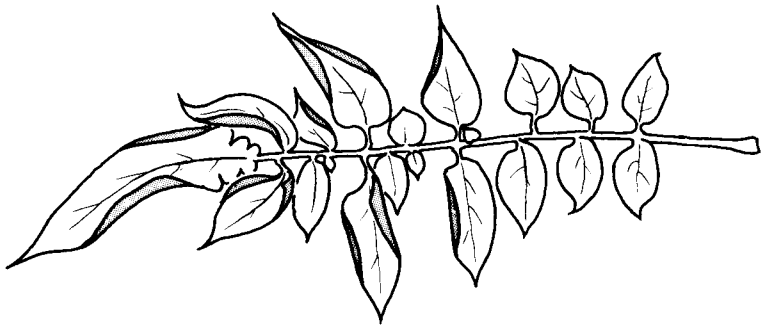
REPORT
of the
TOMATO GENETICS COOPERATIVE



NUMBER 18 FEBRUARY 1968

DEPARTMENT OF VEGETABLE CROPS
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA

This report is a medium of exchange among members of information and stock relating to tomato genetics. None of the information herein may be used in publications without consent of the respective authors.

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.

As of December 31, 1967, membership of the TGC stood at 310, including 145 (46%) in foreign countries. Canada leads with 21 members, Italy and Netherlands next with 15 each. At the end of 1967 our financial balance was $188.73.

The regular annual meeting was held under the auspices of AIBS at the Texas A&M University on August 29. Minutes appear on the next page. Arrangements are in progress for the 1968 meeting and when completed, notices will be sent to members.

Special features of this TGC Report are (1) a biennial report on the New Mutant Program, (2) a linkage summary, and (3) a report of the Committee on Varietal Pedigrees.

We report with regrets that rising costs incurred particularly by the increased size of TGC Reports and increased publication charges have required us to raise membership assessments from $1.00 to $1.50 per year and charges for backnumbers (except Nos. 1-7) from $1.50 to $2.00 each. The expression of support for this action voiced at the annual meeting is much appreciated.

Dora Hunt again shouldered a very large share of the work necessary to keep the TGC moving: she took charge of all membership and financial affairs for the year and assembled and edited most sections of this report. Betty Bell again applied her expert typing skills to preparation of the master copies. To both and to the many others who assisted with TGC 18 and other activities during the year we offer our sincere thanks.

Five hundred copies of this Report have been issued.

Coordinating Committee

L. Butler
G. B. Reynard
R. W. Robinson
M. L. Tomes

C. M. Rick, Chairman
Department of Vegetable Crops
University of California
Davis, California 95616

Minutes of the Texas A&M Meeting

College Station, Texas, August 29, 1967

General remarks were made by acting chairman, A. L. Harrison, concerning the agenda suggested by Dr. C. M. Rick from the Coordinating Committee.

The members in attendance were unanimous in agreeing to the proposal that membership fee be increased to $1.50 per annum. Some even commented that they would be favorably inclined to go to $2.00, if the need arises. They also agreed that there should be a charge of $5.00 per page for TGC Research Notes when any one contributor has more than three pages of notes in one issue. The group was also in favor of including the following items: 1. Linkage summary, 2. New Mutant Program, 3. Complete List of Members, in the forthcoming issue of Report No. 18.

The Hardin Collection was discussed, and C. A. John, P. W. Leeper, E. Casseres, A. L. Harrison, and B. A. Perry agreed to increase up to 25 lines of the collection in any one season. Mr. John of H. J. Heinz Company stated that he had about 100 of these lines in his planting this year. He stated that he would be glad to save seed, but there would always be the danger of bacterial canker since it is frequently present in their plantings.

Site for future meetings was discussed and the following recommendation made to the Coordinating Committee: that the 1968 meeting be held with the ASHS at Davis, California, and the 1969 meeting in conjunction with the Tomato Breeders' Round Table.

Mr. C. A. John moved that the group recommend that future tomato collecting expeditions include tomato species and primitive cultivars and that close cooperation be attempted with local individuals, especially members of TGC, in the respective areas to be visited so as to make the collection as complete as possible for any particular area or country. Seconded by Mr. Robbins. Carried.

Several other items were discussed; however, no general recommendations were made. Mr. John spoke on the urgent need for resistance to bacterial canker. Mr. E. Casseres spoke on the development of a germplasm bank in three areas of the Mexico and Central and South American areas.

There being no further business, the meeting adjourned.

Bruce A. Perry, Secretary, pro tem.

NEW MUTANT PROGRAM

The preceding report of the New Mutant Program was issued in TGC 16:3-4. The following brief report summarizes activities for the ensuing biennium. During this period 32 additional mutants in various categories were contributed by Dr. Kay Verkerk, and 6 in group 12, and 3 in group 14 by C. M. Rick. Volunteers are needed for several unassigned groups. Inquiries and comments concerning the New Mutant Program should be directed to C. M. Rick, its acting coordinator.

Group 1 (anthocyanin modifiers) Penny von Wettstein-Knowles: Extensive Research Note in TGC 17:34-36.

Group 2 (whitish chloro. defic.) unassigned.

Groups 3-5 (yellowish, light green, and yellow-green chloro. defics.) R. G. Creech: no report.

Groups 6-8 (virescent & variegated chloro. defic., necrotic) K. Verkerk: Mutants of all groups were grown, reclassified, and described in the 1966 season. Performance in three different seasons is considered necessary for proper evaluation. Until now no mutants in groups 6 and 8 showed sufficient phenotypic similarity to justify allele test crosses.

Group 9 (hair modifications) unassigned.

Group 10 (leaf form) R. G. Creech: no report.

