NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 55 Number 1, April 2024 Pg. 24-34
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng

Prospects of Increased Production of Cucumber (*Cucumis sativus* L.) through Heterosis

[1]Chinatu, L. N., [1]Adedoyin C., [1]James, M. S. and [2]Davids, E. C. M.

[1]Department of Agronomy, College of Crop and Soil Sciences,
Michael Okpara University of Agriculture, Umudike
[2]Crop Science and Biotechnology Department, Faculty of Agriculture and Veterinary Medicine,
Imo State University, Nigeria
Corresponding author's email: lawrencechinatu@yahoo.com

Abstract
Twelve varieties of Cucumber (*Cucumis sativus* L) were evaluated for yield and yield components in a randomized complete block design replicated three times at the Michael Okpara University of Agriculture, Umudike in 2020 and 2021. Data were collected on the length of the main vine, the number of leaves plant^{-1}, number of vines plant^{-1}, number of fruits plant^{-1}, fruit diameter, the weight of fruit plant^{-1}, length of fruit and fruit yield^{-1}. Analysis of variance showed that the varieties differed significantly (P<0.05) in all the attributes studied. Thai 986, Thai 999 and Cu 4315, recorded superior vegetative and reproductive characters performance, and also recorded higher fruit yield in both 2020 and 2021. Except for the length of fruit, all the vegetative and reproductive characters had positive and significant associations with fruit yield ha^{-1}. The number and weight of fruit plant^{-1} were the major direct contributors to fruit yield. In 2020, a crossing block was also established and crosses made between the parents to raise F_1 seeds. The F_1 seeds were planted alongside the parents in a randomized complete block design. Heterosis was studied on fruit yield and yield components. The following crosses (Thai 999 x Thai 986, Thai 986 x Thai 999, Marketer x poitsett76, Pointsett76x Marketer, Marketmore76 x Marketmore and Marketmore x Marketmore76 recorded heteroses of 28.24, 46.56, 94.99, 97.17, 86.12 and 88.40% and 32.51, 51.45, 98.86, 101.07, 91.91and 93.07% over their better and mid parents respectively. These crosses could be exploited for an increase in fruit yield through the use of their F_1 seeds.
Keywords: Cucumber varieties, heterosis, F_1 hybrids, yield and yield components

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 (Okonmah, 2011). It originated in Northern India and is widely distributed throughout the world. Economically, 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 knowledge of its usefulness. They are produced mainly in the Northern States of Nigeria (Adetula and Denton, 2003). It is necessary to increase its production to supplement the high intake of carbohydrates in Nigeria, especially in the Southern parts where there are sparse and over-dependence of its supply for salad vegetables and fruits on major suppliers from the North. The resultant effect is higher price due to transportation costs, mechanical and other forms of spoilage of the fruit (Enujeke, 2013). Soft and succulent, the vegetable crop is cherished by man and eaten in salads or sliced into stew in tropical regions. Its juices are often recommended as sources of silicon to improve the health and complexion of the skin. It is also a good source of vitamins A, C, K, B_6, potassium, pantothenic acids, magnesium, phosphorus, copper and manganese (Vimala *et al*, 1999). It helps in reducing irritation and swollen skin due to the presence of ascorbic acid (Okonmah, 2011). In Nigeria, low yields are obtained in farmers' fields because of declining soil fertility due to continuous cropping and disregard for soil amendment materials. The application of poultry manure is one of the ways of improving soil fertility and the yield of crops. (Eifefiyi and Remison, 2011). The primary breeding objective in the development of Cucumber varieties is increased fruit yield, (Wehner, 1989). Yield components have been used to study fruit yield in vegetable crops such as cucumber (Shah *et al*. 2016; Chinatu *et al* 2017), West African okra, (*Abelmoschus caillei*) (Chinatu *et al*. 2017), tomatoes (*Lycopersicom lycopersicum*) (Mc Giffen *et al*, 1994).

According to Rajesh and Gulshan (2001) and Chinatu and Okocha, (2006), the emphasis on the development of hybrid varieties/lines is because of several inherent advantages such as high fresh pod yield in okra. Heterosis is the increase in productivity and vigour of F_1 hybrids over and above the parental forms and is a way of increasing crop production. Heterosis breeding is one of the ways to improve the production and productivity of a crop to harness the potential of F_1 hybrids (Dhumal, *et al*. 2019). According to Atanassova *et al.* (2002), Chinatu and Okocha (2006) and Kumar et *al*., (2016), heterosis in tomatoes, okra and many other crops is one of the primary reasons for the success of plant breeding endeavours. Atanassova *et al*., (2002) in their study of F_1 hybrids of mutant lines observed high level of heterosis, especially for productivity, early yield and fruit length, and obtained heterotic values that ranged from 28.94 to 157.84% in tomatoes. Heterosis has also greatly enhanced the increase in rice production. The first commercial hybrid was released to Chinese farmers in 1976, when the area under rice cultivation was only 0.15 million hectares. The area under hybrid rice cultivation jumped to more than 2.1 million hectares in 1977, 6.75 million hectares in 1983 and about 8 million in 1984(Singh, 1988). A wide range of genetic variability is available in Cucumber providing good scope for improvement in yield and other characteristics of the crop through selection, (Manivannan *et al*., 2020). The exploitation of heterosis has become a potential tool to improve Cucumber yield. Therefore, the objectives of this work are to evaluate their fruit yield potentials, determine the level of heterosis in crosses between the varieties and select cross combinations that present brighter opportunities for improved Cucumber production in Umudike, Southeastern Nigeria.

