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MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSE OF *Monodora tenufolia* BENTH. SEEDLINGS TO DIFFERENT FIELD ESPACEMENT

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Abstract

Planting espacement is a vital process which affects the quality of tree's growth and development but this information is lacking in Monodora tenufolia (a multipurpose species). This study aimed at obtaining the appropriate espacement for plantation of this species by subjecting seedlings to three (3) different espacement on field trial. Forty five (45) seedlings were selected and planted in 1m x 1m, 2m x 2m and 3m x 3m spacing. Randomized Complete Block Design was the experimental design used. Tending operations were carried out. Morphological parameters such as seedling height, diameter, number of leaves and number of branches and physiological parameters [Relative Growth Rate (RGR) and Absolute Growth Rate (AGR)] were assessed. Data collected was subjected to analysis of variance and descriptive statistics. Seedlings subjected to 1m x 1m spacing (77.01±4.7 cm) were significantly taller than in 2m x2m and 3m x3m spacing and had highest mean diameter at base (9.02±0.6), mean number of leaves (63.6±7.7) and number of branches with 6.89±0.9. Seedlings in 2m x 2m had highest values for both RGR (0.22 gg^{-1} wk^{-1}) which was followed by 3m x3m (0.15 gg^{-1} wk^{-1}) while least was observed in 1m x 1m (0.13 gg^{-1} wk^{-1}) while highest mean value (1.55 g^{-1} wk^{-1}) was observed in 3m x 3m while 2m x 2m had the least (1.22 g^{-1} wk^{-1}). In conclusion, closer spacing (1m x1m) favoured the morphological parameters but wider spacing supported the physiological parameters (2m x2m and 3m x 3m). Therefore, wider spacing is recommended when seed production is the management objective but for ornamental, closer spacing can be considered with proper maintenance.

Key Words: *Espacement, Monodora tenufolia, Relative Growth Rate, Absolute Growth Rate*

Introduction

Monodora is a genus of the plant in the family Annonaceae. *Monodora tenuifolia* known as African nutmeg is a member of this genus found in the forest regions of East Indies, West Indies, Malaysia, Sri Lanka and Africa and so prevalent in southern part of Nigeria (Talagi, 1965). This species is a small tree which can be up to 17m in height of evergreen and fringing forest. *M. tenuifolia* is an attractive ornamental both in foliage and flowers. It shows some fire resistance, sprouting again after injury, coppice well after felling. Its branching pattern determines the shape of the canopy, maybe irregular when growing in the shade or round when growing in the open (Azeez *et al*., 2014). The plant is widely used in ethnomedicine, especially to relieve toothache, treat dysentery, diarrhea, dermatitis, headache, and can be used as vermifuge (Ezenwali *et al.,* 2010; Nielson, 1979). They also have good antioxidant activity and can be important in management and treatment of stress induced diseases (Njoku *et al*., 2012). The seeds are aromatic and used as an ingredient in Trado-medicine in southern Nigeria. In nutrition, the seeds are used as spices, condiments and flavor enhancers (Ezenwali *et al.,* 2010). Many studies have been carried out on its nutritional (Ekeanyanwu and Njoku, 2013), insecticidal (Okosun and Adedire, 2017) and medicinal properties (Njoku *et al.,* 2012; Simo *et al*., 2018) and seed germination (Ariwaodo, 2019) but there is lack of information on its seedling espacement trial on the field.