Groups 11 & 13 (plant habit, inflorescence modifications) R. W. Robinson: no report.

Groups 12 & 17 (flower modifications, disease resistance) F. Angell: Research Notes on three mutants in this Report. Mutant phenotypes not observed in the additional mutants received.

Group 14 (sterility) A. Andrásfalvy: Progress summarized in extensive Research Notes in this Report. Test crosses are being continued. A transfer of mutants to standard varietal background is needed.

Group 15 (fruit form) B. O. Bergh: Studies continuing with 63 lines including the new mutants received. Each of the latter has been crossed with 4 isogenic tester lines involving *o* and *f*, and F_1's measured in an attempt to detect the mutant allele in heterozygous condition. Project will continue to F_2.

Group 16 (fruit color) M. L. Tomes: Research Notes on three mutants in TGC 17 and this Report.

Group 18 (physiological characters) unassigned.

Group 19 (miscellaneous) R. W. Zobel has undertaken a study of mutants with modified root development. Although, according to the NMP classification scheme, many such mutants would be classified in other groups, particularly No. 11, his interest in root mutants merits attention in this category. Research Note on *lz-3* in this Report.

LINKAGE SUMMARY

The last summary appeared in TGC 15:3-5. The following reports have been received from linkage cooperators:

Chromosome 1--R. K. Soost. With increasing work load in other areas I believe that I should turn chromosome 1 over to someone else. I haven't been able to do sufficient work to determine linkages more accurately. Several genes have deficient monogenic ratios and many do not score well in combination with others. This past summer I had mainly F_2 populations of irregularis with several markers. Irregularis did not score well in the greenhouse and we had to go to the field. To the linkage map in TGC 15 should be added Lpg at 16 units from au.

Chromosome 2--L. Butler. Over 100,000 segregants have been added to the data since TGC 15. These new data have not produced any striking changes in the map. There is still a great deal of heterogeneity in linkage values and this will not be eliminated until all the genes are put on a standard background. Progress is being made in transferring the genes to an Ailsa Craig background and in completing the 3-point backcrosses which are necessary to get the proper position for some of the genes. The most up-to-date data have been incorporated in the present map.

Chromosome 3--G. W. Bohn and R. H. Whalen. Bohn reports lack of funds to carry on tomato work at La Jolla but that Whalen, now at South Dakota State University, will work with this chromosome.

Chromosome 4--Gurdev S. Khush. The latest findings are summarized on the present map. Detailed information has been published in Genetica 38:74-94.

Chromosome 5--H. W. Young is now in a position to initiate a reasonably large program with this linkage group.

Chromosome 6--J. C. Gilbert. Reports difficulty getting the tester stocks to live long enough because of disease-prone conditions, but has succeeded in getting seed for some 3-point tests. Until this material is scored, no changes in the linkage map are suggested.

Chromosome 7--R. G. Creech. Because of increasing work with physiological genetics of maize, resigns as coordinator for chromosome 7.

Chromosome 8--C. M. Rick. Loci for l, bu, and dl as well as the centromere position were approximated by induced chromosomal alterations (reported in Riley and Lewis: Chromosome Manipulations and Plant Genetics, 1966). Since the last linkage summary we have spotted pca and re and Robinson and Mishanec have placed ae on the map. Multiple tests are being made to explore the poorly known distal end of the long arm.

Chromosome 9--R. W. Robinson. No report.

Chromosome 10--E. A. Kerr. Data on this chromosome show many inconsistencies, probably because there is differential germination of the mutants in populations segregating for Xa, Xa-2, Xa-3, nd, oli, l-2, and t. The results with the old mutants are still consistent although the distances have changed slightly. There is evidence from some crosses that Xa is the other side of ag, and from some crosses that segregation is random; also that both Xa-2 and Xa-3 are between u and h, and that oli and nd are between h and l-2.

Chromosome 11--W. H. Lachman. Research Notes in TGC 17.

Chromosome 12--Not assigned.

