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Influence of Seed Storage Duration on Chemical Composition, Germination and Early Seedling Growth of *Jatropha curcas* in the Northern Guinea Savanna Agro-Ecological Zone

EMEGHARA, U.U., ADELANI, D.O., SODIMU, A.I and SIRAJO, A
Federal College of Forestry Mechanisation, P. M. B 2273, Afaka –Kaduna.
E-mail; amakaopec @ yahoo.com., adelani.olusegun@yahoo.com

Abstract

Physic nut, *Jatropha curcas* seeds is a source of biodiesel. The field experiment was conducted for 5years during cropping seasons at the experimental farm of Federal College of Forestry Mechanization, Afaka, Kaduna. Investigation was conducted to determine the influence of storage durations of *J. curcas* seeds on chemical composition, germination and early seedling growth. *J. curcas*seeds harvested in 2009, 2010, 2011 and 2012 stored under room temperature (27 ± 5°C) in polythene bags and 2013 Freshly Harvested Seeds (FHS) were collected. The experiment was laid out in a complete randomized design with five replicates to assess the effect five seed storage durations (4, 3, 2, 1 and 0 years) on the germination, oil content and seedling growth of *J. curcas.* Highest values of moisture (2.53%)., ash(4.71%)., fat (47.11%)., protein (23.98%) and carbohydrate (32.68%) were recorded in 2013 FHS. The least value of 26.70% was recorded for fiber. A decrease in chemical composition of seeds was recorded with increasing years of seed storage but reverse was the case in fiber content. The percentage germination of 45%, 60%, 75% and 80% were recorded for seeds in year 2009, 2010, 2011, 2012 and 2013 (FHS) respectively. Highest germination percentage of 80% was recorded in 2013 (FHS). Highest height (34.90cm)., girth (2.065cm)., number of leaves (17.44) and primary branches (7.74) were recorded at 8 weeks for seedlings of seeds stored for 0 year (FHS). A significant decrease in germination and seedling growth were recorded with increasing years of seed storage. Seed age affected chemical composition, germination andseedling growth of *J. curcas*.

Key words: Bio diesel, Freshly Harvested Seeds, Chemical composition, Viability

Introduction

Jatropha curcas (Euphorbiaceae) commonly called physic nut is a deciduous, multipurpose shrub or small tree distributed naturally in Mexico (Achten *et al.,* 2010a) and elsewhere in Central America (Duong *et al.,* 2013). It is a drought avoidant perennial small tree of tropical America, and was then largely spread out in India, Africa and South East Asia (Achten *et al.,* 2010a). Nowadays, *J. curcas* grows in tropical and subtropical regions in a wide range of climatic conditions from semi-arid to humid (Achten *et al.,* 2010a). *J. curcas* produces large quantities of oil-seed within 2–3 years after planting. Seed yields vary considerably from 1.7–2.2 t ha^{-1} on poor barren soils to 3.9–7.5 t ha^{-1} on normal fertile soils (Kant and Wu, 2011). Anonymous (2006) reported that seed yield of *J. curcas* ranges from 2 tons/ha under dry conditions to over 12.5 tons/ha/year under irrigated conditions.

The World Annual biodiesel production of *J. curcas* seeds is about 3.5 billion litres (William, 2006). It is one of the prospective bio diesel yielding crops (Martínez-Herrera *et al.*, 2006, Kumar *et al.,* 2007). The fatty acid methyl ester of its seed oil is suitable for use as biodiesel, which meets the specification of international biodiesel standards (Azam*et al.*, 2005). Bio-diesel is an eco-friendly-alternative fuel derived from vegetable oil (edible and non-edible) and animal fat which is renewable (Singh *et. al.,* 2007). Interest in biodiesel as an alternative fuel for diesel engines has increased in recent years due to environmental concerns on emissions from petroleum based fuels (Akowuah *et al.,* 2012). The emission of the greenhouse gases such as CO_2 can be reduced when 'green' biomass – derived transportation fuels such as biodiesel is used. Biodiesel has therefore attracted extensive attention as a renewable, biodegradable and non-toxic fuel since the past decade

(Stavarache *et al.,* 2007; Sarin *et al.,* 2007; and Tiwari *et al.,* 2007).

