PREREQUISITES FOR BIOCROPS UP-SCALING I: AN ASSESSMENT OF SEED PROPAGATION OF OILFEROUS PLANT SPECIES WITH POTENTIAL FOR BIODIESEL PRODUCTION

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ABSTRACT

This study assessed the propagation of non- edible oil plant species with potential for biodiesel production on 4 potting media forest, sandy, clay and loamy soil using seeds. Investigation was based on assessment of seed germination capacity, rooting ability and seedling growth rate of six selected plant species Telfairia pedata, Jatropha curcas, Excoecaria bussei, Croton macrostachyus, Croton megalocarpus and Ricinus communis. Completely randomized design (CRD) was adopted for this study using 10 seeds per plot (5L capacity pots) with 4 replications. An ANOVA was conducted to test for the significance of the treatments while Tukey-Kramer Multiple Comparisons test was used to test for the differences between treatment means. Species giving highest germination percentage also portrayed highest germination energy. Telfairia pedata grew luxuriously in all soil types while Jatropha curcas performed poorly in almost all soil types except in loam soil. Ricinus communis and Excoecaria bussei growth were moderate. Based on propagation ability and growth performance; multiplication by seeds was recommended for Telfairia pedata, Ricinus communis, Excoecaria bussei and Telfairia pedata but not for Croton macrostachyus, Croton megalocarpus which did not germinate at all. Croton seems to be recalcitrant and probably needed special attention and shortest storage time from harvesting prior to sowing.

Key Words: Propagation, germinability, germination capacity.

INTRODUCTION

The fact that fossil fuels are not sustainable and have a negative impact on the environment cannot be overemphasized. The alternative encompasses exploring the use of fuel from other sources that are environmentally sound. Research at the University of Dar es Salaam (UDSM) has concentrated on delineating plants that can produce biofuel and six indigenous plant species whose oil content is comparable to that of the exotic *J. curcas* have been identified (Moshi *et al*. 2010). If oil from these plant species has to be sustainably harvested for biofuel production, they must be cultivated on a large scale. However, there is very little information on their propagation methods. This gap of information justified conduction of this research study.

Plant propagation can be conducted by vegetative means such as cuttings, wildings, coppices and root suckers or using seeds. The challenges of using vegetative propagation methods for mass/commercial purposes would be destruction of mature trees if hard pruning was to be done. For that case propagation using seed would be more appropriate. In agriculture, one factor that is required to assess when using seeds is the germination rate which describes how many seeds of a particular plant species, variety or seed lot are likely to germinate after a given period. It is usually expressed as a percentage. The germination rate is therefore useful for calculating the seed requirements for a given area or desired number of plants (Willan 1985).

A seed contains an embryonic plant in a resting condition, and germination entails its resumption of growth resulting in formation of a seedling which depends on both internal and external conditions. For oil seeds intricate metabolic interaction of seed reserves and lipid status and conversion into simple sugar plays a major role (Alex *et al*. 2006). Various plants species require different factors for successful seed germination and often this depends on the individual seed variety and is closely linked to the ecological conditions of the plant's natural habitat (Baskin and Baskin 1971). For some seeds, their germination response is affected by environmental conditions such as soil moisture, temperature and day length during seed formation and most often these responses are linked to innate seed dormancy (Baskin and Baskin 2004). Germination of the seed is a critical stage, because the rest of the plant life is directly dependent upon the rate of its germination (Qadir and Shahzadi 1969). The growing media play an important role in enhancing the soil physical and chemical properties and thereby increasing the penetrating capacity of roots in the planting media. Soil types is an important factor in seed germination because it may cause poor aeration, water logging and an impervious layer formed by the compact mass structure of the clay soil which may account for a lowered germination for seeds sown.

The effects of some soil media *viz.,* sand, clay, loam and sawdust (in a 1:1 ratio), and "Garden" soil on the seed germination of 9 cultivars of the *Helianthus annulus* L. was investigated in a laboratory study. The results obtained showed that higher germination percentages of above 60% in most of the cultivars were observed in the sandy and loam + sawdust media. A consequent performance was also recorded for the garden soil treatment while, low germination percentage of below 40% was observed in the clay treatments (Idu *et al*. 2003). On the other hand, seed size and germination speed are other important prerequisites to cope successfully with unstable soil surfaces (Wolfgang *et al*. 2002).

Plants have evolved to alter how they grow and develop in response to signals from the environment. Germination of seeds in-situ often takes place over several months or years as nature's way of insuring that some plants will survive the vagaries of weather. This cannot be tolerated ex-situ in established nurseries where one is primarily interested in the number of plants that can be expected from a given seed lot which makes estimating seed viability necessary. The germination energy (GE) is one of the commonly employed indices for the speed of germination. The germination energy is based on the theory that only those seeds which germinate fast and at once under favourable conditions are likely to produce more vigorous seedlings that can survive under field conditions than those which are weak and germinating slowly. Delayed or staggered germination often results in failure in field establishment due to smothering by weeds.

