Heterosis for Yield and Its Components in Cucumber (*Cucumis sativus* L.) in Owerri Southeastern Nigeria.

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Abstract
The low yield of cucumber obtained by cucumber farmers in southeastern Nigeria is on the increase, despite the high potential yield which can be achieved. The wide gap between the actual yields obtained and the potential yield is partly due to the use of unimproved varieties of cucumber by majority of farmers. Hence, the use of improved and high yielding hybrids stands a better chance of increasing yieldof cucumber. Therefore, the present study was undertaken to study the heterosis of cucumber for yield and yield component traits. The experiment was conducted at the Green house of the Teaching and Research farm of the Federal University of Technology, Owerri (FUTO). Six Direct F1 and six reciprocal F1 hybrids were developed by crossing 4 parental lines in full diallel fashion during 2018-19 season.The six direct F1 and six reciprocal F1 hybrids along with the 4 parents were evaluated in Randomised Complete Block Design (RCBD) with three replications during the off season of 2019. Significant differences among genotypes were obtained for all the characters studied with the exception of days to emergence. The crosses Cu 100 x Cu 999 was found to be superior combination as it exhibited significant heterosis forfruit yield per hectare over mid parent and better parent. Cu 999 x Cu 100, Cu 100 x Songhai local, Cu 971x cu100 and Cu 971 x Songhailocalexhibited highest significant negative heterosis over better parent (-15.58%) for earliness (days to male/ female flower initiations); Cu 100 x Cu 999 for days to maturity. For vine length Cu 971 x Songhailocal was found to be best.Cu 100 x Cu 999 was found to be best for number of fruits per plant, fruit weight and fruit yield per hectare. The high yielding F1 hybridof (Cu 100 x Cu 999) and Cu 971 x Cu may be recommended for commercial exploitation.

Introduction

Cucumber(*Cucumis sativus* L.) is an important vegetable crop of the cucurbitaceae family. It is grown in tropical and subtropical countries. Cucumber does well on well-drained fertile soils with pH 6.0 -7.0 and ample richness in organic matter. It is often planted on raised beds and thrives in sandy loam soils. The crop requires a good amount of sunshine, warmth and is mostly grown in green houses (Jeffery, 2001). Cucumber grown for eating are called slicers and those intended for pickling are called picklers. Picklers refer to cucumber that is primarily used for processing (Grubben, 1997). it is a very good source of vitamins, minerals and phytonutrients such as flavonoid, beta-carotene, triterpene, lycopene, lignin (Vimala *et al*., 1999).

The phenomen of heterosis resulting from the cross between genotypically distinct parents forms an important means of crop improvement in cucumber**(**Nimitha *et al*., 2018). The cross pollinated nature of the crop and large number of seeds in a fruit provides ample scope for the utilization of hybrid vigour and its commercial exploitation in this crop(Nimitha *et al*., 2018). Hays and Jones (1916) were the first to report heterosis in cucumber. In Nigeria, cucumber production has not been ranked; it is grown mainly in the northern states especially, in Jos, Plateau State, South- South and little in Southeast. This reflects the size ofthe problem and the efforts needed to increase cucumber production in Southeastern Nigeria. Hybrid cucumber is an alternative approach toincrease productivity through the exploitation of heterosis (Golabadi *et al*., 2013). The adoption of hybrids and hybrid breeding programme in this crop is still in its infancy in Nigeria. Therefore, in view of the above and to make further studies in cucumber improvement, it was considered imperative to carry out a study to obtain information on heterosis for different characters in cucumber.

