A COMPARISON OF VIGOR BETWEEN SELFS AND CROSSES OF THE FLORIST GLOXINIA(*SINNINGIA SPECIOSA* BENTH. AND HOOK.)

By

JAMES GLYNN KARAS

AN ABSTRACT

Submitted to the College of Agriculture of Michigan State
University of Agriculture and Applied Sciences
in partial fulfillment of the requirements
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MASTER OF SCIENCE

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Approved Walter J Haney

JAMES GLYNN KARAS ABSTRACT

This study is an attempt to compare selfs and crosses in the florist gloxinia (*Sinningia speciosa* Benth. and Hook.) for which there is neither a report nor systematic commercial utilization of heterotic behavior.

All possible combinations of fifteen parental plants were attempted. Seed from the eight plants judged highest in fertility, as evidenced by available seed, was used in the present study.

Dry weight as a criterion of vigor did not permit the successive determinations of vigor on the same plant that were needed to construct the characteristic growth curve. Maximum diameter, which correlated + 0.867 with dry weight, permitted successive determinations.

The expressions of heterosis noted, specific combining ability, and vigor contributed by individual parental plants are summarized graphically and tabularly. The extent of heterosis noted compared favorably with that reported in corn, onions, *Sorghum*, and snapdragons.

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TABLE OF CONTENTS

INTRODUCTION

This study is an attempt to compare selfs and crosses in the florist gloxinia (Sinningia speciosa Benth. and Hook.) for which there is neither a report of nor systematic commercial utilization of hybrid vigor.

Heterosis is indicated when the expression of a given character in the F_1 is above the mean value of that character in the parental selfs. Heterosis is specifically, a similar degree of expression in less time or greater expression in the same time.

Shull (1948) points out that he originally proposed the term "heterosis" as a means of providing a concise term free from any implication of the mechanism involved. Prior to the introduction of this term, the literature was pervaded with such cumbersome expressions as "heterozygosis" and "stimulus of heterozygosity".

REVIEW OF LITERATURE

The precise mechanism responsible for the extreme manifestations of vigor and other characteristics which biological scientists collectively call heterosis has long been a puzzling situation. Numerous accounts in the literature postulate the apparent mechanism.

Ashby (1930, '32, '37, '39) suggests that certain hybrids manifest heterosis as a result of a larger embryo (greater initial capital). He attributes reciprocal differences to differences in embryo weight. Ashby (1939) found a high correlation between seed weight and dry weight at floral initiation in the tomato. Transplanting destroyed this correlation. Furthermore, the growth curve of the hybrid was essentially parallel to that of one parent (1930).

Passmore (1934) with reciprocal crosses of *Cucurbita pepo* shows that plants from larger embryos are larger during early growth; whereas, plants from small embryos attain the same size, but require a longer season.

Luckwill (1939) in tomatoes suggests that greater hybrid seed weight is not always indicative of heterosis. Whaley (1939a) states that existence of heterosis in a hybrid is not necessarily the result of a larger embryo.

Cowan (1943) relates that previous work shows that hybrid vigor is greatest in single crosses between lines possessing the greatest genetic disparity.

Brieger (1950), in work with maize, states that heterosis does not affect the organism as an entity, but merely individual characteristics.

Luckwill (1939) points out that heterotic behavior can express itself differentially in respect to various traits, portions of the life cycle, and parts of the organism affected.

Burdick (1954) shows that some hybrids express the maturity genes of one parent at one stage and those of the other at another stage of development.

Whaley (1939b) found in Lycopersicum that nuclei decrease to a smaller size in the hybrid than in the inbreds. Furthermore, cell and nuclear size in the meristem decrease more slowly in the hybrid than in the inbreds. Fundamental metabolic differences could be responsible.

Luckwill (1939) found that early flowering is almost completely dominant to late flowering in crosses of cultivated varieties of Lycopersicum esculentum, while in intraspecific crosses, early flowering was dominant only when a primary growth factor such as dwarfness or brachytic stem was involved. Interspecific crosses produced intermediate flowering hybrids.

Burdick (1954) found that early fruiting is a manifestation of heterosis in the tomato; however, it is not apparent until the first ripe fruit. Haskell and Brown (1955) found that varietal hybrids of tomatoes express heterosis mainly as early fruit yield and more stable yield than commercial varieties under varying environmental conditions.

