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MORPHO-GENETIC VARIATION IN CASTOR PLANTS SELECTED FROM DIFFERENT AGRO-ECOLOGICAL REGIONS OF NIGERIA

*[1]Odeje S. C., [2]Alonge S. O.

[1]Nigeria Nigeria Police Academy, Wudil, Kano
[2]Department of Botany, Ahmadu Bello University, Zaria

*Corresponding authors' email: chrissaliuodeje@gmail.com

ABSTRACT

In Nigeria, different forms of castor plants are available but the lack of proper record of these diverse forms makes proper identification and classification of this plant difficult. This research is aimed at characterizing the accessions using morphological, markers towards assessing their genetic diversity. Eighty (80) accessions were used for this study. For the field work, the farm was cleared and planted using the IAR Extension Workers Guide of 2013. A Completely Randomized Design (CRD) was adopted with three replications. Data were collected on agro- morphological, and traits from systematically sampled plants. The results of this study revealed great variation. All growth traits, yield and leaf traits were shown to be significantly different ($P \leq 0.05$). Seeds were characterized into small (≤ 9), medium ($\geq 9 \leq 28$) and large (≥ 30). The results further revealed that 52% of the accessions were small while 12.5% were observed to be large. Furthermore, 40% of the accessions were considered promising lines in terms of yield with at least 1000Kg/ha of yield. However, the accession with the highest yield was 20ZShka (2236 kg/ha). Five principal components accounted for about 52% of the variations observed. Seed length, width and area accounted for the first principal component while number of capsules and yield correlated with the fourth principal component. Furthermore, grouping the accessions revealed eight distinct clusters which did not show any region-specific association. It can therefore be concluded that castor accessions from Nigeria showed great variation in morphological traits.

Keywords: accessions, castor, characterization, genetic, morphology, variation

INTRODUCTION

The castor oil plant (*Ricinus communis* L.) is a species of flowering plant in the spurge family i.e., Euphorbiaceae (Kyoung-In *et al*., 2011. The spurge family also includes *Jathropha curcas*, The Castor bean is the only member of the genus *Ricinus*, and it has no immediate relatives. Global castor seed production is around one million tonnes per year (FAO, 2008) and India is the world's leading producer of this plant with over three quarters of the global yield. It produces 830, 000 tonnes per year (FAO, 2008). In Africa, Ethiopia has the highest production with 15, 000 tonnes (FAO, 2008). Nigeria is not quoted among the first ten world producers of this plant. The reason may be that, not much record is available with respect to commercial production of castor in Nigeria. It is probably produced only by research institutes for the purpose of research.

However, in recent time (2014), there was report that Nigeria has joined the league of world castor producers. It produces about 2,000 tons annually now (Daily Trust Newspapers, 2014). The castor seed has a long history of use. It is used in medicine as a mitotic inhibitor used in cancer therapy (Micha *et al*., 2006). It is also a great additive and powerful laxative that serves as remedy for ailments like Multiple Sclerosis, Parkinson's disease, Cerebral Palsy, Pain from Rheumatism and Gastrointestinal problems (Salihu *et al*., 2014). Castor meal detoxified by boiling could be added up to 100g in 1 kg of broiler finishing diets without deleterious effects (Ani and Okorie, 2009).

Although, the genus *Ricinus* is considered monotypic, castor bean varies greatly in its growth habit, colour of foliage and stems, seed size and oil content (Weiss, 2000; Li *et al*., 2008). Some grow too tall (about 10 to 13 meters) (Encyclopedia Britannica, 2012), while in areas prone to frost, it is shorter (Lijun *et al*., 2010). In Nigeria different forms of castor plants are seen but the lack of proper record of these diverse forms found in this country makes proper identification and classification of this plant difficult.

The great variation in the height of this plant which has not been adequately characterized makes mechanical harvesting difficult as such hampering commercial production. Morphological characterization is the first step in the identification of plants and could lead to solving this problem through the data collected. According to Allard *et al*. (1991) germplasm collection constitutes one of the world's most readily available sources of plant material. Nigeria is very far behind as far as production of castor is concerned. This may be due to lack of proficient cultivars of this plant. In order to enhance the production by developing new cultivars, knowledge about the genetic wealth of available germplasms is necessary. In view of the above and the importance of castor in solving a lot of problems, the desire has been expressed for the need to collect and assess diversity, select best provenances based on products such as seeds as well as genetic and propagation improvement of the castor oil plant.