Of all the quality measurements of seed lots, none is more important than the potential germination of the seeds (Bonner 1974), although this test can take several weeks to complete and for some species further pretreatment may be needed and take some additional weeks or months. The most rapid method is the tetrazolium test, a biochemical method by which only living cells capable of germinating are stained red by the reduction of a colourless tetrazolium salt to form a red formazan. The method emphasizes the need for knowledge of the soundness of individual embryo parts for predicting the development of embryos into countable seedlings (Moore 1973).

The main objective of this study was to assess the effect of growth media on seed germination and seedling growth of different indigenous oil plant species.

MATERIALS AND METHODS

Experimental Site and Source of Planting Materials

The experiments were conducted at the Department of Botany laboratory and nursery area of the University of Dar es Salaam. Seeds from the six identified potential oil producing plant species (*Croton macrostachyus*, *Ricinus communis*, *Jatropha curcas*, *Telfairia pedata*, *Croton megalocarpus and Excoecaria bussei*) were collected from Manyara, Arusha and Iringa regions through 24th-26th August 2009.

Monitoring Viability of Seeds Using Tetrazolium Test

Twenty seeds were randomly selected from each species for viability test. Seeds were soaked in water overnight after which the seed coats were peeled off and the seeds cut into two halves to expose their embryo. Each half was immersed in 1% solution of tetrazolium chloride (2, 3, 5-triphenyl tetrazolium chloride) and kept in darkness for 24 hours at ambient temperature as described by AOSA (2000). Observations were made on the brick red colour intensity of the stained endosperm. The proportion of seeds that stained was recorded as percentage of the total tested seeds.

Physical and Chemical Characterization of Potting Media

Four different potting media were tested namely forest top soil, sandy soil, loam soil and clay soil. The forest top soil was collected at a depth of 0-15 cm from a forest near the botanical garden of the Department of Botany, sandy soil was collected from the riverbed; loam soil was mixed from sandy, silt, and clay in a ratio of 2:2:l by volume and clay soil was mined in the vicinity. Parameters determined included; total porosity, water holding porosity, and aeration porosity of the potting media. This was done by calculating water-holding capacity and porosity as described by Jaenicke (1999). Media pH was determined electrometrically using a Metrohm E510 pH meter. This was done using a ratio of 1:1 soil and water that was stirred and allowed to equilibrate in a beaker for 30 minutes (EO 1992).

Experimental Set-up and Seed Parameters Recorded

For each potting media, 10 seeds from selected biodiesel plant species that showed high viability were evaluated for germination. The experiment was replicated four (4) times and arranged in a Complete Randomized Design (CRD) making a total of 640 seeds. Seeds were kept moist by watering once a day or whenever needed. Parameters recorded included; germination capacity (GC) which included germination percentage and germination energy (GE). Germination percentage was computed as the proportion of total seeds that germinated and expressed as percentage. From this GE also expressed in percentage was computed as the percentage of tested seeds that cumulatively germinated up to the time of peak germination.

Seedling Growth, Plant Height and Shoot Biomass

Growth of the germinated seeds was monitored at weekly interval by measuring seedling height from the soil level to the seedling apex for a period of three months. The number of roots and root length, which was measured from the tip of the root to the stem base, was recorded at the end of experimentation. Samples of shoot biomass were harvested three times at intervals of 90, 150 and 180 days since germination by cutting at the soil level. Then shoots biomass of each harvest was oven dried at 85 °C for a period of 72 hours to get shoot biomass dry weight. One eighty days after germination the remaining standing seedlings were harvested to record the fresh and dry root biomass weight. Plants were thoroughly watered to loosen potting media from roots. All root materials were collected, washed to remove debris and separated from shoots. Root numbers and length measurements were recorded before drying the roots at 85 °C to constant weight.

Data Analysis

ANOVA was used to test for significance of the differences between treatments. The Tukey-Kramer Multiple Comparison was used to identify pairs that showed the significant differences between treatment means. Tables and figures were used to summarize the data. The significance level for all tests was 5% and 1% ($\alpha = 0.05$ and $\alpha = 0.01$).

RESULTS

Influence of Oil Plant Species on Seed Germination and Seedling Growth

Seed Viability

Results from Tetrazolium test are as shown in Figure 1. Based on colour intensity, the three species namely *Excoecaria bussei*, *Ricinus communis* and *Jatropha curcas* showed 100% viability; *Telfairia pedata* seeds were 85% viability. *Croton macrostachyus* was only 10% viable while the *Croton megalocarpus* showed no viability at all and was, consequently, dropped from the experiment.

Characterization of Physical Properties and pH of the Potting Media

The potting media used showed high variation of their physical characteristics and pH. The clay soil showed the poorest aeration porosity (7.2%) and sand soil showed the lowest water holding porosity (28.8%). Forest and loam soil showed good aeration porosity as well as water holding porosity of 18.0 and 32.4%, respectively. Soil pH ranged between 6.2 to 7.6% and was close to neutral for all soil types (Table 1).

