Variability, Broad Sense Heritability Estimates and Genetic Advance for Fruit Yield and Yield Components in Cucumber (*Cucumis Sativul* L.) in Southeastern Nigeria.

Chinatu, L.N*, Okoronkwo, C & Henry, C
Department of Agronomy,
College of Crop and Soil Sciences,
Michael Okpara University of Agriculture,
Umudike. P.M.B. 7276
Email: lawremcechinatu@yahoo.com

Abstract
Seven varieties of Cucumis sativus L. were evaluated for quantitative traits performance in a randomized complete block design with three replicates, at the Research Farm of the Michael Okpara University of Agriculture, Umudike. Analysis of variance showed that the varieties were significantly different (P<0.05) in vine length, number of vines plant^{-1}, number of leaves plant^{-1}, fruit length, fruit girth, fruit weight, number of fruit plant^{-1} and fruit yield ha^{-1}. All the yield components with the exception of vine length had positive and highly significant (P<0.01) coefficients of correlation with fruit yield ha^{-1}. The high genetic coefficient of variation and broad sense heritability estimates deduced for number of vines plant^{-1}, number of leaves plant^{-1}, and fruit yield ha^{-1}, implied that exploitable variations exist among the varieties. High heritability estimates and high genetic advance for number of vines plant^{-1}, number of leaves plant^{-1}, and fruit yield ha^{-1} showed that these genetic variations are controlled by additive gene effects, hence, can be transferred from parents to progenies for high genetic gain. Direct selection of varieties with higher performance in number of vines, number of leaves plant^{-1} and fruit yield ha^{-1} for breeding programme could lead to genetic improvement of C. sativus for increased production of the crop.

***Keywords**: Cucumis sativus, evaluation, genotypic variance, heritability.*

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important vegetable crop in the Cucurbitacea family that has been cultivated by man for over 3,000 years (Adetula and Denton, 2003; Okonmah, 2011). It originated in Northern India and is widely distributed throughout the world (Remison, 2005). With respect to economic importance, it ranks fourth after tomatoes, cabbage and onion in Asia (Eifediyi and Remison, 2001), and second after tomatoes in Western Europe (Phu, 1997). However, the production of the fruit in Nigeria is very low due to limited use. They are produced mainly in the Northern states of Nigeria (Adetula and Denton, 2003). It is necessary to increase the production in order to supplement the high intake of carbohydrate in Nigeria. Especially in the southern parts of Nigeria where there are sparse and over dependence of its supply for salad vegetables and fruits on major suppliers from the north, resulting to relative higher price because of transportation cost and spoilage production of the fruit. Soft and succulent, the vegetable crop is cherished by man and eaten in salads or sliced into stew in tropical regions. And its juices are often recommended as sources of silicon to improve the health and complexion of the skin

(Duke, 1997). It is also a good source of vitamin A, C, K, B_6, potassium, pantothenic acids, magnesium, phosphorus, copper and manganese (Vimala *et al*, 1999). Cucumber helps to reduce irritation and swollen skin due to presence of ascorbic acid (Okonmah, 2011). In spite of the increasing relevance of cucumber in Nigeria, low yields are obtained in farmers' fields because of declining soil fertility due to continuous cropping and disregard for soil amendment materials. Application of poultry manure is one of the ways of improving soil fertility and the yield of crops. (Eifefiyi and Remison, 2011).

Increased fruit yield is the primary breeding objectives in the development of cucumber cultivars (Wehner, 1989). Yield components have been used to study fruit yield, in vegetables crops such as cucumber (Abusaleha and Dutta, 1988; Cramer and Wehner, 1998; Solanki and Shah, 1989), blueberry (*Vaccinium corymosum*. L), strawberry (*Fragaria xananassa*, Mill), (Hancock *et al*, 1984) and tomatoes (*Lycopersicom lycopersicon*) (Mc Giffen *et al*, 1994). In some instances, yield components have been positively correlated with yield and could be selected to improve yield. Also the significances of yield may be qualified by factors such as fruit quality, fruit size, or price development of the market determined by season. Fruit exceeding a certain size are of no value. Nowadays, consumers demand good fruit shape and quality. Hence, the need for breeding improvement programmes to enhance the yield of the crop. The objectives of this study were to ascertain the level of variation among the *Cucumis sativus* varieties, with a view of partitioning variability into heritable and non heritable components, determine broad sense heritability and genetic advance for improvement of the crop.