Tables one and two show diversified reports of heterotic behavior in agriculturally important plants. Basic variations in heterotic criteria, as well as morphological and genetic variations, do not allow comparisons between the plants listed. However, this does give an indication as to the extent of heterosis reported in the crops.

PROCEDURE

All possible combinations of fifteen parental plants were attempted with varying degrees of success. The populations used in the present study were produced from seed matured by the eight plants judged highest in fertility as evidenced by available seed. Parental plant descriptions are given in table three. Twenty-five of the twenty-eight possible combinations were obtained.

Approximately 11.2 cubic millimeters of seed was sown on steam pasteurized sphagnum moss over a mixture of equal parts of shredded peat moss, soil, and silica sand in three-inch pots. The pots were placed in pans and covered with plastic to provide uniform germination conditions. A complete, high analysis fertilizer in dilute solution provided adequate and uniform fertilization during subsequent growth.

Seven weeks after sowing, the vigor of the seedlings in pots was determined visually with a graded series of five standards. The standards encompassed the entire range of vigor in the populations and differed by approximately equal growth increments.

As soon as the plants were of sufficient size, they were transplanted two inches apart in flats filled with a mixture of three parts peat moss, one part Conover silt loam, and one part sand.

For correlation of maximum rosette diameter and dry weight, data were obtained from three 150-plant samples containing twenty-five plants from each of three crosses and three selfs. Samples were evaluated at two, nine, and fourteen weeks after transplanting. At these intervals, diameter measurements were made of all remaining plants.

RESULTS

Figure one shows percentage distribution of vigor classes of cross and self populations seven weeks after sowing. The largest selfs are equal in vigor to the largest crosses at this time. Visual comparisons were made with a graded series of five standards, since measurement of vigor by dry weight or diameter is not practical at this stage because of the small size of individual seedlings. The distribution of the crosses is skewed to the right, while that of the selfs is to the left.

Figure two shows heterotic behavior of a cross and the two parental selfs on a dry weight basis. This figure suggests an increasing growth rate through successive vigor determinations. A greater mean weight is indicated for the cross than for either self at all three vigor determinations. This difference increases as growth progresses.

The most valid basis for determining vigor is dry weight; however, this criterion does not permit the successive determinations of vigor on the same plant that are needed to construct the characteristic growth curve. Diameter measurements permit such determinations. The correlation of maximum diameter and dry weight is + 0.867 for 449 individual plants representing three self and three F_1 populations.

Figure three shows successive diameter measurements for a total of five hundred plants of the cross and both selfs. Here again the vigor differential increases as growth progresses.

Figure four illustrates reciprocal differences. The reciprocals have a greater mean diameter at all stages than the selfs and show a smaller vigor differential between reciprocals at the last vigor determination than at the second.

Table four is a summary of the means of three consecutive vigor determinations. The data indicates that parental plants contribute varying degrees of vigor to their F_1 progeny. This figure further shows vigor means of plants as male and female parents and illustrates general combining ability. At the last vigor determination thirty-one of thirty-five crosses were more vigorous than either parent.

Figure five shows frequency distribution of final diameter means of all populations in units of least significant difference from the mean of unweighted population means. Evaluation of table four and figure five indicates that reciprocals of two crosses fall within the same least significant difference from the mean of means, two are adjacent, and six are non-adjacent.

Table five identifies parental sources of extreme vigor. Vigor is shown as the ratio of the second and third diameter measurements to the first diameter measurement. The most vigorous progenies are distinguished by vigor exceeding twice the grand mean of the ratios less that of the selfs. Such progeny ratios exceeding 5.74 are identified by an asterisk.

DISCUSSION

The comparatively greater vigor of the crosses at seven weeks is shown in figure one.

Ashby (1930) has shown in corn that the growth curve of the cross and one parent are essentially parallel. However, figures two to four indicate a materially different growth rate for gloxinia crosses in which the growth curves are not parallel. This superior growth rate cumulatively results in a striking increase in vigor, especially in later growth.

Figures two to four illustrate the superior growth rates of the crosses compared with the selfs. The cumulative increase in vigor displayed by crosses 3 x 1, 5 x 8, and 8 x 5 for three successive measurements probably is a direct function of the superior growth rate and initial vigor differences.

