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SEASONAL EVALUATION OF YIELD AND YIELD COMPONENT TRAITS OF THIRTEEN OKRA GENOTYPES IN A DERIVED SAVANNAH

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ABSTRACT
Ten improved okra genotypes obtained from National Institute for Horticultural Research and Training, Okigwe, Nigeria and three local cultivars were evaluated under early and late planting seasons of 2014 and 2015. The aim of this study is to estimate the relationship and magnitude of direct effects among the traits as well as determine the degree of heritability and variability among the genotypes. Genotypic stability analysis was also performed on the yield and the two traits most related to yield. 'Ele Uhie' genotype had the highest values for most of the parameters measured for both early and late planting seasons. Among the improved genotypes, 'TAE 38' had relatively appreciable yield. In both seasons, all the traits studied showed positive and significant ($p < 0.01$) correlation with total fruit yield, although number of fruits/plant and plant height at maturity had the strongest relationship. The yield stability estimates showed that the genotypes independently expressed their traits in the four different stability groups. Path coefficient analysis revealed that number of fruits/plant and plant height at maturity had higher positive and higher magnitude of direct effect than the direct effects of the associated parameters studied for both planting seasons. Thus, selecting 'Ele Uhie', 'Ele Ogwu', 'Ele Ndu' and 'TAE 38' genotypes with relatively stable and high number of fruits/plant and plant height at maturity would have greater impact in sustaining high yields in okra.

Key words: correlation, genotypes, heritability, stability analysis, yield

INTRODUCTION
Okra (*Abelmoschus* spp.) has gained considerable interest as an alternative to more traditional vegetables in many countries throughout the world despite being widely regarded as a minor crop (Gemede *et al.,* 2015). Growers strive to plant okra varieties that are well improved to optimize yield and quality. Abdelmageed *et al.* (2012) reported that despite increases in the production of okra and other vegetables in West Africa, the production does not meet the demand of the population.

A number of okra varieties grown in Nigeria have low yields due to associated biotic and abiotic stresses, lack of improvement, limited agro-inputs and low quality of seeds among others (Ijoyah *et al.,* 2010). Therefore, to meet increasing demands for okra in Nigeria, selection of adaptable and high yielding genotypes planted across different planting seasons for selection and release to farmers was considered valuable and necessary.

The traits contributing to fruit yield potential in okra include branch length, number of fruits/plant, number of branches/plant, fruit weight, plant height and fruit girth (NIHORT, 2014). Similarly, More and Chaudhari (2016) reported that the major yield components of okra are seed yield, number of pods/plant, pod length, pod width, pod weight, plant height and days to flowering. Kumar and Reddy (2016) further stressed that high performance of hybrids can mainly be attributed to heterosis for high number of fruiting nodes on main stem, number of fruits/plant, number of branches/plant and plant height of which number of fruits/plant showed both positive and direct effect on total fruit yield in okra.

Estimation of yield improvement requires appropriate selection criteria. Francis and Kannenberg (1978) developed the mean yield - coefficient of variation (CV) approach of determining genotypic stability, a simple and descriptive method for grouping genotypes based on yield and consistency of performance. Stable genotypes are those whose CVs are below the mean of the CVs and yield above the grand mean yield of all the genotypes. The genotypic stability of yield over seasons reveals anticipated consistency of yield from such genotype(s) across multiple seasons (Javia, 2014).

To achieve yield improvement, it is important to determine the extent of relationship between any given pair of traits (Dattijo *et al.,* 2016). Neeraj *et al.* (2017) suggested that a plant breeder should know whether the improvement of one character would result in simultaneous change in the others through estimates of inter-character correlation. Simple correlation analysis cannot fully explain the relationships among characters. Therefore, path coefficient analysis has severally been used for a more complete determination of the impact of an independent variable on a dependent one in okra, fennel, wheat, cotton, potato and *Cajanus cajan* (Majid *et al.,* 2011; Udensi and Ikpeme, 2012; Neeraj *et al.,* 2017).

