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Correlation Analysis of Oil Content and its Components in *Jatropha curcas* L. Collected from Five Agro-Ecologies in Nigeria

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ABSTRACT

In recent years *Jatropha curcas* L. has received considerable attention from researchers as a potential source of non-edible vegetable oil which is suitable for the production of liquid biofuel. Knowledge of the association between yield and its component traits and among the component parameters themselves can improve the efficiency of selection in plant breeding. In view of this, this study was carried out to determine the association between the oil content and important oil attributing characters from five agro-ecological zones in Nigeria, selection for which would help in the development of high oil-yielding *Jatropha* genotypes. Samples of *J. curcas* were collected from the five Nigerian agro-ecologies (Asa from Iwo, Ibadan; Ex-Kwagiri from Kaduna; Egbe from Ekiti; Ex-Dala from Kano and Ex-Mbat Daya from Bauchi) and the physical and chemical characteristics, oil and nutrient contents were determined. A negative association existed between oil content and seed weight, kernel weight, length of seed and phosphorus content, while a strong positive association existed between seed weight, seed length and kernel weight, and specific gravity. Selection of a seed for oil content could be based on lower seed weight, lower kernel weight and shorter seed length.

Keywords: association, biofuel, selection, vegetable oil

INTRODUCTION

Jatropha curcas Linn. (physic nut) is a tree-borne oil seed crop. It is native to Tropical America and belongs to the Euphorbiaceae family (Das *et al.* 2010). It can grow well in all kinds of soils, tolerate drought conditions and animals do not browse its leaves (Henning 2002; Patil 2004). It is a versatile plant with multiple uses that has gained more popularity due to its biofuel property (Das *et al.* 2010). Jatropha has evoked interest all over the world in comparison to other tree-borne oil seed crops because of its better adaptation to a wide range of environmental conditions, low cost of seeds, high oil content, small gestation period and smaller plant size that makes seed collection easier (Sujatha 2006). Jatropha as an oil-bearing tree has attracted the attention of several workers for the use of its seed oil as a commercially viable alternative source of fuel (Mandpe *et al*. 2005; Shanker and Dhyani 2006; Achten *et al*. 2009; Gunaseelan 2009). However, the productivity of existing jatropha is comparatively low and not of much economic benefit to farmers (Islam *et al*. 2011b). The wide gap in potential and actual yield is due to the use of locally available 'wild' material (Islam *et al*. 2011b). Superior quality planting material having high oil content and yield are being identified for further multiplication and production of quality planting material from existing germplasm (Islam *et al*. 2009; Islam *et al*. 2011a).

On the backdrop of increased prices of petroleum products coupled with depletion of fossil fuel reserves and compelling environmental reasons to reduce greenhouse gas emission, there has been a world-wide interest for searching alternate sources of raw-material for fuels (Mohapatra and Panda 2010). In recent years, *J. curcas* has received considerable attention from researchers as a potential source of non-edible vegetable oil which is eminently suitable for the production of liquid biofuel, meeting international standards (Azam *et al.* 2005; Tiwari *et al.* 2007). Augustus *et al.* (2002) have reported that *J. curcas* seeds contain around 20-40% oil. Its oil fraction consists of both saturated (14.1% palmitic acid and 6.7% stearic acid) and unsaturated fatty acids (47% oleic acid and 31.6 of linoleic acid) (Nzioku *et al.* 2009). Martínez-Herrera *et al*. (2006) reported that the major fatty acids found in the oil samples were oleic (41.5-48.8%), linoleic (34.6-44.4%), palmitic (10.5-13.0%), and stearic (2.3-2.8%) acids.

Plant breeders are interested in developing cultivars with improved yield and other desirable agronomic and phenological characters (Bello *et al.* 2009). In order to achieve this goal, they have the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations (Puri *et al*. 1982). Knowledge of the association between yield and its component traits and among the component parameters themselves can improve the efficiency of selection in plant breeding (Bello *et al.* 2009). Correlation coefficient measures the mutual association between a pair of variables independent of other variables to be considered. Where more than two variables are involved, the correlation coefficient alone does not give a complete picture of the interrelationship (Fakorede and Opeke 1985). The result of the correlation is of great value in the evaluation of the most effective procedures for selection of superior genotypes (Bello *et al.* 2009).

The objective of the present investigation was to study the association among characters and to identify important oil-attributing characters, selection for which would help in the development of high oil-yielding *Jatropha* genotypes.