Materials and methods Materials and methods

The experiment was conducted at Michael Okpara University of Agriculture Umudike, in 2015 and 2016 cropping seasons. Seven varieties of *Cucumis sativus* used included; Belt apha, Point set, Market more, Regal, Unbeit, Zeina and Ashley. The varieties were obtained from the National Biotechnology Centre, Ibadan, Nigeria, and laid out in a randomized complete block design with 3 replicates. The experiment consisted of 27 plots, each measuring 0.6 x 1.5m^2, with a distance 0.75m and 1m separating plot and blocks. Spacing of 0.30m by 0.75m was used. Data were collected on vine length, number of vines $plant^1$, number of leaves $plant^1$, fruit length, fruit girth, fruit weight, number of fruit $plant^1$ and fruit yield ha^{-1}.

Data analysis

The data were subjected to analysis of variance as described by Snedecor and Cochran (1998). Factor analysis based on principal component analysis (PCA) was performed according to Johnson *et al*., (1995), to determine the traits that contributed most towards diversity in the varieties used (Nwofia and Adikibe, 2012). Correlation analysis was carried out to determine the strength of relationships between yield and each yield component as well as magnitude and direction of changes expected during selection, (Ariyo, 1995). The means were subjected to analysis of variance and the gross variability partitioned into genetic and non – genetic components. The phenotypic, genotypic and error variances were estimated using the formula of Wrikke and Weber (1986) and Prasad *et al*., (1981):

$$\sigma^2P = \frac{MSG}{r}, \quad \sigma^2G = \frac{MSG-MSE}{r}, \quad \delta^2Ph\ E = \frac{MSE}{r}$$

MSG, MSE and r are the mean squares of genotypes, mean square error and number of replication while σ^2P, σ^2G and σ^2 E are phenotypic, genotypic and error variances respectively.

$PCV = \frac{\sigma P \times 100}{mean}$, $GCV = \frac{\sigma G \times 100}{mean}$, $ECV = \frac{\sigma E \times 100}{mean}$ $\frac{\delta^2 g}{\delta^2 Ph} \times \frac{100}{Mean}$

PCV, GCV and ECV are phenotypic, genotypic and environmental coefficients of variations respectively. Broad sense heritability (h^2B) was estimated as the ratio of genotypic (σ^2G) to the phenotypic (σ^2P) variances as described by Allard (1991).Genetic advance (GA) was estimated with the method of Fehr (1987), using the formula, GA = K(Sp)h^2B. K is the standardized selection differential at 5% (K=2.063), sp is the phenotypic standard deviation σP; h^2B is the broad sense heritability. Genetic Advance (G.A) as % of the mean =

RESULTS AND DISCUSSION

From Tables 1 and 2, the seven varieties of *Cucumis sativus* were highly significantly different ($P< 0.01$) in both yield and yield components considered. The varieties Regal, Market more, point set and Ashley recorded higher performance. With the exception of vine length, fruit length and girth, Regal had superior vegetative characters, reproductive characters and fruit yield hectare^{-1} performances which were significantly higher than that of others. Variance ratio was highest in yield, since various components contribute to yield. Highest coefficients of variation were deduced for number of vine (33.66) and number of leaves (26.42%). The moderate to low levels of coefficients of variation indicate that exploitable variations among the varieties may not be large. From Table 3, positive and significant ($P<0.05$) correlation coefficients were observed between fruit yield and number of vines plant^{-1}, (0.7893***), number of leaves plant^{-1} (0.8180***), fruit girth (0.4602*), fruit weight (0.8606***) and number of fruit plant^{-1} (0.8416***). This showed that these characters contributed significantly to fruit yield hectare^{-1} and could be selected for the improvement of fruit yield in *Cucumis sativus*. Chinatu (2015) reported that selection for quantitative traits that are highly significant ($P<0.01$) with positive association with yield could lead to increase in fruit yield in okra. Principal component analysis of fruit yield and yield components in *Cucumis*

Table1:Variance ratio of yield and yield components of Seven varieties of *Cucumis sativus*

