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Heritability, Character Association and Genetic Advance in Six Agronomic and Yield Related Characters in Leaf *Corchorus olitorius*

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ABSTRACT

The objective of this study was to assess 15 genotypes of *Corchorus olitorius* for broad-sense heritability, character association and genetic advance in five yield related characters. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. High estimates of broad-sense heritability was recorded in number of leaves per plant (96.99), plant height at maturity (95.61), leaf weight per plant (94.72), total weight per plant (97.02) and harvest index (75.00) suggesting additive gene effect in the expression of these characters. Meanwhile, Number of leaves per plant, plant height at maturity, leaf weight per plant and total leaf weight per plant, combining high heritability, Genotypic Coefficient of Variability (GCV) and Genetic Advance (GA), suggests that selection based on these characters will be meaningful in predicting for vegetative yield in *C. olitorius*. Strong positive genotypic and phenotypic correlation was reported between number of leaf per plant and plant height at maturity (0.43, 0.45), leaf weight per plant (0.86, 0.87), total plant weight (0.81, 0.82) and harvest index (0.33, 0.38), suggesting that selection based these characters will lead to an increase in vegetative yield of *C. olitorius*. Meanwhile, significant negative phenotypic and genotypic correlations between plant height at maturity and harvest index is an indication that selection based of plant height alone will depress vegetative yield in *C. olitorius*. The results from this study leads to the conclusion that number of leaves per plant, plant height, leaf weight per plant and total plant weight should be considered during selections for vegetative yield in *C. olitorius*.

Key words: Genotype, harvest index, indigenous vegetable, yield, jute mallow

INTRODUCTION

Corchorus olitorius is an important Indigenous Leaf Vegetable (ILV) of Africa. In Ghana and Tanzania *C. olitorius* it is regarded as a vegetable of regional importance, ranking among the top ten indigenous cultivated vegetables (Schippers, 1996, 2000) while in Nigeria, *Corchorus olitorius* ranks among the top five most important vegetables in the south west of the country. In Africa, it is cultivated principally for the slimy leaves which is found suitable for the consumption of the staple food crops products such as eba, tuwo, elubo, etc. in Nigeria. *Corchorus olitorius* is one of the top five most important vegetables with 'draw' properties (others are okra, *Irvingia gabonensis*, *Adansonia digitata*) which are used commonly in parts of West Africa. It is also popular in Egypt and Sudan for the draw property in the traditional dish called Malachia. Industrially, *C. olitorius* is used extensively in Asia for the production of jute hence the name 'jute mallow' (Denton, 1993). There is a wide diversity of cultivated types found on farmers plots in Africa Nath and Denton (1979) and Westphal-Stevels (1986), including intermediate types arising from natural crossing. In traditional African farming system, the yield of *C. olitorius* is made up of the vegetative parts which is harvested by intermittent cutting of the branches or by uprooting of whole plants. The edible leaves are later removed from the branches for consumption. Considerable variation exist in the vegetative characters that are associated with the green leaf yield e.g., branching, plant height, leaf size etc. (National Horticultural Research Institute, 1986). Similar variations also exist in some qualitative characters including, leaf and stem color, branching habit, fruit color etc. Denton (1993) observed that the green leaf yield of the crop in Bangladesh and India was about 5 t ha^{-1} and in Brazil the yields were 1.5-2.0 t ha^{-1}. In West Africa, the average yield on farmers' plots is 5-15 t ha^{-1} although much higher yields have been recorded on experimental plots in Nigeria and Cameroon (Fondio and Grubben, 2004). The yield can be further increased in agronomic areas with application of chemical and organic fertilizers (Olaniyi and Ajibola, 2008). Crop improvement programmes on jute for selection of varieties with finer fiber have, over the years, received considerable attention in Bangladesh and India but there have been limited genetic improvement programme on the African vegetable type of *C. olitorius*. Separation of segregating populations into distinct leaf types was carried out at Nihort, Nigeria (National Horticultural Research Institute, 1986). A review of the application of biotechnology and tissue culture techniques in solving production and improvement related problems in the indigenous leafy vegetables of Africa including *C. olitorius* was done by Opabode and Adebooye (2005). Various attempts had been made to conserve the germplasm of Corchorus spp in national and institutional gene banks in e.g., Nigeria, Ethiopia, Kenya, Sudan and Zambia (Attere, 1997) but the rate of genetic exploitation of the variation for production of improved cultivars and vegetative yield have not received sufficient attention. Rapid genetic improvement of crop depends on the availability of sufficient genetic diversity, which could be selected and combined in various forms to produce reasonable improvement (Denton and Nwangburuka, 2011; Wani *et al.*, 2011). Various methods have been employed in the determination of heritability estimates (Wray and Visscher, 2008; Jindal *et al.*, 2010; Denton and Nwangburuka, 2011; Nwangburuka *et al.*, 2012). Estimates of heritability values become more reliable and meaningful when combined with genetic advance (Denton and Nwangburuka, 2011). High heritability and genetic advance in a trait indicates the presence of additive genes in such trait and further suggest reliable crop improvement through selection of such a trait (Panse, 1957). Similarly, information on character association between yield and yield related characters in crops is important for effective and rapid progress in selection and crop improvement (Binodh *et al.*, 2008; Denton and Nwangburuka, 2011). This will indicate the interrelationship between two or more plant characters and yield, providing suitable means for indirect selection for yield. The present study was aimed at evaluation of fifteen accessions of *C. olitorius* and determination of the heritability, genetic advance and association of quantitative vegetative characters with the leaf yield of vegetable *C. olitorius*.