Table 1: Physical and Chemical Properties of Rooting Media Used for the Experiments

Physical Properties	**Rooting media (Soil)**				
	Sand	Forest top	Clay	Loam	Standard media
Total porosity (%)	53.4	50.3	50.3	50.4	50-80
Aeration porosity (%)	21.6	18.0	7.2	18.0	> 12
Water holding porosity %	28.8	32.4	43.2	32.4	30-60
Soil reaction (pH)	7.6	6.2	7.5	6.7	

Germination Percentage

Seeds started germinating from the 7th day after sowing and continued for 37 days. Results on seed germination percentage of the evaluated species were as shown in Figure 2a. *Ricinus communis* (MRI 4) had the highest germination percent of 93.1% while *Telfairia pedata* had the lowest germination percent of only 48.1%, which was also statistically significant ($p = 0.05$) different.

Germination Energy

Germination energy (GE) for the seed lots that germinated is shown in Figure 2b. *Ricinus communis* (MRI 4) revealed the highest germination energy of 10.6% while *Telfairia pedata* (MTE) showed the lowest germination energy of 0.6%.

Seedling Growth Measured as Plant Height

The four tested species *Excoecaria bussei*, *Ricinus communis*, *Jatropha curcas* and *Telfairia pedata* showed different growth performance in the different potting media as measured by plant height. *Telfairia pedata* performed significantly better in all soil types where as *Jatropha curcas* performed poorly in almost all potting soil media except loam soil while *Ricinus* *communis* grew moderately in all potting media as shown in Figures 3: a, b, c and d. Analysis of Variance revealed that seedling plant growth among the four plant species differed significantly at $P < 0.01$. *Telfairia pedata* which is a vine outperformed other plant species in all 4 potting media during the first 90 days (Figure 3). In sandy soil, *Telfairia pedata* were the tallest (225.5 cm), while *Jatropha curcas* were the shortest (22.7 cm), likewise in forest top soil where *Telfairia pedata* grew to a maximum plant height of 252.6 cm while *Jatropha curcas* plants grew to only 33.1 cm for the duration of 90 days. In loam soil, *Telfairia pedata* grew to 257.0 cm while *Excoecaria bussei* reached only 31.1 cm after 90 days after germination. In clay soil, *Telfairia pedata* had the highest growth having a maximum of 212 cm, while *Excoecaria bussei* showed lowest growth performance with a maximum plant height of only 24.2 cm after 90 days after germination.

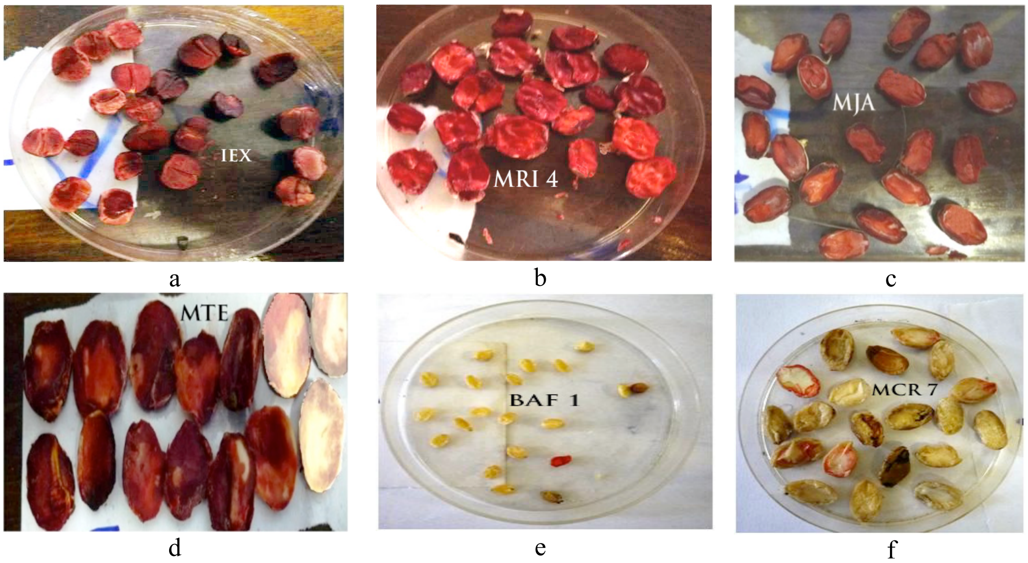


Figure 1: Species viability test results, a = *Excoecaria bussei*, b = *Ricinus communis*, c = *Jatropha curcas*, d = *Telfairia pedata*, e = *Croton macrostachyus* and f = *Croton megalocarpus*.

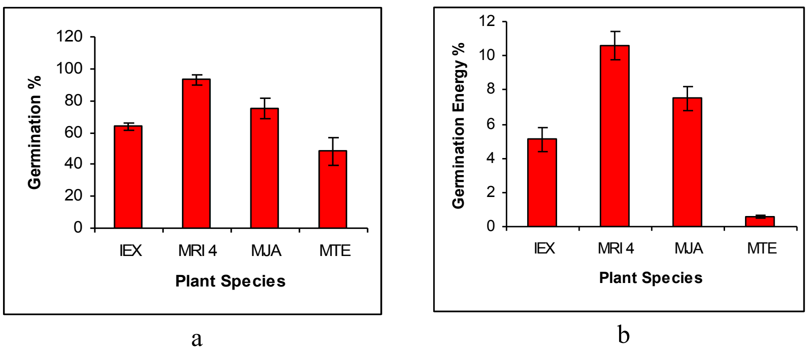


Figure 2: Seed Performance (a) Germination % (b) Germination Energy (%) of the Four Viable Plant Species; IEX= *Excoecaria bussei,* MRI 4= *Ricinus communis*, MJA= *Jatropha curcas*, MTE= *Telfairia pedata.*