MATERIALS AND METHODS

Study Area and Plant Material

The study was carried out in the Institute for Agricultural Research (IAR) farm, Department of Biological Sciences, Ahmadu Bello University, Zaria on Latitude 11° 12' 1. North, Longitude 7° 33'East and on Altitude 610 metres above sea level (Osuhor *et al.,* 2004). Zaria is located in the Northern Guinea Savanna Agro-ecological zone of Nigeria.

Collection of Plant Material

Forty seeds each of castor oil plant (*Ricinus communis*) accessions were collected from the Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU), Zaria and National Cereal Research Institute (NCRI), Badeggi, Minna, Niger State. These research materials are presented in Table 1.

Table 1: Ricinus communis accessions and geo-political regions of collection

SN	NC	NW	NE	SE	SW	SS	EX
1	04Buam	04Bkb	05Ngur3	2Ziko	38Bikoy	-	52Bpt
2	06Blaf	05Zshk	19Zmgm	33Zmke	39Bleoy	-	53Bpt
3	10Bk/ala	06Zdub	23Zmtm	34Zigo	40Bgbm	-	57Bpi
4	15Bnkp	07Zsg	24Zmd	35Zoba	41Balj	-	61Bpb
5	16Bdkik	08Zdtm	-	36Zabi	47Bed	-	63Bpi
6	17Bdk	09Zjb	-	37Zakz	48Biwo	-	64Bpi
7	18Bdek	10Bug	-	38Zumod	-	-	67Bpa
8	19Bdk	11Zkt	-	39Zisia	-	-	74Bpaf
9	22Bof	12Zbas	-	42Zowr	-	-	75Bag
10	23Bofu	13Zat	-	-	-	-	86Bmo
11	24Blkj	14Zexs	-	-	-	-	89Bsaf
12	26Bils	17Zang	-	-	-	-	94Bpru
13	27Bkw	18Zzng	-	-	-	-	01Zbrz
14	28Basa	20Zshka	-	-	-	-	03Zbra
15	29Bile	21Zjib	-	-	-	-	-
16	32Bbd	26Zjig	-	-	-	-	-
17	Bncng	27Zkdw	-	-	-	-	-
18	37Bbwd	28Zdm	-	-	-	-	-
19	46Bum	29Zrm	-	-	-	-	-
20	50Bilw	30Ztwn	-	-	-	-	-
21	103Basa	-	-	-	-	-	-
22	02Zkab	-	-	-	-	-	-
23	15Zkba	-	-	-	-	-	-
24	16Zabj	-	-	-	-	-	-
25	22Zkab	-	-	-	-	-	-
26	41Ziga	-	-	-	-	-	-
27	25Zrmp	-	-	-	-	-	-

Key
NC-North-central
NW-North-west
NE-North-east
SE-South-east
SW-South-west
SS-South-south
EX-Exotic materials

Field Experimentation.

The field experiment was carried out in the Institute for Agricultural Research (IAR) farm, Ahmadu Bello University (ABU), Zaria. The field was chemically treated using systemic herbicide (Picloram). The field was harrowed and ridged with the University Farm (IAR) tractor. Seeds were then planted, with two (2) seeds sown per hole in one row plots (10 m × 7.5 m) in a block comprising of eighty ridges. The length of each ridge was ten meters (10 m). Distance between ridges was seventy-five centimeters (75 cm) while intra row spacing was one hundred centimeters (100 cm) that is, there were ten (10) stands of one accession on a ridge. A Completely Randomized Design (CRD) was adopted with three replications. Weeding was done manually after the fourth and tenth weeks of planting. Fertilizer (NPK -15/15/15) was applied at the rate of 50Kg/ha five weeks and then twelve weeks after planting (WAP). The plant materials from which data was collected were systematically sampled, that is, every third plant in a row was selected. This was done weeks after planting when the plants were already matured (16WAP). From each of these 4 plants, data was collected for each agro-morphological parameter using the methods of Goodarzil *et al*. (2011) and Salihu *et al*. (2013a). Anatomical studies' data were collected

Leaf Area (m^2): This was calculated by transposing individual leaf on a graph sheet. The outline was traced. The squares covered by the leaf were counted and this represented the area in square metre.

