar diameter (mm), and number of leaves plants^{-1} were recorded at monthly intervals for six months while fresh and dry weights of plants were measured at 90 and 180 days after imposing treatment. Based on these parameters, shoot: root ratio and seedling vigor indiceslike sturdiness quotient and seeding quality index were calculated by following formulae.

Root:Shoot Ratio =(Dry weight of root(g)/Dry weight of shoot (g)

Sturdiness Quotient (SQ)=(Final shoot height of seedling (cm)/ (Final collar diameter of seedling (mm)

SQI =(Total dry weight of seedling (cm)/{SQ+[Final shoot+leaves dry weight (g)]/Final root dry weight (g))}

2.5. Statistical analysis

The data ofboth experiments were liable to statistical analysis using OPSTAT software following a Completely Randomized Design (Sheoran et al., 1998). The ANOVA was constructed for further inference. The appropriate standard error of mean [SEm (±)] was calculated in each case and critical difference (CD) at 5% level of probability was worked out to compare the treatment means, where the treatment effects were significant (Panse and Sukatme, 1967) (Panse and Sukatme, 1967).

3. Results and Discussion

3.1. Influence of organic manure on seedling vigour of S. macrophylla

The influence on various growth parameters was found to be varying significantly in case of shoot length and collar diameter. However, the number of leaves plant^{-1} was found to be statistically non-significant towards the end of the experiment (Table 1). For shoot length, red soil + poultry manure (2:1) (37.87 cm) performed best at 90 DAT as well as at 180 DAT, however it was statistically at par with red soil + vermicompost (4:1)(47.89 cm) at the culmination of experiment. At 90 DAT, red soil+vermicompost (2:1) (4.39 cm) resulted into a higher collar diameter which was found to be statistically at par with red soil+poultry manure (4:1) (4.38 cm) and red soil+FYM (4:1) (4.35 cm). This gradually changed at 180 DAT where red soil+poultry manure (2:1) (6.68 cm) out performed others owing to increase in shoot length. Collar diameter was also found out to be higher in red soil+poultry manure (2:1). Moreover, red soil+poultry manure (2:1) (13.29) was found to influence the number of leaves plant^{-1} at 90 DAT but, interestingly the number of leaves plant^{-1} were

Table 1: Influence of organic manures on growth parameters in *Swietenia macrophylla*

Treatment	Shoot length (cm)		Collar diameter (mm)		No. of leaves plant^{-1}	
	90 DAT	180 DAT	90 DAT	180 DAT	90 DAT	180 DAT
T_1	30.14	41.24	4.16	5.86	12.54	34.11
T_2	33.10	44.27	4.16	6.00	12.87	34.57
T_3	36.01	46.93	4.39	6.32	14.15	35.24
T_4	36.14	45.80	4.03	6.11	13.09	35.22
T_5	37.87	48.66	4.25	6.68	13.29	35.36
T_6	36.30	45.65	4.35	6.24	12.66	34.77
T_7	36.29	47.89	4.17	6.47	12.66	34.42
T_8	32.82	43.44	3.92	6.27	12.91	34.98
T_9	36.61	47.19	4.38	6.43	12.85	34.47
Mean	35.03	45.67	4.20	6.26	13.00	34.79
SEm±	0.26	0.35	0.01	0.03	0.16	0.45
CD (p=0.05)	0.77	1.04	0.04	0.10	0.48	NS

not influenced by organic manure during the culmination of experimentation (Table 1).

Addition of organic manure to soil certainly adds to the nutrient availability and increases the mineralization of many essential major nutrients resulting in better growth and development (Khaitov et al., 2019, Adekiya et al., 2020). Apart from being rich in higher amount of NPK as compared to other manures, poultry manure in higher concentration expressed increased growth during the course of experiment which can be credited to the slower degradation and mineralization of poultry manure over time improving soil conditions and increasing the availability of nutrients to seedlings over other organic manures (Chandra, 2005; Asfaw, 2022). Similarly, poultry manure application impacted positively on plant height and collar diameter when applied to *Parkia bicolor* seedlings in nursery condition (Okunomo, 2010).Moreover, this also agrees with the findings of Jameset al. (2020) who showed thatthe sapling of *Eucalyptus torelliana* treated withpoultry droppings recorded the highest mean value of the growth in most of the accessed parameters including plant height and girth.