Materials and Methods

Experiment 1. Twelve varieties of Thai 999, Thai 986, Thai 100, Thai 971, and Marketer, Poinsett76, Marketmore 76, Marketmore, Super marketer, Poinsett, Cu 4315, and Cu 4320of Cucumber obtained from Thailand Agro-farm office in Imo State and National Seed Counsel Office, Umudike respectively were used for the study. The experiment was carried out at the Research Farm of Michael Okpara University of Agriculture, Umudike, in a randomized complete block design (RCBD) with three replicates. The experiment comprised 36 subplots, each measuring 2m by 2m with 1m separating both plots and blocks. Three Seeds were sown per hole but later thinned down to two. Data were collected on the length of the main vine, number of leaves plant^{-1}, number of vines plant^{-1}, number of fruits plant^{-1}, fruit diameter, weight of fruit, length of fruit and fruit yield^{-1}. The performances of these agronomic attributes were evaluated in 2020 and 2021.

Experiment 2. Crossing blocks were established and crosses were made between parents to raise hybrid seeds in 2020. Staggered planting to synchronize flowering was employed at two weeks intervals to a maximum of four plantings. Since the female flowers are different from the male, emasculation was not needed. Mature pollen grains from another variety were collected and dusted on the stigma of mature female flower. The pollinated flowers were covered with paper envelope till the next day to ensure crossing. According to Kehinde, (1999) and Chinatu and Okocha, (2006), since anthers dehisce 2 to 3 hours before anthesis, self-pollination would have been avoided by this method. Crossing was done between 7 am and 10 am, within crossing blocks. The crossed flowers were tagged. The label carried the genotypes crossed and the date of crossing. Both straight and reciprocal crosses were made and F_1 seeds were raised. Fertilization occurs about 6 hours after pollination (Yusuf *et al*. 2017, Kumar, 2019).

Experiment 3. In 2021, comparison blocks between parents and F_1 generation were established in RCBD with the parents and their F_1 hybrids as treatments with three replications. The inter and intra row spacing was 1m by 1m and each subplot measured 2m by 2m. The blocks were separated by a distance of 1m. Data were collected as in experiment 1. Data from experiments 1 and 3 were analyzed following the procedure outlined by Obi (2001) for randomized complete block design using Genstat Edition 4. Comparison of treatment means and significant differences between treatment means were separated using Fisher's Least Significant Differences (FLSD) as outlined by Snedeco and Cochran (1989) and Obi (2001). Correlation analysis was carried out to determine the relationship between fruit yield ha^{-1} and yield components while Path coefficient analysis was carried out to determine the direct and indirect contributions of each yield component to fruit yield ha-^{1}of the varieties.

Biometrical analysis. Heterosis was determined according to Falconer (1989) as follows

Better parent (Bp) and Mid-parent (Mp) heteroses were calculated from the mean values of parents and F_1 generations.

$$\text{H (Bp)\%} = \frac{(\text{F1} - \text{Bp})}{Bp}\ 100 \ldots\ 1$$

$$\text{H (Mp)\%} = 1 + \frac{\frac{(\text{F1 - (Bp + Mp)}}{2}\ 100}{\frac{\text{Bp + Mp}}{2}} + \cdots 2$$

Where F_1= Mean of F_1 generation, Bp = better parent mean and Mp = mean of mid parent

Results and Discussion

The physical and chemical characteristics of the soil experimental site were taken and analyzed before planting. The results are given in Table 1. Soil textural class was sandy loam. Slight. The soil was relatively suitable for the cultivation of *C. sativus*, (Baughman *et al*. 2015; Chinatu *et al.* 2017). The soil was analyzed at the National Root Crop Research Institute Umudike, Soil Science Laboratory. The soil was slightly acidic with pH in H_2O of 5.8 in 2020 and 6.1 in 2021. The rise in organic carbon, total nitrogen and available phosphorus in 2021 was due to the residual effects of uniform application of organic manure, which released nutrients slowly. From Tables 3 and 4, the varieties differed significantly (P< 0.05)in their vegetative characteristics (main vine length, number of leaves plant^{-1} and number of vines plant^{-1}) in both 2020 and 2021. The varieties, Thai 999, CU4320, CU4315, Thai 986, Thai 971 and Marketmore76recorded superior vegetative characters performance, while Poinsett had the shortest main vine length, the fewest number of leaves plant^{-1} and fewest number of vines plant^{-1} in both years. The varieties also differed significantly ($P < 0.05$) in their reproductive characters; (number of fruits plant^{-1}, fruit diameter, weight of fruit plant^{-1}, and length of fruit) performance as well as fruit yield ha^{-1}. In both years, Thai 986 and Thai 999 performed significantly higher ($P<0.05$) than other varieties in number of fruit plant^{-1}, weight of fruit plant^{-1} and fruit yield ha^{-1}. The varieties Marketmore, Marketmore76 and Pointsett recorded the least number of fruit plant^{-1}, the smallest weight of fruit plant^{-1} and the poorest fruit yield ha^{-1} in both years.

