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SEED SOURCE VARIATION AND POLYBAG SIZE ON EARLY GROWTH OF JATROPHA CURCAS

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ABSTRACT

The study was carried out to find the variation in *Jatropha curcas* seed sources and the effect of polybag size on the growth of the seedlings. The germination experiment was laid in Randomized Complete Block Design (RCBD) with 3 replications and the split plot design in RCBD with 3 replicates were used to lay the effect of polybag size and seed source on seedling growth. The results showed significant variation in seed weight from the various seed sources but no significant differences in seed length and seed width. The maximum seed germination was 98% and the lowest was 94%. Seedling growth of *Jatropha curcas* increased with increasing polybag size. Larger polybag size recorded the highest dry weight of seedling root (1.9 g), dry weight of seedling shoot (11.5 g), lateral root length (45.6 cm) and tap root length (22.3 cm). Based on the results obtained larger polybag size would be ideal for raising seedlings.

Keywords: seed source, *Jatropha curcas*, polybag size, growth, germination.

INTRODUCTION

Energy conservation issues in the face of escalating oil prices in the world are catapulting the search for alternative source of energy. This has become even more pressing in the wake of rising fuel and food prices in the world. As the world's oil reserves keep dwindling and more and more automobiles and other machineries are being manufactured and used, with its accompanying adverse climatic changes, it is rational to diversify energy sources. Environmental concerns including air pollution associated with fossil fuel, climate change, land degradation associated with deforestation and erosion are other factors precipitating the search for a renewable energy source. Other areas of alternative energy are the Wind, Solar, Geothermal, Ocean current and these are all being seriously researched into.

There has been a lot of promise of biofuel -liquid fuel like ethanol and biodiesel made from plants - to reduce dependency on fossil fuel. Powerful nations including the United States of America are also elated about the prospect of biofuels (Olmstead, 2006). In principle burning bio fuel add less carbon to the environment than burning fossil fuel because the carbon atom released already existed as part of the modern carbon cycle.

Advocates of biofuel argue that, the efficient use of biomass, will not lead to carbon dioxide concentration in the atmosphere since planted crops - the primary source of biomass will absorb any carbon dioxide produced. Bio fuel includes any solid, liquid, or gaseous fuel produced either directly from plant or indirectly from organic industrial, commercial, domestic or agricultural waste. Maize, soya beans, rapeseed, sorghum, arundo, as well as *Jatropha curcas* are some of the leading plants suitable for bio fuel (Kumarsukhadeo, 2006).

Jatropha curcas has been found to be a highly promising plant species which can yield oil seed as a source of energy in the form of biodiesel owing to it short gestation period (9-12 months), hardy nature which can be exploited to fight desertification, high quality oil that can equally be used both in the soap and in the candle industries.

It can be propagated by seed, stem cutting, grafting, budding, air layering or by clone techniques. Complete germination of seed is achieved within 9 days (Kumarsukhadeo, 2006).

Obviously the basis of any meaningful agricultural production or forest resource establishment is the seed and the nursery. It is known that phenotypic and genotypic as well as broad sense variability exists in every species. This offers a breeder or a researcher ample scope to undertake screening and selection of seed source for desired traits which can lead to the improvement of the species (Kumarsukhadeo, 2006). *Jatropha curcas* has a wide range of adaptability for climatic and edaphic factors and grows well even on marginal lands enduring drought, alkalinity of soil and thus, serves as best source to green up barren wastelands (Tewari, 1994). The wide geographical and climatic distribution is indicative of the fact that there exists a tremendous phenotypic and genetic diversity (Ginwal, 2004). Since *Jatropha curcas* is widely distributed in Ghana the species is expected to have considerable phenotypic and genetic variation. The presence of phenotypic and genetic diversity is crucial for improving any plant species. An understanding of magnitude and pattern of genetic diversity in plants has important implications in breeding programmes and for conservation of genetic resources (Ikbal, *et al*., 2010). Effective participation in the bio fuel industry is important but must be based on concrete research data one of which is the screening of our seed bank to determine possible competitive advantages that might be inherent in any seed source. Possibly *Jatropha curcas* can become one of the most important crops in our agro-forestry systems as it satisfy not only economic and environmental concerns but also soil improvement. The objective of this study is to have an understanding on the seed source phenotypic variations existing, which would serve a basis of selecting the best for subsequent cultivation in the field.