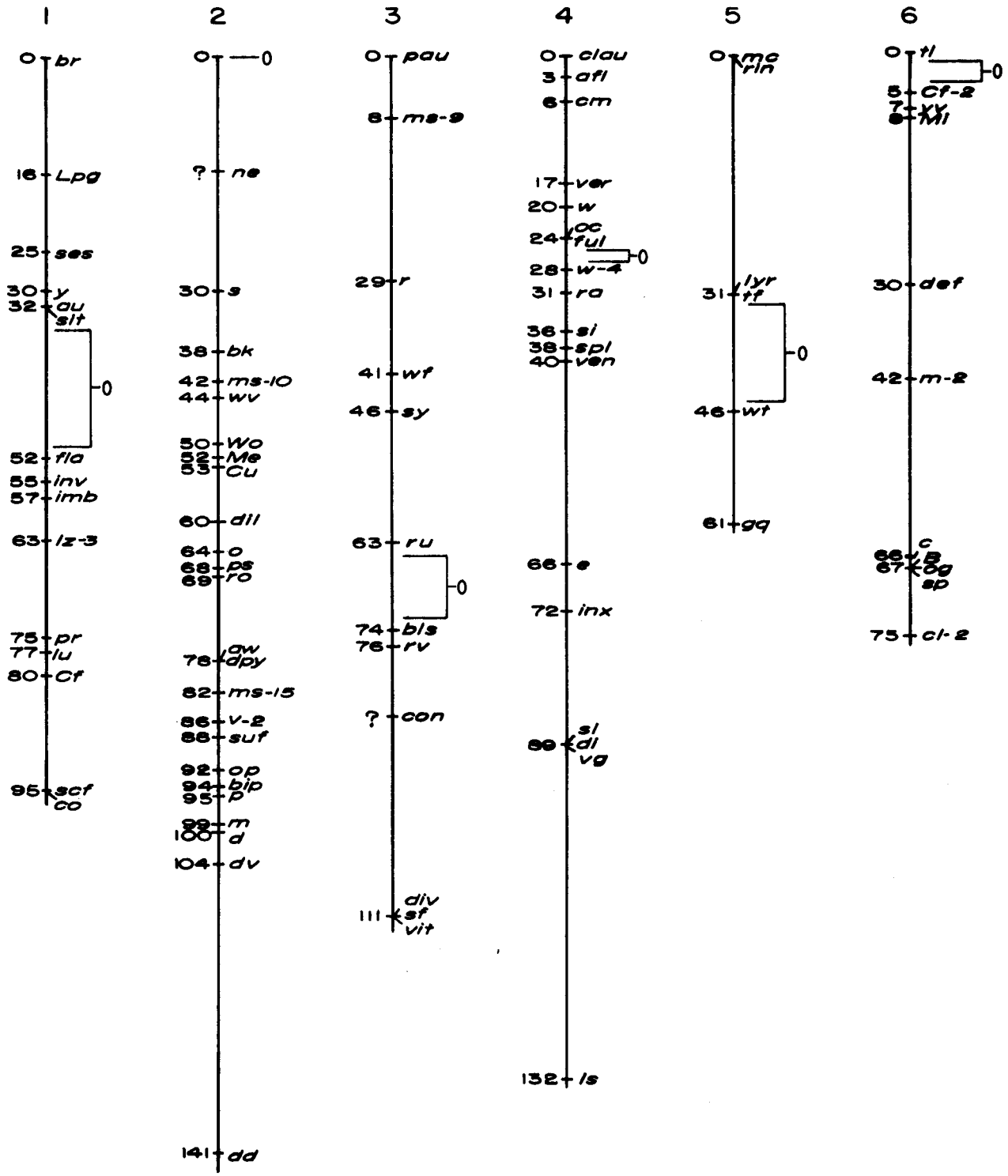
If any one has the facilities and would like to assist in this linkage work, I should very much like to hear from them.

The maps on the next two pages represent the nearest approximations to date for the accumulated data on hand. Centromere positions provided by Khush and Rick.