Espacement or tree spacing is the uniform distance of holes in which tree seedlings are planted in plantation establishment. Spacing in tree plantation plays essential role in the growth and development while management objective or goal, climatic and edaphic conditions, species, and growth habit influence the espacement to be adopted in a plantation as successful planting of trees like *M tenufolia* requires optimum spacing for growth and development (Gurung *et al.*, 2018) as spacing dictates the plant density. Space is one of the major factors which affect the growth of plants in the field (Wilson *et al*., 2007). When spacing is close there may be competition for light, water and nutrients which may support height but wider spacing favours bigger diameter at base. Competition for common resources required by individual plant may later exceed the immediate supply, hence reducing the productivity of the species (Begon and Townsend, 2020). Generally, planting espacement differs with the species and products expected from it according to the management objective. For timber and pole production, taking teak as example, it ranges from 1.8m x 1.8m to 3m x 3m as used by Djagbletey and Adu-Bredu, (2007) while in spacing trial of Merkus pine 1m x 1m, 1m x 2m, 1m x 3m, 2m x 3m and 3m x 3m were considered (Heriansyah *et al*., 2008). Nyaka *et al.* (2022) studied effect of spacing on growth and yield of *Eucalyptus camaldulensis* using 3m x 3m, 3m x 2m, 3m x1.5m, 3m x 1m. It was observed that 3m x 3m was commonly used spacing compared to other closer spacing by these authors as Heriansyah *et al*. (2008) also observed that the wider spacing (3m x3m) showed better results for tree height and mean diameter after about 5 years of planting when compared to closer spacing. This may be because of availability of more nutrients, water and space that encourages optimum vertical growth with minimal cost incurred on weed management at early age of the plantation before canopy closure when other management practices like thinning will be applied for wider girth. This reveals the importance of spacing as an important silvicultural tool that dictates the future silvicultural treatments that will be required in a plantation as it informs the density of plants per area and influences the growth of each plant. Fruit trees orchard or plantations were observed to have wider spacing as collated by FAO (2002) from different countries; in

Vietnam, spacing adopted is 7m or 8m apart, Thailand (3m to 8m), India (9m to 10m by traditional growers but 4.5m x 4.5m x 9m in experimental plots) while China prefers closer spacing (2.5m to 3m and 3.5m to 4m with vegetables and other arable crops in the inter rows). Considering availability of land for tree or fruit plantation establishment at the face of population increase, industrialization and infrastructural development (Mao and Schive, 1995; Jayne *et al*., 2014), it is necessary to study the performance of these species at reduced enspacement.

Many authors have reports of espacement affecting straightness of tree bole (Macdonald and Hubert, 2002), rate of growth and stand productivity (Hébert *et al*., 2016) quality of fruit and yield in fruit trees (Dogar *et al*., 2020) but little information was available on this species. Therefore, this study focused on morphological and physiological response of *Monodora tenufolia* seedlings subjected to different field espacement in order to document the information for future use.

Materials and method

The study site was the nursery of Tree Improvement section of Sustainable Forest Management Department, Forestry Research Institute of Nigeria (FRIN) Jericho hill Ibadan. The area lies between Longitude 07° 26′ 15″ N to 07° 25′ 46″ N and Latitude 03° 54′ 22″ E to 03° 53′ 40″ E. The climatic condition of the area is tropically dominated by annual rainfall range from 1400-1500mm and the average temperature is about 31.2°C, the eco-climate of the dry season usually commencing from (November to March) and the rainy season start from April to October (Afolabi *et al*., 2021). Ripe fruits of *Monodora tenufolia* were freshly collected from Ile-Ife in Osun state which lies between latitudes 07° 30′ N and 07° 35′ N and longitudes 04° 30′ E and 04° 35′ E (Oludare and Muoghalu, 2014). The fruits were de-pulped and seeds extracted. Seeds of *M. tenufolia* were sorted and sown in sterile rivers and filled into germination baskets. The young seedlings were potted and given good care and maintenance. At two months after germination, 45 relatively uniform seedlings of good form were selected for the field espacement trial. The seedlings were subjected to 3 different spacing; 1mx1m, 2m x2m and 3m x 3m. These spacing were considered due to unavailability of land at the face of population increase, industrialization and infrastructural development. The dimension of experimental site is 30m by 15m located in FRIN arboretum. Pegging was carried out according to treatments. The seedlings were arranged and planted in Randomized Complete Block Design. Tending operations like weeding and cleaning were carried out. For weeding operation, hand weeding method was used to reduce competition from weeds while in cleaning; cutlass was used to remove climbers within the plot. Growth parameters considered in this study include seedling height, diameter at base, number of leaves and number of branches while physiological parameters included Relative Growth Rate-Height (RGR) and Absolute Growth Rate-Height (AGR). Data collected was subjected to analysis of variance and descriptive statistics.

