Nigerian Journal of Crop Improvement, Vol.1.Issue 1; 2025
ISSN :3122-0371
Published by the Nigerian Plant Breeders Association (NPBA)

Genetic Variability and Interrelationship between Leaf Yield and Related Attributes of Nigerian *Corchorus olitorius* Accessions

Richmond Emuohwo Edugbo[a1] and Godson Emeka Nwofia[a*]

[a]Department of Crop and Horticultural Science, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria

[1]Department of Applied Biology, Federal University of Technology, Babura, Jigawa State, Nigeria

***Corresponding Author:** Godson E. Nwofia; enwofia@yahoo.co.uk

Authors' Contributions

Abstract

The study was carried out to assess the genetic variability and character association in 33 Nigerian accessions of *Corchorus olitorius* at Benin City in Southern Nigeria. The experiment was set-up using the randomized complete block design with three replications. Data were collected on agronomic traits including leaf yield. Analysis of Variance for leaf yield and all agronomic characters measured indicated highly significant genotypic differences among the accessions. Plant height at flowering ranged from 80.53 cm to 155.18 cm; leaf yield varied between 2.52 t/ha and 8.86 t/ha. The leaf yield of 24% of the accessions exceeded 5 t/ha. Variance components analysis indicated that the broad-sense heritability (29.69 - 98.97%) and the genetic advance (16.59 - 156.88%) values for most characters ranged from moderate to high. Correlation and path analyses further revealed that attributes such as plant height, fresh shoot weight, number of branches per plant, and days to pod maturity had significant positive correlations and contributed positively to leaf yield. These characters could be used to indirectly select for leaf yield. These findings collectively offer valuable guidance for designing breeding programs aimed at enhancing both productivity and adaptability of *C. olitorius* cultivars for Nigeria and other regions of West Africa

Keywords*:* *Corchorus olitorius*; Genetic variability; heritability, Accessions, genotype, correlation, path analysis

Introduction

Corchorus olitorius (L.), commonly called jute mallow, Jews mallow or nalta jute, "tossa jute", "bush okra", "krinkrin", "molokhia", and "West African sorrel", among many other local names, (Nyadanu *et al*., 2017), is a species of shrub belonging to the family, *Malvaceae*. The leaves and immature fruits are used as vegetable, while the dried leaves are used for tea and as a soup thickener. The seeds are also edible (Nyadanu *et al*., 2017). In Nigeria and most parts of Africa, it is cultivated mainly for its slimy leaves which are used in making soups found suitable for the consumption of the staple food crop products such as 'amala', 'eba' and 'tuwo'. It is rich in antioxidants (Chipurura *et al*., 2011; Kumawat *et al*., 2012; Barku *et al*., 2013) and a rich source of nutrients such as proteins, carbohydrates, vitamins and minerals (Steyn *et al*., 2001; Matsufuji *et al*., 2001; Adeniyi *et al*., 2012; Nyadanu and Lowor, 2015).

Improvement programs for selection of high fibre yielding varieties with finer fibre have received considerable attention over the years, particularly in Bangladesh and India (Palit *et al*., 1996; Das and Maiti, 1998; Palve and Sinha, 2005), but efforts on the genetic improvement of *C. olitorius* as an African vegetable crop have been negligible (Nwangburuka and Denton, 2012; Nyadanu *et al.,* 2017; Ngomuo *et al*., 2017). The progress of a breeding program is mostly conditioned by the magnitude and nature of the genotypic and non-genotypic variations in the various characters of the crops to be improved. Crop improvement depends not only on the magnitude of phenotypic variability but also on the extent to which the characters are heritable (Nwofia and Chimaobi, 2012). Many studies have shown that improved yields can be obtained by utilizing additive and non-additive gene effects involving dominance and epistasis (Tucak *et al*., 2012). The study of heritability and genetic advance is crucial for estimating the scope for improvement by selection. Heritability and genetic advance together with genotypic coefficient of variability could provide the best improvement to be expected through phenotypic selection (Johnson *et al*., 1955).

High heritability and genetic advance estimates indicate the presence of additive genes in a trait and suggest that crop improvement can be made through selection of such trait (Panse, 1957). There are many approaches for estimating heritability. It can be estimated by the parent-offspring regression approach, or by comparing full-sibs. Analysis of variance is also commonly used to compute estimates of heritability, as well as correlation and regression. Higher heritability for a trait signals its propensity for greater genetic gain (Nwofia *et al*., 2013).

Similarly information on relationship between yield and yield-related traits in crops is vital for effective and rapid progress in selection and crop improvement (Binodh *et al*., 2008; Denton and Nwangburuka, 2011). According to Nwofia *et al*. (2018), relationship studies among agronomic traits of crops are essential for assessing the feasibility of joint selection of two or more traits that may be integral to a product target. Furthermore, this will show the interrelationship between two or more plant characters and yield, giving suitable means for indirect selection for yield. This study was conducted to evaluate the variability in leaf yield and other agronomic attributes of 33 Nigerian accessions of *C. olitorius* and to determine the association of agronomic characters with leaf yield in *C. olitorius*.

Materials and methods

The experiments were conducted from May to November in 2019 planting seasons at the Teaching and Research Farm of the Department of Crop Science, University of Benin, Benin City, Nigeria (8° 10' N, 4° 10' E, 152m asl). The soils are underlain by sands, clayey sands and discontinuous clay sequences of Benin Formation of the Niger Delta Basin classified as ultisols (Olatunji *et al*., 2014, Umweni *et al*., 2014). Rainfall is of high intensity and bimodal, from March to November. About 2025 mm of precipitation falls annually in Benin City with an average annual temperature of 26.1 °C (Climate-Data.org, 2016).

Pre-planting soil sample collection was done to determine the physical and chemical properties of the soil of the planting site. Soil samples from depths of 0-20cm were collected from different points of the planting site by random sampling, and bulked to form a representative sample before analysis

Seeds of 33 accessions of *C.olitorius* were obtained from the National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan, Oyo State, Nigeria. Seedlings of these accessions were raised in a nursery and then transplanted to the main field three weeks after germination. Dormancy in the *C. olitorius* seeds was broken by steeping in hot water for 3 minutes.

The experiment was laid out in a randomized complete block design with three replications. Each experimental unit consisted of a plot measuring 2m x 1m ($2m^2$) with an alley of 0.5m between each experimental plot. The *C. olitorius* seedlings were transplanted in raised beds under rainfed conditions at a spacing of 50cm between rows and 20cm within rows giving a plant population of 100,000plants/ha. Manual weeding was carried out at 4, 8, 12 and 16 weeks after transplanting.

