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MORPHOLOGICAL AND YIELD CHARACTERISTICS OF SOME CULTIVATED AND WILD ACCESSIONS OF *CORCHORUS OLITORIUS* GROWN UNDER FIELD CONDITION

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author OOO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author OO supervised the work and author KOO managed the data and performed the statistical analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The rationale behind this study was to comparatively evaluate the biological and agronomic characters of the crop. The work aimed at assessing the morphological and yield performances of cultivated and wild accessions of *Corchorus olitorius* under uncontrolled open field condition. Fourteen accessions of *C. olitorius* seeds were sourced from three local Institutions. Seeds of these accessions were subjected to two seed treatments (heat treated seeds and untreated seeds) and were then planted on a 180 m^2 plot following standard agronomic recommendations and using randomized complete block design (RCBD). Data were collected on morphological and yield characters of the crop, and data collected were subjected to analysis of variance to determine if treatments were significant. Significant means of treatment were separated using Duncan's Multiple Range Tests; while Pearson Correlation, cluster and Principal Component Analyses were also employed to study the relationships and variability of the accessions and their characters. Results indicated that accession and treatment were significant on the characters evaluated; and the characters also had significant positive correlation with one another in most cases. The cultivated accessions had very close relationships, while the wild species were distinct and different. This study thus demonstrated that the accessions investigated were highly variable for all the morphological and yield traits evaluated. This variability harbors obvious potential for improvement in *C. olitorius*.

Keywords: Accession; treatment; biological diversity; morphological variability.

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1. INTRODUCTION

There are very few reported preferred varieties of *C. olitorius* in Africa and as such the cultivars found on farmers plots are mostly traditionally inherited mixed populations and locally sourced types. This has aided the protection of the varietal variation and minimized the erosion of the genetic resources of *C. olitorius* [1]. In addition to farmers conservation of the genetic variability of *C. olitorius*, various other steps had been taken to collect and conserve the germplasm of *Corchorus* in national and institutional gene banks in Nigeria, Ethiopia, Kenya, Sudan and Zambia [2]. This facility exists in the tropical areas of the world and consists of about 40 species of herbs and sub-shrubs, 36 of which have been recorded in Africa [3]. However, considerable variations in morphological traits exist within the various local morphotypes [4] of *Corchorus olitorius*. In West Africa, there are 6 species of *Corchorus*, 5 of these occur in Nigeria; Namely *C. fascicularis; C. aestuans, C. tridens, C. olitorius* and *C. trilocularis* [5]. *Corchorus olitorius* L. is the most popular in Nigeria because it is cultivated as vegetable; the rest grow as weeds [4].

The genus *Corchorus* comprises an uncertain number of species with estimates ranging from 40-100. Two important cultivar groups of *Corchorus olitorius* exist: The vegetable types are combined in olitorius group, characterized by a plant height lower than 2 m, often not less than 1m, and a more or less heavily branched plant habit. The fibre types are classified in textile group, with plant height of 4-5 m and plant only slightly branched at the top. Within olitorius group, there are numerous local cultivated, e.g. early and late flowering and with differences in plant habit and leaf shape [6]. In Nigeria, the popular "Angbadu" is reputed to be suitable for transplanting and it has finely serrate elliptical-ovate leaves, where as 'Oniyaya' has smaller and coarsely serrate leaves, it is strongly branched and more suitable for direct sowing. In Nigeria a yield of 20-25 kg per 10 m^2 bed may be expected from 3-9 cuttings of "Amugbadu" during a period of 3-4 months. In an experiment in Cameroon a yield of 38 t/ha was obtained from a well-fertilized field of cultivar "Ewondo". Farmers however, usually obtain yields of 5 t/ha have been obtained in Bangladesh with improved cultivars grown under optimal agronomic conditions [4]. The objectives of this study were to determine the extent of morphological variability among the accessions, and also to identify relationships or associations among the morphological and yield characters of *C. olitorius* accessions evaluated.

2. MATERIALS AND METHODS

2.1 Seed Collection

Fourteen accessions of *C. olitorius* seeds were sourced from both Research centre and University environment namely, National Horticultural Research Institute (NIHORT) Ibadan, Babcock University Ilishan-Remo and Olabisi Onabanjo University Ago-Iwoye. The accessions represent part of the germplasm which are locally grown by local farmers around those areas and some of which were developed by these institutions (Table 1).