Leaf lamina length: A tape rule was used to measure the length of the main leaf without the petiole when the leaves were 16 weeks after planting.

Leaf lamina width: The lamina width was measured at the broadest part of the leaf across the length with a tape rule at maturity (16 weeks after planting).

Petiole length: A ruler was used to measure the distance between the base of the lamina and the point of attachment to the stem to obtain the petiole length.

Petiole colour: The colour of the petiole was observed.

Leaf colour: The colour of the leaf was observed.

Stem colour: The colour of the stem was observed.

Seed colour: The colour of the seeds was observed.

Seed shape: The different shapes of the seeds were observed

Seed size: The size of the seed was measured using a Vernier caliper to measure length and width of the seed. The product of the length and width gave the size of the seed.

Height of plant at maturity (cm): A tape rule was used to measure the distance between the highest point of the plant and the base of the stem at maturity.

Internode length (cm): The internode length was measured by measuring the distance between 4.two nodes using a tape rule when the plants have attained maturity.

Number of nodes: The number of nodes on the stem was counted at maturity.

Length (cm) of first primary branch: This was measured using a tape rule at maturity.

Length (cm) of primary raceme: It was measured using a tape rule at maturity.

Number of racemes at maturity: This was counted manually.

Weight (g) of capsules on primary raceme: This was measured using a weighing machine (Sartorius electric weighing machine-version/model CP8201).

Number of capsules on primary raceme: This was counted manually at maturity.

100 seed weight (g): This was done using a weighing machine (Sartorius electric weighing .machine-version/model CP8201).

Total Yield: TY= Av. HR × Av. no. of GR heads (Norman and Siebert, 1990)

Where, TY= Total Yield**; HR=** Heads already harvested; **GR**= Heads that are green

Statistical Analysis

Descriptive statistics such as mean, Standard deviation, Coefficient of variation, minimum and maximum values were calculated, Principal Component Analysis was carried out and, Dendrogram was also conducted in order to study relationships. Data were processed using Statistical Analysis Software (SAS) Version 12.0.

RESULTS AND DISCUSSION

Results

The colour characteristics of 80 castor accessions used for this study are presented in Fig 1. The results revealed that, there were five different colours observed. These included green colour which was observed in 52 accessions (65 %), 8 accessions (10 %) had bronze/brown colour in which 4 (33Zmke, 18Bdek, 39Bleoy and 94Bpru) were covered with white, thirteen of the Accessions representing 16.25 % were red in colour while 6 (7.5 %) were pink and one was purple in colour.

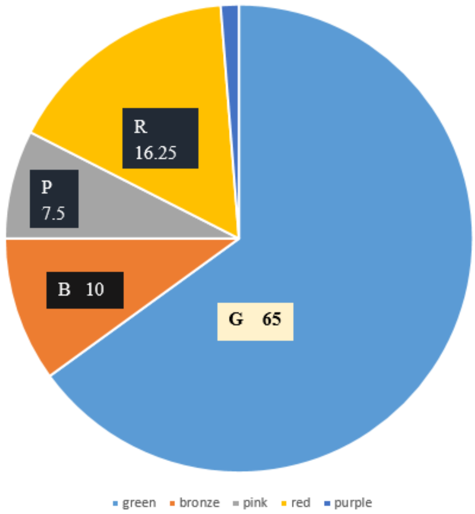

Figure 1: Percentage colour characters of 80 castor accessions
Key: **G** – Green; **R** – Red; **P** – Pink; **P** - Purple

The results also revealed that the coefficient of variation was observed to be moderately high in traits such as number of branches, germination percentage, number of capsules, weight of primary raceme and yield while it was high for leaf area (50.37). The coefficient of variation was observed 7. to be low for all other traits (Table 1).

Principal Component Analysis

The component analysis showing the factor scores of each morphological character among 80 castor accessions, Eigenvalues and percentage variance observed in five principal components is presented in Table 2. The five principal components accounted for about 56.02 % of total variance with the first principal component only taking about 16.69 %. The relative discriminating power of the principal axis was high (3.84) for axis 1 and low (1.52) for axis 5. The first principal component that accounted for the highest proportion (16.69 %) of total variation was mostly correlated with seed area, seed length and seed width. Characters that were mostly correlated with the second principal component were lamina width, lamina length and leaf area. The results further indicated that, only number of capsules per raceme, number of raceme and yield correlated with the fourth principal component (Table 2).