$$RGR = \frac{ln(h2)-ln(h1)}{t2-t2} \text{............ (Eqn. 1)}$$

Mencuccini *et al.* (2007)

$$AGR = \frac{h2-h1}{t2-t1} \text{.....................(Eqn. 2)}$$

Results

Seedling Height

The espacement treatments significantly influenced *M. tenufolia* seedling height (Table 1). Height of seedlings subjected to 1m x 1m spacing (77.01±4.7 cm) significantly differ from those planted in 2m x2m and 3m x3m spacing (Table 2).Throughout the period of assessment, 1m x 1m espacement recorded the highest seedling height values. In first month after planting (MAP), seedlings in 1m x 1m had highest mean height of 52.82cm while those subjected to 2m x 2m had the least (45.8cm). At 3rd MAP, seedlings in 1m x 1m spacing had the mean height of 62.09cm which dropped to 58.85cm at 4th MAP while 3m x 3m spacing had the least value (54.18cm). At 5th and 6th MAP, 1m x 1m spacing still maintained the highest mean values, 77.01cm and 80.03cm respectively and was followed by 2m x 2m with 60.29cm and 70.21 cm respectively (Fig. 1).

Diameter at the Base

Diameter at the base of *M. tenufolia* was not significantly affected by different spacing used (Table 1) but highest mean value was recorded in the seedlings subjected to 1m x 1m spacing (9.02±0.6 mm) while seedlings in 2m x 2m spacing had the least mean value with 7.29±0.9 mm (Table 2). Figure 2 expressed the mean diameter at base of *M. tenufolia* during the period of assessment. At 1st MAP, highest h value was observed in seedlings subjected to 3m x 3m (6.3 mm) while 2m x 2m had the least (5.87mm). Also at 6th MAP, 3m x3m spacing had the highest diameter at base (10. 33 mm) while least value was observed in 2m x 2m with 9.55 mm.

Number of Leaves

Leaf production also was not significantly affected by different espacement (Table 1) but seedlings in 1m x1m had the highest mean value (63.6±7.7) while 2m x2m recorded the least mean value of 49.07± 8.4. Considering the number of leaves produced during the period of assessment, 3m x3m spacing produced highest mean leaves (38.2 leaves) while 2m x2m had the least mean value at 1st MAP. At 5th MAP, 1m x 1m seedlings produced highest number of leaves (63.6 leaves) while 3m x 3m had the least (54 leaves). Similar trend was observed at 6th MAP (Fig. 3).

Branches Production

Branch production by *M. tenufolia* seedlings was not significantly affected by different espacement used though seedlings subjected to 1m x 1m spacing produced the highest number of branches with 6.89±0.9. Figure 4 showed the influence of spacing of *M. tenufolia* during the period of assessment. At 1st MAP, 2m x 2m had the least mean value of 5.87 branches while at 6th MAP, it increased to 9.55 branches, but highest mean value was observed in 3m x3m (10. 33 branches).