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Correlation analysis helps to show the nature or strength of relationship existing between two variables. This determines whether an increase or decrease in one trait will positive or negatively influence another associated trait. Furthermore, path coefficient analysis has proved useful in providing further information that describes priori cause-and-effect relationships that might have been confounded by correlation coefficients, since the later only measures the degree of mutual association between two variables without regard to causation. Information obtained from correlation coefficients can be augmented by partitioning the correlations into direct and indirect effects for a given set of priori cause and effect interrelationships (Dewey and Lu, 1959; Agbo and Obi, 2005; Neeraj *et al.,* 2017). Yield and yield components have such priori cause-and-effect relationship (Agbo and Obi, 2005; Akinyele and Osekita, 2006).

Stability performance is one of the most desirable properties of a genotype for its wide adaptation (More *et al.,* 2018). According to Patil *et al.* (2017), the utilization of stability of significant yield traits and inferences from significant genotypic correlation between yield and its components should permit selection of predictable okra genotypes. So far, there has been paucity of data and increasing challenges on proper selection for the most adaptable, desirable, highly stable and high yielding okra genotypes in the South East of Nigeria to meet the ever-increasing demand for this relished crop. Hence, the objectives were to study okra yield and yield components relationships for different genotypes, and to ascertain the magnitude and direction of changes to be expected during selection in okra under different seasons.

MATERIALS AND METHODS

The experiment was carried out at the Department of Crop Science Research Farm, Faculty of Agriculture, University of Nigeria, Nsukka (6°51′N, 07°29′E), at an altitude of 400 m asl (Figure 1). The field study was carried out in early season (Apr. to Sep. 2014) and late season (Oct. 2014 to Feb. 2015). Okra seeds collected from the early season planting were used as planting material for late planting. Ten genotypes of okra collected from National Institute for Horticultural Research and Training (NIHORT), Okigwe, Nigeria that had been under evaluation and three local varieties sourced from Nsukka community were evaluated. The designations of the genotypes are listed in Table 1. Compound fertilizer, NPK 20:10:10, was applied at the rate of 30 kg N ha^{-1} in two doses, at planting and during flower bud initiation. Such half-split dosing of N-rich fertilizers for vegetable crops is a promising option in the study area (Umezinwa *et al*., 2020).

After ploughing and harrowing, the experiment was laid out in a randomized complete block design (RCBD) with three replications on well-prepared beds. Plots measured 8 m × 5 m each and seeds were sown 60 cm apart between rows and 50 cm apart within rows. Two to three seeds were sown to be able to maintain one seedling per stand. Various cultural practices employed in okra production, which include manure application, weeding, fertilizer application, pest control and harvesting of mature fruit pods were done as the need arose. Data were collected based on standard evaluation system for okra (FAO, 2013). Data on branch length, fruit girth, fruit length, fruit weight, number of branches/plant, number of fruits/plant, number of seeds/pod, plant height at maturity and total fruit yield were measured from three sample plants on each plot. Fruit yield (t ha^{-1}) was also estimated.

Combined analysis of variance for the two seasons was carried out for the collected data using Genstat Release 10.3DE Discovery Edition 4 (GenSTAT, 2011) software. Genotypic correlation (r_g) between the yield component traits and yield was obtained from the genotypic covariance between the two traits and the geometric of their genotypic variance (Agbo and Obi, 2005):

Figure 1: Geographical map showing the location of the study in Nsukka agroecology of the South East, Nigeria
Source: Department of Geography, University of Nigeria, Nsukka

Table 1: Origin and sources of collection of okra genotypes used for the experiment

Serial number	Genotypes	Sources of collection	Remarks
1	*LUDU V*	NIHORT, Okigwe, Imo State	Improved
2	*Esculentus V.*	NIHORT, Okigwe, Imo State	Improved
3	*Jokoso*	NIHORT, Okigwe, Imo State	Improved
4	*Agwu early*	NIHORT, Okigwe, Imo State	Improved
5	*TAE 38*	NIHORT, Okigwe, Imo State	Improved
6	*V-21 Ivra*	NIHORT, Okigwe, Imo State	Improved
7	*Clemson spineless*	NIHORT, Okigwe, Imo State	Improved
8	*LD 88*	NIHORT, Okigwe, Imo State	Improved
9	*V.35*	NIHORT, Okigwe, Imo State	Improved
10	*NHE 47-4 V*	NIHORT, Okigwe, Imo State	Improved
11	*Ele Ndu*	Obukpa community, Nsukka LGA, Enugu State	Local
12	*Ele Ogwu*	Obukpa community, Nsukka LGA, Enugu State	Local
13	*Ele Uhie*	Obukpa community, Nsukka LGA, Enugu State	Local