Ashby (1939) indicated that the high degree of correlation between seed weight and dry weight at floral initiation in tomato is destroyed by transplanting. Data presented in figures two to four and table four indicate marked heterotic advantage in transplanted gloxinia plants.

In figure four the reciprocals show a smaller vigor differential at the last vigor determination than at the second. This tendency of the growth curves of reciprocals to converge suggests differential response to environment. In view of this trend, convergence of the curves of the reciprocals in later growth would not be improbable, especially in view of Passmore's work with squash (1934).

If the growth curve of the more vigorous reciprocal were to level off for a sufficient period of time before maturity, it is likely that a sustained, but initially lower growth rate would be equivalent to an initially greater growth rate of shorter duration.

The indicated differences in vigor of certain reciprocals shown in figure four and table four may show maternal inheritance of specific growth factors in some reciprocals, differentially expressed efficiency indices relative to specific growth stages in others, an initially larger embryo, or greater seed weight.

An analysis of final vigor determinations shown in table four indicates variations in specific combining ability of parental plants. Those crosses whose maximum diameter at the third vigor determination exceeds 61.9 (the mean of means, M, by at least twice the least significant difference) were judged as showing exceptionally high specific combining ability. The individual crosses 1 x 4, 2 x 6, 2 x 7, 3 x 1, 5 x 7, and 6 x 8 and both reciprocals of 3 x 6, 5 x 8, and 7 x 8 exceed this degree of vigor.

Means of specific plants as male and female parents shown in the margins of table four indicate variation in general combining ability. Although certain plants are not of high general combining ability; they, nevertheless, may show high specific combining ability.

The failure of the largest selfs in figure one to maintain the same relative position in figure five points up Luckwill's (1939) view that heterosis can be differentially manifested with respect to portions of the life cycle affected.

The grouping of values greater than 5.74 diameters in the lower right sector of table five suggests apparent heritability of maximal growth rate in terms of initial diameter for the period indicated. Evaluating succeeding vigor determinations in terms of the initial determination serves to eliminate initial size differences between populations and to a marked degree permits more realistic progeny evaluation. The greater ratios of many crosses further shows their superiority.

Since very complex physiological processes must be involved, definite conclusions regarding the mechanisms responsible would be mere conjecture. Furthermore, in view of the almost random selection of parental plants, the extent of vigor expressed in table four is by no means the ultimate.

The data presented indicates substantial hybrid vigor in progeny of certain crosses of the florist gloxinia. Further specific selection of parental types should produce superior hybrids.

The relatively low degree of vigor present in selfed progeny of several parental plants in this study would indicate that previous breeding efforts have been within relatively small distinct populations. This is further pointed up by the relative uniformity for characteristic plant type and pattern in selfed progeny. The marked degree of vigor noted in certain gloxinia crosses is more often found in crosses of diverse parentage than those of related parentage as shown by Cowan (1943). Additional supporting evidence is indicated by the relatively high percentage of crosses that were more vigorous than either parent. Such results would not be expected unless previous breeding was within relatively small distinct populations.

CONCLUSIONS

In this study of vigor of selfs and crosses of the florist gloxinia, a correlation of + 0.867 for plant diameter and dry weight validates plant diameter as a criterion of heterosis.

Transplanting is not necessarily detrimental to the expression of heterosis.

Thirty-one of thirty-five crosses were more vigorous than either parental self.

Variability among parents with respect to general and specific combining ability is indicated.

Increased growth rate of a cross in terms of initial vigor appears to be the result of specific parental plants and specific combinations thereof.

The extent of heterosis in certain crosses of the florist gloxinia compares favorably with that reported in corn, onions, *Sorghum*, and snapdragons.

The data presented suggest that previous breeding efforts with the florist gloxinia have been within relatively small distinct populations.