A lot of research has exploited the viability of using various edible oils such as sunflower seed oil, soyabean oil, palm oil and palm kernel oil as feedstock for biodiesel. Veljkovic´ *et al.* (2006) reported that *J. curcas* is the best feedstock for biodiesel production due to its numerous advantages. Abidin *et al.* (2009) reported that apart from non-competition with food as feedstock, biodiesel from *J. curcas* oil provides a commercially viable alternative to diesel as it has comparable desired physico-chemical and performance characteristics. The co-products from *Jatropha* oil extraction are suitable for cellulosic ethanol production, meeting the alcohol demands of the biodiesel transesterification process (Visser *et al.,* 2011).The seeds when pounded can be used for tanning; the oil is used for making soap, lubricant and raw material for paint production. The oil is used as substitute for kerosene and contains toxic substance called curcin which has been proven to have germicidal, antifungal and pesticides properties (Gour, 2004; Egharevba and Kunle, 2013).

J. curcas seeds contain about 25 to 35% or more of oil (Freitas *et al.,* 2011; Verma and Verma, 2014), which can be extracted and used as lighting and cooking fuel. Its seed oil is used in manufacture of soap, medicine or bio-pesticide and, after further chemical treatments, to produce biodiesel, a renewable energy source alternative to conventional petro diesel (Martínez-Herrera *et al.,* 2006; Pompelli *et al.,* 2010; Contran *et al.,* 2013; Sunil *et al.,* 2013; Sushma, 2014). *J. curcas* crop has the potential adaptability to grow on low-nutrient soils, under arid and semi-arid conditions and as well avoidcompetition against food crops. Furthermore, the plant itself offers the ecological advantage to mitigate soil degradation and to restore marginal land or abandoned farmland (Reubens *et al.,* 2011). *J. curcas* is a valuable multi-purpose crop that can be used to alleviate soil degradation, desertification and deforestation.The cake is bio-degradable when used as organic manure.

In spite of enormous potentials of *J. curcas,* its domestication as well as oil production has been limited by storage. According to Nkang and Umoh (1997), different longevity of seed storage as well as storage conditions exert significant influence on seed germination. The chemical composition of oilseeds causes specific processes to occur during storage. The seed that is rich in lipids has limited longevity due to its specific chemical composition. For example, sunflower seed storage demands special attention due to high oil content, otherwise processes may occur that lead to loss of germinationability and seed viability (Balešević-Tubić *et al.*, 2007a). The ageing seed is characterized by the loss of germination, reduced germination rate and poor seedling development (Tatić*et al.,* 2008). Total oil content and seed germination have been observed to decline during storage of oil seed species. Akowuah *et al.*(2012) reported a significant effect of storage time on seed oil content of *J. Curcas* seeds.

Little work has been reported on the storage time of *J. curcas* seeds which has a significant and direct effect on the yield and quality of seed oil extracted for biodiesel production (Akowuah *et al.,* 2012). There is not enough scientific information documented on optimization of seed germination and seedling growth of *J. curcas* (Abdelgadir *et al.,* 2012).In view of the above problem, it becomes imperative to investigate the effect of seed age on oil content, viability and early growth of *J. curcas* seedlings. The study will help the farmer to know extent to store their seeds for oil production, seed germination and seedling growth.

Materials and Method

The experiment was carried out at Federal College of Forestry Mechanization experimental site, Afaka Kaduna. The college, which is located within the Northern Guinea Savanna ecological zone, is situated at about

30km along Kaduna-Lagos road in Chikun Local Government Area of Kaduna State, Nigeria. The college lies between latitude 10^o 35′ and 10^o 34′Nand longitude 7^o 21′and 7^o 20′E (Adelani, 2015). The mean annual rainfall is approximately 1000 mm, with the lowest mean monthly relative humidity of about 29%. The vegetation is open woodland with tall broad leave trees (Otegbeye *et al.,*2001).The experiment was laid out in a completely randomized design with five replicates. Representative samples of the five storage durations (1, 2, 3, 4 years and freshly harvested seeds) were analyzed for their chemical composition. Seeds used for this study were sourced from experimental farm of the Institute of Agricultural Research (IAR) Samaru, Zaria and stored under conventional condition.

Topsoil, river sand and well cured farmyard manure were mixed in the ratio of 3: 2:1 by volume filled in polythene bags and were irrigated before direct sowing of seeds at two seeds per polythene bag at a planting depth of 3cm according to recommendation by Singh *et al*. (2007).