Table 1. *Corchorus olitorius* accessions evaluated and their sources

S/N	Accession name	Source
1	BUCR8	BU
2	BUCR4	BU
3	BUCR9	BU
4	NIHORT3	NIHORT
5	BUCR20	BU
6	BUCR12	BU
7	BUCR15	BU
8	BUCR6	BU
9	BUCR7	BU
10	BUCR18	BU
11	NIHORT4	NIHORT
12	NIHORT1	NIHORT
13	NIHORT2	NIHORT
14	WILD VARIETY	OOU

2.2 Seed Treatment

The two treatments are: (i) treated seeds and (ii) untreated seeds. Seed lots for each and all of the accessions were divided into two halves: one half was exposed to hot water treatment for 5 minutes and afterwards air-dried (treated), and the other half left untreated (untreated).

2.3 Field Evaluation

The experiment was carried out at the Teaching and Research experimental field of Babcock University Ilishan-Remo; which is located in the southern rainforest belt of Nigeria with an annual average rainfall of 1500 mm and mean daily temperature of 25-27°C between September and December (2015). A plot of 180 m^2 was used for the field evaluation; where the accessions were sown in three replications using a Randomized Complete Block Design (RCBD). Upon emergence, seedlings were thinned to a spacing of about 20 cm between plants. The plants were raised under rain-fed conditions and manual weeding was carried out to maintain weed-free plots. Write the geographical location of the study site.

2.4 Data Collection

Data collection commenced after three weeks of sowing when the accessions were fully established and distinct variations in plant morphological characteristics was evident. Ten plants were sampled in each plot; and observations were taken on some selected morphological and yield characters.

2.5 Statistical Analysis

Data were analyzed using Statistical Analysis Software (7) adopting the method of (8). Analysis of variance (ANOVA) was carried out on the characters evaluated for the treatments according to (9). Treatment means from ANOVA were separated using Duncan's Multiple Range Tests (DMRT). The relationship among the characters evaluated for all accessions was also studied using correlation coefficients which were generated through correlation analysis. The Principal Component Analysis (PCA) was also used to determine the extent of genetic variation and percentage similarity within accessions. Eigen-values and factor scores obtained from PCA were used to determine the relative discriminative power of the axes and their associated characters. Further relationships among *C. olitorius* characters as well as the 14 accessions evaluated were described using cluster analysis; where these accessions and their characters were grouped according to their associations; with the results produced as dendograms.

3. RESULTS AND DISCUSSION

Accession was highly significant on all the parameters evaluated ($P \leq 0.01$) except in number of stamen which was only significant at 5% level of probability (Table 2). Treatment was also highly significant except in leaf width and plant height at flowering which was only significant and in days to flowering and number of stamen which was not significant. Replication was only significant at 5% level of probability in leaf width and plant height at flowering while not significant on all other parameters evaluated. Interaction between the accession and the treatment was however not significant ($P>0.01$). Table 3 shows the means of 14 accessions of *C. olitorius* for morphological and yield character evaluated. The means of petiole length of all the accessions were significantly different from one another. The means of pedicel length, capsule length and pistil length were also different while the means of seed per capsule were not different except in BUCR18 and NIHORT4. The means of days to flowering were significantly different except in NIHORT4 and plant height at flowering. The means of number of stamen were also significantly different for all the accessions. Table 4 shows the means of two seed treatments of *C. olitorius* for morphological and yield characters evaluated. The means of the two seed treatments were significantly different from each another for all the morphological and yield characters of the crop evaluated. These results could implicate that the treatment was able to influence the performance of the accessions for the characters evaluated.

Adequate analyses of germplasm diversity are essential for proper understanding and utilization of genetic variability among accessions and their characters. Furthermore, the result also suggests variability among the accessions, sufficient enough for selection toward crop improvement [10]. Estimation of genetic variability has however been proven to involve morphological evaluation and characterization of accessions [11]. Some of the local land races of *C. olitorius* have been characterized based on differences in their morphological and other biological characters [12]. Several studies across the world have confirmed high morphological variation or differences among *C. olitorius* accessions [13].