L. Butler
Coordinator

REVISED LINKAGE MAP

Chromosomes

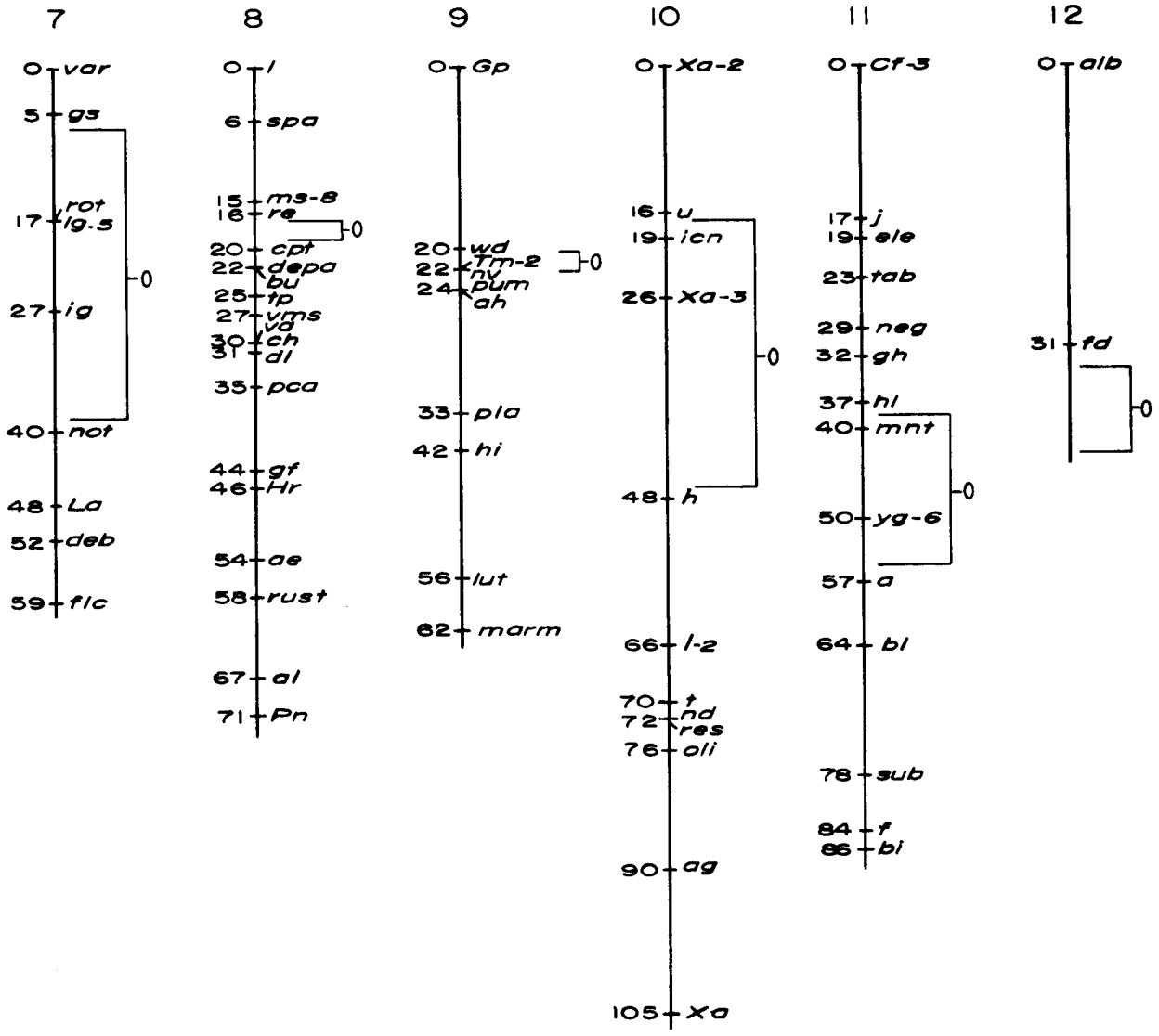


Genes located by two-point or trisomic test only

cb	Lx	pll	ms-16	Fw	inc ?
Cf-4	pen	sl-6	ms-33	inf	int
Crl	prun	Od	Vc	n	mu
in	ms-2			sd	prc
irr	sulf				ri
Jau					vf
ms-6					x-2
per					yg-2
um					yg-3

REVISED LINKAGE MAP (Con't)

Chromosomes



Genes located by two-point or trisomic test only

adp
atv
no
yt

deli
ms-17

Crk
fsc
rela

ms-31
ten
vi

ap
ds
I
id
j-2
mn
ms
ms-3
ms-7
ms-12
ms-14
ms-42
ne-2
pro
uni
x

aud

PART I

RESEARCH NOTES

Andrásfalvy, A. Linkage studies with male-sterile mutants.

This research program of 10 months was performed in 1967 at the University of California, Davis, with facilities and support of Dr. C. M. Rick and his associates. F_1's were raised in the greenhouse starting at the end of February. F_2 families were transplanted to the field as early as August and until September 5. Scoring was possible until the autumn frosts at the end of November. Late season varieties and some mutant phenotypes (au, yv, l, d) did not grow sufficiently to score, and bud shedding was aggravated by San Marzano varietal background, particularly in mutant phenotypes such as ms-11 and ms-30. These unclassified plants give distorted segregation ratios. In some cases an excess of mutant (ms) phenotypes indicates that other genetic mechanisms (as Ge) may also be linked to segregating genes. Additional tests are needed to verify this contention. Results are given in the table.

Further crosses were made up to December, some with special chromosome testers, some on ms mutants which I had not been able to use for crosses in 1966.

	1	2				3	4	5		6			7	8		9	10	11
	au	d	aw	ps	s	wf	e	y	mc	c	sp	yv	La	dl	l	ah	h	a
ms-2		L	L	L	L													
ms-11	S	X						X		X		X	X	S	S	X	X	X
ms-12																		L
ms-13	X	X				X	X	X	X	X		X	X	S	X	X	S	X
ms-14		X	X		X		X		X			X	X	X		X		L
ms-16		X								L	L	L			X			
ms-17														L				
ms-23	X					X	S				X		X	X		X	X	X
ms-24	S	S					S	X	S			X	S	X		X	X	
ms-25							S		X									S
ms-27		S				X	X		X			X	X	X	X	S		
ms-30	S	S		?		X	X	S									S	
ms-31	X	X						X			X	X	X				L	
ms-32	S	X				X	X	X	X	X		X	X	X	X	X	X	X
ms-33		X								L	L	L	X	X	X	X	X	
ms-34				X							X	X		S		X		
ms-35		S		?		X	X		X	X	X				X		X	
ms-38	X	X				X	S	X	X		X	X		X		X		S
ms-40	X	X						X		X	X				X		X	X
ms-41	X	X				X	X	X	X	X	X				X	X	X	X
ms-42																		L
sl-6	X	X		X		L	X	X	X	X	X	X	X	X	X	X	X	X

Andrásfalvy, A. Revision or subdivision of sl and ms mutant groups needed on a uniform background basis.

Stamenless mutants were reported by Bishop (TGC 3) and Hafen and Stevenson (TGC 8). The linkage of the first sl was studied by Butler (TGC 13). Hafen and Stevenson analyzed the morphology and genetics

of sl-2, sl-3, sl-4 and sl-5. According to their description, morphological differences are rather quantitative in nature; no pleiotropism affecting leaf shape or inflorescence initiation was mentioned. In their allele tests, sl and sl-5 seemed to be allelic, the interaction of the others was unclear. Since that time new stamenless mutants have been found, two at Davis by Rick and associates, and one in Hungary by G. Asztalos. The latter was a plant segregating from the variety Feuerball (u, sp) in a variety collection. These three mutants seem similar, as far as the pleiotropic effect of the gene produces blunt-shaped leaflets and less compound leaves. In sp phenotypes there is no evidence of retarded flower formation except sl/sl plants are a little weaker and later than the normals. In crosses of the Hungarian accession (sl-6, preliminary symbol), however, inflorescences of the sp^+ phenotypes are separated by 5-10 nodes instead of 3, and notable suppression of lateral branches was observed. Also, green or suppressed petals may occur in segregates of crosses with the wild L. hirsutum and S. pennellii. The above findings suggest that a phenotypic effect of the genes cannot be characterized fully without transferring the genes to different "standard" genotypic backgrounds as suggested by several authors previously. This is particularly true in the case of the ms group. Some of the ms mutants may be classified equally well as sl, e.g., ms-26, ms-33. In segregating families, a whole series of shifts in expression may be experienced. Pollen production is known to be subjected to environmental factors. In an unfavorable environment certain semi-dominance of the ms gene may result in poor pollen in the F_1 hybrids (Andrásfalvy 1966). On the other hand, recently considerable fruit set by self-pollination was observed in ms-41 and ms-42, homozygous segregates of L. esc. x L. pimpinellifolium and L. esc. racemigerum. It is suspected that normal alleles (ms^+) of different varietal or specific origin may have different interaction with the mutant allele, but this question may be answered only by studying isogenic lines and, keeping in mind the case of vms, we may add, in uniform environment. Following Darby's suggestion (TGC 15), I would like to contribute to the list of "standard" backgrounds required:

1. Early determinate variety as Fireball or Earlinorth.
2. Continuously growing popular forcing type as Money Maker, Ailsa Craig or No. 10.
3. Large-fruited determinate variety as VF36, VFN-8.
4. Large-fruited indeterminate variety as Rutgers, Texas.
5. L. pimpinellifolium.
6. L. esc. primitive types as var. racemigerum.
7. Varieties of special interest, e.g., in ms group, San Marzano.