Character	Mean square Genotype	Error	Variance ratio
Vine length (cm)	**5339.3**	**28.4**	**18.80*** **
Number of leaves	**14105.3**	**593.7**	**23.76*** **
Fruit length (cm)	**3.8146**	**0.6257**	**6.10** **
Fruit girth (cm)	**2.9990**	**0.3162**	**9.49*** **
Fruit weight (kg)	**0.00631**	**0.00083**	**7.51*** **
Number of fruit	**0.5798**	**0.1067**	**5.44** **
Fruit yield ha^{-1}(kg)	**145688008**	**343046**	**424.69*** **

*=significant at 0.05, **= significant at 0.01, ***= significant at 0.001

are presented in Table 4. The first principal component (PC1) contributed 99.99% of the variability. The traits that affected PC1 were yield hectare^{-1}, number of leaves plant^{-1} and number of vines plant^{-1}, with fruit yield plant^{-1} having highest loading (0.99997), thereby contributing most to the variability. The purpose of principal component analysis is to identify patterns in the data in such a way as to highlight their similarities and differences (Winterova *et al.*, 2008). It could be used to determine relationship among genotypes (Azondanlou *et al.*, 2003 : Ruiz and

Egea, 2008). The result showed that the fruit yield-1, number of leaves and number of vines plant^{-1} in PCI and fruit length and girth in PC2 were positive indicating that the five quantitative traits contributed more to the observed differences among the varieties.
The components variance analysis showed both genotypic and environmental effects on all the quantitative traits considered, since phenotypic variance was consistently slightly higher than genotypic variance, (Table 5). The genotypic effect was very high for vine length, number of vines plant^{-1}, number of leaves plant^{-1} and fruit yield hectare^{-1}. The genotypic coefficient of variability (GCV) was also high though slightly lower than phenotypic coefficient of variability (PCV) for number of vines, number of leaves and fruit yield plant^{-1}. This indicated that the three characters offered considerable opportunity for selection among these varieties. A similar result was reported by Rafiq *et al*., (2010) in *Zea mays*, Nwofia and Adikibe (2012) in *Ocimum gratissimum*,and Chinatu (2015) *Albemoschus* spp. GCV provides information on the genetic variability present in quantitative traits, although determination of the amount of heritable variation is not possible from GCV alone. Other genetic parameters for selection such as broad sense heritability estimates, genetic advance and genetic gain indicated varying variability in the traits investigated (Table 5). Broad sense heritability estimates were very high as they ranged from 81.87 for number of fruits plant^{-1} to 99.57%.for number of leaves plant^{-1}. Johnson *et al* (1955) reported that heritability estimates together with genetic advance are more important than heritability alone to predict the resulting effect of selecting the best individual genotypes. Genetic advance and genetic gain also indicated much variability for number of vines plant^{-1}, number of leaves plant^{-1} and fruit yield hectare^{-1} (Table 5). Baye (2002); Chinatu and Ukpaka (2016) reported that traits with high heritability values with corresponding high genetic advance often result in variability among crop varieties considered to be products of additive genetic effects. Since improvement efficiency is related to the magnitude of GCV, heritability and genetic advance (Johnson *et al*. 1995), traits with high GCV, broad sense heritability estimates, genetic advance and genetic gain can be improved through selection for genetic improvement of *Cucumis sativus*. Such traits include vine length, number of vines plant^{-1}, number of leaves plant^{-1} and fruit yield hectare^{-1}. This agrees with the findings of Iwo and Ekaette (2010) in ginger, Nwofia and Adikibe (2012) in *O. gratissimum* and Chinatu (2015) in *Abelmoschus caillei*.

Conclusion

This study indicated that varying genetic variability in the yield and yield components of *Cucumis sativus*. Moderate progress could be expected from selection of number of fruits plant-1, weight of fruit, fruit girth and fruit length, since they have high broad sense heritability estimates but low genetic coefficient of variation and genetic advance. High genetic gain (faster progress) could be expected from selection of number of vines plant^{-1}, number of leaves plant^{-1} and fruit yield hectare^{-1} because they are predominantly under the control of additive gene action.