The same trend was followed up to 180 days (Figure 4) where *Telfairia pedata* performed significantly better in all soil types by having growth height of 379.9 cm, 359.7 cm, 292.9 cm, and 238.8 cm in loam soil, forest top soil, sand soil and clay soil, respectively. *Jatropha curcas* performed poorly in almost all soil types by having plant height of only 48.7 cm, 29.2 cm, 28.6 cm in forest soil, sand soil and clay soil, respectively, except in loam soil whereby *Excoecaria bussei* had the lowest growth height of 39.3 cm compared to Jatropha *curcas* which grew *to* 44.0 cm. *Ricinus communis* growth was average (Figure 4: a, b, c, d).

Seedling Growth Measured as Shoot Dry Weight

As for plant height, *Telfairia pedata* had the highest shoot dry weight of 14.5 g, 13.3 g, 9.4 g and 8.4 g after 90 days since germination in loam, forest top soil, clay soil, and sand soil, respectively. *Ricinus communis* had the smallest shoot dry weight of 2.4 g, 2.3 g, 1.3 g and 0.9 g in forest top soil, loam soil, sand soil and clay soil, respectively (Figure 5: a, b, c, d).

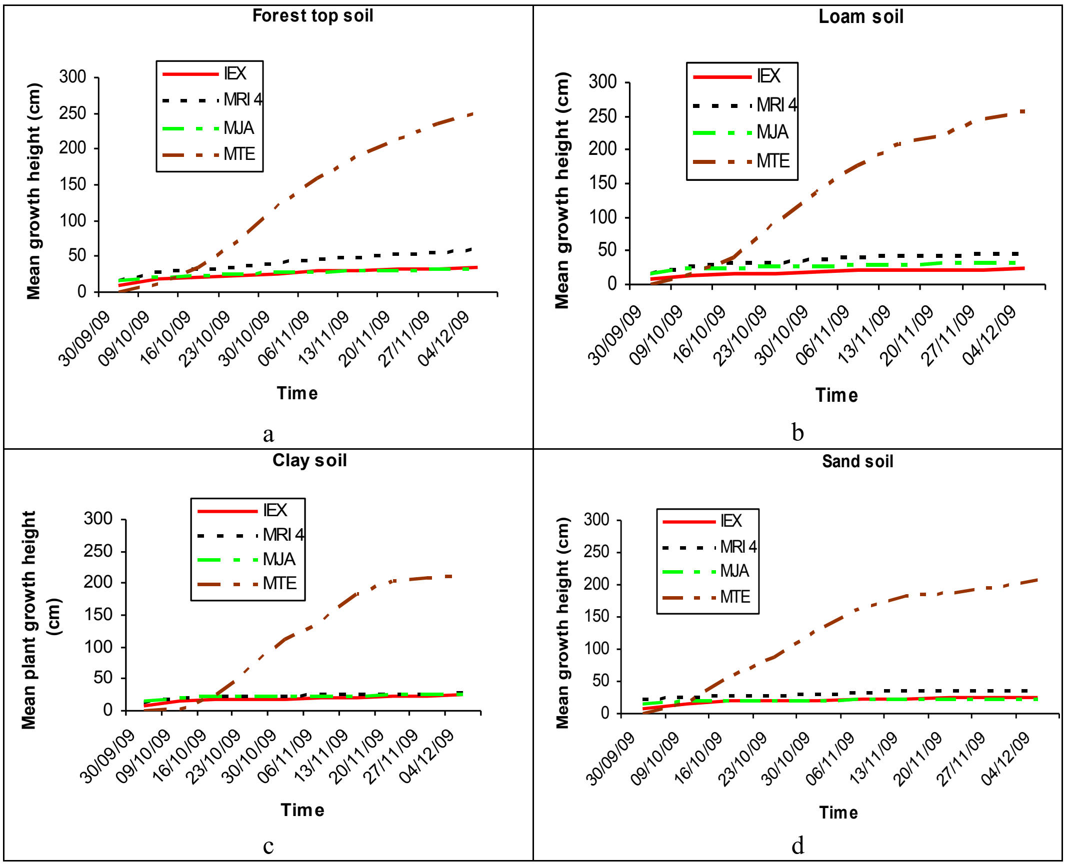
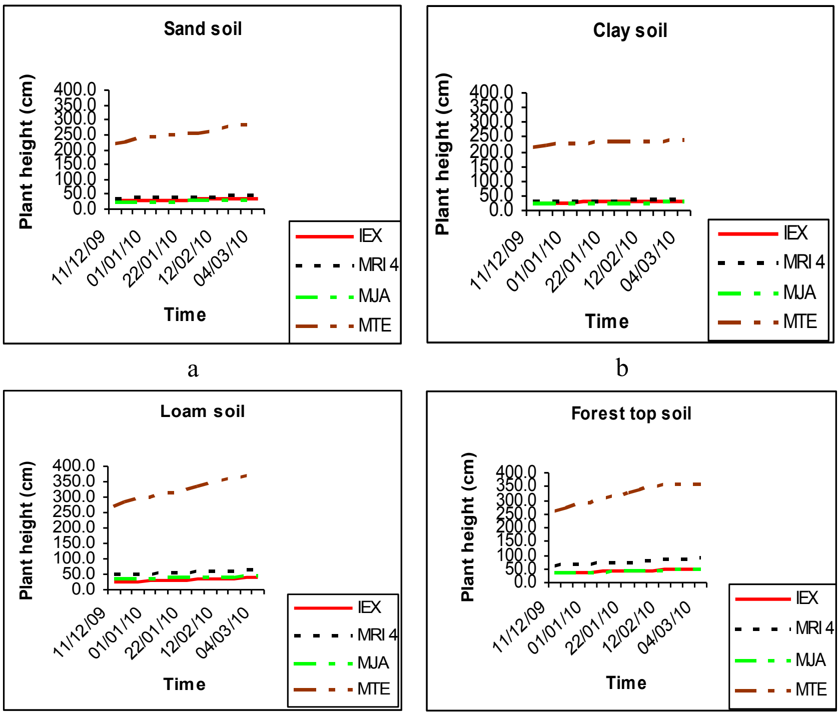


