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Evaluation of Heterosis in Cucumber (*Cucumis sativus* L.) in Girei Local Government Area of Adamawa State

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Abstract
The present study was undertaken to study the heterosis of cucumber for yield and yield component traits. The experiment was conducted at Girei, Adamawa state. Ten F1 hybrids were developed by crossing five parental lines in half diallel crossing in 2023 and 2024. The six parents, Amarisa, Supermarketer, Marketmore, Poinsett 76, Poinsett and Local variety along with their hybrids were evaluated in a Randomized Complete Block Design with three replications. Significant differences among genotypes were obtained for all the characters studied with the exception of fruit length, fruit width and flesh thickness. Amarisa had the highest general combining ability effect for most of the traits under study which include width of leaf, length of leaf, vine length, placental thickness, fruit width, flesh thickness and fruit length. The cross Marketmore x Poinsett 76 has high Specific combining ability in fruit width, flesh thickness, fruit length and days to 50% flowering. Supermarketer x Poinsett had high positive heterosis over mid parent and heterosis over better parent for placental thickness and flesh thickness while Marketmore x Poinsett recorded for fruit length and fruit width. Amarisa x Supermarketer, exhibited superior performance for length of petiole and vine length over other crosses. Similarly, Marketmore x Poinsett has high value for fruit width.

Key words: *Cucumber; general combining ability; Heterosis; Specific combining ability; Yield.*

1.0 Introduction

Cucumber (*Cucumis sativus L*.) is an important member of the family *curcurbitaceae.* The crop is of Asian origin, the progenitor may be closely related to the wild *Cucumis sativus var. hardwickii*, which was first found in the Himalayan foothills of Nepal (Hossain et al., 2010). (Okonmah, 2011), reported that cucumber has been cultivated by man for over 3,000 years. (Preethi et al., 2019), reported that cucumber is distinct from the other *Cucumis species* as it has got seven pairs of chromosomes 2n=2x=14 a true diploid. Cucumber is a monoecious creeper, annual trailing vine vegetable and a nutritious and delicious vegetable of tropical part of the world. It is a primary source of vitamins and mineral (Rahman et al., 2020).

Wide range of genetic variability is available in cucumber, providing good scope for improvement in yield and other characters of cucumber through selection (Sudhakar et al, 2005).

Curcubits are composed of 118 genera and 825 species. Economically, it ranks fourth after tomatoes, cabbage and onion in Asia (Chinatu et al., 2017). Cucumbers with attractive fruit color, high total soluble solids content, less bitterness and high nutritive value are preferred by the consumer (Kumar et al., 2016). The fruit is eaten fresh in salads in accompaniment with other vegetables. The soils where cucumber is cultivated require moderate to high nutrient levels so as to achieve high yields. Infertile soils result in bitter and misshapen fruits which are often rejected by consumers thereby reducing farmers' income. Plant breeding or genetic improvement in crops is the production of new, improved crop varieties. Hybrids or new, varieties with improved morphological traits and nutritional value are also subjected to sterile and vulnerable to one another. Developing new and improved agricultural traits of Cucumis sativus varieties could diversify the choice of varieties available in the market (Wan Shafiin et al., 2022). Crop improvement entails techniques for increasing quality as well as inherent capacity of yield and yield components. Cucurbits can be improved through exploitation of heterosis breeding (Madhu et al, 2010). Heterosis or hybrid vigor is an important biological phenomenon which refers to the manifested superiority of the F1 hybrid resulting from cross of genetically dissimilar homozygous parents over either of the parents. Heterosis or hybrid vigor can play a vital role in increasing the yield quality of cucumber (Simi et al., 2017). Heterosis breeding provides an opportunity for achieving unique improvement in yield and other desirable attributes in one generation that would be more time consuming and difficult with other conventional breeding methods (Sherpa et al., 2014). Hayes and Jones were the first investigators to report heterosis in cucumber. They reported 24-39 per cent yield increase in F1 over the highest yielding parent. However, heterosis for number of fruits per plant was reported to be 6-27 per cent. The cost of cucumber hybrid seed was about thrice compared to open pollinated cucumber seed (Kohli and Vikram, 2016). Heterosis is a useful tool for exploiting dominance and over dominance through the production of hybrids. In commercial production, hybrid seeds are usually heterozygous gynoecious with regard to gynoecoius character and are termed predominantly female. Now a day's heterosis breeding is one of the efficient tools to exploit the heterotic response of several traits (Simi et al., 2017). Exploitation of heterosis in crop plants is one of the most attractive achievements in boosting up the production and productivity of cucumber. Heterosis breeding can be one of the most viable options for breaking the present yield barrier (Devi et al., 2017). For developing superior varieties, it is necessary to improve the earliness and yield in cucumber. This can be achieved through effective utilization of germplasm resources and integration of genomic tools to impart efficiency and pace of breeding processes (Banga, 2012; Thakur et al., 2017). The production of improved cucumber varieties is important for both local and international trades due to its weight or yield, fast fruiting, and various uses such as for pickles, eating raw or cooking. In addition, the development of hybrids with improved nutritional quality and productivity can be utilized in crop improvement programmes. However, before any new hybrids can be introduced to growers, field evaluation is required (Wan Shafiin et al., 2022). Therefore the aim of this study is to determine the existence of heterosis in cucumber and to evaluate the performance of the cucumber hybrids and their parents for yield and quality traits under field condition.