Table 2. Mean values of fruit yield and yield components of Seven *Cucumis sativus* varieties in 2015 and 2016 at Umudike, Nigeria

Varieties	Characters							
	Vine length (cm)	Number of vines plant^{-1}	Number of leaves plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (kg)	Number of fruits plant^{-1}	Fruit yield hectare^{-1} (kg)
Belt alpha	311.33	8.47	165.50	25.55	21.56	0.31	2.90	42222.24
Point set	264.83	12.13	288.17	23.60	21.46	0.34	3.73	55774.07
Market more	313.50	9.13	273.83	25.15	23.45	0.38	3.50	57563.00
Regal	332.83	14.47	344.83	24.46	21.73	0.43	3.87	59755.57
Unbeit	304.17	8.80	258.50	24.89	20.35	0.38	3.23	53611.07
Zeina	402.50	7.52	275.17	22.70	20.75	0.33	3.37	48225.87
Ashley	302.50	5.12	165.17	22.96	21.14	0.30	2.63	43144.30
LSD.0.005	29.51	2.57	42.67	1.385	0.985	0.0505	0.5719	2966.300
C.V (100%)	13.34	33.66	26.42	5.19	4.93	14.15	15.03	12.90

Table3. Correlation matrix of mean values of yield and yield components of Seven varieties of *Cucumis sativus* in 2015 and 2016

Character	Vine length (cm)	Number of vines plant^{-1}	Number of leaves plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (kg)	Number of fruits plant^{-1}	Fruit yield hectare^{-1} (kg)
Vine length (cm)	1.0000							
Number of vines plant^{-1}	0.0564	1.0000						
Number of leaves plant^{-1}	0.3480*	0.6770**	1.0000					
Fruit length (cm)	-0.1326	0.3909*	-0.0164	1.0000				
Fruit girth (cm)	-0.0225	0.3583*	0.1735	0.5087**	1.0000			
Fruit weight (kg)	0.1485	0.7712***	0.7134***	0.4800*	0.4231*	1.0000		
Number of fruits plant^{-1}	0.1792	0.8788***	0.8033***	0.7824***	0.4450*	0.7824***	1.0000	
Fruit yield hectare^{-1} (kg)	-0.0679	0.7893***	0.8180***	0.2469	0.4602*	0.8606***	0.8416***	1.0000

Table4. Eigen vector values for principal component of yield and yield related characters of Seven varieties of *Cucumis sativus*

Character	PC1	PC2	PC3	PC4	PC5
Vine length (cm)	-.00043	-.74440	-.66752	0.00210	0.01490
Number of vines plant^{-1}	0.00037	-.00149	0.01078	0.94521	0.30159
Number of leaves plant^{-1}	0.00824	-.66767	0.74387	-.00166	-.02717
Fruit length (cm)	0.00005	0.00603	-.02601	0.30988	-.84557
Fruit girth (cm)	0.00007	0.00334	-.02275	0.05580	-.43910
Fruit weight (kg)	0.00001	-.000I2	-.00055	0.00494	-.00483
Number of fruits plant^{-1}	0.00006	-.00012	-.00087	0.08602	0.01635
Fruit yield hectare^{-1} (kg)	0.99997	0.00519	-.00642	0.00036	0.00010
Percentage variation (%)	99.9900	0.0100	0.0000	0.0000	0.0000

Table 5: Genetic components of variation for fruit yield and yield related traits of seven varieties of *Cucumis sativus*

Characters	Mean	Range	δ^2Ph	δ^2g	δ^2e	PCV	GCV	H^2bs (%)	GA	GG
Vine length (cm)	318.80	264.8- 402	1779.767	1685.1	94.767	558.271	528.576	94.68	82.28	25.81
Number of vines	9.380	5.12 - 4.74	9.389	8.671	0.718	100.100	92.441	92.35	5.83	62.15
Number of leaves	258.00	165.3-344	47017.667	46819.767	197.900	18223.90	18147.20	99.57	444.80	172.40
Fruit length (cm)	24.22	22.70-25.65	1.2715	1.063	0.2086	4.389	5.250	83.60	1.94	8.05
Fruit girth (cm)	21.47	20.35-23.45	0.9997	0.894	0.1054	4.656	4.165	89.45	1.84	8.58
Fruit weight (kg)	0.307	0.30-0.427	0.0212	0.0182	0.0028	6.906	5.928	85.85	0.257	83.65
Number of fruits	3.319	2.633-3.867	0.193	0.1580	0.036	4.760	5.815	81.87	0.741	22.34
Fruit yieldha^{-1}	51376	42222-59756	48629005.7	47612651.7	956354	92791.68	94653.16	98.03	13,672.6	26.61S

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