Table 2. Means Square from analysis of variance for morphological and yield characters of *C. olitorius* accessions evaluated under field condition

sov	df	Ptl	psl	cpl	cpw	lfl	pdl	Lfw	spc	tsw	dtf	phf	Nos
acce	13	2.322**	11.981**	5.818**	0.053**	39.589**	0.014**	5.396**	4541.917**	0.490**	1701.849**	1241.253**	301.439*
trt	1	5.340**	112.984**	16.122**	0.170**	75.905**	0.242**	17.181*	1435.920*	0.585**	1239.399ns	1149.294*	511.093ns
acce*trt	13	0.271**	0.694ns	0.043ns	0.001ns	0.222ns	0.001ns	0.052ns	7.875ns	0.016ns	117.703ns	3.30ns	117.567ns
rep	2	0.052ns	1.188ns	0.473ns	0.008ns	10.606ns	0.010**	3.949*	761.993ns	0.103ns	892.216ns	923.306	52.171ns
error	54												
total	83												

Key: SOV=Source of variation, acce=accessions, trt=treatment, rep= replication, pdl=pedicel length, cpl= capsule length, cpw=capsule width, psl=pistil length, lfw= leaf width, spc=seedper capsule, tsw=one thousand seed weight, dtf=days to flowering, phf=plant height at flowering, nos=number of stamen

Table 3. Means of 14 accessions of *C. olitorius* for morphological and yield characters evaluated under field condition

Accessions	ptl	psl	cpl	cpw	lfl	pdl	Lfw	spc	tsw	Dtf	Phf	nos
NIHORT2	2.805a	5.008cd	4.477a	0.453ab	14.025a	0.242a	5.477a	112.58a	1.442a	94.16a	29.932ab	134.350cd
NIHORT3	2.337c	6.022abc	3.770bcd	0.425ab	13.797a	0.257a	5.393a	115.17a	1.445a	87.42a	29.900ab	155.567b
BUCR15	2.557abc	5.933bc	2.333e	0.335cd	13.027a	0.238a	6.105a	123.92a	1.472a	98.22a	25.030b	92.863ef
NIHORT1	2.938a	5.005cd	4.375ab	0.487a	14.007a	0.245a	5.523a	113.00a	1.470a	93.34a	27.387b	135.767cd
BUCR18	2.602abc	4.770d	4.075abc	0.435ab	14.012a	0.265a	5.665a	79.66b	1.477a	96.67a	28.170b	151.400bc
NIHORT4	0.497e	1.690f	3.317f	0.133e	13.747a	0.077a	2.393b	39.89c	0.495c	32.64b	10.667b	29.683h
BUCR12	2.632abc	6.773ab	3.577cd	0.342cd	13.010a	0.235a	5.048a	130.10a	1.477a	92.30a	27.992b	83.220f
BUCR7	2.722abc	5.968bc	3.552cd	0.338cd	12.630a	0.247a	5.377a	108.50a	1.462a	86.73a	29.232ab	58.023g
BUCR9	2.600abc	5.848bc 3	3.482cd	0.395bc	12.908a	0.252a	5.203a	114.83a	1.427a	90.28a	29.833ab	130.667d
BUCR20	2.652abc	7.057a	4.003abc	0.455ab	12.052ab	0.253a	5.530a	125.25a	1.467a	85.68a	30.808ab	176.752a
BUCR6	2.403bc	4.762d	4.058abc	0.435ab	13.930a	0.265a	5.347a	118.83a	1.443a	90.18a	30.533ab	141.867bcd
BUCR4	2.602abc	6.005abc	3.317d	0.425ab	13.747a	0.243a	5.550a	123.33a	1.440a	82.15a	43.950a	101.717e
BUCR8	2.435bc	6.315ab	3.428cd	0.447ab	13.148a	0.257a	5.052a	120.17a	1.405a	80.05a	27.317b	62.117g
WILD VAR	1.635d	3.367e	2.010e	0.275d	13.667b	0.190b	3.655b	55.22c	0.902b	104.30a	50.700g	50.700g

Key: means with same letter along the column are not significantly different from one another,pdl=pedicel length, cpl= capsule length, cpw=capsule width, psl=pistil length, lfw= leaf width, spc=seed per capsule, tsw=one thousand seed weight, dtf=days to flowering, phf=plant height at flowering, nos=number of stamen

Table 4. Means of two seed treatments of *C. olitorius* for morphological and yield characters evaluated under field condition

Treatments	ptl	psl	cpl	cpw	lfl	pdl	lfw	spc	tsw	dtf	Phf	nos
Treated	3.169a	0.287a	6.483a	3.825a	0.429a	13.411a	5.546a	109.881a	1.428a	90.564a	111.177a	30.386a
Untreated	1.605b	0.179b	4.163b	2.949b	0.339b	11.509b	4.642b	101.612b	1.261b	82.882b	103.779b	25.452b

Key: means with same letter along the column are not significantly different from one another, pdl=pedicel length, cpl= capsule length, cpw=capsule width, psl=pistil length, lfw= leaf width, spc=seedper capsule, tsw=one thousand seed weight, dtf=days to flowering, phf=plant height at flowering, nos=number of stamen