2.0 Research methodology

2.1 Experimental site

The experiment was conducted at Baggale, Sangere 1 ward, Girei Local Government located within latitude 9° and 10° N of the equator and 12° and 13° E of the Greenwich meridian with an average annual rainfall of 850mm – 1000mm. First planting was carried out during the rainy season on 22nd of July 2023, while the second planting was done on 20th of January 2024 during the dry season using irrigation. The experimental field was marked out using measuring tape, rope and pegs.

2.2 Treatments and experimental design

The experiment was laid out in a Randomized Complete Block Design with three replications. The field was demarcated into three blocks with hoe and each block were divided into six plots with a total of 18 plots. The plot measures 3 m x 3 m and 1 m distance between the blocks. The planting space of 0.5 m x 0.5 m was used. During second planting, each block contains 14 plots with the total of 48 plots.

2.3 Land Preparation

The land was cleared by cutting the grass using hoe and cutlass. After the grass was burned, the land was ploughed and farm yard manure applied before sowing the seeds. Weed control was done manually using hoe

2.4 Planting of Cucumber

Two seeds were sown per hole in each plot at a depth of 2.5cm, using spacing of 0.5 x 0.5cm. A total of 16 seeds were sown in each plot and was later thinned to one seedling 3 weeks after emergence. Insecticide and fungicide was applied to curtail insect and disease incidence in young plants.

2.5 Sample and Sampling Technique

Six varieties of cucumber seeds were obtained from Savannah Seed Company, Jos Plateau State. Five direct parents were used to obtain ten F_1 hybrids using half diallel design while one variety was used as a control.

2.6 Crossing

During the first season, 15 crosses were obtained using the five different varieties. Well-developed female buds were selected and covered with paper bags at evening hours on the day before anthesis. Also, male buds were selected and covered; this is to avoid contamination by foreign pollen. Anthesis takes place at 5:30 – 7:00 am and maximum of pollen grain viability is up to noon. Pollen collected from covered male buds was brushed over the stigma of covered female flowers and then was tagged. The crossed female flowers were kept covered for 2 more days till the fruit develops to avoid pollen contamination. The developed fruits were be covered with perforated polythene bags to protect from damage by insects.

2.7 Application of Fertilizer.

Farm yard manure was applied two weeks before sowing the seeds, and NPK 15:15:15 fertilizer was applied at the rate of 120 kg/ha before flowering as recommended by (Iwalewa and Amujoyegbe, 2019).

2.8 Weed control

Weeding was done manually at two weeks' interval, in order to keep the experimental plot clean, to avoid competition with the crops and pest infestation.

2.9 Data measurement

Data were recorded for the following parameters i.e. Leaf length (cm), Leaf width (cm), Vine length (cm), Length of petiole (cm), Days to 50 % flowering, Flesh thickness, Placental thickness, Fruit length (cm), Fruit width (cm), Days to first flowering

Data Analyses

The data collected was analyzed using Analysis of Variance (ANOVA), while the mean values was separated using Duncan Multiple Range Test.

3.0 RESULTS

3.1 Analysis of Variance

The mean squares from analysis of variance for ten (10) yield contributing characters in six (6) parents for the different seasons are presented in Table1. The result showed significant variability in placental thickness and days to 50% flowering. The results also revealed highly significant differences for leaf length, leaf width, vine length, length of petiole and days to first flowering. There were no significant differences for characters like fruit length, fruit width and placental thickness. Similarly, the mean squares for yield and yield components traits for season 2 are presented in Table2. The results showed that mean squares were significant ($p \leq 0.05$) for fruit length, fruit width, flesh thickness, placental thickness and days to 50% flowering. There was no significant difference for traits like leaf length, leaf width, vine length, length of petiole and days to first flowering. Analysis of variance of the yield and yield components traits of parents and F1 hybrids showed high significance ($p \leq 0.01$) for season in all the traits as presented in Table 3. For season x genotype, there was no significance in leaf width, leaf width, placental thickness, fruit length, days to first flowering and days to 50% flowering. However, vine length, flesh thickness, length of petiole and fruit width were all significant ($p \leq 0.05$). For genotype, vine length, fruit length, fruit width, placental thickness, flesh thickness and days to 50% flowering were all highly significant. Days to first flowering, width of leaf and placental thickness were significant. However, there was no significance recorded for only one trait which was width of leaf.