Particular widely distributed genes may have some effect on certain mutant groups, e.g., d, sp, c, Lc, f, u, cr; so it seems wise to assign to each mutant group some different "standard" background.

Angell, F. F. Flower mutants in the new mutant program.

The mutant 2-281 ("asteroid" Pearson) received from Dr. Rick has highly modified flowers. Most of the flowers are reduced to structures of pinhead dimensions and are nonfunctional. A few of the others are functional. The fruits are multiloped, roughly star-shaped, and have only 2-3 seeds per fruit. The mutant was inherited as a single gene recessive in crosses with the variety Heinz 1350. Allele test crosses are planned.

Mutant 2-257 obtained from Dr. Rick is a "stamenless" type originally found in the variety Pearson. A few stamens appear late in the season; however, there is very little pollen present. The leaves are broad, rugose, and dark green. The mutant was crossed to the variety Heinz 1350. The F_1's had normal phenotype, F_2's segregated 3:1 indicating inheritance as single gene recessive. Tests for allelism with stamenless series are planned.

Angell, F. F. Virescent mutant in the new mutant program.

The mutant Nm 377-117$\alpha\alpha$ was produced by irradiation of Money Maker at Wageningen. The young leaves are yellow, but there is gradual shading to normal green in the older leaves. The plants are generally low in vigor. Flowers are pale yellow, stamens dark orange and fruits red. Crosses with normal phenotype indicated single gene recessive inheritance of the virescent mutant. Tests for allelism with virescent tangerine (t^v) were made and the mutant was shown to be non-allelic with t^v. Further comparison and allelic studies are in progress.

Chmielewski, T. M. New hybrids with L. peruvianum obtained by means of a periclinal chimaera.

The periclinal chimaera L. peruvianum + L. esculentum, for the use of which the writer is indebted to Prof. E. Günther, has an outer layer of L. esculentum cells with the remaining tissues belonging to L. peruvianum. Günther found that the chimaera with L. peruvianum sexual tissues is self-compatible and can be hybridized as the maternal parent with L. esculentum. (Günther, Ber.deut.bot.Ges. 74:333-336, 1961., Naturwissenshaften 51:443-444, 1964).

The chimaera was clonally propagated and hybridized as the pistillate parent with all species of the genus Lycopersicon and with Solanum pennellii. In general, the chimaeras produce fruit under all combinations, but seed setting was rather poor. One had to examine a great number of fruit to find a single hybrid seed.

So far, the following F_1 hybrids have been obtained: L. peruvianum x L. hirsutum typ., L. peruvianum x L. hirsutum f. glabratum, and L. peruvianum x S. pennellii. The crosses always fail when performed on L. peruvianum itself. Moreover, some hybrids have been secured between L. peruvianum and L. esculentum var. Fireball, mutant t—ag, and mutant at.

All the F_1 plants grow vigorously. Hybrids L. peruvianum x L. hirsutum typ. are self-incompatible (SI / SI), but they set fruit and seed abundantly after sib-crossing. Hybrids L. peruvianum x L. hirsutum f. glabratum are self-compatible (SI / Sc) and set fruit readily. Germination rate of F_2 seeds is 51%. A certain number of F_2 plants are weak and abnormal. The population segregates into SI and Sc classes. Hybrids L. peruvianum x S. pennellii are self-compatible (SI / Sc) and highly fertile. Germination capacity of F_2 seeds is 81%. No degeneration in hybrid progeny is observed. In addition to SI and Sc plants, a considerable number of F_2 segregates are male-sterile. Their anthers are more or less reduced, but pistils are evidently functional and set fruit when pollinated with either parent. Hybrids L. peruvianum x L. esculentum are self-incompatible (SI / SC) and their behaviour is the same as in well-known reciprocal hybrids.

Contant, R. B., and K. Verkerk

Dose dependence of M_2 germinability with and without storage and of severity of mutant phenotypes.

Tomato seeds of variety 'Money Maker' were irradiated with a range of fast neutron doses after various durations of aerobic hydration. The M_1 plants were grown to maturity and seeds were harvested from each plant separately. Of each progeny, 24 seeds were sown immediately and from the remainder, stored at room temperature for approximately one year, another 24 seeds were sown. The average germination percentages, from seeds without storage, of progenies belonging to each of 4 prehydration periods and to a low and a high dose, respectively, are shown in Table 1, together with the average reduction in germination capacity due to storage in % of the germination at immediate sowing. It is concluded that:

(1) without storage, germination percentages were considerably lower at the high doses than at the low doses (85 versus 93%);
(2) after storage for one year the germination capacity was reduced by 19% at the low doses and by 32% at the high doses; it is noted for comparison that the germination capacity of unirradiated seed was not affected by one year of storage under the same conditions.

This shows that there is not only an increase of non-germinating M_2 seeds with increasing dose of radiation, but also a progressive reduction with dose in the ability of M_2 seed to withstand storage.

