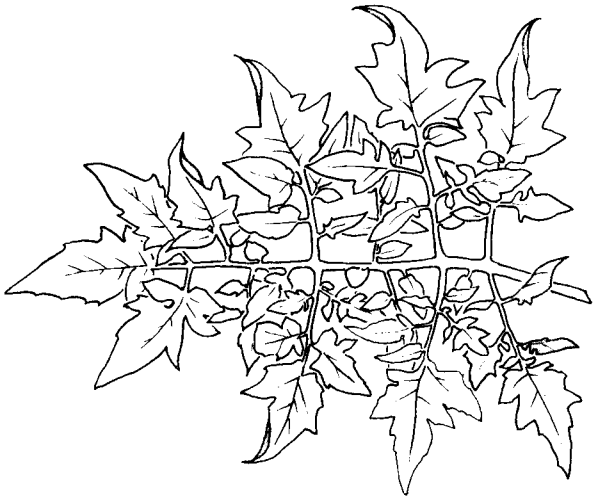
REPORT
of the
TOMATO GENETICS
COOPERATIVE



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DEPARTMENT OF VEGETABLE CROPS
UNIVERSITY OF CALIFORNIA
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FOREWORD

The Tomato Genetics Cooperative is a group of workers who have a common interest in tomato genetics and who are organized informally for the purpose of exchanging information and stocks. Participation is voluntary, and costs of activities are met by assessments to members.

The year 1965 witnessed further growth of the TGC. Membership increased from 285 to an even 300 at January 1, 1966, including 132 (44%) in 38 foreign countries. At that time our financial balance stood at $279.77.

The regular annual meeting was held under the auspices of AIBS at Purdue University on August 16, 1965. Minutes appear on the next page. Arrangements are being made currently for the 1966 meeting at the AIBS sessions in College Park, Maryland.

We report with deep regret that the TGC lost two of its stalwart charter members in 1965. Dr. J. A. Jenkins, who pioneered research on the origin of the cultivated tomato and on the developmental genetics of leaf form, passed away September 15, 1965. The status of Jim's research on the leaf-shape mutants is summarized, and a list of his stocks presented in this Report. Dr. P. A. Young, who was prominent in early linkage investigations and bred new varieties adapted to lower U.S. latitudes, resigned from membership because he has recently removed from tomato research. Both served on various committees and were otherwise prominent in TGC affairs. Both will long be remembered for these contributions and for their resolute, independent thinking.

Another unpleasant duty is to report action taken to increase the annual assessment from $.75 to $1.00 and the price of backnumbers from $1.00 to $1.50 each. As outlined in the minutes of the Purdue meeting, this series of changes--the second since the TGC was organized in 1949--was dictated by the declining trend of our yearly balances.

Special features of this Report are the Report on the New Mutant Program and Summaries of the Committee on Varietal Pedigrees. The former summarizes progress during the first two years of operation. The latter, a sequel to a Report issued in TGC 11, presents the pedigrees of many additional, important tomato introductions.

We take special pleasure in acknowledging the faithful help of the following workers in preparing TGC 16. Dora Hunt, veritably our Editor and Executive Secretary, assembled the bibliography, took charge of the membership list, prepared the financial statement, and edited all copy for TGC 16. She additionally took charge of membership arrangements throughout the year. Credit for the excellent job of typing the stencils goes again to Betty Bell. Many others, including graduate students and colleagues, assisted with assembling the Report and with other details.

Five hundred copies of this Report have been issued.

Minutes of the Urbana Meeting

August 16, 1965

The regular annual meeting of the TGC was held at 4:30 p.m., Monday, August 16, in Room E, Law Building, University of Illinois, in conjunction with the AIBS meetings. Sixteen members of TGC were in attendance.

The financial condition of TGC was reported in some detail from information supplied by C. M. Rick. The balance on August 1, 1965 was $197.21 with a membership of 281. This compares with a balance of approximately $300 on August 1, 1964. Increased size of the report, increased mailing costs, and the probable income for TGC were discussed with the conclusion that an increase in dues was necessary to maintain solvency.

It was moved and seconded that the annual dues be raised to $1.00 per year, with $1.50 per year for backnumbers. The motion passed without dissent. There was voiced an expression of appreciation to Dr. Rick, and to the Department of Vegetable Crops, University of California, for obvious time and effort expended without monetary compensation.

It was reported that the tomato gene list is in the process of being assembled for publication in the Journal of Heredity by Carl Clayberg and that the latest linkage map will be included by consent of all concerned.

It was noted that TGC 16 probably will include a report by the committee on varietal pedigrees headed by T. O. Graham.

The fact that the demand for backnumbers of TGC had diminished somewhat was reported with the comment that enough copies are on hand to meet most of the requests anticipated in the next year or two. A large number of extra copies of the last five TGC reports are available.

There was a brief discussion of the isogenic stock program suggested by L. A. Darby in TGC 15. A committee had been appointed to examine the proposal and to make recommendations to TGC. The deliberations of the committee were reported briefly, but no formal committee report was given. It was reported that Kerr and Darby had conferred in England this summer but that the results of these discussions were not yet available. R. W. Robinson expressed the feeling that the selection of one or two specific recurrent parents might not be desirable.

The fact that additional mutants in the new mutant program would be received for distribution from Dr. Verkerk and that Dr. Verkerk would take over the mutant categories relinquished by Dr. Bell of Penn State was reported.

The meeting adjourned at 5:15 p.m.

M. L. Tomes, Secretary, pro tem.

NEW MUTANT PROGRAM

Since the New Mutant Program has been in effect for two years, it is appropriate to make the following brief report on the activities of volunteer cooperators. Seeds of 110 mutants induced by radiation and EI were received from Dr. Kay Verkerk and Ir. G. J. Hildering of the University of Agriculture, Wageningen, The Netherlands. These were classified in 19 arbitrary phenotypic groups and distributed to eight cooperators. The purposes of the program are to compare the mutants and make allele tests with other genes of similar phenotype; to name, symbolize, and describe the distinguishable mutants; and to carry out linkage tests or other research of interest to the cooperator. As with any such volunteer program, the progress that is realized will depend on such factors as incentive, interest, and free time of the volunteer. Considering these and other factors, we can be pleased with the results of this initial effort and anticipate that in the next biennium the program will expand and its objectives become better crystallized. Opportunity still exists in the program for participation of more cooperators. Inquiries concerning this and any other aspects of the program are welcomed by its acting coordinator, C. M. Rick.

In the following report summaries are classified according to mutant categories.

Group No.	Type	Cooperator	Report
1	Anthocyanin modifiers	Penny Knowles	The three anthocyanin deficiencies referred to me proved to be allelic with previously described genes. Research Note in this Report.
2	Chloro. defic.: whitish	Unassigned	
3	Chloro. defic.: yellowish	R. G. Creech	Progress was made on the following aspects: a. Seed increase was made in the greenhouse in 1964 for all stocks. b. The phenotypes for all mutants were observed and recorded in the field in 1965. c. Allele test crosses are being made in the greenhouse this spring.
4	Chloro. defic.: light green		
5	Chloro. defic.: yellow-green		
10	Leaf form		

Group No.	Type	Cooperator	Report
6	Chloro. defic.: virescent	K. Verkerk	This group was originally assigned to Dr. W. D. Bell, but a change in the direction of his research required him to relinquish it. The groups were recently reassigned to Dr. K. Verkerk.
7	Chloro. defic.: variegated		
8	Necrotic		
9	Hair modifications	Unassigned	
11	Plant habit	R. W. Robinson	Two of Verkerk's genes, 377-20aa and 242, are closely linked with ah, hence are almost certainly distinct from any previously named gene. I've crossed the Verkerk mutants in my groups with mutants of similar phenotypes; results should be available next summer. Fifteen additional mutants, very distinct in phenotype from any named gene, deserve symbols.
13	Modifications of inflorescence		
12	Flower form and color	F. Angell	Assignment made in Nov., 1966.
17	Disease resistance		
14	Sterility	A. Andrasfalvy	No mutants yet received.
15	Fruit form	B. Bergh	Two mutants received in spring, 1965.
16	Fruit color	M. L. Tomes	Three mutants received in 1964; pigment analyses reported in TGC 15:61-62. Analyses of two additional mutants received in 1965 reported in a separate Research Note in this Report.
18	Physiological characters	Unassigned	
19	Miscellaneous	Unassigned	

PART I

RESEARCH NOTES

Bohn, G. W., and G. A. Sanderson
Grafting improved pau seed yields.

Seeds were difficult to obtain from plants with the pau marker because the genetically depauperate plants grew poorly in the greenhouse and died in the field. We improved growth and obtained a few good seeds by grafting pau cions (whip and tongue) onto normal stocks. Depauperate cions grew better on stocks with considerable normal foliage than on severely pruned stocks. Normal cions remained alive but failed to grow on depauperate stocks. [Photos are available].

Boynton, John E. A search for biochemical mutants in the tomato.

The present study was initiated in 1961 with the hypothesis that among the many mutants described in the tomato (see gene lists, TGC 4, 9, 12, 15) some might represent simple metabolic blocks that could be corrected by supplying an exogenous source of the blocked compound. During the last 20 years many such biochemical mutants have been found in mutagenic experiments with Neurospora, bacteria and a number of other lower organisms. It was felt that if biochemical mutants should be found among the many chlorophyll-deficient and other morphologically distinct tomato mutant types, these would be unusually favorable material for learning more about the way in which genes control the complex processes of differentiation.

For the initial screening, a collection of 25 spontaneous and induced mutants were selected, all of which had distinct phenotypes strongly manifested in the first 3 weeks following germination. Nineteen could be classified as semi-vital chlorophyll-deficient types with varying patterns of white to yellow-green pigmentation and growth rates of 10 to 50% of normal (mutants dv, rv, wv, yv, t^v, au_1, gh, ten_1, ven_1, ph, afl, deb_1, inv_1, Xa/+, exl_1, plus 4 unnamed albino accessions). Three mutants, Cri_1, neg_1, and m_1, produced variously shaped patches of necrotic tissue on an otherwise normally pigmented background and grew at sub-normal rates. Two mutants, Fw and pr, with strongly modified patterns of epicotyl differentiation that resulted in greatly thickened and laterally unexpanded laminae, produced plants of weak and distorted stature but with normal pigmentation. An unnamed diminutive mutant, which grows at about 10% of normal rate, produced an otherwise normal phenotype.

Three replicates of 5 plants per mutant and 5 plants of normal genotype (Marglobe--homozygous for the normal alleles of all the mutants tested) were grown on washed quartz sand in 4-inch plastic pots watered as needed with standard Hoagland's solution. Each replicate was treated 3 times weekly with one of the following which was applied to the sand along with the Hoagland's solution: total amino acid solution, total vitamin solution, or distilled water. All plants were grown under natural daylight in a heated and air-conditioned greenhouse with a 65° F night and 75° F day temperature. The total amino acid solution was composed of a 0.002 Molar solution in distilled water of either the DL or L form of each of the 21 naturally

occurring amino acids. The total vitamin solution contained the following 17 vitamins each at a concentration of 20 ppm: vitamin A acetate, vitamin B_{12}, vitamin D, d-alpha tocopheryl acetate and folic acid--fat soluble compounds that were dissolved in a small quantity of ethyl acetate prior to mixing in the aqueous solution; thiamine (B_1), riboflavin (B_2), panthothenic acid (B_3), niacin (B_5), pyridoxine HCl (B_6), inositol, p-amino benzoic acid, menadione sodium bisulfite (K), choline chloride, biotin and ascorbic acid (C)--water soluble compounds that were dissolved directly in distilled water. All chemicals were obtained from Nutritional Biochemicals, Cleveland, Ohio. Solutions were stored in the dark at 4° C for the duration of the experiment. Treatments were continued for six weeks during which weekly visual comparisons were made between plants of each mutant treated with total amino acids, total vitamins, or distilled water; and the treated mutants were compared with the normal genotype grown on the three regimes.

One radiation-induced mutant, ten_1, from Stubbe's Group I, showed a significant growth response to the total vitamin solution from the second week of treatment. By the termination of the experiments 6 weeks later, plants of ten_1 in the vitamin treated replicate were about 4 times larger and of darker green color than the untreated and amino acid treated cultures. No other responses were detected among the 24 mutants tested. Replicated cultures of the mutant ten_1, prepared in the manner previously described, were then treated in a similar fashion with individual 20 ppm solutions of the 17 vitamins that comprised the total vitamin solution. Plants of the mutant ten_1 treated with vitamin B_1 (thiamine) gave the same significant growth response that was observed when this mutant was treated with total vitamin solution. None of the other 16 individual vitamin treatments gave any detectable growth or pigment response.

Since subsidary experiments have shown that the elaborate sand culture techniques of our first experiment were unnecessary, all subsequent plantings have been made on a standardized soil mixture in either 4-inch plastic pots or in shallow wooden flats. Thiamine, or other related compounds, is then applied to the leaves of mutant plants as a foliar spray to the point of run-off by means of small atomizers (DeVilbiss #15).

While our initial study was in its infancy, Langridge and Brock reported a thiamine-requiring tomato mutant, of spontaneous origin, with a striking chlorophyll phenotype that could be entirely corrected by treatment with foliar sprays of thiamine or of appropriate thiamine precursors (Australian J. Biol. Sci. 14:66, 1961). They have kindly provided seeds of their seedling-lethal mutant, tl, for further study.

In 1964, a second group of 57 chlorophyll-deficient tomato mutants was screened specifically for thiamine deficiencies. Twenty of the mutants have been described in the gene lists of TGC 15 and earlier: cla_1, ful_1^1, ful_1^2, var_1, cn_1, dis_1, ru_1, tab_1, mu_1, si_1, spa_1, sy, nv, spl_1, res_1, ga_1, era_1, vga_1, pl_1, and a new accession, citrine. Thirty-seven were chlorophyll-deficient selections from the new mutant program started with accessions from Hildering and Verkerk (TGC 14). One mutant, spa_1, (Stubbe III) proved to be a thiamine-requiring mutant.

Genetic tests have shown that the thiamine mutants ten_1, tl, and spa_1 are not allelic and are located on chromosomes 10, 6, and 8, respectively. Studies

of the physiology of these mutants, the location of the gene blocks in the biosynthesis of thiamine in them, and the effect of thiamine on the development of normal chloroplast ultrastructure will be published elsewhere.

Clayberg, C. D. Further data on the aw-ms_{15} linkage.

As described in TGC 15, no aw-ms_{15} recombinants were recovered in a repulsion F_2 of 413 plants in 1964. Consequently, in 1965 small F_3 families were grown from each of the 119 F_2 aw segregants. One of these families segregated for aw and thus was discarded. Among the rest only two families were segregating for ms_{15}. The following data were used to estimate the crossover value, using the method of Rick (TGC 10:33).

Family size	Segregating families	Non-segregating families	P for ms detection	Effective number non-segregating families
9		3	0.925	2.8
10	1	5	0.944	4.7
11	1	27	0.958	25.9
12		81	0.968	78.4
Total	2	116		111.8

The crossover value (p) can be calculated from the following formulas: $q^2 = 0.9833$ and $2pq = 0.01759$. The values obtained, 0.84 and 0.89, agree well with each other and with the F_2 value of 1.3% previously calculated. They further suggest that even though the F_2 value obtained for the aw-d_1 interval was low (TGC 15:29), the aw-ms_{15} interval is probably more accurately represented as 1 crossover unit, rather than 3 units. Thus aw should be highly effective in identifying ms_{15} segregants in the transfer of the latter into parental stocks of F_1 hybrids. This male sterile is quite satisfactory for hand pollination, as the stigma is well exserted. Limited amounts of ++/aw-ms_{15} seed are available.

Contant, R. B. Bench performance of short internode lines.

Our radiobiological studies require the growing to maturity of 2000-3000 irradiated tomato plants per experiment and the testing of their progeny for segregating mutants in the seedling stage. The normal spacing of about 50 sq cm per plant is extremely costly in greenhouses and prohibitive in growth chamber culture which is often required. As a substitute for Money Maker we have therefore searched for early, vigorous dwarf types with good fruiting and seed set under local greenhouse conditions and also in early and late season culture.

Ten lines, obtained from Dr. N. Kedar, contain the gene(s) br, cv, fru^{hem}, glo, d_1, bu, bu d_1, sd?, another unidentified gene for short internodes (his No. 522), and bc conferring different types of compact growth. These lines were tested in 12 cm peat-embedded pots at 15 x 20 cm spacing in a greenhouse at 23° C during the 16-hour day and 17° C at night with RH of 75%, and under natural light with an extra 200 watts/m^2 of mixed light during the last month of the test. The growth period was from 1st August till 14th December, 1964, when final evaluation took place. Some of the data are summarized below.

Line	Height (cm)	Avg. internode length (cm)	ø stem base (cm)	Seed harvest	Wt 100 seeds (mg)	Spread of foliage
br	55	2.5	0.9	++	332	large
sd	115	5	0.7	nil	-	little
cv	80	3.5	1.3	++	327	little
fru^{hem}	84	2.5	1.3	+	269	little
glo	100	2	?	++	266	little
d_1	100	6.5	1.3	±	368	very little
bu	50	3	1.5	nil	-	very little
bu d_1	45	3	1.3	nil	-	very little
No. 522	65	6	0.8	++	241	medium
bc	100	3.5	0.7	++	247	little

Only br, bu, bu d_1 and No. 522 maintained a short phenotype after 4 1/2 months. The internodes of these lines were relatively short, except for No. 522 which had very long internodes; the sd line was also characterized by long internodes (in strong contrast to out-of-doors performance in California, Israel and Holland), which may support Kedar's hypothesis that one of the genes of No. 522 is in fact sd. A possible anomaly arises from the long internodes of the d_1 line: bu d_1 has short internodes, which would imply that bu is epistatic over d_1 were it not that other d_1 lines, obtained from Dr. E. A. Kerr, remained short in the same period on the same bench (but in 1965); it may therefore be that the long internodes observed in Dr. Kedar's d_1 line are due to other factors.

In both lines with bu, the flowers and young fruits aborted. In line sd also, all fruits aborted by shrivelling of the pedicels. Consequently, for the present purpose only line br and No. 522 warrant further testing. It should be noted that in this experiment both lines had thin stems after 4 1/2 months; in this respect they seem to have reacted more to close spacing than some of the other lines. The long internodes of No. 522 probably signify that a more balanced plant would be obtained under higher light intensity, again at very close spacing. A growth chamber test on br and No. 522 will be made in 1966. This may yield more data on the possible causes of long internodes of sd types under greenhouse conditions, notably on the effect of certain parts of the visible and UV spectrums.

Of 10 lines from Dr. Kerr, each containing 6-9 recessives, amongst which were either br, d_1, sp or inc_2 for dwarfness, line 587-21-1958 (br (wf?) c sp n u f-j_1) performed excellently in the greenhouse at 15 x 20 cm spacing in 12 cm pots. This behavior confirms the superiority of br-containing lines under our greenhouse conditions. This line is very compact and strong, with large, heavy, medium-green, drooping foliage and persistent lower leaves; it flowers early and after 114 days under low-light autumn conditions gives a good harvest of fruits 2 1/2-3 cm in diam containing many medium sized seeds (276 mg/100 seeds). It is probably a good parent for crossing with other multi-recessive lines (aim: making hybrids, heterozygous on many known loci for mutability experiments, as done by Scarascia Mugnozza et al.). It may also be useful as breeding stock for obtaining types suitable for early-season greenhouse culture in beds at very close spacing.