Materials and Methods

A set of 4 x 4 full diallel crosses of cucumber involving the direct and reciprocal F1s were evaluated along with their four parents (Cu 999, Cu 100, Cu971and Songhai local) in a randomized block design with three replications. The experiment was conducted at the Teaching and Research farm of the Federal University of Technology, Owerri (FUTO).The experimental field size measuring 22.1m by 11.7m (258.57m^2) (0.025857ha) was marked out using measuring tape, rope and pegs. The field was demarcated into 3 blocks with hoe and each block containing 16 plots giving a total of 48 plots of 1.5m x 1.0m (1.5m ^{2}) each. 0.8m and 0.5m alleys separated adjacent blocks and plots respectively. Seeds were sown on the plots at three seeds per hole at a depth of 2.5cm, using spacing of 0.5cm x0.5cm. A total of 18 seeds were sown in each plot which was later thinned down to six after two weeks of planting. Recommended cultural practices were followed to raise a good crop. Observations were recorded on 2 randomly taken plants of parents,direct F1s and reciprocal F1s for the characters viz., days to emergence, days to 50 percentage emergence, days to male flower initiation, days to first female flower initiation, number of pistillate flowers plant^{-1}, days to fruit maturity, number of branches per plant ,vine length at 8WAP,number of leaves at 8WAP,leaf area, number of fruits per plant ,fruit length, fruit girth, fruit weight plant^{-1}, total fruit yield hectare^{-1}(ton)

Heterosis over better parent(heterobeltiosis) and mid-parent (relative heterosis) for different characters under study were estimated by the formulaeas described by Liang *et al*.,(1972) and Uguru (2004):

Mid Parent Heterosis (%) = $\frac{\overline{F}_{1-\overline{MP}}}{MP} \times \frac{100}{1}$

Better Parent Heterosis (%) = $\frac{\overline{F_1}-\overline{BP}}{BP} \times \frac{100}{1}$

Where $\overline{F}_1$ = mean of F_1 cross

$\overline{MP}$ =Mid parental value

$\overline{BP}$ =Mean of better parent

Significance of heterosis was tested with the help of standard error using't' test.

Results and Discussion

Estimates of mid and better parentheterosis of the yield and yield component traits of cucumber showedthat in days to 50% emergence positive mid parent heterosis was observed for all the crosses made except for Cu 100 x Songhai local (-0.07) and Songhai local x Cu 971(-0.06). Out of the 12 hybrids, 10 crosses (83.33%) were observed to have positive better parent heterosis which varied from 0.03 (Cu 100 x Cu 971 and Songhai local x Cu 100) respectively to 0.31(Cu 999 x Cu 971). Negative heterosis over the better parent heterosis was observed for Cu 100 x Songhai local (-0.07) and Songhai local x Cu 971(-0.10);negative mid -parent heterosis was recorded for 33.33% of the crossesin days to male flower initiation while 66.66% of the crosses recorded positive mid parent heterosis. Out of the 12 crosses, 8 (66.66%) were observed to have negative better parent heterosiswhile positive better parent heterosis was recorded in the remaining 4 crosses. In days to female flower initiation, negative heterosis was recorded for these cross combinations: Cu 999 x Cu 100 (-0.1), Cu 100 x Songhai local (-0.13), Cu 971 x Cu 100 (-0.02), Cu 971 x Songhai local (-0.07) and Songhai local x Cu 100 (-0.01), however, 58.33% of the hybrids were observed to have positive mid –parent heterosis. Out of the 12 crosses, 9 (75%) were observed to have negative better parent heterosis which ranged from (-0.05) to (-0.13) respectively, while 25% of the crosses recorded positive better parent heterosis (Table 1). With respect to days to maturity, negative mid-parent heterosis was recorded for 4 (33.33%) crosses out of the 12, while 66% were observed to have positive mid-parent heterosis. The result revealed negative better parent heterosis recorded for all the crosses expect in the cross combinations of Cu 999 x Cu 971 (0.02), Cu 999 x Songhai local (0.00) and Cu 100 x Cu 971(0.00)respectively.The negative better parent heterotic values observed in number of days to 50%emergence,number of days to male and female flower initiations and in days to maturity showed the possibility that those crosses emerged and matured earlier than the parents involved in the hybridization. The result aligned with the findings of (Laxuman *et al*., 2012) who observed negative heterosis in number of days to flower appearance in bitter gourd, a member of the Cucurbitaceae family. In accordance with the present finding, Singh and Singh (1993), Joshi & Thakur (2003) also observed earliness in heterotic combinations of tomato.

