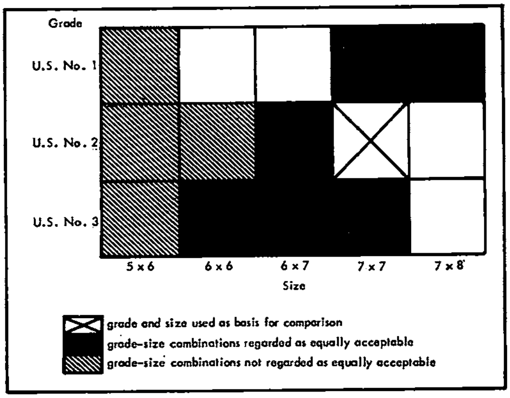

Figure 4.—The ability of consumers to discriminate between Florida tomatoes, using the U.S. No. 2 size 7 x 7 as the basis for comparison.

grade standards used in marketing the Florida tomato crop are more rigorous and represent divisions with respect to both grade and size that are finer than the discriminatory powers of the consumer. Within this generalization of the results, it appears relevant to point out that consumers are somewhat more discriminatory with respect to both grade and size in tomatoes when large sizes are involved than is the case when small sizes are involved. That is, the results indicate that they more quickly discern either grade or size variations when they are making a buying decision involving large tomatoes than they do when they are making a decision involving small ones.

The standards currently employed in marketing the tomato crop are designed primarily to facilitate trading. Presumably, both demand and operational considerations are reflected in the system of differentiation which the standards provide. This study shows that consumers do not discriminate between all current grades and sizes of tomatoes. It does not take into account the operational problems and loss rates involved in handling tomatoes of varying size and quality in the distribution process. However, casual observation of the marketing system indicates that these considerations fail to support the need for the existing number of grade and size categories. If the current system cannot be justified on the basis of operational difficulties and loss rates, there is some question as to the real need for the number of grade and size designations that are currently used in marketing the tomato crop. It may well be that the industry in Florida could effect substantial economies by a re-examination of grading and sizing procedures to the end of developing standards that would simplify the packing and trading problem and, at the same time, conform more closely to the ability of consumers to discern differences in the product.

INHERITED FRUIT CRACKING RESISTANCE IN THE TOMATO

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Fruit cracking is a major cause for the downgrading of tomato crops even though this condition can be controlled to some extent by cultural methods. Losses are particularly high when the fruit is harvested in the "pink" or later stages of maturity.

The literature on tomato fruit cracking has been reviewed by Reynard (2), Johnstone (1) and Young (3). The evidence indicates that the fruit cracking tendencies of a variety or line are inherited. Reynard (1) and Young (4) each suggested a two-gene pair mode of inheritance for radial crack resistance, even though different parental lines were used in crosses studied. There is no literature suggesting the genetic pattern involved in other types of cracking.

The purpose of this study is to give a better understanding of fruit cracking, with emphasis on the patterns of inheritance of resistance. The ultimate goal is to provide information that will permit rapid incorporation of cracking resistance into otherwise suitable horticultural lines.

Materials and Methods

In this study the three distinct types of cracks that have been recognized are: (1) radial cracks on the stem end of the fruit extending distally from the corky layer at the end of attachment of the fruit and pedicel; (2) concentric cracks which occur as arcs or cir-

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cles on the stem end of the fruit; and (3) bursts in the sidewalls usually on the blossom-scar half of the fruit. Concentric cracks may be either well defined, such as commonly found in the Earliana variety; or milder, as in Marglobe variety; or as very shallow, scattered cracks which affect only the epidermis. It has been necessary to study the three major types of cracking separately, since there appear to be different patterns of genetic control in each case.

The parental plant material of crosses reported in this paper consisted of selected lines of Alabama 10-1, Marglobe and Burgess Crackproof. The Alabama 10-1 line is characterized by a semi-determinate type of plant habit, rather weak vegetative growth, compound inflorescences, five or more fruits per cluster, uniform unripe fruit color (u allele), pink ripe fruits of rather small size, and an average of about three locules per fruit. The Marglobe line has an indeterminate type of plant, rather heavy vegetative growth, simple raceme inflorescences, three to five fruits per cluster, dark green shouldered unripe fruit color, red ripe fruits of medium size and an average of more than five locules per fruit. The Crackproof line, a selection from Burgess Crackproof, has an indeterminate type of plant, rather heavy vegetative growth, simple raceme inflorescences, three to five fruits per cluster, uniform unripe fruit color (ug allele), somewhat flattened red ripe fruits of medium size and an average of about six locules per fruit. The parental lines, two or more successive generations, and backcrosses to the F_1 were studied. The plants were grown in the spring and fall of 1959, and the spring of 1960. The plants were grown on moderately fertilized plots and were pruned to two stems and staked. Withholding of irrigation water during dry periods resulted in adequate cracking for study. It has been difficult to study cracking unless a large incidence of cracking is present in a susceptible test variety. Under conditions favoring little cracking it has been almost impossible to determine the relative resistance of various lines.

