

A STUDY OF THE HYBRID VIGOR OF
REDSKIN TOMATO IN RECIPROCAL CROSSES

A THESIS

Presented to
the Committee on Graduate Studies of
The University of Manitoba

In Partial Fulfilment
of the Requirements for the Degree of
Master of Science

by

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April 1948



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ACKNOWLEDGMENTS

The writer wishes to express appreciation to Dr. T. M. Currence, Division of Horticulture, University of Minnesota, who suggested the present study, and the design of the experiment. Thanks are due to Mr. C. Walkof, Assistant in Vegetable Crops, Morden Experimental Station, for valuable data, which prompted this study, and for supplying four parental strains used in this study. Acknowledgment is made to Mr. John Walker, Superintendent of the Forest Nursery Station at Indian Head, by whose kind permission the study was carried out. The writer is also indebted to Professor E. T. Anderson, Assistant Professor of Plant Science, and Dr. P. J. Olson, Professor of Plant Science, for their advice and assistance, and for their constructive criticism of the manuscript.

INTRODUCTION

The fact that the offspring of reciprocal crosses usually have been identical, indicates that most hereditary characters are equally contributed by the male and female gametes. This is in agreement with a generally accepted genetic theory. However, cases do arise where reciprocal crosses produce unlike results for certain characters, and these appear to be inherited almost entirely through the female parent by means of the cytoplasmic contents of the egg cell.

Tomato reciprocal crosses have repeatedly been shown to be alike, indicating that there was no detectable material or cytoplasmic influence. The subject has recently been reopened by the finding of significant differences in the yield of reciprocal hybrids involving the Redskin variety. This fact takes on greater importance in the light of present day trends toward the utilization of the heterosis of F_1 hybrids, which have demonstrated superior fruit yields and earliness when compared to selfed lines of tomatoes.

In this study the Redskin variety has been used in four reciprocal crosses, and the differences in hybrid vigor of the F_1 as manifested by earliness and yield, size and weight of fruit, have been analysed statistically.

REVIEW OF LITERATURE

A number of reports comparing reciprocal hybrids of the tomato, which have shown no differences, have been published since 1900. Hedrick and Booth (11) in 1907 reported that "seedlings from the direct and the reciprocal cross were similar in all respects" when Livingstone Stone and Dwarf Aristocrat were crossed. Craig (5) who worked with Hedrick stated that reciprocal crosses gave practically the same results. Price and Drinkard (16) from an extensive study of the inheritance in the F_1 of such fruit characteristics as color, shape and locule number, concluded that "the reciprocal crosses gave similar results in the hybrid offspring."

Halstead (9) made a study of the relative values of the two directions of the cross in reciprocal breeding and used the contrasting varieties Dandy Dwarf and Yellow Cherry. He concluded that the fruit characters - weight and size - of the seed parent were approached in both crosses. Driver (7) reported a case where reciprocal hybrids seemed to differ, where "The fruit quality of Kondine x Market Favorite was good, but that from the reciprocal was not so satisfactory. Here maturity was equal to the earlier parent in one cross but intermediate in the reciprocal."

In another reciprocal cross he states, "only one was earlier than both parents." Meyer and Peacock (15) found a strain of Marglobe which when used as a male parent for the production of F_1 hybrids, was somewhat superior in early yield and total yield than when used as a female parent.

Barrons and Lucas (4) from the results of three years study reported that it was immaterial whether a variety was used as the male or female for the production of F_1 hybrid tomato seed. Continuing these studies Barrons (3) found a new greenhouse hybrid-- Michigan State Forcing x Coopers Special-- no different in yield than its reciprocal.

Larson and Currence (14) tested seven reciprocals involving the varieties Earliana, Red River and Marglobe, and "found that they did not differ significantly from one another in any character." Currence, Larson and Virta (6) made the observation that "those instances where differences have been statistically tested show no significance between reciprocal crosses.

Recently Walkof (19) found that F_1 hybrids with Redskin as the female parent produced significantly more ripe fruit than their reciprocals. He also found the cross Bounty x Redskin to be later ripening than its reciprocal.

In addition to the above studies of the tomato, interesting related information concerning reciprocal crosses and F_1 hybrids has been reported for other crops.

Ashley (1) when studying the nature of hybrid vigor in corn, found F_1 seed heavier than either parent. Further, that the hybrid embryo was larger and heavier than that of the parents and so germinated with an initial advantage which was retained throughout the life cycle. In a later article (2) he reported the embryo weight of the seed of two parents to differ significantly as well as the embryo weights of the reciprocal crosses, even though the reciprocal crosses had the same genetical constitution. He presented this as evidence that the difference was due to a maternal effect during the development of the embryo before the seed entered upon its resting period.