Effect of espacement on physiological parameters of Monodora tenufolia

According to the result in Table 2, seedling subjected to 2m x 2m spacing had the highest Relative Growth Rate with mean value 0.22 gg^{-1} wk^{-1} which was followed by 3m x3m (0.15 gg^{-1} wk^{-1}) while least value was observed in 1m x 1m (0.13 gg^{-1} wk^{-1}). Absolute Growth Rate did not follow this trend as highest mean value (1.55 g^{-1} wk^{-1}) was observed in 3m x 3m while 2m x 2m had the least value (1.22 g^{-1} wk^{-1}). Figure 5 and 6 expressed the relative growth rate and absolute growth rate of seedlings subjected to different espacement over the period of assessment. At RGR 1, 1m x 1m had the highest value (0.0105 gg^{-1} wk^{-1}), 3m x3m had negative value (-0.012 gg^{-1} wk^{-1}) while other treatments were positive. Increase in value was observed in RGR 2 for all the treatments but at RGR 3, there was decrease in the values with 1m x 1m recording negative value (-0.0104 gg^{-1} wk^{-1}). The value increased drastically at RGR 4 for 1m x 1m while 3m x 3m recorded negative value (-0.054 gg^{-1} wk^{-1}). This similar trend was observed in AGR of *M. tenufolia* treated with different espacement.

Table 1: Analysis of Variance of Espacement influence on growth of *M. tenufolia*

Parameters	Source	df	Sum of Squares	Mean Square	F	Sig.
	Espacement	2	2313.844	1156.922	4.671	.015
Height	Error	42	10402.556	247.680		
	Total	44	12716.400			
	Espacement	2	24.505	12.252	1.326	.276
Collar diameter	Error	42	387.948	9.237		
	Total	44	412.453			
	Espacement	2	2121.911	1060.956	.772	.469
Number of leaves	Error	42	57724.533	1374.394		
	Total	44	59846.444			
	Espacement	2	4.133	2.067	.133	.876
Number of branches	Error	42	651.067	15.502		
	Total	44	655.200			

There is significant difference at 5% of probability level

Table 2: Effects of different spacing on morphological growth characteristics of *M. tenufolia* seedlings

Espacement	Height (cm)	Diameter at base (mm)	Number of leaves	Number of branches	RGR ($gg^{-1}day^{-1}$)	AGR ($g^{-1}day^{-1}$)
1m x 1m	77.01±4.7^{a}	9.02±0.6^{ns}	63.6±7.7^{ns}	6.89±0.9^{ns}	0.013	1.36
2m x 2m	60.29±3.9^{b}	7.29±0.9^{ns}	49.07±8.4^{ns}	6.4±1.0^{ns}	0.022	1.22
3m x 3m	63.99±3.4^{b}	7.71±0.9^{ns}	49±12.0^{ns}	6.13±1.2^{ns}	0.015	1.55

Note: Means with same letter under each column are not significantly different from each other at 5% probability level according to Duncan Multiple Range Test

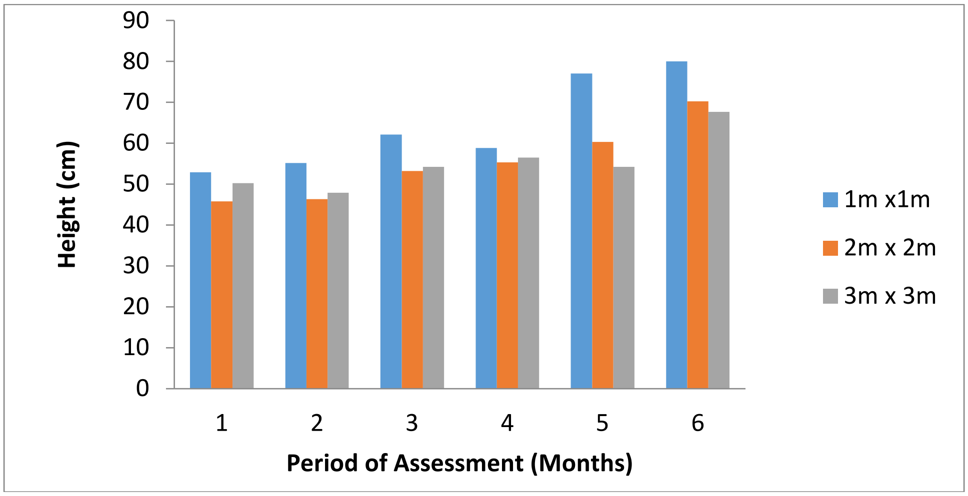

Fig. 1: Showing the Mean Seedling Height of *M. tenufolia* subjected to different espacement for six month after planting