Data were collected on the following agronomic attributes using the methods as outlined by Loumerem and Alercia (2016) and Ngomuo *et al* (2017); plant height (cm), stem width (cm), canopy diameter (cm), number of branches per plant, number of leaves per plant, petiole length (cm), leaf length (cm), leaf width (cm), number of days to flowering, number of days to maturity, number of days to pod maturity, number of pods per plant: pod length (cm), number of seeds per pod, 100 seed weight (g), fresh shoot weight (g), and leaf yield (t/ha).

Data were subjected to analysis of variance (ANOVA) using GenStat for Windows, 12th edition (2009) and mean separation done using the Least Significant Difference (LSD) test at the 5% probability level. Variance component analysis was used to determine the proportion of the total variation in each trait that is of breeding value. Genotypic variance, environmental variance and phenotypic variance were estimated from the ANOVA table according to the methods of Alika (2010) as follows:

$$\text{Genotypicvariance}\left(\sigma_g^2\right) = \frac{MS_g - MS_e}{r}$$

$$\text{Error variance } \left(\sigma_e^2\right) = MS_e$$

$$\text{Phenotypic variance } \left(\sigma_p^2\right) = \frac{MS_g}{r}$$

Where MS_g = Genotype mean square

MS_e = Error mean square

Genotypic and phenotypic coefficient of variability (GCV% and PCV%) were estimated according to Singh and Chaudhary (1995) as follows:

$$GCV(\%) = \frac{\sqrt{\sigma_g^2}}{\overline{x}} \times \frac{100}{1}$$

$$PCV(\%) = \frac{\sqrt{\sigma_p^2}}{\overline{x}} \times \frac{100}{1}$$

Where GCV = Genotypic coefficient of variability

PCV = Phenotypic coefficient of variability

σ_g^2 = Genotypic variance

σ_p^2 = Phenotypic variance

$\overline{x}$ = Mean

Broad sense heritability and genetic advance were estimated according to Johnson *et al*. (1955) as follows:

$$H^2 = \frac{\sigma_g^2}{\sigma_p^2} \times \frac{100}{1}$$

$$GA = \frac{k \times \sqrt{\sigma_p^2} \times \sigma_g^2}{\sigma_p^2}$$

$$GAM = \frac{GA}{\overline{x}} \times \frac{100}{1}$$

where;

H^2 = Broad-sense heritability

GA = Genetic advance

GAM = Genetic advance as a percentage of the mean

K = 2.06 at 5% selection intensity

Pearson's correlation analysis was used to estimate the strength and direction of the association between leaf yield and other characters. Stepwise multiple regression and sequential path diagrams were used to explain the causal relationships among traits using the procedure described by Mohammadi *et al*. (2003). The stepwise multiple regression analysis was performed using the Statistical Package for the Social Sciences, SPSS version 17.0 (SPSS Inc., 2007) to determine the first, second, third and fourth order predictor traits based on their contributions to the total variation in leaf yield with minimized multi-collinearity (Badu-Apraku *et al*., 2017).

Result and discussion

Table 1-3 show the mean values of the growth and yield attributes of the 33 *C. olitorius* accessions. Analysis of variance indicated that jute accessions differed significantly in their performances for various morphological and agronomic traits ($P < 0.05$). The mean plant height of all the accessions was 119.9cm and ranged from 80.53cm to 155.18cm (Table 1). NGB00188 produced the tallest plants (155.18cm) which also had the widest stems (1.42cm) and the highest number of branches per plant (18). Its performance across many of the vegetative growth attributes were above average and among the top three for some. The highest number of leaves per plant was produced by NGB00235 (378) while the lowest number of leaves per plant was recorded in NGB00226 (70). NGB00195 had the widest plant canopy (65cm) and had the highest fresh shoot weight (173.8g). NGB00207 produced the longest leaves with mean leaf length of 15.72cm, while NGB00232 had the widest leaves with mean leaf width of 8.33cm. NGB00222 performed poorly across many of the vegetative growth attributes. However, it produced the second highest number of branches per plant (17.93) (Table 1) and. required the shortest time to pod maturity (42.67 days) after NGB00225 (41 days) (Table 2). NGB00210 was the earliest flowering (52 days) and earliest maturing (134 days) accession. NGB00210 also produced the highest number of pods per plant (100.33), the heaviest seeds (0.8667g), and the longest pods (5.2cm) alongside NGB00232 (5.2cm) (Table 3). The leaf yield of the accessions differed significantly ($P < 0.001$). The overall mean yield of all the accessions was 4.28t/ha and ranged from 2.517t/ha to 8.86t/ha (Table 3). The highest leaf yield was given by NGB00196 with mean yield of 8.86t/ha followed by NGB00188 with mean leaf yield of 6.927t/ha and NGB00210 with mean leaf yield of 5.88t/ha. The lowest yield was given by NGB00222, NGB00207 and NGB00653 with mean leaf yield of 2.517t/ha, 2.593t/ha and 2.697t/ha respectively. Eight accessions (NGB00196 NGB00188, NGB00210, NGB00230, NGB00195, NGB00226, NGB00236 and NGB00201) gave yield of ≥ 5t/ha while five accessions gave mean leaf yield that was lower than 3t/ha

Table 1: Mean plant height, stem width, canopy diameter, number of branches per plant and number of leaves per plant of 33*C. olitorius* accessions evaluated in Nigeria.

