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Effect of media type on initial establishment and early growth of multipurpose moringa

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Abstract In spite of the importance of *Moringa oleifera,* there has been, surprisingly, little horticultural research on this multi-purpose tree. Such research is necessary to develop the multi-purpose tree for widespread commercial usage. One such area lacking in research is that of seedling production techniques, including research to establish the right substrate of seedling production. This study was carried out to contribute to such knowledge. Six substrate mixes were evaluated for their effect on initial establishment and early growth of *Moringa oleifera*. The substrates based on pine bark and washed river sand mixes were; 100% sand, 80% sand + 20 % pine bark, 60% sand + 40 % pine bark, 40 % sand + 60 % pine bark, 20% sand + 80 % pine bark and 100 % pine bark. The experiment was laid out in a greenhouse as a completely randomised design (CRD) at the University of Zimbabwe, Department of Crop Science. The results indicated that all substrate mixes had acceptable emergence and survival of seedlings except the 60% sand + 40% pine-bark mix. The Relative Growth Rate in height (RGRh) was lowest with the 80% sand + 20% pine bark substrate and similar with the rest of the treatments. The Relative Growth Rate in diameter (RGRd) was the same for all substrate mixes. The stem length was highest with the 60% sand + 40% pine bark and 20% sand + 80% pine bark relative to the rest of the treatments. Lastly the root collar diameter (RCD) was lowest with the 100% pine bark substrate and virtually the same for the rest of the treatments. The results suggest that almost all the substrates were good for the germination and initial survival of the seedlings. We concluded therefore, that all the mixes were acceptable but perhaps the 60% sand + 40% pine bark could be singled out for further development especially by improving the survival of the seedlings.

Key words: *Moringa oleifera,* Pine bark, Sand, Seedling.

Introduction

Moringa (*Moringa oleifera*) is a valuable tree with nutritional, medicinal, industrial and numerous agronomic uses (Crosby, 2007). In Guatemala, Moringa is used as food, feed, ornament, live fence, soap, insect repellent, fuel,

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and, medicine for many ailments including joint, skin, digestive and respiratory diseases (Cáceres *et al*., 1991). Moringa has not received widespread horticultural research despite the mounting evidence that it is a valuable tree. To enable widespread usage and adoption this emerging crop requires research to establish nursery as well as agronomic practices. Crosby (2007) and Crosby & Craker (n.d.) explored soilless culture (hydroponics and aeroponics) and found acceptable germination of dehulled seed (65%) and good growth after germination. Germination of hulled seed was, however, very poor. Cáceres et al. (1991) observed a drop in viability of Moringa seed from 94 to 78% in 12 months of storage. The need for technically feasible, economically viable but simple nursery practices is of great importance if widespread adoption is to be achieved.

Work by (Goss, 2012) found good growth (stem length) in clay soil better than in pine bark. Of the three media, un-amended sand was the worst. (Asadicorom *et al*., 2009). failed to get good germination of *M. oleifera* and *M. peregrina* with vermiculite mixed with pit, either sterilized or not.

In the present study, the emergence, initial growth and establishment of *Moringa oleifera*, grown in pine bark and sand substrate, was studied.

Materials and methods

Study Site and Experimental Design

The experiment was conducted at the University of Zimbabwe in the green house at the Department of Crop Science, Harare, with altitude of 1500m above sea level. The experiment was laid out as a completely randomised design with six treatments, each replicated 13 times.