NIHORT - National Institute for Horticultural Research and Training, LGA - local government area

$$R_{gxy} = \frac{\sigma gxy}{\sqrt{\sigma^2 g_{x*}\ \sigma^2 g_y}}$$

where R_{gxy} is genotypic correlation coefficient; $\sigma^2 g_{xy}$ is genotypic variance of cross product of the traits x and y; $\sigma^2 g_x$ is genotypic variance of the trait x and $\sigma^2 g_y$ is genotypic variance of the trait y.

$$\text{CV (\%)} = \frac{\sqrt{\text{MSg}}}{\bar{X}} \times 100$$

$$\text{GCV} = \frac{\sqrt{\text{Vg}}}{\bar{X}} \times 100$$

$$\text{ECV} = \frac{\sqrt{Ve}}{\bar{X}} \times 100$$

$$\text{PCV} = \frac{\sqrt{\text{Vp}}}{\bar{X}} \times 100$$

$$H^2{}_{BS} = \frac{Vg}{Vp} \times 100$$

$$\text{GA} = K\ (\delta p)\ h^2_{bs}$$

where K is a constant (2.06) at 5% selection intensity, δ_p is phenotypic standard deviation. Then, %CV is percent coefficient of variation; GCV is genotypic coefficient of variation; ECV is environmental coefficient of variation; PCV is phenotypic coefficient of variation; and H^2_{BS} is broad sense heritability.

The genotypic stability of yield and those of the two most related traits to yield were estimated by mean-CV approach following the procedure described by Francis and Kannenberg (1978). In this approach, mean CV and grand mean yield bi-plot divides the table into four groups. The groups of yield stability conditions estimated were as follows:

Group 1 is high yield and low variation; Group 2 is high yield and high variation; Group 3 is low yield and low variation; Group 4 is low yield and high variation. Stable genotypes for traits are those whose CVs are below the mean CV and yields higher than the grand mean yield. The means of the variables were subjected to path-coefficient analysis and the direct and indirect effects of each year were estimated according to the procedure of Dewey and Lu (1959) as reported by Javia (2014).

RESULTS AND DISCUSSION

The results of this study showed that the okra genotypes differed significantly ($p < 0.05$) in most studied traits in the two seasons (Table 2). Genotype *'Ele Uhie'* gave the highest total fruit yield in both seasons which was significantly ($p < 0.05$) different from others with the exception of *'Ele Ndu'* in the late season. This same genotype, '*Ele Uhie'* also had the highest fruit girth, fruit weight, number of fruits/plant, number of seeds/pod and plant height at maturity inearly and late planting seasons. *'Ele Ndu'* genotype had the highest branch length compared to other genotypes studied. *'Clemson spineless'* gave the highest fruit length in both seasons and was similar to *'Ele Uhie'*. Conversely, *'Clemson spineless'* had the least total fruit yield in both seasons. This agrees with the report of Kumar *et al.* (2018) of which most of the local genotypes used gave higher yield compared to the improved genotypes.

Table 3 shows the mean squares of the yield and yield components across the two planting seasons. There was no significant seasonal effect on branch length and number of branches/plant. The effect of seasons was highly significant ($p < 0.01$) on fruit girth, fruit length, fruit weight, number of fruits per plant, number of seeds per pod, plant height at maturity and total fruit yield, indicating wide range of variations between the two seasons. This conforms to the studies of Firoz *et al.* (2007) and Falodun and Ogedegbe (2016) which showed significant differences for fruit weight, fruit size, fruits per plant and fruit yield per hectare at different sowing dates. This study thus indicates that early season planting had higher results than late season planting.