Accession	Plant height (cm)	Stem girth (cm)	Canopy Diameter (cm)	No. of Branches Per plant	No. of Leaves per plant
NGB 00200	112.39	1.167	48.38	13.07	185.5
NGB 00188	155.18	1.420	49.20	18.00	175.6
NGB 00196	138.20	1.293	46.93	14.47	162.6
NGB 00210	141.73	1.153	45.66	16.00	161.3
NGB 00225	116.53	0.920	45.13	13.80	148.2
NGB 00230	113.67	1.220	56.30	13.87	169.0
NGB 00199	135.93	1.113	41.33	12.87	112.7
NGB 00224	117.27	1.200	44.13	11.73	97.3
NGB 00221	136.33	1.300	42.87	15.53	126.9
NGB 00190	129.27	1.240	63.33	17.60	236.0
NGB 00195	149.10	1.167	65.00	15.73	220.5
NGB 00193	101.27	1.233	40.40	16.20	200.5
NGB 00198	132.00	1.147	48.60	15.27	153.1
NGB 00202	103.97	0.920	50.27	14.53	242.3
NGB 00235	131.73	1.133	49.97	16.53	376.5
NGB 00201	129.20	0.980	36.93	10.47	86.8
NGB 00191	129.27	1.220	48.93	14.67	135.2
NGB 00194	112.53	0.807	45.93	14.20	155.6
NGB 00197	108.67	0.973	48.77	17.13	154.8
NGB 00205	122.50	1.100	59.40	17.07	244.3
NGB 00207	128.87	1.253	56.87	16.20	172.4
NGB 00213	101.07	1.040	43.47	17.33	171.5
NGB 00217	114.47	0.887	44.87	14.20	147.7
NGB 00222	94.60	0.673	47.07	17.93	214.9
NGB 00223	107.80	0.787	46.20	16.00	205.8
NGB 00226	109.47	0.913	38.27	10.60	69.7
NGB 00227	113.93	1.000	41.20	11.93	103.3
NGB 00232	137.47	1.353	30.07	15.60	81.0
NGB 00233	109.53	1.073	52.53	14.13	190.8
NGB 00236	116.87	1.093	57.80	14.47	202.0
NGB 00238	109.67	0.733	42.33	12.80	125.6
NGB 00652	80.53	1.160	30.53	11.47	96.5
NGB 00653	115.87	0.833	40.87	14.87	133.0
Mean	119.9	1.076	46.96	14.74	165.4
$LSD_{(0.05)}$	25.98	0.2972	16.184	3.979	87.10
	***	***	*	**	***

NS=Not significant (P>0.05); *=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

Table 2: Mean leaf length, leaf width, petiole length, days to flowering, days to pod maturity, and of days to maturity of 33 *C. olitorius* accessions evaluated in Nigeria.

Accession	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	No. of days to flowering	No. of days to pod maturity	No. of days to maturity
NGB 00200	13.700	5.320	4.610	63.00	81.00	144.00
NGB 00188	9.490	7.500	5.530	131.67	70.67	202.33
NGB 00196	13.553	5.987	5.277	70.67	91.67	162.33
NGB 00210	10.333	7.343	4.723	52.00	82.00	134.00
NGB 00225	11.453	4.633	3.990	145.00	41.00	186.00
NGB 00230	13.447	5.633	5.667	107.00	77.00	184.00
NGB 00199	13.367	5.800	5.030	108.33	78.67	187.00
NGB 00224	13.553	5.757	5.000	108.67	63.00	171.67
NGB 00221	12.503	7.603	5.447	111.00	70.33	181.33
NGB 00190	13.067	5.353	4.833	53.00	87.00	140.00
NGB 00195	11.443	7.243	4.943	78.00	76.00	154.00
NGB 00193	12.590	7.777	4.667	145.00	59.00	204.00
NGB 00198	14.723	6.057	4.137	96.00	64.67	167.33
NGB 00202	11.577	4.690	4.333	102.33	84.67	187.00
NGB 00235	12.223	5.157	4.443	144.00	64.00	204.00
NGB 00201	13.720	5.920	3.833	115.00	52.00	167.00
NGB 00191	9.523	7.000	4.333	72.00	103.67	175.67
NGB 00194	9.590	5.843	4.917	109.00	73.67	182.67
NGB 00197	12.497	4.723	4.277	109.00	79.00	188.00
NGB 00205	12.723	4.857	4.110	106.33	66.33	172.67
NGB 00207	15.720	6.767	3.667	82.67	71.33	154.00
NGB 00213	9.777	5.023	3.777	140.00	46.00	186.00
NGB 00217	10.467	4.200	3.777	136.67	67.33	204.00
NGB 00222	8.780	3.333	3.500	140.00	42.67	182.67
NGB 00223	8.790	5.443	4.083	136.67	62.33	199.00
NGB 00226	10.077	7.077	4.470	108.33	82.00	190.33
NGB 00227	14.090	5.933	3.500	105.00	77.00	182.00
NGB 00232	9.667	8.330	4.890	81.67	69.67	151.33
NGB 00233	13.330	5.890	4.583	66.67	84.67	151.33
NGB 00236	13.443	5.610	3.833	97.67	93.33	191.00
NGB 00238	10.757	4.243	3.500	118.33	78.67	197.00
NGB 00652	11.867	7.647	3.583	136.00	68.00	204.00
NGB 00653	11.110	4.677	4.000	109.00	95.00	204.00
Mean	11.91	5.890	4.402	105.3	72.83	178.54
$LSD_{(0.05)}$	2.677 ***	1.2627 ***	1.3619 *	7.892 ***	9.101 ***	6.494 ***

NS=Not significant (P>0.05); *=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

Table 3: Mean number of pods per plant, pod length, number of seeds per plant, 100 seed weight, fresh shoot weight and leaf yield of 33 *C. olitorius* accessions evaluated in Nigeria.

Accession	No. of pods per plant	Pod Length (cm)	No. of seeds per pod	100 seed weight (g)	Fresh shoot weight (g)	Leaf yield (t/ha)
NGB 00200	38.40	4.200	123.53	0.6733	172.4	3.970
NGB 00188	28.53	4.433	144.97	0.7367	158.3	6.927
NGB 00196	50.37	4.467	133.67	0.7133	133.7	8.860
NGB 00210	100.33	5.200	139.00	0.8667	170.9	5.880
NGB 00225	25.07	4.767	151.00	0.6633	161.7	4.487
NGB 00230	32.60	4.133	115.53	0.7000	159.0	5.647
NGB 00199	26.47	3.733	105.47	0.6667	118.2	4.993
NGB 00224	17.90	3.767	106.87	0.7033	110.2	3.017