Of many other short varieties tested, Hardin's Miniature (Rick's LA 314) was very weak (wilty appearance, slow growth, abnormal shedding of foliage, aborting flowers) in one type of growth chamber, but performed very well in another, in which the only detected difference was a higher light intensity and a lesser exposure to the stream of conditioning air.

Finally, Chanasyk Early (Rick's LA 657) was very promising both in the greenhouse and in hydroponic culture in the growth chamber. The correlated timing of leaf development, flowering, development and then temporary arrest of axillary shoots, leaf abscission and other morphogenetic features is such that the plants are completely self-regulating. No pruning was required, even with hydroponic culture. At 12 1/2 x 15 cm the plants had to be supported, but development and fruit yield remained very good. Fruit ripening on a cluster was extremely uniform and the fruits(3-3 1/2 cm) were of good color and contained many seeds. First harvest was 96 days from sowing which was 15-20 days earlier than Money Maker under similar conditions. The disadvantage of germination of the seeds inside the ripe, intact, very juicy fruits could be overcome by slightly earlier harvesting.

Chanasyk Early and Dr. Kerr's line 587-21-1958 are now being tested with respect to their potentialities for cultivation at very close spacing in beds in the greenhouse under early-season low-light conditions.

Contant, R. B., and Nelly S. Tims

Tomato plants at close spacing in growth chambers.

In addition to searching for short-internode types to be grown on a restricted growth chamber and greenhouse surface for use in large scale radiobiological and mutation-induction studies, several methods of cultivation have been tried, chiefly with Money Maker and Tiny Tim.

In hydroponic culture using Hoagland's solution and aeration with pressurized air and with a density of 32 plants/m^2, vegetative growth was healthy and abundant and a good fruit set was obtained. Conditions of climate were well balanced at a day-length of 16 hrs, a measured light intensity of 12000-14000 lux (selenium cell) of Philips TL33RS with an admixture of red light from Philinea tubes, and a day/night temperature of 20° C/16° C. Because of excessive vegetative growth, especially in Tiny Tim, pruning was required. With only light pruning or no pruning at all, the ratio of fruits to vegetative parts was low. With very heavy pruning, growth was checked and small dark plants resulted with a high ratio weight to weight of fruit and vegetative parts; however, the average number of seeds per fruit was reduced to 1/2 or even 1/4, and many fruits were sterile. The cause of this phenomenon has not yet been studied and no satisfactory explanation is available.

In view of the difficulties associated with hydroponic culture at the very close spacings desired, culture in pots was then tried with perlite, vermicullite, or a 1:1 leaf mould:compost mixture as the rooting medium. Perlite and vermicullite gave irregular results, highly dependent on the watering regime; if watering was done with Hoagland's solution alone, plants turned yellow and necrotic, notably on perlite; a good practical procedure appeared to be to water with Hoagland's solution and normal water on alternate days. Watering should be quite abundant in order to avoid high

salt concentrations, and good drainage should be provided. The leaf mould: compost mixture, to which 6 vol.% of bird-dung may be added, yielded the most uniform results with the least effort; the same result was obtained with small seedlings in seed-boxes. This rooting medium has therefore replaced the previous ones. Plants are now grown to maturity in plastic pots of 12 cm diam (if embedded in peat, stone pots are better). The restricted root volume limits the growth of axillaries and relatively little pruning is needed; one shoot is always left to grow. Under the above growth chamber conditions, 35-40 plants of Money Maker per m^2 can now be grown to maturity on a scale of 2000 per experiment. If one cluster is kept, 3-5 fruits may be harvested, each of fair size and containing many seeds; if two clusters are desired, not more than 2-3 fruits should be permitted to develop on each cluster. Fruit maturity was reached after 120 days from sowing. Seed set is stimulated by daily treatment of open flowers with an electric vibrator. Experiments to improve the present technique by automatic watering on a sand tablet are in progress.

Gilbert, J. C., and James T. Chinn

"Spider Mite" resistance in tomato.

Resistance to defoliation of tomato plants by the common species of spider mite, Tetranychus telarius, has been observed for some time in tomato lines selected in Hawaii for 20 years (lines derived originally from combinations of L. esculentum, L. pimpinnelifolium and L. peruvianum). Leaf counts of partly defoliated mature plants in the five replicated trials of the Southern Tomato Exchange Program showed 7.4% defoliation in the Hawaii variety Anahu. From five to eight times as much defoliation occurred in the STEP lines from mainland sources. Homestead 24 showed 60.8% defoliation.

In this and all other trials observed here when spider mites were a factor, F_1 hybrids between resistant and susceptible parents showed intermediate levels of defoliation. In this trial, Hawaii hybrids N-52 and N-64 showed 30.0% and 28.8% defoliation, respectively. This 1965 STEP trial was conducted at Poamoho farm, Oahu. The spider mites there had apparently developed some resistance to parathion sprays.

Herrmann, F., and R. Hagemann

Cytogenetic study of variegated plants of a yv^{ms} line.

In TGC 12:27, 1962 and TGC 14:13, 1964, the second author has described an ever-sporting mutant line, which consists of green-yellow variegated and yellow male-sterile plants (homozygous for yv^{ms}). The green-yellow variegation is the result of an interaction between the genotype $yv^{ms}yv^{ms}$ and fragments. The green parts of variegated plants contain 24 chromosomes plus one or more fragments. The fragment carries either a yv^{+} allele or a complementary factor or a suppressor which with the mutated chromosomes No. 6 ($yv^{ms}yv^{ms}$) determines a normal green phenotype. During ontogenetic development in a portion of cells, the fragments are lost. Cells without fragments are yellow.

The loss of the fragments in the course of mitotic divisions occurs at random during the different stages of ontogenetic development. If it takes place in an early developmental stage, large yellow sectors or uniform yellow (and male-sterile) branches are formed; loss of the fragments in late stages results in the formation of small yellow spots. The random loss of the fragment with regard to the developmental stage explains the variety of the patterns of this variegation.

In order to define the relation between the degree of variegation and the number of fragments per cell, mitotic divisions have been studied in the shoot apices of both weakly and intensely variegated seedlings. The findings were that cells of weakly variegated seedlings contain on an average more fragments than cells of intensely variegated seedlings. (In weakly variegated seedlings 30% of the cells have 2 or more fragments, 68% have 1, and 2% have no fragment; by contrast, in intensely variegated seedlings only 6% of the cells have 2 fragments, 75% have 1, and 19% have no fragment.) Thus, the degree of variegation is mainly determined by the number of fragments per cell.

About one-third of all p.m.c. of weakly variegated plants contain one (or more) fragment(s). In pachytene the fragment was found to be free; an attachment to a particular chromosome does not seem to exist. The fragment has two heterochromatic regions, which are close together, and a short euchromatic part.

In 45.7% of the p.m.c. which do contain a fragment, the fragment remains undivided in the course of meiotic divisions. When the fragment divides, the division mostly takes place in A1, seldom in A2. In A1 and A2 the fragments go belatedly to the poles.

Assuming that all fragments which are observed in A2 and T2 reach the poles, our studies lead to the result that about one-third of the microspores of weakly variegated plants carry a fragment and two-thirds of the microspores do not.

Using these values one can try to predict the frequency of plants with and without fragments in F_1 and F_2 of crosses with variegated plants of the mutant line. The results of such crosses (Hagemann TGC 12:27, 1962) significantly deviate from the predictions. The reason for this is that the genetically different types of pollen tubes have not the same chance of fertilization (i.e. there is certation or selective fertilization). All results can be explained by the assumption that there is a decreasing chance of fertilization in the series: $\underline{yv}^{+} > \underline{yv}^{ms} + F > \underline{yv}^{ms}$.

Honma, Shigemi, and M. J. Bukovac
Inheritance of gibberellin induced exserted stigma.

Environmental and genetic control of heterostyly or exserted stigma in the tomato has been observed by earlier investigators. Flowers developing subsequent to gibberellin treatment have been reported by the authors to have a similar effect. In a cross between a responding variety, Indian River, and a non-responding variety, Fireball, the F_1 showed stigma protrusion due to the gibberellin treatment. From the results of the F_2 and backcross segregation, it appeared that this response was conditioned by a single dominant gene. There was no linkage between this character and uniform fruit, u, and between this character and self-pruning, sp, habit.

Hornby, C. A., and W. B. Charles
Pollen germination as affected by variety and number of pollen grains.

During the work on developing cool-temperature tolerant tomatoes, there was reason to question the effects of amounts of pollen on a given stigma, as well as of genetic differences between varieties. Pollen grains were counted and applied to stigmas, and after 48 hours, stigmas were removed. After staining with water soluble aniline blue, the pollen tubes could be

counted under ultraviolet light. Several experiments yielded similar results, and can be illustrated with the following data which is expressed as means of percentages of pollen germination from three replications.

Number of pollen grains per stigma	Percentages pollen germination Variety	
	Puck	Bonny Best
15	0	0
50	11	0
100	23	14
200	37	10

There were highly significant differences between varieties and among the numbers of pollen grains used per stigma.

Some apparent genetic differences in pollen germination may be a result of "density" of pollen on a given stigma.

Kedar, N., and Nira Retig

The performance of high pigment lines.

Some doubts have been expressed concerning the agricultural value of hp hp lines. New breeding lines of this genotype were therefore tested in comparison with the best locally accepted varieties.

In a backcross program, the high pigment character from Ill. acc. #135 was introduced into the local market variety, Rehovot #13 (F.R., indeterminate, fasciated fruits). Two of the resulting hp hp lines, #100 and #110, were tested in a replicated trial and were as high yielding as the local variety. The new lines were superior in firmness, color, and in average weight of fruits, but did not equal the local line in earliness.

In a second breeding program, a number of high pigment lines for processing were produced after crossings between Ill. acc. #135 and Roma or Red Top, respectively. Five of these hp hp lines were compared with Roma in a replicated trial. Again, no significant differences in yielding capacity were found.

Laboratory tests in general confirmed the superior color characteristics of the high pigment fruits. It was found, however, that adverse conditions during ripening affected hp hp lines more strongly than + lines. Partial defoliation some time before harvest caused a decrease in the Hunter a/b ratio. Under hot weather conditions this decrease was more pronounced in the hp hp than in the + lines.

Our present opinion is that the superior quality of high pigment fruits can be combined with good foliage cover and high yielding capacity. The material may be more liable to defoliation and appears to be most promising under climatic conditions minimizing the risks of sunscald or of overheating of the fruits.

Kemp, G. A.
Fruit set at low night temperatures.

Night temperatures below 55° F during the early part of the growing season result in the failure of flowers of many tomato varieties to set fruit. In the variety Earlinorth the presence of a recessive gene permits fruit set to occur at night temperatures of 40° F. This character differs under our test conditions from other varieties reported to possess cold tolerance, resistance to cold sterility, etc. For this reason the gene designation ft (fruiting temperature) is proposed as it will not infringe on the descriptive terminology used to describe similar characters.

Kemp, G. A. Yellow calyx--a marker gene for fruit maturity studies.

Investigations of ripe tomato fruit, e.g., ripe color, total soluble solids, are frequently hampered by the inability of the investigator to ascertain the degree of fruit maturity. A simply inherited recessive gene for yellow calyx was obtained from segregating material sent to us by Dr. Arvo Kallio of College, Alaska. This character first expresses itself at the red ripe stage when the calyx starts to turn from the normal green to yellow at the point of attachment to the stem. Over a period of 3-4 days the calyx becomes completely yellow as the fruit becomes riper. The gene symbol yc (yellow calyx) is proposed for this character.

This symbol is not to be confused with yc temporarily used for yg_2 (yellow-green-2).

Kerr, E. A. Another xanthophyllous (Xa_3) for chromosome 10.

The mutant Xa_3 was crossed with testers a c d gf gs h hp mc wf y, a h Nr u v_2 y yv and d h l_1 mon. No linkages were detected except with genes on chromosome 10. The combined data are as follows:

	a	b	c	d	Co.
Xa_3-h	602	130	110	241	22
Xa_3-u	187	13	13	88	8
u-h	160	40	36	64	26

The population was scored for u late in the season when all the fruits were ripe on some plants. Consequently these data are incomplete. The u-h data, however, gave 26 crossover units which is the accepted distance between these genes.

These data place Xa_3 between u and h and very close to Xa_2. It is possible that Xa_2 and Xa_3 are allelic but, as Gröber (TGC 13:48) has pointed out, Xa_3 tends to become green in midsummer whereas Xa_1 and Xa_2 remain yellowish.

Kerr, E. A.
Linkage relations of pst and j_2.

This mutant has been incorporated into several testers since it was obtained from Rick in 1956. Hints of about 40 to 48 units were obtained with several genes. Most of these

populations, however, indicated differential survival, or tests in later years did not confirm any linkage. Tests with gs, lg_5, and j_2 have been consistent.

		a	b	c	d	Co.
pst-gs	F_2 Coupling	118	4	12	11	15
	F_2 Repulsion	16	40	16	1	11
pst-lg_5	F_2 Repulsion	57	41	31	1	14
	F_2 Repulsion	138	84	63	2	15
pst-j_2	F_2 Coupling	251	69	66	21	48
	F_2 Repulsion	146	24	68	7	43
	Backcross	42	33	32	42	43

These data confirm a personal communication from Rick that pst is on chromosome 7 and further hint that the order might be pst-gs-lg_5.

The suggested linkage with j_2 is much more distant and consequently may be due to chance. Rick (TGC 10:34) assigned j_2 to chromosome 11 about 28 units from a_1, but I have not been able to confirm linkage of j_2 with genes of this chromosome.

		a	b	c	d	Co.
j_2-a	F_2 Coupling	78	31	26	10	> 50
j_2-a	F_2 Repulsion	127	33	49	14	> 50
j_2-a	F_2 Repulsion	111	34	22	10	44
j_2-f	F_2 Repulsion	111	21	24	24	> 50
j_2-j_1	F_2 Repulsion	103	29	31	17	> 50

The results of the j_2-f test appear to indicate linkage in an F_2 coupling population. However, these genes were definitely in repulsion phase.

The backcross population from which the pst-j_2 data were obtained came from the cross (Vinequeen x ah pst j_2 sf sp wf) x ah pst j_2 sp wf. Besides the indication of loose linkage between pst-j_2, there was also evidence of loose linkage for ah-pst (39 : 35 : 36 : 39), ah-j_2 (45 : 32 : 32 : 43), ah-wf (42 : 32 : 32 : 43), and pst-wf (38 : 37 : 36 : 38). Obviously most of these data do not indicate real linkages unless some chromosomal aberration such as translocations were present in the stocks. This is possible because Vinequeen has a complex ancestry involving two interspecific crosses. It contains Cf_2 from L. pimpinellifolium and Cf_4 from L. hirsutum.

Kerr, E.A. Lutescent-2 and lutescent-3 are duplicates.

Lutescent-2 appeared as a mutation in a field of the variety Longred. In 1961, Stubbe reported a gene which appeared in L. pimpinellifolium following irradiation. It resembled l_1 and l_2 and has been designated l_3. Single F_1 plants of l_1 x l_2, l_1 x l_3 and l_2 x l_3 were grown in the fall 1965. The first two hybrids had normal green foliage but l_2 x l_3 was lutescent. This could not have been an accidental selfing as the fruits were intermediate in size between the two parents and had u^+ fruits similar to the l_3 parent. No differences have been detected between these two l_2 mutations, and consequently they are considered to be synonymous.

Khush, G. S., and C. M. Rick At long last, a marker for chromosome 12.

It is gratifying to report that a marker gene has finally been found for chromosome 12. By means of the induced-deficiency technique (Genetics 46:1398, 1961) in which alb/alb (an unstable chlorophyll mutant described by Thompson, TGC 13:27) plants were pollinated with irradiated + pollen, five plants were obtained that showed pseudodominance for alb. Up to the present time two of these plants have been analyzed cytologically: one is deficient for the euchromatic region of the short arm of chromosome 12, while the other is monosomic for chromosome 12. Accordingly, alb must lie in the euchromatic of 12S. The viability of this new monosomic, haplo-12, was predicted on the basis of our studies of 18 tertiary monosomics and haplo-11 (Khush and Rick, Chromosoma 18: in press). Since alb is a seedling mutant of good viability and well-distinguished phenotype, it should prove a useful tester for chromosome 12.

Khush, G. S., J. E. Boynton, and C. M. Rick A naturally occurring tetraploid of L. chilense.

Accession LA869 was obtained in the form of seeds taken by CMR from a herbarium sheet Nov. 15, 1961 at the Museo de Historia Natural in Lima, Perú. The specimen had been collected by Dr. Ramón Ferreyra (his No. 13476) Nov. 26, 1958 in a dry creek bed, 900-1000 m elev., at Cháparra, SE of Chala, Prov. Caravelí, Dept. Arequipa, Perú. The site of collection is of special interest because it is a loma that is unusually rich in endemic plant species and because it represents the northernmost extension known for L. chilense. The specimen appeared to be typical L. chilense, an identification that was verified by the subsequently grown culture.

A culture of 15 plants was grown in 1962 from the seeds of a single fruit. The plants were uniform for slow growth, rugose leaves, and unusually large showy flowers--characters that suggested tetraploidy to JEB. Sib pollination between plants of the same family grown in the greenhouse gave only 10% of the normal chilense seed yield. Unexpectedly, self-pollinations responded similarly, strengthening the suspicions of tetraploidy. Speculation about tetraploid character continued as the plants were retained overwinter and cloned to the field the following summer. GSK, who was persuaded by JEB to smear PMC's, discovered 48 chromosomes at diakinesis, with frequent quadrivalent associations. Too little is known about this biotype to permit much speculation about its nature. The herbarium material suggests that the collected plant was more fertile in the wild than its progeny under our cultural conditions, but nevertheless less fertile than 2N chilense. Considering its lower fertility and the unhospitable character of the native habitat for vegetative propagation, this entity more likely represents a chance tetraploid plant or plant sector than an established tetraploid species.

Knowles, Penny Anthocyanin mutants in the new mutant program.

The three anthocyanin mutants, 704-27$\alpha\alpha$, 705-70$\beta\beta$, and 707-1$\alpha\alpha$, produced by irradiation at Wageningen and shown to be non-allelic with ah (TGC 15:2, 1965) have been found to be alleles of previously reported anthocyanin mutants. In those cells of the normal genotype where

the purple anthocyanin is present, there is a masking of the chlorophyll. The mutant 704-27αα does not produce anthocyanin that is detectable either visually or spectrophotometrically but remains bright green, even when given optimum light and temperature conditions for flavonoid formation. Although the other two mutants, 705-70ββ and 707-1αα, also have green hypocotyls, they manifest a purple coloration in the lower epidermis of the cotyledons and the first true leaves, in the tips of the young buds, and in the axillary shoots. The quantity of this pigment ranges from a transient tinge when the plants are grown in a warm greenhouse to an intense purple when the plants are grown under low temperatures and high light. The results of crosses show that 705-27αα is an allele of aw whereas 705-70ββ and 707-1αα are alleles of ag and of each other. Under the same environmental conditions 705-70ββ and 707-1αα differ from ag by producing less pigment. This modified phenotype is more likely to be the result of differences in genetic backgrounds than of differences in the alleles themselves.