3.2 Combining Ability

Analysis of variance for combining ability of the yield and yield components traits of the parents and F1 hybrids of cucumber showed high significant GCA variance for vine length and fruit length as shown in Table 4. High significant SCA variance was only recorded in vine length while there was no significant difference among other traits: leaf width, leaf length, length of petiole, fruit length, fruit width, placental thickness, flesh thickness, days to first flowering and days to 50% flowering. The replication mean squares were not significant for all traits while the cross mean squares showed high significant for all traits. Combining ability is useful in successful prediction of genetic capability of parental lines and crosses. The GCA of the yield and yield component traits of the parents showed that Amarisa, Super marketer, Poinsett and Marketmore has positive GCA in all traits while 'Local variety showed negative GCA in all traits as presented in Table 5. It was also observed that the GCA of 'Poinsett 76' was negative in all traits except in length of petiole. On the basis of GCA effects, the parent Amarisa for leaf width (0.85), leaf length (0.63), vine length (3.73), placental thickness (0.23) fruit width (0.65), flesh thickness (0.34), and fruit length (2.60) was found to be the best general combiner. For days to first flowering and days to 50% flowering, Poinsett had the highest GCA effect of 3.82 and 3.88 respectively. Super marketer (0.35) was the best general combiner for length of petiole. The specific combining ability (SCA) effects of the yield and yield component traits of Poinsett 76 x Poinsett had the highest SCA effect in leaf width (4.48), leaf length (2.98), ine length (18.49) and length of petiole (1.36). the other best performing crosses that showed the highest SCA effect were Marketmore x Poinsett 76 for fruit width (2.25), flesh thickness (0.57), fruit length (7.45), days to first flowering (11.26) and days to 50% flowering (11.66) while the cross Super marketer x Poinsett for length of petiole (1.85) as presented in Table 6. Amarisa x Poinsett 76, Super marketer x Poinsett 76 and Market more x Poinsett all had negative SCA value for all traits. Also, the cross Super marketer x Marketmore had positive SCA effect in all traits except in length of leaf, while Amarisa x Supermarketer also had negative SCA effect for flesh thickness and fruit length. However, Amarisa x Poinsett, Amarisa x Super marketer and Super marketer x Poinsett have positive SCA effect in all traits.

3.3 Heterosis

The estimates of better parent (Hb) heterosis of the yield and yield component traits of cucumber as presented in Table 7. Showed that the cross Amarisa x Supermarketer had high positive Hb value for leaf length (4.23) and length of petiole (22.90) while the cross Poinsett 76 x Poinsett had the highest positive Hb value for leaf width (7.62), vine length (31. 77) and fruit length (11.69). Super marketer x Poinsett also had high positive Hb value for placental thickness (35.65) and flesh thickness (7.84). The Hb value for days to 50% flowering had negative value for all crosses while for days to first flowering was also negative for all crosses except for Super marketer x marketmore (3.49). Amarisa x Marketmore had negative Hb for all traits. The highest Hb value was recorded for placental thickness (35.65) in the hybrid Marketmore x Poinsett. The highest mid parent heterosis (Hm) was recorded in the cross Super marketer x poinsett (56.36) for placental thickness. The hybrid Amarisa x Marketmore has negative Hm in all traits except in fruit length (10.92) and days to 50% flowering (6.25). All crosses recorded negative Hm for days to 50% flowering except for the cross Super marketer x Marketmore (3.95). Days to 50% flowering was also negative for all crosses except Amarisa x Marketmore (6.25) and Super marketer x Marketmore (0.55). This was also evident in flesh thickness whereby all values were negative except for the hybrid Super marketer x Poinsett (17.86) and Marketmore x Poinsett 76 (7.69). Width of leaf, length of leaf and fruit width has eight (8) negative Hm value and two (2) positive values for all the crosses while for vine length and placental thickness, seven (7) crosses recorded negative values and three (3) crosses were all positive. Amarisa x Supermarketer (24.92), Supermarketer x Marketmore (16.58), Supermarketer x Poinsett (2.96) and Poinsett 76 x Poinsett (6.39) had positive Hm value for length of petiole while the other crosses were all negative. For fruit length, six crosses had positive values while the other crosses had negative Hm values. The highest Hm value was Marketmore x Poinsett 76 (33.68), then Supermarketer x Poinsett (22.38), Supermarketer x Marketmore (16.52), Amarisa x Marketmore (10.92), Poinsett 76 x Poinsett (7.04) and lastly Amarisa x Poinsett (4.50).