MATERIALS AND METHODS

Seed samples of *J. curcas* were collected randomly from five locations around Nigeria and labeled as follows: Asa from Iwo near Ibadan, Ex-Kwagiri from Kaduna, Egbe from Ekiti, Ex- Dala from Kano, Ex-Mbat Daya from Bauchi. The seeds were dried to constant weight and the seed kernels were extracted from each of the

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Short Communication

Table 1 Correlation coefficients of oil content, nutrient, physical and chemical properties of *Jatropha curcas*.

	Oil	WS	SS	SL	SK	N	P	K	CAL	FP	PP	CR	SG	OS
Oil	1.00													
WS	-0.76**	1.00												
SS	0.00	0.57**	1.00											
SL	-0.79**	0.91**	0.46	1.00										
SK	-0.90**	0.96**	0.36	0.92**	1.00									
N	0.27	-0.20	-0.00	-0.53*	-0.22	1.00								
P	0.90**	-0.56*	0.31	-0.59*	-0.74**	0.14	1.00							
K	-0.01	-0.19	-0.32	-0.49	-0.11	0.87**	-0.13	1.00						
CAL	-0.31	0.32	-0.02	0.48	0.36	-0.37	-0.47	-0.47	1.00					
FP	0.09	-0.02	-0.05	0.12	-0.01	-0.07	-0.17	-0.33	0.85**	1.00				
PP	0.09	-0.07	-0.05	-0.03	-0.09	0.05	-0.13	-0.10	0.15	0.27	1.00			
CR	0.37	-0.30	-0.12	-0.50	-0.33	0.67	0.15	0.52*	-0.10	0.09	0.18	1.00		
SG	-0.40	0.74**	0.58**	0.63**	0.67**	0.05	-0.30	-0.14	0.59*	0.45	-0.22	-0.11	1.00	
OS	0.16	0.32	0.71**	0.32	0.15	-0.24	0.40	-0.52*	0.31	0.25	-0.46	-0.22	0.65**	1.00

*,** Indicates significance at 5 % and 1% level respectively according to Pearson correlation test. Oil = Oil content, WS = Weight of whole seed, SS = Weight of seed shell, SL = seed length, SK = Weight of seed kernel, N = Nitrogen, P = Phosphorus, K = Potassium, CAL = Calorific value, FP = Fire point, PP = Pour point, CR = Carbon residue, SG = Specific gravity, OS = Oxidative stability.

seed samples. 100 g of seed kernel was crushed using a mechanical grinder (Martínez-Herrera *et al.* 2006). The oil was extracted in a Soxhlet apparatus using petroleum ether as the extractant, 50 g of ground seeds were placed into a cellulose paper cone and extracted using light petroleum ether (40-60°C) in a 5-L Soxhlet extractor for 8 h (Peña *et al.* 1992). The oil was then recovered by evaporating off the solvent using rotary evaporator Model N-1 (Eyela, Tokyo Rikakikal Co., Ltd., Japan) and residual solvent was removed by drying in an oven at 60°C for 1 h and flushing with 99.9% nitrogen. Some chemical characteristics of the oil which qualify it as a fuel were analyzed. These include the specific gravity, pour point, firing point (Umer *et al.* 2010) and percentage of carbon residue (Heanes 1984). Specific gravity was determined by heating 10 ml of distilled water at 25°C. The distilled water was weighed. Simultaneously, 10 ml of *J. curcas* oil was heated at 25°C then weighed. Specific gravity is the weight of 10 ml of *J. curcas* oil at 25°C divided by the weight of 10 ml of distilled water at 25°C.

The percentage of carbon residue was determined by weighing 1.0 g of oil into a 250-ml conical flask to which 10 ml of potassium dichromate and 20 ml of concentration H_2SO_4 were added. An exothermic reaction occurs instantly which makes the flask very hot. The exothermic mixture was allowed to cool for 1 h by adding 120 ml of distilled water to it. The dilute mixture was titrated against 0.5 M ferrous ammonium sulphate (FAS) using diphenylamine as an indicator. FAS changes colour from violet to purple and finally at the equivalence point the colour will change to green. A blank was also treated and titrated as above. The percentage carbon residue was calculated using the formula: (Blank titre-Sample titre) × 0.4 × 0.004 × 100 divided by the weight of sample. 5 ml of oil was drawn into a capillary tube tied to a thermometer, placed in a 250-ml beaker containing distilled water and immersed together in a water bath to control heating. The temperature at which oil begins to move downward due to its weight is called the pour point. 50 ml of oil was measured into a 250-ml conical flask with a rubber cork containing a thermometer and placed on a heating mantle. The flask and its content were heated to decompose the oil to the point of evolution of the volatiles which proceeds so rapidly that continuous combustion occurs and this temperature is considered to be the firing point.