With respect to number of pistillate flower per plant,positive mid- parent heterosis was recorded for 50% of the crosses and negative mid-parent heterosis for the remaining 50%while 41.67% showed negative better parent heterosis in number of pistillate flowers (Table 1).For number of branches, positive mid-parent heterosis was recorded for 6 (50%) crosses out of the 12, while 50% were observed to have negative mid-parent heterosis. However, negative better parent heterosis was recorded for all the crosses. The only two crosses where positive better parent heterosis was observed were Cu 100 x Cu 971 (0.00) and Cu 100 x Songhai local (0.02). In vine length, two crosses showed positive mid and better parent heterosis and were Cu 971 x Songhai local (0.01) and Songhai local x Cu 971 (0.01) respectively. Positive heterosis for plant height has also been reported by Singh and Asati (2011), Kumari and Sharma (2011) and Ahmed *et al.,* (2011) in tomato.With respect to number of leaves at 8WAP and leaf area index, negative mid-parent and better parent heterosis were recorded in all the crosses for number of leaves at 8WAP while for leaf area index positive mid parent heterosis was recorded for 3 (25%) crosses out of the 12, however, 75% of the cross combinations revealed negative better parent heterosis.The result suggestthat the positive better parent heterotic values observed in these traits depict the superior performance of the crosses with regards to number of pistillate flower per plant, number of branches,vine length,number of leaves at 8WAP and leaf area index showed the possibility that those crosses emerged and matured earlier than the parents employed in the hybridization programme.The resultwas in line with the findings of Ogbonna (2005) who reported positive heterosis in seed yield/plant for egusi melon, Singh *et al*. (2013) for bitter gourdand Nassimi *et al*. (2006) who reported significant positive heterotic effect in number of branches/plantin *Brassica napus*.

With regards to yield attributes,for number of fruitsper plant and fruit weight per plant, the estimate of mid-parent and better-parent heterosis indicated that negative mid-parent heterosis was recorded for 11(91.66%) crosses out of the 12, while 8.33% (Cu 100 x Cu 999) was observed to have positive mid-parent heterosis (Table 2).In fruit length, positive mid parent heterosis was recorded for Cu 100 x Cu 971 and Cu 971 x Cu 100. Out of the 12 crosses, 91.66 % showed negative mid-parent heterosis for fruit length, estimate of the better parent heterosis indicated negative better parent heterosis for fruit length except for the cross combination of Cu 100 x Cu 971 (0.00) that showed positive better parent heterosis for fruit length. With respect to fruit girth,positive mid- parent heterosis varied from 0.00 to 0.09 for Cu 971 x Cu 999, Cu 100 x Cu 971 and Cu 971 x Cu 100 respectively. While positive better parent heterosis was shown in the cross combination of Cu 100 x Cu 971. For fruit yield per hectare,negative mid-parent heterosis was recorded for 10 (83.33%) crosses out of the 12, while 16.66% (Cu 100 x Cu 999 and Cu 971 x Cu 999) were observed to have positive mid-parent heterosis. Thus,negative better parent heterosis was recorded for all the crosses except for (Cu 100 x Cu 999) Table 2.The hybrids, Cu 100 x Cu 971, Cu 971 x Cu 999 and Cu 100 x Cu 999, showed significant heterosis over the mid and better parentheterosis for number of fruits per plant,fruit length, fruit girth, fruit weight and fruit yield per hectare. This make them good materials for hybridization in developing high yielding varieties of cucumber that can adapt to the zone. The highest total fruit yield was recorded in the best performing hybrid of, ' Cu 100 x Cu 999' and Cu 971 x Cu 999 for both better- mid parentheterosis, respectively, and could have been possibly due to their higher number of fruits per plant, fruit weight, fruit length and fruit girth. The result was in consonance with the findings of Munshi and Verma (1997) in muskmelon, Chaubey and Ram (2004) in bitter gourd, Sarkar and Sirohi (2011), and Munshi *et al*. (2005) in cucumber. In total fruit yield, the positive better- mid parent heterotic values recorded in the cross involving 'Cu 100' as the mother plant (Pistillate parent), showed that 'Cu 100' among others, had transferred traits for high yield to such hybrids. Acquaah (2007) implicated maternal cytoplasmic effect for yield in plants. The high or low negative heterosis that occurred in total fruit yield in most crosses could be attributed to a long or short genetic distance, respectively in the trait between the parents. Also, the negative better- mid parent heterosis recorded in fruit yield for some hybrids showed that none of the crosses had fruits that yielded more than the parent. This could be attributed to the dominating effect of the parent with small fruit size over the one with larger fruit size. This opposes the suggestion of Reddy *et al.* (2013) who observed that some cross combinations especially from parents with wide opposing genetic distance give hybrids with superior traits while others which may involve seemingly parents with desirable traits produce discouraging hybrids. Negative heterosis in fruit yield had been reported in cucumber (Munshi *et al*.,2005) and tomato (Amaefula *et al*., 2014).