Cracking data, as well as records on other horticultural characters, both quantitatively and qualitatively inherited, were taken on fruit as they ripened. An average of 25 fruit was recorded from each individual plant. In all cases individual plant averages were used to obtain averages for the various generations.

In the case of radial cracking, the three measurements used were: (1) average number of cracks per fruit; (2) percentage of fruit with cracks; and (3) an index of cracking. Index numbers were assigned on the basis of the actual length and greatest depth of each crack on each fruit and are shown in Table 1. These index numbers were totaled, the totals were averaged to obtain a plant mean, for all the fruit of a plant and the plant means were averaged to obtain the generation mean.

Table 1. Radial crack index arbitrarily established from length and depth measurements of the cracks.

Radial Crack Length in Millimeters	Radial Crack Index Numbers for Depth of Radial Cracks as Indicated			
	Very Shallow under 0.25 mm *	Shallow 0.25 to 1 mm	Deep 1-2 mm	Very Deep over 2 mm
1-10	1	8	15	22
11-20	2	9	16	23
21-30	3	10	17	24
31-40	4	11	18	25
41-50	5	12	19	26
51-60	6	13	20	27
Over 60	7	14	21	28

* Epidermis cracked only.

Table 2. Three seasons' data on radial cracking in an Alabama 10-1 x Marglobe cross.

	No. of plants	Ave. no. of cracks per fruit	Crack index	Percent of fruits with cracks
		SPRING, 1959		
Alabama 10-1	20	0.39	4.76	20.9
Marglobe	20	4.00	58.62	96.7
F1	20	2.18	31.70	72.5
F2	100	3.15	32.60	72.5
BX to Ala. 10-1	20	1.07	13.41	51.6
BX to Marglobe	20	3.28	38.85	92.3
		FALL, 1959		
Alabama 10-1	20	0.76	9.06	42.0
Marglobe	20	4.09	53.67	98.8
F1	20	2.29	30.09	80.3
F2	100	2.91	29.25	90.9
BX to Ala. 10-1	20	1.98	22.92	75.7
BX to Marglobe	20	3.07	37.92	89.2
		SPRING, 1960		
Alabama 10-1	20	1.12	12.59	57.2
Marglobe	20	5.21	69.52	100.0
F1	20	3.40	32.08	98.7
F2	100	2.68	29.45	86.2
BX to Ala. 10-1	20	1.31	16.18	45.3
BX to Marglobe	20	2.95	35.83	90.8
		THREE SEASON AVERAGE		
Alabama 10-1	60	0.75	8.80	40.0
Marglobe	60	4.43	60.60	98.5
F1	60	2.62	31.29	83.8
F2	300	2.91	30.43	83.2
BX to Ala. 10-1	60	1.45	17.50	57.5
BX to Marglobe	60	3.10	37.53	90.7

Locule numbers and diameters were also the average of all the fruits observed during the harvest periods.

Results and Discussion

In an Alabama 10-1 x Marglobe cross, the generations maintained their relative position in each of the three seasons. (Table 2.) The differences between the two parental lines are more nearly expressed by the crack index than by the other measurements. When the susceptible parent exhibited a maximum of cracking expression, as in each of the three seasons, a clear distinction was seen between the parental and the hybrid populations.

Young (4) suggested that radial cracking was determined by two major gene pairs. The 1959-1960 work conducted at Quincy, Florida (Table 3) gave results quite similar to the 1951-1953 study conducted in Ohio with the same Alabama 10-1 x Marglobe cross. In fact the 1959-1960 results supported the earlier hypothesis. Results indicate that radial crack

Table 3. Number of plants falling into each of the radial crack index class groups as compared with expected number of plants using a two-gene pair hypothesis.