From Tables 5 and 6, positive and significant ($P<0.05$) association existed between vegetative characters and reproductive characters (number of fruit plant^{-1} and weight of fruit plant^{-1}), also between vegetative characters and fruit yield ha^{-1} exception for number of vines plant^{-1} in both years. Positive and significant ($P<0.05$) association existed between number of fruits plant^{-1}, weight of fruits plant^{-1} and fruit yield ha^{-1}. This implied that an increase in the performance of vegetative characters led to an increase in the number of fruits and weight of fruit plant^{-1} which led to an increase in fruit yield ha^{-1} of Cucumber. This agrees with the work of Tenebe *et al*. (1995), who reported that growth parameters (plant height, number of leaves and number of branches) are strong yield parameters.

From Tables 7 and 8, Path analyses showed that the number of fruit plant^{-1} and the weight of fruit plant^{-1} were the highest direct contributors to fruit yield in Cucumber. High performance of vegetative characters led to high performance of reproductive characters (number of fruits and weight of fruits plant^{-1}) which led to high fruit yield ha^{-1}. Vegetative characters according to Ajibade and Morakinyo (2000), Chinatu and Okocha, (2006) and Anonymous (2010) determine the amount of photosynthates available to plants for growth and fresh pod yield. Adeniji and Aramu (2007) and Chinatu *et al*. (2017) reported that the proportion of the assimilates (photosynthates) allocated to the reproductive parts during flowering and fruit set go a long way in determining the number of fruit plant^{-1}, weight of fruit plant^{-1}, length fruit and fruit diameter in Cucumber. The findings from this work are that the varieties with higher vegetative characters performance recorded higher reproductive characters performance, which led to higher fruit yield in Cucumber Hence, Thai 986, Thai 999 and Cu 4315, recorded superior vegetative and reproductive characters performance, also recorded higher fruit yield in both 2020 and 2021.

From Table 9, the 26 genotypes (14F_1 hybrids and 12 parents) differed significantly ($P<0.05$) in their vegetative and reproductive characteristics as well as fruit yield ha^{-1}. Least Significant Difference (LSD) showed that the means of most of the F_1 hybrids were higher than the means of their parents. The straight and reciprocal crosses between the parents Thai 999 and Thai 986 produced F_1 hybrids (Thai 999x Thai 986, Thai 986x Thai 999) that performed significantly higher ($P < 0.05$) than their parents in length of vines, number of leaves plant^{-1}, number of vine plant^{-1}, number of fruit plant^{-1}, fruit diameter, weight of fruit, length of fruit and fruit yield ha^{-1}. The superior performance of the F_1 hybrids over and above their parents is called heterosis. Heterosis has been reported in tomatoes (Atanassova *et al.*, 2002). pepper, (Nwofia *et al*., 2001) okra (Chinatu and Okocha, 2006) and rice (Singh. 1998).

From Table 10, Better parent and Mid-parent heterosis for fruit yield ha^{-1}varied from – 14.14 to 97.17% and from -5.43 to 101.07% respectively, indicating varying heterotic values. High and low, negative and positive heteroses observed over the mid and better parents resulted mainly due to the varying extent of genetic composition between parents of different crosses of the component characters (Rajesh and Gulshan, 2001, Chinatu and Okocha, 2006). Only the crosses between Thai 986 and Thai 100 produced F_1 hybrids that performed lower than the parents in fruit yield (Table 10). Crosses between Marketer and Pointsett76, Thai 999 and Thai 986 and Supermarketer and pointsett could be exploited for an increase in Cucumber fruit production through the use of their hybrid seeds.

Conclusion

Agronomic practice that could lead to an increase in the performance of vegetative characters will lead to an increase in the performance of reproductive characters which could translate to an improvement in the fruit yield of Cucumber. Improvement in fruit yield in Cucumber through heterosis is feasible. Crosses between Marketer and Pointsett76, Thai 999 and Thai 986, and Supermarketer and Pointsett, whose better and mid parents heterotic values ranged from 28 to 97.17% and from 32.51 to 101.07% could be exploited for an increase in cucumber fruit production through the use of their hybrid seeds.

References

Adeniji, O. T. and Aremu, C. O. (2007). Interrelationships among characters and path analysis for pod yield component in West African Okra (*Abelmoschus caillei* (A. Chev) Stev *J. Agron*. 6(1) 162166 http//dx.doi.org/10.3923/ja.2007.162.166

Adetula. O. Dento, L. (2003). Performances of vegetation and yields of accessions of Cucumber (*Cucumis sativus* L.). Horticulture Society of Nigeria (HORTSON) Proceedings of 21st annual conferences.P10-12.

Ajibade, S. R. and Morakinyo, J. A. (2000). Heritability and correlation studies in cowpea (*vignia unguiculata* (L. Walp). *Nigeria J Genet*., 15 (2000): 29-33

Anonymous, (2010). Productivity of okra (*A. esculentus* (L.) Moench) at varying sowing dates In Makurdi, *Nigeria. Journal of Applied Bioscience*, 32:2015-

2019.

