Studies on Genetic Variability, Heritability and Genetic Advance in Cucumber (*Cucumis sativus* L.) Cultivars Collected from China and Nigeria

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Abstract: ***Cucumber is an important vegetable crop but has received insufficient breeding attention. The objectives of this work were to assess the genetic variability among the collected cultivars and estimate heritability and genetic advance to enhance selection for genetic improvement of Cucumber. The experimental materials comprised four cultivars from Nigeria and four cultivars from China. The cultivars were evaluated using randomized complete block design (RCBD) with three replications. Analysis of variance showed that the cultivars differed significantly (P<0.01%) in all twelve parameters measured. Agronomic characterization showed there was genetic variability for genetic improvement. Estimate of genetic parameters indicated slightly higher phenotypic to genotypic variance indicating an environmental effect on the agronomic performance of the cultivars. Estimate of coefficient of variation showed high genetic coefficient of variation in all the characters measured indicating exploitable variations among the cultivars. All the traits were highly heritable implying that these traits are genetically controlled. High heritability coupled with high genetic advance over mean (GAM) observed in eleven parameters implied that these traits were controlled by additive genetic effect and can be transferred to generations. Since additive genetic effect predominates, cucumber genetic improvement through recurrent selection was recommended.***

Keywords: *Cucumis sativus* L., genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance, selection, improvement.

1. Introduction

Cucumber (*Cucumissativus* L.) is one of the most important members of Cucurbitaceae family. It is believed to have originated from India and China which remains the secondary centre of diversity [1]. It is a popular fresh vegetable that can be eaten raw or used for making salad [2]. Vegetables are inevitable for healthy and nutritional diets. The flesh of cucumber is a very good source of vitamin A, C and folic acid [3]. The hard skin is rich in a variety of minerals including calcium, potassium and magnesium. Cucumber has cooling effect and can be used as cooling vegetable [4]. It is ideal for people suffering from jaundice and allied diseases and also very much useful in preventing constipation [5].Genetic variability is the presence of genetic differences as a result of gene recombination while genetic diversity is the measure of the amount of heritable variations in a population of organisms which helps the population to adapt to a changing environment. According to Kalaiyarasi *et al*. [6], genetic variability is essential for continued genetic improvement of any crop species. The knowledge of existing variability with respect to yield and yield attributing traits in the germplasm of a crop is the basic requirement in order to select the desirable types [1].Information on genetic variability is used to identify the promising diverse genotypes which may be useful in further breeding programme [7]. Knowledge of genetic diversity helps breeders to make right choice of breeding parents for a successful breeding programme. The improvement of selected plants over the parents is the function of genetic variability of the base population, heritability of the characters under selection and the selection intensity. Heritability estimates give an insight into the extent of genetic control to express a particular trait and phenotypic reliability in predicting its breeding value [8]. Heritability gives the information on the magnitude of inheritance of characters from parent to offspring, while genetic advance will be helpful in finding the actual gain expected under selection [9].Genetic advance (GA) measures the genetic gain of selected plants over the parental population. Genetic improvement is a continuous process and its success depends upon the availability of variability at the breeder's hand [8, 10].

In order to have a successful breeding programme aimed at cucumber improvement, the knowledge of heritability, genetic advance, genetic variability available to the breeders and the judicious selection of parents are of utmost importance. This is because heritability of traits and its expected genetic advance aid the effective utilization of available genetic resources in a population. Thus, the present study was carried out to assess the genetic variability among the collected cultivars and estimate heritability and genetic advance to enhance selection for genetic improvement.