Kakizaki (13) investigated hybrid vigor in egg plants and reported that the F_1 seed in most crosses was heavier due to the immediate effect of cross pollination, than the selfed seed of the mother parent.

Hutchins (12) found that "there was no difference in the behavior of reciprocal crosses insofar as yield per plant of the F_1 generations was concerned," in cucumber.

MATERIALS AND METHOD

Parental varieties - Redskin, Earliana, Earliest North, Harkness and Early Chatham - were selected on the basis of contrasting and similar characteristics, namely plant habit, maturity, fruit size and fruit shape. These have been listed in Table A of the appendix.

Reciprocal crosses were made in the greenhouse of the Dominion Experimental Farm, Indian Head, Saskatchewan, during the spring of 1946, using the variety Redskin, as either the male or female parent in each cross. A single plant of each variety, with the exception of Redskin, was used as the pollen and seed parent in the crosses made. In the case of Redskin, four plants were deemed necessary to ensure sufficient seed. The resulting eight reciprocal F_1 hybrids were assigned at random the planting numbers listed in Table B of the appendix. Duplicate samples of 25 seeds, from each cross, were weighed in milligrams; these data are given in Table C of the appendix.

The hybrid seed was sown in the greenhouse on April 25, 1947. Plants, produced and handled according to standard practice, were set out in the field on June 11, 1947. The planting plan adopted was an 8 x 8 latin square as described by Goulden (8), and is given in Table D of the appendix. Plots consisted of four plants spaced 4 feet by 4 feet.

Fruits were harvested twice a week beginning August 16. A general red coloration was used as the indication of harvest maturity. Eight subsequent harvests were made before September 15, when frost terminated the season. The number of fruits of each harvest and their weights in grams were recorded. Fruits of each harvest were classified as to quality into grades of No. 1, Marketable, and Culls.

Fruit weight in grams was used as an index of fruit size. Fruit sizes herein reported were computed by averaging the weights of individual fruits obtained from two prime pickings. Polar and equatorial measurements to tenths of an inch were also made, and the average fruit shape index, E/P , was calculated by dividing the equatorial dimension of each fruit by its polar dimension.

The term "total yield" constituted the grand total of all fruits harvested from a plot, while the term "marketable" was used to designate the total of no. 1 and marketable fruits, when the number of no. 1 fruits proved to be few due to the limited season. Similarly, "total early yield" is used to refer to the grand total of fruits harvested in the first two weeks, and "early marketable yield" indicates the total marketable fruits produced in the same period.

For the purpose of analysis plot totals were converted to pounds. The records were analyzed for early yield, total yield, fruit shape, fruit size and seed weight, to determine whether the differences between reciprocals were significant. Analysis of variance was first applied to the data to ascertain the need of further analysis, and also to find the standard error value. As significant F values were obtained for the treatments in all cases, the mean values of the respective pairs of reciprocal hybrids were calculated to determine whether their differences were significant. Procedures as outlined by Goulden (8) and Hayes and Immer (10), for the analysis of variance of a latin square design, and for the calculation of the differences required for significance at the 5% and 1% levels, were followed in this study.

Seed weight data of reciprocal hybrids were analyzed as paired variates. The method as outlined by Goulden (8) for testing the significance of small samples was followed, and the difference necessary for significance at the 5% level has been given. Total yields were used, as a source of fruit size data rather than marketable yields, on the assumption that if unmarketable fruits were excluded, a bias would be introduced in favor of hybrids producing a large number of undesirable fruits in addition to a few superior marketable fruits.

RESULTS AND DISCUSSION

1. Total Yields of the F₁ Reciprocal Crosses.

The analysis of variance computed in Table 1, showed treatments, which are the eight reciprocal hybrids, to be highly significant, and indicated that significant differences occurred between the mean yields of the hybrids. It indicated also that significant differences in yield occurred between the various rows and columns of the plantation due to environmental effects. Total yields of the eight reciprocal F₁ hybrids in pounds, have been listed by plots in Table D of the appendix.

Table 1. Analysis of Variance of Total Yields in Pounds

Source	S.S.	D.F.	Variance	F.	S.D.
Rows	190.6811	7	27.2402	3.54 ^{XX}	
Columns	247.0806	7	35.2972	4.59 ^{XX}	
Treatments	1179.9808	7	168.5687	21.92 ^{XX}	
Error	322.9917	42	7.6903		2.7731
Total	1940.7342	63			

^{XX}Significant at the 1% level

Table II presents the total yields along with mean yields and the differences between reciprocal hybrids. Definite differences are exhibited between the means of certain reciprocals. In crosses involving Earliana, where Redskin was the female parent, yields were significantly

greater than when Redskin was the pollen parent. The reverse was true for reciprocal hybrids of Redskin and Early Chatham. When Redskin was the male or pollen parent, the yields were greater than with the reciprocal to the highly significant level. No significant difference was apparent between the mean total yields of reciprocal crosses of Redskin and Harkness. Reciprocals of Redskin and Farthest North showed highly significant differences in favor of the hybrid with Redskin as the pollen parent.