Lesley, Margaret, J. W. Lesley, and R. K. Soost A triploid Woolly composed of tissue similar to that found on variegated Woolly Wo Wo$^+$ and their progeny.

A tomato plant heterozygous for Woolly and for aw, anthocyaninless, was crossed with non-Woolly anthocyaninless, Wo$^+$ Wo$^+$ aw aw. In a family of 143 plants, 44 were variegated. One type of variegation--dark distorted--involves hairiness of the epidermis and a more intense green of the sub-epidermal layers. One seedling was not variegated, but the leaves consisted wholly of tissue resembling the dark distorted sectors of variegated plants. The plant was small, slow-growing, and had dark green buckled leaves with curled rachises It was Woolly, but less so than normal Wo Wo$^+$ plants; also, it was anthocyaninless, aw. Pollen and seed production was scanty. The pollen mother cells were triploid. Triploidy and curling of the leaves appeared simultaneously. Meiosis in a tetraploid pollen mother cell could give a Wo Wo$^+$ aw aw egg which, fertilized by a normal Wo$^+$ aw gamete, would result in triploid plant that was anthocyaninless and less woolly than a Wo Wo$^+$ diploid. However, the plant was not a normal triploid in leaf shape or in size of stomata. Stomatal size, usually an index of chromosome numbers, was similar in mean diameter and range to a diploid but more variable. For the diploid variety, Canary Export, the mean diameter in empirical units was $1.829 \pm .165$ and of the triploid, $2.072 \pm .285$. The ratio of the variances, $F = .081 \div .027 = 3.0$ with D.F. 61 and 54, indicates a significant difference in variability. This suggests the possibility that the triploid mutant is a chimera of cells with an epidermis composed of 3x and 2x chromosomes and a 3x subepidermal layer. At pachytene in the pollen mother cells, one of the three number 2 chromosomes sometimes appears to differ in the amount and arrangement of heterochromatin. Position effect previously has been suggested to explain variegation in Wo Wo$^+$ seedlings on account of some anomalous recombination values between Wo and other genes in chromosome 2 and cytological evidence indicating an inversion (Genetics 1963, 48, No. 8).

Eleven trisomic plants and three diploids were obtained from the triploid x non-Woolly diploids. Four of these were Wo and 12 Wo$^+$, suggesting that the triploid was Wo Wo$^+$ Wo$^+$. Three of the four curled F_1 plants were Woolly and one was non-Woolly. One of the 11 non-curled F_1 plants was Woolly and 10 were non-Woolly. Three of the curled plants were trisomic, one was diploid.

Evidently curled does not depend on a triple dose of chromosome 2, which contains the Wo locus, since none of the curled trisomics contained this extra chromosome. Curly seems to be a new dominant gene that is not at the Wo locus. The similarity of curled to some of the sectors arising from somatic mutation of Wo and related plants and the occurrence of two recessive lethals at the Wo locus suggests some unusual condition there. According to Swanson (1957), lethals "frequently produce detectable morphological changes that are inherited as dominant characters." The Wo locus alleles may be interstitial deficiencies at the Wo locus or adjacent duplications. Breeding tests of the allelism and possible lethality of curly are projected.

Lona, J. L. Additional experience with the use of male-sterile mutants in hybrid seed production.

During the 1964-65 season the mutants ms_{31} (VF6) and ms_{33} (VF11) were compared for their effectiveness as female parents for hybrid seed production. The methods used in hand pollination and other operations are the same as those reported in TGC 15. Seed was produced at the rate of 160 lb per acre, but the return in terms of yield per working day, 1 lb, is lower than the 1.5 lb realized in 1963-64. The lower yields are attributed to the hiring of unskilled workers and lack of supervision, the 1963-64 yields being considered a realistic expectation for our conditions. These prospects for the cost of F_1 hybrid seed and the outlook for superior performance of F_1 hybrids are so good that we plan to triple the area devoted to hybrid seed production in the coming season.

The ms_{33} mutant seems very promising as a female parent because its combining ability is very good and its sterile flowers differ from normal to a remarkable extent, permitting easy identification of male-sterile plants in the nursery. The anthers do not require dissection for identification as in the case of ms_{31}. Thus far these are the only two mutants that are suitable for F_1 seed production under our conditions.

The rather impressive performance of our tomato hybrids in 1963-64 stimulated us to test yields again in 1964-65. Two hybrids were compared with their male parents and the standard Platense var. in trellised plantings with plants spaced 1.0 m x 0.4 m. The 1964-65 results are summarized as follows:

	Marketable fruits yield (kg/plant)	Difference	
		Over male parent	Over standard var. Platense
Pearson VF11 ms_{33} x Santa Clara	3.24	116%	120%
Santa Clara	1.49		
Pearson VF11 ms_{33} x Saint Pierre	3.44	76%	134%
Saint Pierre	1.96		
Platense	1.47		

L.S.D. 99:1 = 1.07 kg.

We are astounded by such a phenomenal superiority of the hybrids and can guarantee that it is not a case of tropical imagination. Actually the hybrid yields are about the same as they were in the previous year, while those of Platense decreased considerably. Soil, irrigation, and weather conditions were similar in both seasons. The dominant resistance of VF11 to fusarium and verticillium might possibly explain the difference, although no visible symptoms of either disease were seen in the plantings.

Machold, O., and K. Gröber

Effect on the chlorophyll content of different reduction agents in the mutant xantha-5 of Lycopersicon esculentum.

In an earlier report (TGC 14), we described that light, temperature and nitrogen nutrition affect the chlorophyll content of the mutant xantha-5. This mutant proved able under optimal conditions to grow on its own roots and to produce chlorophyll. Under these conditions the delivery of ammonia nitrogen in the culture solution had a more favorable effect on chlorophyll production than nitrate nitrogen. Even with most favorable culture conditions, the youngest leaves were slightly chlorotic, but the older ones became normal green. A chlorophyll distribution of this type is characteristic of iron chlorosis effected by iron deficiencies, and therefore the iron metabolism of this mutant was checked. By means of ^{59}Fe it was established that there was no difference in iron uptake between mutant and control (Condine Red). As shown by autoradiographic studies, the iron distribution in the leaves was also normal, and therefore the iron chlorosis of the mutant is not a consequence of an absolute iron deficiency. Since the iron content in the chlorotic leaves of xantha-5 was found to be even higher in some cases than in the corresponding leaves of Condine Red (440 vs. 100 μg Fe/g dry matter), these results may be taken as a hint that iron is normally taken up by the mutant and transported into the leaves, where it exists in a form ineffective for chlorophyll synthesis.

Experiments during the last years concerning the effect of iron in plant metabolism lead to the assumption that chlorophyll synthesis is catalyzed only by Fe^{++}. Therefore we studied the influence of several reducing agents on the chlorophyll content of xantha-5 with the following results:

Effect of different reducing agents on chlorophyll content of xantha-5

Reducing agents*	Daily application mg/l	Chlorophyll content mg/g fresh weight
-	-	0.19 ± 0.01
Hydroquinone	10	0.84 ± 0.04
Hydroxylamine	10	1.39 ± 0.07
Pyrocatechol	10	1.01 ± 0.04
Na_2SO_3	50	0.62 ± 0.05

*Applied with Hoagland's solution containing 0.5 mg Fe/l as Fe-EDTA.

As evident from the table all reducing agents exerted a positive influence on the chlorophyll content of the mutant (chlorophyll measurements were made ten days after application of the reducing agents). These results show that the mutant is unable to transfer the iron which is taken up into the form (Fe^{++}) effective in chlorophyll synthesis. Other processes also catalyzed by Fe, e.g.

protein synthesis, are in all probability proceeding quite normally as shown by preliminary results on the incorporation of ^{15}N into the protein of the leaves.

Martin, Franklin W. Avoiding unilateral barriers in tomato species crosses.

The possibility of obtaining cytoplasmic male sterility in the tomato by combining the L. esculentum genome with cytoplasm of other species has lead me to try various methods of breaking down the unilateral barrier that generally exists between the species. So far three such barriers have been broken, but the subsequent backcrossing has not yet proceeded to a stage where pronouncements concerning sterility can be made. Techniques and results are as summarized below and in Table 1.

1. L. hirsutum f. glabratum x L. esculentum. This cross was achieved through taking advantage of pseudocompatibility in older plants. One hundred cross-pollinations without emasculation were made weekly to a series of plants, and the bases of the flowers were treated with 0.1% alphanaphthalene acetamide. Crosses failed during the first 11 weeks, but succeeded during weeks 12-14. One hundred eighty fruits with 2187 seeds were obtained. A sample of 50 seedlings consisted entirely of hybrids. The subsequent first backcross was achieved without problems.

2. L. hirsutum f. typicum x L. esculentum. Although 37 fruit and 40 seed were produced through end-of-season pseudocompatibility, all proved to be contaminations. Consequently, an indirect series of crosses was used as follows: L. esculentum x L. hirsutum f. typicum, L. hirsutum f. typicum x F_1, BC hybrid x F_1, complex hybrid x L. esculentum. Success in each cross depended on utilization of pseudocompatibility. The fourth cross, roughly equivalent to a first BC of L. hirsutum x L. esculentum, was made with ease.

3. Solanum pennellii x L. esculentum. This cross proved more difficult than either of the two previous crosses. Attempts to cross the species directly through use of pseudocompatibility failed, as did also crosses with L. esculentum x L. hirsutum and L. esculentum x S. pennellii hybrids. The use of L. hirsutum as a bridge species in the cross S. pennellii x L. hirsutum f. glabratum was then attempted, with success. I now am ready to produce the BC_2, (S. pennellii x L. hirsutum) x L. hirsutum, and then, using an essentially L. hirsutum f. glabratum plant with S. pennellii cytoplasm, I shall be ready, using pseudocompatibility, to begin transfer of L. esculentum chromosomes to the S. pennellii cytoplasm donor.

The success of these crosses demonstrates how incompatibility barriers can be broken in tomato by use of pseudocompatibility, introgression of fertility genes, and use of bridging species.

Table 1

Pollinations, fruit, and seed set in attempts to break unilateral barriers.

Cross	Polli-nations	Fruits	Seeds
L. hirsutum f. glabratum x L. esculentum	1535	180	2187
F_1 (above) x L. esculentum	168	77	1432
L. hirsutum f. typicum x L. esculentum	1431	37	40*
L. esculentum x L. hirsutum f. typicum	100	73	324
L. hirsutum f. typicum x above F_1	90	4	17
Above BC_1 x Original F_1	100	17	68
Above hybrid x L. esculentum	95	43	561
Above complex hybrid x L. esculentum	15	12	379
Solanum pennellii x L. esculentum	730	0	0
S. pennellii x F_1 (L. esculentum x L. hirsutum f. glabratum	338	0	0
S. pennellii x F_1 (L. esculentum x L. hirsutum f. typicum	171	8	0
S. pennellii x F_1 (L. esculentum x S. pennellii)	1170	0	0
S. pennellii x F_2 (L. esculentum x S. pennellii)	142	0	0
S. pennellii x L. hirsutum f. glabratum	542	64	422
Above F_1 x L. hirsutum f. glabratum	115	22	178

*Not hybrids.

Martin, M. W., and R. L. Clark

Increasing levels of curly-top resistance by transgressive segregation.

High levels of curly-top resistance have been found in most of the wild species of Lycopersicon, but efforts to transfer these high levels of resistance into tomatoes of commercial type have not been very successful. Resistance is apparently multigenic in inheritance, greatly affected by environment, and easily lost in the back-crossing and horticultural selection necessary to reconstitute recurrent commercial parents. L. esculentum-type breeding lines which express moderate levels of curly-top resistance have been developed from different wild sources of resistance. Unfortunately, heavy losses are observed even in these lines in severe curly-top epiphytotics.

Efforts have been made to improve the level of curly-top resistance and horticultural characteristics of these lines by intercrossing lines derived from different wild sources. Two of the many intercrosses tested gave progeny lines which have much higher levels of curly-top resistance than the component

parent lines. The first of these, (25 x 28) x 193, is a three-way cross between line 25, which derives curly-top resistance from L. peruvianum var. humifusum; line 28, which derives curly-top resistance from L. peruvianum var. dentatum; and line 193, which derives curly-top resistance from L. hirsutum, L. pimpinellifolium, and L. peruvianum var. dentatum. The second three-way cross, (45 x 28) x 193, involves the same lines 28 and 193, but instead of the line 25 it has a line 45, which is a curly-top resistant selection of L. pimpinellifolium.

Table 1 shows results obtained in greenhouse seedling tests at Logan, Utah, and field tests at Prosser, Washington, in 1962 and 1963, in which the resistance of these two intercross lines was compared with that of their component parent lines. The results of these tests, and results of many other tests (where these lines have been tested, but not in direct comparison with each other), indicate that transgressive variation in progenies of these intercrosses has produced lines which exceed any of the parent lines in curly-top resistance. Apparently, genes with cumulative and complementary effects have been accumulated from different moderately resistant sources to produce higher levels of resistance.

It is assumed, however, that additional genes for tomato curly-top resistance are still available since the resistance of these intercrosses is still not as high as that found in the wild species of Lycopersicon. The resistance of the first intercross mentioned, (25 x 28) x 193, is apparently still linked with undesirable horticultural characteristics, since efforts to backcross the resistance from this source into commercial types have not been very successful. However, the resistance of the other intercross, (45 x 28) x 193, has recombined quite readily with good horticultural characters through three backcrosses. Lines derived from this intercross are now available as breeding material for anyone interested in incorporating curly-top resistance into their program.

Table 1

Responses of two 3-way crosses, (25 x 28) x 193 and (45 x 28) x 193, exposed to curly-top compared to the responses of each of the component parent lines.

Line	Filial generation	1962 results				1963 results			
		Greenhouse		Field		Greenhouse		Field	
		H/T*	%H	H/T	%H	H/T	%H	H/T	%H
Susc. Con.		5/110	5	5/106	5	0/111	0	44/155	28
25	F_6	13/73	18	7/21	33	5/36	14	19/34	56
28	F_7	8/105	8	5/19	26	5/31	16	6/20	30
(25 x 28)	F_4	31/147	21	9/18	50	11/51	22	95/132	72
193	F_{11}	19/82	23	9/14	64	21/64	33	107/117	91
(25 x 28) x 193	F_6	11/28	39	142/151	94	79/145	54	220/232	95
45 (No data from these tests, but other tests show that 45 has a low level of curly-top resistance, comparable to line 28.)									
(45 x 28) x 193	F_4	22/50	44	30/32	94	26/48	54	112/136	82

*Number of healthy plants over total number of plants.

Moens, Peter B. The transmission of heterochromatic isochromosome fragments.

In TGC 15, I reported that a heterochromatic isochromosome of the short arm of chromosome 2 was transmitted through 30% of the gametes. In some of the progeny partial isochromosomes were recovered. Two such reduced forms have been examined in more detail. The point of interest was to see if various shapes and sizes of reduced isochromosomes affected gametic or zygotic viability, keeping in mind that these fragments are heterochromatic and apparently genetically inert.

Large reduced isochromosome

This centric fragment lacks one of the two satellites and is therefore asymmetric. The structure is a centromere with a short arm and a nucleolar organizer on each side followed by a satellite on one side (photographs in Can. J. Gen. Cyt. VII-2).

The cross female 2n with male 2n + large reduced isochrom. gave no isochrom. in 50 progeny and one isochrom. in 41. Transmission here is 45%, well in excess of the 30% for the complete isochromosome. It would appear that a reduction in the amount of heterochromatin is favourable to the transmission of the isochromosome. However, the following crosses contradict this.

Small reduced isochromosome

This fragment lacks both satellites and is therefore smaller than the previous one,and its symmetry is restored. The cross female 2n + small reduced isochrom. with male 2n gave no isochrom. in 43 progeny and one in 26. Transmission here is about 37%, intermediate between the complete form (30%) and the large reduced form (45%).

Selfing of a plant with the small form gave no isochrom. in 53, one isochrom. in 44 and two isochrom. in 12 progeny, or about 30% transmission. If the female carries two small reduced isochromosomes and the male none, identical results are obtained: no isochrom. in 53, one isochrom. in 43 and two isochrom. in 10 progeny. The last two crosses indicate that the isochromosomes do not affect the gamete; apparently the zygote is affected by small isochromosomes. Also, a plant with these two selfed gave no offspring with 3 and 4 isochromosomes, no isochrom. in 28, one isochrom. in 31 and two isochrom. in 22 in a total of 81 progeny.

Some additional crosses are being prepared with these and smaller fragments to determine their effects more accurately.

Palevitch, D., and N. Kedar
Resistance of tomato fruits to puffiness.

Puffiness was found to be a serious disorder in outdoor production of tomatoes of European type during winter and early spring. Investigations in Israel with the variety Moneymaker showed that the disorder was not caused by lack of pollination or embryo abortion.

The relative resistance to puffiness of more than 60 varieties was tested during several years in three areas. The percentage of puffy fruits was highly influenced by location, season and climatic conditions.

Significant differences between varieties in respect to resistance were found and proved to be relatively stable under varying conditions. In one experiment with 16 varieties the percentage of puffy fruits ranged from 0.4% (Bonner Beste) and 7.3% (Potentate) to 81.8% (Exhibition).

Crosses between resistant and susceptible varieties showed that inheritance of resistance can be explained by multiplicative or geometric gene action. Figures for the F_1 were very near the geometric mean of the two parents as exemplified in the following table.

Table 1

Average percentage of puffiness in F_1 between E.S.1 and Potentate (10-20 fruits per plant).

Harvest No.	E.S.1 (26 plants)	Potentate (32 plants)	F_1 (36 plants)	Mean between parents geometric	Mean between parents arithmetric
1	88.1	1.1	9.0	9.9	44.6
2	97.7	5.6	25.3	23.4	51.7
3	72.5	7.5	22.8	23.3	40.0

Similar results were obtained in diallel crosses including 5 susceptible and 2 resistant varieties. Yet in crosses between susceptible varieties, only minor differences were found between the percentage of puffiness of the F_1 and the geometric or the arithmetric means of the parents.

The F_2 frequency distribution of the cross susceptible x resistant was distinctively skewed. Transformation of the F_2 experimental data to logarithms resulted in better agreement with the normal distribution curve.

Figures for heritability of resistance varied between 57% and 69%, depending on the formula employed.

Reeves, A. F., J. E. Boynton, G. Hernandez B., and C. M. Rick
Additional linkage tests with mutants of Stubbe's groups I, II, III, and IV.

Linkage survey tests were continued, following methods outlined in previous reports. Significant indices of linkage were obtained for nine mutants, and loci of the majority can be estimated from these preliminary data. In the first of the following tables, linkages are signified by L; variable, usually non-significant, deviations suggesting linkage, by S; and apparent random recombinations by X. Data in the second table are given only for segregations that deviated significantly from random recombination; data for other segregations are available on request.

In order of chromosome number, $\underline{pli}_1$ showed convincing dissociation with $\underline{con}_1$ on chromosome 3, and the two estimates of the $\underline{pli}_1$-$\underline{con}_1$ interval, 12 and 16 units, are reasonably consistent. Since the position on chromosome 3 is not clear for $\underline{con}_1$, neither can it be for $\underline{pli}_1$. Much needs to be done with the known markers of this chromosome.

