EFFECT OF POTTING MIXTURES ON SEED GERMINATION AND EARLY GROWTH RESPONSE OF *Jathropha curcas* L. IN MAKURDI, BENUE STATE, NIGERIA

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Abstract: Increasing demand for *Jatropha curcas* products and ability of the plant to absorb carbon monoxide which attracts carbon credits to *Jathropha* farmers justify commercial farming of the shrub. This necessitates adoption of good nursery practices to ensure production of strong and healthy seedlings within the shortest possible time. This study investigated seed germination and early growth response of *Jatropha curcas* to different potting mixtures. The Completely Randomized Design was used. Descriptive and inferential statistics were employed to analyze collected data (percentages, one-way analysis of variance and Duncan Multiple Range Test). Sharp sand, topsoil and cow dung were mixed in the following ten ratios, viz: M_a (1:4:1), M_b (1:2:1), M_c (2:2:1), M_d (2:3:1), M_e (4:4:1), M_f (1:0:0), M_g (0:1:0), M_h (3:2:3), M_i (4:1:4) and M_j (1:3:1), respectively. A total of five hundred seeds were planted (fifty seeds per each treatment). Seed germination percentage, stem height, leaf area and leaf count were assessed from weeks 1 to 10 after planting. Treatment M_g (0:1:0) had the highest germination percentage (100%). Treatment Mc (2:2:1) had the highest mean height (20.79 cm); Treatment M_j (1:3:1) had the highest mean leaf area (46.04 cm^2) while treatment M_e (4:4:1) had the highest mean leaf count (2.78). Correlation coefficient (r) showed a significant relationship between germination percentage, stem height, leaf area and number of leaves. Treatment M_g (0:1:0) and M_J (1:3:1) gave the best performance as potting mixtures and are hereby recommended to be used in raising seedlings of *Jatropha curcas* L. in the nursery.

Keywords: Seed germination, potting mixtures, early growth, Savannah

Introduction

Jatropha curcas L. plant (family Euphorbiaceae) originated from Central America but has been naturalised in most tropical and subtropical countries from South-America to Africa and Asia (Heller, 1996). Its tolerance to diverse soil and climatic conditions allows a vast distribution within the "*Jatropha* belt" stretching between 30° N and 35° S (Jongschaap *et al*., 2007). The shrub is well adapted to arid conditions. It is suitable for sand dune stabilization and soil conservation (Heller 1996). It can be conveniently propagated from seeds as well as branch cuttings which make the species most suited for afforestation purposes.

Over 10,000 small-scale farmers are currently establishing *Jatropha* plantations in Africa (Loos, 2008) and other parts of the world. *Jatropha* is already found in a number of tropical countries where it is used for boundary marking and fencing. Despite being generally highly toxic, parts of the plant have been used medicinally for some time and the oil is used in small-scale soap-making (Jongschaap *et al*. 2007). The seeds are considered anthelemintic in Brazil. They are ground with palm oil and used as rat poison in Gabon. Aqueous extract of leaves is reported to have insecticidal properties. In Ghana, the leaves find use in fumigating houses against bed bugs. The ether extract shows antibiotic activity against *Staphylococcus aures* and *Escherichia coli*. The juice of the whole plant is used for stupefying fish in Philippines (Gubitz *et al*, 1999). *Jatropha* generates income to rural women in the production of soap, candle and cosmetics (Kabir 2009). *Jatropha* oil is an environmentally safe, cost effective and renewable source of non-conventional energy as a promising substitute to diesel, kerosene, coal and firewood.

The fuel properties of the *Jatropha* oil closely resemble diesel oil. The specific gravity of *Jatropha* oil is 0.9180 (g/ml) compared to diesel oil 0.8410 (g/ml); similarly, the calorific value of the *Jatropha* oil is 41 and diesel oil is 45 MJ/kg (Rosenblum, 2000). The Institute of Plant Genetics and Crop Plant Research (IPGRI) study reports that the seeds are edible once the embryo has been removed (Mike 2006 and Becker, 1999). The nut is a violent purgative and the seeds can be used for many purposes including soap manufacture (Ekele, 2011). *Jatropha curcas L.* leaves provide plentiful organic matter and increase the soil microbial activity and earthworm populations are indicators of ecological improvement of site (Gubitz *et al*, 1999; Ranjan, 2009).