Table 2: Principal component analysis showing the contribution (factor scores) of each character among the 80 castor accessions, Eigen values and percentage total variance of five principal components.

Trait	Prin1	Prin2	Prin3	Prin4	Prin5
Gm	0.12	-0.16	-0.15	-0.20	0.15
Sv	-0.10	0.09	0.23	0.07	-0.20
PH	0.14	0.08	**0.34**	-0.10	**0.35**
LPB	0.04	0.12	**0.36**	0.10	0.14
IL	0.24	0.02	0.20	-0.09	0.10
NN	-0.07	0.21	0.23	-0.06	0.19
NBB	-0.07	0.01	0.20	-0.20	0.19
NB	0.07	0.13	**0.41**	-0.03	0.06
GS	0.13	0.04	0.13	-0.19	**0.35**
PL	0.19	0.28	-0.04	-0.06	-0.02
LL	0.27	**0.41**	-0.12	0.19	0.05
LW	0.25	**0.43**	-0.20	0.17	0.00
LA	0.22	**0.39**	-0.08	0.16	-0.05
NL	-0.04	0.02	**0.30**	0.22	-0.45
LN	-0.15	0.05	**0.42**	0.00	-0.30
Seed_L	**0.41**	-0.27	0.10	0.11	-0.13
Seed_W	**0.43**	-0.27	0.09	0.09	-0.09
Seed_A	**0.43**	-0.28	0.08	0.10	-0.09
NR	-0.15	0.10	-0.04	**0.39**	0.07
LPR	-0.18	-0.05	0.05	0.15	0.22
WPR	0.09	-0.18	-0.04	0.18	**0.34**
NCPR	-0.15	-0.16	0.06	**0.42**	0.28
100sw	0.05	0.13	0.02	0.27	0.01
Yield	-0.05	-0.11	0.02	**0.54**	0.15
Eigen Value	3.84	2.66	2.51	2.36	1.52
% Variance	16.96	11.55	10.90	10.27	6.62
Cum Variance	16.69	28.24	39.14	49.41	56.02

Cluster Analysis

The morphological dendrogram showing the genetic similarity among 80 accessions is presented in Figure 2. There are eight clusters on the basis of the similarity coefficient of 35. Cluster 1 (C1) is simplicifolious, having only accession 30Ztwn, while cluster 2 (C2) is further divided into 2 sub-clusters c2a and c2b, in which c2a has one accession (37Bbwd), while sub-cluster c2b is further divided into sub-sub-cluster c2bi and c2bii. Sub-sub-cluster c2bi has five accessions (01Zbr, 15Zkba, 16Zabj, 21Zjib and 34Zigo) while sub-sub-cluster c2bii has 15 accessions. On the other 12.hand, cluster 3 (C3) is made up of four accessions (38Bikoy, 74Bpaf, 18Zzng and 61Bpb) of which accession 38Bikoy stands alone (Figure 1). Similarly, cluster 4 (C4) is bifolious having just accessions 19Zmgm and 32Ziko. However, Cluster 5 (C5) has two sub-clusters (c5a and c5b). Sub-cluster c5a is further divided into sub-sub-clusters c5ai and c5aii in which c5ai has a solitary accession (23Bofu) while c5aii has 19 accessions. Sub –cluster c5b on the other hand also has two sub-sub-clusters c5bi and c5bii in which c5bi has 14 accessions while c5bii has 3 accessions (2Blkj, 20Zshka and 35Zoba). Furthermore, cluster 6 (C6) has two sub-clusters (c6a and c6b) in which c6a is simplicifolious with one accession (06Blaf) and c6b has ten accessions: including six from Bida (86Bmo, 75Bag, 89Bsaf, 94Bru, 04Buam and 46Bum) and four from Zaria (11Zkt, 08Zdtm, 10Zbug and 12Zbas). Similarly, cluster 7 has only three accessions (28Basa, 39Bleoy 22.and 41Balj while, cluster 8 (C8) has four accessions including 103Basa, 25Zrmp, 26Zjig and 23.41Ziga (Figure 2).