Some nutrients were also determined from the shell of *J. curcas*. These include nitrogen (N), phosphorus (P) and potassium (K). Shells were ground and 1 g was weighed into a digestion flask, 5 ml of concentrated hydrogen tetraoxosulphate(VI) acid (H_2SO_4) (36N Sp. gr. 1.84) was added together with selenium as a catalyst. The sample was digested at 350°C for 1 h 30 min. The digest was poured into a 50-ml volumetric flask and made up to the mark, 0.2 ml of the digest was placed into the flask. 4 ml of the dilutent (mixture of NaCl and H_2SO_4) and the content of the flask was mixed. 1.5 ml of sodium tartrate was added and mixed, 2.5 ml of alkaline phenate was added and shaken then 1.5 ml of commercial bleach (3.8% m/v sodium hypochlorite; Jik) was added. N concentration of the mixture was determined in the digest on a visible spectrophotometer (Labomed 20D; Chicago, USA) by colorimetric method.

Sample of seed shell were ground and was ashed in a muffle furnace at 500°C for 8 h. Dilute hydrochloric acid (HCl) solution was added to dissolve the ash. P and K concentration were determined from the ash solution. P concentration was determined from the digest using the vanadomolybdate colorimetric method in which 5 ml of the digest was placed into a 50 ml volumetric flask, 10 ml of vanadomolybdate reagent was added and the flask was made up to the mark. P concentration was determined on Visible Labomed Spectrophotometer, Chicago, USA. K was determined in the digest using Jenway Flame Photometer, USA.

Data analysis

Correlation analysis (Dewey and Lu 1959) was carried out to find out the association between oil yield and its component characters using Pearson's correlation at $P = 0.05$.

RESULTS AND DISCUSSION

Correlation analysis established the extent and cause of association between yield and its attributes. In this study, simple correlation coefficients of the characters were studied for *J. curcas* seeds collected from five locations in Nigeria. A significant negative correlation existed between oil content and weight of the whole seed (r = -0.76), seed length (r = -0.79) and weight of the kernel (r = -0.90) while P was significantly positively correlated with oil content (r = 0.90). However, there was no significant correlation between oil content and other parameters measured in this study. The oil content of seeds represents a reasonable opportunity for renewable fuel (Ruan *et al.* 2011). This result implies that there was a negative association between oil content and seed weight, kernel weight, length of seed and P content. This is contrary to the report of Rao *et al.* (2008), which stated that 100-seed weight showed a positive correlation with seed oil content ($P = 0.05$). Mohapatra and Panda (2010) and Rao *et al.* (2008) found no significant correlation between oil content, seed length and seed weight. The negative association observed between oil content and seed length was also observed by Rao *et al.* (2008) although Freitas *et al.* (2011) observed no correlation between these two parameters.

The weight of whole seed had a significant positive correlation with shell weight, seed length, kernel weight and specific gravity (r = 0.57, 0.91, 0.96 and 0.74, respectively). On the other hand, a significant negative correlation existed between the weight of the whole seed and P content of the seed (r = -0.56). This shows that the higher the seed weight, the longer the seeds, the greater the kernel weight and the higher the specific gravity. Abugre and Oti-Boateng (2011) also noted a positive correlation between seed weight and seed length. Shell weight was significantly positively correlated with only specific gravity and oxidative stability (r =

0.58 and 0.71, respectively). This shows that there is positive association between shell weight and specific gravity and between shell weight and oxidative stability i.e., the greater the shell weight, the higher the specific gravity and oxidative stability. Seed length had a significant positive correlation with kernel weight (r = 0.92) and specific gravity (r = 0.63) while significant negative correlation existed between seed length and N and P content (r = -0.53 and -0.59, respectively). This implies that the longer the seed, the greater the weight of the kernel and the higher the specific gravity. However, a negative association was observed between seed length and N and P content, which signifies that the longer the seed, the lower the N and P content. This support the result of Abou-Arab and Abu-Salem (2010) who reported that statistical analysis proved that highly significant differences ($P < 0.05$) were detected with kernel seeds with macro elements compared with whole seeds and shell samples. Similar result was also reported by Oladele and Oshodi (2007). N content of *J. curcas* was significantly positively correlated with K content of the seed (r = 0.87), this implies that the higher the N content of a seed, the higher the K content. Moreover, K had a significant positive correlation with carbon residue (r = 0.52) and negatively with oxidative stability (r = -0.52). This indicates that the higher the K content, the higher the C residue and the lower the oxidative stability. Calorific value had a significant positive correlation with fire point (r = 0.85) while specific gravity had a significant positive correlation with oxidative stability (r = 0.65).

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