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APPENDIX

LIST OF TABLES

LIST OF FIGURES

TABLE ONE

SOME OF THE REPORTED EXPRESSIONS OF HETEROTIC BEHAVIOR

Reference	Crop	Expression of Heterosis
Capinpin and Alivar, 1949	Eggplant	Yield of a varietal hybrid was 38.5% above parental mean
Coffman, 1933	Oats	A varietal hybrid had 35.2% greater yield than higher parent
Jones and Loden, 1951	Upland Cotton	Certain hybrids had larger bolls, 16.4% greater yield at first picking, and up to 47% greater total yield than higher parent
Odland and Noll, 1948	Eggplant	Mean of all F_1's 62% greater than mean of all varieties tested
Thompson, 1956	Spinach	Harvest 1 2 (% greater)
		F_1/V 20.1 16.3 V = Variety
		F_1/I 22.6 23.3 I = Inbred
		V/I 2.1 6.2
		Yield of Early hybrid number 7 was fifty per cent greater than four standard varieties

TABLE TWO

OTHER REPORTED MANIFESTATIONS OF HETEROSIS PERMITTING MORE COMPLETE COMPARISONS THAN THOSE IN TABLE ONE

Reference	Crop	Age (Days)	P1	P2	$\bar{X}$	F1	% of $\bar{X}$	Criterion
Ashby, 1930	Maize	83	10.9	27.5	19.2	97.7	508	DW
			.370	.163	.266	.405	152	SW
1932	Maize	56	43.7	33.0	38.33	105.3	376	DW
Gartner, et. al., 1953	Snapdragon	63	.231	.206	.216	.570	264	DW
Jones and Davis, 1944	Onion	M	198	202	200	343	171	BW
Karper and Quinby, 1937	*Sorghum*	95	1.07	1.47	1.27	1.94	153	PW
		M	100	100	100	95	95	
Luckwill, 1939	*Lycopersicum*	145	523	637	580	937	162	FW
Robinson, et. al., 1956	Maize	M	38	36.6	37.3	54.5	146	Y
Stewart, et. al., 1946	Sugar Beets	M	17.29	18.09	17.69	19.51	110	Y
			13.4	13.6	13.5	14.0	104	%
Unrau, 1947	Sunflower		85	85	85	77	91	DF
Whaley, 1939a	*Lycopersicum*	105	188	235	211	461	219	DW
		105	210	555	382	622	163	DW

Criteria:
DF - days to flower
M - maturity
% - per cent sucrose
BW - bulb weight
DW - dry weight
FW - fresh weight
PW - plant weight
SW - seed weight
Y - yield per acre

TABLE THREE

DESCRIPTION OF PARENTAL PLANTS

	Seedling (First Year)					Tuber (Second Year)	
Parent No.	Source (1)	Flower Ruffling (2)	Flrs.	Leaf Size (3)	Flower Color (4)	Plant Diam. (CM.)	Flower Size (CM.)
1	B	2	7	L	827/1	35.6	15.2
2	P	2	25	S	822/3	40.6	8.3
3	L	2	40	M	639	63.5	9.1
4	L	2	11	S	724	36.8	9.5
5	L	2	9	M	733	33	7.8
6	B	3	8	M	028	33	10.2
7	B	1	17	S	637/1	41	8.9
8	B	0	10	S	822	40	8.9

1. Source:

L = Lewis, Lockport, N.Y.
(Seed of German origin)
P = Panzer, Portland, Ore.
B = Buell, Eastford, Conn.

2. Ruffling:

0 - None
1 - Slight
2 - Moderate
3 - Extreme

3. Leaf size:

S - Small
M - Medium
L - Large

4. Flower Color:

British Color Council
Horticultural Color Chart

TABLE FOUR

VIGOR DETERMINATIONS EXPRESSED AS MAXIMUM DIAMETER IN MM. AT TWO, NINE, AND FOURTEEN WEEKS(UPPER, MIDDLE, AND LOWER FIGURES RESPECTIVELY).