It is therefore necessary to develop alternative energy sources hence cultural methods that ensure fast growth and vitality of *Jatropha curcas* need to be developed to provide healthy seedlings to be planted in plantation, hence the justification for this research. Sustenance of soil fertility and maintenance of a productive cropping/plantation system depends to a large extent on a proper balance between residue management and inorganic fertilizer use, (SSSA, 2001).

Jathropha curcas seedlings can do well when raised on potting mixtures of soil, sharp sand and compost (1: 1: 1). The growing medium should not contain too much salts. Two seeds can be dibbled at each spot. When seedlings are one-month old, weaker seedlings should be removed and used for gap filling and one healthy seedling per pit can be retained (Chandy, 2010).To date, the potential of *Jatropha curcas* is still constrained by the lack of technical information particularly in selecting the best fruit maturity colour that could give the most excellent seed germination and seedling growth performance (Charlie, 2011).

This research examines the use of different potting mixtures as they affect seed germination and early growth of *Jatropha curcas* for the purpose of facilitating plantation establishment in Makurdi, Benue State, Southern Giunea Savanna Zone of Nigeria. The specific objectives of this research are to: (a) determine the germination percentage of *Jatropha curcas* under different potting mixtures and (b) assess the growth rate of *Jatropha curcas L.* seedlings using different potting mixtures

Materials and Methods

The research was conducted at the Teaching and Research Nursery of the University of Agriculture Makurdi in Benue State. Benue state is located between latitude 6^0 to 10^0E and longitude 6^0N to 8^0N, with an elevation of about 97 M above sea level. This falls within the southern guinea savanna agro-ecological zone of Nigeria and it is characterized by bi-modal rainfall pattern. The rainy season starts from March to

November. Temperature ranges between 21 to 30° C. The area has mean annual rainfall is about 1250 mm.

The seeds of *Jatropha curcas L.* were collected from matured mother trees in June, 2012 in Makurdi, and stored in dry cold room for two weeks before sowing. The potting mixtures were obtained by varying the mix ratio of River sand, Top soil, and Cow dung as indicated in Table 1.

Table 1: Ratios of river sand top soil and cow dung used in the potting mixtures

Treatment Identity(M)	Ratio of potting mix		
	River sand	Top soil	Cow dung
M_a	1	4	1
M_b	1	2	1
M_c	2	2	1
M_d	2	3	1
M_e	4	4	1
M_f	1	0	0
M_g	0	1	0
M_h	3	2	3
M_I	4	1	4
M_j	1	3	1

Jatropha seeds were first tested for viability through floatation, visual examination and colour method (Verinumbe, personal communication)..Finally, seeds were sown directly into the poly pots (a seed per germination pot). 50 seeds were sown in each mixture and a total of 500 seeds were planted in all the mixtures. Ten (10) different treatment were randomly selected to as representative samples within the ratio mix range of 0 – 4, using sharp sand, topsoil and cow dung. All the plots in the field were laid out in completely randomized design (CRD) as required. All possible mix ratios of three soil materials between 0- 4 were made and ten treatments were randomly selected.

The stem height was measured in centimetres (cm), leave area was measured in centimetre square (cm^2) and leaf count commenced the 10th day after sowing. Stem height and leave area were measured using graduated 30 cm rule and the number of leaves were counted. After germination was first observed, readings were taken weekly until after the 6th week. Data was analyzed using descriptive (percentages, relative frequency distributions) and inferential statistics (one-way analysis of variance, Duncan Multiple Range Test and correlation analysis). Correlation between seedlings parameters as to stem height and leaf area, stem height and leaf count growth performance were performed.

Results and Discussion

The percentage germination of *Jatropha curcas* seeds under different potting mixtures (treatments) are presented in Fig. 1. The percentage ranged from zero to hundred (0 – 100) and the number of days germination was observed ranged between one to ten (1 – 10) days; the treatments (different potting mixtures) also ranged between Ma to M_j. Fig. 1 indicates that seed germination in the different [potting mixtures ranged from 22% to the maximum of 66% within 7 days in treatment Ma (1:4:1), 16 to 66% within 7 days in treatment Mb (1:2:1), from 22 to 92% within 8 days in treatment Mc (2:2:1), from 22 to 70% within 9 days in treatment Md (2:3:1), from 24 to 82% within 7 days in treatment Me (4:4:1), from 12% to 66% within 9 days in treatment Mf (1:0:0), from 26% to 100% within 7 days in treatment Mg (0:1:0), from 20% to 80% within 9 days in treatment Mh (3:2:3), from 28% to 86% within 8 days in treatment Mi (4:1:4), and from 18 to 82% within 7 days in treatment Mi (1:3:1). However, from Fig. 1, treatment Mg (0:1:0) had the maximum germination percentage of 100%, while treatment Mb (1:2:1), Mf (1:0:0) and Ma (1:4:1) had the minimum germination percentage of 66%; also the mean of germination percentage of 77.8% wsa observed for all the treatments. Fig 1 also shows that most of the treatments, the germination percentage remained constant as from the 7th day after sowing of *Jathropha caucas* seeds.

