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Genetic Variability and Correlation Studies in Some Varieties of Cucumber (*Cucumis sativus* L.)

Afangideh, U. [*] ***and E. A. Uyoh*** [*]

ABSTRACT

Eleven exotic and six indigenous cultivars of cucumber (*Cucumis sativus*) were evaluated for yield and quality characteristics. Total fruit yield was significantly higher (P<0.01) in the indigenous cultivars; while some exotic cultivars like W12757, Ashley, Addis and Regal had longer vines (P< 0.01) and fewer days to flowering (P < 0.05). Linear correlation analyses showed that mean fruit number per plant and length of vine at 6 weeks were significantly and positively associated with yield (P < 0.001 and 0.01, respectively). Genetic analyses indicated that Phenotypic Coefficients of Variation (PCV) were higher than genotypic coefficients of variation in all of the attributes studied; while length of vine at 6 weeks had the highest genetic gain. High heritability (broad sense) estimates of 94% and 85% were obtained for days to flower initiation and days to 50 percent flowering, respectively. Length of vine at 6 weeks, days to flower initiation and days to 50% flowering had high to moderate genotypic variance, high to moderate heritability and greater genetic gain. Selection can, therefore, be based on these characters, and their phenotypic expression would be a good indicator of their genotypic potentiality.

Keywords: Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), Genetic Advance, Heritability (broad sense), *Cucumis sativus.*

1. INTRODUCTION

Cucumber is a member of the gourd family, Cucurbitacea along with crops like melons, squash and fluted pumpkin. A large number of local cucumber lines are cultivated in Nigeria but no serious attempts have been made to upgrade the productivity and acceptability of this crop within the country (Afangideh *et al.*, 2005). With current emphasis on consumption of fruits and vegetables to promote good health and longevity, it is expected that consumption of vegetables like cucumber may be increased in Nigeria (Eneobong, 2001) and this increase must be matched with an increase in cucumber production. The local variety of cucumber widely consumed and preferred in the Calabar area is a late-maturing, low – yielding variety and thus there is the need to improve this variety through vigorous breeding programs. The success of any breeding program depends to a large extent on the amount of genetic variability present in the population. Overall variability must be partitioned into heritable and non- heritable components with the aid of genetic parameters such as genotypic and phenotypic coefficients of variation and heritability (Ariyo, 1987). This study was carried out to correlate specific vegetative and yield traits with each other and with yield and to determine the extent of genetic variation among available cucumber genotypes with the specific objective of using suitable genetic parameters such as phenotypic and genotypic variances, phenotypic and

* Dept. of Genetics and Biotechnology, University of Calabar, Calabar, Nigeria.
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genotypic coefficients of variation and genetic advance as a basis for future breeding work in cucumber.

2. MATERIALS AND METHODS

Sixteen cucumber varieties obtained from NIHORT, a research station in Nigeria, and from a cucumber breeding station in the United States of America, together with a local Calabar variety (Table 1) were used for this study conducted at the teaching and research farm of the University of Calabar. Calabar is located within the forest zone of South eastern Nigeria and lies between latitude 4.5°N to 5. 2 °N and longitude 8.0 °E and 8.31° E of the equator with annual rainfall from 3500mm to 5000mm and an average monthly temperature of between 25 °C to 27.5 °C. A Randomized Complete Block Design (RCBD) with 3 replicates was used with a plot size of 2.4m X 2.4m. There were 16 plants per plot with a net plot size of 1.2m x 1.2m (1.44m^2) allowing for border row effects. Plant spacing of 60cm by 60cm giving a plant population of 27,778 plants per hectare was used. Two seeds were planted per hole and they were thinned to one per stand at 3 weeks after planting.

