Genetic Divergence, Principal Components and K-Means Clustering Analyses of Some Agronomic Characteristics of Eleven Castor (*Ricinus communis* L.) Accessions

Salihu, Bolaji. Z.[1]; Gana, Andrew K.[2]; Agboire Samuel. A.[3]; Isong, Abasianyanga E.[4], Shaahu, A[5]

[1, 2] National Cereals Research Institute (NCRI), Castor Research Programme, Badeggi, P.M.B.8, Bida, Niger State, Nigeria

[3, 4] National Cereals Research Institute (NCRI), Research Support Services, Badeggi, P.M.B.8, Bida, Niger State, Nigeria

[5]National Cereals Research Institute (NCRI), Soybean Research Programme, Badeggi, P.M.B.8, Bida, Niger State, Nigeria

Abstract: ***Morphological Characterization of 11 castor (Ricinus communis L.) accessions was carried out in 2012 at Castor Research field of National Cereals Research Institute (NCRI), Nigeria. The accessions were evaluated for 24 morphological characters at different growth stages. The data generated were subjected to One-way ANOVA, principal components analysis and K-means non-hierarchical clustering analysis. The accessions differed significantly at $p < 0.01$ for all characters evaluated, with exception of length of leaf petiole which only significant at $p < 0.05$. The first 5 PCs revealed 93.9% of the total variation, with PC1 and PC2 being responsible for 50.2% and 22.4% respectively. PC1 was mainly associated with number of nodes to 1st raceme, weight of 100 seeds and days to maturity. The contributory characters on PC2 axis were height at maturity, number of nodes on the main stem and length of leaf petiole. Specific grouping of the accessions in 5 clusters indicated that cluster 1, 2, 3, 4 and 5 contained 2, 1, 2, 4, 2 members respectively. The members (1, 9) of cluster 1 had the highest yield followed by the only member (10) of cluster 2 while the members of clusters 3 and 4 recorded low yield. This study revealed the distinctiveness of each accession, which could serve as basis for the crop improvement.***

Keywords: Castor accessions, morphological characterization, principal components, clustering analyses and NCRI Badeggi.

1. Introduction

Castor (*Ricinus communis* L.) is a non-edible oilseed crop with vast economic importance. The crop is a member of spurge family, Euphorbiaceae, along with cassava and rubber plants. Castor is grown for its oil which ranges between 48 – 60% of seed content [5]. The oil has a demonstrated market, guaranteed by variety of 700 uses, ranging from medicines and cosmetics to bio-diesel, plastics and lubricants [3].

Castor as well as some other cultivated crops; the primary economic characters are inherited in a quantitative manner. High heritability was reported for earliness, seed weight and plant height [11]. Studies on general combining ability and specific combining ability for seed yield, seed yield components and other agronomic traits were reported by [10] – [9]. These reports showed that selection in conventional breeding could enhance these traits and therefore generating improved castor genotypes.

Despite its economic importance, castor is yet to be realized as a commercial crop in Nigeria due to unavailability of scientific information for its improvement. The use of genetic resources can only be effective, if there are proper characterization of germplasm and free access to the information on the germplasm [1]. Therefore, this study is to document useful information for the improvement and characterization of castor in Nigeria

2. Materials and Methods

Morphological characterization of castor (*Ricinus communis* L.) accessions was carried out in 2012 on castor experimental field of National Cereals Research Institute (NCRI), Badeggi (lat. 9°45ʹN, long. 0.6°07ʹE; 70.5 metres above sea level) in the Southern Guinea Savannah ecological zone of Nigeria. The soil of the experimental site had been classified as ultisol and sandy loam in texture with a bulk density of $1.459m^{-1}$ [4]. The area has an average annual rainfall of 1124mm and mean temperature of 23° - 33°C.

The castor accessions were collected from Benue, Kaduna and Yobe States in Nigeria (Table 1). The seeds were characterized on the seed shape, seed colour, mottle, caruncle, and seed size (Table 1).The field was ploughed, harrowed and leveled a week before planting. Two replicate blocks (4 X 10m each); each containing a replicate of each accession were used. Three seeds were sown at an inter row of 50cm and intra row of 75cm and after emergence the seedlings were thinned to two plants per hole.

The accessions were critically observed from seedling to maturity and 24 morphological characters were taken from five randomly selected plants per accession. ANOVA was used to test for significant differences among the accessions; Principal Component Analysis was employed to identify the major contributors to the total variation while K-means clustering analysis was used to delineate the accessions into specific group.

3. Results and Discussion

The results showed significant differences for all the characters evaluated from the accessions (Table 2). This indicates wide genetic variability which can be exploited in selection and breeding for improved varieties. Mean, minimum, maximum and mean square values for all the characters evaluated are shown in table 2. Days to flowering ranged from 64 to 85 days; days to maturity ranged from 94 to 129 days; height at maturity was from 88 to 139cm; number of capsules/plant from 20 to 144; 100 seeds weight showed a range between 8.6g and 49.6g; and yield/plant ranged from 38.16g to 104.42g among all the accessions.