In the study apart from poultry manure, vermicompost also enhanced the collar diameter in *S. macrophylla* at early stage (90 DAT), the trend in collar diameter increase may be credited to the nature of vermicompost as it is a well decomposed by-product which releases nutrient at faster rate in early stage as compared to other organic manure. Ghising et al. (2022) viewed that vermicompost was best performing growing media in terms of collar diameter, which was also similar to the findings of Navamaniraj et al. (2008) in seedling of *Bixa orellana*. However, as the study came to end poultry manure might have released nutrients, favoring a significant increase in collar diameter. When talking of number of leavesplant^{-1}, leaves constitute to be the major part of plant. The application of various doses of organic manures might have resulted in optimum assimilation of nutrients aiding in growth and development of number of leaves plant^{-1} not influencing it towards the end of study.

Biomass being an important measure of growth of the plant was also determined during the growth stages of the plant and was found to be significantly varying amongst the applied organic manure treatments (Figure 1). AT 90 DAT, the fresh weight of the plants was found to be maximum in red soil+vermicompost (2:1) (19.37 g) which was found to be statistically at par with red soil+FYM (2:1) (18.43 g). This trend, however, reverted at 180 DAT where red soil+neem cake (2:1) (40.22 g) was found to be resulting in higher fresh weight and was statistically at par with red soil+ vermicompost (2:1) (38.22 g), red soil+poultry manure (2:1) (39.02g), red soil + FYM (4:1) (39.30 g) and red soil+poultry manure (4:1) (38.39 g). Similar results were observed for dry biomass where red soil+vermicompost (2:1) (6.17 g) resulted in maximum dry biomass and was statistically at par with red soil+FYM (2:1) (5.88 g) at 90 DAT. Furthermore, at 180 DAT, red soil+neem cake (2:1) (16.70 g) was found to be exhibiting higher biomass and was statistically at par with red soil+ vermicompost (2:1) (15.79 g), red soil+poultry manure (2:1) (15.86g), red soil+FYM (4:1) (16.29 g) and red soil + poultry manure (4:1) (16.01 g). The variations observed in the study can be credited to application of organic manure viz. neem cake, poultry manure, vermicompost and FYM as they all are rich in major plant nutrients and release of these nutrients gradually upon decomposition and degradation results in enhanced biomass. The findings in our study are supported by the findings of Kumar et al. (2014) and Sondarva et al. (2017). Moreover, Ghising et al. (2022) also recorded maximum total biomass in sand: soil: vermicompost (1:2:1) planting media for teak seedlings.

To get an idea about the vigour of the seedlings raised in the

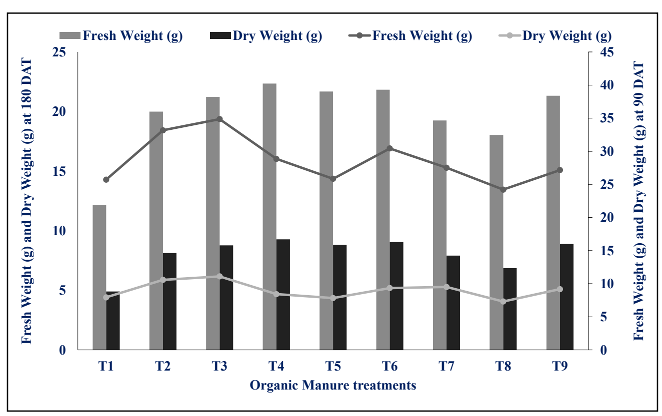

Figure 1: Influence of organic manures on biomass of Mahogany seedlings

nursery, root: shoot ratio along with sturdiness index and seedling quality index were determined at the end of the experiment (Figure 2). Based on the analysis, it was found out that T_1 (0.37) and T_3 (0.37) exhibited higher root: shoot ratio. Eventually, T_1 (6.40) resulted into a lower sturdiness quotient along with T_8 (6.48) and T_7 (6.97).The seedling quality index was found out to be varying significantly across the applied treatments where, T_3 (0.90) was found out to be best amongst the treatments applied and T_4 (0.87), T_5 (0.86), T_7 (0.86) and T_6 (0.83) were found to be statistically at par with it.