Similar effects have been commonly observed in irradiated M_1 seeds. In the same experiment the mutations were classified according to their phenotype and, on the basis of personal judgment, their degree of severity, as there was an indication that the proportion of severe aberrations was higher at high doses than at low doses. In order to obtain a more objective measure of fitness, the mutation-containing M_2's of which sufficient seed was available were sown again and of each progeny a sample of mutant and normal-appearing individuals was weighed 3 weeks after sowing. The results are summarized in Table 2. The average weight of the normal-appearing individuals was 12.85 grams at the low doses and 10.34 grams at the high doses; this shows that fitness-affecting disturbances other than the visible mutation had accumulated with dose. Furthermore, the mutated individuals weighed on the average 48% of the corresponding normal-appearing plants at the low doses and only 31% at the high doses. This tends to confirm the earlier indication that the phenotypic severity of induced mutations is not at random but at least to some extent dose-dependent. It is not yet possible to conclude which part of these effects is due to physiological and which part to genetical damage.

Table 1:--Storage effect on germination of progenies of neutron irradiated seed.

Hours of hydration	Low doses			High doses		
	Number of progenies	Germination % unstored	Reduction due to storage %	Number of progenies	Germination % unstored	Reduction due to storage %
0.5	19	95	29	32	85	41
3	23	88	20	27	85	27
6	20	93	5	21	87	25
12	25	95	19	16	85	32
Total	87	93	19	96	85	32

Table 2:--Relationship between radiation dose and the average severity of mutant phenotypes.

Hours of hydration	Low doses		High doses	
	Number of progenies	Fresh weight of mutants as % of normal-looking plants in the same progeny	Number of progenies	Fresh weight of mutants as % of normal-looking plants in the same progeny
0.5	4	28	14	29
3	9	53	11	30
6	11	55	8	36
12	11	55	6	29
Total	35	51	39	31

Contant, R. B., and K. Verkerk

Selection of high yielding, easy peeling tomato lines for fresh consumption and canning.

Simultaneously with the genetic analysis of the easy peeling (ep) and oblate-fruited (obl) mutants of 'Money Maker' (Verkerk and Contant, TGC 17, and this issue) selection was started for absence of 'corky root' (associated with ep in the original mutant) and for high yield in both round- and oblate-fruited segregants. The latter are of a type desired in the 'pelati' industry. The combination of ep with round fruit is desired for the fresh market. Skin cracking, to which the round-fruited ep mutant of 'Money Maker' is relatively susceptible, may be avoided by early picking and cool storage. The obl gene for oblate fruit shape is associated with strong skin, conferring market resistance to cracking; this advantage is also maintained in combination with the ep gene. Crossing ep with obl is being tried to obtain recombinants of round fruit with strong skin in the F_2. So far it seems that linkage between obl and strong skin is very tight; the possibility cannot be excluded that true pleiotropy is involved. If not, radiation may be useful for breaking linkage. Alternatively, strong skin might be introduced from other round-fruited varieties. In view of the foregoing, the problem of skin cracking does not arise in ep obl varieties desired for the 'pelati' industry.

It should be noted that obl plants were much more susceptible to blossom-end rot than the round-fruited plants, at least under our rather high temperature greenhouse conditions; this susceptibility was not affected by the ep gene.

In the F_2 of the hybrid (ep x obl) and reciprocal, 6 plants not having corky roots were selected on the basis of yield. The offspring (F_3) of five of these plants had normal roots, suggesting that homozygous individuals had been selected. In the 6th line all plants had corky roots, indicating erroneous classification in the F_2; this line was discarded. All lines except the latter were true to type for easy peeling, but segregated 3 : 1 for fruit shape (round : oblate); as in the F_2, the plants with oblate fruit were significantly taller than the round-fruited plants (height to 5th cluster 158.3 ± 3.0 versus 143.6 ± 1.6 cm). These F_3 lines were markedly taller than 'Money Maker' or the ep mutant, of which plant heights to 5th cluster were 112 and 125 cm, respectively. This confirms the association between oblate fruits and tallness, while showing furthermore that selection for yield has

also led to increased plant height. The selected lines flowered 2-6 days later than 'Money Maker' (significant at P = 0.05); the ep mutant was 3 days later, which approximately agrees with previous data. Differences in earliness of maturation roughly corresponded with those for flowering date.

Yields ranged from 80-96% of 'Money Maker'; average weight per fruit was lowest in 'Money Maker' (70 grams) and highest in the least productive line (83 grams). The best yielding F_3 line, number 505-57, did not differ significantly from 'Money Maker' in yield, its mean plant height was less than in the other lines. Its parent plant (F_2) had also been the highest yielding selection; this tends to show that selection for yield in the F_2 can be successful in tomato. Seed was harvested from the 6 highest yielding round-fruited F_3 plants of number 505-57, for a further selection cycle. In addition, the 4 highest yielding oblate-fruited F_3 plants of the same line were also selected. It is expected that, in both the round-fruited and oblate-fruited easy peeling material, selections will be recovered with a yielding capacity equal to the original variety 'Money Maker'.

The commercial interest in the easy peeling mutant has been further explored. At first, the canning industry seemed to be satisfied with the modern peeling process (treatment with weak HCl for softening the fruit wall, followed by mechanized peeling with the aid of rubber suckers); however, fruit wall softening appeared to reduce the resistance to bursting of the canned fruit; this disadvantage has not yet been overcome by conventional breeding. As the ep gene may shorten or obviate HCl treatment for canning while also being desirable for fresh consumption varieties, there is now a keen interest from the main tomato growing countries in using selected round- and oblate-fruited ep lines for breeding purposes. So far, 22 applications for seed were received and answered.