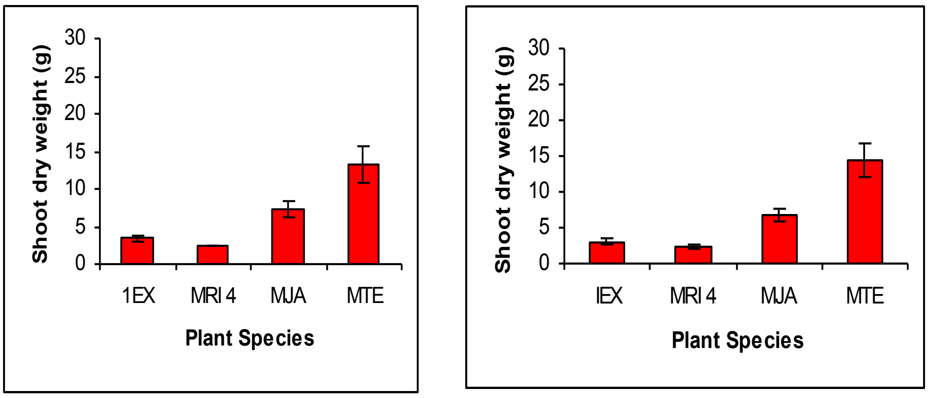
Figure 3: Plant Height of 4 Plant Species Grown in (a) Forest top soil (b) Loam soil (c) Clay soil and (d) Sand Soils for 90 Days. IEX= *Excoecaria bussei,* MRI 4= *Ricinus communis*, MJA= *Jatropha curcas*, MTE= *Telfairia peda*ta.



a b

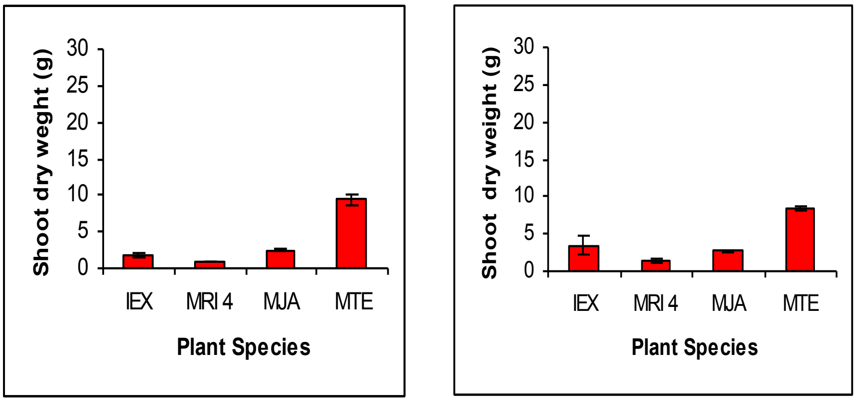
c d

Figure 4: Plant height of 4 plant species grown in 4 different soils 180 days after seed emergence (a) Sand,(b) Clay,(c) Loam, and (d) Forest top soil:. IEX= *Excoecaria bussei,* MRI 4= *Ricinus communis*, MJA= *Jatropha curcas*, MTE= *Telfairia pedata*