2. Materials and Methods

The experimental materials comprised eight cultivars; four from China and four from Nigeria. Cultivars from China include CU100, CU102, CU986 and CU999 while cultivars from Nigeria include Poinsett76, Market more, Ikom local and Kaduna local. Two of the cultivars (Ikom and Kaduna local) were landraces. The study was carried out at the teaching and research farm of the Department of Crop

Production and Landscape Management, Ebonyi State University, Abakaliki. The research area is an ultisol located at longitude 08^0 65^1E and latitude 06^0 04^1N with a relative humidity of 65% during dry season and 75% during rainy season. The average annual rainfall is 1700mm. The research was conducted using two experiments (phenotypic characterization and evaluation of cultivars).Phenotypic characterization was laid out in a cultivar per row fashion and data was analysed using simple descriptive statistics (mean, variance and standard deviation) while evaluation was laid out using randomized complete block design (RCBD) with three replications and data was analysed using analysis of variance (ANOVA). The seeds were sown at the spacing of 0.75m x 0.5m. Also, standard cultural practices were carried out to ensure proper growth and development of the crop. The following data were collected and recorded: days to 50% flowering (D50%F), average number of staminate (male) flowers per plant (MF), average number of pistillate (female) flowers per plant (FF), average leaf area (LA), leaf area index (LAI), average number of fruit per plant (NF), average fruit length (FL), average fruit girth (FG), average fruit weight (FW), average number of vine per plant (NV), average vine length (VL) and average number of leaf per plant (NL).Genetic variability was assessed using the quantitative traits. Variance components, heritability and genetic advance were estimated to assess the available variation and predict advances in selection. Data collected for agronomic traits were subjected to analysis of variance procedure for RCBD experiment using GenStat software 5th edition version 4.0 as outlined by Roger *et al.* [11]. Means were separated using Fishers least significant difference (F-LSD) of GenStat software at 99% probability levels as described by Roger *et al.* [11] and Obi [12]. Mean values were used for genetic analyses to determine phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) according to Singh and Chaudhary [13] and Allard [14]:

$$PCV\ (\%) = \frac{\sqrt{\delta 2P}}{x} X\ 100.$$

$$GCV\ (\%) = \frac{\sqrt{\delta 2g}}{x} X\ 100.$$

Broad sense heritability (H_B) was estimated according to Falconer and Mackay [15] and Okporie*et al.* [16]as $H^2 = \delta^2 g/\delta^2 p$.Genetic advance (GA) assuming selection pressure of 5%; and genetic advance over mean (GAM) was estimated according to Johnson *et al. [*17]as GA=k x $\sqrt{\delta^2 p}$ x $\delta^2 g/\delta^2 p$. Where GA=Expected genetic advance. k = standardized selection differential constant (2.06) at 5% selection intensity. $\sqrt{\delta^2 p}$ = phenotypic variance and $\delta^2 g$ = genetic variance. GAM (%) = GA/X. Where GA= genetic advance, X= the grand mean of the population. Heritability was then classified into low (<30%), moderate (30-60%) and high (>60%) according to Kumari *et al.* [18].Genetic advance and GAM were classified according to Teklu*et al.* [19]as low (0-10%), moderate (10-20%) and high (>20%).

3. Results

Results obtained from mean agro-morphological traits of the Cucumber cultivars collected from China and Nigeria are as presented in Table 1.All the agro-morphological traits studied for cultivars in both populations had significant differences (Table 2).Generally, Chinese population was early maturing; flowering on the average of 25.2days compared to Nigerian population (30.4days). Nigerian population had more staminate flowers (93.4) and lesser pistillate flowers (8.7) than Chinese population which had 68.1 staminate flowers and 10.8 pistillate flowers. Morphologically, Nigerian population performed better than Chinese population; recording higher value in all the morphological traits than Chinese population. On the contrary, Chinese population performed better than Nigerian population in yield and some yield component traits. The varieties in each of the populations (China and Nigeria) differed significantly (P<0.01) from each other in all agro-morphological traits studied except average number of female flowers per plant, fruit girth and vine length. All the cultivars differed from each other in days to 50% flowering. However, Market more from Nigeria had no significant difference from CU102 collected from China. In average number of male flowers per plant, CU999 collected from China was statistically the same with Ikom local, Market more and Pointsett76 collected from Nigeria. Also, CU986 collected from China was statistically the same with Ikom local and Pointsett76 collected from Nigeria while others differed significantly. In average number of female flowers per plant, all the cultivars collected from China was statistically the same with Nigerian population except CU100 which differed significantly from all Nigerian population and CU102 which differed from Ikom and Kadunal local. In number of branches per plant, CU999 differed from every other cultivar. However, CU100 was statistically the same with Poinsett76 and differed significantly from others while CU102 and CU986 differed from Kaduna local. Ikom and Kaduna local collected from Nigeria differed significantly from the Chinese population in number of leaves per plant.