Table 1: Estimates of the Mid Parent Heterosis(MPH) and Better Parent Heterosis (BPH) of the Growth parameters

Crosses	Heterosis	Days to 50%emergence	Days to male flower initiation	Days to female flower initiation	Number of pistillate flower per plant	Days to maturity	Number of branches at 8WAP	Vine Length at 8WAP(cm)	Number of leaves at 8WAP	Leaf Area at 8WAP(cm)
Cu 999 x Cu 100	MP	0.21	-0.08	-0.1	-0.2	-0.04	-0.11	-0.06	-0.05	-0.07
Cu 999 x Cu 971	MP	0.31	0.03	0.04	0.01	0.02	0.33	-0.26	-0.21	-0.22
Cu 999 x Songhai local	MP	0.19	0.00	0.00	0.00	0.00	-0.22	-0.27	-0.23	-0.28
Cu 100 x Cu 999	MP	0.04	0.02	0.00	0.12	-0.01	0.00	-0.05	-0.05	0.02
Cu 100 x Cu 971	MP	0.03	0.00	0.00	-0.13	0.00	0.00	-0.15	-0.1	-0.18
Cu 100 x Songhai local	MP	-0.07	-0.09	-0.13	-0.19	-0.07	0.2	-0.12	-0.13	-0.23
Cu 971 x Cu 999	MP	0.05	0.02	0.02	0.06	0.01	-0.14	-0.01	-0.06	0
Cu 971 x Cu 100	MP	0.03	-0.01	-0.02	-0.09	0.01	-0.2	-0.03	-0.08	-0.05
Cu 971 x Songhai local	MP	0.11	-0.05	-0.07	-0.05	-0.05	-0.2	0.01	-0.08	-0.03
Songhai local x Cu 999	MP	0.02	0.04	0.03	0.00	0.01	0.4	-0.10	-0.07	-0.07
Songhai local x Cu 100	MP	0.02	0.01	-0.01	-0.08	0.02	-0.17	-0.08	-0.07	-0.06
Songhai local x Cu 971	MP	-0.06	0.02	0.00	0.04	0.00	0.00	0.01	-0.05	0.00
Cu 999 x Cu 100	BP	0.21	-0.08	-0.1	-0.2	-0.06	-0.11	-0.06	-0.05	-0.07
Cu 999 x Cu 971	BP	0.31	0.03	0.04	0.01	0.02	-0.17	-0.26	-0.21	-0.22
Cu 999 x Songhai local	BP	0.19	0.00	0.00	0.00	0.00	-0.22	-0.27	-0.23	-0.28
Cu 100 x Cu 999	BP	0.29	0.07	-0.05	0.20	-0.03	-0.22	-0.16	-0.14	-0.09
Cu 100 x Cu 971	BP	0.03	0.00	0.00	-0.13	0.00	0.00	-0.15	-0.1	-0.18
Cu 100 x Songhai local	BP	-0.07	-0.09	-0.13	-0.19	0.00	0.2	-0.12	-0.13	-0.23
Cu 971 x Cu 999	BP	0.41	-0.06	-0.06	0.02	-0.04	-0.33	-0.29	-0.26	-0.25
Cu 971 x Cu 100	BP	0.1	-0.04	-0.05	-0.25	-0.02	-0.2	-0.24	-0.2	-0.22
Cu 971 x Songhai	BP	0.11	-0.05	-0.07	-0.05	-0.05	-0.2	0.01	-0.08	-0.03