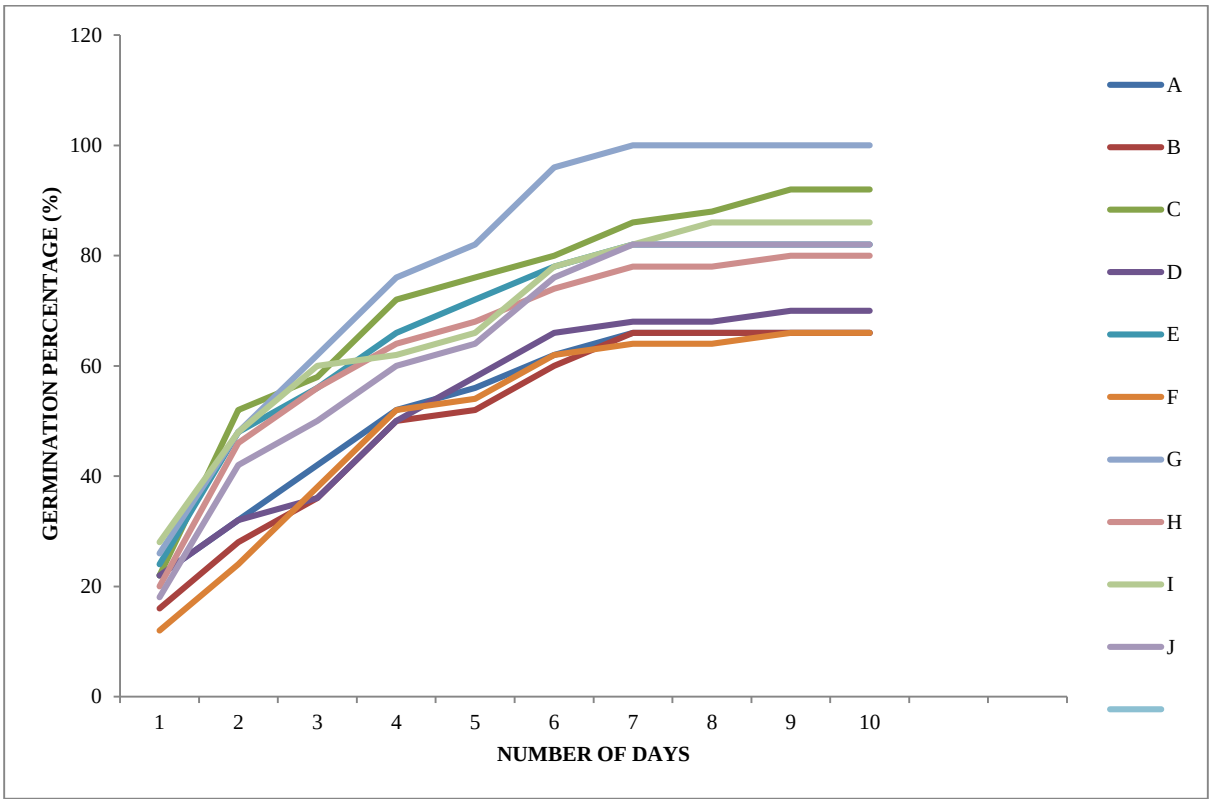

Fig. 1: Percentage germination of *Jatropha curcas* seeds by potting mixtures

Table 2: Mean variation between different treatment levels and parameters of *Jatropha curcas* L. (stem height, leaf count and leaf area)

Parameter assessed	Potting mixture treatment									
	Ma (1:4:1)	Mb (1:2:1)	Mc (2:2:1)	Md (2:3:1)	Me (4:4:1)	Mf (1:0:0)	Mg (0:1:0)	Mh (3:2:3)	Mi (4:1:4)	Mj (1:3:1)
Stem height (cm)	19.03	18.78	20.79	20.09	17.91	18.42	18.62	19.41	18.74	19.85
Leaf count	2.47	2.27	2.35	2.45	2.78	2.67	2.28	2.43	2.50	2.67
Leaf area (cm)	40.64	36.92	36.4	38.71	38.28	41.09	36.69	38.32	39.12	46.04

