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CONTENTS

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THE IMPROVEMENT OF TOMATOES BY SELECTION

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INTRODUCTION

Although the numerous present-day varieties of tomatoes have been developed in the last 75 years from forms with smaller and less desirably-shaped fruits, the history of the evolution of our cultivated forms is obscure. As Bailey[1] has pointed out, the extremely large fruit-size of certain cultivated forms is generally associated with that type of fasciation known as synanthy. Whereas the number of loculi or cells in the fruit of the small-fruited and doubtless more primitive forms, such as Red Cherry, is from two to three, in the large fruited varieties, such as Trophy and Ponderosa, the number is from 15 to 20. According to Warren[12] fasciation of fruit is determined by the recessive allelomorphs of two dominant Mendelian factors which inhibit fasciation. On this hypothesis the fasciated condition has presumably arisen by gene mutations.

It is generally believed that in the later development of the tomato, selection has played an important role, though the literature on this subject is meager. Myers[8] reports that in some instances the general character of the fruit produced by the progeny of single plant selections of Earliana and Matchless was less desirable than that of the original selection, but in others some improvement was recorded. Using statistical methods, Myers found that the progenies of selections were less variable than the parent variety. Later, this author reported that there was no cumulative improvement through further selection and that the original selection was the important one. From

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this it may be inferred that the different lines isolated by Myers in his original selections were homozygous biotypes occurring in the parent variety.

Hayes and Jones[5] found that continuous self-fertilization of tomatoes for three or four years, in four commercial varieties, did not cause any significant changes in productivity but resulted in the isolation in the first year of lines some of which were more, others less, productive than the original variety.

Brown[2] states that in the Greater Baltimore variety his lines selected for increased yield have given positive results, though his data have not yet been published.

Strains of tomatoes resistant to the wilt disease caused by *Fusarium lycopersici,* have been developed by selection by several workers. According to Pritchard[10] single plant selections within such strains usually transmitted to their progency the same degree resistance found in the original selections, and only in a few instances was increased resistance obtained by a second selection within such lines; still later selections gave no increased resistance.

The object of the work reported here is to isolate by selection within the Santa Clara Canner variety lines which are superior in fruit-shape and relatively free from the defects of the parent variety, while retaining its yielding capacity, solidity of fruit, resistance to *Fusarium* wilt, and other desirable characters.

MATERIAL

The variety of tomato most extensively grown for canning and the manufacture of tomato products in California is variously known as San Jose Canner, San Filippo, Jap Canner and Santa Clara Canner. The last name, recently suggested by Mr. Frank A. Dixon of the Canners League of California, seems the most likely to meet with general acceptance and is used in the present report. Closely similar to it are the varieties Diener and Santa Rosa.

Santa Clara Canner is said to have been developed from the old Trophy variety. Indeed, it resembles the present-day type of Trophy as grown in Alameda County, California. The flower is fasciated to a degree greatly exceeding that in most cultivated varieties, as shown in fig. 1; the fruit is very large, many-celled, has a deep cavity (stem-end depression), a deep basin (stylar-end depression), and is often irregularly convoluted. The fruit color is scarlet. In form and gross interior structure, the fruit resembles the Ponderosa variety, though the latter has pink fruit due to the recessive non-yellow skin.

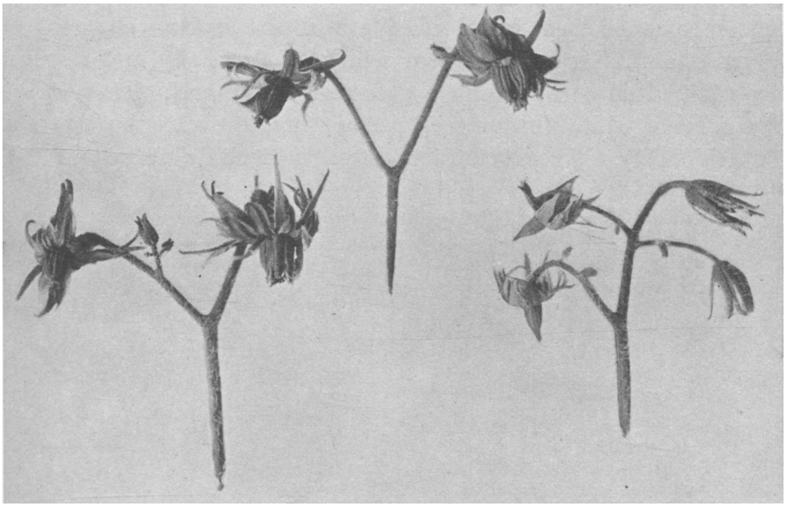

Fig. 1.—The left and central flower clusters are of the Santa Clara Canner variety. Note the large, fasciated styles, projecting beyond the stamens in some cases. At the right is a flower cluster of the Stone variety.

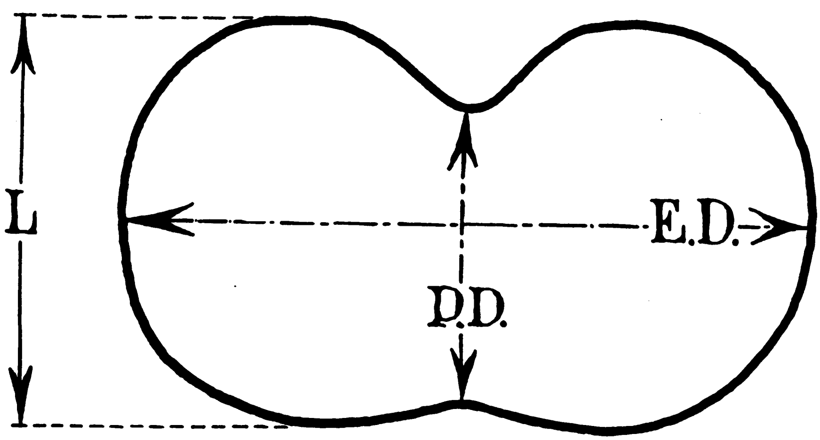

Fig. 2.—Measurements used to determine fruit shape in tomato. E D, equatorial diameter; P D, polar diameter; L, length.