NGB 00221	21.33	4.567	171.00	0.6933	150.4	4.497
NGB 00190	66.87	4.567	158.80	0.6700	171.3	4.407
NGB 00195	32.33	4.067	153.60	0.7067	173.8	5.410
NGB 00193	21.80	3.200	97.17	0.6567	150.9	3.540
NGB 00198	16.20	4.500	135.07	0.6267	133.7	3.470
NGB 00202	24.23	4.267	161.67	0.6933	133.7	4.490
NGB 00235	17.13	3.467	121.97	0.5600	140.3	4.993
NGB 00201	14.37	3.867	115.87	0.7333	103.9	5.090
NGB 00191	21.67	4.233	122.00	0.6900	113.3	3.890
NGB 00194	14.33	3.467	115.00	0.6333	155.3	3.037
NGB 00197	16.73	3.867	128.07	0.6967	133.2	3.107
NGB 00205	20.53	3.633	136.67	0.6167	137.6	4.547
NGB 00207	79.00	4.833	138.40	0.6600	79.5	2.593
NGB 00213	44.40	4.300	123.80	0.5367	125.6	3.253
NGB 00217	20.53	4.200	105.20	0.8667	72.3	2.703
NGB 00222	19.00	4.267	137.03	0.7200	116.3	2.517
NGB 00223	23.50	3.000	101.07	0.6067	120.4	4.363
NGB 00226	16.43	3.000	130.60	0.6400	86.9	5.413
NGB 00227	8.40	3.067	70.53	0.5700	94.1	3.183
NGB 00232	15.53	5.233	167.47	0.6433	76.0	3.687
NGB 00233	62.80	4.267	153.73	0.6100	112.6	2.743
NGB 00236	18.73	3.700	101.00	0.5367	108.2	5.253
NGB 00238	29.07	3.833	82.87	0.8000	81.0	4.570
NGB 00652	37.47	4.333	122.13	0.7067	87.1	4.067
NGB 00653	29.60	4.033	145.00	0.8233	88.1	2.697
Mean	30.66	4.075	127.7	0.6794	125.1	4.28
$LSD_{(0.05)}$	14.652 ***	0.4425 ***	20.23 ***	0.13905 ***	34.17 ***	2.059 ***

NS=Not significant (P>0.05); *=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

Variance component analysis

The variance components for seventeen agronomic traits among thirty-three *C. olitorius* accessions are presented in Table 4. Both phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) exhibited moderate to high values across all traits. PCV ranged from 13.96% for the number of days to maturity to 81.47% for the number of pods per plant, whereas GCV ranged from 10.97% for petiole length to 78.80% for the number of pods per plant. In all traits, PCV values were consistently higher than their corresponding GCV values.

Broad-sense heritability estimates for the measured traits are also shown in Table 4. Very high heritability was recorded for the number of days to flowering (98.97%), days to maturity (98.72%), days to pod maturity (95.13%), number of pods per plant (93.53%), pod length (91.84%), and number of seeds per pod (91.00%). Similarly, leaf width (86.30%) and fresh shoot weight (84.99%) exhibited very high heritability values. Moderately high heritability was observed for leaf yield (71.52%), number of leaves per plant (74.04%), leaf length (73.08%), plant height (67.71%), stem width (67.96%), and 100-seed weight (62.89%). Medium heritability values were obtained for the number of branches per plant (53.40%) and canopy diameter (49.29%), while petiole length recorded the lowest heritability (39.69%).

Genetic advance as a percentage of the mean (GAM) ranged widely among traits (Table 4). High GAM estimates were observed for leaf yield (57.71%), number of pods per plant (156.88%), number of leaves per plant (68.33%), number of days to flowering (64.96%), fresh shoot weight (53.50%), number of days to pod maturity (48.12%), leaf width (44.67%), number of seeds per pod (42.90%), and pod length (32.50%). Moderate GAM values were obtained for stem width (29.66%), leaf length (28.48%), number of days to maturity (28.38%), plant height (22.81%), and canopy diameter (21.21%). The lowest GAM values were recorded for the number of branches per plant (18.84%) and 100-seed weight (18.78%).Character association

Character Association

Correlation coefficients among the seventeen agronomic traits are presented in Table 5. Leaf yield showed significant positive correlations with plant heigh (r = 0.554***), fresh shoot weight (r = 0.387***), number of branches per plant (r = 0.231*), petiole length (r = 0.202*) and number of days to pod maturity (r = 0.228*). Fresh shoot weight exhibited significant positive associations with plant height (r = 0.379***), stem width (r = 0.216*), canopy diameter (r = 0.479***), number of branches per plant (r = 0.407***), number of leaves per plant (r = 0.494***) and petiole length (r = 0.355***). It also significantly and positively correlated with number of pods per plant (r = 0.211*) and number of seeds per pod (r = 0.213*).

Plant height had significant and positive relationship with stem width (r = 0.327***), canopy diameter(r = 0.247*), number of branches per plant (r = 0.412***), leaf length (r = 0.216*), leaf width (r = 0.297**) and petiole length(r = 0.249*). It also significantly and positively correlated with number of days to pod maturity (r = 0.211*), pod length (r = 0.225*) and number of seeds per pod (r = 0.215*). Canopy diameter had significant positive correlations with number of branches per plant (r = 0.497***) and number of leaves per plant (r = 0.590***), while the number of branches per plant was strongly correlated with number of leaves per plant (r = 0.561***).

Number of days to flowering and number of days to were highly positively correlated (r = 0.840***), but both generally correlated negatively with the other measured attributes. Number of days to pod maturity correlated strongly negatively with number of days to flowering (r = -0.664***). Number of pods per plant had significant and positive relationships with pod length (r = 0.506***), number of seeds per pod (r = 0.290**), stem width (r = 0.207*), canopy diameter (r = 0.249*) and number of branches per plant (r = 0.214*), while its association with number of days to flowering (r = -0.568***) and number of days to maturity (r = -0.574***) were strong and negative. Pod length had significant and positive correlations with number of seeds per pod (r = 0.633***), and with 100 seed weight (r = 0.248*).

The result of the path analysis on leaf yield (Figure 1) showed that the biggest contributors to leaf yield were plant height (0.519), fresh shoot weight (0.234) and number of days to maturity (0.179). Number of branches per plant (0.431) and leaf width had strong positive indirect effects on leaf yield through plant height, while number of leaves per plant (0.374) and petiole length (0.352) contributed indirectly through fresh shoot weight. Number of days to flowering (1.301) and number of days to pod maturity (0.711) had high indirect effect through number of days to maturity. Canopy diameter (0.530) had high positive indirect effect through number of branches per plant.