3.4 Mean Performance for Parents

In Table 8, means of the parents ranked according to their significant differences for yield and yield attributing traits are presented. Amarisa (29.33) had the earliest days to first flowering followed by Poinsett 76 (30.00) while Local variety (33.66) was the last to reach days to first flowering. This was also similar for days to 50% flowering where Amarisa (32.00) was the first followed by Poinsett (33.00) while local variety (37.00) was the last. The longest fruit was recorded by Amarisa (20.20) while the shortest was Poinsett 76 (16.13). Amarisa recorded the highest mean performance for all traits except length of petiole, placental thickness, days to first flowering and days to 50% flowering. For placental thickness, Poinsett (3.43) had the highest value followed by Local variety (2.97) with Marketmore having the lowest value of (2.33).

3.5 Mean Performance for Crosses

The ranked mean values of crosses for all the traits studied are presented in Table 9. The cross Amarisa x Supermarketer (34.00) was the lowest hence the first to flower followed by Amarisa x Marketmore (35) while Supermarketer x Poinsett (37.33) had the highest value for days to first flowering. The hybrid Poinsett 76 xPoinsett had the highest value for width of leaf (11.73) and leaf length. For vine length, Amarisa x Supermarketer (41.43) had the longest vine length while Supermarketer x Marketmore had the lowest value of (25.77). The hybrids Amarisa x Poinsett (5.35), Amarisa x Marketmore (5.33), Marketmore x Poinsett 76 (5.43) and Supermarketer x Marketmore (5.13) had the largest fruit width while Supermarketer x Poinsett (4.53), Amarisa x Supermarketer and Poinsett 76 x Poinsett (4.13) had the lowest value. The shortest length of petiole was recorded in Amarisa x Marketmore (2.93) and Marketmore x Poinsett 76 also the mean ranking among all hybrids showed no significant differences. Amarisa x Marketmore (19.69) followed by Supermarketer x Poinsett (19.16) had the longest fruit length while Poinsett 76 x Poinsett (13.37) and Amarisa x Supermarketer (12.27) has the shortest fruit length. For Placental thickness, the hybrid Supermarketer x Poinsett (4.31) followed by Amarisa x Poinsett (3.20) had the highest value while Poinsett 76 x Poinsett (2.50), Marketmore x Poinsett 76 (2.67), Amarisa x Marketmore (2.50), Amarisa x Supermarketer (2.27) and Supermarketer x Marketmore (2.20) had the lowest placental thickness.

DISCUSSION

4.1 Analysis of Variance

The result for analysis of variance showed significant genetic variability among the six parents for ten yield contributing traits in both seasons. Genetic variability among genotypes for desirable traits plays crucial role for proficient selection (Mule et al., 2012). The mean squares for genotypes were significant in all characters except for fruit length, fruit width and flesh thickness similar to (Khan et al., 2017) which suggest that these traits are influenced by genetic factors which can be exploited for heterosis breeding. The result for season 2 also showed significant genetic differences for fruit length, fruit width, flesh thickness, placental thickness and days to 50% flowering which highlights the importance of genetic factors in these traits. However, leaf length, leaf width, vine length, length of petiole and days to first flowering were not significant in line with the findings of (Wang et al., 2019). The significant season x genotype interaction for vine length, flesh thickness, length of petiole and fruit width indicates that the expression of these traits is influenced by both genetic and environmental factors (Yadav et al., 2019). While the traits that were not significant suggests that the genetic effects on these traits were relatively stable across seasons. Furthermore, highly significant effect was recorded on all yield and yield component traits, indicating that environmental factors played a crucial role in shaping the phenotypes of the parents and F1 (Kumar et al., 2020).

4.2 Combining Ability

General combining ability of parent is a vital technique for identifying superior parental materials based on their hybrid performance. This helps in selecting best parents which when crossed would give rise to more desirable segregates. The high general combiners for any of the measured traits identified in this study should produce desirable segregates for selection when crossed together (Fakuta, 2010). Highly significant GCA was recorded for vine length and fruit length, indicating that these traits suggesting the importance of additive components of heritable variance which are responsible for variation observed in these traits. This finding is in line with the report of (Ene et al., 2019). The significant SCA variance for vine length suggests that non-additive genetic effects also play a role in this trait (Khan et al., 2017). The GCA effects of the parents showed that Amarisa, Supermarketer, Poinsett and Marketmore have positive GCA effects for most traits indicating their potential as good general combiners (Singh et al., 2015). In constrast, Local variety showed negative GCA effects for all traits suggesting its limited potential as a parent. The best general combiners for specific traits were identified as Amarisa for leaf width, leaf length, vine length, placental thickness, fruit width, flesh thickness and fruit length while Poinsett for days to first flowering and days to 50% flowering. The SCA effects of the crosses showed that Poinsett 76 x Poinsett had the highest SCA effect for width of leaf, length of leaf, vine length and length of petiole. Some crosses like Amarisa x Poinsett, Supermarketerx Poinsett, and Marketmore x Poinsett showed negative SCA values for all traits (Kumar et al., 2020).