Objectives of the study

The objectives of the study were:

a) To determine the seed source variation of *Jatropha curcas*.
b) To determine possible poly bag sizes for optimum seedling growth and root development of *Jatropha curcas.*

MATERIALS AND METHODS

The investigation was carried out within the nursery of the Faculty of Forest Resources Technology, Kwame Nkrumah University of Science and Technology, Sunyani Campus. It was located at 7.35^{o}N and 2.34^{o}W, at an elevation of 360m.

Seeds were collected from seven localities across Ghana covering the major ecological zones (high forest, deciduous forest, transition zone and the savanna zone.) The specific localities were:

I. Agotime kpetoe, volta region (wooded savannah, south type) - (1)
II. Juaboso, Western Region (High forest) - (2)
III. Kumasi, Ashanti Region (Semi deciduous forest) - (3)
IV. Fiapre, Brong Ahafo Region (Transitional zone) - (4)
V. Tamale, northern region (wooded savannah, north type)-(5)
VI. Koforidua, Eastern Region (Deciduous forest) - (6)
VII. Wa, Upper Western Region (Dry savannah) - (7)

Seed germination

100 seeds from each location were randomly picked for the germination test at the nursery. The Randomized Complete Block Design was used to lay out the experiment. In each block 100 seeds from each location were randomly placed in the block. The experiment was replicated 3 times. Seeds were considered germinated when the radicle had emerged 1cm above soil. Seed germination was recorded and quantified as germination percent (Table-2).

Growth measurement of seedlings

The factors under examination were seed source and polythene bag (polybag) size. A Split plot design in Randomized Complete Block Design with three replications was used. The main plot treatments of poly bag size were Large (L): (16 cm×19.80 cm), Medium (M): (13 cm×17.80 cm), Small (S): (10.30×13 cm). The sub-plot treatments were the seed sources from Agotime Kpetoe (1), Juaboso (2), Kumasi (3), Fiapre (4), Tamale (5), Koforidua (6), Wa (7).

Seeds were collected from the various sources within two weeks, air dried and nursed in three different poly bag sizes filled with well mixed forest soil. One hundred and forty four (144) polybags were prepared in this way. Data on five (5) seedlings from each poly bag size group were taken each month. In each subplot 35 seedlings were laid. Seedling traits in the nursery were recorded for plant survival percentage at four (4) months. Seedling height in centimeters (cm), collar diameter in millimeters (mm), number of leaves per plant, above and below ground biomass in grams per seedlings was also measured.

Root biomass was determined by carefully washing the seedlings to retrieve majority of the root system. After taking all the necessary measurement on the fresh seedlings, the seedlings were dried in an oven at 65^{o}C for 72 hours for dry weight measurement.

Morphology

The variation in seed and seed characteristics were investigated as follows. From each seed lot, 50 seeds were drawn at random and measured for their maximum length, width and thickness in millimeters up to two decimal places using electronic vernier caliper. For the measurement of seed weight 5 replicates of 100 seeds each were used and expressed as weight of whole seeds (Table-1). The data gathered was analyzed using the GenStat package.

RESULTS

Seed characteristics

Weights of seeds did not differ significantly from the various sources except the lot from Kpetoe which differed significantly ($P < 0.05$) from the rest (Table-1). Kpetoe was significantly different from the other treatments (Table-1). No significant differences were for seed length and seed width (Table-1). Seed weight and seed length had a positive correlation coefficient (r) of 0.758 whilst seed length and seed width had a negative correlation of -0.722.