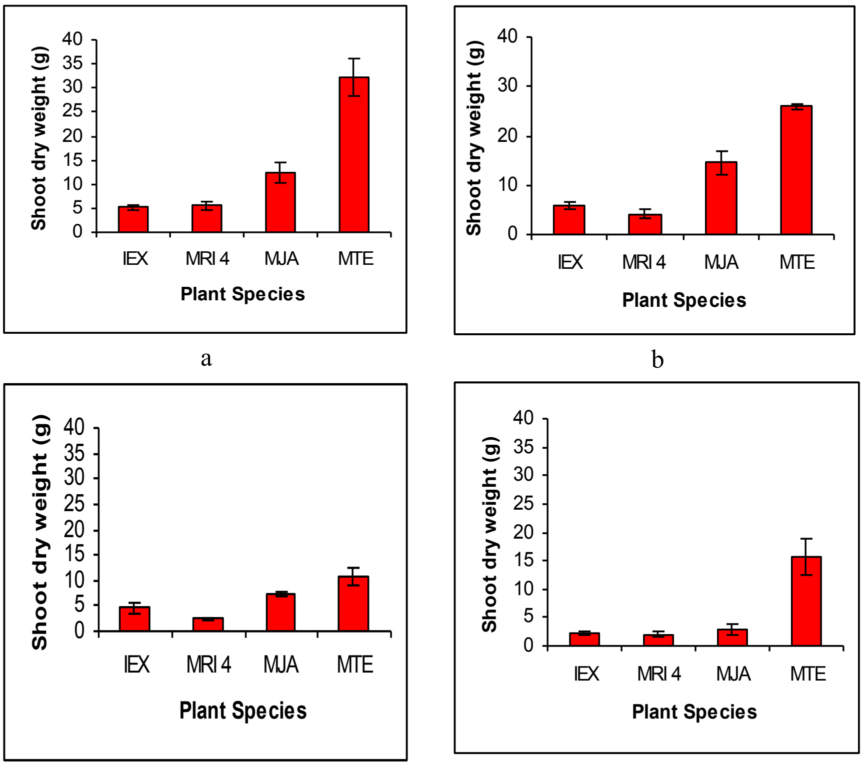
a b

Figure 5: Shoot Dry Weights of Plant Species in 4 Different Potting Media 90 Days after seed emergence (a) Forest top soil, (b) Loam soil. …. *Figure 5 continues*



c d

Figure 5: (c) Sand, and (d) Clay soil, IEX= *Excoecaria bussei,* MRI 4= *Ricinus communis*, MJA= *Jatropha curcas*, MTE= *Telfairia pedata*



c d

Figure 6: Shoot Dry Weights 150 Days after Seed Emergence in the 4 soil types (a) Forest top soil, (b) Loam soil, (c) clay soil and (d) Sand soil. IEX= *Excoecaria bussei,* MRI 4= *Ricinus communis*, MJA= *Jatropha curcas*, MTE= *Telfairia pedata*

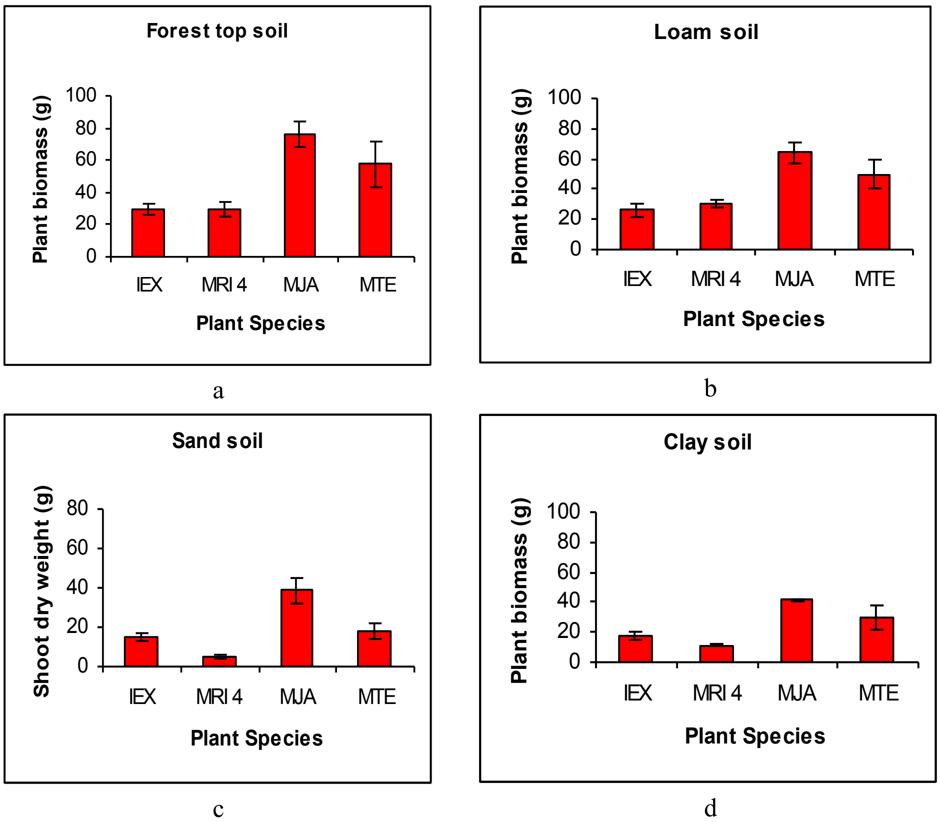


Figure 7: Results on Shoot Dry Weight 180 Days after germination (a) Forest top soil, (b) Loam soil, (c) Clay soil and (d) Sand soil. IEX= *Excoecaria bussei,* MRI 4= *Ricinus communis*, MJA= *Jatropha curcas*, MTE= *Telfairia pedata.*