Table 5. Relationships among Morphological and Yield Characters of *C. olitorius* Evaluated under Field Condition

	ptl	pdl	Psl	cpl	cpw	lfl	lfw	spc	tsw	Phf	nos	dtf
ptl		0.918**	0.873**	0.786**	0.783**	0.761**	0.736**	0.605**	0.727**	0.438**	0.458**	0.279**
Pdl			0.876**	0.805**	0.855**	0.850**	0.827**	0.671**	0.812**	0.518**	0.459**	0.396**
psl				0.721**	0.757**	0.767**	0.792**	0.786**	0.802**	0.430**	0.504**	0.316**
Cpl					0.915**	0.854**	0.767**	0.693**	0.830**	0.726**	0.499**	0.425**
Cpw						0.904**	0.847**	0.753**	0.864**	0.723**	0.547**	0.482**
Lfl							0.938**	0.832**	0.952**	0.626**	0.579**	0.639**
Lfw								0.829**	0.939**	0.602**	0.538**	0.610**
Spc									0.894**	0.529**	0.531**	0.508**
Tsw										0.636**	0.559**	0.624**
Phf											0.336**	0.405**
Nos												0.304**
Dtf												

*Key: **significant at 1% level of probability, pdl=pedicel length, cpl= capsule length, cpw=capsule width, psl=pistil length, lfw= leaf width, spc=seedper capsule, tsw=one thousand seed weight, dtf=days to flowering, phf=plant height at flowering, nos=number of stamen*

All the characters had significant and positive correlation (P≤0.01) with one another. The positive and significant correlation among characters is indicative of a complementary association where an increase or appreciation in one character leads to an increase in the other. For example increase in the length of the petiole, pistil and capsule also increases the leaf size and the overall vegetative and dry matter yield of the crop. Several related studies also have reported positive and significant correlation among variables evaluated [10,13].

The principal component relationships among morphological and yield characters of C, *olitorius* evaluated on the field are presented with the Eigen values or vectors of the characters (Table 6). Positive values were also recorded (as in screen house evaluation) only at the principal axis 1 for all the characters evaluated; with leaf length having the highest Eigen value (0.321647) and days to flowering having the least (0.201199). Other principal axes (2 – 13) showed distribution of positive and negative relationships among the characters (Table 6).

Table 6. Eigen values from principal component analysis of morphological and yield characters of *C. olitorius* evaluated under field condition

PC7	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Ptl	0.272653	-.404011	0.057547	-.198704	0.318018	0.164963	0.173527
Pdl	0.295274	-.270443	0.012916	-.234177	0.247993	0.136543	-.025248
Psl	0.281425	-.334903	0.212913	-.171634	-.175092	0.018344	0.529440
Cpl	0.296621	-.102443	-.294266	0.107574	0.231036	-.285495	-.088937
Cpw	0.310420	-.063569	-.201748	0.090034	0.145421	-.159377	-.214129
Lfl	0.321647	0.089388	0.031477	-.048085	0.025350	-.064721	-.359150
Lfw	0.308711	0.017331	0.050976	-.089793	-.267690	0.368121	-.484631
Spc	0.284400	0.049939	0.168396	0.009381	-.640798	-.338764	0.184482
Tsw	0.317956	0.072481	0.037216	-.045211	-.253775	-.029604	-.185348
Dtf	0.201199	0.627654	0.078259	-.259107	0.118781	0.495002	0.246630
Lwr	0.249087	0.467796	0.120189	-.097092	0.344344	-.516180	0.165826
Phf	0.224942	0.090108	-.720905	0.361137	-.144318	0.217798	0.335491
Nos	0.202647	-.000222	0.500289	0.798155	0.177054	0.180707	0.045397
	PC8	**PC9**	**PC10**	**PC11**	**PC12**	**PC13**	
Ptl	0.248276	-.175060	0.611039	-.240977	-.120895	0.151124	
Pdl	-.435163	0.032910	-.073066	0.706428	0.088430	0.035189	
Psl	-.084870	0.053624	-.516115	-.336725	0.058356	-.171193	
Cpl	0.654337	-.090881	-.342124	0.184387	0.259303	0.076550	
Cpw	-.095655	0.784148	0.037604	-.199465	-.298368	-.064256	
Lfl	-.129623	-.237075	0.156760	-.179780	0.299931	-.729089	
Lfw	0.299931	-.027809	-.137622	-.272492	0.282583	0.520693	
Spc	0.125416	0.181683	0.398253	0.279212	0.195942	0.071168	
Tsw	0.090039	-.365126	-.155549	0.123494	-.779657	-.043057	
Dtf	0.299994	0.224151	-.009206	0.120193	0.000941	-.132571	
Lwr	-.320876	-.189512	-.004005	-.184005	0.029640	0.330316	
Phf	-.253227	-.180922	0.099978	-.047923	0.030795	0.015560	
Nos	-.002018	-.007255	-.006674	0.073058	0.000476	0.009548	