The first five principal components (PCs) contributed to 93.9% of the total variation, with PC1 contributing 50.2%, PC2 responsible for 22.4%, PC3 provided 12.1% while 5.7% and 3.5% were contributed by PC4 and PC5 respectively (Table 3). The main contributory characters of PC1 were weight of 100 seeds, number of nodes to 1^{st} raceme and days to maturity. PC2 was associated with height at maturity, number of nodes on the main stem and length of leaf petiole. The main discriminatory factors on the PC3 were branch/plant and spikes/plant. Number of leaves and number of leaf lobes were the major contributors of PC4 while length of internodes dominated PC 5 axis.

The results of specific grouping of the accessions into 5 clusters are showed in table 4. Cluster 1, 2, 3, 4 and 5 contained 2, 1, 2, 4, and 2 members respectively. Each cluster contained accessions that were highly similar. Members (1, 9) of cluster 1 were high yielding, tall accessions with high seed weight and late maturity. The only member (10) of cluster 2 was high yielding, tall accession with high capsules/spikes, long spike length, low seed weight and early maturity. The 4 members (3, 5, 6, 11) of cluster 4 were average yielding, dwarf accessions with low seed weight and early maturity. The members of cluster 3 and 5 were low yielding accessions. The results revealed the distinctiveness of members of each cluster, indicating variability among the accessions. Similar variability in castor was reported by [2], [6], [7], [12].

The knowledge of existing variation of the various characters in castor germplasm is essential for developing high yielding genotypes. Accession 1, 9 and 10 could be selected for direct introduction to farmers. These accessions could also be bred with members of cluster 4 to develop better yielding, dwarf and early maturing genotypes. However, though the result of the study justified the conclusion, there is needed to establish the trial multi-locationally since castor may exhibit variation in growth due to environment. Also, the use of molecular markers to screen the accessories is of importance.

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Author Profile

Salihu Bolaji Zuluqurineen obtained B.Sc. and M.Sc. in Plant Biology from University of Ilorin Nigeria in 2007 and 2011 respectively. 2010-2012, he was with Kwara State Teaching Service Commission and now with National Cereal Research Institute (NCRI). He is a member of Agricultural Society of Nigeria.

Table 1: Seed characteristics and source of the castor accessions

Accessions' Number	Source (State)*	Seed Shape	Seed Colour	Seed Mottling	Caruncle	Seed Size
1	Kaduna	Square	Dark Brownish-red	Less conspicuous	Conspicuous	Large
2	Kaduna	Oval	Dark Chocolate	Conspicuous	Conspicuous	Medium
3	Kaduna	Oval	Dark Chocolate	Conspicuous	Less conspicuous	Medium
4	Benue	Elongated	Brown	Less conspicuous	Less conspicuous	Small
5	Yobe	Elongated	Brown	Less conspicuous	Less conspicuous	Small
6	Benue	Oval	Brown	Less conspicuous	Less conspicuous	Small
7	Kaduna	Oval	Brown	Less conspicuous	Conspicuous	Medium
8	Kaduna	Oval	Dark Brownish red	Conspicuous	Conspicuous	Medium
9	Kaduna	Oval	White	Conspicuous	Conspicuous	Large
10	Benue	Elongated	Dark Chocolate	Less conspicuous	Less conspicuous	Small
11	Benue	Elongated	Dark Chocolate	Less conspicuous	Less conspicuous	Small

*All the states where accessions were collected are from Nigeria

Table 2: Mean, minimum, maximum and mean square values of castor agronomic characteristics at National Cereals Research Institute, Nigeria

Parameters	Mean	Minimum	Maximum	Mean Square
Length of Internodes (cm)	3.913	2.726	5.932	4.849**
Length of Capsule (cm)	2.069	1.4	2.76	1.686**
% of Lascination of 3rd leaf from top	66.12	59.62	70.76	83.921**
NO of Leaves/plant	16.84	10.6	22.2	80.793**
NO of Lobes of 3rd leaf from top	8.564	7.8	9.2	0.993**
Length of Petiole (cm)	16.731	14.18	20.62	12.898*
Leaf Length (cm)	28.71	23.48	37	87.998**
Stem Girth (cm)	7.057	5.414	9.78	6.939**
NO of Nodes on the stem	24.782	22.6	29.2	19.418**
Branches/Plant	1.982	1.6	3	0.978**
Height at Flowering (cm)	57.35	24.2	94.2	2775.444**
Height to 1st Raceme (cm)	73.85	38	113.4	3031.724**
NO of Nodes to 1st Raceme	17.255	13.2	22.6	46.724**
Height at Maturity (cm)	106.58	88	139.6	1596.978**
Days to 50% Flowering	75.89	63.6	85	255.655**
Days to Capsules Formation	83.24	71.2	93.2	286.393**
Days to Maturity	106.96	94	129	497.484**
NO of Spikes/Plant	2.218	1.6	3	1.698**
Length of Spikes (cm)	25.89	15.8	37.6	323.495**
NO of Capsules/Spike	59	20	144.2	6267.804**
NO of Seeds/Plant	177	60	432.6	56410.233**
Length of Capsule Spine (mm)	4.943	2.9	8.2	15.430**
Weight of 100 seeds (g)	23.35	8.6	49.6	1212.644**
Seed Yield/Plant (g)	59.09	38.16	104.42	2695.904**