MATERIALS AND METHODS

Fifteen accessions of *Corchorus olitorius* (Table 1) including single plant selections and cultivars obtained from the National Horticultural Research Institute, Idi Ishin Nigeria and local seed markets, were planted between May 2009 and May 2010 at the teaching and research experimental plot of Babcock University Horticultural Unit, in the southern rainforest belt of

Table 1: Accessions and their sources

Accession name	Source
BUCor 02	UNAAB
BUCor 04	NIHORT
BUCor 05	NIHORT
BUCor 08	NIHORT
BUCor 10	UNAAB
BUCor 12	NIHORT
BUCor 13	NIHORT
BUCor 14	UNAAB
BUCor 15	NACGRAB
BUCor 18	NIHORT
BUCor 19	NIHORT
BUCor 23	NIHORT
BUCor 24	NIHORT
BUCor 31	UNAAB
BUCor 40	NIHORT

NIHORT: National Horticultural Research Institute, Ibadan, UNAAB: University of Agriculture, Abeokuta, BU: Babcock University Ilishan-Remo, NACGRAB: National Centre for Genetic Resources and Biotechnology

Nigeria. The seed dormancy for each accession was first removed with hot water treatment for ten seconds and the trial was then set up in a Randomized Complete Block Design (RCBD). The seeds of the accessions were mixed separately with fine river sand (1 g seed:10 kg sand) and then drilled in rows on raised beds, each row was 5.0 m long with a spacing of 50 cm between two rows and within rows the seedlings were thinned to a spacing of 2.0 cm between plants. There were four rows of plants per plot for each accession and each plot was replicated three times. Before drilling the seeds, a pretreatment of cured poultry manure was applied on all the plots at the rate of 20 t ha^{-1}. The plants were raised under rain fed conditions and manual weeding was carried out to maintain weed free plots. Regular insecticidal control measure was maintained during the investigation. At eight weeks after sowing when the accessions were fully established and there were distinct variations in plant morphological characteristics, ten competitive plants in each plot were harvested and observations were taken on the following morphological characteristics on each plant:

- Plant height at maturity (cm)
- Number of leaves per plant
- Fresh leaf weight per plant (g)
- Stem weight (g)
- Total plant weight (g)
- Harvest index (%): Determined by dividing the fresh leaf weight by total plant weight and expressing the value in percentage

The mean value for each character was calculated as the average for the ten harvested plants and was used for the statistical analysis.

Data analysis: Data collected on the morphological characters were analyzed using SAS (1999). The yield and yield component were used to determine the genotypic and phenotypic variances according to Prasad *et al*. (1981) as follows:

$$\text{Genotypic varience } (\delta^2 g) = \frac{MSG - MSE}{r}$$

$$\text{Phenotypic variance } (\delta^2 ph) = \frac{MSG}{r}$$

$$\text{Error variance } (\delta^2 e) = \frac{MSE}{r}$$

Where:
MSG = Genotype mean squares
MSE = Mean square error
R = Number of replications

The variance component was used to compute the Genotypic Coefficient of Variability (GCV), Phenotypic Coefficient of Variability (PCV), estimates of broad-sense heritability and Genetic Advance (GA) according to Burton (1952), Johnson *et al.* (1955) and Kumar *et al.* (1985) as follows:

$$\text{Genotypic coefficient of variability } = 100 \times \frac{\delta g}{x}$$

$$\text{Phenotypic coefficient of variability } = 100 \times \frac{\delta ph}{x}$$

where, δg and δph are the genotypic and phenotypic standard deviations, respectively and X is the grand mean for the character under consideration:

$$\text{Herbility (Broad - sense)} = \frac{\delta^2 g}{\delta^2 g + \delta^2 e}$$

where, $\delta^2 g$ is the estimate of genotypic variance, $\delta^2 e$ is the estimate of environmental variance

$$\text{Genetic advance} = \text{heritability} \times k \times \delta ph$$

where, K (selection differential expressed in phenotypic standard deviations) = 2.06.