However, Market more and Poinsett76from Nigeria was statistically the same with Chinese population. Kaduna local from Nigeria had significant difference from Chinese population in vine length. Also, Market more and Poinsett76differed significantly from CU999. In leaf area, Poinsett76from Nigeria was statistically the same with Chinese population except CU100. However, Kaduna local differed significantly from Chinese population, Market more and Ikom local differed from Chinese population except with CU100 andCU999 respectively. Ikom and Kaduna local had significant difference from Chinese population in leaf area index while Market more and Poinsett76was statistically the same with CU100, CU986 and CU999 but differed significantly from CU102. All the cultivars differed significantly from each other in number of fruits per plant except Poinsett and Ikom local (both from Nigeria), Kaduna local and CU986, Ikom local and CU999. In fruit length, all cultivars differed significantly except Poinsett76and Market more which was statistically the same with CU102. However, Market more and Poinsett76, Ikom and Kaduna local (all from Nigeria) was statistically the same. Kaduna and Ikom local from Nigeria differed significantly in fruit girth. However, CU102 and CU986 from China differed from Market more and Poinsett76 from Nigeria respectively. Significant difference was recorded among the cultivars in fruit weight except in Poinsett76 and CU100, Ikom local and CU999 and in CU986 and CU102.

The level of variability among the 12 agro-morphological traits with respect to variance components was presented in Table 3. The GCV values ranged from 6.50-52.25. Low GCV value was recorded for average fruit girth, having value less than 10%, moderate GCV was recorded for days to 50% flowering, number of male flowers per plant, average leaf area, leaf area index and average fruit length (10-20%). However, six traits (number of female flowers per plant, number of branches per plant, average vine length, number of leaves per plant, leaf area index, number of fruits per plant and average fruit weight) had high GCV (>20%). As for PCV, number of female flowers per plant, number of branches per plant, average vine length, number of leaves per plant, number of fruits per plant and average fruit weight recorded a high percentage of PCV (>20%). However, moderate value was recorded for days to 50% flowering, number of male flowers per plant, average leaf area, and average fruit length (10-20%). Low PCV value was observed in average fruit girth (<10%).

The result in Table 3 also shows the broad-sense heritability and genetic advance of the studied traits. High heritability value was recorded for all 12 traits which range between 66.7% and 98.8%. The highest heritability value was found in number of fruits per plant (98.8%) followed by days to 50% flowering (98.6%) and average fruit length (98.3%). In this study, GA value of these 12 traits ranged between 0.24% - 169.68%. High genetic advance (GA) was found in number of leaves per plant (169.68%), average leaf area (79. 51%) and number of male flowers per plant (26.07%). Other 9 traits showed low GA percentage. However, genetic advance over mean (GAM) ranged between 12.57% and 105.92%. High GAM value (>20%) was recorded for all the 12 traits evaluated except average fruit girth which recorded moderate GAM value (10-20%).

Table 1: Mean agro-morphological traits of the Cucumber cultivars collected from China and Nigeria

Source	Cultivars	D50%F	MF	FF	NL	NB	VL	LA	LAI	NF	FL	FG	FW
China	CU100	25.0	59.0	15.3	106.5	5.5	2.7	221.4	1.97	7.8	22.7	10.0	0.5
	CU999	24.3	76.7	9.7	99.0	4.3	3.3	287.1	2.04	4.3	34.3	9.9	0.8
	CU102	27.3	60.7	11.0	148.5	7.2	3.0	269.2	1.23	6.0	24.6	10.8	0.6
	CU986	24.0	76.0	7.3	120.8	7.8	2.5	260.3	2.19	5.1	30.2	9.4	0.6
	Mean	**25.2**	**68.1**	**10.8**	**118.7**	**6.2**	**2.9**	**259.5**	**1.9**	**5.8**	**27.9**	**10**	**0.6**
Nigeria	Ikom local	33.7	94.0	7.7	271.3	9.0	3.5	307.9	3.88	3.9	28.4	11. 5	0.8
	Kaduna local	32.3	98.0	8.6	317.2	14.2	4.7	336.2	3.49	5.3	27.7	11.0	0.9
	Poinsett76	27.3	86.0	9.3	104.8	6.2	2.4	264.1	2.93	3.8	24.6	10.3	0.5
	Market more	28.3	95.7	9.3	113.2	7.5	2.3	215.4	2.43	2. 5	24.8	9.7	0.4
	Mean	**30.4**	**93.4**	**8.7**	**201.6**	**9.2**	**3.2**	**280.9**	**3.2**	**4.3**	**26.4**	**10.3**	**0.7**
	LSD(P<0.01)	1.3	19.3	2.3	45.0	1.9	0.9	27.8	1.1	0.5	1.5	0.7	0.1
	%CV	2.6	13.6	2.3	16.1	13.8	16.6	5.9	6.5	6.0	3.2	4.0	8.4