Atanassova, B., Shtereva, L. and Balatcheva, E. (2002). Estimation of heterosis for productivity and early yields in F_1 hybrids of tomato (*L. esculentum* Mill) mutants differing in their vitality. In proc. of 2nd Balakan Symp. on Vegetables and Potatoes. Pp.54-58.

Baughman, T., Grichar, J., Black, M., Woodward, J., Porter, Pat., New, L., Baumann, P. and McFarland, M. (2015) "Texas Peanut Production Guides" [PDF]. Texas A&M University.

Chinatu, L. N. and Okocha, P. I. (2006). Prospects of increased production of okra (*Abelmoschus esculentus* L. Moench) through heterosis in the Southeastern. *Nigeria. Journal of Sust. Tropical Agric. Research,* 17: 66-71.

Chinatu, L.N., Onwuchekwa-Henry, C.B. and Okoronkwo, C. M. (2017). Assessment of yield and yield components of cucumber (*Cucumis sativus* L.) in Southeastern Nigeria. *International Journal of Agriculture and Earth Science*, 3(1): 35- 40.

Dhumal, T. L., Jagtap, V.S., Nkale, T.S. and Padekar, V.D. (2019) Inbreeding depression and Heritability in Ridge Gourd. *Int. J. of Pure App. Biosci*. 7(2):503-508.

Eifediyi, E.K. and Remison, S.U.(2010). Growth and yield of Cucumber (*Cucumis sativa* L.) as influenced by farm yard manure and inorganic fertilizer. *J.plant Breeding and Crop Sci*. 2(7): 216-220.

Enujeke, E.C. (2013) Growth and yield responses of cucumber to five different rates of poultry manure in Asaba, Delta State, Nigeria. *Int. Res. J. Agric. Sci. Soil Sci*. 3(11) 369-375.

Falconer D. S. (1989). Introduction to quantitative genetics. England, Longman Science and Technical 3rd Edition p. 254.

Kehinde O. B. (1999). Floral Biology of West Africa Okra. *Nigeria J. of Genetics*.14:95-97.

Kumar, S.R., Kumar, D. Kumar, N., Guatam, R.K., Dogra and Mehta, D.K. (2016). Parthenocarpic gynoecious parental lines of Cucumber were introduced from the Netherlands to develope high-yielding, quality hybrids. *J. Crop Improvement*, 30,352-369.

Kumar, M., Chauhan, A. S., Yusuf, M. A. and Sanyal, I. (2019). Transcriptome sequencing of Chickpea (*Cicer arietinum* L.) genotypes for identification of drought-responsive genes under drought stress conditions. *Plant Molecular Biology Reporter*, 37 (3), 186 -203.

Manivannan, M.I., Arulmozhiyan, R. and Suresh, R. (2020) Genetic Analysis for Quantitative Traits in Cucumber (*Cucumis sativus* L). *International Journal of Current Microbiol. App. Sci*. 9(12): 1547-1552.

Giffen, M.C., Pantonre, M.E. and Maisuna, J. B. (1994). Path analysis of tomato yield components to competition with block and eastern block might shade *.J. Am. Soc. Hort. Sci*. 119: 6-11.

Nwofia, G. E., Echiemunor, J.J and Ene-Obong, E. E. (2001). Cross-ability Relationships and Heterosis in Intra and Interspecific Hybrid of *Capsicum. Journal of Sustainability Agriculture and Environment*, 3 No. 2.

Obi, U. I. (2001), Statistical Method of Detecting Differences between Treatment Means and Research Methodology in Laboratory and Field Experiments. Nsukka, AP Publishing Company Ltd. Nsukka Nigeria, P 116.

Okonmah, L.U. (2011). Effects of different types of staking and their cost-effectiveness of the growth, yield and yield components of cucumber (*Cucumis sativa* L.). *Int. Journal of Agric. Science*. 1(5): 290-295.

Phyu, N.T. (1997). Nitrogen and potassium effects on Cucumber yield. Avi 1996 report, ARC/AVRDC training Thailand. Press, Ames 56-210 Publishing Company Ltd. Nsukka Nigeria, P 116. Retrieved 16 OCT, 2015.

Rajesh, K. and Culshan, L. (2001). Expression of heterosis in hot pepper (*Capsicum annum* L.) *Capsicum and Eggplant Newsletter* 20(2002): 38-41.

Shah, K. N., Rana, D. K. and Singh, V. (2016) Evaluation of Different Cucumber strains for various horticulture traits under valley condition of Garhwal Himalaya*. J. Plant Dev. Sci* 8(12) P599-603.

Singh, R. B. (1988). Prospects for Hybrid rice in the Asia-Pacific region. In: Hybrid rice. A proc. of the international symposium on hybrid rice, 6 – 10 October, 1986, Changsha, Human, China. International Rice Research Institute, Philippines. Pp 25-31.