Table-1. Characteristics of *Jatropha curcas* seeds.

Locality	Number	**100 Seed weight** (g)	**Seed length** (mm)	**Seed width** (mm)
KPETOE	1	83.45 ± 1.15 a	19.71±0.82	10.44±1.14
JUABOSO	2	62.6±1.6 b	17.84±1.6	10.84±0.88
KUMASI	3	74.9±0.3 b	19.55±0.55	10.59±1.11
FIAPRE	4	67.3±0.5 b	17.5±0.5	11.25±0.36
TAMALE	5	72.9±1.3 b	18.35±0.83	10.91±0.6
KOFORIDUA	6	75.32±0.32 b	18.21±1.03	11.16±0.35
WA	7	68.55±0.95 b	18.85±0.55	11.24±0.5
P-value		9.4E-12	0.126	0.72
LSD (0.05)		12.88	2.24	0.99

± = Standard deviation; LSD = Least significant difference at α = 0.05. Values of same letters are not significant at P = 0.05.

Seed germination from seed source

All seed sources recorded a germination percent of more than 90. The highest percentage germination of 98% was recorded for Juaboso and Fiapre while Tamale recorded the lowest germination of 94% (Table-2). Germination started on the fourth day and ended on the ninth day. No germination occurred from the tenth day onwards. Differences in germination percentage did not vary significantly between the treatments.

Seedling survival was above 90% percent in all 7 seed sources. Tamale recorded 94% survival, whilst Juaboso and Fiapre recorded 98% survival (Table-3). The survival percentage recorded did not show any significant differences between the treatments.

Table-2. Variation in germination percentages of seed sources.

Locality	Number	Mean number planted	Mean number germinated	% Germination
KPETOE	1	100	96	96
JUABOSO	2	100	98	98
KUMASI	3	100	96	96
FIAPRE	4	100	98	98
TAMALE	5	100	94	94
KOFORIDUA	6	100	97	97
WA	7	100	96	96
P- value				0.27

Table-3. Variation in survival percentages of seed sources.

Locality	Number	Number germinated	Number surviving	Number dead	% Survival
KPETOE	1	96	92	4	96
JUABOSO	2	98	96	2	98
KUMASI	3	96	92	4	96
FIAPRE	4	98	94	4	96
TAMALE	5	94	91	3	97
KOFORIDUA	6	97	93	4	96
WA	7	96	92	4	96
C.V. (%)					1.22
P-Value					0.23

Interactive effect of seed source and polybag size on seedling growth

There were no significant interactions between seed sources and polybag size for plant height and diameter of seedlings (Table-4). Generally a positive correlation of 0.78 was attained between diameter and height of seedling.

Fresh weight of seedling roots differed significantly different between the treatments (Table-4). L6 and M4 had the highest fresh root weight. These did not differ significantly from L1, L7, L5, M6 and M2. The least fresh weight of roots was in S2 (Table-4). With respect to the root dry weight of seedling, No significant differences were realized between the treatments on root dry weight basis at $P \leq 0.05$ (Table-4).

Table-4. Effect of Polybag size and seed source on growth of seedlings.

Interaction of polybag size and seed source	Seedling height (cm)	Seedling diameter (mm)	Fresh weight of root (g)	Dry weight of root (g)
S1	23.75	12.27	5.52	1.04
S2	18.72	9.70	2.25	0.4
S3	17.83	9.94	2.62	0.46
S4	20.38	11.30	4.45	0.56
S5	21.35	11.42	3.45	0.61
S6	20.90	11.76	4.48	0.86
S7	24.15	13.28	6.03	1.35
M1	21.85	13.63	6.62	1.51
M2	21.05	14.13	8.45	1.86
M3	19.57	12.03	5.17	1.24
M4	31.12	16.39	14.11	2.63
M5	21.00	12.00	4.60	1.11
M6	24.52	13.99	10.03	2.12
M7	18.30	12.49	5.77	1.13
L1	28.47	15.71	13.00	1.97
L2	20.87	13.34	7.35	1.37
L3	20.85	13.92	7.60	1.40
L4	20.40	13.96	8.28	1.64
L5	27.35	14.44	10.22	1.78
L6	25.07	16.38	14.18	2.96
L7	23.52	13.85	11.91	2.24
SE	2.01	0.80	1.77	0.44
LSD (0.05)	5.56	2.28	5.02	1.26