Table 4: Estimates of variance components, genotypic coefficient of variation (GCV), Phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic advance as percent of mean for different agronomic characters of *C. olitorius*

Trait	Mean	σ_g^2	σ_p^2	GCV (%)	PCV (%)	H^2 (%)	GA	GAM (%)
Plant height (cm)	119.9	265.9	392.7	13.60	16.52	67.71	27.35	22.81
Stem width (cm)	1.076	0.035	0.051	17.43	21.15	67.96	0.32	29.66
Canopy diameter (cm)	46.96	47.57	96.79	14.74	20.95	49.15	9.96	21.21
Number of branches/plant	14.74	3.404	6.375	12.51	17.13	53.40	2.78	18.84
Number of leaves/plant	165.4	4065	5490.5	38.54	44.80	74.04	113.01	68.33
Leaf length (cm)	11.91	3.70	5.05	14.71	18.86	73.08	3.39	28.48
Leaf width (cm)	5.89	1.89	2.19	23.37	25.15	86.30	2.63	44.67
Petiole length (cm)	4.402	0.23	0.58	10.97	17.33	39.69	0.62	14.13
Number of days to flowering	105.3	1121.14	1132.84	31.70	31.86	98.97	68.62	64.96
Number of days to maturity	178.54	613.02	620.95	13.86	13.96	98.72	50.68	28.38
Number of days to pod maturity	72.83	304.29	319.86	23.31	24.56	95.13	35.05	48.12
Number of pods/plant	30.66	583.65	624.00	78.80	81.47	93.53	48.1	156.88
Pod length (cm)	4.075	0.45	0.49	16.49	17.15	91.84	1.32	32.50
Number of seeds/pod	127.7	777.20	854.05	21.83	22.88	91.00	54.28	42.90
100 seed weight (g)	0.6794	0.0061	0.0097	11.50	14.52	62.89	0.13	18.78
Fresh shoot weight (g)	125.1	1242	1461.4	28.17	30.56	84.99	66.93	53.5
Leaf yield (t/ha)	4.28	2.01	2.81	33.11	39.13	71.53	2.47	57.71

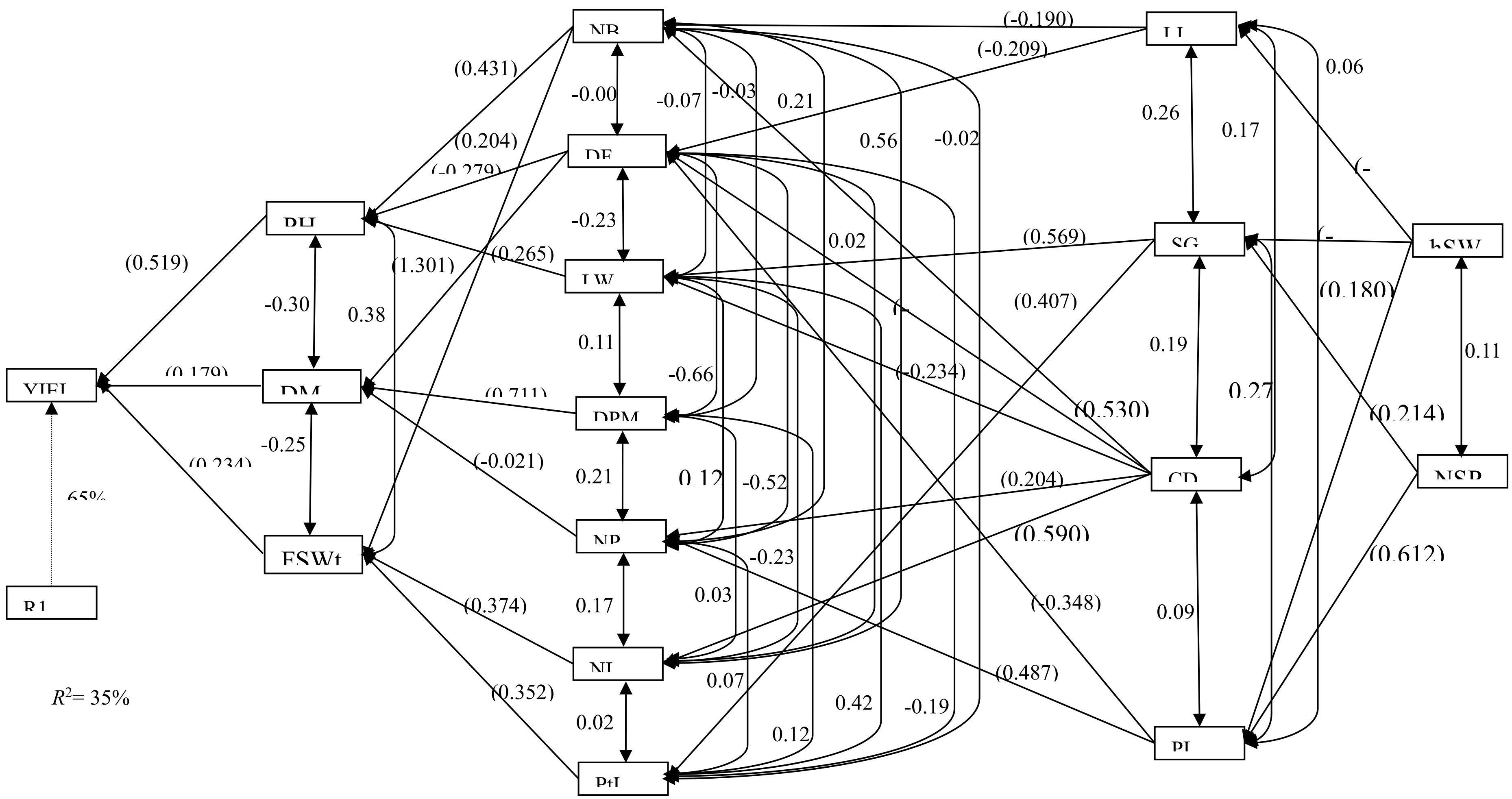
σ_g^2=Genotypic variance; σ_e^2 =Environmental variance; σ_p^2=Phenotypic variance; GCV=Genotypic coefficient of variation; PCV=Phenotypic coefficient of variation; H^2=Broad Sense Heritability; GA=Genetic advance; GAM=Genetic advance as percent of mean

Table 5: Correlation coefficients among seventeen agronomic characters of 33 *C. olitorius* accessions