Vegetative attributes which were measured fortnightly until the reproductive stage of development began, included length of vine and number of leaves. Reproductive attributes measured were number of days to flower initiation, number of days to 50% flowering, number of staminate flowers per plant, number of pistillate flowers per plant, fruit length, fruit width (at widest portion), mean number of fruits per plant and total fruit weight per hectare. The data obtained were subjected to Analysis of variance and significant means were separated using Duncan's Multiple Range Test (DMRT). The mean values were used for genetic analyses to determine Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV), according to Singh and Chaudhury (1985) as follows:

$$\text{PCV (\%)} = \frac{\sqrt{\sigma^2 p}}{\bar{X}} \times 100$$

$$\text{GCV (\%)} = \frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$$

where: $\sigma^2 g$ = genotypic variance.

$\sigma^2 p$ = phenotypic variance.

$\bar{X}$ = sample mean.

Components of variation were partitioned using the expected mean square (EMS) method by Uguru 1995 where Genotypic variance ($\sigma^2 g$) was calculated as the mean difference between variety mean square and error mean square as follows:

$$\sigma^2 g = \frac{Mg - \sigma^2 e}{r} \quad \text{(Uguru, 1998).}$$

where Mg = genotype (variety) mean square.

$\sigma^2 e$ = error variance.

r = replications.

Expected Genetic Advance (GA) of the genotypes at 5% selection pressure was calculated according to Singh and Chaudhary as follows:

$$\text{GA (\%)} = \frac{k\sigma^2 g}{\sigma^2 p} \times \frac{\sqrt{\sigma^2 g}}{1}$$

where $\sigma^2 g$ = genotypic variance.

$\sigma^2 p$ = phenotypic variance.

$K_{(0.05)}$ = 2.06.

Estimates of broad sense heritability were calculated as suggested by Singh and Chaudhary (1985) as follows:

$$h^2_{(bs)} = \frac{\sigma^2 g}{\sigma^2 g + \sigma^2 e} \times 100$$

where $\sigma^2 g$ = genotypic variance.

$\sigma^2 e$ = environmental variance.

The mean characters that showed significant variations were used to determine partial correlation and simple linear correlation coefficients according to Snedecor and Cochran (1967). A correlation matrix was drawn up using the linear correlation coefficients.

3. RESULTS AND DISCUSSION

Statistical analysis of the means for the measured parameters showed that there were significant differences

in the vegetative and reproductive parameters studied (Table 2). Estimates of genotypic coefficients, genetic advance as well as broad sense heritability are presented in Table 3. The genotypic coefficient of variation ranged from 4.49 for number of leaves at 2 weeks to 158.81 for days to 50% flowering while phenotypic coefficient of variation ranged from 13.34 to 187.96 for the same traits respectively. Heritability estimates for days to flower initiation was the highest at 94% while the highest genetic gain of 133.81 was obtained for length of vine at 6weeks. The values for other parameters are shown in Table 3.

The results in Table 4 indicate that mean fruit number per plant and length of vine at 6 weeks correlated positively and significantly ($P< 0.01$ and $P<0.05$ respectively) with fruit yield while days to flower initiation and days to 50% flowering showed negative correlation with yield. Length of vine at 6 weeks also correlated positively and significantly with mean number of fruits ($P<0.05$). Similarly, there were positive and significant relationships between number of leaves at 4 weeks and number of leaves at 6 weeks ($r = 0.71$), days to flower initiation and days to 50% flowering ($r = 0.89$). Early maturing varieties showed lower yields while the late maturing varieties (with the exception of Ex-Calabar) had higher yields. There were negative, though insignificant correlations ($P> 0.05$) between days to flowering and total fruit yield. These results differ with those of Cramer and Wehner, (2000), who showed a positive correlation between early flowering and total yield, and could be explained by the fact that cucumber is sensitive to amount of rainfall (Uwah and Afangideh, 2000). Thus, those varieties that flowered too early had higher rates of flower abscission resulting in low yields, as did those that flowered late or reached 50% flowering after the heavy rains. Partial correlation was significant ($P < 0.05$) for mean number of fruits (Table 5) and indicated that mean number of fruits contributed over 60% to total fruit yield.