Ecochard R., and D. de Nettancourt

A radiogenetic study of tomato pollen irradiation with thermal neutrons.

The dose absorbed in tissues exposed to neutrons depends upon the chemical composition of the treated material. In the case of thermal neutrons, boron is responsible, through the ^{10}B (n, α) reaction, for an important proportion of the induced ionizations. It could therefore be expected that a modification in the ratio of the two stable isotopic components of this element present in a living tissue (^{10}B, 20% and ^{11}B, 80% in nature) would influence its radiosensitivity.

In order to test this hypothesis, a study was made of the mutagenic effect of thermal neutron irradiation on dry tomato pollen. Two groups of plants of wild L. pimpinellifolium were grown on a Hoagland nutrient solution containing 2.86 mg per liter of boric acid with extreme proportions of the isotopes:

Treatment 1: 91% ^{10}B; σ = 3,500 barn

Treatment 2: 5% ^{10}B; σ = 192 barn

Pollen collected from both groups was submitted during 48 hours to a flux of 5.2×10^7 n_{th}/cm^2 sec in the biological reactor of the Association Euratom - ITAL at Wageningen, and then applied to emasculated flowers of L. esculentum line 221 (kindly supplied by R. D. Brock) which has the three recessive genes a, aw, hl in the homozygous condition.

As in Brock and Franklin's experiment (TGC 14:8) the mutation rate was evaluated in the F_1 progeny in terms of anthocyaninless and hairless phenotypes; data were also obtained for other criteria of radiosensitivity.

A consistent effect of boron composition on the degree of radiosensitivity was observed for all criteria except seed germinability (Table).

		Treatment		Boron effect
		1	2	$\frac{(1-2)}{2}$
Number of hybrid seeds		11,484	9,193	
Percentage of germination		36.31	35.48	nil
Percentage mutations:	anthocyanin	3.15	2.58	22%
	pilosity	1.74	1.37	25%
	chlorophyll	4.13	2.50	65%
	morphology	3.24	2.25	44%
	viability	6.83	5.15	33%

This effect appears greater for the multifactorial characters than for the specific factors.

The induced mutation rate at the marker loci investigated averaged 1.5%, a value which is approximately twice the one observed by Brock and Franklin. As a matter of fact the dose used by these authors was the 50 percent reducing dose for fertility whereas in the present case the seed setting was about a third of the control value, including all the aborted seeds.

Again, most of the mutations can be ascribed to deletions.

Ecochard R., and D. de Nettancourt
Tomato haploid and monosomics after pollen irradiation.

In the F_1 material resulting from the experiment described in the previous article, a number of aberrant seedlings were grown to maturity. As expected, pollen stainability was found to be reduced in the majority of the plants investigated.

A cytological analysis was made with special attention to the individuals expressing the homozygous recessive phenotype for anthocyanin and pilosity.

Among these plants two were haploid. These two plants expressed the same general feature as L. esculentum line 221 but with somewhat reduced dimensions. They are sterile, but one of them produces parthenocarpic fruits.

Six plants also recessive for both marker characters were found to be monosomic. The missing chromosome is without doubt chromosome 11 (linkage group V), and examination of meiotic metaphases suggests that monosomy is of the primary form, a possibility which must be confirmed by pachytene analysis.

Two individuals expressing the dominant phenotype for anthocyanin and pilosity exhibited a translocation. In addition, one of these plants was monosomic.

Further study of the material is in progress and attempts are being made to derive a homozygous diploid line from the two haploids obtained.

Fehleisen, S. O. A spontaneous mutant in var. Platense: incisifolia (ics).

Modifications of the phenotype of this mutant permit its accurate identification from the seedling stage of 4-5 leaves. Changes in the form of the ovary and style

modify the normal alignment of anthers. In view of its resemblance to clau, C. M. Rick completed allele tests, finding that the respective genes are not allelic.

Phenotype: The most perceptible leaf modifications are the deep incisions of the segment margins and acute dentations, in contrast to the shallow incisions and more obtuse dentations of normal leaves. This well-defined trait suggested the name "incisifolia" for the mutant and the corresponding symbol ics. Shoots are observed originating from buds along the mid-vein of the leaves, which curve moderately in proportion to their growth.

Modifications are observed in the ovary and style that result in very low fruitfulness of the mutant, although it is possible to maintain the line without resorting to artificial selfing or backcrossing. Starting with the broad base of the ovary, the style assumes a conical form for 2/3 of its length, resulting in a lack of visible differentiation between ovary and style. Pollen and ovules are functional, and the unfruitfulness is likely attributable to such irregularities of the flower as the abnormal disposition of anthers, which interfere with normal pollination.

Inheritance: Families obtained for the F_2 and the BC were derived from a cross between Platense positional-sterile and incisifolia, the observed segregations presented in Tables 1 and 2.

Table 1:--F_2 segregation in families of the cross Platense ps x incisifolia.

Family	Phenotype			χ^2	p
	+	ics			
66.21	194	84	(30.21%)	4.03	0.05-0.02
66.24	320	103	(24.34%)	0.09	0.70-0.80
66.27	533	158	(22.86%)	1.67	0.10-0.20
66.32	245	63	(20.45%)	3.39	0.05-0.10
Total	1292	408	(24.00%)	0.90	0.30-0.50

Table 2:--Segregation in backcross families.