Two new markers are added to chromosome 4--och_1 and ver_1--to the great delight of Gurdev Khush.* The och_1-$clau_1$ test is based on too small a population to have much meaning, but the means of och_1-ful_1 values, 4 units, and of och_1-e, 32 units, appear reasonably consistent with the present map in placing och_1 about 4 units to the right of ful_1. The relationships of ver_1 with $clau_1$, ful_1, and e are likewise reasonably concordant with the map and suggest a locus for it between $clau_1$ and ful_1 at about position 18. In keeping with this approximation, the three point test--ver_1 x ful_1-e--yielded two individuals that were homozygous recessive for all three genes.

Our trials add two new markers to chromosome 7: flc_1 and rot_1. Since the distance between the flc_1 and La is estimated at 11.5, the interval between it and lg_5, at 40-46 units, and the La-lg_5 previously known to be about 21 units, a locus to the right of La at about 54 seems reasonable. The strong similarity in phenotype between not_1 and flc_1 and the fact that both lie on 7 might suggest an allelic situation, but this is discounted by the present linkage information as well as by the normal phenotype of F_1 flc_1 x not_1. The tests for rot_1 reveal a distance from La of 35.5-41.0 units, the former being more reliable because the corresponding F_2 was larger and better classified, and from not_1 of 21.5 units. With a standard distance of 8 units between not_1 and La, the locus of rot_1 should be to the left of not_1 with a map position of approximately 12. The rot_1-um_1 test does not assist much because the locus of um_1 is uncertain.

Chromosome 8 receives two new markers as the result of this survey. The results with re_1 are unequivocal; its distance from l_1 is estimated as 19.5, that from dl as 18.5, and in the same test the dl-l_1 interval as 31, corresponding exactly to the standard value. For pca_1 the data reveal a tight linkage, as yet not broken, with dl. Two tests of pca_1 vs. l_1 gave the same linkage value, 36.5. Although the l_1-dl_1 values in the same tests--38 and 32--are contradictory in respect to the position of pca_1, the latter value is probably more reliable because it was estimated from a much larger population and it corresponds closer to the standard value. It is therefore likely that pca_1 lies a short distance to the right of dl.

The mutant ten_1 is clearly linked with H on chromosome 10. More tests are needed to approximate its locus. For ele_1 a locus to the left of hl is suggested, although the data suffer from heterogeneity and very low frequencies of ele_1.

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*It is important to note here that the och_1 scored here, although unquestionably originating from our accession of this mutant, displayed a much more extreme phenotype than the original.

Summary of linkage tests

		Stubbe I		Stubbe II		Stubbe III				Stubbe IV
Chsm	Tester	ele_1	ten_1	re_1	ver_1	flc_1	och_1	pli_1	rot_1	pca_1
1	au_1	S			X	X	X	X	X	
	Jau	S			S	X	X	X		
	pr	X				X			X	
	y	X						X	X	
2	m_1									
	d_1	X	X		X	X		X	X	X
	aw				X					
	Wo^m				X	X		X	X	X
3	con_1							L		
	r_1	X								
	rv		X				X	X	X	
	sf	X		X	X	X	X	X		X
	sy	X		X	X	X	X			X
	wf							X	X	
4	$clau_1$	X	X		L	S	L	X		
	cm	X			L			S	X	
	di_1	X			X	X		X	X	
	c	X	X	X	S	X	L	X	X	X
	ful_1	X		X	L	X	L	X	X	X
	ht							X	X	
5	mc							X	X	
	tf	X	X		X	X	X	X	X	X
6	c	X	X	X	X	X	X		X	X
	yv	X		X		X	X	X	X	X
7	deb_1					L				
	ig_1							X		
	La	X	X	X	X	L	X		L	X
	lg_5	X		X	X	S	X	X		S
	not_1				X			X	L	
	um_1								S	
8	al						X		X	
	dl	X	X	L	X		X		X	L
	l_1	X		L	X		X		X	L
9	ah	X	X	X	X		X		X	X
10	ag	X		X	X	X	X			X
	H	X	L	X	S	X	X	X	X	X
	t							X	X	
	u							X	X	
11	a_1	L	X	X	X	X	X	X	X	X
	hl	L		X	X	X	X	X		X

Linkage data for significant tests

Combination	+ +	+ t	m +	m t	Adj. cont. chi-square	Co.
ele_1-a	114	52	27	2	6.2	27.0
	185	110	19	1	7.2	Seg. too
	167	128	32	3	14.4	distorted
ele_1-hl	112	54	28	1	7.6	18.5
	195	100	20	0	8.4	Seg. too
	209	86	28	7	0.9	distorted
ten_1-H	207	122	62	12	10.9	26.5
	75	57	38	0	22.8	0
re_1-dl	206	107	103	4	33.2	18.5
re_1-l_1	196	117	102	5	39.6	19.5
		no l_1-re-dl				dl-l = 31.0
ver_1-$clau_1$	268	113	106	4	30.4	20.0
ver_1-cm	158	94	82	2	35.9	14.0
ver_1-e	119	36	49	7	11.4	39.5
ver_1-ful_1	113	42	54	2	11.7	7.0
		incl. 2 ver-ful-e recomb's				
flc_1-La	36	292	133	31	235.3	11.5
flc_1-lg_5	190	96	72	18	5.3	40.0
	120	26	31	5	n.s.	46.0
och_1-$clau_1$	63	32	9	0	2.9	0
och-ful_1	159	84	102	0	43.8	0
	280	132	68	1	26.0	12.0
	119	70	41	0	20.1	0
		no och-ful-e				
och-e	165	78	95	7	23.3	25.5
	299	113	64	5	8.6	29.0
	139	50	34	7	< 2.0	42.0
pli_1-con_1	178	92	66	1	26.9	12.0
	527	223	170	4	55.9	16.0
rot_1-La	26	43	14	7	4.4	41.0
	113	291	78	23	81.3	35.5

Combination	+ +	+ t	m +	m t	Adj. cont. chi-square	Co.
rot_1-not_1	130	67	37	2	11.8	21.5
rot_1-um_1	288	44	47	2	2.6	32.5
pca_1-dl	158	88	73	0	34.3	0
	373	175	172	0	70.8	0
pca_1-l_1	174	72	63	10	6.3	36.5
	432	116	156	16	11.5	36.5

Rick, C. M. Inheritance and linkage relations of fy, mnt, Pn, and pst.

fy (field yellow). This mutant was first encountered as a single plant (2-565) in a field of var. VF36. It was distinguished from surrounding plants by the bright yellow-green color of all of its vegetative parts. This plant had a heavy load of seedy fruits. Its progeny have bred true for the aforementioned characteristics, but we have not been able to identify it in the seedling stage under greenhouse conditions with any degree of reliability--hence the name, field yellow. Hybridization with various tester lines yielded F_1's of normal phenotype, and seven F_2's yielded a total of 1028+:395fy, the proportion of the latter falling below 25% expectation ($X^2 = 5.63^*$) with a high degree of heterogeneity indicated between families ($X^2 = 31.99^{***}$, 6 d.f.). Two separate tests with La indicate a locus on chromosome 7. The remarkable similarity with yt in both phenotype and linkage relations with La suggests that fy and yt may be alleles. The appropriate tests are in progress.

mnt (miniature). This mutant made its first appearance in the F_2 Lpg x a Roumanian variety with drooping leaves and fasciated fruits. Segregating as a recessive in that population, it was clearly distinguished by its greatly reduced size of plant and all plant parts. The mnt plants remain about 1/5 size throughout the season in the field, produce few branches, and tend to remain erect. A few fruits are usually set spontaneously. The products of six different crosses with mnt had normal phenotype, and their F_2's collectively showed a highly significant deficiency of recessives--840+:201mnt ($X^2 = 17.68^{***}$) with no indication of heterogeneity between families ($X^2 = 9.15$, 5 d.f.). The linkage relations of mnt are not entirely clear, significant dissociation tendencies being shown by combinations with both dl and a_1. Our failure to recover any mnt-a_1 suggests that a locus on chromosome 11 is more likely.

Pn (Punctate). A segregation that has been repeatedly observed in backcrosses to L. esculentum with hybrids of S. pennellii is that for stippled margins of the seedling leaves. Under low-power magnification the dots are seen to be the bases of the large trichomes heavily pigmented with anthocyanin. As with segregations of other anthocyanin traits, intensity of Pn--hence ease of classification--is improved by growth at low temperatures. The Pn trait is also seen in tetraploid + seedlings and certain other tomato materials. It does not persist to later stages of growth unless the plants are grown at nearly the lowest temperatures that they will tolerate. Epistasis

of anthocyanin eliminators renders interactions between them and Pn impossible to score. In numerous combinations Pn has been classified with variable success, thereby probably accounting for the significant heterogeneity (X^2 = 16.51**, 3 d.f.) encountered among 4 F_2 families. The total segregation, 162+:409Pn, did not deviate significantly from 1:3 (X^2 = 3.23). In our substitution project it became apparent that Pn was persisting in all backcross lines for chromosome 8, even to BC_6, despite its random disappearance from substitution lines for other chromosomes. Data from a typical segregation in BC_6, appearing in the second table below, reveal significant association with l_1 and dl. The tighter linkage with dl than that with l_1 hints that Pn lies to the right of dl in the vicinity of al. It was also typical of these BC progenies that the monogenic ratios are disturbed and linkage values diminished.

pst (persistent style). One of the first unfruitful tomato mutants that I discovered is pst (16-5), found in a field of Early Santa Clara in 1943. It was mentioned briefly and illustrated in GENETICS 30:352, 1945. Styles remain adnate to the fruit throughout development; the fruit becomes strongly beaked, part of the tissue sometimes deriving from the style. In the unripe fruit, veins are prominent and color is darker than normal. A few fruits are usually set on pst plants, but seldom more than 10% normal. In seven different crosses investigated, pst behaves as a recessive, the pooled F_2--685+:224pst--conforming with expectation (X^2 = 0.03) and showing no appreciable interfamily heterogeneity (X^2 = 3.63, 6 d.f.). Heterozygotes may display an intermediate expression of beaking but not of unfruitfulness. Over a period of several years trouble was experienced in efforts to combine pst with gs in a single stock. That the source of this trouble was linkage was finally proven in the F_2 reported below. The two plants listed as pst-gs recombinants were unquestionably gs, but may not have been homozygous for pst. The classification of the + + group is dependable. The pst-gs linkage is therefore a tight one, representing a distance of 3 or less units. Additional information concerning the locus of pst is given in a research note by Dr. Kerr.

Summary of linkage tests

Chromosome	Tester	fy	mnt	Pn	pst
1	Jau			X	
	y	X			X
2	d	X	X	S	X
	Wo	X	X	X	
3	r	X			X
	rv	X	X	S	
	sy			X	
	wf	X	X		
4	clau			X	
	e	S	X	X	
6	c	X	X	X	X
	yv	X		X	

Chromosome	Tester	fy	mnt	Pn	pst
7	gs				L
	La	L	X		
	lg_5			X	
8	dl	X	L	L	
	l_1	X	X	L	X
9	ah	X	X		
10	ag			X	
	H	X	X	X	
11	a_1	X	L		X
	j_1	X	X		

Linkage data for combinations with fy, mnt, Pn, and pst

Combination	Prog.	+ +	+ t	m +	m t	Adj. cont. chi-square	Co.
fy-La	F_2	9	55	33	12	36.7)	20.5
	F_2	36	117	44	15	45.4)	
mnt-dl	F_2	118	43	46	4	7.2	30.5
mnt-a_1	F_2	72	23	28	0	6.8	0
Pn-l_1	BC	45	91	92	90	8.3	42.5
Pn-dl	BC	47	89	101	81	12.3	40.2
pst-gs	F_2	5	167	53	2	186.4	3.0

Rick, C. M., and J. E. Boynton
New linkage tests with Lpg and tl. In TGC 14:24 a strong indication of linkage was reported between Lpg and au_1. At that time four independent tests gave conflicting results for a Lpg-yv linkage; however, since then we have repeated the Lpg-yv test without finding any significant deviation from random recombination. Recent tests of Lpg with other markers on chromosome 1 dispel any doubts that the mutant resides on that chromosome. Of primary importance in the data listed below are the estimates of 15 for the Lpg-y interval and 38.5 for Lpg-inv_1. Considered with the 16.5 previously indicated for Lpg-au, they argue for a locus of Lpg in the short arm of chromosome 1 to the left of y.

Thiamineless (tl) was systematically tested against the following markers: (1) au_1, Jau, Lpg; (2) d_1, Wo^m; (3) rv, sf; (4) $clau_1$, e; (5) tf; (6) c, m_2, yv; (8) dl, l_1; (9) ah; (10) H; (11) a_1, hl. Except for variable, but non-significant tendencies of dissociation with hl and the following tests with m_2 and yv, these tests gave no indications of linkage.

The first convincing indication of linkage between tl and yv was encountered in a two-point test (third set of F_2 data under tl-yv below). For analysis of this combination the normal seedlings are scored and rogued out early, leaving behind the tl and yv phenotypes, which are then sprayed with thiamine. Subsequently, as tl-yv$^+$ plants assume a normal phenotype, they can be scored and removed. The remaining yv segregants are allowed to grow without further thiamine treatment. The tl-yv recombinants will ultimately show the bleaching and necrosis typical of the tl phenotype when they become sufficiently thiamine starved. With a little experience in these manipulations, the interaction can be scored readily.

Some uncertainly is attached to the third set of data, since it was obtained in our first experience with this technique. The best comparisons of linkage values can be made between the estimates made from a four-point test--tl x c-m_2-yv--of which two large populations were scored (all sets of data for tl-c, tl-m_2, and the first two sets of tl-yv). Thus, by eliminating the two sets of data from the two-point tests (the last two sets), the tl-yv interval is estimated at 7.0 units vs. 10.5 from the total of all sets. The linkage intensity for tl-m_2 is very much less (30.5-35.0), and tl is virtually independent from c. Of particular significance is the fact that the only tl-yv recombinant recovered from the 4-point crosses was also homozygous for m_2 and c. It follows that tl probably lies outside the c-m_2-yv group, about 7 units to the right of yv.

Linkage data for combinations with Lpg and tl

Combination	+ +	+ t	m +	m t	Adj. cont. chi-square	Co.
Lpg-y	8	21	37	8	19.9	15.0*
Lpg-scf	46	36	151	17	35.7	33.5*
Lpg-inv	51	31	140	28	12.5	38.5*
tl-c	203	72	87	22	n.s.	45.0
	271	97	97	35	n.s.	50.0
tl-m_2	176	99	96	13	20.7	30.5
	280	88	119	13	11.0	35.0
tl-yv	184	91	109	0	45.0	0
	251	117	131	1	52.2	9.0
	167	89	126	3	48.4	14.5
	103	28	41	1	6.9	20.0
Total	838	402	474	5	145.0	10.5

*Co. values were estimated from the +t/++ proportion because the yield of Lpg is far below expectation.

Rick, C. M., J. E. Boynton, and A. F. Reeves New mutations at old loci.

Over the past several years we have accumulated the following four new mutants, all of which proved to be allelic with other, previously described genes.

$clau_1$(ff) The vc mutant received from Dr. Kerr (TGC 14:17) showed remarkable similarity to $clau_1$ in all stages of growth. A cross was made between it and $clau_1$, yielding four seedlings, each showing the clau phenotype. The vc mutant thus constitutes the fourth mutation known at the $clau_1$ locus.

flc_1 In one of their breeding lines, Dr. P. G. Smith and Archie Millet found segregation (15+:8mutant) for a reduced seedling that tended to wilt excessively and to become permanently dessicated in the margins of wilted leaves. Test crosses were made with the phenotypically similar flc_1 and not_1. The cross with flc_1 yielded 15 seedlings of flc_1 phenotype; that with not_1, 17 normal seedlings.

l_1 Fruits of two plants (2-611, 2-613) found in var. VF14 were brought to us by Mel Zobel in 1964. In respect to foliage and fruit color, both conformed suspiciously to the lutescent phenotype. Progeny of both bred true for the trait. Allele tests with l_1 yielded two progenies of 3 and 8 plants, all of which were lutescent; a second cross with l_2 gave 25 seedlings, all of normal phenotype. These mutants, with 2-491 (TGC 12:42), might prove useful to workers who need isogenic lutescent, since they conform to the respective parent variety in every respect except for the phenotype of l_1.

ru_1 In 1963 Dr. P. G. Smith and Archie Millet discovered segregation in one of their breeding lines for a mutant that closely resembled ru_1. Presumably the same mutant appeared in 1965 in another one of their lines, segregating 24+:6mutant. Crosses between mutants of the first segregation and ru_1 yielded four families of 11, 11, 17, and 20 seedlings, all with ru_1 phenotype.

Robinson, R. W., and W. Mishanec Another gene (ae) for chromosome 8.

In our search for new genes on chromosome 9, we previously overlooked several anthocyaninless mutants because their phenotype is identical to that of the marker gene ah used to detect linkage. The finding by Rick that the chlorophyll deficiency gene nv is closely linked with ah afforded us an opportunity to determine if any more anthocyaninless genes are on chromosome 9.

Results to date have been negative. None of the anthocyaninless genes tested appear linked with nv or allelic with ah. Fortuitously, however, the entirely anthocyaninless gene was found to be on chromosome 8. The stock used as the source of nv in the cross with ae also happened to be dl. Independent segregation occurred with nv and ae but not for ae and dl (Table 1), with $30.8 \pm 8.1\%$ crossing over indicated between ae and dl.

Burdick (TGC 9:21) previously reported a highly significant deviation from expected in the F_2 of a cross of ae with another chromosome 8 gene, l. The deviation, however, could not be attributed to linkage because he obtained more crossover types than expected. Since l and dl are linked about as closely as dl and ae appear to be, dl is evidently between l and ae.

Table 1. F_2 repulsion phase segregation.

	++	+dl	ae +	ae dl
Obs.	77	42	53	7
Cont. Exp.	86.4	32.6	43.6	16.4

$X^2 = 11.15$, $p < .01$

Robinson, R. W., and S. Shannon

Interaction of crimson genes and temperature influences flower color.

The original stock we received for the cultivar High Crimson proved to be quite variable. Some plants were dominant and others recessive for sp and u. Some had normal fruit and flower color while others had crimson fruit and an unusual flower color, the petals being paler than normal and the anthers a deep orange. When plants with the unusual flower color were progeny tested they were found to be homozygous for the crimson fruit color genes and the dominant alleles of sp and u. Flower color was not consistent; all of the progeny in the field had unusual flower color during part of the season, but at other times they had normal flower color.

The influence of environmental factors on the expression of flower color of High Crimson was studied in the greenhouse. Exploratory experiments with different light intensities and photoperiods were unsuccessful. Exposure to high temperature also did not affect flower color, although it did influence foliage color. Leaves of High Crimson, but not of the 4 cultivars tested that do not have the crimson genes, became yellow after 125 continuous hours at 90° F. The unusual flower color was produced only when the temperature was cold. A few days after the temperature was reduced to 50° F, the plants having the crimson gene or genes developed the unusual flower color while plants with normal fruit color continued to have normal colored flowers.