The number of clusters obtained among the characters ranged between 0.5 and 8.0, with as much as 4 – 5 characters constituting the highest cluster number of 8.0 (Fig. 1). The number of clusters obtained among the characters ranged between 0.2 and 2.2 with all the accessions including the wild variety showing a close clustering relationship under field conditions (Fig. 2). The relative discriminating capacity of the principal components (PC) is shown by their Eigen-values. In the work of (15), results indicated that only two of the seven PC had Eigen values greater than 1.0 and together accounted for over 85% of the total variability. The PC 1 had the highest discriminating power revealed by its highest Eigen -value of 4.97 followed by PC 2 with Eigen-value of 1.02. The first PC accounted for 71.02% of the total variation with an exception of days to 50% flowering (0.082). Multivariate methods such as principal component analysis (PCA) have proven to be useful for characterizing, evaluating and classifying germplasm when a large number of accessions are assessed for several characteristics of agronomic importance [14]. A 3-year study was carried out at a rain-forest site where 41 accessions were studied for 13 shoot, growth and productivity characters. Leaf shape and days to flowering were the first characters to be distinguished. Plant branching also varied within accessions, depending on spacing and soil fertility [4].

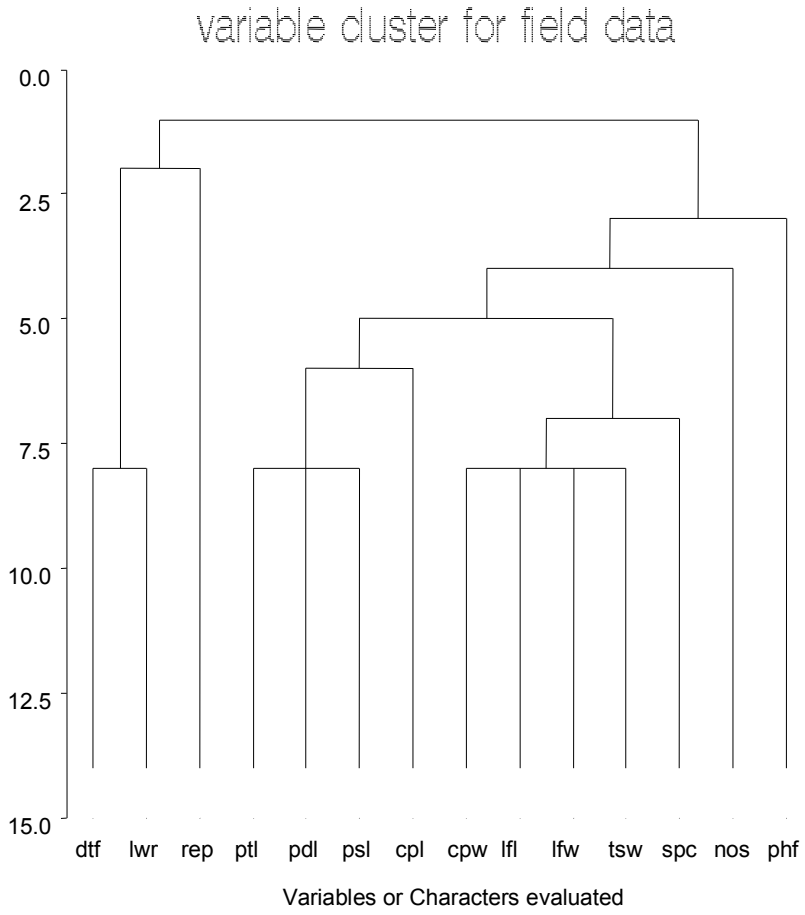

Fig. 1. Dendograms showing clustering relationship among 13 characters of *C. olitorius* evaluated under field condition

Key: ptl=petiole length, pdl=pedicel length, cpl= capsule length, cpw=capsule width, psl=pistil length, lfw= leaf width, spc=seed per capsule, tsw=one thousand seed weight, dtf=days to flowering, phf=plant height at flowering, nos=number of stamen, lfl=leaf length