Table 2 shows that the mean stem height ranged from 17.91 cm in treatment Me (4:4:1), to 20.79 cm in treatment Mc (2:2:1). However, treatment M_c (2:2:1) with 20'79 cm had the highest mean of stem height. From Table 2 above, the mean stem height ranged from 17.91 cm in treatment Me (4:4:1), to 20.79 cm in treatment Mc (2:2:1). However, treatment C (2:2:1) had the highest mean of stem height (20'79 cm) of *Jatropha curcas L.* among the potting mixtures, while treatment Me (4:4:1) had the least stem height (17.91 cm). From Table 2, the mean leaf area ranged from 36.40 cm^2 in treatment Mc (2:2:1), to 46. 04 cm^2 in treatment M_j (1:3:1). As such, treatment M_j (1:3:1) had the highest mean leaf area of 46.04 cm^2 between the treatments, while treatment Mc (2:2:1) with a mean leaf area of 36.40 cm^2 had the least mean leaf area value (36.40 cm^2). Table 2 also indicates that the mean leaf count was in the range of 2.27 to 2.78 in treatment Me (4:4:1). Whereas, treatment Me (4:4:1) with a mean leaf count of 2.78 had the highest leaf number of *Jatropha curcas L.* seedlings among the treatments, while treatment Mb (1:2:1) had the least mean leaf count (2.27).

Table 3 shows that treatments Ma (19.03 ± 0.63^{ab}), M_b (18.78 ± 0.65^{ab}), M_f (18.42 ± 0.52^{ab}), Mg (18.62 ± 0.49^{ab}), M_i (18.74 ± 0.58^{ab}), M_d (20.79 ± 0.47^{bc}) and M_j (19.85 ± 0.66^{bc}) were not significantly different but in treatment M_c (20.79 ± 0.47^{c}), M_e (17.91 ± 0.43^{a}), M_h (19.41 ± 0.50^{abc}) and other treatments the results were significantly different. Whereas treatment Mc (20.79 ± 0.47^{c}) recorded the highest growth in stem height (20.79±0.47 cm), it recorded the minimum mean leaf count (17.91 ± 0.43^{a}). There were no significant differences among treatment M_a (2.47 ± 0.07^{ab}), M_d (2.45 ± 0.09^{ab}), M_h (2.43 ± 0.08^{ab}), M_i (2.50 ± 0.08^{ab}); M_b (2.27 ± 0.09^{a}), M_c (2.35 ± 0.08^{a}), Mg (2.28 ± 0.09^{a}); M_f (2.67 ± 0.07^{bc}) and M_j (2.67 ± 0.10^{bc}. However, treatment M_e (2.78 ± 0.07^{c}) performed better in leaf count growth performance. But in leaf area (cm^2), the highest values were observed in treatment M_j (46.04±1.71) and showed significant difference among treatment M_j (46.04±1.71) and others (40.64 ± 1.47^{a}, 36.92 ± 1.62^{a}, 36.40 ± 1.17^{a}, 38.71 ± 1.31^{a}, 38.28 ± 1.49^{a}, 41.09 ± 1.62^{a}, 36.69 ± 1.44^{a}, 38.33 ± 1.59^{a} and 39.12 ± 1.55^{a})

Table 3: Mean growth rate of *Jatropha curcas L.* seedlings in different potting mixtures at the Forestry Nursery of University of Agriculture, Makurdi

Treatments (potting mixture ratio)	Growth parameter assessed		
	Stem height (cm)	Leaf count	Leaf area (cm^2)
M_a (1:4:1)	$19.03\pm O.63^{ab}$	2.47 ± 0.09^{ab}	40.64 ± 1.47^{a}
M_b (1:2:1)	18.78 ± 0.65^{ab}	2.27 ± 0.09^{a}	36.92 ± 1.62^{a}
M_c (2:2:1)	20.79±0.47c	2.35 ± 0.08^{a}	36.40 ± 1.17^{a}
M_d (2:3:1)	20.08 ± 0.62^{bc}	2.45 ± 0.09^{ab}	38.71 ± 1.31^{a}
Me (4:4:1)	17.91 ± 0.43^{a}	2.78 ± 0.07^{c}	38.28 ± 1.49^{a}
M_f (1:0:0)	18.42 ± 0.52^{ab}	2.67 ± 0.07^{bc}	41.09 ± 1.62^{a}
M_g (0:1:0)	18.62 ± 0.49^{ab}	2.28 ± 0.09^{a}	36.69 ± 1.44^{a}
M_h (3:2:3)	19.41 ± 0.50^{abc}	2.43 ± 0.08^{ab}	38.33 ± 1.59^{a}
M_i (4:1:4)	18.74 ± 0.58^{ab}	2.50 ± 0.08^{ab}	39.12 ± 1.55^{a}
M_j (1:3:1)	19.85 ± 0.66^{bc}	2.67 ± 0.10^{bc}	46.04 ± 1.71^{b}
F- Statement	2.59	4.12	3.61
Probability	0.01	0.01	0.01