The cold temperature exerts its influence in a late stage of floral development. Flowers exposed to cold temperature in the bud stage had normal color if the subsequent temperature was warm, and flowers which did not receive a cold treatment until just prior to anthesis developed the orange pigment. Induction of the unusual flower color was obtained when newly opened flowers were detached, placed on moist blotter inside a plastic box, and kept for a week in a refrigerator. It would be useful for breeding purposes to identify at the time for pollinating which plants will have crimson fruit, and it appears promising that this can be accomplished by exposing detached flowers from plants in the field to low temperature in the laboratory.

The unusual flower color is associated with crimson fruit and indeterminate habit in segregating generations. It is considered most likely that the unusual flower color is a pleiotropic effect of the crimson genes and not due to the alternate possibility of different but closely linked genes.

Robinson, R. W., W. Mishanec, and S. Shannon Fruit setting ability in relation to extreme temperatures.

Tomato varieties bred to set fruit when the temperature is cold have been observed to have superior fruit setting ability at high as well as low temperature. Breeding for improved fruit setting at high temperature has also resulted in varieties with excellent fruit set at both extremes of temperature. Accordingly, it is suspected that genes governing fruit set at high temperature may also influence fruit set at low temperature.

Cold temperature appears to affect fruit setting primarily through its influence on microsporogenesis (TGC 15:57). An experiment was undertaken to see if high temperature has a similar effect, as would be expected if the same genetic system determines fruit setting response to both high and low temperature. Plants were grown in a greenhouse at 65-75° F until the flowering stage, kept in a growth chamber at 90° F for 24 hours, then returned to the greenhouse. Pollinations made when the plants were at the high temperature and for the following week were successful, but the plants were unfruitful 10 days after the heat treatment. The interval from extreme temperature exposure until the unfruitful period coincided for both high and low temperature treatments. Varietal response to both high and low temperature was similar; Fireball and Geneva breeding line 790 had the best fruit set, and Earliana the poorest following exposure to 90° F or 50° F. During the unfruitful period, there was reduced production and increased sterility of pollen by plants previously exposed to either high or low temperature. At this time, flowers of both heat and cold treated plants had greenish petals and shrunken anthers. Anthers of abnormal flowers produced after either heat or cold treatments occasionally contained tetrads which stained poorly with acetocarmine, suggesting that high temperature disrupted the same stage of meiosis as low temperature. Conclusive evidence is lacking to prove that the same genes influence fruit setting at both high and low temperature, but our results are in agreement with this theory.

It was also observed that fruit shape was influenced by temperature during the flowering period. Flowers pollinated the day before or on the day the temperature was increased to 90° F developed into fruit pointed at the blossom end, similar to the effect of n. High temperature treatment also stimulated elongation of styles of flowers that opened several days after the end of the high temperature treatment, and this effect persisted for several weeks.

Scholz, Günter Chloronerva: a peptide deficient mutant.

The chlorotic mutant chloronerva is changed to the phenotype of the wildtype "Bonner Beste" with respect to morphology, differentiation, and chlorophyll content by grafting upon normal rootstocks as well as by application of water extracts from normal plants to the leaves of the mutant. The "normalizing factor" has been shown to be a hydrophile compound of organic nature with moderate molecular weight. It occurs throughout the whole plant and has been found in several species investigated (TGC 11:5).

According to recent findings, the compound is a peptide, which has been isolated from Medicago sativa by means of ion exchange chromatography and gel

filtration. After acid hydrolysis eight different amino acids have so far been identified. The pure compound is fully active in the biotest with mutant seedlings in the range of less than one milligram peptide per plant. Work on its constitution is in progress. Thus chloronerva represents a genetically caused peptide deficiency, a pattern hitherto unknown among higher plants and rarely described from microorganisms (Flora 154:589, 1964).

In the course of nutrition experiments using radioactive iron, a disturbed iron distribution in chlorotic leaves was established by autoradiography. The pattern of iron distribution seems to be exactly identical with the distribution of chlorophyll, both limited to the nerves of the leaflets (Kulturpflanze 13:239, 1965). The hypothesis is put forward regarding the peptide responsible for iron translocation.

Stettler, R. F., and Dorot Imber

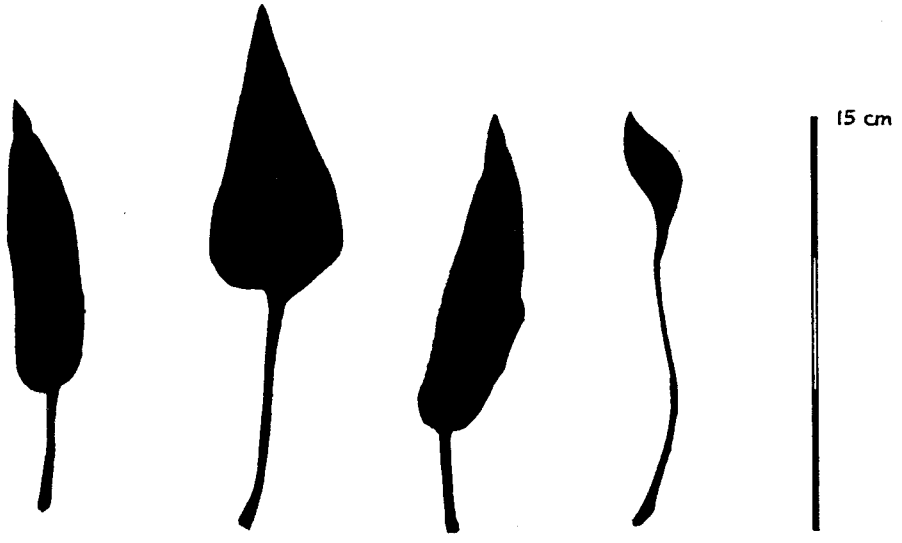
Available leaf-shape stock from the research of the late James A. Jenkins.

Over the period of the last ten years James A. Jenkins devoted much effort to the study of leaf morphogenesis. In the last description of this research he proposed: "The underlying assumption in this study is that genes determine developmental processes in much the same manner as they do in the control and regulation of biosynthetic pathways. The procedure has been to assemble several mutant lines, each differing from normal by a single gene and each, presumably, blocking or modifying a single step in the pathway to normal leaf development. By examining the morphological and biochemical differences between plants containing the genes acting singly and in combination, hopefully something can be learned about the way in which the normal alleles of these mutant genes cooperate with others in the production of a normal leaf."

The basic material for the study consisted of seven different mutant stocks of the tomato, namely potato (c), Curl (Cu), dwarf (d), entire (e), Lanceolate (La), Mouse ear (Me), and trifoliate (tf). Since La is sterile when homozygous it had to be carried as a heterozygote.

The first step in the study was to compare mutants with normals to determine the morphological and biochemical differences that result from the mutant genes acting singly. Significant results were obtained and reported with the lanceolate material (Mathan, D. S. and J. A. Jenkins, 1962, Am. Jour. Bot. 49:504-514; Stettler, R. F., 1963, Am. Jour. Bot. 51:253-264). To improve the power of comparison between the seven mutant genes, they were transferred to a common standard background (Marglobe).

The second step planned was to compare each of the mutant genes in dihybrid combinations with normal and with the two corresponding single-gene lines. Again, to avoid the influence of modifying genes, it was planned to transfer the gene pairs to the Marglobe background. As of the fall of 1965, 20 of the 21 possible digenic combinations had been produced, 16 of them verified in several generations. Typical leaf silhouettes from four of these dihybrids are illustrated below. Remarkably, the combinations of c/c tf/tf and Me/Me tf/tf produced exclusively simple, entire leaves whereas each of these genes acting singly produces compound leaves. This shows that similar leaf phenotypes may be produced by different genotypes; furthermore, it shows that in the case of leaf morphogenesis the phenotypic expression of two genes



c/c La/+ c/c tf/tf e/e La/+ Me/Me tf/tf

acting jointly may be quite different from the phenotypic expression of the same two genes acting singly (Jenkins, J. A., 1963, Proc. XI. Intern. Congr. Genetics, I:233).

While much effort in the leaf-shape study was devoted to the production of the experimental plant material itself, parallel studies were conducted to develop adequate techniques for the biochemical analysis of the material (El-Sahrigy, M., 1964, Ph.D. Diss.; Imber, Dorot, unpublished). It was at this stage that this promising research was brought to a sudden halt by the death of the senior investigator.

Although there are no plans by any member of the Genetics Department in Berkeley to continue the leaf-shape project, it is felt that the available stock may be of considerable interest to researchers elsewhere. The material consists of (a) single-gene stock, (b) single-gene stock with varying degrees of Marglobe background, (c) digenic stock, and (d) some trigenic stock. A list of the available lines is presented in Part III of this Report. In addition to the leaf-shape stock there is also material available resulting from an earlier study on fruit size and shape. Requests should be addressed to the Genetics Department, University of California, Berkeley, California 94720.

Stringam, G. R. Mutants from chemical and irradiation treatments.

Several new mutants have been isolated from chemical and irradiation treatments to isolate new interchanges. Some of the more extreme mutants are described below along with their proposed symbols. All treatments were made on the determinate variety Early Fireball. These mutants have been observed for several years and appear to be stable.

corollaless-2 (cs_2). Plants without petals; anthers dialytic; stigma protruding; self fertile with only occasional fruits set without hand pollination.

cauliflower-2 (an_2). Inflorescence highly branched, terminates in highly compact ovary-like masses of tissue; aborted flowers.

lazy (lz). Seedlings emerge normally; in about 3 weeks, plants become extremely prostrate; weakly branching but normal fruit and seed set, segregating in the same culture as an_2.

extreme dwarf-7 (d_7). Plants much reduced, seldom more than 10-12 inches tall; short internodes; leaves highly divided with many leaf segments; high anthocyanin content gives purplish cast to leaves; small seedless fruits.

extreme dwarf-8 (d_8). Plants much reduced,seldom more than 6-8 inches tall; short internodes; normal flowers, but no fruit set under field conditions.

albina-4 (ala_4). White or cream-colored cotyledons; lethal; irradiation induced in Early Fireball; shows linkage with T2-8 interchange induced in the same stock.

Stringam, G. R. A new mordant for tomato sporocytes.

A new technique in mordanting sporocyte material has been used with some success on buds collected from mature plants. I have found that buds collected from mature plants do not take up the iron acetate mordant when it is added to the fixative. After fixing in the usual way with the iron acetate mordant, buds are transferred to 70% alcohol. Staining can be improved by addition of a few drops of 5% EDTA to each vial (about 1 drop EDTA/ml of alcohol). The material is then refrigerated over night before use to allow the mordant to penetrate the buds.

Stringam, G. R., and C. R. Burnham Interchanges from chemical and irradiation treatments.

Work is under way to identify 13 new interchanges induced by chemical treatment and irradiation of dry seed. Break positions are of interest in determining whether there is a differential action of certain chemicals vs. irradiation in causing breakage in hetero- vs. euchromatin.

4 interchanges have been isolated from thermal neutron treatment 4500 rads for 25 hours

2 from .05% ethylene oxide treatment for 9 hours

6 from .06% " " " " "

1 from .07% " " " " "

No interchanges were found in material treated with ethylene imine.

We are attempting to establish a tester set of interchanges which will identify the chromosomes of any unknown interchange. Data from intercrosses of previously identified interchanges obtained from Brian Snoad indicate that some of the designations were in error.

Tal, M. Estimation of genetic differences between L. esculentum and S. pennellii.

The hybrid Lycopersicon esculentum x Solanum pennellii was studied in respect to the inheritance of nine morphological characters: degenerate inflorescences, number of flower parts, determinate plant habit, sterility of the anther tip and the ratios: style/anther length, petal width/length, sepal/petal length, terminal leaf segment width/length and pedicel lower segment/whole length. The last six characters differentiate the two species, whereas the first appeared as a novel character only in advanced hybrid generations, and the second and the third are mutants within L. esculentum.

The analysis included: (a) estimation of the number of 'major factors', i.e., chromosomal segments transmitted as hereditary units, (b) calculation of genetic correlations, (c) test of linkages, and (d) test of variability. The estimation (a) was based on the frequency of lines that were heterozygous for pennellii major factors among the total lines derived by one selfed generation following four successive backcrosses to L. esculentum. In respect to assumptions made for several variables, the number of major factors estimated is minimal. The correlations (b) were derived from the analysis of variance and covariance of the selfed BC_4 lines. The tests of linkage (c) and variability (d) were based on comparisons, for the last five characters listed above, between the means and coefficients of variation, respectively, of groups that were homozygous and heterozygous for genes marking eight chromosomes in the BC_1 [L. esculentum x (L. esculentum x S. pennellii)] generation. These analyses were supplemented by study of an F_2 generation.

The characters were found to range from monogenic through intermediate (such as di- and trigenic) to more complex inheritance. Three characters--number of flower parts, pedicel ratio and sterility of the anther tip, which were found to be under simple genetic control, are important systematic characters. Degeneration of inflorescences appears to be the product of an interaction between a recessive gene incorporated from S. pennellii and a certain minimal proportion of esculentum genome. High genetic correlations were found between style, petal and leaf ratios. These can be explained by the pleiotropic effects of major factors. A pleiotropic action was ascribed also to the gene controlling the number of sepals, petals and anthers.

Several aspects of the research reveal that the esculentum parent varies more in phenotypic expression than does the wild species. This phenomenon is explained by the stronger developmental canalization of S. pennellii, which has been exposed continuously to the action of natural selection.

A high proportion of the morphological differences between the species shows definite dominance relations. Dominance is not limited exclusively to either parent.

Tomes, M. L. Flesh pigment analyses--new mutant program.

Pigment analyses of three fruit color mutants received from K. Verkerk at Wageningen were reported last year. Of these, 704-2$\alpha\alpha$ gave values typical of an r r strain, 706-27$\alpha\alpha$ gave values typical of an at at type, and 377-2$\alpha\alpha$ appeared to be a new flesh color mutant.

We have reanalyzed each of the above using samples from the 1965 field,

with conclusions as reported (Tomes and Verkerk, TGC 15:61-62). Included were two other mutants from the irradiation program at Wageningen. One of these, Verkerk's 509-105αα, gave pigment values almost identical to those obtained for 377-2αα. Under 1965 conditions these were (means in μg/g fresh wt):

	No. of samples	Phytoene	Phyto-fluene	Beta-carotene	Zeta-carotene	Gamma-carotene	Lycopene
509-105αα	8	60.0	20.2	5.2	17.2	1.0	14.2
377-2αα	4	55.0	23.9	5.6	17.2	1.1	14.6

These two mutants are similar in appearance, having orange-fleshed fruit which shades to yellow in the center. Both also have the same chlorophyll abnormality in that the growing tips and new leaves are pale yellow. From the chemical analyses and phenotypic similarities, these are believed to be identical.

The other mutant, Hildering's I 1-20, appears distinct, if chemical analyses can be used as a criterion. This mutant has pale orange-red flesh. Four samples averaged: 3.1 μg/g phytoene, traces of phytofluene, 4.6 μg/g beta-carotene, 0.4 μg/g gamma-carotene, and 12.2 μg/g lycopene. These values are somewhat like those obtained with apricot (at), except that in apricot there is usually almost complete inhibition of lycopene. Here lycopene is grossly restricted from normal values of 60-90 μg/g.

Tomes, M. L., H. T. Erickson, and R. J. Barman Crimson, its location, inheritance, and modification of flower color.

Butler (TGC 12:17-18) postulated a two gene difference to account for the observed recombination between crimson and normal. Graham, in his mimeo "Work with High Crimson - 1964," noted that more than 5000 plants from crosses between self-pruning (sp) and crimson failed to yield an sp-crimson recombinant. The latter was sufficient to explain the data from a small (37 plants) greenhouse F_2 of BB x crimson. Of 9 red-fleshed recombinants, 8 were classed as crimson (Tomes, Erickson and Barman, Veg. Imp. Newsletter 7:16-17). Thus, the crimson factor (or one of them) is linked to B. B is very closely linked to sp on chromosome 6 (Ito and Currence, TGC 14:14-15).

Three F_2 progenies involving B and crimson were classified in 1965, as follows:

	orange	orange-red	crimson	normal red	total
F_2 - high beta (BB) x crimson	33	103	57	0	193
F_2 - intermediate beta (Bb) x crimson		116	32	0	148
F_2 - Caro-Red (Bb) x crimson		139	49	0	188

The mature fruit classifications were made by three people and the crimson character of the red-fleshed recombinants seemed clear. Thus, crimson is fairly closely linked to B. If one assumed complete linkage, these data give an acceptable fit for a 9:3:4 (expected from high beta with the modifier of B),

or a 3:1. No crimson-B recombinants could be distinguished among the orange or orange-red fleshed plants. If a second gene is involved in the expression of crimson, these 3 BB parents must have shared this gene in common with the crimson parent.

The F_2's of 6 crosses between red, self-pruning varieties and various crimson selections all gave ratios which failed to deviate significantly from a 3:1 for normal versus crimson. But, these ratios would be difficult to distinguish from the 13:3 expected if the parents differed by both a dominant and a recessive. No sp-crimson recombinants were recovered in any of the 6 F_2's totaling 890 plants, confirming the close linkage to sp.

In other F_2's, rr x crimson gave 67 red : 22 crimson : 38 yellow, an acceptable fit for a 9:3:4. High Crimson x at at, however, gave 78 red : 50 crimson : 51 apricot, a significant deviation from a 9:3:4. Linkage between at and crimson is suggested. It should be noted that the F_1 of this cross appeared somewhat crimson-like, in contrast to the F_1's of the other crosses reported.

Graham also noted that certain crimson selections have flowers which have an orange tint. He has attempted to use this flower color difference as an index of intensity of flesh color in crimson stocks. In each of the crosses reported, flower colors were classified. In almost every case, would-be crimson-fleshed plants could be distinguished by orange tinted flowers prior to fruit maturity. In certain crosses, the prediction was almost perfect. A few crosses were extremely difficult to classify, although several attempts were made. This suggests genotypic modification. As noted by Graham and others, high temperatures also caused flowers to bleach making classification difficult. Greater accuracy was achieved during cool weather, or by taking cuttings with unopened flowers into controlled climate chambers. Since old gold (og) is located in the same region of chromosome 6, and since the phenotype of og is similar, it seems possible that og and the crimson factor linked to B or sp are synonymous. An effort to test this, and to locate the crimson factor more precisely is being made.

Wann, E. V., W. A. Hills, and E. J. King The expression of crimson in combination with at at. The expression of crimson is known to be a reduction of the beta-carotene fraction in the tomato fruit and an enhancement of the lycopene fraction (TGC 15:60-61). The apricot mutant (at at) is known to inhibit the synthesis of lycopene to only a trace without apparent effect on the beta-carotene fraction (Jenkins and Mackinney,1955, Genetics 40:715-720). Preliminary data on lycopene contents (Table 1) indicate that the crimson genes have some effect on the lycopene content in the presence of homozygous recessive at. The backcross of the F_1 (crimson x apricot) to apricot further indicates that the gene(s) in crimson affecting lycopene content is probably recessive.