Experimental Management

The substrates were made up of different proportions of pine bark and sand namely:

100% sand
80% sand + 20% Pine bark,
60% sand + 40% Pine bark,
40% sand + 60% Pine bark, and
20% sand + 800% Pine bark.
100% pine bark,

The sand had 0.48% of particles below 0.045 mm in diameter, 63.60 % of particles 0.45 to 1 mm and 35.92% of particles between 1 and 1.5 mm. The water holding capacity and air porosity of 100% sand were 8.06 and 4.30%, respectively. For the pine bark the particle size distribution was 20% for particles less than 1mm, 70% for particles greater than 1mm but less than 4mm and 10% for particles above 4mm but below 6mm in diameter. The water holding capacity and air porosity were 25.75% and 11.27 % respectively. An estimation of aeration and water holding capacity is presented in Table 1. Three Moringa seeds were placed in 2cm deep holes and covered in each pot (16cm diameter) of appropriate substrate. Five grams of Single Super Phosphate (SSP) (0%N 9.1% P 0% K 10.5% S) was applied as a basal dressing/plant. Three weeks after emergence the seedlings were thinned down to two seedlings per pot and various measurements were recorded. Watering was at 0.5 litres of water per pot twice per week. Measurements were done on all the trees in the pots. Tree survival was determined by Equation 1 and was done one month after planting.

Seed viability was measured under room temperature in the lab and found to be 87.5%. Two weeks after planting, seedling emergence counts were conducted on daily basis for a week. Total survival (%) was calculated utilizing equation 1.

Survival (%) = 100 x (plants established-Total dead plants)/(Total plants established) *Eqn 1*

Relative Growth Rate in height and root collar diameter (RCD) were taken according to (Balderrama and Chazdon 2005). Growth in height and root collar diameter (RCD) was measured first at three weeks after emergence and lastly at six weeks after emergence. Plant height was measured as the distance in cm, between the RCD and the apical meristem. In cases of damaged apical meristems, branch leader meristems were considered for height measurement (Balderrama and Chazdon 2005).

Plant growth was evaluated as the mean relative growth rate in height (RGRh) and relative growth rate in diameter (RGRd) over the first six weeks using the formulae for classic plant growth analysis (Balderrama and Chazdon, 2005). as shown in Equations 2 and 3.

$RGR_h = (\log_e hf - \log_e hi) / (t_2 - t_1)$ *Eqn 2*

Where RGRh =Relative growth rate in height,

hi = the initial (3 WAP , ‘ t_1 ’) growth in height,
hf = the final (6 WAP, ‘ t_2 ’) growth in height.
$RGR_d = (\log_e df - \log_e di) / (t_2 - t_1)$
Eqn 3

Where RGRd =Relative growth rate in diameter,
di = the initial (3 WAP, ‘ t_1 ’) growth in diameter,
df = the final (6 WAP, ‘ t_2 ’) growth in diameter.

Plant survival, height and RCD, RGRh and RGRd were tested for significance among treatments by analysis of variance (ANOVA) using Genstat Version 12.1. Differences between means were tested using the LSD tests at the 5% level of significance.

Table 1. Estimated water holding capacity and air porosity for the various media mixes

Sand (%)	Pine Bark (%)	Water holding capacity (%)	Air porosity (%)
0	100	27.8	11.3
20	80	23.8	9.9
40	60	19.9	8.5
60	40	15.9	7.1
80	20	12.0	5.7
100	0	8.1	4.3

Results

Emergence and seedling survival

In general, emergence was very good across all treatments (Fig. 1) but survival was lowest in the 60% sand + 40% pine bark substrate and acceptable as the proportion of pine bark rose from 60 to 100% (Fig. 1). Survival was best with the 80% sand + 20% pine bark followed by the 100% pine bark substrate.

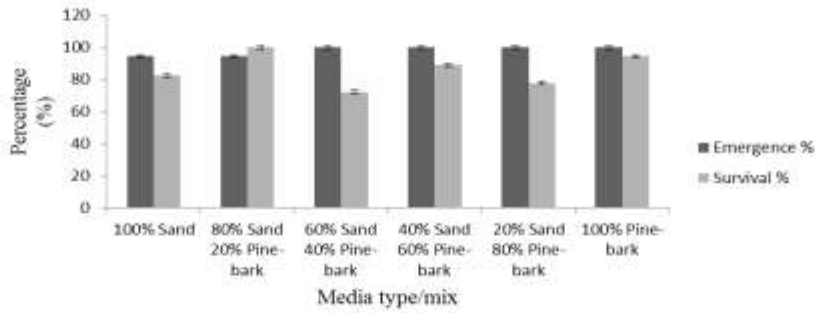

Fig. 1. Effects of substrate mix on emergence and survival of Moringa seedlings.