	PH	SG	CD	NB	NL	LL	LW	Pt.L	DF	DPM	DM	NP	PL	NS.P	100SWt	FSWt	Lf.Yld
PH	-	0.327***	0.247*	0.412***	0.170	0.216*	0.297**	0.249*	-0.341***	0.211*	-0.301**	0.156	0.225*	0.215*	-0.042	0.379***	0.554***
SG		-	0.185	0.187	0.110	0.255*	0.526***	0.407***	-0.262**	0.122	-0.258**	0.207*	0.271**	0.188	-0.205*	0.216*	0.160
CD			-	0.497***	0.590***	0.173	-0.129	0.176	-0.261**	0.183	-0.212*	0.249*	0.092	0.184	-0.097	0.479***	0.175
NB				-	0.561***	-0.098	-0.074	-0.017	-0.002	-0.025	-0.029	0.214*	0.184	0.262**	-0.142	0.407***	0.231*
NL					-	0.055	-0.225*	0.016	0.019	-0.034	0.033	0.167	-0.050	0.119	-0.207*	0.494***	0.172
LL						-	0.143	0.022	-0.261**	0.076	-0.277**	0.130	0.055	-0.142	-0.201*	0.109	0.090
LW							-	0.417***	-0.231*	0.115	-0.218*	0.119	0.160	0.168	-0.107	0.089	0.146
Pt.L								-	-0.188	0.118	-0.169	0.070	0.112	0.235*	0.040	0.355***	0.202*
DF									-	-0.664***	0.840***	-0.524***	-0.377***	-0.299**	-0.072	-0.186	-0.145
DPM										-	-0.157	0.209*	-0.004	0.032	0.104	-0.002	0.228*
DM											-	-0.554***	-0.500***	-0.381***	-0.018	-0.247*	-0.035
NP												-	0.506***	0.290**	0.164	0.211*	0.131
PL													-	0.633***	0.248*	0.110	0.019
NSP														-	0.112	0.213*	0.043
100SWt															-	-0.069	0.055
FSWt																-	0.387***
Lf.Yld																	-

*=significant at P<0.05; **=significant at P<0.01; ***=significant at P<0.001

EC=Establishment count; PH=Plant height; SG=Stem girth; CD=Canopy diameter; NB=Number of branches/plant; NL=Number of leaves/plant; LL=Leaf length; LW=Leaf width; Pt.L=Petiole length; DF=Number of days to flowering; DPM=Number of days to pod maturity; DM=Number of days to maturity; NP=Number of pods/plant; PL=Pod length; NSP=Number of seeds/pod; 100SWt=100 seed weight; FSWt=Fresh shoot weight; Lf.Yld=Leaf yield;



PH=Plant height; SG=Stem girth; CD=Canopy diameter; NB=Number of branches/plant; NL=Number of leaves/plant; LL=Leaf length; LW=Leaf width; Pt.L=Petiole length; DF=Number of days to flowering; DPM=Number of days to pod maturity; DM=Number of days to maturity; NP=Number of pods/plant; PL=Pod length; NSP=Number of seeds/pod; 100SWt=100 seed weight; FSWt=Fresh shoot weight; Lf.Yld=Leaf yield

Figure 1. Path analysis for leaf yield of thirty-three (33) *C. olitorius* accessions

Discussion

The significant variability observed among the 33 *C. olitorius* accessions demonstrates the existence of substantial genetic diversity within the germplasm. Similar variability across agronomic traits has been reported by Ngomuo *et al*. (2017), Nwangburuka and Denton (2012), Pervin and Haque (2012), and Sawarkar *et al*. (2014).According to Loumerem and Alercia (2016), information about such genotypic differences across diverse traits among individuals or groups of accessions is helpful for management of germplasm collections, determination of the economic potentials of genotypes as well as their utilization in improvement of any of the economic characters of the crop. Gerrano *et al*. (2014) stated that the existence of significant genetic variability among accessions is an indication of the potentials of exploiting the evaluated germplasm for the improvement of the crop. The evaluation of varietal or accession differences in leaf yield, yield components, and other useful agronomic traits is vital for the purpose of germplasm characterization and selection of promising genotypes adapted to the local environment. Efforts to increase production will rely on the ability of selected genotypes to produce a high leaf yield, as well as high number of pods and seeds for its propagation. The identified high performing accessions for leaf yield and other economically important traits in this study can thus be useful as genetic materials in breeding programs directed towards producing high leaf yielding varieties, as well as for improvement of other desirable traits.

The observed high genotypic coefficients of variation (GCV) for several agronomic traits indicate substantial inherent genetic diversity within the evaluated *C. olitorius* accessions, suggesting significant potential for genetic improvement through selection. Genetic variability forms the foundation for successful crop improvement, as it determines the scope for selecting superior genotypes for desirable traits. As noted by Adam (2008), understanding the extent and nature of genetic variability is essential for devising efficient breeding strategies. The effectiveness of selection depends on the relative magnitude of genetic and environmental components of variation, with higher genetic variance favoring greater breeding progress (Allard, 1999; Ayalneh *et al*., 2012).

In this study, several traits—including days to flowering, days to maturity, days to pod maturity, number of pods per plant, pod length, and number of seeds per pod—exhibited very high broad-sense heritability estimates (>80%). According to Singh (2001), such high heritability values indicate that much of the phenotypic variation is genetically controlled and, therefore, potentially transmissible to subsequent generations. Moderate heritability values (60–79%) observed for traits such as leaf yield, number of leaves per plant, and stem width further suggest reliable selection prospects for these attributes, although some environmental influence remains. Conversely, traits like petiole length, which showed low heritability (<40%), are likely to require alternative breeding approaches such as hybridization or recurrent selection to achieve meaningful improvement.

However, heritability estimates alone may not always provide a reliable prediction of genetic gain. As emphasized by Johnson *et al*. (1955), heritability should be considered jointly with genetic advance to accurately assess the efficiency of selection. In this study, several traits combined high heritability with high genetic advance as a percentage of mean (GAM)—notably leaf yield, number of pods per plant, number of leaves per plant, fresh shoot weight, and days to flowering. Such a combination suggests predominance of additive gene action, making direct selection an effective strategy for improving these traits (Shulka *et al*., 2006). Conversely, traits with medium heritability coupled with low GAM, such as canopy diameter and number of branches per plant, are likely influenced by non-additive gene effects, indicating slower progress through direct selection alone (Nwagburuka & Denton, 2012).

As highlighted by Hussein (2006), combining estimates of GCV, heritability, and genetic advance offers a more robust basis for predicting selection response than relying on individual parameters. Accordingly, the high variability and favorable genetic parameters reported here provide a strong foundation for the genetic improvement of key yield-related traits in *C. olitorius*.

Understanding the interrelationships among agronomic traits is crucial for selecting attributes that contribute effectively to yield improvement. In this study, significant positive correlations were observed between leaf yield and several vegetative traits, including plant height, fresh shoot weight, number of branches per plant, petiole length, and days to pod maturity. These associations indicate that simultaneous improvement of these traits could lead to enhanced leaf productivity, as supported by earlier findings in jute and related crops (Nwofia *et al*., 2016; Dube *et al*., 2018; Nyadanu *et al*., 2017; Sawarkar *et al*., 2014; Ghosh *et al*., 2013; Pervin & Haque, 2012).