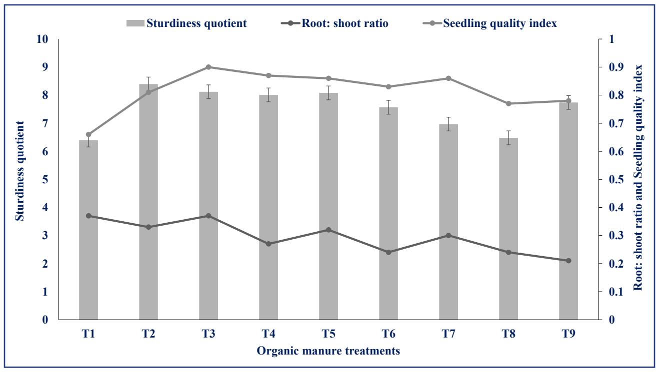

Figure 2: Influence of organic manure treatments on seedling vigour of mahogany seedlings

The root: shoot ratio is dependent upon the nitrogen availability which implies that reduced nitrogen concentration will result into an increased root: shoot ratio (Harris, 1992). This is clearly evident from our findings where control treatment exhibits higher root: shoot ratio as it is most lacking in nitrogen content when compared to organic manure treatments. Lowest sturdiness quotient was reported in control. Higher sturdiness quotient represents seedlings intolerant to strong wind, drought and frost leading to losses. The stocky or spindly nature of the seedlings dependsupon the sturdiness quotient of the plant (Ghising et al., 2022). Similar results were reported by Patel and Suresh (2018) where lowest sturdiness quotient was expressed by control treatment.

Seedling Quality Index (SQI) is considered a promising integrated measure of morphological traits and a good indicator of seedling quality as it computes robustness and biomass distribution while considering several important parameters (Binotto et al., 2010). Normally, higher the value of SQI, better is the ability of the seedling to survive and establishment in the field conditions. In our case higher seedling quality index was expressed by seedlings raised in vermicompost. This is supported by Patel and Suresh (2018) where higher seedling quality index was found in treatment having combination of vermicompost plus biofertilizer. Atik and Yilmaz (2014) also opined that vermicompost treatment had a positive impact on the seedling quality index in their experiment of growing scot pine seedlings, compared to control treatments.

3.2. *Influence of biofertilizer on seedling vigour of S. macrophylla*

The shoot length of*S. macrophylla* was found to vary significantly on the biofertilizer drenching after establishment. VAM (32.04 cm) outperformed rest treatments at 90 DAT as well as at 180 DAT (38.38 cm). At 90 DAT, VAM and Azospirillum (4.10 mm) resulted into a higher collar diameter which was found to be statistically at par with Red soil (4.05 mm) and PSB (4.07 mm). This gradually changed at 180 DAT where VAM (4.60 mm) outperformed others owing to increase in shoot length the collar diameter. Further, Azotobacter (4.49 mm) was recorded to be statistically at par with VAM at 180 DAT. According to Thomas et al. (2022), VAM hyphal network work on the soil volume, thus mobilizing fixed phosphorous in soil. Increment in P efficiency leads to better root growth leading to higher uptake of nutrients and thus boosting overall plant growth. Application of biofertilizer resulted in boosting soil properties which eventually might have resulted in good growth of seedlings. However, the number of leavesplant^{-1} was not found to be significantly influenced by biofertilizer treatments. However, VAM exhibited higher number of leaves plant^{-1} (15.79 and 21.22) (Table 2).

Table 2: Influence of biofertilizers on seedling growth parameters in *Swietenia macrophylla*

Treatment	Shoot length (cm)		Collar diameter (mm)		No. of leaves plant^{-1}	
	90 DAT	180 DAT	90 DAT	180 DAT	90 DAT	180 DAT
T_1	29.90	36.19	4.05	4.52	15.25	20.35
T_2	31.01	36.81	3.98	4.49	15.50	20.79
T_3	31.11	37.16	4.10	4.48	15.07	20.55
T_4	29.67	35.07	3.80	4.29	15.08	20.72
T_5	29.76	35.07	4.07	4.55	14.54	20.46
T_6	29.56	35.31	3.99	4.46	15.01	20.48
T_7	32.04	38.38	4.10	4.60	15.79	21.11
T_8	30.18	36.04	4.04	4.53	15.30	21.22
Mean	30.40	36.25	4.01	4.49	15.19	20.71
SEm±	0.25	0.20	0.02	0.04	0.23	0.31
CD (p=0.05)	0.75	0.63	0.08	0.14	NS	NS

Biomass was observed to be varying significantly across different biofertilizer treatments applied where, Red soil (12.95) exhibited higher fresh biomass and was statistically at par with Acetobacter (12.87), Pseudomonas (12.31) and VAM (12.39) at 90 DAT. This trend changed at 180 DAT where VAM (26.41) emerged out to be the best performer amongst the given treatments.