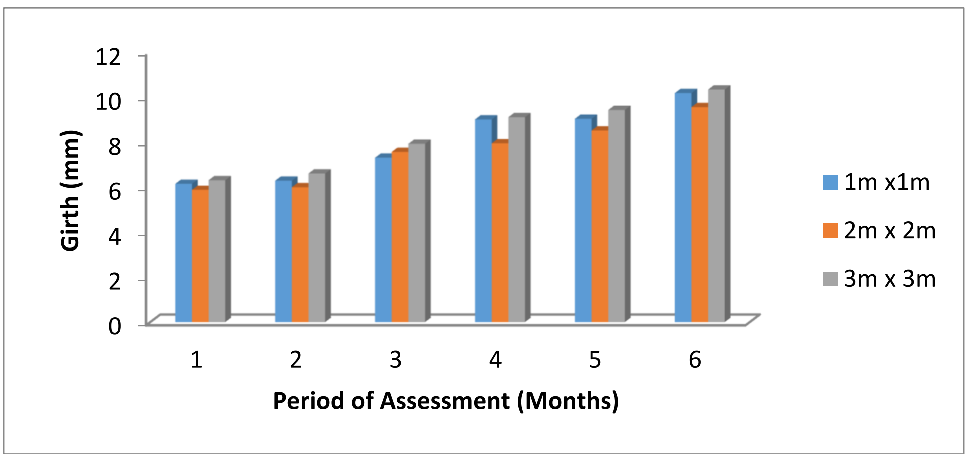

Fig. 2: Showing the Mean Seedling Diameter at base of *M. tenufolia* subjected to different espacement for six month after planting

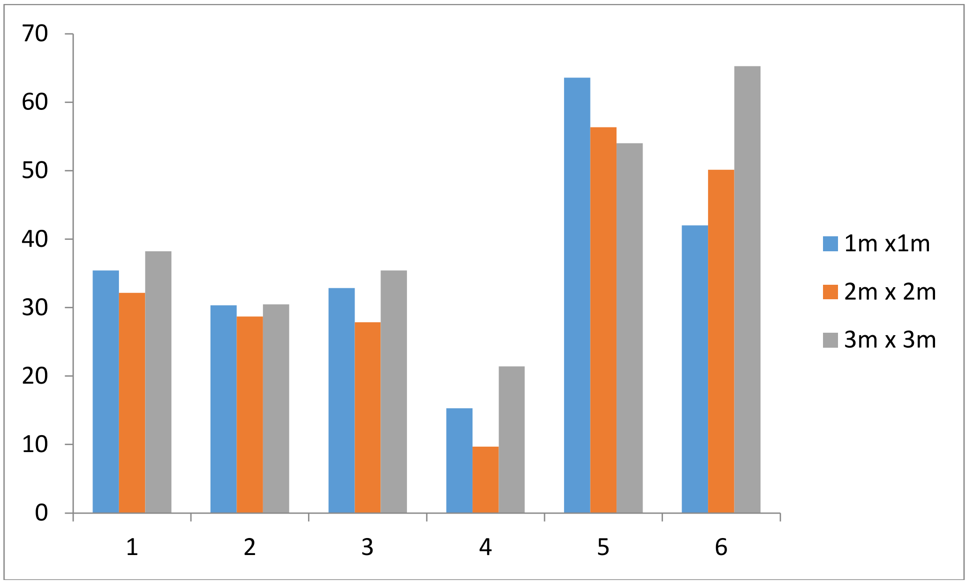

Fig. 3: Showing the Mean Number of leaves produced by *M. tenufolia* subjected to different espacement for six month after planting