PARENT NUMBER ♀/♂	1	2	3	4	5	6	7	8	Mean
1	9.1 15.0 23.9			25.6 44.7 83.7		16.0 31.6 54.6	7.8 19.4 44.0		16.5 31.9 60.8
2	12.4 29.1 59.5	7.5 16.0 36.0	13.3 34.9 57.9		6.3 12.1 30.7	13.9 48.5 79.7	10.6 38.7 72.6	9.4 22.5 56.6	11.0 31.0 59.5
3	12.7 35.9 62.6	11.3 46.3 61.4	6.8 14.1 28.6	13.8 31.7 57.2	10.2 26.7 52.3	17.1 58.2 86.8	8.7 20.8 42.8	7.5 23.7 55.1	11.6 34.8 59.7
4	11.4 24.4 43.1	5.1 10.7 26.5		8.5 17.1 34.6	8.7 23.1 50.2	8.9 27.7 56.7	5.3 14.1 38.3		7.9 20.0 43.0
5	9.7 22.8 47.3		11.3 28.2 41.6	10.9 24.1 41.6	6.6 10.2 24.9		10.8 38.0 65.8	11.8 38.1 69.6	10.9 30.2 53.2
6			14.8 42.4 79.9	9.6 28.7 58.6	11.1 21.1 41.9	10.3 29.2 45.7		17.6 60.6 88.1	13.3 38.2 67.1
7				7.1 15.2 34.6	12.2 20.9 37.4		5.0 12.1 22.3	11.1 35.6 70.6	10.1 23.9 47.5
8					15.3 62.7 90.9		12.4 34.9 69.4	5.4 10.0 23.4	13.9 48.8 80.2
Mean	11.6 27.8 53.1	8.2 28.5 44.0	13.1 35.2 59.8	13.4 28.9 55.1	10.6 27.8 50.6	14.0 41.5 69.5	9.3 27.7 55.5	11.5 36.1 68.0	

TABLE FIVE

RATIOS OF NINE (UPPER) AND FOURTEEN (LOWER) WEEK DIAMETERS IN TERMS OF INITIAL (TWO WEEK) DIAMETER.

PARENT NUMBER ♀/♂	1	2	3	4	5	6	7	8
1	1.66 2.64			1.75 3.27		1.97 3.41	2.47 5.62	
2	2.35 4.81	2.13 4.78	2.63 4.35		1.91 4.87	3.49 5.72	3.64 6.84*	2.41 6.05*
3	2.82 4.91	4.09 5.43	2.07 4.22	2.30 4.14	2.63 5.15	3.41 5.09	2.39 4.91	3.15 7.32*
4	2.15 3.80	2.11 5.23		2.01 4.07	2.67 5.80*	3.13 6.40*	2.65 7.18*	
5	2.34 4.86		2.49 3.67	2.21 3.82	1.57 3.75		3.54 6.12*	3.22 5.88*
6			2.86 5.39	2.98 6.10*	1.90 3.77	2.84 4.44		3.45 5.02
7				2.14 4.87	1.71 3.07		2.40 4.43	3.18 6.31*
8					4.11 5.95*		2.81 5.59	1.86 4.33

* Ratio Exceeds 5.74. See Text.