Estimates of heritability and variance components are shown in Table 4. Heritability was high for all the traits except for fruit girth and number of branches/plant for both early and late planting seasons, indicating that environmental influence had low influence on the expression of most agronomic and yield component traits. Heritability along with genetic advance is more useful than heritability alone in predicting the resultant effect of selecting best individual genotype as it offers the most suitable condition for selection as well as suggests the presence of additive gene effects. This further suggests reliable crop improvement through selection of such traits (Ogunniyan and Olakojo, 2014; Nwofia *et al*., 2016). The higher estimates of heritability coupled with higher genetic advance for number of fruits/plant, number of seeds/pod, plant height at maturity and total fruit yield and consequently a high genetic gain is expected from selection under such conditions. Low heritability accompanied by low genetic advance in fruit girth and number of branches per plant is an indication of large environmental effects on its inheritance and that the trait can be improved by hybridization (Akinyele and Osekita, 2006). Branch length and plant height at maturity had the highest magnitude of PCV and GCV. This indicates better scope of phenotypic selection through improvement of these traits (Ahamed *et al*., 2015). There was highly significant ($p < 0.01$) genotypic effect on yield and its components indicating that there are variations among the genotypes upon which selection can be imposed. The genotype by season (G × S) interaction was significant for most of the traits with the exception of branch length, fruit girth, fruit length and fruit weight. The significant G × S interaction implies that genotypes reacted differently in the seasons, thus suggesting that certain genotypes may be better suited for higher performance within a specific season. The traits with non-significant G × S effect might be showing consistency in spite of the various differences that existed in the two seasons (Adekoya *et al.,* 2014).

Table 2: Performance of okra genotypes for agronomic and yield component traits evaluated in early and late planting seasons for 2014 to 2015 cropping season

Genotypes	BL (cm)	FG (cm)	FL (cm)	FW (g)	NoBP	NoFP	NoSP	PH (cm)	TFY (t ha^{-1})
				Early season					
Agwu early	18.51	7.59	6.07	21.34	2.00	8.80	67.68	42.47	6.86
Clemson	28.60	7.67	15.68	26.40	2.33	5.67	72.55	75.79	3.20
Ele NDU	128.75	11.46	10.62	33.39	7.33	31.96	104.36	213.88	33.56
Ele OGWU	78.17	8.66	6.08	21.88	2.67	17.52	56.64	189.4	12.84
Ele UHIE	83.32	12.10	13.43	34.50	5.67	33.67	125.57	237.66	35.59
Esculentus	28.57	10.13	9.59	29.40	2.67	9.22	75.96	54.89	8.98
Jokoso	0.00	9.00	7.85	19.65	2.00	7.17	55.32	64.65	5.02
LD 88	31.43	8.93	10.04	29.00	4.00	8.95	77.84	64.16	9.30
LUDU V	22.38	10.08	9.37	25.42	2.33	9.70	78.14	65.07	8.57
NHE 47.4	13.92	9.83	9.02	24.28	1.33	8.56	57.18	63.97	7.74
TAE 38	36.08	9.57	9.93	30.89	4.00	9.73	76.85	48.92	10.5
V-21 Ivra	32.37	6.56	7.85	17.14	2.33	7.09	61.25	66.63	4.80
V.35	24.25	9.47	9.4	28.87	2.00	9.81	82.84	49.03	10.05
F-LSD (0.05)	39.15	2.18	1.47	3.77	2.75	2.72	5.74	8.26	2.61
				Late season					
Agwu early	15.68	5.98	4.77	18.36	2.33	7.07	61.00	38.02	5.89
Clemson	25.55	6.56	11.73	22.73	2.33	4.43	66.25	69.82	3.17
Ele NDU	113.44	9.58	9.57	29.54	6.00	28.65	88.03	200.21	30.03
Ele OGWU	97.19	8.16	4.50	22.89	3.00	14.30	47.15	164.13	12.25
Ele UHIE	75.26	9.67	11.85	29.80	4.00	26.73	106.63	217.95	30.96
Esculentus	38.92	9.33	8.77	27.03	2.67	7.74	68.75	48.02	7.50
Jokoso	0.00	7.54	5.67	18.94	1.67	6.29	48.08	57.37	3.65
LD 88	27.85	7.17	9.22	29.01	3.67	7.51	70.93	57.65	8.53
LUDU V	19.16	8.14	7.06	23.20	1.67	8.24	74.55	58.29	7.77
NHE 47.4	25.39	8.45	8.92	20.97	1.00	6.66	49.78	56.95	6.77
TAE 38	33.40	7.90	9.04	26.84	3.67	8.54	69.92	43.17	8.41
V-21 IVRA	28.77	5.82	7.13	15.98	2.00	6.01	50.70	59.85	3.61
V.35	32.49	8.24	7.41	26.64	2.00	8.38	74.65	45.53	8.42
F-LSD (0.05)	18.86	2.07	2.27	4.81	2.28	2.53	8.50	7.11	2.56