Estimates of genotypic and phenotypic correlation coefficients among the characters were obtained using the formula of Miller *et al.* (1958) as follows:

$$r_{x,y} = \frac{CoV_{(x,y)}}{\sqrt{(\delta^2 x)(\delta^2 y)}}$$

where, $r_{x,y}$ is either genotypic or phenotypic correlation between variables x and y, $CoV_{(x,y)}$ is the genotypic or phenotypic covariance between two variables, $\delta^2 x$ is the genotypic or phenotypic variance of the variable x and $\delta^2 y$ is the genotypic or phenotypic variance of the variable yield y.

RESULTS AND DISCUSSION

The result of analysis of variance indicated significant differences (p = 0.01) among the genotypes in all the characters studied except in stem weight per plant (Table 2). This suggests that there were genetic diversity in these characters among the accessions studied and further suggests prospects for meaningful selection for Corchorus improvement. This agrees with the reports of Dar and Sharma (2011), who reported significant variation in quantitative characters in 60 tomatoes genotypes, Kitila *et al.* (2011) reported significant variations in quantitative traits in coffee; Singh *et al.* (2011) reported significant variations quantitative characters in field pea, Nwangburuka *et al.* (2012) reported significant variations in nine yield related characters in twenty nine accessions of okra and Denton and Nwangburuka (2011) reported significant genetic variations in six yield related characters in eighteen accessions in *Solanum anguivi*. Table 3, shows the mean, standard error, phenotypic, genotypic and environmental variances, Phenotypic Coefficient of Variability (PCV) and Genotypic Coefficient of Variability (GCV), heritability in the broad-sense and genetic advance observed in the characters studied in the fifteen accessions of *Corchorus olitorius*. Generally, the value of PCV was slightly higher than the GCV value in all the traits except for stem weight per plant. This may suggest slight environmental effect on the phenotype of all the other characters except stem weight per plant. This report corresponds to the report of Denton and Nwangburuka (2011), Nwangburuka *et al.* (2012), Mohammed *et al.* (2012), Yadav *et al.* (2011) and Ayalneh *et al.* (2012) who observed slight differences between PCV and GCV in characters studied in *Solanum anguivi*, okra, Ethiopian Duram wheat, Rice and in seven out of sixteen characters in Tef, respectively. The PCV ranged from (8.92) for harvest index to (70.66) for stem weight. Similarly, GCV ranged from (7.73) for harvest index to (36.39) for leaf weight. The high PCV and GCV values recorded in stem weight and leaf weight suggests that these traits accounts for most of the variation recorded in *C. olitorius*. This may also suggest a huge prospect for selection based on these characters for yield improvement in *C. olitorius* (Denton and Nwangburuka, 2011; Aragaw *et al.*, 2011; Ayalneh *et al.*, 2012). The phenotypic and genotypic

Table 2: Mean squares of vegetative and yield related characters of fifteen *Corchorus olitorius* accessions in Ilishan-Remo rainy season

Source of variation	df	No. of leaves per plant	Plant height at maturity (cm)	Stem weight (g)	Fresh leaf weight per plant (g)	Total weight per plant (g)	Harvest index (%)
Block	2	0.79	2.36	14.72	0.07	0.007	0.003
Varieties	14	40.89**	58.25**	18.09	1.63**	7.95**	0.004**
Error	28	1.23	2.56	14.97	0.09	0.24	0.001
CV (%)		9.29	5.79	111.34	14.88	10.07	6.98

**Significant at 1% (p = 0.01) level of probability

Table 3: General mean, estimate of phenotypic and genotypic variance, phenotypic and genotypic coefficient of variability, broad-sense heritability and genetic advance expressed for 15 *Corchorus olitorius* accessions

Character	Mean	SE	Phenotypic variance	Genotypic variance	Phenotypic coeff. of variability	Genotypic coeff. of variability	Heritability (broad-sense)	Genetic advance (% of mean)
No. of leaves	11.94	0.55	13.63	13.22	30.91	30.44	96.99	61.76
Plant height	27.62	0.67	19.42	18.57	15.96	15.60	95.61	31.43
Stem weight	3.48	0.60	6.03	1.04	70.66	29.36	17.26	25.13
Leaf weight	1.97	0.11	0.54	0.51	37.39	36.39	94.72	72.96
Total weight	4.84	0.24	2.65	2.57	33.65	33.15	97.02	67.26
Harvest index	0.41	0.01	0.00	0.00	8.92	7.73	75.00	13.78