Improvement in yield as a quantitative trait often requires the improvement of a secondary trait that is positively correlated with yield (Smith *et al*., 1978). Cramer and Wehner (1998) reported that number of branches per cucumber plant was positively correlated with total fruit number per plant in a pickling cucumber population. In this study, there were strong and positive correlations between mean number of fruits per plant and length of vine at 6 weeks with yield. Therefore a breeder interested in improvement in cucumber yield could either select plants with longer vines at the end of the vegetative phase of growth, or select plants with more fruits, and be fairly certain of obtaining high yielding plants. Selection to increase length of vine and mean number of fruits would invariably result in increased fruit yield in cucumber (Afangideh *et al*., 2005). Islam *et al*.(1993) reported significant positive correlation between number of fruits per plant and yield ($r= 0.98$) in cucumber. Ramirez *et al*.(1988) also observed significant positive correlations between number of fruits per plant and fruit yield ($r = 0.97$) and stem length and fruit yield ($r = 0.54$) in cucumber.

In trying to determine the extent to which variation in yield components are responsible for differences in yield among various cultivars, it must be borne in mind that overall variability depends on heritable and non-heritable components. While coefficients of variation measure the magnitude of variability present in a population, estimates of heritability and genetic advances are important preliminary steps in any breeding program as they provide information needed in designing the most effective breeding programme and the relative practicability of selection. In this study, the highest Phenotypic Coefficients of Variation (PCV) was observed for the characters number of leaves at 6 weeks, days to 50 percent flowering, number of staminate flowers and total fruit yield. Greater potential could therefore be expected in the selection for these characters (Badaru *et al*.). A comparatively low PCV was shown for number of leaves at 2 weeks, days to flower initiation and fruit length. This low variation indicated the highly stable nature of these characters among the different genotypes studied and are indicative of less scope for improvement (Okoye and Eneobong, 1992). Estimates of Genotypic coefficients of variation were lower in

magnitude than PCV and this trend was similar to observations in African yam bean (Okoye and Eneobong, 1992) and in cashew (Harris *et al*., 1994).

In all the characters studied, a large environmental influence was observed in the manifestation of the traits studied as reflected by the differences in the values between phenotypic and genotypic differences (Ogbonna and Ubi, 2005). The high heritability estimates in characters like days to flower initiation (94%) and days to 50 percent flowering (84%) indicated a high response to selection in these traits (Shadakshari et. al, 1995; Shan and Mishra, 1995).

The estimate of genetic advance is more useful as a selection tool when considered jointly with heritability estimates (Johnson *et al*., 1995; Parnse, 1957). The attributes which had high to moderate heritability as well as genetic gain were length of vine at 6 weeks, days to flower initiation and days to 50 percent flowering, indicating that these are simply inherited traits. Similar results were reported by Islam *et al*. (1993) for vine length, number of fruits per plant and fruit yield in cucumber.

From the above discussion, length of vine at 6 weeks, days to flower initiation and days to 50% flowering were shown to have high to moderate genotypic variance, high to moderate heritability and greater genetic gain. Selection can therefore be based on these characters and their phenotypic expression would be a good indicator of their genotypic potentiality. The remaining traits recorded lower scores in the three genetic parameters considered in this study and therefore offered less scope for selection as they were much more under the influence of the environment.

Table(1): Origin and source of cucumber germplasm for research studies carried out in Calabar, Nigeria between 2002 and 2004.

S/N		VARIETY SOURCE	REMARK
1.	Ex-Calabar	Calabar local variety	Local Variety (unimproved)
2.	Unbeit	NIHORT* improved variety	Local Variety (improved)
3.	Lovita	NIHORT* improved variety	Local Variety (improved)
4.	Delilha	NIHORT* improved variety	Local Variety (improved)
5.	Zeina	NIHORT* improved variety	Local Variety (improved)
6.	Beit alpha	NIHORT* improved variety	Local Variety (improved)
7.	Calypso	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
8.	M21	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
9.	Regal	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
10.	Ashley	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
11.	Straight 8	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
12.	Addis	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
13.	Sumter	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
14.	W12757	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
15.	Tablegreen 72	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
16.	Markmore 76	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety
17.	Poinsett	Cucumber Breeding Station, NCSU**, U. S.A.	Exotic Variety

*- Nigerian Horticultural Research Center.
**- North Carolina State University.