4.3 Heterosis

Heterosis, the superiority of F1 over the mean of the parents or over the better parent is dependent on the accumulation of favorable dominant alleles in the F1 population. Highest yield is the foremost and desirable character for any breeding programme. It is a complex trait resulting from the interaction of its component character of a crop. It was pointed out that heterosis estimates should indicate whether heterozygote's or homozygote's represent the ideal genotype (Thakur et al., 2017). High positive Hm value for length of leaf and length of petiole was recorded for Amarisa x Supermarketer, Poinsett 76 x Poinsett and Supermarketer x Poinsett. Also, Marketmore x Poinsett 76, Supermarketer x Poinsett showed positive Hm and Hb values for placental thickness and flesh thickness. For days to first flowering, all crosses except for two showed negative Hm values which is in line with the findings of (Simi et al., 2017) Furthermore, positive Hb values were obtained in two crosses for vine length with the other eight crosses all negative. This was also reported by (Umeh et al., 2021). (Grafius, 1959) was of the opinion that hybrid vigor of even small magnitude of individual yield components may have additive or synergistic effect on the end product, as had mentioned that heterosis for yield is the result of interaction of simultaneous increase in the expression of heterosis for yield components. All crosses had negative Hb values for days to 50% flowering except for Amarisa x Marketmore while for Hb values, all crosses were negative which suggest a possibility that those crosses matured earlier than the parents involved in the hybridization. These results are in agreement with the findings of (Ene et al., 2019).

4.4 Mean Performance

The mean performance of parents and their hybrids is believed to be one of the essential events for their appraisal. The parents with high mean value may or may not converse their high performance to their hybrids (Kaur and Dhall, 2017). Amarisa showed overwhelming superiority over the other provenances for leaf length, vine length, fruit length, fruit width and flesh thickness, which shows that Amarisa may be a valuable parent for improving yield and quality traits in cucumber breeding programs. Amarisa also recorded the lowest value for days to first flowering and days to 50% flowering indicating its potential for early maturity. Similarly, some crosses expressed superiority in respect to some of the traits. Amarisa x Supermarketer was distinct for days to first flowering and vine length while Poinsett 76 x Poinsett showed superior performance for leaf width and leaf length. For fruit width, Amarisa x Poinsett, Amarisa x Marketmore, Marketmore x Poinsett 76 and Supermarketer x Marketmore showed superior potential. For placental thickness, Supermarketer x Poinsett and Amarisa x Poinsett showed superior performance. Depending on the breeding objectives, there is a wide range of provenances and hybrid to choose from. For longer fruits, Amarisa x Marketmore and Supermarketer x Poinsett are the superior crosses. If the objective is to produce early maturing variety, then Amarisa, Supermarketer and Marketmore are good choices for hybridization as a result of their good potential in respect of this trait.

Conclusion

In terms of best general combiner and performance, Amarisa was found to be best general combiner in most of the traits studied. The crosses Amarisa x Poinsett, Amarisa x Supermarketer and Supermarketer x Poinsett could be exploited for the production of F1 hybrids and used in recombination breeding in other to evolve high yielding varieties suitable for cucumber. In this study, yield and yield contributing traits of cucumber were governed by additive and non-additive genes alike but there is the prevalence of additive gene action, therefore improvement in those traits can best be done by effective recurrent selection procedure. Estimate of heterosis showed that the cross Supermarketer x Poinsett had the highest mid parent heterosis in placental thickness while Amarisa x Marketmore had a record of the highest better parent heterosis in the same trait.

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Table 1: Mean Squares for Ten (10) Traits of Cucumber Genotypes in Girei, Adamawa State.

Source of Variation	Df	LW(cm)	LL (cm)	VL (cm)	LP (cm)	FL(cm)	FW(cm)	PT(cm)	FT(cm)	DFF	D50% F
Replication	2	0.457	0.042	208.754	0.096	14.304	0.034	0.111	0.017	8.667	19.056
Genotype	5	0.693**	1.830**	1227.863**	0.913**	7.630^{ns}	0.209^{ns}	0.394*	0.088^{ns}	7.467**	18.322*
Error	10	0.267	0.393	28.238	0.120	3.506	0.097	0.107	0.043	1.133	5.789
Total	17										

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering, *= significant at 5% level of significance, **= significant at 1% level of significance.