FIGURE ONE

FREQUENCY OF VIGOR CLASSES OF CROSSES AND SELFS

AT SEVEN WEEKS EXPRESSED IN PER CENT

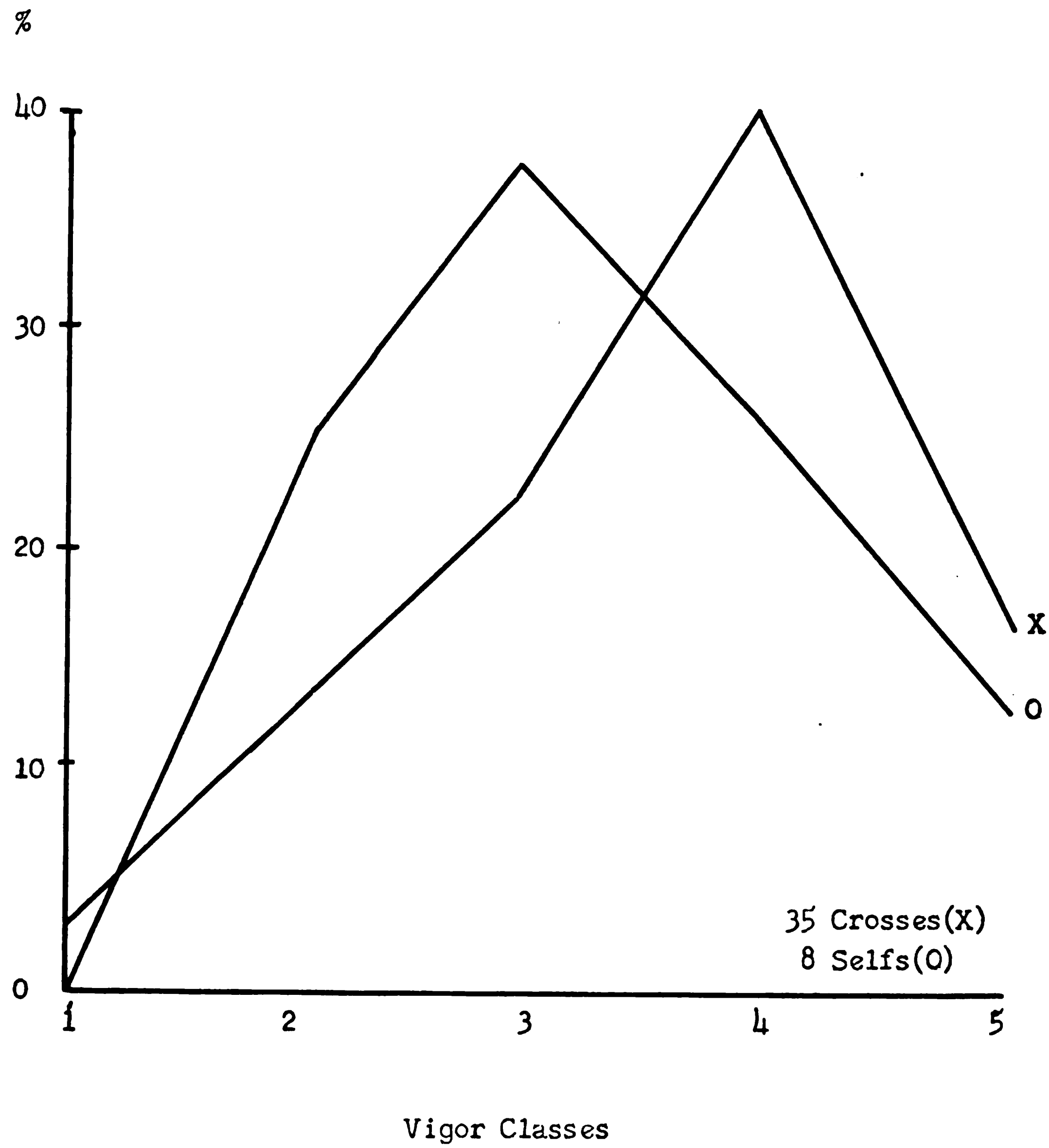


FIGURE TWO

DRY WEIGHT IN MG. OF SELFS AND F_1 OF TWO PARENTAL PLANTS (EACH POINT REPRESENTS MEAN OF TWENTY-FIVE PLANTS)