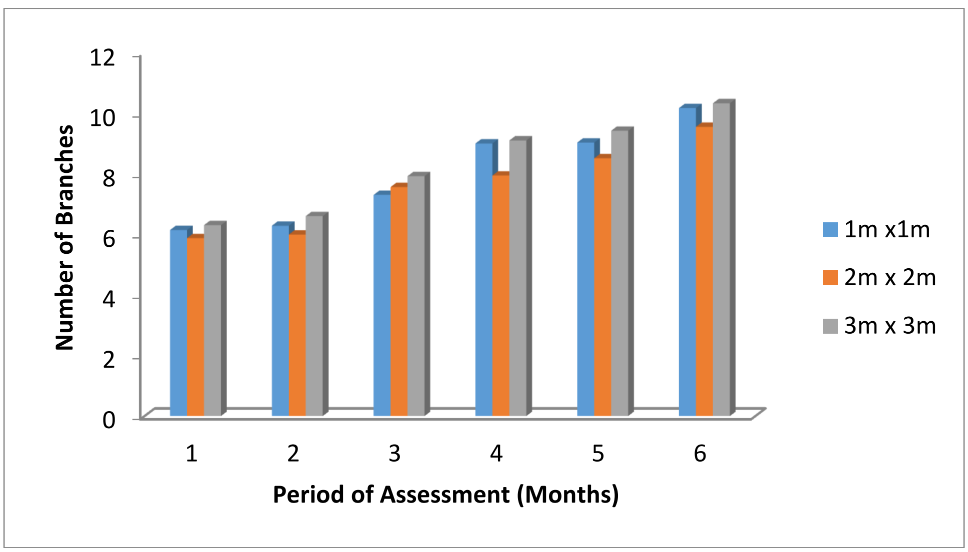

Fig. 4: Showing the Mean Number of Branches produced by *M. tenufolia* subjected to different espacement for six month after planting

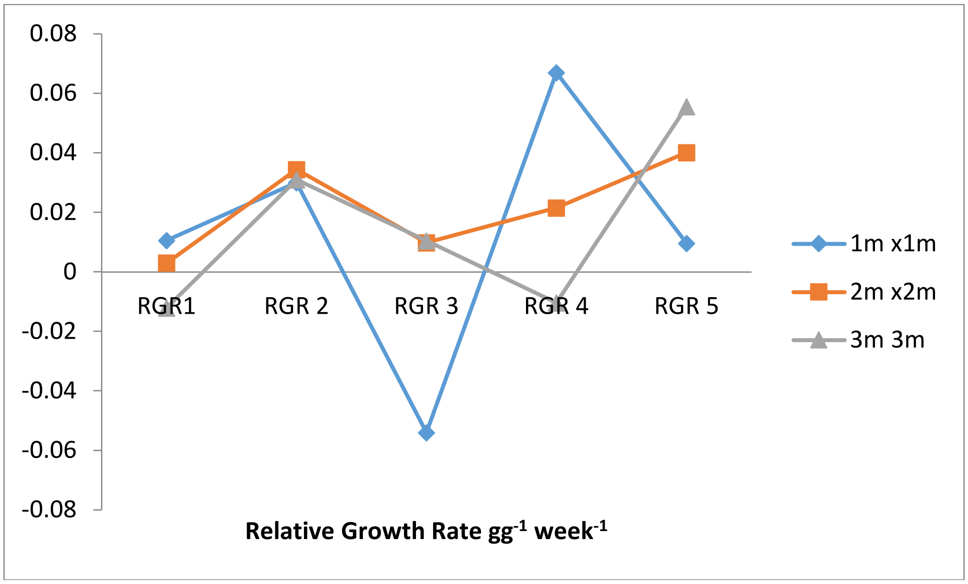

Fig. 5: Showing Relative Growth Rate of *M. tenufolia* subjected to different espacement for the period of assessment