NOTE: Days to50% flowering, D50%F; Number of male flowers per plant, MF; Number of female flowers per plant, FF; Number of leaves per plant, NL; Number of branches per plant, NB; Vine length, VL; Leaf area, LA; Leaf area index, LAI; Number of fruits per plant, NF; Fruit length, FL; Fruit girth FG; Fruit weight, FW.

Table 2: Analysis of variance for agro-morphological traits of the Cucumber cultivars collected from China and Nigeria

Sources of variation	df	D50%F	MF	FF	NL	NB	VL	LA	LAI	NF	FL	FG	FW
Replication	2	0.2917	77.4	5.042	231.0	1.010	0.0237	1408.5	0.3847	0.1579	0.8812	0.0935	0.0004
Treatment	7	38.5655**	702.4**	19.042**	21678**	26.732**	1.9696**	49633.4**	0.9044**	7.8689**	42.8874**	1.5084**	0.0826**
Error	14	0.5298	121.1	1.756	662.2	1.129	0.2564	253.4	0.1837	0.085	0.7432	0.1737	0.0028

NOTE: Days to50% flowering, D50%F; Number of male flowers per plant, MF; Number of female flowers per plant, FF; Number of leaves per plant, NL; Number of branches per plant, NB; Vine length, VL; Leaf area, LA; Leaf area index, LAI; Number of fruits per plant, NF; Fruit length, FL; Fruit girth FG; Fruit weight, FW.

Table 3: Phenotypic and genetic coefficient of variation, heritability and genetic advance for agro-morphological traits of the Cucumber cultivars collected from China and Nigeria

Traits	$\sigma^2 e$	σ^2p	$\sigma^2 g$	PCV (%)	GCV (%)	h^2b (%)	GA	GAM (%)
Days to 50% flowering	0.18	12.86	12.68	12.90	12.81	98.6	7.29	26.26
Number of male flowers /plant	40.46	234.14	193.68	18.93	17.22	82.7	26.07	32.26
No. of female flowers /plant	0.59	6.39	5.80	25.82	24.59	90.8	4.73	48.27
Number of branches / plant	0.38	8.92	8.54	38.74	37.90	95.7	5.88	76.36
Average vine length (m)	0.09	0.66	0.57	26.55	24.67	86.4	1.45	47.23
Number of leaves / plant	220.63	7226	7005.37	54.87	52.25	96.9	169.68	105.92
Average leaf area (cm^2)	84.14	1654	1569.86	15.05	14.66	94.9	79.51	29.42
Leaf area index	0.06	0.31	0.25	21.66	19.46	80.6	0.93	36.19
Number of fruit per plant	0.03	2.62	2.59	33.51	33.32	98.8	3.29	68.21
Average fruit weight(kg)	0.01	0.03	0.02	27.49	22.45	66.7	0.24	37.72
Average fruit length (cm)	0.25	14.30	14.05	13.92	13.79	98.3	7.65	28.17
Average fruit girth(cm)	0.06	0.51	0.45	6.92	6.50	88.2	1.30	12.57

NOTE: Error variance, $\sigma^2 e$; Phenotypic variance, $\sigma^2 p$; Genotypic variance, $\sigma^2 g$; Phenotypic coefficient of variation, PCV; Genotypic coefficient of variation, GCV; Broad sense heritability, h_B^2; Genetic advance, GA; Genetic advance over mean, GAM.