Effects of media type on relative growth rate in diameter (RGRd) and relative growth rate in height (RGRh)

Relative growth rate in height (RGRh) was lowest in the 80% sand + 20% pine bark and the same for the rest of the substrate mixes. Treatments were not significantly different in terms of relative growth rate in stem diameter (RGRd) (Fig. 2).

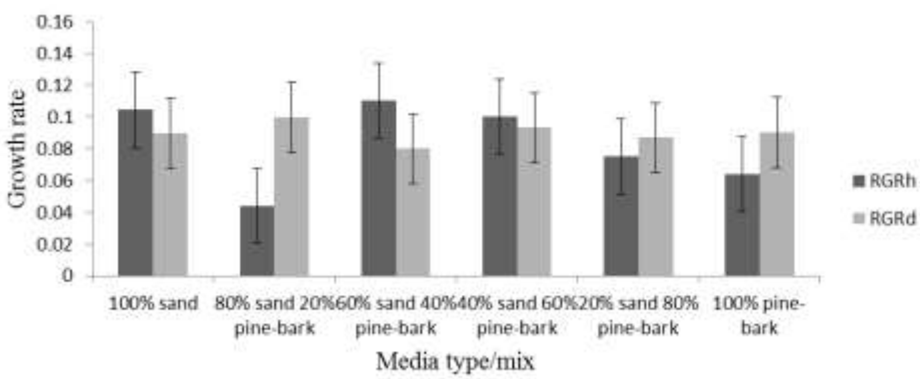

Fig. 2. Effect of substrate mix on RGRh and RGRd

Effects of substrate mix on stem length

Final stem length was greatest with the 60% sand + 40% pine bark substrate mix while the rest of the substrates were statistically the same ($P<0.05$) (Fig. 3).

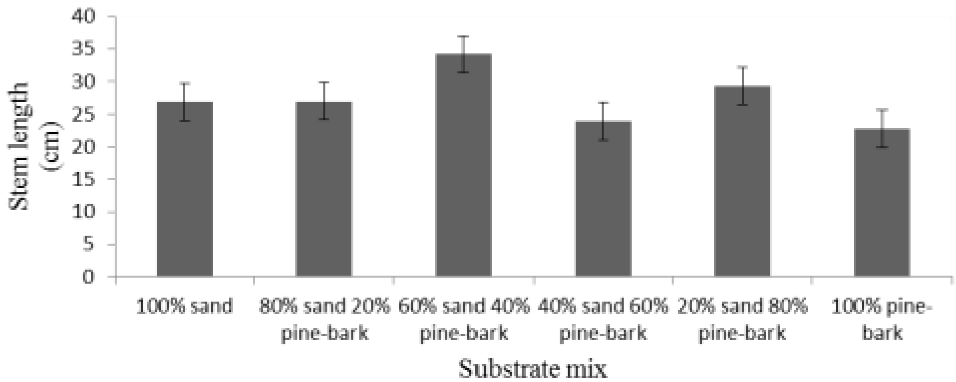

Fig. 3. Effect of substrate mix on initial and final stem height

Effects of substrate mix on root collar diameter (RCD)

The root collar diameter (RCD) measurements were lowest in the 100% pine bark substrate and virtually the same for the other mixes (Fig. 4).