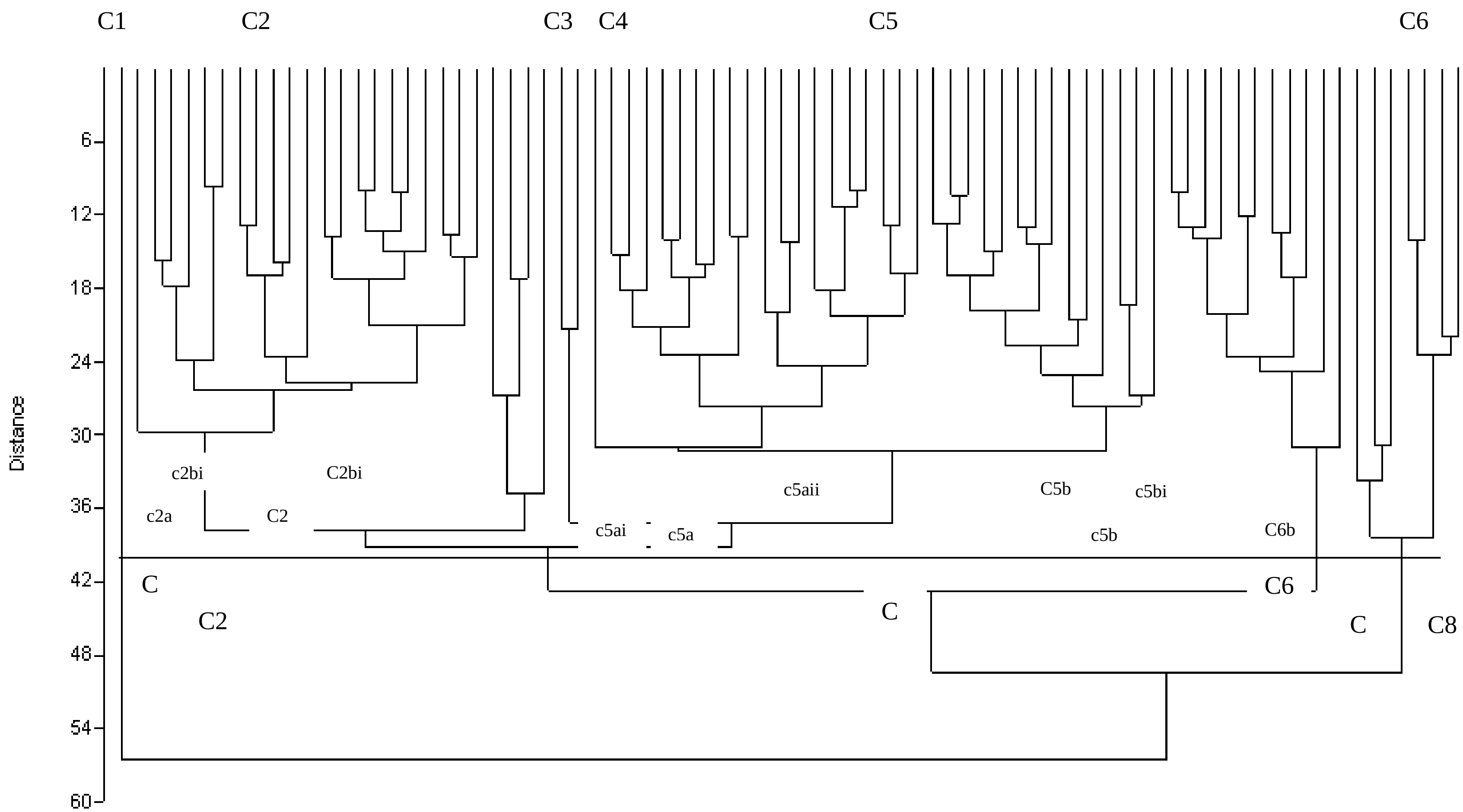

Figure 2: Dendrogram of morphological traits of 80 castor accessions from different agro-ecological regions of Nigeria

Discussion

The description for identification of crop accessions has assumed critical importance in seed programmes internationally and there is a considerable need for the development of reliable methods and identifiable characters for the purpose. The characters for which an accession is distinct from others could be morphological, chemical and biochemical in nature and these aid in the identification of accessions (Suhasini, 2006).