BL - branch length, FG - fruit girth, FL - fruit length, FW - fruit weight, NoBP - number of branches per plant, NoFP - number of fruits per plant, NoSP - number of seeds per pod, PH - plant height, , TFY - total fruit yield

Table 3: Analysis of variance showing mean squares of the traits for the two seasons

Sources of variation	df	BL	FG	FL	FW	NB/PL	NF/PL	NS/P	PHM	TFY
Genotype	12	6930.10**	10.27**	35.93**	140.80**	13.90**	388.55**	2041.75**	26153.49**	518.64**
Season	1	5.30	43.97**	42.92**	108.91**	1.55	57.38**	1546.02**	1648.92**	33.56**
Genotype × season	12	128.10	0.81	1.43	4.68	0.39*	0.85*	26.89*	62.35*	0.48*
Error	50	328.30	1.54	1.29	6.33	2.18	2.35	18.06	21.25	2.27

df - degree of freedom, BL - branch length, FG - fruit girth, FL - fruit length, FW - fruit weight, NB/PL - number of branches per plant, NF/PL - number of fruits per plant, NS/P - number of seeds per pod, PHM - plant height at maturity, TFY - total fruit yield, *significant at 5% probability level, **significant at 1% level of probability

The results presented in Table 5 show the multiple genotypic correlation coefficients (rg) of okra yield and yield components. All the yield traits were significant and positively correlated with yield in both early and late planting seasons which implied that improvement of one trait will improve the other. Also, the positive and significant correlations among most of the yield related traits, showed that those traits were linked or were complementary in action. Number of fruits/plant and plant height at maturity and number of seeds/pod had higher correlation values with yield in both seasons. This agrees with the work of Kumar and Reddy (2016) who stressed the positive contribution of increased number of fruits/plant and fruit weight towards improved yield performance of the okra genotypes.

The direct effects of number of fruits/plant from the path analysis were positive and of greater magnitude than direct effects of other seven traits in both seasons (Table 6). Plant height at maturity had negative direct effect on yield in both early and late planting seasons. Fruit girth and number of branches per plant also had negative direct effect in the late planting season. However, the positive in direct effects of these traits through number of fruits per plant indicated that genotypes that had high plant height at maturity, number of branches per plant and fruit girth ensured high number of fruits per plant and thus had higher fruit yields. The indirect effects seem to be the cause of high correlation of plant height at maturity and number of branches/plant with fruit yield (Singh and Chaudhary, 1979; Javia, 2014). Earlier report by Adekoya *et al.* (2014) indicated that number of pod per plant and final plant height had significant correlation coefficients in all seasons and large indirect effect through the branch length but had negative direct effects. This indicated that improvement in seed yield can be made indirect selection for branch length. Path-coefficients obtained (Table 6) will be useful when

Table 4: Mean squares and genetic parameters for some quantitative traits in 13 okra genotypes in early and late planting of 2014 to 2015