Table 2: Mean Squares for Ten (10) Traits of Cucumber Genotypes in Girei, Adamawa State.

Source of Variation	Df	LW(cm)	LL (cm)	VL (cm)	LP (cm)	FL(cm)	FW(cm)	PT(cm)	FT(cm)	DFF	D50% F
Replication	2	0.455	0.637	60.527	0.162	1.340	0.117	0.041	0.001	4.222	0.500
Genotype	5	0.021^{ns}	0.962^{ns}	12.412^{ns}	0.133^{ns}	33.774**	1.067**	0.401**	0.476**	18.589^{ns}	21.700*
Error	10	1.598	1.187	44.529	0.169	4.645	0.150	0.046	0.041	98.689	5.700
Total	17										

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering, *= significant at 5% level of significance, **= significant at 1% level of significance.

Table 3: Mean squares for Ten (10) traits of cucumber genotypes for parent x crosses in Girei, Adamawa State.

Source of Variation	**Df**	**LW(cm)**	**LL (cm)**	**VL (cm)**	**LP (cm)**	**FL(cm)**	**FW(cm)**	**PT(cm)**	**FT(cm)**	**DFF**	**D50% F**
Genotype	5	0.302^{ns}	1.809*	648.152**	0.553*	33.966**	0.912**	0.712**	0.448**	21.428*	28.111**
Season	1	27.738**	455.111**	52402.840**	60.580**	57.633**	2.103**	0.364**	0.250**	476.694**	336.111**
Season x genotype	5	0.412^{ns}	0.983^{ns}	592.123**	0.493*	7.439^{ns}	0.364*	0.083^{ns}	0.115*	4.628^{ns}	11.911^{ns}
Error	12	0.880	0.535	47.764	0.168	6.296	0.117	0.103	0.031	6.306	5.111
Total	35										

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering, *= significant at 5% level of significance, **= significant at 1% level of significance.

Table 4: Analysis of Variance for Combining Ability of Ten (10) Traits of Cucumber Genotypes used for the Study.

Scale	Df	**LW(cm)**	**LL (cm)**	**VL (cm)**	**LP (cm)**	**FL(cm)**	**FW(cm)**	**PT(cm)**	**FT(cm)**	**DFF**	**D50% F**
Rep	3	0.107^{ns}	0.127^{ns}	23.181^{ns}	0.003^{ns}	0.139^{ns}	0.026^{ns}	0.006^{ns}	0.072^{ns}	0.335^{ns}	2.394^{ns}
Cross	20	83.056**	49.061**	778.448**	6.164**	7.981**	19.008**	1.873**	213.701**	1042.387**	1195.076**
GCA	5	73.893^{ns}	37.335^{ns}	840.683**	6.843^{ns}	7.481**	19.218^{ns}	2.547^{ns}	270.264^{ns}	924.770^{ns}	1082.978^{ns}

SCA	15	123.025^{ns}	74.775^{ns}	1103.680**	8.677^{ns}	11.695^{ns}	27.878^{ns}	2.480^{ns}	289.824^{ns}	1544.876^{ns}	1763.587^{ns}
Residual	39	0.637	0.521	61.614	0.052	0.277	0.105	0.016	1.465	6.846	5.286

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering, *= significant at 5% level of significance, **= significant at 1% level of significance.

Table 5: General Combining Ability estimates of Ten (10) Traits in the Cucumber Parents used.

GCA	LW(cm)	LL (cm)	VL (cm)	LP (cm)	FL(cm)	FW(cm)	PT(cm)	FT(cm)	DFF	D50% F
Amarisa	0.850	0.625	3.728	0.231	0.217	0.645	0.342	2.604	1.528	1.833
Super marketer	0.754	0.513	3.578	0.198	0.350	0.292	0.109	1.513	3.403	3.625
Marketmore	0.629	0.596	1.032	0.044	0.133	0.582	0.124	1.800	3.236	3.667
Poinsett 76	-0.221	-0.054	-1.176	-0.270	0.088	-0.477	-0.164	-2.519	-1.889	-2.042
Poinsett	0.967	0.467	2.607	0.563	0.321	0.313	0.061	1.284	3.819	3.875
Local variety	-2.979	-2.146	-9.768	-0.765	-0.933	-1.356	-0.472	-4.682	-10.097	-10.958

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering, *= significant at 5% level of significance, **= significant at 1% level of significance.