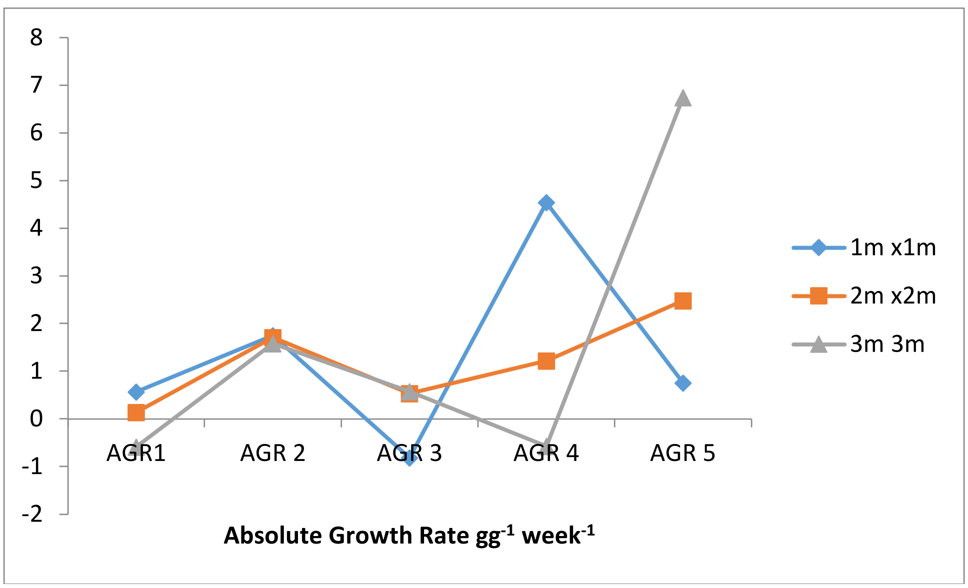

Fig. 6: Showing Absolute Growth Rate of *M. tenufolia* subjected to different espacement for the period of assessment

Discussion

Application of appropriate espacement in plantation can have considerable effect on tree growth and morphology (Larson *et al*., 2001). The results from this study showed significant influence of spacing on the height of juvenile *M. tenufolia* at six month period of assessment. Other parameters were not significantly affected but there were considerable variations in the mean values assessed. Seedlings subjected to 1m x 1m spacing had the highest mean values for height (77.01±4.7 cm), diameter at base (9.02±0.6), number of leaves (63.6±7.7) and branches (6.89±0.9) when compared with those planted in 2m x2m and 3m x3m spacing. Wider espacement do cause decrease in seedling height as observed in this study as seedlings in 1m x 1m had the highest mean height. This may be due to competition for sunlight needed for photosynthesis and better micro ecological conditions in closer spacing (Duwaiman *et al*. 2021). Erasmus *et al.* (2018) also reported significant influence of plant spacing on mean tree height where in tree height decreased by 8% for wider spacing to closer spacing. Diameter at base of the studied species was not significantly affected by espacement as revealed by the result. Similar result was observed by Clara-Manasa *et al*. (2022) in *Eucalyptus urophylla* S.T Blake and Kumar *et al.* (2014) in *Acrocarpus fraxinifolius* Arn. But Duwaiman *et al*. (2021) reported significant variations in diameter at breast height of tree species subjected to different spacing study. Leaf and branches production reduced as the spacing got wider in this study as seedlings in 1m x 1m had the highest number of leaves and branches. This was at variance to the result of Henskens *et al.* (2001) who reported increase in mass foliage and branches of *E. globulus* Labill. as spacing became wider. Absolute Growth Rate was higher in 3m x 3m while Relative growth rate was higher in 2m x 2m than 3m x 3m and 1m x 1m similar was observed by Paelmo *et al*. (2014) in *Jatropha curcas* L. grown under different spacing in agroforestry.

Conclusion

In conclusion, this study reveals the effect of spacing on growth of *M. tenufolia* on the field as morphological growth of the species is supported by 1m x 1m while wider spacing favoured physiological parameters considered. There is need for further investigation where older trees and longer period of assessment will be considered.

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