As a variety for the cannery Santa Clara Canner has some serious defects. The fruit shape is very variable. Forms that are oblate, with a deep depression at the stem-end and a wrinkled, irregularly lobed or so-called "cat-face" condition at the stylar (blossom) end predominate. A large stylar scar which cracks easily and results in leaky fruit often accompanies a defective stylar end. There is generally a large white fibrous core permeating the central part of the fruit (fig. 3D). These characteristics necessitate increased labor

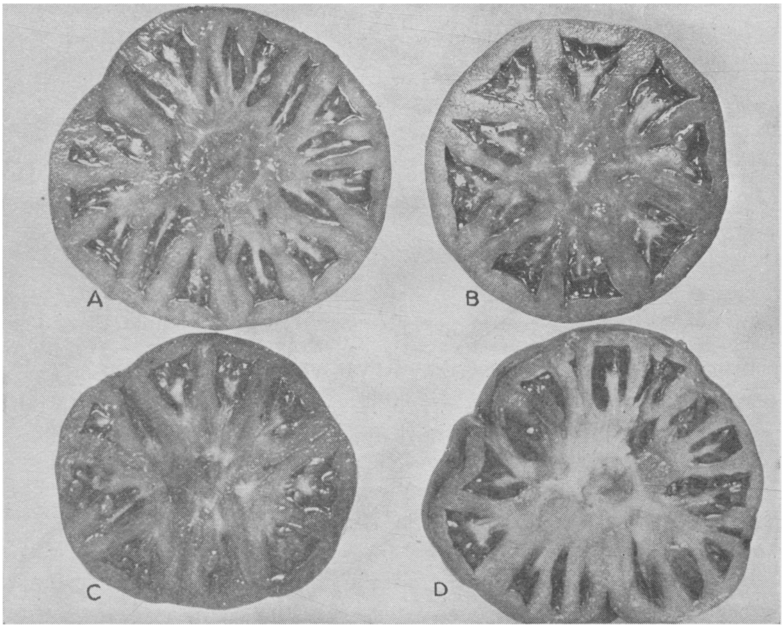

Fig. 3.—Internal characteristics in the Santa Clara Canner variety: A, large meaty core with a "cherry center," good type; B, cells too large, not enough cross-walls; C, many abortive locules, characteristic of rough fruit; D, large hard white core in center of fruit.

and the loss of a large part of the fruit in preparing it for canning, make it difficult to secure an attractive "solid pack" and detract from the quality when such tomatoes are used for the manufacture of pulp, catsup or paste. On the other hand, this variety has some very good qualities which cause it to be considered the best of existing types from the canner's point of view for production in California. The yield is often very heavy; the fruit is unusually firm and solid; it stands handling well; the walls or interlocular septa are thick, and the cells or loculi are numerous but small (fig. 3A). The color of the flesh is fairly satisfactory. The fruit is very large which makes picking economical, but it is often too large to permit the canning of whole fruit. Furthermore it has been shown[7] that this variety possesses a fair degree of resistance to Fusarium wilt.

PROCEDURE

In 1922, in connection with a general program of tomato breeding, selections were made of fruit from single plants in commercial fields of Santa Clara Canner in different parts of the state. In 1923 the progenies of these selections were tested at the Citrus Experiment Station, Riverside, and at the Branch of the College of Agriculture, Davis, California, and further selections were made within the progenies that seemed to approach most nearly the ideal sought. Additional selections were made also from the original variety in this year. These subsequent selections have been made chiefly of fruit from flowers bagged and self-pollinated by hand at Riverside, but also from fruit of unprotected flowers at Davis. Lesley[6] found that at Riverside nearly 5 per cent cross-fertilization occurred in unprotected flowers of the variety of Magnus, which has a relatively long style with the stigma usually projecting beyond the staminal cone; the short-styled variety Dwarf Champion was much less subject to cross-pollination. It has been shown by Fink[4] that wind-pollination does not occur in the tomato at St. Paul, Minnesota. According to his observations, bumble bees were the only insects that visited tomato flowers in a manner that might cause cross-pollination. At Riverside bumble bees visit tomato flowers freely, and no doubt contribute to the cross-pollination. These insects are relatively rare in the interior valleys, and have not been observed to visit tomato flowers at Davis, where little evidence of cross-pollination was found. Hence it was thought that at Davis selections could be made more safely from the fruit of unprotected flowers.

In 1924 and 1925 the progeny tests and further selections within them were continued. In 1925 three generations of single plant selection appeared to have given rise to lines of definite types, different from the parent variety, and from one another. It therefore became necessary to devise methods of measuring certain of these differences, in order that the most desirable lines might be selected for propagation. Some qualities, such as color of flesh, presence or absence of fibrous core, thickness of walls and number of cells may be roughly evaluated by eye. For others, particularly form, size and uniformity of fruit, it seemed that biometrical methods might readily be applied.

FRUIT SHAPE

The first method tested was simply to record the percentage of defective fruit produced by each line. In classifying the fruit the word "rough" is used here to denote defectiveness of fruit shape; as applied to the stem or basal end of the fruit it denotes a deep cavity and more or less corrugation or folding of the surface around the cavity (fig. 4); as applied to the stylar end, "rough" implies a wrinkled or lobed condition forming an irregular basin and a large stylar scar (fig. 5). The terms "smoothness" and "roughness" are conveniently used to express the proportion of "smooth" and "not-smooth" fruit.