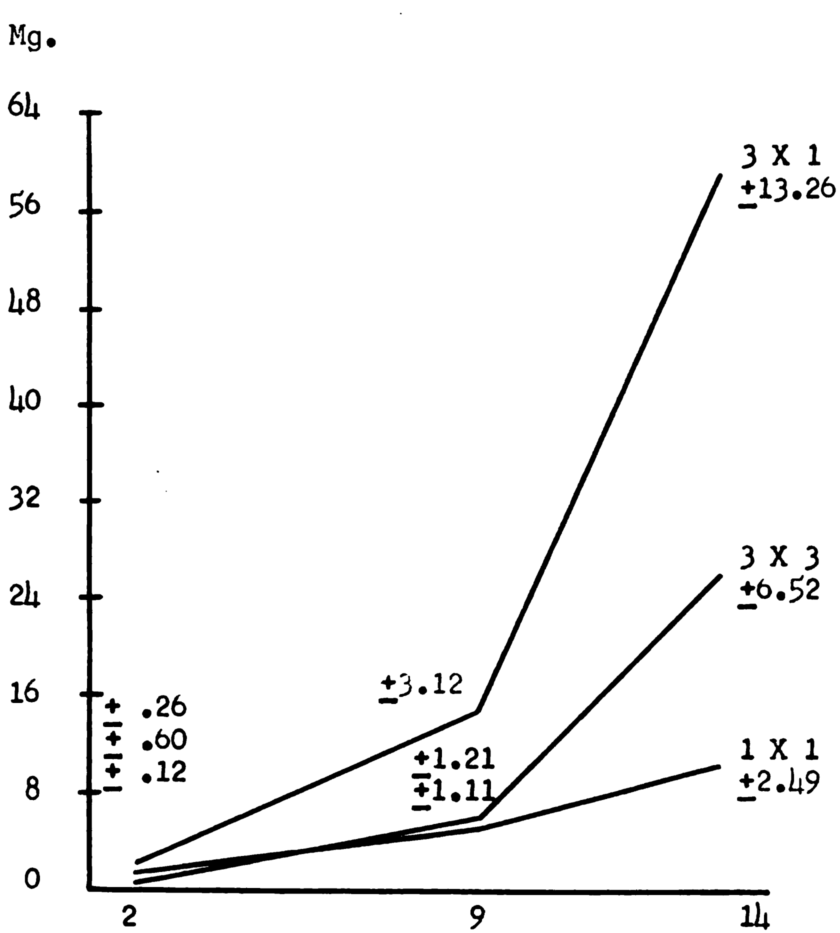
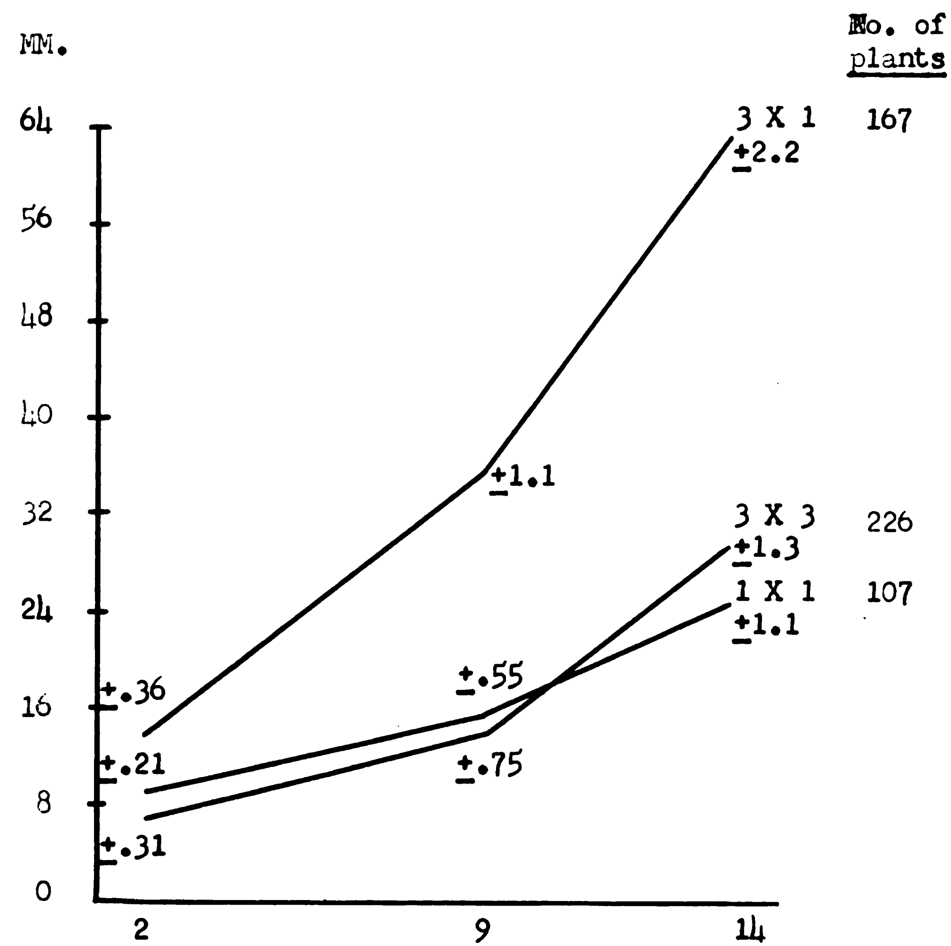