The beta-carotene contents were similar in both normal and apricot segregants. Therefore, all individuals in the progenies segregating for at at were used to establish the frequency distributions for beta-carotene content (Table 2). Conceivably, the distribution of the F_2 could be judged to fit a 1:2:1 segregation ratio, and each of the backcross progenies to fit a 1:1 ratio. These segregation ratios and the overlapping of the backcross progenies for the intermediate class suggest a single factor difference with incomplete dominance controlling the beta-carotene contents.

If the above conclusions prove to be true, perhaps more of the details of the inheritance of crimson and the nature of gene action can be determined from the crimson-apricot recombinants.

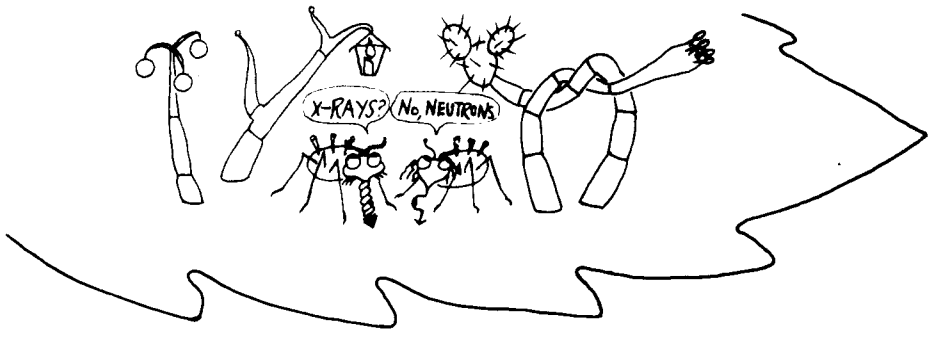
Table 1. Frequency distributions for progenies segregating for lycopene content from the cross crimson (P_1) x apricot (P_2); at at segregants only.

Population	Micrographs/gram lycopene												
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
	Frequencies												
F_2	8	1	5	1	3	3	3	0	2	2	1	2	1
$BC_1 P_2$	4	4	13	2	2								
P_2	1	1	2	1									

Table 2. Frequency distributions for progenies segregating for beta-carotene content from the cross crimson x apricot.

Population	Micrograms/gram beta-carotene										
	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.8	4.2	4.6	5.0
	Frequencies										
P_1 (crim)	1	5	2	1							
P_2 (apr.)									2	2	1
$F_1(P_1 \times P_2)$					2	6	3				
F_2 "	0	0	5	8	12	20	17	9	5	4	1
$BC_1 P_1$	2	2	5	8	6	7	3	1	1		
$BC_1 P_2$				2	4	4	2	3	4	3	1

** ** ** ** ** ** ** **



PART II

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PART III

ADDITIONS TO STOCK LIST

STOCKS AVAILABLE

Source	Name	Description
Bohn, G. W.	ms$_9$ Od pau r r$_1$ y wf r wf	Marker testers for chromosome 3. F_1 and F_3 multiple marker stocks available.

Univ. of Calif. at Berkeley
Dept. of Genetics

Stocks of genes affecting leaf shape.

The following list was condensed from an enumeration by Miss Dorot Imber of seed lots in the collections of the late Dr. J. A. Jenkins. For any combination of genes only the most advanced material is listed; seeds of some of the intermediate generations utilized in breeding these combinations are available.

A. Lines used in the Leaf-shape project.

1) Pure lines.*

No.	Gener.		Variety/Genes Present
152	P16		L. pimpinellifolium
156	P12		L. esculentum var. Marglobe
170	P19		d, r, y, c, a, l
234	P18	"Dwarf-Dwarf modifier" line	d, c, l, u, H, dm
378	P15	"Dwarf"	d, p, o, s, bk, r
766	P18	"Entire"	e
837	P 7	"Potato"	c var. red pear
1504	P13	"Lanceolate"	La
1583A	P 3	"Trifoliate"	tf, wt, mc
1595	P 8	"Mouse ear"	Me
1596	P 7	"Curl"	Cu

2) Hybrid lines.

X260	F10	c-e	(766 x 234)
X3549A	F 6	d-c	(170 x 234)
X4527A	F 7	c-e	(766 x 837)
X4534A	F 6	d-e	(766 x 378)
X4696A	F 7	c-Me	(837 x 1595)
X4817A	F 5	d-c	(837 x 378)

*Note: The lines were used as standard lines of the underlined genes.

B. Leaf shape monohybrid. Stocks of single genes being bred into lines of uniform genetic background. All lots still segregating.

Acc. No.	Gene	(source)	Background	Generation**	Proportion of background***
X5902, X5903	d	(378)	156 (Marglobe)	"B_1"	3/4
X5904, X5905, X5906	c	(837)	156	"B_1"	3/4
X5907, X5908	e	(766)	156	"B_1"	3/4
X5909, X5911	La	(1504)	156	$2B_1$	7/8
X5918, X5923	tf	(1583)	156	$2B_1$	7/8
X5912, X5913	Me	(1595)	156	$2B_1$	7/8
X5914, X5959	Cu	(1596)	156	$2B_1$	7/8
X5814, X5815 } X5675, X5811 }	La		152 (L. pimpinellifolium)	$2B_2$	7/8

** B = backcross; T = test cross; coefficient = number of recurrent backcrosses and test crosses; subscript = number of selfed generations (e.g., $4B_3$ = third selfed generation of fourth backcross).

*** Theoretical proportion of the genome of the line serving as the background in the genetic material of the hybrid.

C. Dihybrid stocks.

Acc. No.	Genes	Generation**	Background		Segr.	Establ.
X5783I, X5787 } X5656, X5142 }	d-c	F_2	156	1/2	x	
X5734	d-e	T_2	156	3/4	x	
X5901, X5953	d-La	"$4B_1$"	156	31/32	x	
X5636, X5710, X5830	d-+/La	T_2				x
X5370, X5375	d-tf	T_3	1583	3/4		x
X4536	d-tf	F_{3-5}				x
X5920	d-Me	$5B_1$	378	63/64	x	
X4537	d-Me	$F_{5,6}$	378			x
X5962	d-Cu	$5B_1$	378	63/64	x	
X4826	d-Cu	$B_{4,5}$				x
X5781, X5801	c-e	F_2			x	
X5926, X5927	c-La	$5B_1$	837	63/64	x	
X5632, X5633	c-+/La	$4B_2$	837	31/32		x
X4529	c-tf	$F_{6,7}$				x
X5931, X5932	c-Me	$5B_1$	837	63/64	x	
X4769	c-Me	$F_{5,6}$				x
X5933, X5948	c-Cu	$5T_1$	837	63/64	x	
X4667	c-Cu	$F_{6,7}$				x
X5934, X5947	e-La	$4T_1$	766	31/32	x	
X4614	e-+/La	F_7				x
X4857	e-tf	$F_{4,5}$				x
X5935	e-Me	$4T_1$	766	31/32	x	
X5695	e-Me	$F_{6,7}$				x

Acc. No.	Genes	Generation**	Background		Segr.	Establ.
X5930, X5946	e-Cu	$4T_1$	766	31/32	x	
X4668	e-Cu	F_7				x
X5723	tf-La	"$3B_2$"	1583	63/64	x	
X5222	tf-+/La	B_4				x
X5796	+/La-Me	$3T_2$	1595	15/16		x
X5729	La-Cu	$3T_2$	1596	15/16	x	
X4669	+/La-Cu	$F_{5,6}$				x
X5944	tf-Me	$4T_1$	1583	31/32	x	
X4698	tf-Me	$F_{6,7}$				x
X5772	tf-Cu	$2B_2$	1583	7/8	x	
X5143	tf-Cu	F_4			x	
X5711	Me-Cu	$2B_2$	1595	7/8	x	

** B = backcross; T = test cross; coefficient = number of recurrent backcrosses and test crosses; subscript = number of selfed generations (e.g., $4B_3$ = third selfed generation of fourth backcross).

Clayberg, C. ++/aw-ms_{15} Limited amount seed available.

Martin, M. W. Loran Blood VeVe with Sp (Phytopath. 41:986-990).
VR Moscow VeVe with sp
CVF4 Resistant to curly top, Verticillium wilt, and Fusarium wilt.

Dept. de Horticultura
Universidad Agraria
La Molina, Lima, Peru

Small amounts of several collections of L. pimpinellifolium.

Retig, Nira Low bushy lines with short internodes, determinate or indeterminate, resistant to Fusarium wilt. Fruits oval, oblate, or fasciated.

High pigment lines, determinate or indeterminate, resistant to Fusarium wilt. Fruits oval-shaped, globular or fasciated. (Kedar & Retig:TGC 16).

Rick, C. M. 2-72 Autodiploid San Marzano
2-95 4N San Marzano
2-227 4N Pearson

LA291 ms_2 a hl
LA319 ms_{17} Wo^m d_1
LA321 ms_{17} a d_1 c l_1

Linkage testers:

LA780 c-yv (6) ag-H (10)
LA782 sy-sf (3)
LA783 au (1) Wo^m-d (2) Af (5)
LA784 ful_1-e (4) a_1-hl (11)
LA785 dl-l_1 (8) ah (9) La (7)

Multiple markers for chromosomes 4, 6, 8, and 11:

LA917 *clau*$_1$-*ful*$_1$-*ra*$_1$-*e*-*di*$_1$ (4) (synthesized by G. S. Khush)
LA773 *c*-*m*$_2$-*yv* (6)
LA897 *l*$_1$-*bu*-*dl*-*al* (8)
LA925 *j*$_1$-*hl*-*a*$_1$-*f* (11)

Stocks of various species of *Lycopersicon* and closely related species of *Solanum*.

Stocks of the primary trisomics can be supplied in limited quantity. Seed transmission is so poor in some that they must be sent as cuttings.

Clones of the following items are available. Cuttings are taken in May or later.

F_1 *L. esculentum* x *S. lycopersicoides*
F_1 *L. esculentum* x *L. chilense*

The following seed lots were transmitted to me for distribution from Dr. P. A. Young:

Banana leaf
Jagged leaf
Summer cherry
CP 1951 var. Young
G912 *pe*-*lg*$_1$-*vi*
T2300) Improved strain of var. Porter
T2301) (cold resistant?)

Robinson, R. W. *ah*-*nv*-*Tm*$_2$ Multiple gene stocks for chromosome 9 seed

Skrdla, W. H.
Regional Plant Introduction Station, Iowa State University, Ames, Iowa 50010

The world collection of tomato introductions for the Crops Research Division ARS, USDA is maintained: species, species hybrids, named varieties as well as foreign introductions of *L. esculentum* and certain genetic marker stocks.

STOCKS DESIRED

Whalen, R. H.

Holmes Supreme
Honor Bright
Rouge Naine Hative
Tuckswood

PART IV

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PUBLISHED IN 1964

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PART V

FINANCIAL STATEMENT

(to December 31, 1965)

		Total
Balance from 1964		$367.26
Receipts		
Assessments	$174.75	
Sale, back numbers	74.75	
Interest on savings	8.11	257.61
Assets		624.87
Expenditures		
TGC Report No. 15, 1965		
Multilithing and covers	296.35	
Postage	27.63	
Miscellaneous		
Postage for notices and back issues	4.87	
Mimeographing newsletter	15.64	
Invoice pad	.61	345.10
Balance		$279.77

MEMBERSHIP STATUS

Assessments paid for 1965	49
1966	151
1967	67
1968	13
1969	10
1970	7
1971	1
1978	2
Total members	300

APPENDIX

Interim Report of the Committee on Varietal Pedigrees 1962-1965

This is the third attempt to illustrate the rapidity with which the factorial work is being utilized in the creating of the modern tomato. If one wishes to search for the past parentage of a variety, this Report and the earlier ones may help. The two issued in the past are as follows:

TGC 9: 1959--an attached supplement between pages 36 and 37;
TGC 11:36-51, 1961.

In reading the pedigrees it will be noted that there is a drift towards small, compact plants, caused by the search for types to fit into machine picking. The use of such terms as brachytic, birdsnest, dwarf, and compact habit are on the increase. Unless a careful record is made of parentage, confusion may creep into the use of such terminology.

The southern type of self-pruning habit, created to cope with summer dormancy and often termed self-topping, might best be called self-pruning or determinate (long season). The other heavily branched type might be called self-pruning (short season).

The pedigrees suffer from regionalism. To correct this, an effort will be made to include on the Varietal Committee workers from such areas as Hungary, Israel, Italy, Poland, and Japan.

COMMITTEE ON VARIETAL PEDIGREES

Alexander, L. J.	Graham, T. O. (Chairman)	Miller, J. C.
Darby, L. A.	Hernandez, T. P.	Odland, M. L.
Foskett, R. W.	Honma, S.	Peto, H.
Frazer, W. A.	John, C. A.	Robinson, R. W.
Gobelman, W. H.	Lambeth, U. N.	Stark, F. C.
Gilbert, J. C.	Lana, E. P.	Strobel, J. W.

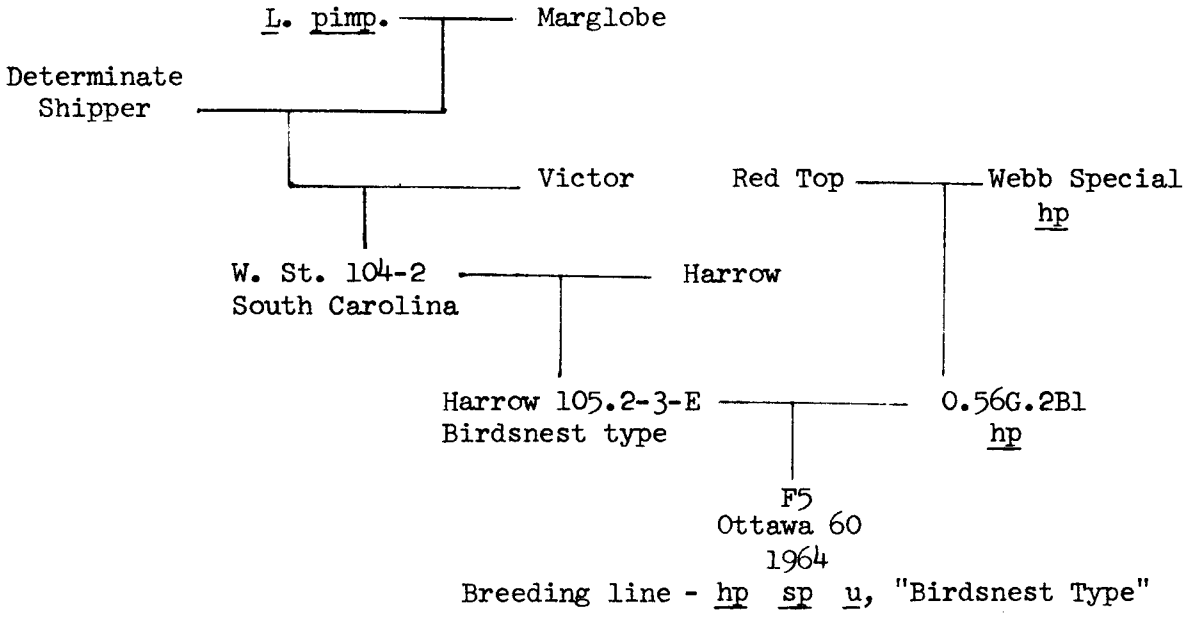
BIRDSNEST TOMATO TYPE--ONTARIO CO-OPERATIVE VARIETY DEVELOPMENT TRIALS

Metcalf, J. G., L. Lyall, and T. O. Graham.

The first description in Vegetable Improvement News Letter, 1965, stated that the leaves curved inward and circled over the fruit, and that the fruit nested in a layer of incurved leaves; thus the term birdsnest was used. This description is not entirely accurate. In a letter of December 17, 1965, J. G. Metcalf describes the birdsnest type as follows:

"We have noticed no incurving of leaves on our lines. The birdsnest habit seems to be caused by a reduction of the internode length accompanied by an increase in leaf size. Leaf colour appears to be darker than normal. Birdsnest does not appear to be connected to sp. We have developed birdsnest lines which carry the gene for indeterminance. It is, of course, impossible to classify determinance in the birdsnest material except by outcrossing."

The first birdsnest pedigree to receive mention traces to Lloyd Lyall, Vegetable Crop Section, Research Station, Central Experimental Farm, Ottawa, Ontario. Ottawa 60 was described. The section of this pedigree dealing with the parentage which traces to South Carolina has been supplied by Dr. E. V. Wann of the USDA Crop Research Division, Charleston, South Carolina.



Ottawa 60, like all birdsnest types, has small compact plants approximately 1 1/2 feet high, is brachytic in appearance, and may carry the br gene. The plants are so small that they can be placed in the field at approximately 20,000 plants per acre.

The second pedigree is the result of a cross made by Dr. L. Butler, Department of Zoology, University of Toronto. In this cross all efforts carried out at Guelph by Dr. Butler and T. O. Graham failed to combine the crimson gene combination with the birdsnest type. The pedigree is as follows:

(Birdsnest Harrow 105.2-3-E x $\underline{Crn_1}$ $\underline{Crn_1}$ $\underline{crn_2}$ $\underline{crn_2}$) F_5

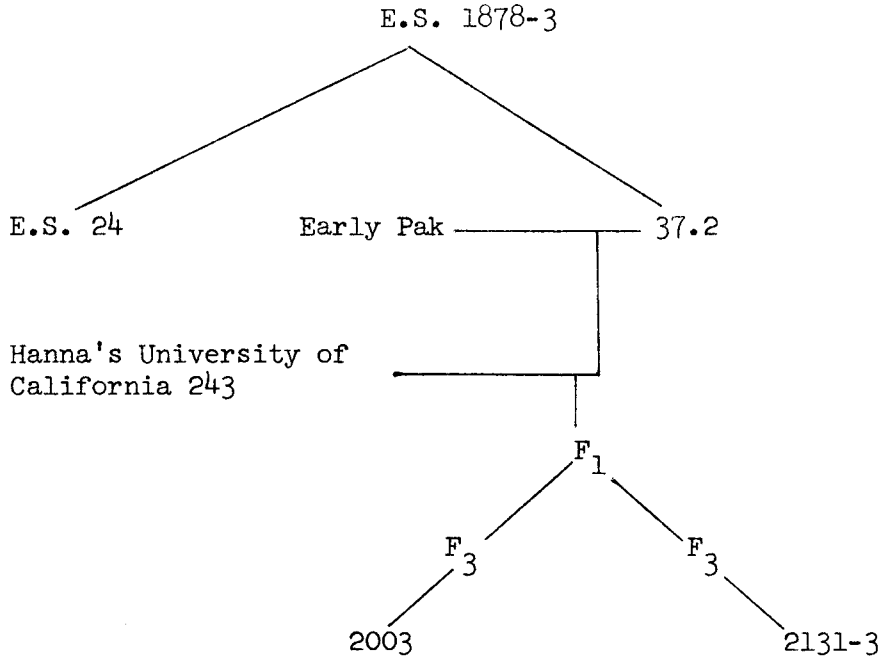
Work with this cross has ceased, but Professor J. H. Lee, at the School of Agricultural Engineering, Guelph, intends to work with the Ottawa 60 as a prelude to machine picking.

The third birdsnest type traces to Dr. B. Heeney and J. D. Metcalf, Smithfield Experimental Farm, R. R. #4, Trenton, and the basis of this work follows with mention made to the variety Ottawa 6. Look up pedigree under Ottawa 6 (p. 65).