Table II. Total Yields, Means and Mean Differences of the F_1 Reciprocal Hybrids in Pounds

F_1 Hybrid	Total Yield	Mean	Diff.
Redskin x Farthest North . . .	67.25	8.41	
Farthest North x Redskin . . .	121.77	15.22	6.81
Redskin x Earliana	154.65	19.33	
Earliana x Redskin	124.49	15.56	3.77
Redskin x Harkness	71.19	8.90	
Harkness x Redskin	69.20	8.65	0.25
Redskin x Early Chatham . . .	112.86	14.11	
Early Chatham x Redskin . . .	155.74	19.47	5.36
Significant Difference at the 5% level = 2.80 lbs.			
Significant Difference at the 1% level = 3.74 lbs.			

II. Total Marketable Yields of the F_1 Reciprocal Crosses.

Total marketable yields have been summarized in Table F of the appendix. These were analyzed by analysis of variance and the mean differences were tested for significance.

The analysis of variance is given in Table III, and the mean differences in Table IV.

Table III. Analysis of Variance of Total Marketable Yields in Pounds

Source	S.S.	D.F.	Variance	F.	S.D.
Rows	142.2436	7	20.3205	2.75 ^x	
Columns	168.8544	7	24.1221	3.27 ^{xx}	
Treatments	830.5039	7	118.6434	16.09 ^{xx}	
Error	309.7844	42	7.3758		2.7158
Total	1451.3863	63			

^{xx}Significant at the 1% level

^xSignificant at the 5% level

Table IV. The Total Marketable Yields, Means and Mean Differences of F₁ Reciprocal Hybrids in Pounds

F ₁ Hybrid	Marketable Yields	Mean	Diff.
Redskin x Farthest North . . .	63.36	7.92	
Farthest North x Redskin . . .	107.65	13.46	5.54
Redskin x Earliana	135.67	16.96	
Earliana x Redskin	110.00	13.75	3.21
Redskin x Harkness	68.16	8.52	
Harkness x Redskin	67.90	8.49	0.03
Redskin x Early Chatham . . .	106.32	13.29	
Early Chatham x Redskin . . .	142.27	17.78	4.49

Significant Difference at the 5% level = 2.74 lbs.

Significant Difference at the 1% level = 3.66 lbs.

Analysis of variance of total marketable yields similar to that of total yields, showed highly significant F-value differences between treatments. It is evident from this that certain reciprocal hybrids were definitely different in mean marketable yields.

F₁ hybrids of Redskin and Farthest North gave mean marketable yield, which exceeded that of the reciprocal by a highly significant amount, when Redskin was the male parent of the cross. The same was true with the F₁ hybrids of Redskin and Early Chatham, for significantly superior yields were obtained where Redskin was the pollen parent. Redskin and Harkness reciprocals showed no significant differences. In the above six hybrids, the results for marketable yields were similar to those obtained for total yields; that is apparent in Table IV.

However, the difference between mean yields of Redskin and Earliana reciprocals, which was highly significant for total yields, was found to be significant only at the five percent level for marketable yields. This indicated that harvests of the F₁ Redskin x Earliana contained more cull fruit (fasciated and small) than the reciprocal. By actual count, the number of cull fruits for the former was 56 and for the latter 39.

III. Total Early Yields of Reciprocal F₁ Hybrids

Fruit yields harvested the first two weeks were used to evaluate the earliness of maturity exhibited by the F₁ hybrids. A summary of the total early yields has been given in Table G of the appendix.

The analysis of variance of total early yields, given in Table V, shows a highly significant F value for treatments, indicating that significant differences occurred between the mean yields of the hybrids.

Table V. The Analysis of Variance of Total Early Yields

Source	S.S.	D.F.	Variance	F.	S.D.
Rows	10.6246	7	1.5178	1.58	
Columns	14.5656	7	2.0808	2.16	
Treatments	72.5381	7	10.3626	10.78 ^{xx}	
Error	40.3867	42	0.9616		0.9806
Total	221.4400	63			

^{xx}Significant at the 1% level

The mean early yields of reciprocal crosses were tested for significant differences in Table VI. Two F₁ hybrids, Farthest North x Redskin, and Early Chatham x Redskin, proved to be earlier beyond the highly significant level than their respective reciprocals. In both cases the superior F₁ of the reciprocals had the Redskin variety as its pollen parent. The remaining reciprocals showed no significant differences.