Snedecor, G. W. and Cochran, W. G. (1989) Statistical Method 8th ed. Iowa State University Press, Ames 56-210

Tenebe, V.A., Yusuf, Y., Kaiagama, B. K. and Asenime, I. E. O. (1995). The effects of sources of levels of phosphorus on the growth and yield of cowpea (Vigna unguiculata (L.) Walp) varieties. Tropical Science, 35:223-228.Vimala P. Ting C.C. Salbiah, H. Ibrahim, B. Ismail, .L.1999. Biomass production and their effects on the yield of Cucumber. *Journal of tropical Agric and food science*. 27: 47-55

Wehner T. C. 1989. Breading for improved yield in Cucumber in J. Janick (ed). Plant Breeding Reviews AVI Press, Stanford, C.T. 6: 323-359

Yusuf, Z., Zeleke, H., Mohammed W., Hussien S., Hugo A, (2017) Estimates of Genetic Variability parameters among Groundnut (*A. hypogaea* L.) Genotypes in Ethiopia. *International Journal of Plant Breeding and Crop Science*, 4:225-230.

Table 2: Physico-chemical properties of the soil of the experiment sites in 2020 and 2021

Soil characteristics	2020	2021
Physical properties		
Sand (%)	75.20	73.20
Silt (%)	18.40	20.40
Clay (%)	6.40	6.40
Textural Class	Sandy loam	Sandy loam
Chemical Properties		
pH (H_2O)	5.90	6.10
Available P (mg kg^{-1})	1.90	2.14
Total N (%)	1.11	1.25
Organic Carbon (%)	0.19	0.19
Organic Matter (%)	1.71	1.93
Exchange Base (cmol kg^{-1})		
Ca	0.15	0.15
Mg	0.28	0.261
K	3.60	3.20
Na	1.60	7.20
Exchangeable Acidity		
Effective CEC	6.90	6.17
Base saturation (%)	81.45	77.95
Aluminum (Al^{3+}) (mmol/kg)	0.52	0.58

Source: National Root Crops Research Institute (NRCRI) Soil Laboratory, Umudike

Table 1: Average Monthly Rainfall (Mm), Temperature (^{O}c), Relative Humidity (%) and Sunshine (Hrs) of The Experiment Site 2019 and 2020

Months	Rainfall (mm) Eastern site 2020	Rainfall (mm) Eastern site 2021	Temp. (^{O}C) Eastern site 2020		Temp. (^{O}C) Eastern site 2021		Relative humidity (%) Eastern side 2020		Relative humidity (%) Eastern side 2021		Sunshine (hrs) Eastern side 2020	Sunshine (hrs) Eastern side 2021
	Amount	**Amount**	**Max.**	**Min.**	**Max.**	**Min.**	**0900**	**1500**	**0900**	**1500**		
January	5.0	74.8	33	23	35	23	72	45	74	49	5.6	6.4
February	41.7	76.4	34	24	35	24	73	50	79	55	6.0	6.3
March	132.8	42.4	34	24	34	24	77	53	78	56	4.6	3.9
April	87.8	91.4	33	23	34	24	76	59	78	62	5.1	6.1
May	33.27	450.1	33	23	32	24	84	70	80	70	5.7	5.0
June	264.2	242.4	31	23	30	24	87	77	83	72	4.5	3.5
July	133.4	320.5	30	22	30	23	86	75	87	78	3.2	3.4
August	138.5	232.1	29	23	29	23	88	78	88	78	2.3	2.2
September	412.7	314	30	22	29	23	88	75	86	72	3.7	2.9
October	165.2	162.4	31	23	30	23	86	78	82	72	4.9	4.1
November	147.4	88.8	32	22	31	23	87	70	74	58	6.5	4.9
December	00	80.4	34	22	33	22	75	49	78	53	7.6	7.5
Total	**2150mm**	**2186.1mm**	**384**	**274**	**382**	**280**	**779**	**779**	**967**	**777**	**58.76**	**56.2**

Table 3: Mean value of fruit yield and yield component of twelve varieties of *Cucumis sativus* in 2019

Varieties	Length of main vine (cm)	Number of leaves/plant	Number of vine/plant	Number of fruit/plant	Fruit diameter (cm)	Weight of fruit (kg)	Length of fruit (cm)	Fruit yield/hectare
Thai 999	263.417	31.333	2.000	2.167	22.121	0.443	29.000	24.630
Thai 986	228.667	29.917	1.917	2.583	22.727	0.474	27.083	26.333
Thai 100	213.583	29.000	2.417	1.500	19.333	0.327	24.083	18.167
Thai 971	240.433	31.000	2.083	2.000	20.545	0.377	25.417	20.926
Marketer	228.333	29.333	2.250	1.500	15.303	0.320	15.167	17.796
Poinsett 76	213.250	28.500	2.167	1.667	15.076	0.333	16.333	18.519
Marketmore	240.000	28.583	1.840	1.417	14.394	0.310	16.083	17.222
Marketmore	217.333	27.667	1.833	1.250	12.500	0.310	15.000	17.241
Supermarket	245.600	30.333	2.583	1.583	15.227	0.347	15.917	19.259
Poinsett	196.333	29.250	1.333	1.333	13.485	0.323	16.167	17.037
Cu 4315	248.000	28.500	2.167	1.833	15.606	0.410	17.250	22.778
Cu 4320	252.417	30.333	1.750	1.667	11.515	0.357	12.833	21.296
LSD (0.05)	**33.5039**	**1.6395**	**0.4681**	**0.4437**	**1.9669**	**0.0522**	**3.7051**	**2.6764**