At each picking the fruit was graded into 4 classes: (1) rough at both ends, (2) rough at the stem end only, (3) rough at the stylar end only, and (4) smooth. Tables 1 and 2 give the proportions observed and the average weight of a single fruit in the selected lines grown at Davis and Riverside in 1925. Although depending on personal judgment, this method of classifying individual fruits seemed to give useful indices of type and this impression was confirmed by the measurements of the fruits shortly to be described.

Among the lines grown at Davis, listed in table 1, the percentage of smooth fruit varied from 48 per cent to 98 per cent, while the original variety had only 38 per cent in this class. Evidently some of the selections had transmitted the desirable qualities of shape to a much greater extent than others. The two strains having the highest percentage of smooth fruit resembled the Stone variety in size and shape of fruit, and were too small to be commercially desirable. Line 78–1–4 consisted of smooth fruits, about the size of Stone but resembling Santa Clara Canner in their firmness and interior characteristics. Whereas the original variety had a high percentage of fruits in all three classes of defectives, some of the strains showed a predominance of one class of defect. Thus 72–3–1 had a high percentage of fruits rough at the stylar end, though otherwise smooth and of good type. Considerable difference also occurred in the average weight per fruit, some lines exceeding and others falling short of the original variety. Some of the lines discarded in earlier years had large celled, soft, watery and puffy fruit. Practically all the lines grown in 1925 had the thick walls, numerous small cells and firmness characteristic of Santa Clara Canner, but were largely free of the fibrous core. There were very marked differences in season of maturity. Some of the strains were much earlier than the parent variety. It was not pos-

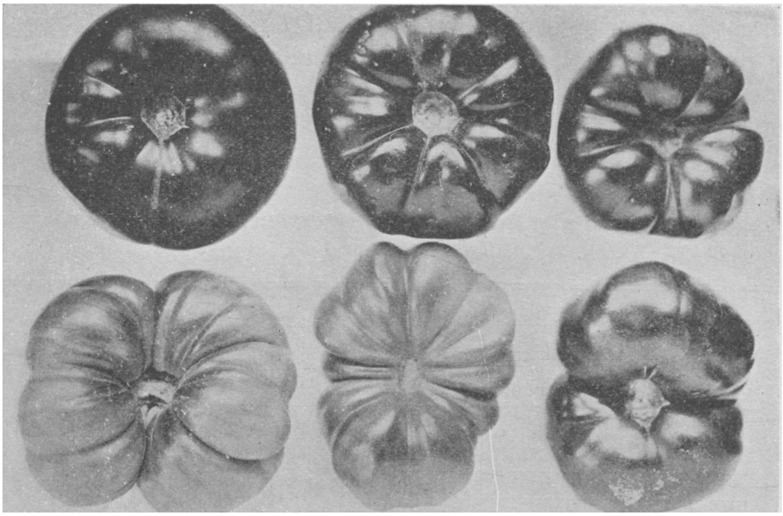

Fig. 4.—Showing various degrees of roughness at the stem end of fruits of the Santa Clara Canner variety; the rougher types predominate in the commercial strains.

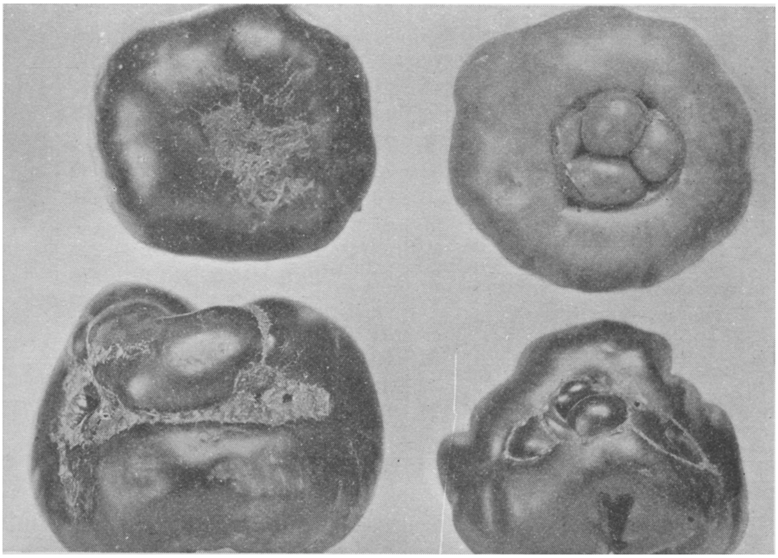

Fig. 5.—Irregular or rough stylar ends, characteristic of many fruits in the Santa Clara Canner variety. Such defects have been practically eliminated in some of the selected lines.

sible to obtain satisfactory data on this point at Davis in 1925, as only two pickings were made, and the number of plants in most strains was not large enough to give reliable data on production. The yield per plant in table 1 may be taken to indicate roughly the relative earliness of the strains rather than any real differences in yielding power.