The results obtained for the morphological traits of the 80 castor accessions revealed that there were variations among the 80 accessions. However, no region-specific pattern of variation was observed for the different morphological traits. It was observed that four accessions (61Bpb, 19Zmgm 41Balj and 42Zowr) had the highest values in more than one character studied. Accession 42Zowr had the highest values for all the leaf morphological traits, though it was collected from Owerri in Eastern Nigeria, a region different from the site of the research. On the other hand, accession 64Bpi was observed to be consistently low for traits such as seed yield (57.50 Kg/ha), seed area, number of capsules (1.33) per raceme and length of primary raceme (12.67 mm). This accession is also associated with 54 other accessions with a yield range of 75.30 to 573.30 including 39Bleoy, 63Bpi, 67Ba, 74Bpaf, 75Bag, 27Zkdw and 16Zabj which are not necessarily similar in terms of seed size. This is an indication of low 16.variability (Ogunbayo *et al*., 2005). It has been reported that, diagnostic characteristics have been used to identify plant varieties. (Pandey and Misra, 2009; Zhigila *et al*., 2015). The data obtained in the present study revealed that, the height of castor plants ranged from 50-238 cm. Majority of the plants grew above the mean (123.14 cm) but lower than 180 cm which is an indication that almost all the castor accessions were of the short type (Encyclopaedia Brittannica, 2012). The coefficient of variation for this trait was very low (6.56 %) suggesting the closeness of these varieties. This may be as a result of growing the accessions closely together which may have led to exchange of genetic materials between them or, there was over-selection of the genotypes with good agronomic traits. This may have resulted in lowering the genetic base of these accessions. Songsri *et al*. (2011), made a similar observation in Physic nut. Internode length and number of nodes influence the height of the plant. The longer the distance between two nodes and the number of such nodes on the stem axis, the taller the plant grows. In this study, it was observed that, the accession with the tallest plants (61Bpb) also had the internode length and number of nodes which were above the average values for these traits in the populations studied. Salihu *et al*. (2014) reported that, castor plants have been characterized into dwarf and tall plants depending on whether their internodes were short or long. Alemaw and Merrera (2015), classified two varieties of castor into short (≤ 150 cm with an internode length of about 3 cm) and tall (≥200 cm with an internode length of 15 cm). The results of the present study agree with this finding as 21 % of the accessions fell into the category of tall plants.

A good germination can be ingredient for good yield if establishment of the plants is successful. There was great variation in the germination of these accessions as the percentage germination ranged from 30 – 76.67 % with the mean pegged at 52 %. However, 58.75 % of the accessions had a germination percent of 50 % and above. This is an indication that these accessions have moderate percentage germination although there is no specific pattern as, this moderately high germination cuts across every region as well as sizes of these accessions. Coefficient of variability was shown to be 18 %. This is low and may be as a result of over-selection of desirable traits which probably narrowed the genetic base of these accessions. However, Douaihy *et al.* (2012) thought this may be slightly high variability. Furthermore, seed size has been reported to influence the relative emergence of plants (Turnbull *et al*., 2008). According to the authors, small-seeded plants have a greater relative germination rate than large seeded ones.

Survivability of a plant is an indication of its adaptation and establishment after germination. The present study recorded about 56 % of the accessions having survival percent above the average (90.42 %) with 16 of these having 100 % survival. Out of these number, 11 accessions were obtained from I. A. R., 23.Zaria, which were either small or medium in size, and grey or brown in colour. However, seed size was observed not to significantly influence the survival of the percentage survival as, 7 out of the 16 accessions with 100 % survival were small-seeded. This result differs from that of Nduwayezu *et al*. (2007) and Jofuku *et al.* (2005) who had earlier reported that, *Moringa oleifera* samples with big seed kernel gave high plant survival and growth rate, increased tolerance to flooding and tolerance to insect predation in fields.

The seed size is also an important trait used for grouping plants. The results obtained from this study revealed some level of variation in seed size (7.97-59.83 mm^2) and the accessions can be grouped into three types based on size. These are large ≥ 28 mm^2, medium ≥ 12 ≤ 28 mm^2 and small ≤ 12 mm^2 (Akande *et al*., 2012). Two types of seed sizes (large and small) have been reported in castor by Salihu *et al*. (2013a), while seven varieties were recognized on the basis of size and colour by Van-Rheeney (1976). However, Akande *et al*. (2012) pointed out that, since size is a continuous variation, it will be difficult to identify all categories. The results obtained from this research is comparable with this assertion. As such, the three categories identified in this study were found to be consistent after different field trials and, considering that the ones classified as medium in this study did not appear quite as big as the large-12.seeded varieties reported by Akande *et al.* (2012), and not as small as the small-seeded ones, hence the need for this categorization. The authors also reported that, seeds vary in size from 5-250 mm. In this study, seed size of up to 59 mm^2 was observed. However, there is low variability with respect to this trait since, 52 % of the seeds were classified as small and another 35 % classified as medium size.