Effect of seed source on fresh and dry weights of root and shoot

The analysis of variance showed that no significant differences existed between the seed sources with respect to dry weight of roots at $P \leq 0.05$ (Table-5). Fresh weight however, was significantly different. Effect of seed source was realized at dry stem weight of seedlings. Seeds from Wa produced the highest dry shoot weight (12.35g) but did not differ significantly from Kpetoe, Fiapre, Tamale and Koforidua seeds (Table-5).

Effect of poly bag size on fresh and dry weight of roots and shoot of seedling growth

The results showed significant different between poly bag size on fresh weight and dry weight of roots and stem (Table-6). Dry weight of roots and shoot was increased with increasing poly bag size (Table-6). The highest dry weight of 1.91g and 11.48 g was attained by seedling from large poly bag size for root dry weight and shoot dry weight, respectively (Table-6).

Table-5. Effect of seed source on fresh and dry weight of roots and shoots of seedling growth.

Seed source	**Fresh weight of root** (g)	**Dry weight of root** (g)	**Fresh weight of seedling stem** (g)	**Dry weight of seedling stem** (g)
Kpetoe	8.38	1.50	49.29	11.03
Juaboso	6.01	1.21	32.92	8.04
Kumasi	5.13	1.61	29.14	7.30
Fiapre	8.95	1.61	49.23	11.69
Tamale	6.09	1.72	40.39	8.97
Koforidua	9.57	1.98	54.27	11.17
Wa	7.90	1.57	47.65	12.35
SE	1.02	0.25	1.02	1.27
LSD (0.05)	2.90	0.72	2.90	3.61

Table-6. Effect of polybag size on fresh and dry weight of root and stem.

Poly bag size	**Fresh weight of root** (g)	**Dry weight of root** (g)	**Fresh weight of seedling stem** (g)	**Dry weight of seedling stem** (g)
Small	4.11	0.76	30.75	8.37
Medium	7.82	1.66	44.11	10.39
Large	10.36	1.91	54.95	11.48
SE	0.67	0.16	3.39	0.83
LSD (0.05)	1.90	0.47	9.58	2.36

Effect of polybag size on root architecture of *Jatropha curcas*

It was also observed that poly bag size had a significant influence on root length developed by seedlings, root length of seedlings decreased drastically with reducing poly bag size. Seed source and poly bag size interaction did not have any significant effect on lateral roots and tap roots of seedlings. Seed sources alone also did not differ significantly at $P \leq 0.05$ with respect to lateral and tap root of seedlings. Lateral root was longest in the large sized polybags but they differed significantly from the roots of the small sized poly bag only. Tap root length followed the same trend as lateral root length. (Table-7).

Table-7. Effect of polybag size on lateral root and tap root length.

Poly bag size	**Mean lateral root length** (cm)	**Mean tap root length** (cm)
Small	27.88	14.94
Medium	41.28	18.69
Large	45.62	22.31
SE	2.61	1.24
LSD (0.05)	7.38	3.51