[Birdsnest Harrow 105.2-3-E x (Ottawa 6 x Manitoba)] F_7

The birdsnest type from Smithfield was crossed in the F_3 to the High Crimson variety. With this cross they have succeeded in combining the crimson gene combination to the birdsnest material. The resulting seed on hand is in the F_4. They have also transferred jointlessness to the birdsnest habit. This cross is in the F_3. These all have the ability to germinate in cool soils.

The birdsnest type as located in Ontario is similar to at least three stocks which trace to California. The first two of these stocks to receive mention were received in Ontario from Dr. O. H. Pearson, Seed Research Specialists, San Juan Bautista, as Seed Research Selections 2003 and 2131-3. In these the line 37-2 receives mention. This is a straight derivative of E.S. 1878-3. The background of E.S. 1878-3 is given in the section which follows under the caption 'Firm Textured Tomato Types'. The pedigree leading to 2003 and 2131-3 as given by Dr. Pearson is as follows:



The third stock from California that is similar to a birdsnest type is from G. C. Hanna, Department of Vegetable Crops, Agricultural Experimental Station at Davis. It has the following parentage:

C1327 br br x Hardin's Miniature.

BREHMS SOLID. See Firm Textured Tomato Types, p. 62, 63.

CANNON 10. See Firm Textured Tomato Types, p. 62, 63.

CHEYENNE SELECTION 614. See Cold and Heat Sterility, p. 56.

COLD SET. See Cold and Heat Sterility, p. 58.

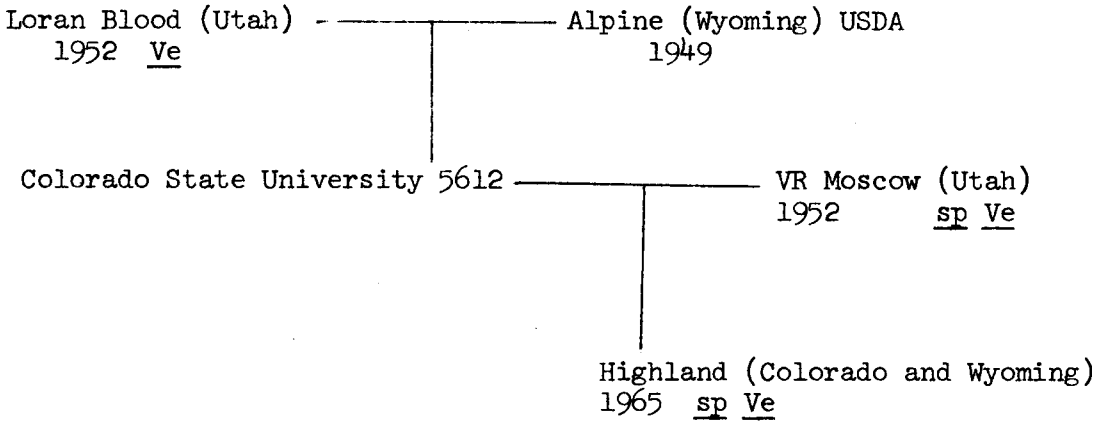
COLORADO RED. See Cold and Heat Sterility, p. 56, 57.

COLD AND HEAT STERILITY--NEW TOMATO TYPES WHICH HELP COMBAT ADVERSE FLORAL SET

Graham, T. O., Horticulture Department, University of Guelph, Guelph, Ontario.

HIGHLAND

The USDA and the Hort. Dept. of the Colorado State University released the variety Highland in 1965. The cross was made by R. L. Fosket at the University of Colorado. It was selected and tested by Gene S. Howard and B. D. Thyr at the Cheyenne Horticultural Field Station in Wyoming, at an altitude of 6200 feet. The pedigree is as follows:



Plants average 13" in height at Cheyenne.
Concentrated fruiting.

CHEYENNE SELECTION 614

As the Cheyenne Station has a number of valuable cold and heat set selections, the pedigree of one will be given, namely, Cheyenne Selection 614. Two varieties in the pedigree will receive special mention, namely, Colorado Red and K-9 (3). (See p. 57)

COLORADO RED

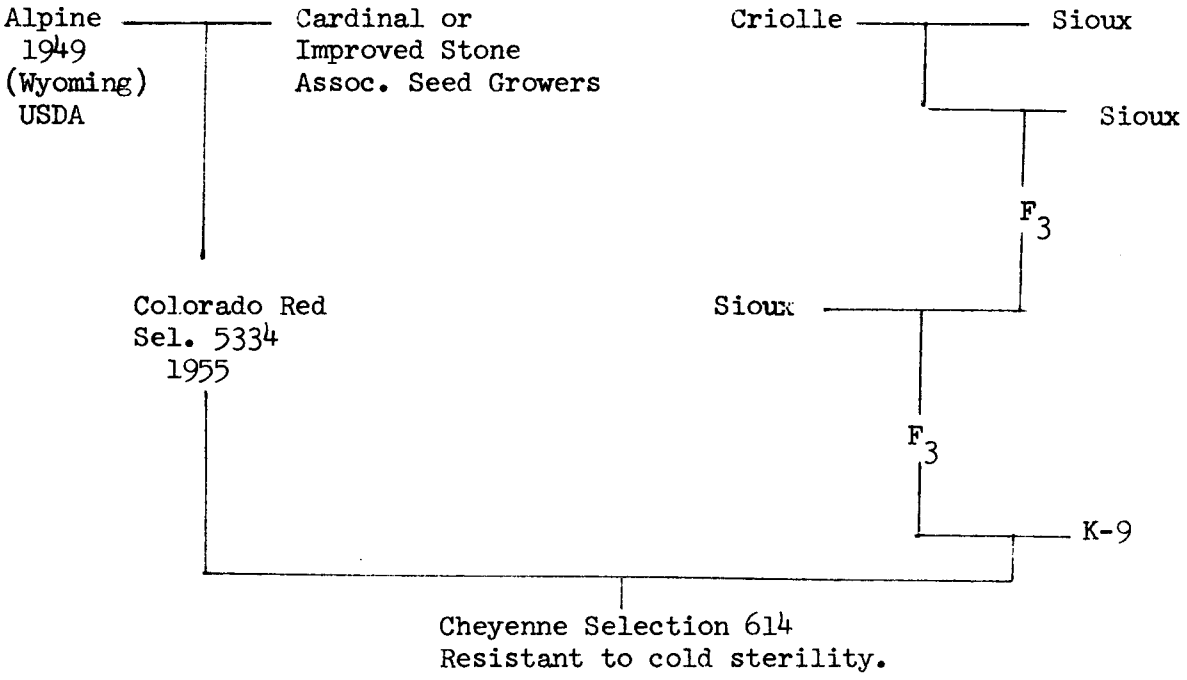
This variety was produced in 1955 by Le Roy Powers and E. D. Krouch of the Horticultural Field Stations, Cheyenne, in cooperation with Ben F. Counter of the Fort Lupton Canning Company, Fort Lupton, Colorado. (See p. 57)

EARLICROP

The Research Station at Lethbridge, Alberta, released Earlicrop in 1963(4). It was selected from a cross between Early Chatham and Bounty which was among a number of F_1 hybrids sent to Lethbridge by C. Walkof of the Morden Experimental Farm in Manitoba. It is determinate, compact, and uniform ripening.

K-9

This variety was developed by the Kuner-Empson Canning Company at Brighton, Colorado.



SUMMERTIME

For several years northern varieties which can overcome normal cold sterility have been tested in Texas and vice versa. Such northern types as Early Alberta, Early Lethbridge, Earlinorth, Swift, and Cold Set which can set at unusually cool temperatures in Canada can also set at unusually warm temperatures at Jacksonville and Yoakum in Texas (2,5). Recently, on the basis of this exchange of tomato varieties, A. L. Harrison of the Plant Disease Laboratory, Joakum, Texas, sent seed of the variety Summertime to Guelph, Ontario. He has found that this variety consistently sets fruit under high night temperatures in Texas. By high he means in the high 70's.

Summertime has small, compact vines. This may be the Summer Tomato mentioned in the publication of the NORTHEASTERN REGIONAL PLANT INTRODUCTION STATION, New York State Agricultural Experimental Station, Geneva, issued in August, 1964. It was developed by Texas AES and traces to P.I.19025 (New Caledonia) as a parent.

The Northeastern Regional Plant Introduction Station has also been cooperating with experimental institutions which wish to work with types which germinate in cool soils, even as low as 48°F. This could prove important, especially if an association is found between plants which can germinate in cool soils and those which will set fruit under adverse conditions. If this is found to be the case, as direct seeding pushes into the north, it would help to eliminate types which set poorly under adverse conditions.

SWIFT

The Experimental Farm at Swift Current, Saskatchewan, released the variety Swift in 1961 (1). The pedigree is as follows:

Farthest North — Bounty
Redskin — F25
Swift
sp u

Resistant to concentric cracking.

COLD SET

In 1962 the University of Guelph, Ontario, introduced the Cold Set variety, which has the following pedigree:

Fireball — Filipino #2 Pink Selection
r + sp u — r + y u +
Cold Set Type — Cold Set Type

Cold Set
r + y + sp u
Cold Set Type

REFERENCES

1. Blakely, R. M., and C. W. Carlberg. 1964. Swift Tomato. Can. J. Plant Science 44: p.497.

2. Harrison, A. L. 1961 to 1966 (Plant Disease Laboratory, Yoakum, Texas A.E.S.) Correspondence.

3. Howard, Gene S. 1962. (USDA Horticultural Field Station, Cheyenne, Wyoming). Correspondence.

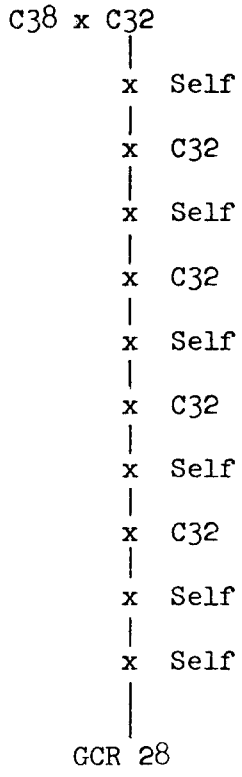
4. Kemp, G. A. and I. L. Nonnecke, 1963. Note on Earlicrop Tomato. Can. J. Plant Science 43: 611-612.

5. Young, P. A. 1962. Yield and Resistance of Tomato Varieties to Physiological Abnormalities. (Tomato Disease Investigations Laboratory. Jacksonville, Texas). Progress Report 2261.

COMPACT HABIT MONEYMAKER

Darby, L. A., Glasshouse Crops, Research Institute, Worthing Road, Rustington, Little Hampton, Sussex.

In a letter of January 11, 1963, L. A. Darby gives the following pedigree for G.C.R. 28 or Compact Habit Moneymaker.



38 = C
Baby Lea
(See TGC 11:36)

C32 = Moneymaker

Compact habit as expressed by Baby Lea is typified by short drooping leaves, short internodes, and close trusses. It is controlled by a recessive determinant which is inherited in simple Mendelian fashion, and it is either tightly linked or pleiotropic with green stem. By selecting green stem seedlings when picking out from a segregating family, compact plants are recovered (1).

REFERENCE

1. Darby, L. A. 1961. The Production of Improved Tomato Varieties NAAS Quarterly Review 53: Autumn, 1-10.

CRIMSON GENE COMBINATION--BREEDING RECORD AT GUELPH

Graham, T. O., Horticulture Department, University of Guelph, Ontario.

In 1962 the High Crimson variety was introduced at the University of Guelph. It contained the crimson gene combination designated as $\underline{Crn_1}$ $\underline{Crn_1}$ $\underline{crn_2}$ $\underline{crn_2}$. At the time of introduction it possessed the normal yellow-colored type of flower. Orange flowers were located in a field of the High Crimson variety at Guelph in 1960. This is shown in the pedigree which follows.

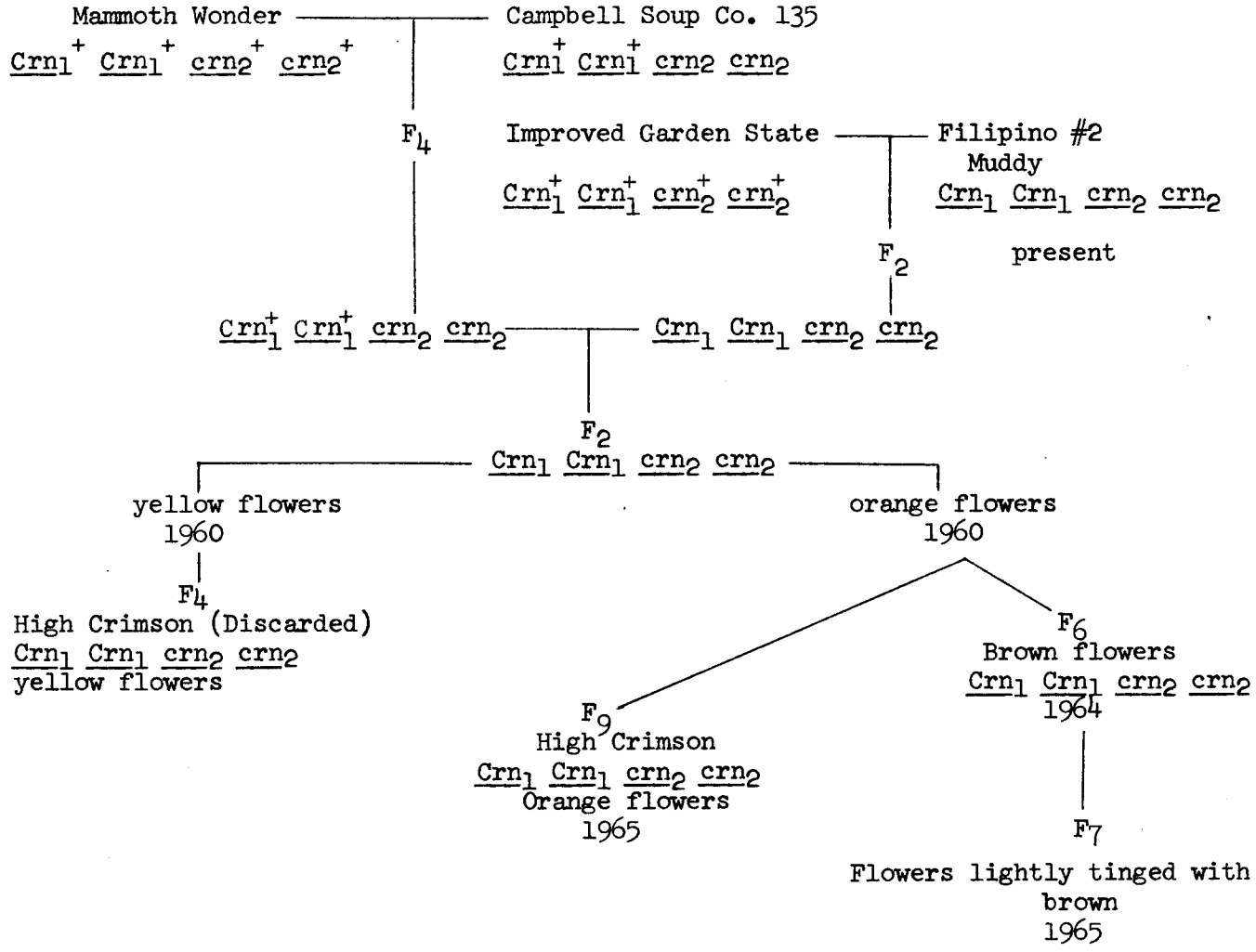
Orange flowers were found to be a satisfactory marker for intensity of crimson pigmentation. As soon as possible after 1962, the yellow-flowered form of the High Crimson variety was discarded and at present, plants of the High Crimson variety growing under cool conditions should have a heavy percentage of orange flowers.

In 1964 a brown-flowered form of the High Crimson variety was located under fairly warm conditions at Leamington, Ontario. Seed was saved and in 1965 when plants were grown further north and under cool conditions they produced flowers that were lightly tinged with brown. It is not known as yet whether brown will prove a better marker for intensity of 'crimson' than orange. So far, fruit tracing to brown flowers possesses rich crimson flesh.

In 1964 seed of og (old gold) was obtained from the University of California as LA 348. This mutant, under cool conditions, produces flowers and flesh almost identical to that of the High Crimson variety. Old gold was crossed with High Crimson and the resulting F_2 was grown in the greenhouse at Guelph during the winter of 1965-66. By count the 234 F_2 plants had 211 plants with orange flowers, 19 plants with flowers tinged with brown, and 4 with flowers distinctly brown in color. All 234 plants had 'crimson' flesh.

In the past it has been considered that the High Crimson variety carried ug. This point is being checked by Dr. Guy Weston Bohn of the U.S. Horticultural Field Station, La Jolla, California. So far all attempts at Guelph to combine intense crimson pigmentation with self-pruning plant habit have failed. The present High Crimson variety is non-self-pruning.

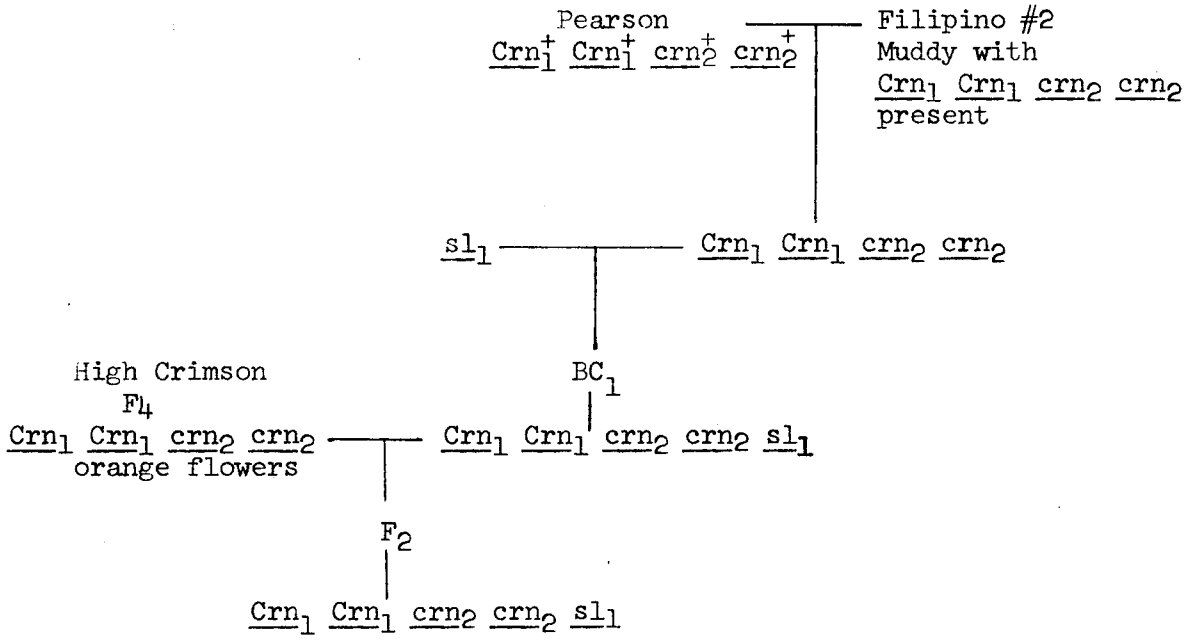
Pedigree of the High Crimson and the separation of crimson gene combination into yellow, orange, and brown-flowered forms:



It was considered that pistillate plants having the crimson gene combination might be of value in the production of F_1 hybrid seed. With this in mind the factors for 'crimson' were combined with the $\underline{sl_1}$ (stamenless) gene.