Values with the same superscript are not significantly different from each other.

Table 4: Correlation between Stem height, leaf area and leaf count in seedlings of *Jatropha curcas L.* at Forestry Nursery, UAM

Seedling parameter	Correlation coefficient		
	Stem height (cm)/week	Leaf area (cm^2)/week	Leaf count (No)
Stem height (cm)/week	1.00	-	
Leaf area (cm)/week	0.73	1.00	-
Leaf count (No)	0.28	0.26	1.00

Table 4 shows the correlation between stem height, leaf area and leaf count. The correlation coefficient between stem height and leaf area ((17.91 ± 0.43^{a}) was most highly significant ($p < 0.01$) compared to the correlation coefficient between stem height and leaf count (0.28) and between leaf count and leaf area (0.26).

Many other factors influence seedling establishment by direct seeding of *Jatropha curcas L.* such as depth of planting the seeds, age of seeds (post-harvest), quality of seed, soil moisture content, seed handling, storage, pest and disease infestation (Heller, 1996). However, it was revealed from this study that, for potted plants potting mixture preparation also plays an important role in controlling the germination and subsequent growth and development of plants. The seeds of *Jatropha curcas L.* germinated over a wide range of potting mixtures in the course of this study. The highest germination percentage (100%) occurred in treatment M_g (0:1:0) within 10 days, exhibiting a faster germination rate, while treatment M_b (1:2:1) and M_f (1:0:0) had the minimum percentage germination (66%) (Fig. 1). This study is in agreement with Charlie (2011), who investigated on seed germination and seedlings performance of *Jatropha curcas* L. Fruit based on colour within two different seasons in Northern Philippines and attained a maximum germination of 93.3% from dark yellow fruit. This research is also not at variance with the result of Samba *et al.* (2007) who worked on germination and propagation methods of *Jatropha curcas L.* and recorded maximum germination percentage of 86% within 15 days after sowing. On the other hand, this result disagree with the result of Mwang'Ingo *et al.* (2004) who investigated on the effectiveness of various seed pre-sowing treatments in enhancing germination and early seedling growth and attained the highest germination percentage of 66.5% in their study. This work is also in consonance with the results obtained by FACT Foundation (2006), which reported that with good moisture conditions the germination of *Jatropha curcas L.* seed takes 10 days.

Seedlings parameters (stem height, leaf area and leaf count) of *Jatropha curcas L.* at 6 weeks (Table 2) were statistically significant among all the treatments. Treatment Mc (2:2:1) with a mean height of 20.79 cm performed best with respect to stem height, but had poor performance of 36.40 cm^2 in leaf area. However, it was revealed from this study that, Soil preparation plays an important role in controlling the growth and development of plants and the effect of potting mixture on seed germination is quite complex because it affects each stage of germination process in a different way and is not

independent of other factors. Though, the seeds of *Jatropha curcas L.* germinate over a wide range of potting mixtures in the cause of this study. The highest germination rate were found in treatment Mg (0:1:0) of 100% within 10 days, which behaved better in terms of faster germination, while in treatment Mb (1:2:1) and Mf (1:0:0) had the minimum of 66%, respectively (Fig. 1). This study is in agreement with Charlie, (2011), who investigated on seed germination and seedlings performance of *Jatropha curcas L.* Fruit Based on Colour at Two Different Seasons in Northern Philippines and attained a maximum germination of 93.3% from dark yellow fruit. This research is also not at variance with the result of Samba *et al.* (2007) who worked on germination and propagation methods of *Jatropha curcas L.* and recorded maximum germination percentage of 86% within 15 days after sowing. On the other hand, this disagree with the result of Mwang'Ingo *et al.* (2004) who investigated on the effectiveness of various seed pre – sowing treatments in enhancing germination and early seedling growth and attained the highest germination percentage of 66.5% in their study. This work confirmed the result obtained by FACT Foundation (2006), with good moisture conditions the germination of *Jatropha curcas L.* seed takes 10 days.