Leaf and stem colour are one of the important characteristics used for grouping of accessions (Zhigila *et al*., 2015). This colour is dependent upon the intensity of chlorophyll and anthocyanin pigmentation which in turn varies with the genotype according to their genetic constitution. It was observed in the present study that, the leaves of all the accessions appeared green, but there were different shades of green which included light green and deep green. The stem and petiole however revealed great variation in colours which included bronze, pink, red and purple (in accession 01Zbr). This variation could have resulted due to the response of the plant to different conditions of the environment such as light intensity and nutrition. A similar finding was reported by Zhigila *et al*. (2015). The leaf size and number of leaves are also important traits used for grouping plants.

The results of this research indicated a wide variation (17 and 522 cm^2) in the leaf size with a coefficient of variation of 50 %. This high coefficient probably resulted due to a few extreme values among the accessions. In addition to this, accession 42Zowr was observed to have the highest value for all the leaf traits except for number of leaves and lobes. This may be as a result of the genetic make-up of this accession or, it may have adapted well to the environment as also suggested by Serebrayanaya and Shipunov (2009), who worked on six different plant species including *Atriplex nudicaulis 5.*(Chenopodiaceae)*; Euphrasia wettsteinii* (Orobanche)*; Achillea millefolium* (Asteraceae)*; Parnassia 6.palustris* (Parnassiaceae)*; Potentilla egedii* (Rosaceae) *and Rhodiola rosea* (Crassulaceae).

The yield potential of the accessions revealed that, there were some variations in the yield with values that ranged from 57.50-2236 Kg/ha. A good number of accessions performed better than the 500 kg/ha yield in castor reported by Verma and Rana (2012). The results however agree with the work of Li *et al*. (2014) who reported a yield of 1000 Kg/ha in a Nebraska test. The size of the seed has also been reported to influence the quantity of yield (Salihu *et al*., 2014). According to them, accessions with large seeds were more likely to have higher yield in terms of weight but will contain fewer seeds. A similar result was also observed in this research. For instance, accession 35Zoba which is large seeded had a yield of 1111 Kg/ha though, the number of capsules per raceme were just 13 compared with accession 34Zigo, a small-seeded accession that had a yield of 2024 Kg/ha with 119 capsules per raceme. However, a great variation was observed with respect to this trait among the accessions collected from Nigeria in which over 56 % of the accessions had yield of 500 Kg/ha and less. Similarly, 41.25 % of the accessions had over 1000 Kg/ha yield and 2.5 % had 2000 Kg/ha and above. As such, this study classifies the accessions into high-yielding (2000 Kg/ha), promising (1000 Kg/ha) and low-yielding lines having less than 500 Kg/ha. Verma and Rana (2012) had earlier reported that a yield of 500 Kg/ha was good yield.

Furthermore, it was observed that, the correlation matrix revealed a positive correlation between yield and number of racemes, whereas the seed area was positively and significantly correlated to leaf length and width. Therefore, these two traits contributed greatly to the variations observed in the castor accessions' yield performance. Ogunbayo *et al*. (2005) reported that, number of fertile tillers and yield contributed significantly to the variations they observed in the rice accessions agro-morphological traits they studied.

According to Aliyu *et al*. (2000), cluster analysis has the efficacy and ability to identify crop accessions with highest level of similarity using the dendrogram. The cluster analysis as revealed by the morphological dendrogram indicates that, there were eight distinct clusters which showed little or no region-specific structuring. For instance, cluster 6 had four exotic accessions clustered together with four North-western accessions and three North-central accessions from Nigeria. Similarly, cluster 5 which has the largest number of accessions clustered together had six exotic accessions alongside several other accessions from different geographical regions in Nigeria. This pattern-less clustering could have been as a result of certain genetic material being common to these accessions. For instance, accessions 20Zshka and 34Zigo which were collected from the North-west and South-east, respectively, their seeds had grey colour. Based on the results obtained from this study, it can be concluded that, castor accessions found in Nigeria possess great variation in their morphological characters such as size of seeds, plant colour and yield.

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