TABLE 1

CLASSIFICATION OF FRUIT ACCORDING TO DEFECTS, IN LINES GROWN AT DAVIS, CALIFORNIA, IN 1925

Pedigree Number	Number of fruits	Smooth	Rough both ends	Rough stem end	Rough stylar end	Average weight (grams)	Average yield per plant (grams)
		Per cent	*Per cent*	*Per cent*	*Per cent*		
46–1–1	47	98	0	2	0	224	
55–3–1	25	92	4	0	4	170	
55–1–2	34	91.2	3	0	6	303	
53–1–1	86	91	2	0	7	210	
78–1–4	344	88.4	5	1.4	5.2	212	10,381
55–1–1	581	86.6	8.2	2.6	2.6	309	13,405
57–10	834	85.2	6.8	3.5	4.4	289	13,155
78–1–1	132	84.9	6.8	1.5	6.8	322	8,490
57–4–1	26	84.6	7.7	0	7.7	298	
17–1–1	367	83.7	8.7	4.3	3.3	284	7,321
72–2–1	278	80.6	6.1	9.8	3.6	190	13,270*
53–1–2	546	76.6	8.2	1.5	13.5	264	
78–1–3	195	74.8	12.8	7.7	4.6	360	8,270
78–1–2	481	73.8	13.7	4.8	7.7	314	11,417
246–1	32	75	15.6	0	9.4	359	
75–1–1	550	73.8	12.4	10.3	3.5	351	13,776
57–1–1	67	67.2	14.9	11.9	6.0	292	
23–2–2	32	63	18.7	3.1	15.6	258	
55–2–1	58	62	19.0	5.2	13.8	378	
72–3–1	27	52	7.4	7.4	33.3	376	
46–1–2	37	51	18.9	24.3	5.4	330	
23–2–4	32	50	47	0	3	300	
46–1–3	29	48	52	0	0	358	
Santa Clara Canner	124	38	32	17	13	320	5,686

* Only one picking—very early strain.

Beside the selected lines discussed above, lines have been obtained which have small 2-celled fruits, pink (non-yellow skinned) fruits, and fruits bearing corky flecks near the stem end or fine golden specks over the entire surface.

Great differences were also found in the lines grown at Riverside in the same year (table 2). The percentage of smooth fruit varied from 43 per cent to 78 per cent in the selected lines and the parent variety had 54 per cent. Except in 78–1–3, lines superior to the parent variety in percentage of smooth fruit at Davis were also superior at Riverside, although the order of superiority was different perhaps owing to differences in response to environmental conditions. Among the smoothest lines in both trials was 17–1–1. The 8 lines with initial numbers 55 and 78 are derived from a single plant selected in 1922. Except for one small lot (78–1–3, table 2) all of them showed, both at Davis and Riverside, a higher percentage of smooth and a lower proportion of fruit rough at both ends than the parent variety. Typical fruits of one of these lines are shown in Fig. 8. As was the case at Davis the parent variety contained a considerable proportion of all three classes of defectives; however, several selected lines showed a predominance of stylar-end defects. Probably in making selections this defect is more easily overlooked than the more obvious stem-end roughness. In one line a larger proportion of the fruits showed the longitudinal corky sutures than in the original variety (figs. 6 and 7). Another line, 23–2–1, though superior in smoothness to the parent variety at Riverside, contained a much larger proportion of soft and puffy fruits than the parent (fig. 9).

TABLE 2

CLASSIFICATION OF FRUIT ACCORDING TO DEFECTS, IN LINES GROWN AT RIVERSIDE, CALIFORNIA, IN 1925

Pedigree Number	Number of fruits	Smooth	Rough both ends	Rough stem end	Rough stylar end	Average weight per fruit (grams)
		Per cent	*Per cent*	*Per cent*	*Per cent*	
17–1–1	51	78	4	6	12	314
24–2–1	47	70	11	6	13	353
246–1	64	69	11	12	8	319
23–2–1	44	66	7	2	25	227
46–1–3	33	61	9	12	18	268
78–1–1	107	60	7	7	26	275
78–1–2	78	58	4	4	35	282
78–1–4	39	56	3	8	33	259
78–1–3	30	43	7	3	47	285
Santa Clara Canner	61	54	11	16	18	308
Norton	213					130

Western blight was so severe on the Riverside plots that no yield determinations were practicable.

The diversity of types that have been isolated indicates that the parental variety must consist of a mixture of genotypes. Probably this condition is in part a result of natural cross-pollination, small in degree but repeated over a number of years. Doubtless in some cases plants selected for their smooth fruit were the result of earlier natural crossing with some smaller smooth-fruited variety, such as Stone.

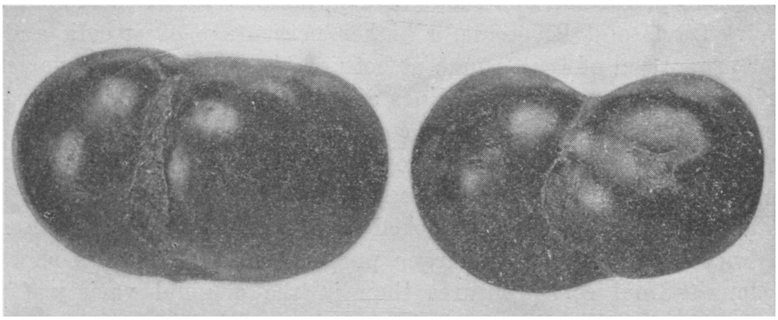

Fig. 6.—Side view of fruits having a longitudinal suture and scar. Such fruits occur commonly in the Santa Clara Canner variety, and predominate in certain inbred lines, but are absent in others.

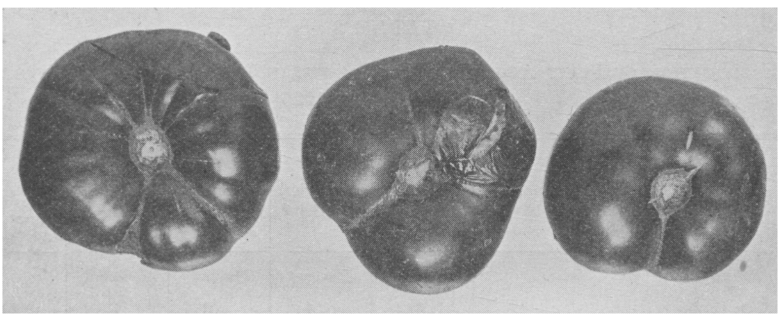

Fig. 7.—Stem-end view of fruits having one or more longitudinal sutures with corky scars extending the entire length of the fruit.