Table 6: Specific Combining Ability effects for Ten (10) Traits of the Cucumber's F_1 Hybrids Studied.

SCA	LW(cm)	LL (cm)	VL (cm)	LP (cm)	FL(cm)	FW(cm)	PT(cm)	FT(cm)	DFF	D50% F
Amarisa x Supermarketer	3.09	2.22	14.545	0.144	1.257	0.164	-0.158	-1.925	6.006	5.494

Amarisa x Marketmore	1.81	1.67	5.591	0.532	0.574	1.024	0.328	5.211	7.173	10.452
Amarisa x Poinsett 76	-7.14	-5.58	-22.134	-1.655	-2.139	-3.251	-1.118	-10.159	-22.702	-24.506
Amarisa x Poinsett	1.64	1.60	5.216	0.716	0.486	1.312	0.340	4.504	6.923	9.577
Supermarketer x Marketmore	1.11	-0.99	1.574	0.265	1.007	1.178	0.327	4.946	10.298	9.661
Supermarketer x Poinsett 76	-7.04	-5.46	-21.984	-1.622	-2.272	-2.898	-0.885	-9.068	-24.577	-26.298
Supermarketer x Poinsett	1.57	1.68	4.399	1.852	0.653	0.845	0.540	6.288	7.048	8.452
Marketmore x Poinsett 76	3.48	2.79	8.729	1.199	0.911	2.245	0.567	7.445	11.256	11.661
Marketmore x Poinsett	-8.11	-6.07	-23.221	-2.300	-2.464	-3.978	-1.124	-13.159	-30.119	-32.256
Poinsett 76 x Poinsett	4.48	2.98	18.487	0.513	1.357	1.214	0.363	4.528	10.339	10.536

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering, *= significant at 5% level of significance, **= significant at 1% level of significance.

Table 7: Estimates of Mid Parent Heterosis (Hm) and Better Parent Heterosis (Hb) of Yield and Yield Component Traits of the F_1 Hybrids of Cucumber

	LW		**LL**		**VL**		**LP**		**FL**	
	Hm	Hb	Hm	Hb	Hm	Hb	Hm	Hb	Hm	Hb
Amarisa x Supermarketer	4.186	3.704	4.429	4.234	24.966	21.364	24.918	22.903	-33.442	-40.010
Amarisa x Marketmore	-8.411	-8.411	-2.829	-4.100	-4.751	-6.925	-0.852	-3.000	10.923	-3.762
Amarisa x Poinsett 76	-100	-100	-100	-100	-99.904	-99.907	-100.625	-100.588	-99.935	-99.951
Amarisa x Poinsett	-7.778	-8.624	-0.837	-4.110	2.584	-3.199	-4.897	-9.610	4.495	-9.722
Supermarketer x Marketmore	-16.280	-16.667	-12.508	-13.730	-20.493	-24.495	16.583	12.258	16.518	11.625
Supermarketer x Poinsett 76	-100	-100	-100	-100	-99.906	-99.912	-100.615	-100.588	-99.925	-99.939
Supermarketer x Poinsett	-9.677	-10.092	-1.032	-4.125	-3.730	-11.618	2.955	-0.601	22.375	16.677

Marketmore x Poinsett 76	-3.391	-3.970	-2.914	-6.719	-7.130	-8.233	-5.901	-13.235	33.678	11.694
Marketmore x Poinsett	-100	-100	-100	-100	-99.899	-99.902	-100.645	-100.601	-99.933	-99.934
Poinsett 76 x Poinsett	7.961	7.615	2.252	-5.935	34.984	31.767	6.389	5.294	7.040	-10.201

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness.

Table 7: Cont.

	FW		**PT**		**FT**		**DFF**		**D50%F**	
	Hm	Hb	Hm	Hb	Hm	Hb	Hm	Hb	Hm	Hb
Amarisa x Supermarketer	-23.358	-29.174	-13.077	-21.254	-36.269	-47.210	-7.227	-12.025	-7.995	-14.929
Amarisa x Marketmore	-3.604	-9.781	-5.482	-12.892	-7.979	-25.751	-4.055	-8.636	6.248	-0.659
Amarisa x Poinsett 76	-99.801	-99.831	-100	-100	-100	-100	-99.945	-99.947	-99.842	-99.852
Amarisa x Poinsett	-2.007	-9.444	5.960	0.946	-6.667	-27.897	-7.787	-99.947	-99.843	-99.852
Supermarketer x Marketmore	0.980	-0.387	-7.368	-9.091	-1.351	1.961	3.948	3.491	0.554	-0.643
Supermarketer x Poinsett 76	-99.780	-99.801	-100	-100	-100	-100	-99.948	-99.948	-99.855	-99.857
Supermarketer x Poinsett	-9.543	-9.543	56.364	35.647	17.857	7.843	-7.401	-11.071	-4.165	-5.279
Marketmore x Poinsett 76	17.584	5.416	13.433	9.917	7.692	2.797	-6.105	-6.914	-6.796	-7.171
Marketmore x Poinsett	-99.804	-99.807	-100	-100	-100	-100	-99.950	-99.952	-99.856	-99.859
Poinsett 76 x Poinsett	-9.091	-17.495	-8.088	-21.136	-6.615	-7.692	-11.259	-15.833	-10.601	-13.023

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering.