DISCUSSIONS

Effect of seed source on seed characteristics

Results from the study did not show significant effects of seed sources on seed characteristics although seeds from Kpetoe appeared to perform significantly better than seeds from the other sources. The significantly higher 100 seed weight recorded by this treatment may have been due to the fact that it was the last to be acquired within the two week period and probably had higher moisture content than the rest. Variation in *Jatropha curcas* seed sources with respect to their morphological traits could be due to the fact that the species grow over a wide range of climatic condition ranging from tropical rain forest to the savanna. The amount of rainfall and its distribution in these areas also vary widely in the country. Populations in these areas may therefore experience remarkable differences in selective pressure. Since the seeds were collected from different areas, differences observed in the parameters studied could be genetic in nature or modified as a result of exposure and consequent adaptation to the different environmental conditions prevailing in their areas of collection. Vakshaya *et al*., (1992) stated that differences observed in phenotypic values are genetic in nature because randomization, replication and uniform environmental conditions must have dealt with any outside effects that might influence the evaluation. Seed length and seed width did not vary significantly between the seed sources. Even though Kpetoe had the highest 100 seed weight; its seed length and width were not significantly different from the other treatments. Seed weight was observed to have a positive correlation with seed length. This accounted for the highest value in seed length for Kpetoe. A negative correlation was however obtained between seed length and seed width. Turnbull and Griffin (1986) have reported that different varieties and provenances often perform differently when tested together under one site. The influence of this assertion cannot be ruled out.

Effect of seed source on germination and survival of *Jatropha curcas*

From the foregoing, the present investigation does not indicate considerable variability in *Jatropha curcas* with respect to germination and seedling survival. Genetic variation is manifested through provenance test designed to assess the degree and pattern of variation across species. Seed source variation in germination percentage and related traits may be ascribed to the significant differences observed in seed dimensions and weight (Rawat *et al*., 2006). Dunlap and Barnett (1983) observed that germination values varied considerably among seed sources and exhibited a random pattern, in which an index of combining speed and completeness of germination is a function of seed size and weight. It was expected that since a significant effect was obtained for seed weight this would be manifested in significant effect on germination. In this study seed sources did not significantly influence germination. The differences observed in seed weight in Kpetoe could be explained by the time it was acquired. Survival of seedlings is an important factor to consider immediately after planting. At this time, the seedlings are highly susceptible to rapid changes in relative humidity, temperatures and light levels (Biber and Caldwell, 2008). Since no significant difference was observed in the survival of the *Jatropha curcas* seedlings, it is presumed that there is not much variation between seed sources provided extreme conditions do not exist in the area.

Interactive effect of seed source and polythene (polybag) **size on growth of seedlings**

The different sizes of poly bag also showed significant effect on growth, dry weight of root and shoot. These findings are similar to that of Annapurna *et al*., (2004) in which he reported that larger containers produced better growth of *Santalium album* seedlings. A similar relationship has been reported between container volume and seedling height and biomass in *Pinus contorta* (Endean and Carlson, 1975), and in *Grevillea robusta* (Misra and Jaiswal, 1993). Increased seedling growth of 72 - 360% was observed in *Picea glauca, P. banksiana* when container volume was tripled. The primary function of any container is to hold a discrete supply of growing medium, which in turn supplies water, air, mineral nutrients and physical support. The highest growth in the larger polybags may be due to the content of higher volume of rooting media. The causes of the differences in growth may be the difference of water holding capacity and differences of nutrient status in the media. Similar results were obtained on lateral root and tap root of *Jatropha curcas*. Smaller polybag size had decreased lateral root and tap root. This may have profound effect on the survival of transplanted seedlings later under field condition.

CONCLUSIONS

The study observed variation in *Jatropha curcas* with respect to seed weight. Seed germination, survival, seed length and width were not significantly different from the various seed sources. Since most of the parameters measured did not show any variation between the seed source, it can be suggested that the differences observed in seed of Kpetoe could be due to moisture in the seeds since it was the last seed source to be harvested or acquired. It can be concluded that there is no wide phenotypic variation in *Jatropha curcas* from the various seed sources. Larger polybags recorded the best performance in growth and should be considered in raising seedlings at the nursery. Root architecture was highly influenced by the polybag size. With the larger polybag size outperforming the others. Seedlings raised in large polybags are more likely to survive on the field than small polybags.

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