FIGURE THREE

MEAN MAXIMUM DIAMETER IN MM. OF SELFS AND F_1'S. THE SAME PLANTS USED AT EACH VIGOR DETERMINATION



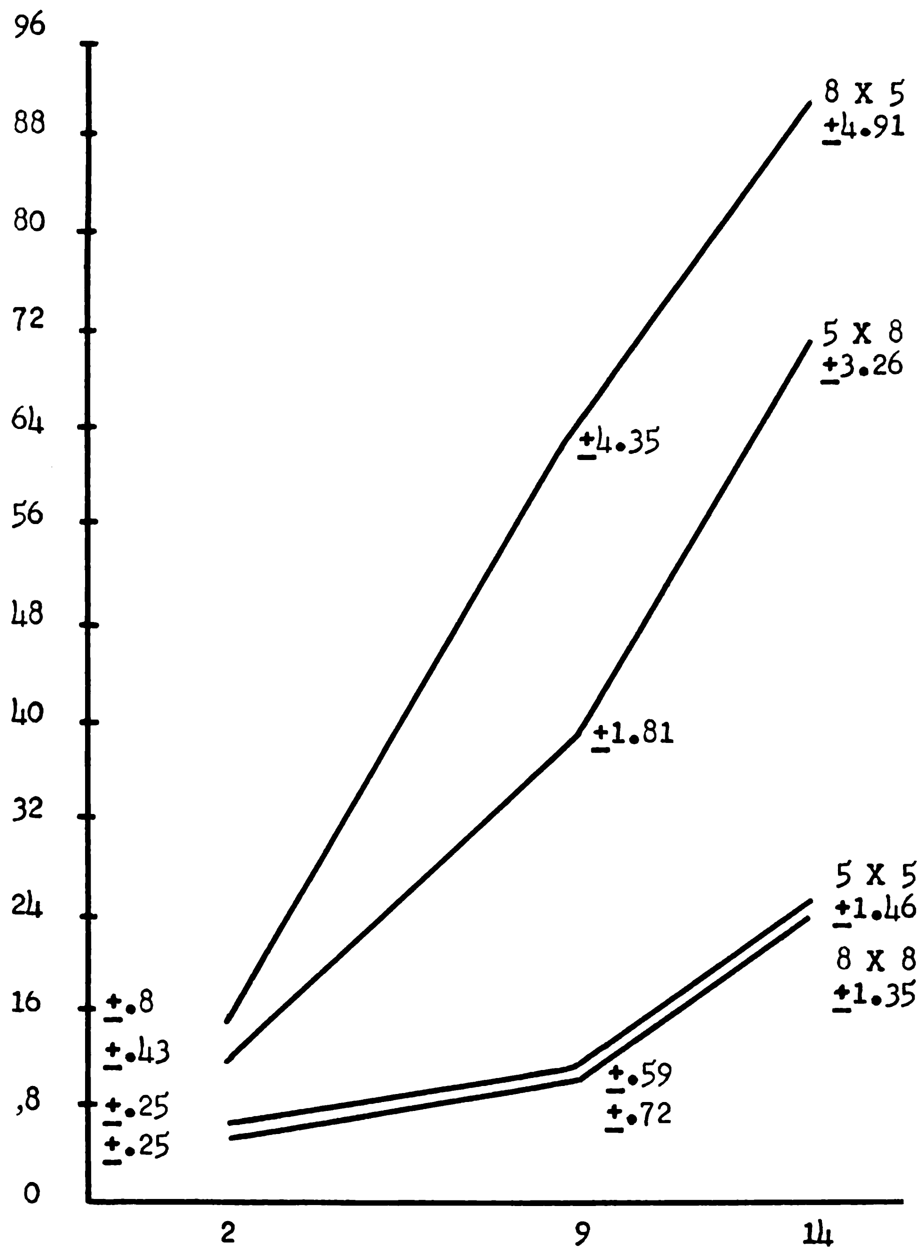
Weeks After Transplanting

(Standard Deviation of Mean Indicated)

FIGURE FOUR

COMPARATIVE VIGOR BY MAXIMUM DIAMETER IN

MM. OF SELFED AND RECIPROCAL PROGENIES



Weeks After Transplanting

(Standard Deviation of Mean Indicated)

FIGURE FIVE

FREQUENCY DISTRIBUTION OF MEAN VIGOR FOR ALL SELFS AND CROSSES FOURTEEN WEEKS AFTER TRANSPLANTING, IN UNITS OF LEAST SIGNIFICANT DIFFERENCE (LSD = 4.77) FROM THE UNWEIGHTED MEAN OF MEANS (M)

Sum left of M			Sum right of M	
Selfs	(O)	8	Selfs	0
Crosses	(X)	13	Crosses	22