Table (2):Means for vegetative and reproductive traits in selected cultivars of *cucumis sativus* studied in Calabar, Nigeria between 2002 and 2004.

Variety	Length of vine at 4 weeks	Length of vine at 6 weeks	Number of leaves at 2 weeks	Number of leaves at 6 weeks	Days to flowering initiation	Days to 50% flowering	Fruit length (cm)	Mean number of fruits	Total yield
Ex–Calabar++	50.63 a	70.83 bcd	4.08 ab	37.52 abc	58.67 a	66.33 a	15.60 cde	0.78 e	0.09 f
Zeina ++	32.00 abc	113.83 ab	4.42 ab	31.50 bcd	30.67 bcd	43.33 cd	22.57 bc	17.08 a	4.11 a
Delilha ++	47.27 ab	99.10 abc	4.75 ab	31.67 bcd	25.67 ef	35.33 fg	19.48 bc	10.67 bc	2.74 bc
Lovita ++	55.28 a	109.67 ab	4.92 a	40.17 abc	25.67 ef	34.33 fg	21.97 bc	14.08 ab	2.97 abc
Unbeit ++	54.68 a	114.60 ab	5.00 a	40.92 abc	27.00 def	38.00 defg	17.95 cd	8.92 bcd	3.10 ab
Beit Alpha++	42.76 abc	91.68 abc	4.58 ab	39.00 abc	24.00 f	33.67 fg	16.93 cd	10.25 bc	2.76 bc
Poinsett 76+	13.55 bc	53.50 cde	3.75 b	23.13 cd	29.00 cde	37.00 efg	24.48 ab	4.58 de	0.43 f
Sumter+	34.53 abc	50.88 cde	4.25 ab	27.30 bcd	28.33 cde	40.00 cdef	12.58 de	5.32 de	1.75 cde
W112757+	62.85 a	128.28 a	4.75 ab	47.17 ab	29.00 cde	45.00 c	16.59 cd	5.75 cde	1.26 def
Tablegreen +	30.17 abc	71.52 bcd	4.72 ab	30.77 bcd	32.67 b	43.67 cd	17.52 cd	3.55 de	2.09 bcd
Markmore 76+	6.33 c	26.43 de	4.17 ab	12.93 d	31.00 bc	52.00 b	15.23 de	0.37 e	0.22 f
Addis+	40.00 abc	50.00cde	5.08 a	40.25 ab	25.67 ef	38.00 defg	14.14 cde	6.93 cde	1.25 def
Straight 8+	18.59 bc	22.50 de	4.67 ab	20.80 cd	29.00 cde	34.00 fg	27.17 a	6.50 cde	0.13 f
Ashley+	50.18 a	55.88 cde	4.63 ab	48.86 a	29.00 cde	42.0 cde	16.92 cd	1.25 e	0.69 ef
Regal+	20.85 bc	41.52 de	4.33 ab	45.50 abc	26.33 ef	37.00 efg	14.64 cde	11.92 abc	1.74 cde
M21+	15.00 bc	17.83 e	4.00 ab	18.62 cd	25.50 ef	32.00 g	14.49 cde	3.58 de	1.15 ef
Calypso+	39.14 abc	50.00 abc	4.63 ab	40.50 ab	28.67 cde	36.00 fg	13.82 de	6.92 cde	1.75 cde

+ Exotic cultivars.
++ Indigenous cultivars.
Means followed by same letters in each column are not significantly different (from the DMRT table used).

Table (3): Coefficient of variability and genetic advance of various attributes of C. *sativus* in Calabar, Nigeria between 2002 and 2004.