The study was conducted twice to enhance accuracy and their mean values were used for analysis. Observations on the crop growth parameters; percent germination, plant height, numbers of leaves, primary branches and plant girthwere made fortnightly from five tagged plants per plot. Mean values of these five plants were considered for analysis. Representative samples of the five seed ages (1, 2, 3, 4 years and freshly harvested seeds) were further analyzed for physico-chemical properties (proximate analysis) at Project Development Research Programmed, Institute of Agricultural Research, Ahmadu Bello University, Zaria. The data collected were subjected to analysis of variance as described by Snedecor and Cochran (1967). The treatment means were compared using Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

Influence of storage duration on chemical properties of Jatropha curcas seeds

The percentage range values of 1-2.53%., 3.44-4.71%., 42.10-47.11%., 20.00-23.98%., 30.95-26.70% and 30.13-32.68% were recorded for moisture, ash, fat, protein, fiber and carbohydrate of seeds harvested in year 2009, 2010, 2011, 2012 and 2013 (FHS) respectively. Highest values of moisture (2.53%)., ash (4.71%)., fat (47.11%)., protein (23.98%) and carbohydrate (32.68%) were recorded in year 2013 FHS. The least value of 26.70% was recorded in fiber. Proximate analysis of physic nut seeds revealed that percent moisture content, fat, protein, ash and carbohydrate decreased with increasing storage duration but the reverse was the case in fiber (Table 1). It can be deduced that reduction in bio chemical composition of *J. curcas* seeds was as a result of nutrient loss to ageing. This is consonance with the reports of Sandoval *et al*. (2002) and Shah *et al.* (2002). Similar results have been reported by Ghasemnezhad and Honermeier (2007), Sisman (2005) and Sisman and Delibas (2004).

Suriyong (2007) also reported that the ageing process naturally affects the quality of seeds during storage at various conditions, particularly the oil content which is sensitive to deterioration as a result of the oxidation processes – a reaction between unsaturated fatty acids and oxygen. The rate of oxidation of *J.curcas* seeds increased with increase in oxygen concentration and the duration of exposure (the length of storage time). The oxidation of oil requires the presence of atmospheric oxygen (Akowuah *et al.,* 2012). The longer the storage time, the higher the oxygen availability and vice versa. This could be reason the percentage of oil of stored *J. curcas* seed reduced during storage. Similar observations have been made by Kartika (2010) and Canakci (2007). The development of rancidity due to oxygen dependent deterioration of lipids in *J.curcas* seeds caused oil deterioration and reduction during storage. Similar reports have been made by

Ahmadkhan and Shahidi (2000) and Morello *et al*. (2004). The reduction in oil content of *J.curcas* seeds was adduced to metabolism of seeds during storage, which provide energy for physiological activities. This is in agreement with the reports of Ghasemnezhad and Honermeier (2009).

Table 1: Chemical properties of *J. curcas* seeds as influenced by storage durations

S/N	Sample	% moisture	%Ash	%Fat	%Protein	%Fiber	%CHO
1	2009(4yrs)	1.00	3.44	42.10	20.00	30.95	30.13
2	2010(3yrs)	1.04	3.50	42.33	20.01	30.55	30.88
3	2011(2yrs)	1.15	3.63	42.87	20.22	29.98	31.82
4	2012(1yr)	1.68	3.70	42.99	21.01	28.33	32.49
5	2013 (freshly harvested)	2.53	4.71	47.11	23.98	26.70	32.68

Influence of storage duration on seed germination and early growth of Jatropha curcas

The percentage germination of 45%, 60%, 75% and 80% were recorded for seeds collected in year 2009, 2010, 2011, 2012 and 2013 (FHS). Highest germination percentage of 80% was recorded in 2013 (FHS). Germination of *J. curcas* seeds decreased with increasing storage duration (Table 2). Some authors reported loss of seed viability and germinability after medium and long term storage (Duong *et al.,* 2013; Moncaleano-Escandon *et al.,* 2013).Decrease in germination percentage with increasing storage duration, could be traced to loss of viability in seeds as result of seed deterioration due to ageing. Similar observations have been made by Rao *et al.* (2006) and Scalon *et al.* (2012) who stated that storage duration significantly influenced viability of the seeds, with great loss of their reserve as age increased. Prolongation of ageing led to deterioration of both germinability and seed viability (Kapoor *et al.,* 2011).

The delay in the viability of aged *J. curcas* seeds could be attributed to the loss of seed vigor due to ultra-cellular changes as storage period and temperature increased. These conditions significantly affected seed germination (Bilia *et al*., 1994; Rice and Dyer, 2001). The lower germination of aged *J. curcas* seeds was due to the natural aging process which occurred as a result of continued respiratory activity of the seeds in storage that led to loss of organic solute. This result is in conformity with that of Booth and Sowa (2001) and Srivastava (2002). A significant reduction in germination percentage of *J. curcas* seeds with increasing periods of storage could be traced to continued exposure of stored seeds to oxygen during respiration. Height and girth recorded for seedlings from seeds stored for storage periods ranged between 0-34.90cm and 0-2.065cm, respectively. Highest height (34.90cm) and girth (2.065cm) were recorded at 8weeks for seedlings of seeds stored for0 years (FHS). Early seedling growth reduced with increasing seed storage duration (Table 3).