BIOMETRICAL STUDY OF THE SELECTIONS

Brown and Hoffman[3] assume that a perfectly globular shape is ideal for the tomato fruit and propose as a measure of shape, the ratio of polar diameter to equatorial diameter. In practice this assumption appears to be not entirely warranted, at least for the size and type of fruit desired for the cannery in California where the ideal is a fruit of large size, composed of a large fleshy core, many small cells and sufficient mechanical strength to withstand rough handling. We know of no existing type of tomato approaching

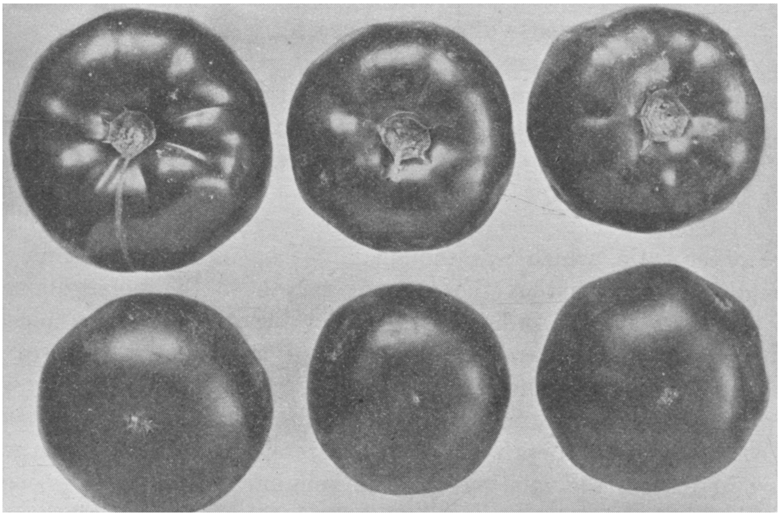

Fig. 8.—Fruit of selected line 55–1–1, showing the smoothness of this strain at both stem and stylar ends, while the size is only slightly less than that of the parental variety.

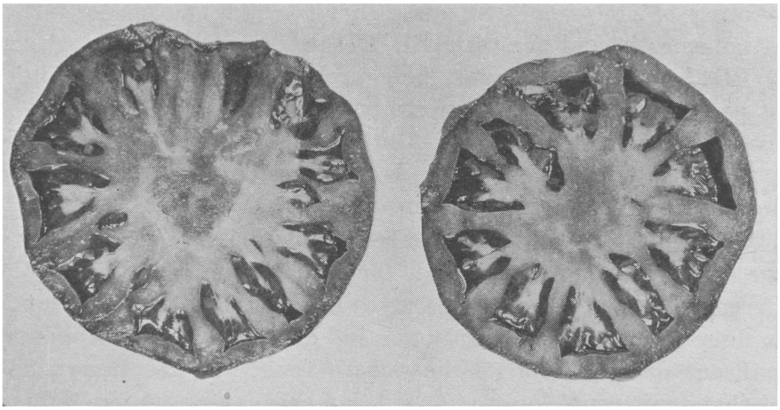

Fig. 9.—''Puffy'' fruits; note air spaces between seed jelly and outer wall.

the desired size and internal characteristics which is even approximately globular in shape. In our earlier work many selections were made of nearly spherical fruit, but all of these have since been discarded as lacking in firmness and size. A considerable degree of ''oblateness'' seemed inevitable. And yet the improvement of the common canning variety of California seemed to involve the development of fruit having a longer polar axis in proportion to its equatorial diameter, more especially since it was suspected that the roughness of the commercial stocks of Santa Clara Canner was correlated with the deep cavity and more or less depressed basin. Hence to eliminate rough fruits some measure of depth of cavity and basin was required.

In the measurement of fruit shape two ratios were used. The polar and mean equatorial diameters were measured and the ratio ED/PD calculated for individual fruits. This ratio is a measure of oblateness but is also influenced by depth of cavity and basin. The other ratio, which was though might be useful as an index of smoothness, was that of the extreme length to the polar diameter of the fruit (fig. 2 indicates the exact meaning of these terms). The ratio L/PD is largely a measure of the depth of the cavity although influenced somewhat by the roughness of the stylar end; it differentiates between spherical and oblate fruit in so far as shape is correlated with depth of polar depressions. These ratios were used in testing the relation between roughness and depth of polar cavities. For this purpose, one hundred twenty-four fruits of the parent variety, grown at Davis, were graded by eye into four classes according to smoothness, and the ratios ED/PD and L/PD determined for each fruit. Of the parent variety grown at Riverside, a sample consisting of sixty-one fruits was divided into two classes, smooth and not-smooth, and the ratio ED/PD determined. The mean ratio ED/PD for each class with their probable error, is given in the first part of Table 3. Similar comparisons were made also with the fruit of the selected lines 46–1–3 at Davis, and 78–1–1 at Riverside. On the same samples the ratio L/PD was determined, the results being given in the second section of table 3.