Table 4: Mean value of fruit yield and yield component of twelve varieties of *Cucumis sativus* in 2021

Varieties	Length of main vine (cm)	Number of leaves/plant	Number of vine/plant	Number of fruit/plant	Fruit diameter (cm)	Weight of fruit (kg)	Length of fruit (cm)	Fruit yield/hectare
Thai 999	259.350	34.267	2.500	2.667	21.944	0.653	31.000	24.750
Thai 986	224.667	32.917	2.417	3.083	22.500	0.674	29.083	26.453
Thai 100	209.500	32.000	2.917	2.000	19.375	0.527	26.083	21.580
Thai 971	236.417	34.000	2.583	2.500	20.486	0.577	27.417	21.046
Marketer	224.333	32.333	2.750	2.000	15.694	0.520	17.167	17.916

Poinsett 76	209.267	31.500	2.667	2.167	15.486	0.533	18.333	18.639
Marketmore	236.017	31.770	2.333	1.917	14.861	0.510	18.083	18.009
Marketmore	213.350	30.667	2.333	1.750	13.125	0.510	17.000	17.361
Supermarket	241.600	33.350	2.750	2.083	15.625	0.547	17.917	19.379
Poinsett	192.333	32.100	1.833	1.833	14.028	0.523	18.167	17.157
Cu 4315	236.333	31.500	2.667	2.333	15.972	0.610	19.250	22.898
Cu 4320	248.433	33.350	2.250	2.167	12.222	0.583	14.833	21.416
LSD (0.05)	**33.9362**	**1.7313**	**0.5276**	**0.4437**	**1.8123**	**0.0495**	**3.7051**	**6.3451**

Table 5: Person Correlation matrix for vegetative and yield parameters of cucumber evaluated in 2020

PARAMETERS	Vine length	No. of leaves	No. of vine	No. of fruits per plant	Fruit diameter	Weight per fruit	Fruit length	Fruit yield
Vine length	1.000							
No. of leaves	0.592**	1.000						
No. of vine	0.236	0.178	1.000					
No. of fruits per plant	0.332*	0.455**	0.099	1.000				
Fruit diameter	0.169	0.399*	0.226	0.591**	1.000			
Weight per fruit	0.385*	0.474**	0.046	0.871**	0.620**	1.000		
Fruit length	0.193	0.501**	0.157	0.645**	0.872**	0.658**	1.000	
Fruit yield	0.465**	0.478**	0.067	0.897**	0.584**	0.964**	0.616**	1.000

***. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at 0.01 level (2-tailed)**

Table 6: Person Correlation matrix for vegetative and yield parameters of cucumber evaluated in 2021

PARAMETERS	Vine length	No. of leaves	No. of vine	No. of fruits per plant	Fruit diameter	Weight per fruit	Fruit length	Fruit yield
Vine length	-							
No. of leaves	0.630**	-						
No. of vine	0.070	0.110	-					
No. of fruits per plant	0.302	0.449**	0.141	-				
Fruit diameter	0.186	0.388*	0.257	0.591**	-			
Weight per fruit	0.439**	0.522**	0.040	0.876**	0.588**	-		
Fruit length	0.208	0.490**	0.196	0.645**	0.872**	0.626**	-	
Fruit yield	0.305	0.365*	0.145	0.685**	0.517**	0.749**	0.538**	-

***. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at 0.01 level (2-tail)**

Table 7: Estimate of direct and indirect effects of seven characters on fruit yield per hectare of cucumber in 2020

TRAITS	Vine length	No. of leaves	No. of vine	No. of fruits per plant	Fruit diameter	Weight per fruit	Fruit length	**Direct effect on fruit yield**
Vine length	-							**0.135**
No. of leaves	0.592	-						**-0.047**
No. of vine	0.178	0.236	-					**-0.013**
No. of fruits per plant	0.332	0.455	0.099	-				**0.262**
Fruit diameter	0.169	0.339	0.226	0.591	-			**0.021**
Weight per fruit	0.385	0.474	0.046	0.871	0.620	-		**0.727**

Fruit length	0.501	0.193	0.157	0.645	0.871	0.658	-	**-0.049**

Table 8: Estimate of direct and indirect effects of seven characters on fruit yield per hectare of cucumber in 2021

TRAITS	Vine length	No. of leaves	No. of vine	No. of fruits per plant	Fruit diameter	Weight per fruit	Fruit length	**Direct effect on fruit yield**
Vine length	-							**0.015**
No. of leaves	0.630	-						**-0.076**
No. of vine	0.110	0.110	-					**0.096**
No. of fruits per plant	0.302	0.449	0.141	-				**0.041**
Fruit diameter	0.188	0.040	0.257	0.591	-			**0.030**
Weight per fruit	0.522	0.522	0.040	0.876	0.588	-		**0.677**
Fruit length	0.208	0.490	0.196	0.645	0.872	0.626	-	**0.076**

No = number

Table 9: Means of parents and F₁ hybrids raised through straight and reciprocal crosses between *Cucumis sativus* genotypes in 2021 in Umudike