Traits	Mean	MSg	Vg	Mse	Ve	Vp	%CV	GCV	PCV	ECV	H^2B (%)	GA	GA %Mean
Early													
BL	40.49	3728.60	1066.33	529.60	176.53	1772.47	150.81	80.65	103.98	32.81	60.16	5217.60	12886.16
FG	9.31	6.98	1.77	1.67	0.56	4.00	28.38	14.29	21.47	8.01	44.31	182.49	1959.76
FL	9.61	21.08	6.77	0.78	0.26	7.81	47.78	27.07	29.08	5.31	86.68	498.95	5192.02
FW	26.32	84.84	26.61	5.00	1.67	33.28	35.00	19.60	21.92	4.90	79.97	950.32	3610.65
NoBPL	2.82	8.70	2.01	2.67	0.89	5.57	104.56	50.26	83.66	33.44	36.09	175.47	6220.02
NoFPL	12.60	208.03	68.48	2.60	0.87	71.94	114.47	65.67	67.32	7.39	95.18	1663.07	13198.96
NoSP	76.32	1192.67	393.69	11.59	3.86	409.15	45.25	26.00	26.50	2.58	96.22	4009.46	5253.48
PHM	95.12	14226.54	4734.18	24.00	8.00	4766.18	125.39	72.34	72.58	2.97	99.33	14126.25	14850.97
TFY	11.92	268.72	88.77	2.40	0.80	91.97	137.52	79.04	80.45	7.50	96.52	1906.84	15996.99
Late													
BL	37.01	3329.50	1068.10	125.20	41.73	1235.03	155.91	88.31	94.96	17.46	86.48	6260.94	16916.90
FG	7.81	4.10	0.87	1.50	0.50	2.87	25.93	11.92	21.68	9.05	30.25	105.51	1351.02
FL	8.13	16.28	4.82	1.82	0.61	7.25	49.65	27.02	33.13	9.59	66.51	368.85	4539.08
FW	23.96	60.64	17.50	8.14	2.71	28.35	32.50	17.46	22.22	6.87	61.72	677.00	2825.53
NoBPL	2.54	5.59	1.25	1.84	0.61	3.70	93.12	44.02	75.81	30.86	33.72	133.66	5266.32
NoFPL	10.89	181.37	59.70	2.26	0.75	62.72	123.67	70.95	72.72	7.97	95.20	1553.02	14261.01
NoSP	67.42	875.97	283.51	25.43	8.48	317.42	43.90	24.97	26.43	4.32	89.32	3278.11	4862.22
PHM	85.92	11989.30	3990.50	17.79	5.93	4014.22	127.44	73.52	73.74	2.83	99.41	12974.60	15100.80
TFY	10.61	250.41	82.70	2.30	0.77	85.77	149.14	85.71	87.29	8.25	96.42	1839.58	17338.22

BL - branch length, FG - fruit girth, FL- fruit length, FW - fruit weight, NoBPL - number of branches per plant, NoFPL - number of fruits per plant, NoSP - number of seeds per pod, PHM - plant height at maturity, TFY - total fruit yield (tonnes per hectare); MS_g - genotypic mean sum of squares, V_g - genotypic variance, MS_e - environmental mean sum of squares, Ve - environmental variance, Vp - phenotypic variance, %CV - percentage coefficient of variation, GCV - genotypic coefficient of variation, PCV - phenotypic coefficient of variation, ECV - environmental coefficient of variation, H^2B - broad sense heritability, GA - genetic advance, GA%Mean - percentage mean of genetic advance

Table 5: Multiple genotypic correlation of yield and yield components of the okra genotypes in both seasons

	Early season									Late season								
	BL	FG	FL	FW	NoBP	NoFPL	NoSP	PHM	TFY	BL	FG	FL	FW	NoBP	NoFPl	NoSP	PHM	TFY
BL	1	.385*	0.125	.447**	.772**	.782**	.505**	.755**	.753**	1	.371*	0.096	.427**	.609**	.787**	.370*	.826**	.753**
FG		1	0.308	.661**	0.14	.623**	.593**	.467**	.675**		1	0.157	.436**	0.202	.493**	0.31	.365*	.484**
FL			1	.566**	0.047	0.218	.562**	0.225	0.306			1	.439**	-0.023	.323*	.576**	0.26	.389*
FW				1	.399*	.554**	.766**	.400*	.678**				1	.409**	.479**	.639**	.402*	.553**
NoBP					1	.420**	.348*	.317*	.440**					1	.385*	0.234	0.307	.367*
NoFPL						1	.750**	.918**	.978**						1	.677**	.923**	.982**
NoSP							1	.619**	.830**							1	.526**	.741**
PHM								1	.866**								1	.895**
TFY									1									

* - Correlation is significant at the 0.05 level (2-tailed); ** - Correlation is significant at the 0.01 level (2-tailed); BL - branch length, FG - fruit girth, FL - fruit length, FW - fruit weight, NoBP - number of branches per plant, NoFPL - number of fruits per plant, NoSP - number of seeds per pod, PHM - plant height at maturity, TFY - total fruit yield (tonnes per hectare)

Table 6: Path coefficient analysis of okra showing components of direct and indirect effects for yield and yield component traits for early and late seasons of 2014 to 2015