NOTE
*Significant at the $P < 0.05$
**Significant at the $P < 0.01$

Table 3: Contributions of some agronomic characteristics of castor accessions evaluated to Principal Components PC1-PC5

Parameters	PC1	PC2	PC3	PC4	PC5
% of Lascination of 3rd leaf	0.252	-0.158	-0.001	0.212	0.075
NO of Leaves/plant	0.124	-0.137	0.382	-0.402	-0.17
NO of Lobes of 3rd Leaf	-0.197	-0.052	-0.191	-0.479	0.226
Length of Petiole (cm)	0.006	-0.354	-0.153	-0.383	-0.218
Length of Leave (cm)	-0.268	-0.072	0.146	-0.059	0.042
Length of Internodes (cm)	-0.135	-0.268	-0.266	0.057	-0.303
Stem Girth (cm)	-0.232	-0.192	0.156	0.149	0.178
Number of Nodes on Main Stem	-0.086	-0.354	-0.196	0.141	-0.291
Branches/Plant	0	-0.155	0.493	0	0.093
Height at Flowering (cm)	-0.268	-0.051	-0.054	0.157	-0.208
Height to 1st Racemes (cm)	-0.247	-0.177	-0.09	0.199	-0.075
NO of Nodes to 1st Raceme	-0.276	-0.009	0.079	-0.004	-0.216
Height at Maturity (cm)	-0.137	-0.358	0.03	0.199	-0.046

Days to %50% Flowering	-0.244	0.121	-0.106	-0.272	-0.01
Days to Capsules Formation	-0.246	0.122	-0.102	-0.293	-0.025
Days to Maturity	-0.271	0.051	-0.052	-0.04	0.124
NO of Spikes/Plant	0.111	-0.082	0.457	-0.563	-0.451
Length of Spikes (cm)	0.077	-0.326	0.06	0.088	0.286
NO of Capsules/Spike	0.184	-0.287	-0.144	-0.104	0.215
Length of Capsules (cm)	-0.248	0.077	0.147	0.245	0.162
NO of Seeds/Plant	0.184	-0.287	-0.144	-0.104	0.215
Length of Spine (mm)	-0.252	-0.03	0.186	-0.077	0.242
Weight of 100 seeds (g)	-0.276	0.041	0.109	0.04	-0.038
Seed Yield/Plant	-0.153	-0.291	0.175	-0.09	0.266
Eigen value	12.056	5.383	2.902	1.357	0.834
Proportion	0.502	0.224	0.121	0.057	0.035
Cumulative	0.502	0.727	0.848	0.904	0.939

Table 4: Profiles of 5 clusters based on K –means clustering analysis of castor accessions

	Cluster				
Parameters	*1*	*2*	*3*	*4*	*5*
Length of Internodes (cm)	5.43	5.33	3.21	3.52	3.41
Capsule Length (cm)	2.77	1.44	2.49	1.70	1.94
% of Lascination of the 3rd Leaf from top	61.37	70.56	62.93	69.65	65.32
Stem Girth (cm)	9.10	7.29	6.94	6.38	6.54
Leaf Number	17.00	17.20	12.50	17.74	20.00
Number of Lobes of the 3rd Leaf from Top	8.89	8.80	8.75	8.21	8.60
Length of Petiole of the 3rd Leaf from Top	19.68	17.30	15.13	16.20	16.73
Length of the 3rd Leaf from Top	35.93	26.98	29.53	25.14	28.87
Total Number of Nodes on the Main Stem	26.89	29.20	24.08	23.95	23.10
Length of the Spines (mm)	7.26	3.93	5.56	3.72	4.95
Height at Flowering (cm)	95.33	57.20	72.75	37.37	42.20
Branch per Plant	2.33	1.80	1.75	2.05	1.90
NO. of Racemes/Plant	2.33	2.00	1.83	2.37	2.40
Days to Flowering	82.11	71.00	82.08	69.89	76.70
Days to Capsule Formation	89.44	78.00	89.67	76.89	84.60
Days to Maturity	118.33	99.00	113.92	98.84	103.30
Length of Spike (cm)	26.89	37.60	17.58	29.37	22.50
Height to 1st Racemes (cm)	113.67	91.00	77.92	53.95	62.40
NO. of Internodes to 1st Raceme	21.89	16.00	19.50	14.26	16.70
NO. of Capsules/Spikes	33.67	144.20	22.17	67.63	43.60
Height at Maturity (cm)	132.56	137.40	99.50	97.11	94.30
NO. of Seeds/Racemes	101.00	432.60	66.50	202.89	130.80
100 Seeds Weight (g)	47.67	9.00	33.25	11.32	19.60
Yield/Plant (g)	92.40	77.22	44.11	57.97	40.16