Seedlings parameters (stem height, leaf area and leaf count) of *Jatropha curcas L.* at 6 weeks (Table 2) were statistically significant among all the treatments. Treatment Mc (2:2:1) with a mean height of 20.79 cm performed best with respect to stem height, but had poor performance by recording the lowest leaf area (36.40 $cm^{2)}$. Treatment M_e (4:4:1) with a mean leaf count of 2.78 showed the highest mean leaf count but poor performance in stem height (17.91 cm). Whereas, treatment M_j (1:3:1) performed better in mean stem height (19.85 cm) it had a mean leaf count of 2.67 and a mean leaf area of 46.04 cm^2. However, this good performance was not at variance with the result obtained by Ekele (2011) who worked on 'Comparative Effect of Some Selected Organic and Inorganic Fertilizers on Germination and Nursery Establishment of *Jatropha curcas L.* in the Guinea Savannah Zone of Nigeria', and obtained a maximum height of 20.90 cm within 6 weeks but observed a complete germination of seeds within 14 days.

From all indications, different treatments can have various effects on seed germination, stem height, leaf area and leaf count parameters in *Iatropha curcas L*. The amount of nutrients in the soil can also affect the seedlings growth in *Jatropha curcas L.* Similarly, correlation coefficients between stem height, leaf area and the number of leaves count were all positive. The correlation results were highly significant between stem height and leaf area (0.73) compared to other parameters (Table 4). This implies that leaf area can result in increased photosynthesis which can in turn boost increment in the above-ground height of *Jathropha curcas* seedlings. It was observed that the ratio of soil used the potting mixtures had differents effects on different stages of growth of *Jatropha curcas L.* seedlings.

Treatment M_e (4:4:1) with a mean leaf count of 2.78 exhibited the highest mean of leaf count in *Jatropha curcas L* but recorded low performance in stem height (17.91 cm). Whereas, treatment M_j (1:3:1) performed best in stem height (19.85cm), it had a mean leaf count of 2.67 and a mean leaf area of 46.04 cm^2. This good performance was not at variance with the result obtained by Ekele, (2011) who worked on 'Comparative Effect of Some Selected Organic and Inorganic Fertilizers on Germination and Nursery Establishment of *Jatropha curcas L.* in the Guinea Savannah Zone of Nigeria, and obtained a maximum height of 20.90cm within 6 weeks but reported complete germination within 14 days.

Different treatments can have various effects on seed germination, stem height, leaf area and the number of leaves parameters produced in *jatropha curcas*. The amount of nutrients in the soil could also affect the assessed parameters whenever growth is to be assessed in *Jatropha curcas* seedlings. Similarly, correlation between stem height, leaf area and the number of leaves counted were all positive. The correlation results were all positive and highly significant between stem height and leaf area (0.73) when compared to other parameters (Table 4). It was observed that the ratio of soil used during nursery practice had various effects on different stages of growth in *Jatropha curcas L.* seedlings.

Conclusion

Complete germination (100 per cent) of *Jathropha curcas* seeds was recorded within 10 days after sowing of *Jathropha curcas* seeds. There were significant differences observed in the germination and early growth of *Jathropha curcas* seedlings raised using the 10 potting mixture treatments (M_a to M_j). The observation of significant differences in germination percentage, stem height, leaf area and leaf count of *Jatropha* measured shows the interaction of potting mixture mix ratios used on germination and early growth of the plant. Based on these four (4) parameters (seed germination rate, stem height, leaf area and leaf count) assessed, it could be inferred that treatment Mg (0:1:0) with germination percentage of 100% and treatment Mj (1:3:1) with overall mean of; 19.85 cm (stem height), 2.67 (leaf count) and mean leaf area of 46.04 cm^2 gave the highest performance as potting mixtures for raising *Jatropha curcas L.* for extensive nursery establishment

Recommendations

1. Plantation establishment of *Jatropha curcas* is advocated to ensure a steady supply of its products and make up for the current supply current from the farms and wild.
2. Treatments M_g (0:1:0) and M_j (1:3:1) are recommended for use in nursery establishment of *Jatropha curcas.*
3. The use of various organic manure sources (poultry, plant and livestock) should be tested in raising *Jathropha curcas* seedlings in the nursery in order to cut costs and non-target effects inherent in use of inorganic fertilisers in the nursery.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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