Comparing the fruit rough at both ends to the smooth fruit, very large differences are shown both for ED/PD and L/PD, and these differences cannot be due merely to the fluctuations of random sampling. Fruit rough at only one end gives smaller but apparently significant differences from the smooth fruit. It was surprising to find that fruit rough only at the stylar end gave a larger difference for both ratios than that rough only at the stem end. In some cases the samples are small, but all show differences in the same direction. It seems therefore that either of these ratios gives a measurement of smoothness of fruit which is reliable and at the same time likely to be more consistent than eye judgment. Similar measurements were therefore applied to some of the more promising lines, considering all the fruit from one picking. Table 4 gives the results of the measurements of eleven lines at Davis in 1925, the ratio ED/PD being given in the first section and L/PD in the second; the data from the lines grown at Riverside in the same season are shown in table 5.

TABLE 3

Comparison of Different Types of Fruit with Reference to the Ratios ED/PD and L/PD

Class of fruit	Place	Number of fruit	Ratio	Difference from smooth	In random sampling, odds against such a difference are
Unselected parent variety	Davis		*ED/PD*		
Rough at both ends		45	2.530±.039	.538±.046	∞ to 1
Rough at stem end only		16	2.265±.035	.273±.042	∞ to 1
Rough at stylar end only		15	2.350±.046	.358±.053	∞ to 1
Smooth		48	1.993±.026		
Unselected parent variety	Riverside				
Not smooth		32	2.14 ±.043	.40 ±.049	∞ to 1
Smooth		29	1.74 ±.024		
Selected line 46-1-3	Davis				
Rough at both ends		15	2.517±.058	.560±.045	∞ to 1
Smooth		14	1.957±.045		
Selected line 78-1-1	Riverside				
Not smooth		18	2.03 ±.040	.32 ±.043	∞ to 1
Smooth		34	1.71 ±.016		
Unselected parent variety	Davis		*L/PD*		
Rough at both ends		45	1.690±.038	.397±.040	∞ to 1
Rough at stem end only		16	1.413±.016	.120±.017	∞ to 1
Rough at stylar end only		15	1.478±.021	.185±.022	∞ to 1
Smooth		48	1.293±.010		
Selected line 46-1-3	Davis				
Rough at both ends		15	1.614±.049	.311±.072	267 to 1
Smooth		14	1.303±.053		

The selected lines (tables 4 and 5) are listed in the order of their difference from the original variety. In ED/PD, these differences range from 13.7 times the probable error to less than the probable error. It is evident that some of the selections differ materially from the parent variety in shape, while others are almost the same as the parental type. At Riverside (table 5) the ratio ED/PD was lower than at Davis; lines such as 17-1-1 and 246-1 differed significantly from the parent variety.

With regard to the ratio L/PD, in tables 4 and 5, the order of the the different selected lines is similar to that for ED/PD. While the differences are smaller, they show about the same order of significance. An advantage of the ratio L/PD is that it tends to be approximately a measure of the smoothness of the fruit without reference to its shape. Such lines as 17–1–1 and 72–3–1, which are among the lowest both in ED/PD and L/PD appear to be smoother and less depressed at the poles than the parental variety. Nearly in agreement with the data of tables 1 and 2, many of the selected lines are lower in ED/PD and L/PD both at Davis and at Riverside; it may therefore be concluded that they also are smoother than the parental variety.

TABLE 4

COMPARISON OF SELECTED LINES WITH THE ORIGINAL PARENT VARIETY, WITH REFERENCE TO RATIOS FOR SMOOTHNESS AND SHAPE OF FRUIT, AT DAVIS, CALIFORNIA

Selected line	Number of fruits	*ED/PD*	Difference from parent variety	Odds
55-1-1	163	1.908±.015	.357±.026	∞ to 1
72-3-1	27	1.927±.039	.338±.045	∞ to 1
78-1-1	60	1.965±.014	.300±.026	∞ to 1
C 246-1	32	2.005±.032	.260±.039	Approx. 200,000 to one
78-1-3	104	2.011±.018	.254±.028	∞ to 1
55-1-2	34	2.020±.030	.245±.037	Approx. 200,000 to one
78-1-2	147	2.076±.009	.189±.024	Approx. 200,000 to one
75-1-1	99	2.125±.007	.140±.024	Approx. 15,000 to one
57-1-1	34	2.163±.044	.102±.050	5 to 1
23-2-4	31	2.191±.044	.074±.050	2 to 1
46-1-3	29	2.247±.051	.018±.056	None
Parent variety	124	2.265±.023	...	
		L/PD		
55-1-1	163	1.310±.008	.178±.017	∞ to 1
78-1-1	60	1.310±.002	.178±.014	∞ to 1
72-3-1	27	1.326±.019	.162±.024	Approx. 400,000 to one
55-1-2	34	1.345±.029	.143±.032	415 to 1
78-1-3	104	1.361±.011	.127±.014	∞ to 1
C 246-1	32	1.380±.021	.108±.026	215 to 1
78-1-2	147	1.385±.009	.103±.017	Approx. 20,000 to one
23-2-4	31	1.408±.033	.080±.036	7 to 1
75-1-1	99	1.426±.012	.062±.017	65 to 1
57-1-1	34	1.430±.022	.058±.026	7 to 1
46-1-3	29	1.464±.038	.024±.041	None
Parent variety	124	1.488±.015	...	...