	Path coefficient by yield components								
Traits	BL	FG	FL	FW	NoBP	NoFPL	NoSP	PH	Genotypic correlation
Early									
BL	(-0.022)	0.004	-0.002	0.061	0.010	0.677	0.055	-0.030	0.753
FG	-0.009	(0.010)	-0.004	0.090	0.002	0.540	0.065	-0.019	0.675
FL	-0.003	0.003	(-0.013)	0.077	0.001	0.189	0.061	-0.009	0.306
FW	-0.010	0.007	-0.007	(0.136)	0.005	0.480	0.083	-0.016	0.678
NoBP	-0.017	0.001	-0.001	0.054	(0.013)	0.364	0.038	-0.013	0.440
NoFPL	-0.017	0.007	-0.003	0.075	0.006	(0.866)	0.082	-0.037	0.978
NoSP	-0.011	0.006	-0.007	0.104	0.005	0.650	(0.109)	-0.025	0.830
PH	-0.017	0.005	-0.003	0.054	0.004	0.795	0.067	(-0.040)	0.866
Residual									0.013
Late									
BL	(0.014)	-0.009	0.002	0.036	-0.022	0.733	0.028	-0.028	0.753
FG	0.005	(-0.023)	0.003	0.036	-0.007	0.459	0.023	-0.013	0.484
FL	0.001	-0.004	(0.019)	0.037	0.001	0.301	0.043	-0.009	0.389
FW	0.006	-0.010	0.008	(0.084)	-0.015	0.446	0.048	-0.014	0.553
NoBP	0.008	-0.005	0.000	0.034	(-0.036)	0.359	0.017	-0.011	0.367
NoFPL	0.011	-0.011	0.006	0.040	-0.014	(0.932)	0.051	-0.032	0.982
NoSP	0.005	-0.007	0.011	0.053	-0.008	0.631	(0.075)	-0.018	0.741
PH	0.011	-0.008	0.005	0.034	-0.011	0.860	0.039	(-0.034)	0.895
Residual									0.021

BL - branch length, FG - fruit girth, FL- fruit length, FW - fruit weight, NoBP - number of branches per plant, NoFPL - number of fruits per plant, NoSP - number of seeds per pod, PH - plant height

deciding upon selection criterion among different okra genotypes. The number of fruits/plant was the most important factor that increased fruit yield. The direct effects for fruit weight and number of seeds/ pod were positive and moderate. They can thus be regarded as secondary contributors to fruit yield.

Yirga *et al*. (2021) opined that Genotype × environment interaction (GEI) is a challenge for plant breeders since it compounds variety recommendation because of the inconsistency of best-yielding genotypes across cropping environments and seasons. However, the effect of GEI or GSI (Genotype × Season interaction) is mostly minimized by repeating the experiment at several sites or over cropping seasons so as to ensure performance stability. The result of the genotypic stability of yield and the two most related yield component traits over two seasons showed that the genotypes independently expressed their traits in different stability groups (1-4) (Table 7, Figure 2). As such, the most stable genotype is the one with the least deviation from the maximum yield of each season. Genotypes *'Ele Uhie'* and *'Ele Ndu'* were the most stable for fruit weight, number of fruits per plant and total fruit yield. This was because they had significantly higher mean yields (Table 2) and lower percentages coefficient of variation; thus having reduced chances of variation across seasons. This indicates the suitability of these genotypes to adapt to varying seasonal conditions in respect to the

Table 7: Grouping of okra genotypes by yield, fruit weight and number of fruits/plant using yield and CV% values

Group	Fruit weight	Number of fruits/plant	Fruit yield (t/ha)
1. High yield and low variation	*LUDU V.* *Esculentus* *Agwu Early* *TAE-38* *Clemson spineless* *LD-88* *V.35* *NHE 47.4 V* *Ele Ndu* *Ele Uhie*	*Ele Uhie* *Ele Ndu*	*Ele Ndu* *Ele Uhie*
High yield and high variation	*Ele Ogwu*		
2. Low yield and low variation	*Jokoso* *V-21 Ivra*	*LUDU V.* *Esculentus V.* *Jokoso* *V-21 Ivra* *LD-88* *V.35* *NHE 47.4 V*	*LUDU V.* *Esculentus* *LD-88* *V.35* *NHE 47.4 V*
Low yield and high variation		*Ele Ogwu* *TAE-38* *Esculentus V.* *Clemson spineless* *Agwu early*	*Ele Ogwu* *TAE-38* *V-21 Ivra* *Clemson spineless* *Agwu early*