Moreover, positive and significant correlations among key vegetative attributes—such as plant height, canopy diameter, number of leaves per plant, and stem width—suggest coordinated growth patterns in *C. olitorius*. Such positive associations imply that selection for one trait may concurrently enhance related traits, thereby accelerating breeding progress (Mhlaba *et al*., 2018). On the other hand, traits like days to flowering and days to maturity exhibited strong negative correlations with leaf yield and most vegetative traits. These relationships highlight the potential advantage of selecting for early-maturing genotypes to optimize leaf productivity, particularly in environments where growing seasons are limited. Correlation analyses thus provide valuable insights for identifying secondary traits that could serve as effective selection indices for improving leaf yield in *C. olitorius* breeding programs.

While correlation analysis establishes the direction and strength of associations among traits, it does not distinguish between direct and indirect effects. Path coefficient analysis addresses this limitation by partitioning correlations into causal components, thereby clarifying the relative contribution of individual traits to yield (Nwofia *et al*., 2016). In the present study, plant height, fresh shoot weight, and days to maturity exerted the highest direct positive effects on leaf yield, indicating that these traits can serve as reliable targets for selection in breeding programs.

Additionally, several traits—including number of branches per plant, leaf width, number of leaves per plant, and petiole length—contributed indirectly to leaf yield through their strong associations with plant height and fresh shoot weight. Similarly, days to flowering and days to pod maturity exhibited substantial indirect effects mediated through days to maturity, underscoring the importance of phenological development in determining leaf productivity. These results are consistent with findings reported by Sawarkar *et al*. (2014) and Pervin & Haque (2012) in related studies on *C. olitorius*.

Conclusion

This study revealed the existence of highly significant genotypic differences among the accessions for all the agronomic characters measured except petiole length. The highest leaf yield was given by NGB00196, followed by NGB00188 and NGB00210 while NGB00222 and NGB00207 gave the lowest leaf yield. Eight accessions (NGB00196 NGB00188, NGB00210, NGB00230, NGB00195, NGB00226, NGB00237 and NGB00201) gave yield of 5t/ha and above. These accessions are therefore recommended as high yielding genotypes which can be utilized in breeding programs geared towards higher leaf yield for vegetable production and as germplasm material for improvement of leaf yield in *C. olitorius* breeding programs. The combined insights from genetic variability, heritability, genetic advance, correlation, and path analyses underscore the substantial potential for improving *C. olitorius* through selection-based breeding strategies. Traits such as plant height, number of pods per plant, fresh shoot weight, and leaf yield are controlled predominantly by additive gene effects, making them ideal candidates for direct selection. Furthermore, the identification of secondary traits with significant indirect contributions to yield provides a basis for developing robust selection indices. These findings collectively offer valuable guidance for designing breeding programs aimed at enhancing both productivity and adaptability of *C. olitorius* cultivars for Nigeria and other regions of West Africa

Competing interests:

The authors report there are no competing interests to declare.

Funding:

No funding was received. However, germplasm materials of *Corchorus olitorius* used for this research were obtained from the National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan, Oyo State, Nigeria.

References

Adam, A. (2008). Evaluation of ginger accessions for yield from the Southwestern parts of the country at Weramit. Progress report for the period 2007-2008, Adet Agricultural Research Center, Adet, Ethiopia

Adeniyi, S. A., Ahiagbonare, J. E. and Nwangwu, S. C. O. (2012). Nutritional evaluation of some staple leafy vegetables in Southern Nigeria. *International Journal of Agriculture and Food Sciences,* 2(2):37–43

Alika, J.E. (2010). Statistics and Research methods (2nd edition) Ambik press Benin City pp225.

Allard, R.W. (1999). *Principles of Plant Breeding*, 2nd ed. John Wiley and Sons Inc., New York. Pp .254.

Ayalneh, T., Habtamu, Z. and Amsalu, A. (2012). Genetic variability, heritability and genetic advance in tef (*Eragrostis tef* (Zucc.) Trotter) lines at sinana and adaba. *International Journal of Plant Breed.* 6: 40-46.

Badu-Apraku, B., Fakorede, M.A.B., Annor, B. and Talabi, A.O. (2017). Improvement in grain yield and low-nitrogen tolerance in maize cultivars of three eras. *Experimental Agriculture*, Pp. 19. doi: 10.1017/S0014479717000394

Barku, V.Y.A., Opoku-Boahen, Y., Owusu-Ansah, E., Dayie, N.T.K.D. and Mensah, F.E. (2013) In-vitro assessment of antioxidant and antimicrobial activities of methanol extracts of six wound healing medicinal plants. *Journal of Natural Science and Research,* 3(1):74–80

Binodh, A.K., Manivannan, N. and Verman, P.V. (2008) Character association and path analysis in sunflower, *Madras Agriculture Journal*, 95: 425-428

Chipurura, B., Muchuweti, M., Parawira, W. and Kasiyamhuru, A. (2011) An assessment of the phenolic content, composition and antioxidant capacity of *Bidens pilosa, Cleome gynandra, Corchorus olitorius, Galinsoga parviflora and Amaranthus hybridus*. ISHS *Acta Hortic* 911:417–426.

Climate-data.org (2016). Climate: Benin city, retrieved 18/11/2016 fromhttp://en.climate data.org/location/764230/

Das, B.B. and Maiti, S. N. (1998) "Jute (Corchorus species) and alliedfibres research in India," *Indian Journal of Agricultural Sciences*, vol. 68, no. 8.