TABLE 5

COMPARISON OF SELECTED LINES WITH ORIGINAL PARENT VARIETY SANTA CLARA CANNER, AT RIVERSIDE, CALIFORNIA

Selected line	Number of fruits	*ED/PD*	Difference from parent variety	In random sampling, odds against such a difference are
78–1–3	34	1.64±.042	.28±.045	∞ to 1
17–1–1	53	1.70±.024	.22±.030	∞ to 1
246–1	74	1.79±.021	.13±.028	657 to 1
23–2–1	60	1.80±.027	.12±.032	78 to 1
78–1–1	120	1.81±.017	.11±.025	416 to 1
24–2–1	39	1.85±.025	.07±.031	7 to 1
23–2–3	56	1.87±.030	.05±.035	2 to 1
46–1–3	61	1.87±.040	.05±.044	1 to 1
78–1–4	56	1.89±.030	.03±.036	1 to 1
78–1–2	41	2.01±.034	.09±.038	
Parent variety	167	1.92±.018		
		L/PD		
17–1–1	26	1.23±.022	.12±.027	416 to 1
24–2–1	30	1.27±.013	.08±.020	142 to 1
246–1	35	1.28±.019	.07±.024	19 to 1
78–1–1	52	1.29±.015	.06±.021	19 to 1
Parent variety	61	1.35±.015		

The formulae used in this paper are as follows:

Standard deviation, $\sigma = \sqrt{\frac{S\ d^2\ f}{n}}$

Probable error of standard deviation, p.e $\sigma = \pm .6745\ \frac{\sigma}{\sqrt{2n}}$

Probable error of mean, p.e $M = \pm .6745\ \frac{\sigma}{\sqrt{n}}$

Probable error of difference between two means: square root of the sum of the squares of the probable errors of the two means.

The significance of the difference between two means is estimated from a table given by Pearl and Miner in Maine Agr. Exp. Sta. Bul. 226, on p. 88.

UNIFORMITY OF FRUIT SHAPE

Three measurements of type of fruit have been evaluated: weight per single fruit, ratio of equatorial diameter to polar diameter, and ratio of length to polar diameter. The standard deviations of these variables and their coefficients of variability are shown in tables 6 and 7. The different lines at Davis and at Riverside are listed in the order of their percentage of smooth fruit.

TABLE 6

STANDARD DEVIATION AND COEFFICIENT OF VARIABILITY IN SIZE AND FRUIT-SHAPE RATIOS OF SELECTED LINES GROWN AT DAVIS IN 1925

Pedigree Number	Number of fruits	Weight per fruit (grams)		*ED/PD*		*L/PD*	
		σ	C. V.	σ	C. V.	σ	C. V.
			%		%		%
55–1–2	34	106± 8.6	35.0	.181±.015	13.4	.264±.022	13.1
55–1–1	163	113± 4.2	37.2	.169±.006	12.9	.281±.010	14.7
78–1–1	60	127± 7.8	41.5	.028±.002	2.2	.164±.010	8.3
78–1–3	104	131± 6.1	38.3	.168±.008	12.3	.274±.013	13.6
78–1–2	147	119± 4.7	38.1	.164±.006	11.8	.287±.011	13.8
C 246–1	32	121±10.2	33.7	.180±.015	13.1	.269±.023	13.4
75–1–1	99	123± 5.9	36.8	.178±.008	12.5	.106±.005	5.0
57–1–1	34	91± 7.5	30.1	.193±.023	13.5	.407±.049	18.8
72–3–1	27	112±10.2	29.8	.148±.014	11.2	.303±.028	15.7
23–2–4	31	129±11.0	43.0	.278±.024	19.7	.368±.032	16.8
46–1–3	29	153±13.5	42.7	.207±.018	14.1	.406±.036	18.1
Parent variety	124	122± 5.2	38.0	.258±.011	17.4	.383±.016	16.9

With regard to weight of fruit, it seems that in general the selected lines are almost as variable as the parent variety; however, lines 24–2–1 and 78–1–1 were distinctly less variable than the parental variety at Riverside, but 78–1–1 was more variable at Davis.

As to shape, measured by ED/PD and L/PD, the smaller coefficients of variability, especially for the former ratio, indicate that in some lines the fruit was much more uniform in shape than the parent stock. Lines 78–1–1 and 24–2–1 are remarkable in this respect. The values of L/PD also suggest that many of the lines were more uniform than the original variety; 24–2–1 and 78–1–1 are again outstanding in this respect.

TABLE 7

STANDARD DEVIATION AND COEFFICIENT OF VARIABILITY IN SIZE AND FRUIT-SHAPE RATIOS OF SELECTED LINES GROWN AT RIVERSIDE IN 1925

Pedigree Number	No. of fruits	Weight per fruit, grams		No. of fruits	*ED/PD*		No. of fruits	*L/PD*	
		σ	C. V.		σ	C. V.		σ	C. V.
			%			%			%
17-1-1	53	106±6.9	34	53	.265±.017	15.6	26	.171±.016	13.9
24-2-1	47	96±7.3	27	39	.229±.018	12.4	30	.107±.009	8.4
246-1	74	116±6.4	36	74	.267±.015	14.9	35	.163±.013	12.7
23-2-1	60	81±5.0	36	60	.305±.019	17.0			
46-1-3	61	109±6.7	41	61	.460±.028	24.5			
78-1-1	120	86±3.7	31	120	.273±.012	15.1	52	.156±.010	12.1
78-1-2	78	121±9.0	43	41	.322±.024	16.0			
78-1-4	56	114±7.2	44	56	.342±.022	18.1			
78-1-3	34	116±9.5	41	34	.359±.030	21.8			
Parent variety	167	120±4.4	39	167	.348±.013	18.2	61	.175±.011	13.0

COMPOSITION OF THE SELECTED LINES

The value of tomatoes to the canner and to the manufacturer of tomato products depends in part on the composition. High percentage of solids, especially of soluble solids, is considered desirable. It is intended to follow these factors closely in the further study of our selected lines. A single series of determinations was made on eight lines at Davis late in the season of 1925. The results are shown in table 8.

The procedure was to take a random sample of 20 fruits, from which longitudinal segments were cut to make a sample of 500 grams. The sample was chopped fine with a knife, transferred to a 1000 cc. volumetric flask, distilled water added and after shaking well, made up to volume and allowed to stand one day, toluol being added to prevent fermentation. The extract was then filtered off. Aliquots of this solution were used for the determination of soluble solids by evaporation to dryness at 65° C., and total acidity by titration, using the indicator phenolpthalein. The insoluble residue was collected on a tared filter paper and dried at 65° C.