Influence of storage duration of *J. curcas* seeds on numbers of leaves and primary branches at 2, 4, 6 and 8 weeks after planting (WAP) are shown in Table 4. Number of leaves and primary branches recorded for seedlings of seeds stored for storage periods ranged between 0-17.44 and 0-7.74, respectively. Highest number of leaves (17.44) and primary branches (7.74) were recorded at 8 weeks for seedlings of seeds stored for 0 years (FHS). Result revealed significant decrease in numbers of leaves and primary branches with increasing seed storage duration.

Table 2: Percent germination as influenced by storage duration of *J.curcas* seeds

Years of seed collection	Duration of seed storage (yrs)	Germination (5-10days) after planting	% germination
2009	4	-	-
2010	3	9	45
2011	2	12	60
2012	1	15	75
2013	0(FHS)	16	80

Table 3: Influence of storage durations of *J. curcas* seeds on plant height during 2013 cropping seasons at Afaka-Kaduna.

Duration of Seed storage (years)	Plant height (cm)				Stem girth (cm)			
	2WAP	4WAP	6WAP	8WAP	2WAP	4WAP	6WAP	8WAP
4	0.00^{d}	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{d}
3	14.87^{c}	27.48^{b}	29.85^{c}	30.77^{c}	0.889^{d}	1.555^{c}	1.697^{d}	1.776^{c}
2	23.42^{b}	27.58^{b}	30.59^{b}	32.93^{b}	0.976^{c}	1.582^{b}	1.725^{c}	1.832^{c}
1	26.47^{a}	31.13^{a}	33.57^{a}	34.89^{a}	1.119^{b}	1.788^{a}	1.886^{b}	1.965^{b}
0	26.50^{a}	31.40^{a}	33.65^{a}	34.94^{a}	1.158^{a}	1.796^{a}	1.963^{a}	2.065^{a}
SE ±	0.034	0.078	0.043	0.109	0.074	0.033	0.014	0.12

1. WAP: Weeks after planting.
2. Means in the same column of treatments followed by different letters are significantly different at 5% of probability using Duncan's Multiple Range Test (DMRT).

Table 4*:* Influence of storage duration of *J.curcas* seeds on numbers of leaves of germinated seedlings

Duration of Seed storage (years)	Number of leaves				Primary branches			
	2WAP	4WAP	6WAP	8WAP	2WAP	4WAP	6WAP	8WAP
4	0.00^{d}	0.00^{d}	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{e}
3	3.88^{c}	11.17^{c}	12.90^{d}	13.90^{d}	2.87^{d}	3.63^{d}	4.13^{d}	5.40^{d}
2	9.32^{b}	13.20^{b}	13.26^{c}	14.22^{c}	3.74^{c}	5.73^{c}	5.81^{c}	6.36^{c}
1	11.33^{a}	15.25^{b}	16.15^{b}	16.90^{b}	5.59^{b}	5.78^{b}	6.51^{b}	7.20^{b}
0	11.54^{a}	15.60^{a}	16.90^{a}	17.44^{a}	5.73^{a}	7.74^{a}	7.75^{a}	7.74^{a}
SE±	0.104	0.065	0.012	0.022	0.078	0.076	0.024	0.085

1. WAP: Weeks after planting.
2. Means in the same column of treatments followed by unlike letter are significantly different at 5% of probability using Duncan's Multiple Range

Conclusion

Investigation on the effect of seed storage on the chemical composition, germination and seedling growth of *J. curcas* revealed that highest values of moisture (2.53%), ash(4.71%), fat (47.11%), protein (23.98%) and carbohydrate (32.68%) were recorded in 2013 (FHS). The least value of 26.70% was recorded for fiber. A decrease in chemical composition of seeds was recorded with increasing years of seed storage but reverse was the trend in fiber content. Highest height (34.90 cm); girth (2.065 cm); number of leaves (17.44) and primary branches (7.74) were recorded at 8 weeks for seedlings of seeds stored for0 years (FHS). A significant decrease in germination and seedling growth were recorded with increasing years of seed storage. Seed age affected chemical composition, germination, growth of *J. curcas.*

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