Similar trend was observed after 150 days whereby *Telfairia pedata* had the highest dry weight of 32.3 g, 25.9 g, 15.6 g, and 10.7 g, in forest top soil, loam soil, clay soil and sandy soil, respectively. *Ricinus communis* had the smallest dry weight of 5 g, 2.4 g, and 2 g, in loam soil, sand soil and clay soil, respectively (Figure 6: a, b, c, d). After 180 days germination, *Jatropha curcas* had highest shoot dry weight in all soil types by having 63.3 g, 51.2 g, 38.8 g, and 33.6 g in forest top soil, loam soil, sand soil and clay soil, respectively. *Excoecaria bussei* had smallest dry weight in loam soil and forest soil by having 20.7 g, 15.8 g, respectively, while *Ricinus communis* had smallest shoot dry weight in sand soil and clay soil by having, 5.1 g and 8.6 g, respectively. *Jatropha curcas* and *Telfairia pedata* were not statistically different in all soil media tested.

Shoot Total Biomass 180 Days after Germination

Jatropha curcas had highest total biomass in all soil types by weighing 76.3 g, 64.0 g, 47.8 g, and 41.6 g in forest soil, loam soil, sand soil, and clay soil, respectively. *Telfairia pedata* and *Excoecaria bussei* were comparably lower in sandy soil and clay soil than *Jatropha curcas* while *Ricinus communis* and *Excoecaria bussei* performed poorly in sand soil and clay soil by having a total biomass of 11.0 g and 7.1 g in clay soil and sandy soil, respectively for *Ricinus communis* and 20.4 g, 17.4 g in sandy soil and clay soil, respectively for *Excoecaria bussei* (Figure 7).

Seedlings Shoot/Root Biomass Ratio

All tested species had different shoot/root biomass ratio in different soil types where by *Telfairia pedata* had highest shoot/root biomass ratio of 7.8, 6.8, 6.6, and 5.1 in sandy, forest, clay and loam soil, respectively. *Excoecaria bussei* had the lowest shoot/root biomass ratio in almost all soil types, *i.e*., 2.9, 2.6, 2.3, and 1.5 in sandy, clay, forest and loamy soils, respectively (Table 2).

Table 2: Shoot/Root Ratio of Seedlings Biomass of the Tested Plant Species

Soil type/Plant Species	Shoot dry wt.(g)	Root dry wt. (g)	Shoot/Root ratio
Sandy soil			
Excoecaria bussei	15.2	5.2	2.9
Ricinus communis	5.1	2	2.6
Jatropha curcas	38.8	9	4.3
Telfairia pedata	17.6	2.6	6.8
Clay soil			
Excoecaria bussei	12.7	4.8	2.6
Ricinus communis	8.6	2.4	3.6
Jatropha curcas	33.6	8	4.2
Telfairia pedata	25.7	3.9	6.6
Loam soil			
Excoecaria bussei	15.8	10.3	1.5
Ricinus communis	21.7	8.8	2.5
Jatropha curcas	51.2	12.9	4.0
Telfairia pedata	44.4	5.7	7.8
Forest soil			
Excoecaria bussei	20.7	9.2	2.3
Ricinus communis	24.2	5.5	4.4
Jatropha curcas	63.3	13	4.9
Telfairia pedata	48	9.4	5.1

DISCUSSION

It was observed that, seed sizes of the selected viable species differed and was related to germination capacity. It has been reported elsewhere (Seiwa and Kikuzawa 1991) that seeds having large size took longer time to germinate than seeds with small sizes. Among the species tested in this study, personal observations showed that *Telfairia pedata* had the largest seed size followed by *Excoecaria bussei*, *Jatropha curcas* and lastly *Ricinus communis*. *Ricinus communis* species and Jatropha *curcas* both with the smallest seed sizes germinated within 10 days. *Excoecaria bussei* germinated within 13 days and *Telfairia pedata* with largest seed size germinated within 37 days. Also EO (1992) reported that small seeds germinate faster than large seeds and took competitive advantage of light although others (Howell 1991) reported faster growth of seedlings in a larger seeded species compared to species with small seeds. In a mixed forest, early germinating seedlings in-situ have an advantage of a higher rate of survival and attainment of a greater biomass than seedlings that germinate later because the former can utilize more light prior to leaf canopy closure. Studies on *Leucaena leucocephala* (Gupta 1983), *Aceroblongum, Kydia calyciana, Terminalia tomentosa, T. bellerica and T. chebula* (Negi and Todaria 1997), grassland species (Jakobsson and

Ericksson 2000) revealed faster seedlings growth from large seeds which had higher recruitment success. Milberg and Lamont (1997) on the other hand reported that, larger seeds have the ability to store greater amounts of carbohydrates in their endosperm or cotyledons than small seeds. Hewitt (1998) observed the same and reported that that large seeds may enable early development of an enlarged resource gathering system (root or photosynthetic tissue) to produce a fast growing plant. Ekta and Singh (2000) stated that seedling from large seeds survived long term extreme water stress than those from small seeds.