Similar results were recorded in case of dry weight where, red soil (4.76) was found to be significantly maximum amongst the given biofertilizer doses at 90 DAT, eventually at 180 DAT, VAM (10.03) outperformed others (Figure 3). The performance of seedlings were significantly influenced by application of biofertilizer in which VAM turned out to be the best due to its properties of improving the physical and chemical properties of soil which eventually results into better growth and optimum nutrient (P, Zn and Cu) release (Sumana and Bagyaraj, 2003, Chiranjeevi et al., 2018). The findings are in line with the findings of Raj et al. (2010) and Chiranjeevi et al. (2018) where VAM application resulted into an increased biomass.

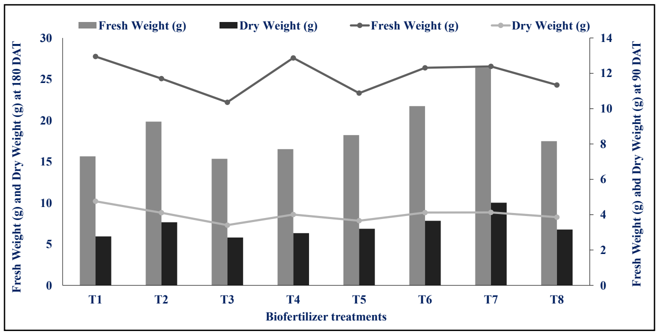

Figure 3: Influence of biofertilizer on biomass of Mahogany seedlings

Root: shoot ratio was worked out which adjourns PSB(0.57) superior to other and statistically at par with Acetobacter (0.53). This eventually resulted into PSB (7.68) having lowest sturdiness quotient, however it was found to be statistically at par with Pseudomonas (7.93), NOVEL (7.92) and Red soil (8.00) respectively. Overall the estimation of seedling quality index found out that VAM (0.78) was significantly superior over others towards the end of the experiment (Figure 4). There seems to be a synergistic interaction between VAM and PSB.

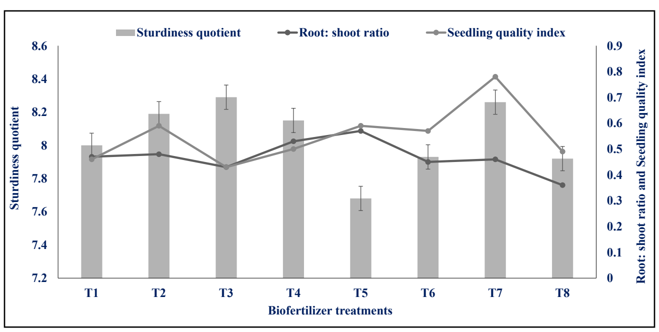

Figure 4: Influence of biofertilizer treatments on seedling vigour of mahogany seedlings

VAM hyphalnetwork in the soil-plant continuum have great bearing onexploration of soil volume by the crop, leading to higher nutrientefficiency especially P (Thomas et al*.,* 2022). VAM treated seedlings produced best result in terms of SQI which may be due to availability of nutrients such as N and P increased with the application of it. Further, the high percentage of root colonization in AM fungi treated seedlings is found to be directly correlated with an improved growth and physiology (Ajeesh et al., 2015). Inoculation of VAM in seedlings of woody species at nursery stage improve the seedling growth and survivality (Agarwal and Dixit, 2015).

4. Conclusion

Poultry manure mixed with red soil resulted into better growth attributes and vermicompost mixed with red soil resulted into better seedling quality. Further, VAM treatment influenced both the growth as well as seedling quality of seedlings at nursery stage.Based on the results it can be advocated that better quality seedlings with more sturdiness and survivality at field can be prepared using vermicompost and poultry manure as growing medium along with inoculation of VAM can be used in nursery conditions.

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