The total solids varied from 4 to nearly 6 per cent of the fresh weight. It is of especial interest that line 78-1-1, a selected line which ranked among the best in smoothness of fruit, also had the highest total solids.

TABLE 8

COMPOSITION OF TOMATOES AT DAVIS, CALIFORNIA, NOV. 3, 1925

Pedigree Number	Per cent of total solids	Per cent of total solids soluble in water
78-1-1	5.920	71.1
Santa Clara Canner	5.043	64.8
75-1-1	5.000	64.0
Morse Canner	4.955	66.3
78-1-2	4.910	64.6
55-1-1	4.784	62.4
78-1-3	4.850	68.3
57-10	4.049	62.4

With regard to soluble solids, important differences seem to exist. Several of the lines have a higher content of soluble solids than the original Santa Clara Canner. It has been shown by Rosa[11] that this factor is also much affected by the maturity of the fruit, soluble solids increasing during the ripening process. It appears that the content of soluble solids may also vary among lines selected within one variety, in fruit of the same stage of maturity.

It has been stated that the fruit of Santa Clara Canner and some of the selections have very thick walls and small cells. To determine how these characteristics would influence yield of seed, a careful extraction of seed was made from fruit of four promising lines. Table 9 gives the result of this experiment.

TABLE 9

YIELD OF SEED IN TOMATO VARIETIES AND SELECTED LINES

Variety	Weight of fruit	Weight of seed	Pounds of seed per ton of fruit
75-1-1	46 lbs.	24.3 grams	2.34
78-1-2	50 lbs.	35.3 grams	3.11
55-1-1	90 lbs.	82.9 grams	4.07
57-10	41 lbs.	41.3 grams	4.48
Santa Clara Canner	15.9 tons	106 lbs.	6.63
Norton	14.3 tons	171 lbs.	11.96
Earliana	4.8 tons	58 lbs.	12.08
Stone	7.1 tons	102 lbs.	14.34

It is seen that the yield of seed in the four selected strains is lower than in Santa Clara Canner.*

* We are indebted to Mr. Walter H. Nixon, of the Morse Seed Company, for the data on yield of seed in the four commercial varieties. These data were obtained from the first and second pickings of fruit at San Carlos, California, in September and October, 1925.

RESISTANCE TO FUSARIUM WILT

In 1923 field trials by Lesley and Shapovalov[7] showed that Santa Clara Canner is fairly resistant to *Fusarium* wilt but is probably not as productive as Norton in severely infested soil. In 1925, in collaboration with Mr. Shapovalov, trials were carried out with the selected lines in two localities. At La Mesa, California, the field used for trial was known to be heavily infested with *Fusarium lycopersici.* The results are shown in table 10. The variety Stone, which was planted as a check, was attacked severely and even Norton was affected considerably. The 7 selected lines from Santa Clara Canner planted in this trial showed wide differences in reaction to the disease. Compared with the very resistant Norton, it appears that some lines such as 78–1–3 and 78–1–4 are about equally resistant, but others such as 23–2–3 and 72–2–1 are more susceptible.

TABLE 10

RESITANCE TO FUSARIUM OF VARIETIES AND SELECTED LINES AT LA MESA AND AT RIVERSIDE, CALIFORNIA, IN 1925

Pedigree Number	La Mesa			Riverside			
	Number of plants	Slightly affected, per cent	Severely affected or died of wilt, per cent	Number of plants	Apparently healthy, per cent	Slightly affected, per cent	Severely affected or died of wilt, per cent
23–2–1	13	62	38				
23–2–3	12	25	75				
56–1–1				10	20	60	20
72–2–1	13		100				
78–1–2	19	47	53				
78–1–3	19	74	26				
78–1–4	14	64	36				
80A–3–2	11	64	36				
Santa Clara Canner				11	45	55	
Norton	26	69	31				
Stone	27	....	100	15		27	73

The other trial was carried out at Riverside in soil which was not previously infested but each plant was inoculated at transplanting time with a pure culture of *Fusarium lycopersici.* Unfortunately the number of plants which could be recorded was much reduced by an epidemic of western yellow blight which affected all the plots. The plants which escaped the blight were not so severely affected by the wilt as plants of the same line at La Mesa. As previous trial has shown, Santa Clara is much more resistant to *Fusarium* wilt than Stone. In some lines much of the resistance of the parental variety has been lost but in other lines, including some of the smoothest in fruit shape, resistance is increased. These differences provide further evidence of the heterogeneous nature of the parent variety.

SUMMARY

A number of lines have been isolated by single plant selection from the tomato variety Santa Clara Canner, which differ from the parental variety in shape and size of fruit, season of maturity, and in other characteristics. The selected lines differ from the parent variety in the proportion of fruits showing certain defects of shape which are prevalent in the Santa Clara Canner, notably roughness at the stylar and stem ends. In addition to estimation by eye, two ratios obtained by measuring individual fruits proved useful in measuring smoothness and shape. Several selected lines are smoother and less variable in shape than the parental variety. In resistance to *Fusarium* wilt, some of the lines were inferior, others equal and a few apparently superior to the parent variety. It must be concluded that Santa Clara Canner is a highly heterogenous variety and that by single plant selection, a number of very distinct lines have been isolated.

Compared with the parent type, some of the selected lines appear to be superior as canning tomatoes, in fruit shape and in content of total solids while at least equal to it in size, fewness of seed, interior characteristics and resistance to *Fusarium* wilt.

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