Among the six potential oil producing plant species tested for viability using Tetrazolium staining test (TZ), four species had more than 50% viability while two species had less than 50% viability. Vigour and viability of the seeds seem to be influenced by physiological maturity of the seeds at harvesting time which is markedly affected by environmental factors like temperature, humidity, and water availability as reported by Gorecki (2001). It has also been reported that the response of maturing seeds to environmental changes like temperature is associated with changes in the content and composition of soluble carbohydrates stored in those seeds (Hung, 2003). Species which scored 100% during viability test by Tetrazolium Test, *i.e.*, *Ricinus communis*, *Jatropha carcus*, and *Excoecaria bussei*, resulted in 93.1%, 75%, and 63.7% germination percentage, respectively. These results are in agreement with those reported by ISTA (2003) which revealed that Tetrazolium Test viability ratings while showing germinability potential are often higher than the actual seed germination and should be used just as a guide to sieve out potential seed lot that may germinate.

The highest germination energy (GE) was observed in plant species which had higher germination percentages. The interest in germination energy is based on the theory that only those seeds which germinate rapidly under favorable conditions are likely to produce vigorous seedlings under field conditions; weak or delayed germination is often fatal to field establishment (Cardoso *et al.* 2008). Germination energy has been used as an integrated measure of seed quality in *Acacia nilotica* (Ginwal and Gera 2000) and *Pinus roxburghii* (Roy *et al.* 2004).

Positive correlation of various seeds parameters in the study revealed that viability and germinability are species specific. The results are in agreement to those reported by Haywood (1994). Germination percentage is affected by seed viability, seed dormancy and environmental effects that impact on the seed and seedling. In agriculture and horticulture quality seeds have high viability measured as germination percentage plus the rate of germination. Germination energy in the current study also correlated well with seed viability and germination percentage implying that seeds which had higher germination energy, had also higher viability and germination percent.

The time taken for germination by the species showed that *Ricinus communis*, *Jatropha carcus* and *Excoecaria bussei* took shorter time to germinate so could be ideal for direct sowing in large plantation. *Telfairia pedata* which took longer period to germinate would be better if it were sown in nursery seed bed prior to field establishment. To establish seeds in the nursery bed have advantages that, it makes it easier to manage the young plants in a small area with many seedlings than in field regarding weed control, pest and diseases control. From the nursery bed, it is possible to select plants with good vigour and discard the weak ones. The method also gives the farmer more time to prepare the field better. By using nursery beds there is also economy of seeds. In any case, seeds which germinate slowly would be non uniform in the field which would make management practices difficult.

Seedling growth in this study measured as plant height was used to evaluate species performance in all soil types to provide room for domestication and large scale production. The results showed that *Telfairia pedata* performed better in all soil types than *Ricinus communis*, *Jatropha carcus* and *Excoecaria bussei.* This implies that it can easily be established in several settings in Tanzania. *Jatropha curcas* performed poorly in most of the tested soil types except in loam soil. Since loam soils are characteristically of high fertility, this means that *Jatropha curcas* requires fertile soils contrary to the current speculations that it can grow in marginal areas in which case it stands as a competitor to growing food crops (Richard 2009). The shoot dry weight in the study after 90 days of growth, showed that *Telfairia pedata* had highest dry weight, followed by *Jatropha curcas*, *Excoecaria bussei* and *Ricinus communis* in all soil types except in sandy soil whereby *Telfairia pedata* had the highest dry weight followed by *Excoecaria bussei*, *Jatropha curcas* and *Ricinus communis*. The reduction in dry weight of *Jatropha curcas* in sandy soil reveals its demand for fertile soils. This puts *Jatropha curcas* at a disadvantage of competing with food crops for fertile land that Jatropha yield in dry land would decline after four years to less than 200 g per plant. *Ricinus communis* and *Excoecaria bussei* growth were relatively moderate in all tested soil types implying that based on soils; they could be easily domesticated in most environments in Tanzania.

The need to determine root length and numbers was meant to assess for potential capacity for nutrient and water uptake from the surrounding medium. Results on number of roots showed that, *Telfairia pedata* had many roots in all soil types followed by *Jatropha carcus* and *Excoecaria bussei* while *Ricinus communis* had few root in all soil types except in clay soil. Root length results showed that *Excoecaria bussei* had the longest roots in all soil types followed by *Telfairia pedata* and *Ricinus communis* while *Jatropha curcas* had shortest roots in all soil types. Species with fewer root numbers had longer roots. While this would compensate for root length density, there is still difference in the levels of soil volume to be mined for water and nutrients. In moist soils many short roots suffices but in dry soils longer roots would be more adventitious.

Shoot to root ratio indicated that, all tested species had a greater proportion of dry mass allocated to the shoots. The proportionately greater shoot mass in the tested species would perhaps, make the recruited seedlings less tolerant of drought and/or nutrient deficiency (Ramakrishnan 1992). Plants with good root system would confer better adaptation ultimately resulting in better survival and growth. Based on propagation ability *Excoecaria bussei*, *Telfairia pedata*, *Ricinus communis*, *Jatropha carcus* and *Excoecaria bussei* are worth to be multiplied from seeds. *Croton megalocarpus* and *Croton macrostachyus* which were not viable on Tetrazolium test may need other rigorous propagation methods.

ACKNOWLEDGEMENT
The financial support from PISCES-UDSM Project is highly acknowledged.

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