Denton, O.A. and Nwangburuka, C.C. (2011). Heritability, genetic advance and character association in six yield related characters of *Solanum anguivi*. *Asian Journal of Agriculture Research*. 5: 201-207

Dube, S.P., Marais, D., Mavengahama, S, Van Jaarsveld, C.M. and Gerrano, A.S. (2018). Characterisation of agro-morphological traits of *corchorus* accessions, *Acta Agriculturae Scandinavica,* Section B —*Soil & Plant Science*, DOI:10.1080/09064710.2018.1514419

Gerrano, A.S., Jansen van Rensburg, W.S. and Adebola, P.O. (2014). Agro-morphological variability of *Amaranthus* genotypes in South Africa. *Acta Horticulturae*. 1035:183–188

Ghosh, R.K., Sreewongchai, T., Nakasathien, S. and Phumichai, C. (2013). Phenotypic variation and the relationships among jute (*Corchorus* species) genotypes using morpho-agronomic traits and multivariate analysis. *Australian Journal of Crop Science* 7(6):830–842

Hussein, R.M (2006). Variability, heritability and genetic advance in some genotypes of roselle (*Hibiscus sabdariffa* L.). World Journal of Agric. Science., 2: 340-345

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955) Estimates of genetic and environmental variability in soybean. *Agronomy Journal* 47: 314-318

Kumawat, B.K., Gupta, M. and Singh, T.Y. (2012). Free radical scavenging effect of various extracts of leaves of *Balanites aegyptiaca* (L.) Delile by DPPH method. *Asian Journal of Plant Science and Research*, 2(3):323–329

Loumerem, M. and Alercia, A. (2016). Descriptors for jute (*Corchorus olitorius* L.). *Genetic Resources and Crop Evolution* 63:1103–1111

Matsufuji, H., Sakai, S., Chino, M., Goda, Y., Toyoda, M. and Takeda, M. (2001). Relationship between cardiac glycoside contents and color of *Corchorus olitorius* seeds. *Journal of Health Sciences* 47(2):89–93

Mhlaba, Z.B., Shimelis, H.A., Amelework, B., Modi A.T. and Mashilo, J. (2018). Variance components and heritability of yield and yield-related traits in tepary bean (*Phaseolus acutifolius*). South *African Journal of Plant and Soil*, 1-12 DOI: 10.1080/02571862.2018.1487593

Mohammadi, S.A., Prasanna, B.M. and Singh, N.N. (2003). Sequential path model for determining interrelationships among grain yield and related characters in maize. *Crop Science,* 43:1690–1697.

Ngomuo, M., Stoilova, T., Feyissa, T. and Ndakidemi, P.A. (2017). Characterization of Morphological Diversity of Jute Mallow (*Corchorusspp*.). *International Journal of Agronomy*, Volume 2017, Article ID 6460498, 12 pages. https://doi.org/10.1155/2017/6460498

Nwangburuka, C.C. and Denton, O.A. (2012). Heritability, character association and genetic advance in six agronomic and yield related characters in leaf of *Corchorus olitorius*. *International Journal of Agricultural Research*. 7(7): 367-375.

Nwofia, G.E. and Chimaobi, A. (2012). Chemical composition and variability among some *Ocimum gratissinum* accessions. *International Journal of Medicinal and Aromatic Plants*. Vol. 2, No. 3, pp. 460-467

Nwofia, G.E., Okoro, M.J. and Agbo, C.U. (2013). Assessment of phenotypic variability, heritable components and character association in egusi melon (*Citrullis vulgaris* (thumb) matsum and nakai acessions. *American-Eurasian Journal of Agricultural and Environmental Science*, 13 (7): 961-966. DOI: 10.5829/idosi.aejaes.2013.13.07.1977

Nwofia, G.E., Onyekwere, C.R. and Mbah, E.U. (2018). Genotype by planting date effects on cowpea in humid fringes, Southeast Nigeria. *Plant Breeding and Biotechnology* 6(2):1~000. https://doi.org/10.9787/PBB.2018.6.2.1

Nyadanu, D. and Lowor, S.T. (2015) Promoting competitiveness of neglected and underutilized crop species: comparative analysis of nutritional composition of indigenous and exotic leafy and fruit vegetables in Ghana. *Genetic Resources and Crop Evolution* 62:14

Nyadanu, D., Amoah, R. Adu, Kwarteng, A. O., Akromah, R., Aboagye, L. M., Adu-Dapaah, H., Dansi, A., Lotsu, F., Tsama, A. (2017). "Domestication of jute mallow (*Corchorus olitorius* L.): ethnobotany, production constraints and phenomics of local cultivars in Ghana". *Genetic Resources and Crop Evolution*. 64 (6): 1313–1329.

Olatunji, A.S., Abimbola, A.F. and Asowata, T.I. (2014). Geochemical evaluation of soil and road deposited sediments of Benin City using GIS and multivariance approaches. British Journal of Applied Science and Technology 4 (18) 2590-2606

Palit, P., Sasmal B.C. and Bhattacharryya, A.C. (1996) "Germplasm diversity and estimate of genetic advance of four morpho-physiological traits in a world collection of jute," *Euphytica*, vol.90, no. 1, pp. 49–58, 1996.

Palve, S.M. M, and Sinha, K. (2005) "Genetic variation and interrelationships among fibre yield attributes in secondary gene pool of Corchorus spp," *SABRAO Journal of Breeding and Genetics*, vol.37, no. 1, pp. 55–64, 2005.

Panse, V.G. (1957). Genetics of qualitative characters in relation to plant breeding. *Indian Journal of Genetics and Plant Breeding*. 17: 318-328.

Pervin, N. and Haque, G. K. M. N. (2012). Path coefficient analysis for fibre yield related traits in deshi jute (*Corchorus capsularis* L.). IRJALS.1(3):72-77

Sawarkar, A., Yumnam, S., Patil, S.G. and Mukherjee, S. (2014) Correlation and path coefficient analysis of yield and its attributing traits in tossa jute (*Corchorus olitorius* L.). *The Bioscan*, 9(2): 883-887

Shulka, S., Bhargava, A., Chatterjee A., Srivatava A.,&Singh S. P. (2006). Genotypic variability in vegetable amaranth (*Amaranthus tricolor* L.) for foliage yield and its contributing traits over successive cuttings and years. *Euphytica,* 151: 103-110

Singh, B.D. (2001). Plant Breeding: Principles and Methods. 6th Edn. Kalyani Publishers, New Delhi, India. p. 304

Steyn, N.P., Olivier, J., Winter, P., Burger, S. and Nesamvuni S. (2001). A survey of wild, green, leafy vegetables and their potential in combating micronutrient deficiencies in rural populations. *South African Journal of Science.* 97: 276-279.

Tucak, M., Popovic, S., Cupic, T., Spanic, V., Simic, B. and Meglic, V. (2012). Combining abilities and heterosis for dry matter yield in alfalfa diallel crosses. *Romanian Agricultural Research*, *29*: 71-77.

Umweni, A.S., Uwadiae, I. and Okunsebor, F.E. (2014). Evaluating the distribution of some selected heavy metals in the soils of a community farm in mid-western Nigeria. Journal of Research Environment and Earth Science 1 (3) 01-16