4. Discussion

Genetic variability is a basic necessity for any crop improvement programme because it creates room for selection of desired genotype and also leads to genetic diversity. Genetic diversity is not only useful in selection of desirable genotype but also helps the population to adapt to the changing environment. The better morphological performance of Nigerian population may be due to adaptive features acquired in their local environment. Ordinarily, this better morphological performance would have been translated into higher yield but reverse is the case due to lack of favourable genes for high yield. Also, higher yield and yield components recorded by the Chinese population may be due to better breeding work received by these cultivars. Significant differences among populations and cultivars observed in most of the agro-morphological traits indicate different genotypes as a result of gene recombination within the two populations and their different area of sources (China and Nigeria). This is in line with the findings of Shah *et al.* [20] who reported high significant difference in all the characters except carbohydrate content. Variation among the cultivars in all the twelve agro-morphological traits studied is desirable and in line with the objective of the study. Such variability is highly recommended by many breeders for genetic improvement. The observed genetic diversity is the function of the genetic variability recorded between and among the populations. Similar results have been found by Al-rawahi *et al.* [21] who reported significant genetic diversity among Oman cucumber accession. Contrarily, Karakurt *et al.* [22] reported low genetic variation among cucumber genotypes. Estimation of variance components (phenotypic, genotypic and environmental variance) is necessary in order to predict genetic gain under selection. For any sound breeding programme, materials at the hands of breeder should have a large variation. The observed higher genotypic to environmental variance in all the measured traits in this work showed that genes contributed more to the performance of these crops than environment. This is similar to the findings of *al.* [18]who reported high genotypic variance in fruit yield, fruit length and number of leaves at which first female flower appear.

High value of CV shows high variability among cultivars but the most desirable to the breeders is a high proportion of GCV to the PCV. The results indicated that phenotypic coefficient of variations (PCV) were slightly higher than genotypic coefficient of variations (GCV) for all the traits, indicating that the apparent variation is not only due to genotypes but also due to environmental influence. However, the influence of environment in the expression of these traits is lower than the genetic influence. These results were in agreement with the findings of Kumari *et al. [*18] and Shah *et al.* [20]on cucumber who reported higher PCV to GCV in all the traits and Ogunniyan and Olakojo [23] on maize but disagree with findings of Chinatu *et al.* [4]who reported higher GCV to PCV in fruit length, fruit girth and yield per ha. The observed high heritability in all the measured traits implies that these traits are genetically controlled, suggesting the important role of genes in the expression of these traits and such traits are considered to be reliable for breeding. Shah *et al.* [20]; Rajawat and Collis [9]; Kumari *et al.* [18] and Kumar *et al.* [24] reported high heritability in most of the morphological and yield traits measured on cucumber, Singh *et al.* [25] in bitter gourd; Kumar *et al.* [26] in Sponge gourd and Teklu *et al.* [19]on sesame.

High heritability coupled with high GAM observed in all the traits except fruit girth implies preponderance of additive gene action for these traits which is fixable in subsequent generations. This also provides evidence that large proportion of phenotypic variance has been attributed to genotypic variance, and reliable selection could be made for these traits on the basis of phenotypic expression. From the above estimates, it is clear that these characters are less influenced by the environmental factors and are controlled by additive gene effect. Rajawat and Collis [9] reported high heritability coupled with high GAM in number of female flowers per vine, number of male flower per plant and node at which first female flower appears; Kumar *et al.* [27] reported same on twelve out of twenty-one traits measured and Shah *et al.* [20]reported high heritability coupled with high GAM in all traits except percentage of fruit setting and days to first fruit harvest.

5. Conclusion

The high level of variability, heritability and genetic advance over mean (GAM) observed among the cultivars used in this work showed the suitability of using the cultivars for initiating cucumber improvement programme. These variations are of breeders' interest in achieving breeding objectives. Due to the preponderance of additive gene action in the traits studied, recurrent selection, using a combined approach of both marker assisted and conventional methods, is recommended for further improvement of these cucumber cultivars.

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