variance was highest in plant height (19.42 and 18.57) but lowest in the harvest index (0.00 and 0.00). High genotypic variance facilitates selection for improvement and widens the probability for heritability of traits from parents to offspring (Ayalneh *et al*., 2012). Broad-sense heritability estimates varied from low to high. Dabholkar (1992) categorized heritability estimates as low (5-10%), medium (11-30%) and high (>30%). Maximum estimates of broad-sense heritability was recorded in total plant weight (97.02), number of Leave per plant (96.99), plant height (95.61), leaf weight per plant (94.72) and harvest index (75.00). This suggests the effect of additive genes in the inheritance of these characters. This further indicates that any selection in *C. olitorius* based on the phenotype of these characters will be effective in the improvement of *C. olitorius* vegetative yield. According to Gandhi *et al*. (1964) and Ibrahim and Hussein (2006), prediction of the response of an individual to selection are more reliable when GCV, estimates of broad-sense heritability and genetic advance is combined instead of relying on the estimates of broad-sense heritability estimates alone. When the GA is high the heritability is mainly due to additive gene effect (Percy and Turcotte, 1991). Hence selection based on characters such as number of leaves per plant (30.44, 96.99 and 61.67), plant height (15.60, 95.61 and 31.43), leave weight per plant (36.39, 94.72 and 72.96) and total plant weight (31.16, 97.02 and 67.26) combining high GCV, heritability and GA, respectively are under additive gene effect and will be effective in accurate prediction of yield (Bello *et al*., 2006). This agrees with the reports of Mohammed *et al*. (2012) in their work with wheat; Yadav *et al*. (2011) in their report on rice, Parthiban *et al*. (2011) in their report with Jathropa and Ayalneh *et al*. (2012), who reported combined high estimates of heritability and genetic advance in days to panicle emergence in Tef. Meanwhile, Nwangburuka *et al*. (2012) reported high combined broadsense heritability, GCV and genetic advance in characters such as plant height at maturity, pod length at maturity, number of branches per plant and pod weight per plant in okra. High heritability and genetic advance is an indication of how much selection to improve a character can be based of phenotypic performance (Johnson *et al*., 1955).

Table 4 shows the genotypic and phenotypic correlation coefficients among six characters of *C. olitorius* in the rainy season. The result shows that there was strong significant and positive

Table 4: Genotypic and phenotypic correlation coefficients among six characters of *Corchorus olitorius* in rainy season at Ilishan-Remo

Character	Plant height at maturity	Stem weight per plant	Leaf weight per plant	Total plant weight	Harvest index
No. of leaves per plant					
P	0.43**	0.16	0.86**	0.81**	0.33**
G	0.45**	0.45**	0.87**	0.82**	0.38**
Plant height at maturity					
P		0.50**	0.59**	0.72*	-0.35**
G		1.29**	0.64**	0.77**	-0.40**
Stem weight per plant					
P			0.25	0.35*	0.11
G			0.68**	0.88**	0.21
Leaf weight per plant					
P				0.97**	0.32*
G				0.98**	0.32*
Total plant weight					
P					0.14
G					0.16

*, **Significant at 5 and 1% level of probability, P: Phenotypic correlation, G: Genotypic correlation

relationship between number of leaves per plant and plant height at maturity (0.43, 0.45); leave weight per plant (0.86, 0.87); total plant weight (0.81, 0.82), Harvest index (0.33, 0.38), whereas there was only significant genotypic significant correlation between number of leaves per plant and stem weight per plant (0.45). This is an indication that the phenotype is a true reflection of the genotype. It further suggests that selection based on these characters will lead to increase in leaf vegetative yield in *C. olitorius*. Similarly, strong significant and positive phenotypic and genotypic correlation exists between plant height at maturity and stem weight per plant (0.50, 1.29), leave weight per plant (0.59, 0.64), total plant weight (0.72, 0.77), while the relationship was negative and significant between plant height at maturity and harvest index on both the phenotypic and genotypic level (-0.35, -0.40). This suggests that selection plant height will influence and increase in the vegetative yield of *C. olitorius*, whereas this will depress the harvest index. This agrees with the report of Nwangburuka *et al.* (2012) and Denton and Nwangburuka (2011) who reported that selection based on plant height will favor a high yield in okra and *Solanum anguivi*, respectively. Stem weight per plant had significant and positive genotype correlation with leaf weight per plant (0.68) whereas stem weight per plant expressed significant and positive phenotypic and genotypic correlation with total plant weight (0.35, 0.88). Total leaf weight per plant had strong significant and positive phenotypic and genotypic correlation with total plant weight (0.97, 0.98), harvest index (0.32, 0.32). This also suggests that any selection based on total plant biomass and harvest index will prove successful in *C. olitorius* yield improvement.

CONCLUSIONS

The results from this study leads to the conclusion that there are significant genetic variability among the accessions studied. The genetic variability were more prominent in number of leaves per plant, leaf weight and stem weight per plant. It further concludes that characters such as number of leaves per plant, plant height, leave weight per plant and total plant weight combining high GCV, heritability and GA, should be considered during selections for vegetative yield in *C. olitorius*.

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