Generation	Crack index class group	No. of plants expected each season	Observed no. of plants: Spring 1959	Fall 1959	Spring 1960
P_1	4-22	20	20	20	20
	31-112	0	0	0	0
P_2	4-22	0	0	0	0
	31-112	20	20	20	20
F_1	4-22	20-0	9	8	4
	31-112	0-20	11	12	16
F_2	4-22	68-43	41	45	49
	31-112	31-56	59	55	51
BX to P_1	4-22	15-20	20	13	17
	31-112	0-5	0	7	3
BX to P_2	4-22	5-0	2	1	4
	31-112	15-20	18	19	16

Table 4. Radial cracking of 20-plant F_3 populations from selfed F_2 plants selected at random.

	F2 plant Mean			F3 population Mean		
Line No.	Ave. no. radial cracks per fruit	% fruits with radial cracks	Index	Ave. No. radial cracks per fruit	% fruits with radial cracks	Index
1	1.79	70.0	12.9	1.33	55.0	12.9
2	4.32	100.0	49.7	3.66	88.6	56.4
3	1.04	46.0	6.7	1.02	46.4	8.9
4	4.38	100.0	47.1	3.65	89.8	47.5
5	1.16	56.0	10.8	1.25	53.2	11.8
6	1.50	55.0	18.8	1.85	58.7	20.3
7	1.87	67.0	14.2	1.31	52.6	14.5
8	2.12	71.0	19.1	2.10	65.4	26.3
9	1.82	89.0	24.3	2.47	76.4	34.5
10	2.38	84.0	25.6	2.16	67.2	27.5

resistance, as found in the cross studied, was recessive.

Results of F_3 population averages (Table 4) illustrated the averages that might be expected from seed of selfed F_2 plants. It can be seen that the percentage of cracked fruit does not give a clear picture of cracking severity; however, the index clearly separates the various lines.

Selection in the segregating progenies of a Crackproof x Alabama 10-1 cross illustrates what might be expected from a cross between two resistant lines (Table 5). Although selection has resulted in less cracking with the locule number and diameter increased to some degree these lines possess certain undesirable horticultural characters. Nevertheless, these lines may prove valuable for recovering crack resistance in crosses with standard varieties. Reynard (2) has isolated lines from Crack-

Table 5. Radial Cracking. Results of selection in the segregating populations of a Crackproof x Alabama 10-1 cross for radial-crack resistance, number of locules and diameter.

Generation	Ave. no. of radial cracks per fruit	Index	Locule average	Diameter
F_3	0.91	9.46	3.73	6.85
F_4	0.49	4.54	4.26	5.84
F_6	0.18	2.31	5.08	6.85

Table 6. F_3 radial crack index data from Alabama 10-1 x Marglobe cross illustrating linkage relationship of radial cracking resistance.

	Radial crack index averages for plants with the following characters segregating			
	Plant habit		Ripe fruit color	
F_3 line No.	Indet.	Det.	Red	Pink
10	14.53	10.27	14.54	10.89
11	-	-	26.67	21.15
14	-	-	16.71	5.37
15	17.32	12.07	16.13	10.46
19	24.95	12.38	-	-
20	-	-	29.66	26.64

proof crosses which have a high degree of radial crack resistance.

To illustrate further the possibility of selection in a resistant x susceptible cross, selected F_3 data (Table 6) illustrates the associations found when selecting for growth habit and ripe fruit color in the Alabama 10-1 x Marglobe cross. From accumulated data, mostly from this cross, it is suggested that genes for resistance to radial cracking are found on the same chromosome as those for plant growth habit (sp) and ripe fruit color (y). Resistance is recessive and in Alabama 10-1 is linked with determine plant habit and pink fruit color. However, there may be lines available which have resistance linked to indeterminate plant habit and red fruit color.

Concentric Cracking. Most of the work to date has been done with a mild type of cracking as found in Marglobe. Three seasons' data with the Alabama 10-1 x Marglobe cross (Table 7) illustrates the relative susceptibilities of the parental lines and segregating populations. Analysis of the data failed to suggest a genetic hypothesis.

Table 7. Three seasons' data on mild concentric cracks in an Alabama 10-1 x Marglobe cross.

	No. of plants	% of fruit with concentric cracks	No. of plants in each cracking group	
			0–35%	36–80%
Alabama 10-1	60	12.9	58	2
Marglobe	60	26.3	44	16
F_1	60	28.3	42	18
F_2	300	31.7	188	112
BX to Alabama 10-1	60	20.8	48	12
BX to Marglobe	60	25.0	46	14

It is believed that failure to establish precise genetic relationship was due to the failure to separate epidermal cracks from deeper and longer cracks. Data are being accumulated which will separate these two types of cracks. Unexplained is the tendency for some F_1's to show more severe concentric cracking than either parent.