Varieties	**Length of main vine (cm)**	**Number of leaves/plant**	**Number of vine/plant**	**Number of fruit/plant**	**Fruit diameter (cm)**	**Weight of fruit (kg)**	**Length of fruit (cm)**	**Fruit yield ha^{-1} (kg)**
Thai 999	259.350	34.267	2.500	2.667	21.944	0.653	31.000	24.750
Thai 986	224.667	32.917	2.417	3.083	22.500	0.674	29.083	26.453
Thai 100	209.500	32.000	2.917	2.000	19.375	0.527	26.083	21.580
Thai 971	236.417	34.000	2.583	2.500	20.486	0.577	27.417	21.046
Marketer	224.333	32.333	2.750	2.000	15.694	0.520	17.167	17.916
Poinsett 76	209.267	31.500	2.667	2.167	15.486	0.533	18.333	18.639
Marketmore 76	206.017	31.770	2.333	1.917	14.861	0.510	18.083	12.009
Marketmore	213.350	30.667	2.333	1.750	13.125	0.510	17.000	17.361
Supermarket	241.600	31.350	2.750	2.083	15.625	0.547	17.917	19.379
Poinsett	192.333	30.100	1.833	1.833	14.028	0.523	18.167	17.157
Cu 4315	236.333	31.500	2.667	2.333	15.972	0.610	19.250	22.898
Cu 4320	248.433	33.350	2.250	2.167	12.222	0.583	14.833	21.416
Offspring/f₁ hybrid								
Thai 999 x Thai 986	306.074	45.542	3.053	3.308	27.732	0.855	30.022	33.923
Thai 986 x Thai 999	317.522	44.270	3.562	3.308	26.715	0.977	30.277	38.770
Thai 986 x Thai 100	274.016	37.401	2.544	2.544	21.881	0.825	18.828	22.712
Thai 100 x Thai 986	284.447	35.111	2.544	2.290	14.502	0.835	18.573	33.116
Thai 100 x Thai 971	214.989	33.075	2.035	1.527	22.389	0.835	25.697	33.716
Thai 971 x Thai 100	267.146	29.513	2.544	2.781	23.407	0.855	20.863	33.923
Marteterx x Poinsett 76	220.155	30.768	2.544	2.035	16.792	0.916	15.775	36.346
Poinsett 76 x Marketer	257.987	33.531	2.035	2.290	16.538	0.926	15.011	36.750
Marketmore 76 x Markmore	234.835	29.005	2.035	1.527	16.792	0.840	15.265	33.318
Marketmore x Marketmore 76	262.312	30.277	2.290	1.527	15.775	0.845	17.047	33.519
Supermarket x Poinsett	216.770	32.496	1.527	1.272	14.248	0.814	16.792	32.308
Poinsett x supermarket	264.857	32.566	2.799	1.272	17.810	0.825	16.029	32.712
Cu 4315 x Cu 4320	208.883	41.472	2.544	1.527	19.082	0.845	23.712	33.519

Cu 4320 x Cu 4315	222.876	42.998	2.544	2.290	22.389	0.804	23.662	31.904
LSD (0.05)	1.7579	0.3037	0.0242	0.0334	0.1048	0.0023	0.2607	0.0953

Table 10: Heterotic Value of F_1 Hybrid Compared to the Parents

Plant Attribute	F_1 Hybrid	Better parent Heterotic value (%)	Mid parent Heterotic value (%)
Length of the main vine	Thai 999 x Thai 986	18.04	26.47
	Thai 986 x Thai 999	22.43	31.20
	Thai 986 x Thai 100	21.97	26.23
	Thai 100 x Thai 986	26.61	31.03
	Thai 100 x Thai 971	-9.06	-2.94
	Thai 971 x Thai 100	13.00	19.94
	Marketer x Poinsett 76	06.86	10.56
	Poinsett 76 x Marketer	14.99	23.83
	Marketmore 76 x Markmore	10.07	11.99
	Marketmore x Marketmore 76	22.95	25.10
	Supermarket x Poinsett	-10.28	-0.09
	Poinsett x supermarket	09.63	22.07
	Cu 4315 x Cu 4320	-15.92	-13.82
	Cu 4320 x Cu 4315	-10.28	-08.05
Number of leaves per plant	Thai 999 x Thai 986	32.90	35.57
	Thai 986 x Thai 999	29.19	31.79
	Thai 986 x Thai 100	13.62	15.23
	Thai 100 x Thai 986	06.27	8.17
	Thai 100 x Thai 971	-2.72	0.23
	Thai 971 x Thai 100	-13.19	-10.57
	Marketer x Poinsett 76	-7.93	-6.73
	Poinsett 76 x Marketer	-5.57	-4.34
	Marketmore 76 x Markmore	-8.70	-7.08
	Marketmore x Marketmore 76	-4.69	-3.01
	Supermarket x Poinsett	-14.55	-12.92
	Poinsett x supermarket	-2.35	-0.48
	Cu 4315 x Cu 4320	24.35	27.90
	Cu 4320 x Cu 4315	29.93	32.61