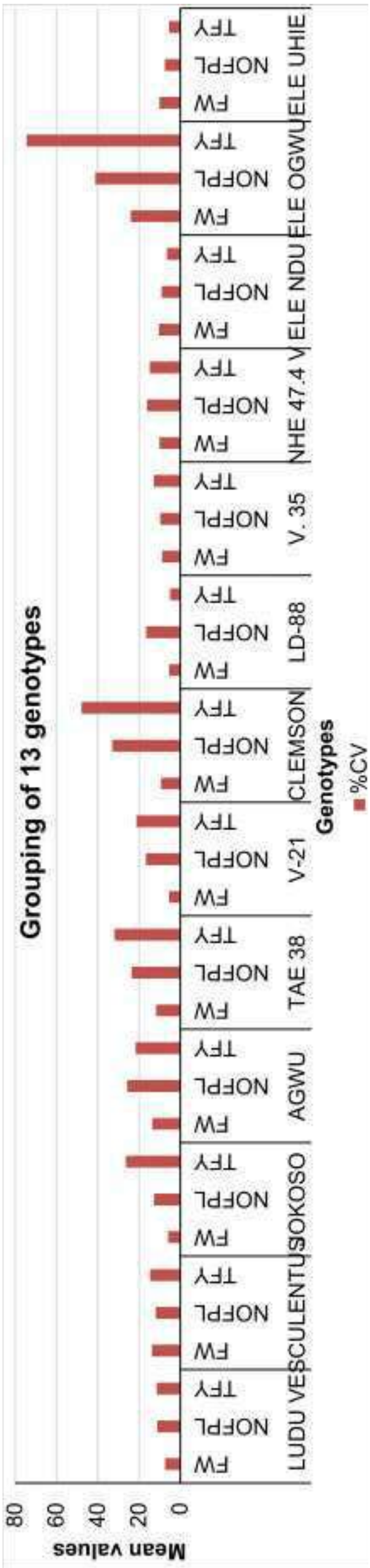

Figure 2: Graphical illustration of mean yield - %CV stability grouping of the 13 okra genotypes for some traits including fruit weight, number of fruits per plant and total fruit yield

aforementioned traits. Similarly, most of the conventional genotypes showed high stability for fruit weight. Although the genotypes, *'LUDU V.'*, *'LD-88'* and *'V.35'* had low mean values for total fruit yield, they however showed low percentage coefficients of variation; thus, indicating their propensity to adapt to varying seasonal effects. In contrast, *'Ele Ogwu'* and *'Clemson spineless'* were the least stable genotypes in relation to total fruit yield. This conforms with the findings of Aladele *et al.* (2011) that genotypes with high mean yield and low coefficient of variation are mostly stable and suitable to different environmental changes. Adekoya *et al*. (2014) observed similar trend in their studies on correlation and path coefficient analyses on seed yield in okra.

CONCLUSION

None of the genotypes exhibited average stability for all the characters studied. The significant genotypes × seasons' interaction effects indicated the inconsistent performance of genotypes across the tested seasons and the differential discriminating ability of the tested seasons. However, the study showed that to obtain optimum productivity, across different seasons, the genotype must be stable in expression of appreciable fruit weight, number of fruits per plant, fruit length and high total fruit yield. Highest mean fruit yield (35.59 t ha^{-1}) was registered at Early season for *'Ele Uhie'* followed by *'Ele Ndu'* (33.56 t ha^{-1}), while *'Clemson spineless'* (3.17 t ha^{-1}) and *'V-21 Ivra'* (3.61 t ha^{-1}) for the late season were the least-yielding. Similar trend was observed for fruit weight and number of fruits per plant across seasons. Among the 13 genotypes, *'Ele Uhie'* and *'Ele Ndu'* were the best performing and most stable genotypes for total fruit yield as well as fruit weight and number of fruits per plant. Most of the conventional genotypes showed poor stability for number of fruits per plant and total fruit yield with low mean values but high percentage coefficients of variation; however, they had significantly shorter duration to attain maturity across seasons. Genotypes *'LUDU V.'*, *'LD-88'* and *'V.*35' showed appreciable stability for fruit weight, of which *'LD-88'* was the most stable. This highlights their potentials for improved yield and productivity.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest on submission of this work.

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