Data are not shown for the more severe type of concentric cracking as exhibited by Earliana. However, of 15 crosses with Earliana, 13 of the F_1's exhibited cracking as severe as Earliana.

Bursting. Young (3) in a study of Alabama 10-1 x Marglobe suggested that one gene pair with major effect and one with minor effect were present. The present data (Table 8) generally fit the hypothesis, however, the previous hypothesis could not be used per se.

Table 8. Three seasons' data on bursting in an Alabama 10-1 x Marglobe cross.

	No. of plants	% of fruit with bursts
Alabama 10-1	60	13.5
Marglobe	60	3.2
F_1	60	9.9
F_2	300	11.0
BX to Alabama 10-1	60	9.8
BX to Marglobe	60	5.1

Marglobe, like many other commercial varieties, apparently possesses a high degree of resistance to bursting. Nevertheless, in introductions and certain breeding materials bursting may be a severe problem. Alabama 10-1 usually exhibits at least four to five times the number of fruits with bursts as Marglobe. This tendency appears to be inherited. Although data is not shown, linkage analysis indicates that genes controlling bursting may be associated with both unripe fruit color and ripe fruit color. This information is of value in cracking studies because bursting susceptibility may be partially linked with both concentric and radial cracking.

General Discussion

The results of these studies have indicated that to clarify study of genetically controlled cracking it will be necessary to obtain data which separate the types of cracking into radial, concentric and bursting. Furthermore, the depth and length of the cracks and their time of occurrence is important because some advanced breeding lines possess a large degree of crack resistance in the mature green stage yet crack considerably in the pink or red ripe stage.

It is imperative to grow the plants in an environment where a maximum of cracking is exhibited to provide marked differences between resistant and susceptible lines. Pruning and moisture control have provided suitable conditions.

Space does not permit the inclusion of linkage data which strengthens the hypothesis that concentric and bursting are genetically controlled; however, further work with additional cracking categories will be needed to clarify the situation.

To determine linkage relationships, data on as many other horticultural characters as feasible would be needed.

SUMMARY

The three distinct types of cracking observed in this study were radial, concentric and bursting.

Crosses were made between Alabama 10-1 and both Marglobe and Crackproof and tested at Quincy, Florida, in the spring and fall of 1959 and the spring of 1960.

Conditions for cracking were favorable during all three seasons. Cracking data, as well as records on other horticultural characters, were taken on all fruit ripening during the harvest period.

Data appear to support the contention that radial cracking resistance is controlled by two major pairs of recessive independent genes; and associated with plant habit and ripe fruit color.

The concentric cracking data to date, although indicating a genetic control, does not fit a precise genetic hypothesis.

The data confirm that the tendency to bursting is inherited.

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ARTIFICIALLY CURING FLORIDA ONIONS

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At the present time, dry onions are not commercially produced in Florida. Varieties are available that will bulb under short-day conditions which prevail at this location. The type of onions which can be grown in the South is relatively mild, and generally of rather poor keeping quality. In view of this fact, plus the cost of production, storage facilities and atmospheric conditions which are encountered in this location, it is questionable whether the storage of this product would be economically feasible.

Indications are that dry onions can now be economically and successfully grown in this state. By the use of adaptable varieties, yields up to 1,200 50-pound bags per acre have been attained. Areas which produce onions in direct competition to those which could be grown here have average yields of about 135 and 280 50-pound bags per acre for the early and late spring crop. It is to be assumed that our production costs would be somewhat higher than competing areas but this could be offset by increased yields.

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The price level for spring onions has fluctuated considerably during the past ten years due to weather conditions – both during production and harvest – supply of onions remaining in storage from Northern States and volume of foreign import shipments of new onions. One of the limiting factors which has restricted Florida in onion production in the past has been the uncertainty of weather conditions during the harvesting operation.

The normal and preferred practice is to field-cure onions for several days during which time the necks dry out and roots are sloughed off. A heavy shipment of onions generally results when conditions are conducive to field curing. Conversely, inclement weather causes a cessation of harvest and generally results in an increase in the price of onions due to short supply.

The establishment of an economic method for artificially curing onions would alleviate a short supply caused by inclement weather and would thus allow Florida growers to compete with other areas producing spring onions.

Another factor in favor of growing onions in Florida is the possibility of increased sales of other vegetables. Buyers which now purchase vegetables in mixed carload lots must go to other areas to purchase onions. Consequently they complete their loads with other vegetables produced in the same area. Geographically, buyers would prefer to load in Florida if the produce was available.