Table 10 Continued

Plant Attribute	F_1 Hybrid	Better parent Heterotic value (%)	Mid parent Heterotic value (%)
Number of vines per plant	Thai 999 x Thai 986	22.12	24.21
	Thai 986 x Thai 999	42.48	44.91
	Thai 986 x Thai 100	-12.78	-4.61
	Thai 100 x Thai 986	-12.78	-4.61
	Thai 100 x Thai 971	-30.24	-26.00
	Thai 971 x Thai 100	-12.78	-6.40

	Marketer x Poinsett 76	-7.49	-6.05
	Poinsett 76 x Marketer	-26.00	-24.85
	Marketmore 76 x Markmore	-12.77	-12.77
	Marketmore x Marketmore 76	-1.84	-1.84
	Supermarket x Poinsett	-44.47	-33.12
	Poinsett x supermarket	1.78	22.12
	Cu 4315 x Cu 4320	-4.61	3.46
	Cu 4320 x Cu 4315	-4.61	3.46
Number of fruits per plant	Thai 999 x Thai 986	7.29	15.06
	Thai 986 x Thai 999	7.29	15.06
	Thai 986 x Thai 100	-17.48	0.07
	Thai 100 x Thai 986	-25.72	-9.91
	Thai 100 x Thai 971	-38.92	-32.13
	Thai 971 x Thai 100	-28.76	-20.84
	Marketer x Poinsett 76	-6.09	-2.35
	Poinsett 76 x Marketer	5.67	9.88
	Marketmore 76 x Markmore	-20.34	-16.74
	Marketmore x Marketmore 76	-20.34	-16.74
	Supermarket x Poinsett	-38.93	-35.04
	Poinsett x supermarket	-28.93	-35.04
	Cu 4315 x Cu 4320	-34.55	-32.13
	Cu 4320 x Cu 4315	-1.84	1.77

Table 10 Continued

Plant Attribute	F_1 Hybrid	Better parent Heterotic value (%)	Mid parent Heterotic value (%)
Fruit diameter	Thai 999 x Thai 986	23.25	24.79
	Thai 986 x Thai 999	18.73	20.22
	Thai 986 x Thai 100	-2.75	4.51
	Thai 100 x Thai 986	-35.55	-30.74
	Thai 100 x Thai 971	9.29	12.33
	Thai 971 x Thai 100	14.26	17.44
	Marketer x Poinsett 76	6.99	7.71
	Poinsett 76 x Marketer	5.37	6.08
	Marketmore 76 x Markmore	12.99	20.00
	Marketmore x Marketmore 76	6.15	12.73
	Supermarket x Poinsett	-8.81	-3.92
	Poinsett x supermarket	13.98	20.09
	Cu 4315 x Cu 4320	19.47	35.36
	Cu 4320 x Cu 4315	40.17	58.82
Weight of fruit	Thai 999 x Thai 986	26.85	29.54
	Thai 986 x Thai 999	44.95	48.03
	Thai 986 x Thai 100	22.40	36.36
	Thai 100 x Thai 986	22.88	38.02

	Thai 100 x Thai 971	44.71	49.91
	Thai 971 x Thai 100	48.18	53.50
	Marketer x Poinsett 76	71.86	74.14
	Poinsett 76 x Marketer	73.73	76.05
	Marketmore 76 x Markmore	64.70	64.70
	Marketmore x Marketmore 76	65.68	65.68
	Supermarket x Poinsett	48.81	52.14
	Poinsett x supermarket	50.82	54.20
	Cu 4315 x Cu 4320	38.52	41.77
	Cu 4320 x Cu 4315	31.80	34.89

Table 10 Continued

Plant Attribute	F_1 Hybrid	Better parent Heterotic value (%)	Mid parent Heterotic value (%)
Length of fruit	Thai 999 x Thai 986	-3.15	-0.06
	Thai 986 x Thai 999	-2.33	0.78
	Thai 986 x Thai 100	-35.26	-31.74
	Thai 100 x Thai 986	-36.14	-32.66
	Thai 100 x Thai 971	-6.27	-3.93
	Thai 971 x Thai 100	-23.90	-22.01
	Marketer x Poinsett 76	-13.95	-11.13
	Poinsett 76 x Marketer	-18.12	-15.43
	Marketmore 76 x Markmore	-15.58	-12.97
	Marketmore x Marketmore 76	-5.73	-2.81
	Supermarket x Poinsett	-7.57	-6.92
	Poinsett x supermarket	-11.77	-11.16
	Cu 4315 x Cu 4320	23.18	39.14
	Cu 4320 x Cu 4315	22.92	38.84
Fruit yield	Thai 999 x Thai 986	28.24	32.51
	Thai 986 x Thai 999	46.56	51.45
	Thai 986 x Thai 100	-14.14	-5.43
	Thai 100 x Thai 986	25.19	37.87
	Thai 100 x Thai 971	45.09	55.38
	Thai 971 x Thai 100	57.19	59.16
	Marketer x Poinsett 76	94.99	98.86
	Poinsett 76 x Marketer	97.17	101.07
	Marketmore 76 x Markmore	86.12	91.91
	Marketmore x Marketmore 76	88.40	93.07
	Supermarket x Poinsett	66.72	76.86
	Poinsett x supermarket	60.82	79.07
	Cu 4315 x Cu 4320	46.38	51.28
	Cu 4320 x Cu 4315	39.33	43.99