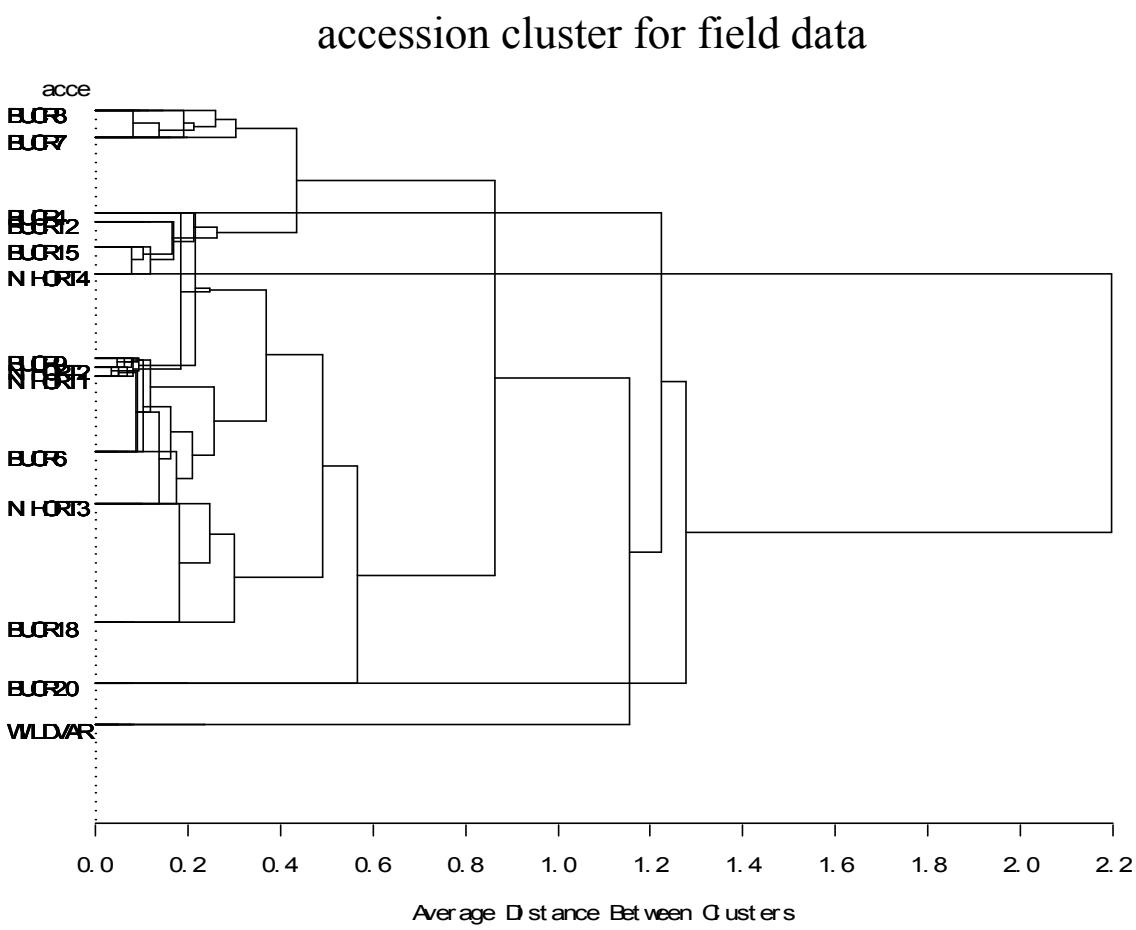

Fig. 2. Dendograms showing clustering relationship among 14 accessions of *C. olitorius* evaluated under field condition. Vertical scale on the dendogram is not clear

4. CONCLUSION

Generally, the results of this work at all levels showed distinct and significant variations and variability among the accessions evaluated; with the wild *C. olitorius* accessions maintaining also a significant distance from the cultivated accessions. The study demonstrates that the accessions investigated were highly variable for all the morphological and yield traits evaluated. This variability harbors obvious potential for improvement in *C. olitorius*. Therefore, some of the cultivated accessions that were outstanding could be used for further breeding works and also serve as potential parents with the wild relatives. The molecular and chromosomal characteristics of these accessions can be studied in the future to ascertain genetic variability that could not be identified at the morphological level; and more wild varieties of *C. olitorius* can be included in this kind of study in order to broaden the basis for morphological and genetic comparison between wild and improved accessions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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