In 1961 the University of Michigan released an inbred male sterile cucumber which was perpetuated by means of a mutagenic agent (1). This work resulted in correspondence between Michigan and Ontario to see if it was possible to obtain a mutagenic agent in Michigan that would cause $\underline{sl_1}$ tomato plants to restore the missing stamens and produce perfect flowers with viable pollen. Such pollen would be homozygous for the $\underline{sl_1}$ factor and in the next generation, would cause the large scale production of male sterile plants for F_1 hybrid work.

The treatment of $\underline{sl_1}$ plants at Michigan with gibberellin to restore the missing stamens has resulted at times in the production of perfect flowers with viable pollen (2,3). This work has renewed interest in the production of F_1 hybrids. As a result several institutions, aside from Michigan, have recently requested $\underline{sl_1}\ \underline{sl_1}\ \underline{Crn_1}\ \underline{Crn_1}\ \underline{crn_2}\ \underline{crn_2}$ seed. The pedigree showing the background of the seed distributed is as follows:



It should be noted that in the case of $\underline{sl_1}\ \underline{sl_1}$ plants anther development under normal circumstances is completely reduced. At the advice of Dr. L. Butler, Department of Zoology, University of Toronto, work in the use of $\underline{ms_{10}}$ has been started at Guelph. This gene is not completely antherless but is completely male-sterile. Because anther development is not completely reduced, $\underline{ms_{10}}$ might react more favorably to mutagenic agents.

REFERENCES

1. Peterson, C. E. 1961. Memorandum to cucumber seed producers regarding release of monoecious pickling cucumber inbred line. MSU 238.

2. Phatak, S. C., and S. H. Wittwer. 1965. Gibberellin-induced anther development in the stamenless (sl sl) tomato mutant. T.G.C. 15:50.

3. Phatak, S. C., S. H. Wittwer, S. Honma, and M. J. Bukovac. 1965. Gibberellin induced anther and pollen development in a stamenless tomato mutant. Nature. (in press).

EARLICROP

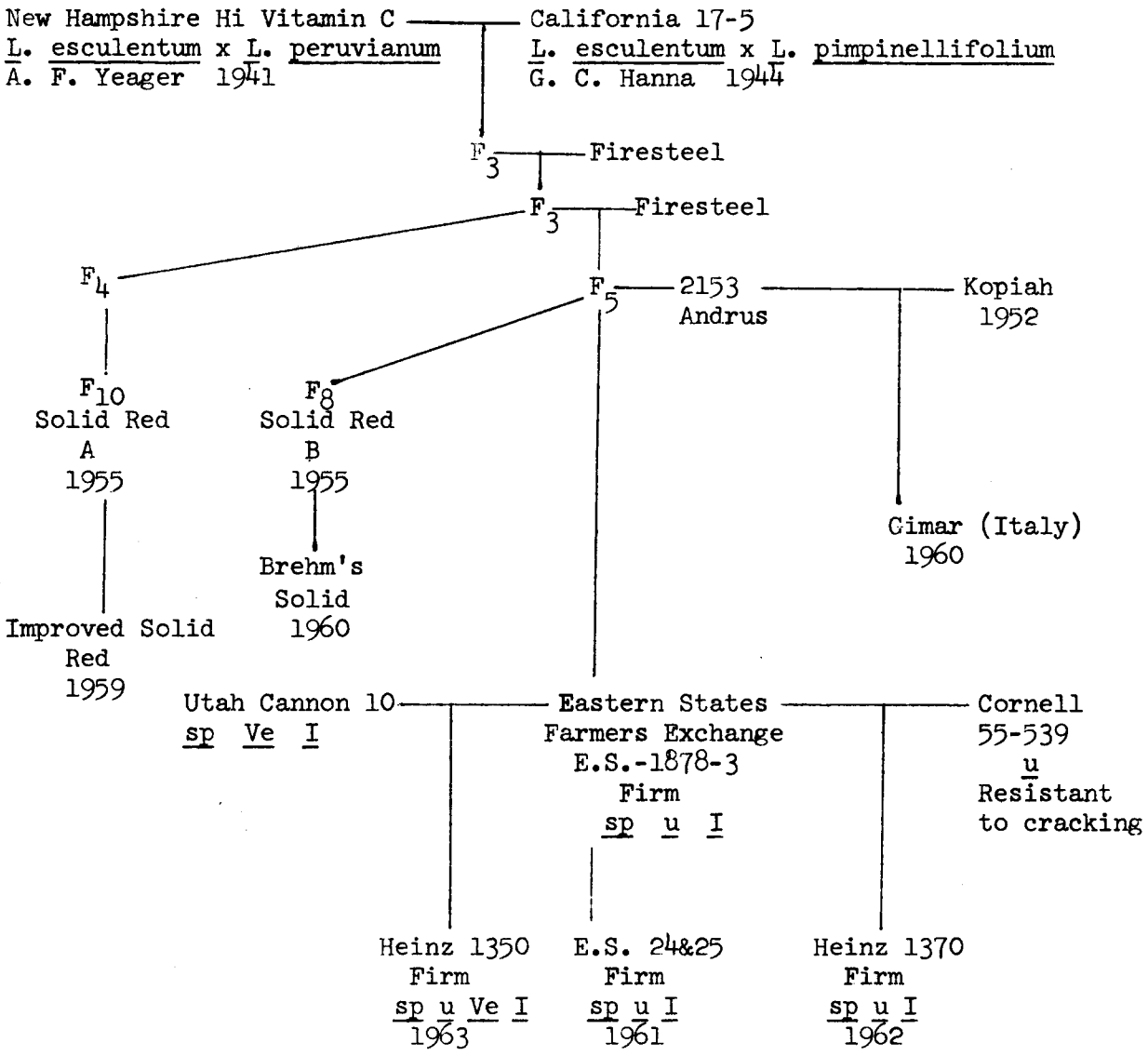
See Cold and Heat Sterility, p. 56.

E.S. 24 and 25

See Firm Textured Tomato types below.

FIRM TEXTURED TOMATO TYPES--BREEDING RECORD

John, C. A., Crop Research Department, H. J. Heinz Company, Bowling Green, Ohio, and Dr. O. H. Pearson, Seed Research Specialists, Inc., San Juan Bautista, California.



ANDRUS 2153 was developed by C. F. Andrus, U.S.D.A. Vegetable Breeding Laboratory, Charleston, South Carolina. Its pedigree is as follows:

[(South Land x (L. pimp. x Marglobe)) x Stokesdale] x Illinois T19

Crosses with Andrus 2153 gave firm segregants.

BREHM'S SOLID was selected by Fred Brehm, a grower at Dilltown, Pennsylvania.

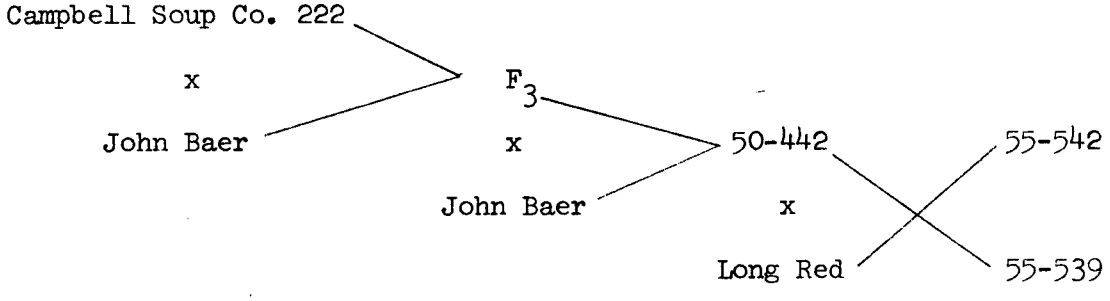
CANNON 10 was developed in Utah by crossing Ohio W R Globe and Utah 59-1. This cross was then backcrossed four times to Rutgers. As a result of crossing Cannon 10 with a selection tracing, in part, to Andrus 2153, the resulting Heinz 1350 possesses firm fruit and the plants show resistance to both fusarium and verticillium.

CORNELL 55-539

In a letter of January 3, 1966, Dr. H. M. Munger, Department of Plant Breeding, Cornell University, Ithaca, New York, states as follows:

"Perhaps you will recognize the number 55-542 as the line which Paul Prashar used in his Ph.D. study on crack resistance at the University of Missouri. These two lines, namely 55-539 and 55-542, came from two different F_2 plants of the cross 50-442 x Long Red".

The pedigree of both 55-539 and 55-542 is as follows:



KOPIAH

Released by Dr. J. A. Campbell, Agricultural Experimental Station, Crystal Springs, Mississippi, and designated as Step 183 in the Southern Trials. Was entered under the Mississippi No. 25-46-1 MFA.

FLORADEL

Hayslip, N. C., J. M. Walter, D. G. A. Kelbert, P. H. Everett. 1964. University of Florida A.E.S. Circular S-162: Indeterminate staking type. Smooth stem and blossom or stylar scars. Resistant to common race of fusarium; also to gray leafspot, leafmold, graywall, and growth cracks. Pedigree of Floradel (Step 430) is charted on page 4 of Circular S-162.

GARDENER

Munger, H. M. Department of Plant Breeding, Cornell University, Ithaca, New York.

Farthest North x Valiant → F_2 x Valiant → F_2 x Valiant → F_2 x Valiant → Valnorth x Wasatch Beauty → 54-179 Gardener 1960 Early, indeterminate, good flavor

GIMAR — See Firm Textured Tomato Types, p. 62.

HEINZ 1350 — See Firm Textured Tomato Types, p. 62.

HEINZ 1370 — See Firm Textured Tomato Types, p. 62.

HIGH CRIMSON — See Crimson Gene Combination, pp. 59, 60.

HIGHLAND — See Cold and Heat Sterility, p. 56.

VARIETAL PROGRESS

Kerr, E. A., Horticultural Experimental Station, Vineland, Ontario.

RECENT

VOGUE — Massachusett's Hybrid x Red Cloud sp u → Vogue sp^+ u

VENTURE — Massachusett's Hybrid x Pritchard sp → Venture sp u

VISCOUNT — Ace sp u x Rideau sp u → Viscount sp u

VANTAGE

Tuckqueen x Breeding line M 61

|

Vantage u, Cf_2, Cf_4, possibly Cf_1, Cf_3

Breeding line M 61 has a very complex ancestry going back to Stirling Castle (Cf_1), Vetomold (Cf_2), V 121 (Cf_3), L. peruvianum (Cf_4), and Pan America and a wf breeding line.

REFERENCES

Wiebe, J. 1960. The vogue staking tomato. Rept. Ont. Hort. Expt. Sta. 1959 and 1960: 50-51

Wiebe, J. 1961. Venture tomato. Rept. Ont. Hort. Expt. Sta. 1961: 75.

Kerr, E. A. 1961. Viscount tomato. Rept. Ont. Hort. Expt. Sta. 1961: 75-76.

Kerr, E. A. 1961. Vantage greenhouse tomato. Rept. Ont. Hort. Expt. Sta. 1961: 73-75.

IMMOKALEE

Everett, P. H., D. G. A. Kelbert, N. C. Hayslip, and J. M. Walter. 1964. University of Florida A.E.S. Circular S-161:

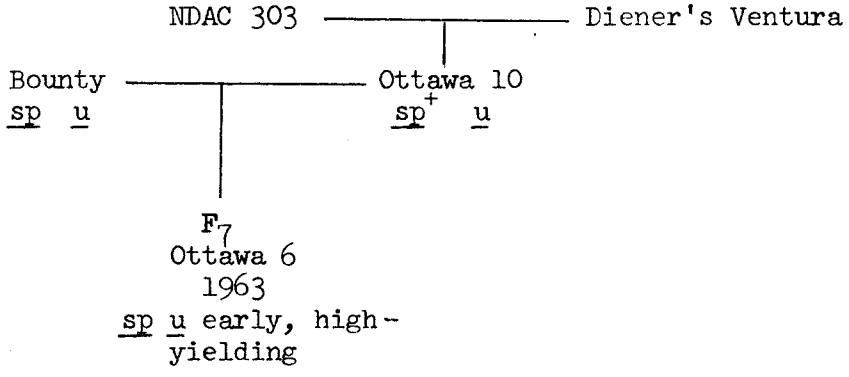
Immokalee has a determinate vine type with concentrated fruit set, is highly resistant to the gray wall phase of the disorder known as blotchy ripening and to gray leafspot disease caused by Stemphylium solani Weber. The pedigree of Immokalee (Step 410) is charted on page 4 of Circular S-161.

K-9 See Cold and Heat Sterility, p. 57.

KOPIAH See Firm Textures Tomato Types, p. 62.

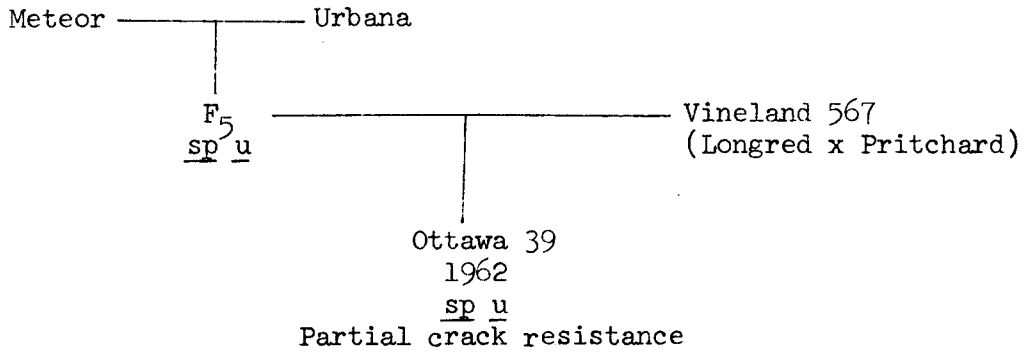
OTTAWA 6

Lyall, L. A., Vegetable Crops Section, Research Station, Central Experimental Farm, Ottawa, Ontario.



OTTAWA 39

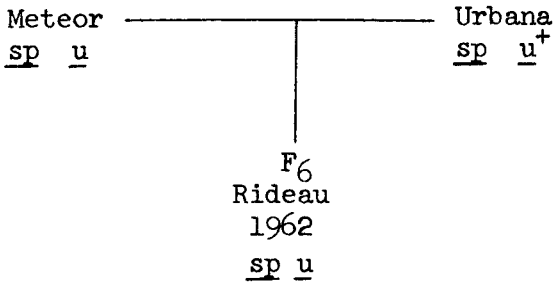
Lyall, L. A., Vegetable Crops Section, Research Station, Central Experimental Farm, Ottawa, Ontario.



OTTAWA 60 See Birdsnest Tomato Type, p. 54.

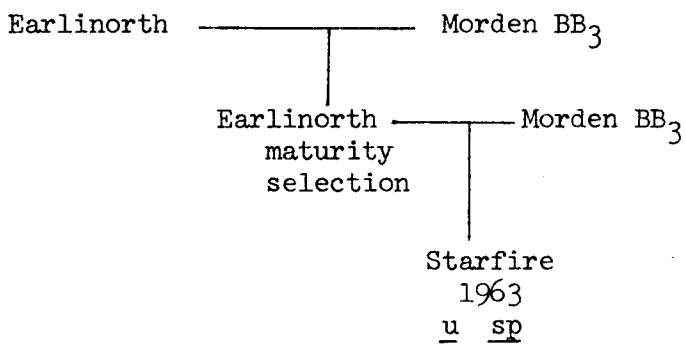
RIDEAU

Lyall, L. A. Vegetable Crops Section, Research Station, Central Experimental Farm, Ottawa, Ontario.



STARFIRE

Walkof, C. Experimental Farm, Morden, Manitoba.



Starfire is the first variety to be developed under the auspices of the Co-operative Tomato Breeding Project for the Prairie Provinces in Canada. Although the project involves several Experimental Farms, the main developmental work of Starfire was done at Morden and Brandon, Manitoba.

SUMMERTIME See Cold and Heat Sterility, p. 57.

SWIFT See Cold and Heat Sterility, p. 58.

VALNORTH See Gardener, p. 64.

VANTAGE See Horticultural Experimental Station, Vineland, Ontario, p. 65.

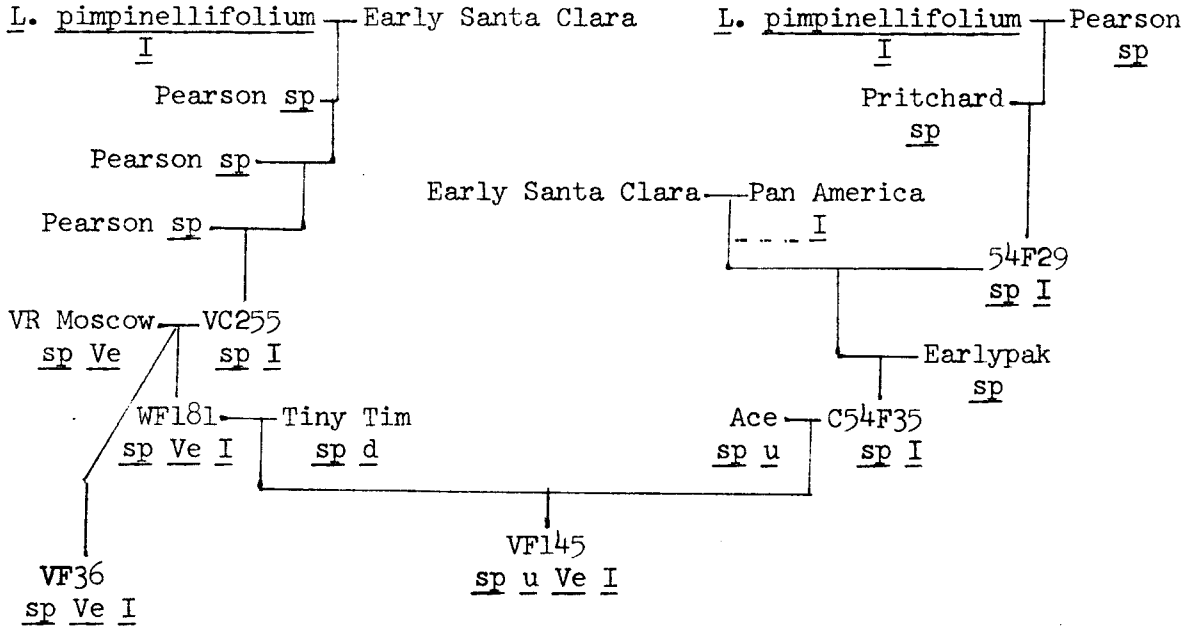
VENTURE See Horticultural Experimental Station, Vineland, Ontario, p. 64.

VISCOUNT See Horticultural Experimental Station, Vineland, Ontario, p. 64.

VOGUE See Horticultural Experimental Station, Vineland, Ontario, p. 64.

MECHANICAL HARVEST VARIETIES

VF145



13L