local										
Songhai local x Cu 999	BP	0.29	-0.09	-0.12	-0.03	-0.06	-0.22	-0.35	-0.3	-0.33
Songhai local x Cu 100	BP	0.03	-0.08	-0.1	-0.25	-0.04	-0.2	-0.28	-0.24	-0.26
Songhai localx Cu971	BP	-0.1	-0.03	-0.07	0.02	-0.03	-0.4	0.01	-0.11	-0.06

Table 2: Estimates of the Mid Parent Heterosis (MPH) and Better Parent Heterosis (BPH) of the Yield Parameters.

Crosses	Heterosis	Number of fruits	Fruit length(cm)	Fruit girth(cm)	Fruit weight	Fruit yield
Cu 999 x Cu 100	MP	-0.30	-0.13	-0.17	-0.07	-0.15
Cu 999 x Cu 971	MP	-0.10	-0.06	-0.13	-0.28	-0.07
Cu 999 x Songhai local	MP	-0.22	-0.24	-0.38	-0.35	-0.29
Cu 100 x Cu 999	MP	0.08	-0.07	-0.19	0.00	0.07
Cu 100 x Cu 971	MP	-0.23	0.00	0.00	-0.15	-0.22
Cu 100 x Songhai local	MP	-0.31	-0.10	-0.18	-0.34	-0.38
Cu 971 x Cu 999	MP	-0.05	-0.01	0.01	-0.04	0.04
Cu 971 x Cu 100	MP	-0.21	0.03	0.09	-0.07	-0.08
Cu 971 x Songhai local	MP	-0.21	-0.19	-0.15	-0.12	-0.10
Songhai local x Cu 999	MP	-0.17	-0.09	-0.11	-0.19	-0.21
Songhai local x Cu 100	MP	-0.24	-0.04	-0.12	-0.22	-0.23
Songhai localx Cu 971	MP	-0.12	-0.07	-0.11	-0.13	-0.07
Cu 999 x Cu 100	BP	-0.30	-0.13	-0.17	-0.07	-0.15
Cu 999 x Cu 971	BP	-0.10	-0.06	-0.13	-0.28	-0.07
Cu 999 x Songhai local	BP	-0.22	-0.24	-0.38	-0.35	-0.29
Cu 100 x Cu 999	BP	0.16	-0.23	-0.38	0.19	0.11

Cu 100 x Cu 971	BP	-0.23	0.00	0.00	-0.15	-0.22
Cu 100 x Songhai local	BP	-0.31	-0.10	-0.18	-0.34	-0.38
Cu 971 x Cu 999	BP	-0.15	-0.07	-0.17	-0.32	-0.11
Cu 971 x Cu 100	BP	-0.44	-0.11	-0.01	-0.23	-0.32
Cu 971 x Songhai local	BP	-0.21	-0.19	-0.15	-0.12	-0.10
Songhai local x Cu 999	BP	-0.37	-0.30	-0.37	-0.48	-0.42
Songhai local x Cu 100	BP	-0.52	-0.13	-0.22	-0.42	-0.49
Songhai local x Cu 971	BP	-0.28	-0.25	-0.27	-0.26	-0.22

Conclusion

The estimate ofMidand Better Parent Heterosisshowed that thecross (Cu 100 x Cu 999)had the highest number of fruits per plant and also intotal fruit yield/ha.Whilethese hybrids, Cu 100 x Cu 971and Cu 971 x Cu 999 showed positive heterosis over the mid and better parent heterosis forfruit length, fruit girth and fruit weight. From the findings,these cucumber genotypes are highly suitable fordeveloping high yielding varieties of cucumber that can adapt to southeastern part of Nigeria.

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