Attributes	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	Genetic advance	$H_{(bs)}$(%)
Length of vine (2 wks)	0.038	16.73	10.39	68.98	0.15	2.27
Length of vine (4 wks)	228.41	558.36	34.28	53.59	6.18	40.91
Length of vine (6 wks)	997.04	1631.48	44.64	57.11	133.81	61.11
No. of leaves (2 wks)	0.0413	0.3643	4.49	13.34	0.023	11.34
No. of leaves (4 wks)	8.62	50.01	18.75	45.16	0.51	17.24
No. of leaves (6 wks)	84.96	232.71	75.31	124.63	3.36	36.51
Days to flower initiation	59.16	62.93	25.78	26.58	7.23	94.01
Days to 50% flowering	64.65	76.52	158.81	187.96	6.79	84.49
No. of staminate flowers	1.65	30.44	20.92	89.85	0.07	5.42
No. of pistillate flowers	1.85	14.11	29.44	81.31	0.18	13.11
Fruit length	9.23	28.06	17.13	30.73	0.99	32.89
Mean fruit No.	15.80	26.98	53.93	70.48	2.33	58.56
Fruit yield	1.13	2.25	60.66	85.79	0.53	50.22

Table (4): Correlation matrix between attributes studied and with fruit yield of exotic and local cultivars (combined) of *Cucumis sativus* in Calabar, Nigeria between 2002 and 2004.

	Length of vine at 4 wks	Length of vine at 6 wks	No. of leaves at 4 wks	No. of leaves at 6 wks	Days to flower initiation	Days to 50% flowering	Fruit length	Mean fruit no. per plant	Total fruit yield
Length of vine at 4 wks	-	0.768***	0.703***	0.705***	0.131	0.124	-.069	0.214	0.372
Length of vine at 6 wks		-	0.433	0.624**	-0.011	0.063	0.369	0.537*	0.688**
No. of leaves at 4 wks			-	-0.125	-0.123	-0.111	0.062	0.174	0.232
No. of leaves at 6 wks				-	-0.331	-0.228	-.080	0.344	0.565*
Days to flower initiation					-	0.892***	-.066	-0.424	-0.389
Days to 50% flowering						-	-.149	-0.473	-0.366
Fruit length							-	0.496*	0.317
Mean fruit no. per plant								-	0.833***

* = significant at 5%

** = significant at 1%

*** = significant at 0.1%

Table (5): Partial correlation and linear regression coefficients of vegetative and reproductive attributes on yield of exotic and indigenous cultivars of *cucumis sativus* in Calabar, Nigeria between 2002 and 2004.

Attributes	Partial Correlation	Linear Regression Coefficients(b)	t-test for Significance (for b)
Length of vine (4wks)	-0.49	0.026	1.54
Length of vine (6wks)	0.58	0.023	3.64**
No. of leaves (4wks)	0.38	0.089	2.85*
No. of leaves (6wks)	0.32	0.108	2.64*
Days to flower initiation	0.25	-0.59	1.66
Days to 50% flowering	-0.27	-0.052	1.48
Fruit length	0.43	0.092	2.37*
Mean fruit no. per plant	0.67*	0.209	6.10***

* = significant at 5%.

** = significant at 1%.

*** = significant at 0.1%.

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دراسات تتعلق بالتنوع الوراثي والارتباط في بعض أنواع (*Cucumis sativus* L.)

أفانجيده وأويوه**

ملخـص

تم تقييم أحد عشر نوعاً دخيلاً وستة أنواع طبيعية من الخيار (*Cucumis sativus*) للوقوف على محصول كل منها وصفاته النوعية. تضمنت الصفات المدروسة المحصول الكلي من الثمار، وطول العروق، وعدد الأيام اللازمة للإزهار، ومتوسط عدد الثمار، لكل نبتة. وبينت النتائج الواردة في سياق البحث أن الانتقاء يمكن أن يبنى على الخصائص المدروسة.

الكلمات الدالة: GCV, PCV، التقدم الوراثي، قابلية التوريث، الخيار (*Cucumis sativus*).

* قسم الوراثة والتقنية الحيوية، جامعة كالابار، كالابار، نيجيريا.

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