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Table 8: Mean Performance for Ten (10) traits of cucumber Genotypes in Girei, Adamawa State.

Genotypes	LW(cm)	LL (cm)	VL (cm)	LP (cm)	FL(cm)	FW(cm)	PT(cm)	FT(cm)	DFF	D50% F
Amarisa	13.267^{a}	16.600^{a}	145.500^{a}	6.267^{ab}	20.200^{a}	6.033^{a}	2.900^{ab}	2.000^{a}	29.333^{d}	32.000^{c}
Supermarketer	12.433^{ab}	14.700^{c}	100.700^{c}	5.100^{c}	18.300^{ab}	5.467^{ab}	2.667^{b}	1.767^{ab}	31.000^{cd}	33.333^{bc}
Marketmore	12.267^{ab}	14.600^{c}	90.333^{d}	5.767^{bc}	19.233^{ab}	5.267^{b}	2.333^{b}	1.500^{b}	32.333^{ab}	38.333^{a}
Poinsett 76	12.767^{ab}	15.930^{ab}	102.333^{bc}	6.500^{a}	16.133^{b}	5.533^{ab}	2.833^{ab}	1.600^{ab}	30.000^{dc}	34.667^{abc}
Poinsett	11.867^{b}	14.967^{bc}	111.433^{b}	5.700^{bc}	16.367^{b}	5.500^{ab}	3.433^{a}	1.733^{ab}	31.667^{abc}	33.000^{c}
Local variety	12.733^{b}	15.500^{abc}	92.667^{cd}	5.233^{c}	18.433^{ab}	5.733^{ab}	2.967^{ab}	1.667^{ab}	33.667^{a}	37.000^{ab}

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering. *Means with the same letter are not significantly different.

Table 9: Mean Performance for Ten (10) traits of cucumber Genotypes for crosses (F1 hybrids) in Girei, Adamawa State.

Genotypes for crosses	LW(cm)	LL (cm)	VL (cm)	LP (cm)	FL(cm)	FW(cm)	PT(cm)	FT(cm)	DFF	D50% F
Amarisa x Supermarketer	11.20^{ab}	8.37^{a}	41.43^{a}	3.83^{a}	12.27^{e}	4.18^{b}	2.27^{cd}	1.23^{c}	34.00^{b}	35.67^{b}
Amarisa x Marketmore	9.80^{cd}	7.90^{ab}	29.93^{ab}	2.93^{a}	19.69^{d}	5.33^{a}	2.50^{cd}	1.73^{a}	35.00^{b}	40.67^{a}
Amarisa x Pointsett	9.97^{cd}	7.70^{b}	31.13^{ab}	3.03^{a}	18.47^{b}	5.35^{a}	3.20^{b}	1.68^{a}	35.33^{b}	40.00^{a}
Supermarketer x Marketmore	9.00^{d}	7.10^{ab}	25.77^{b}	3.5^{a}	18.33^{b}	5.13^{b}	2.20^{d}	1.50^{b}	40.00^{a}	41.67^{a}
Supermarketer x Poinsett	9.8^{cd}	7.67^{ab}	30.17^{ab}	3.3^{a}	19.16^{ab}	4.53^{b}	4.31^{a}	1.65^{a}	37.33^{a}	40.67^{a}
Marketmore x Poinsett 76	10.4^{bc}	8.37^{ab}	28.17^{ab}	2.97^{a}	16.80^{c}	5.43^{a}	2.67^{c}	1.47^{b}	35.67^{b}	38.00^{ab}
Poinsett 76 x Poinsett	11.73^{a}	8.40^{ab}	39.50^{ab}	3.60^{ab}	13.37^{d}	4.13^{b}	2.50^{cd}	1.2^{c}	35.33^{b}	37.33^{ab}

KEY: LW=Leaf width, LL= Leaf length, VL=Vine length, LP=Length of petiole, FL=Fruit length, FW=Fruit width, PT=Placental thickness, FT=Flesh thickness, DFF=Days to first flowering, D50%F=Days to 50% flowering. *Means with the same letter are not significantly different.