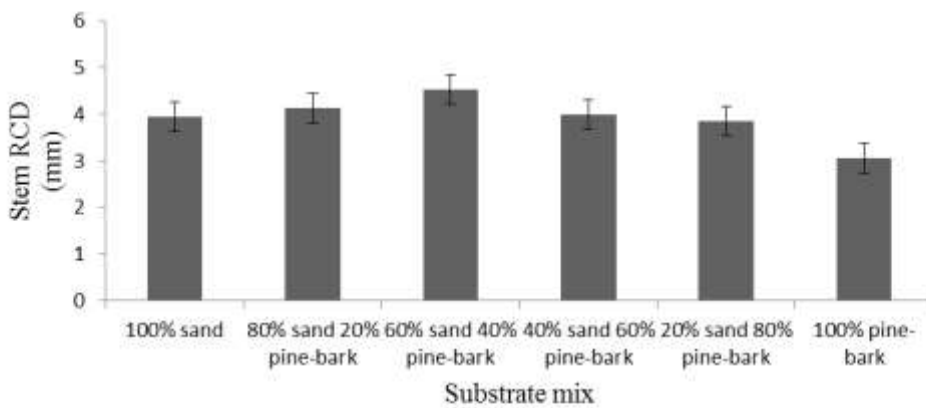

Fig. 4. Effect of substrate mix on RCD.

Discussion

This study shows unique differences in the response of various measured parameters of the substrate mixes used

Emergence and survival percentages

The observation that emergence was very good across all treatments shows the potential of sand and pine bark mixes for use as growing medium.

The slightly lower germination with 100 % sand and 80% sand + 20% pine bark could be a result of lower water holding capacity, air porosity (Table 1) and the high drainage characteristic of sand. In general, aerations of 18 to 28% are regarded as characteristic of the best substrates (Beeson Jr., 1995), and none of the mixes in the present study exhibited aeration in this range. However, the observation that 80% sand + 20 % pine bark and 100% pine bark gave the best survival and acceptable germination suggests aeration did not have a marked effect on both parameters. Hence, the mixes had the right balance for both growth and germination.

Effects substrate mixes on RGRd and RGRh

While there was no treatment difference in terms of relative growth rate in stem diameter (RGRd) (Fig. 2) there were important differences with regards to relative growth rate in height (RGRh). Contrary to survival, which was highest with the 80% sand + 20% pine bark and 100% pine bark substrates, relative growth rate in height (RGRh) was higher in all treatments except in the 80% Sand + 20% pine bark substrate (Fig. 2). This is important because it shows that in general the treatments were equally good. Perhaps this is because there was a very narrow range in aeration and water content between the substrate mixes. One of the factors imparting aggressiveness in some plant species, especially invasive species, is a fast relative growth rate (Grotkopp and Rejmánek, 2007) and hence, the mixes appeared equally successful in this respect.

Effects of substrate mixes on stem length and root collar diameter

Stem length was highest in the treatment 60% sand + 40% pine and virtually the same for the other treatments suggesting that the range of the factors important during emergence and early growth, e.g. aeration and water content, were very similar among the treatments. Similarly, root collar diameter (RCD) was lowest with the 100% pine bark but the same for the other treatments. Zida *et al*. (2008) showed that initial height did not affect survival in *Acacia macrostachya* and *Pterocarpus erinaceus* while RCD did. RCD is an important measure of the seedlings survivability potential in the long term (Gardiner *et al*., 2008; Aphalo and Rikala, 2003) and was associated with survival in yellow Poplar seedlings (Dierauf and Garner, 1993). Although we did not plant out the seedlings to assess survival of full-grown trees, our results showed that our substrate mixes were within good range for all the mixes.

Summary, Conclusions and recommendations

Summary and conclusions

Germination was very good for all treatments while survival was low for only the two treatments 60% sand + 40% pine bark and 20% sand + 80% pine bark. This showed that almost all the substrates were good for the germination and initial survival of the seedlings. Similarly, relative growth rate in height, stem height and root collar diameter were essentially the same for the substrate mixes. We concluded therefore, that all the mixes were acceptable but perhaps the 60% sand + 40% pine bark could be singled out for further development especially by improving the survival of the seedlings.

Recommendations

Further research is required in this area and perhaps an improvement to this study would be the inclusion of vermiculite as a constituent of the mixes. Such an addition would probably raise the initial aeration to an acceptable 18 to 28% range and 25-33% water holding capacity. A natural further extension of this work could be to plant the seedlings out and monitor survival and growth in the long term and attempt to discern which seedling characteristics would be important in the plated out tree.

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