Family	Phenotype		χ^2	p
	+	ics		
66.37	25	23	0.08	0.70-0.80
66.38	29	30	0.01	0.80-0.90
67.84	31	25	0.64	0.30-0.50
Total	85	78	0.30	0.50-0.70

The normal phenotype of the F_1 and the data presented in the above tables suggest that the phenotype of incisifolia is conditioned by a single recessive gene since the χ^2 values for the pooled F_2 and BC data are not significant and the observed segregation fits well to the monogenic hypothesis. For the F_2

families, heterogeneity is moderately significant ($\chi^2 = 8.274$, $p = 0.05\text{-}0.02$) as a result of the excess of recessives in family no. 66.21 and the small number of families, but observations in previous years showed a consistent tendency toward a deficiency of recessives, for which some factor probably affects their viability.

Fehleisen, S. O. The positional-sterile gene in var. Platense.

Among the spontaneous mutants in var. Platense that have been investigated genetically, one was identified as the positional-sterile (ps) gene by allele tests with stock LA 63 received from C. M. Rick.

For our country, especially in the humid zone of greater Buenos Aires, which is the principal region for tomato production in the summer, this mutant provides a way of producing hybrid seed for testing hybrids derived from crosses of Platense with varieties of good fruit type in the search for favorable combinations. Previous tests with introduced varieties having male-sterility genes have not yielded good hybrids under such conditions except for those in which Platense or derivatives of Platense served as a parent. The superior performance of such hybrids owes to the dominant or partially dominant resistance of Platense to spotted wilt ("peste negra") transmitted to the F_1 hybrids (personal communication from Ing. Agr. Alejo von der Pahlen).

Besides this important advantage, other characteristics of the Platense mutant render it useful for producing hybrid seed. Among the additional advantages should be mentioned the semi-exserted style that results from the premature withering of the sterile anther tips which shrink against the stylar column. The stigma thereby partly exposed facilitates artificial pollination and to some extent impedes natural selfing. Also, in artificial crosses it produces a good yield of seed per fruit in the heated greenhouse in winter as well as in summer plantings in the open. For the former conditions the mean number of seeds is estimated at 200 per fruit, which does not differ appreciably from yields in open field culture. Another favorable characteristic is that the frequency of natural selfing of the mutant is low under conditions of greenhouse as well as field culture, being less than 0.11% according to tests in both cultures, a percentage that might be reduced or even eliminated by discarding the smallest harvested fruits, which largely result from natural selfing.

The reduced yield consequent upon incidence of unfruitful plants of such hybrid seed, corresponding to the proportion of natural self-pollination, would be insignificant in comparison with the increased yields realized from the use of a superior hybrid.

These characteristics of the Platense (ps) mutant have permitted a program of crosses with a broader base than formerly available when limited to lines with male-sterility and common parentage. The plan is to seek combinations with hybrid vigor for earliness, yield, and/or size of fruit, which are the characteristics most prized in the Buenos Aires district.

(The valuable cooperation of C. M. Rick and A. v. d. Pahlen is appreciated).

Fierlinger, P. S. Dominant mutant exhibiting a severe determinant growth habit.

An interesting mutant was revealed in M_2 generation of over 15,000 plants after application of 25 kr gamma-ray on seeds. It is a dominant mutation giving a severe determinant growth habit, reminding of the

phenocopy obtained by H. G. Cordner and G. Hedger (Proc. Amer. Soc. Hort. Sci. 73:323-333, 1959) by N-meta-tolylphthalamic acid. The initial variety Stupicka polni ranna is indeterminant with a potato leaf character (c). This mutant is lethal in its homozygote constitution, bearing only rudiments of generative organs (Fig. 1). Propagated by its heterozygote form, its progeny, in spite of a certain deviation caused by its lethality, sufficiently fits the 1:2:1 segregation. For its lethal effect we were not able to gain as yet a satisfactory explanation of the gene constitution.

Figure 1. Homozygote form.

Figure 2. Heterozygote form.

Fierlinger, P. S. Utilization of induced mutation.

The fitness of this method for breeding tomatoes has been evaluated after a period of five years. The main aim was to gain an earlier maturing variety than the earliest Czechoslovak variety, Stupicka polni ranna. It is an indeterminant variety with a good taste (higher content of soluble solids than other commercial varieties) and gives early maturity to its hybrids (Trojničkova E. Ved. Prace VURV 3:125-126, 1957; Betlach J. Rostl. vyr. 2:61-70, 1965). Seeds of this variety were irradiated with gamma-rays (25-45 kr) in 1961. Also, this variety was grown on the gamma-field in 1962 under chronic irradiation from seedling to harvest. In the M_2 generation fruit progenies and further progenies from succeeding plants were selected and planted. This recurrent selection was made, besides other, for early maturity and higher content of soluble solids.

In Table 1 the increase of soluble solids in M_2 - M_6 generations of progenies after application of acute gamma-rays and selection (see population) compared with the initial variety (see standard) is clear. In Table 2 it is evident that progress in population after chronic gamma-irradiation and selection is not obtained, probably due to a lower mutation frequency. The same material was evaluated for earlier maturity exceeding the initial variety. Preliminary estimations of results obtained from three-year trials (in M_4 - M_6) of selected progenies did not reveal values deviating from those of the initial variety. The reason why recurrent selection is not effective and does not reveal mutations in characters where its manifestation is strongly influenced by the environment is probably due to environmental conditions which vary from year to year. This material is under further study.

Table 1:--After acute application of gamma-rays (25-40 kr).

Generation	Standard		Population		F	F_{tab}	LDS
	$\bar{X}_s$	s^2	$\bar{X}_p$	s^2			
M_2	5.75	1.04	5.8	1.98	1.90	1.1	0.01
M_3	5.95	1.57	6.0	0.79	2.01	1.5	0.01
M_4	6.35	2.66	7.05	2.44	1.09	1.1	0.05
M_5	5.3	1.06	5.7	2.17	2.04	1.4	0.01
M_6	4.7	1.40	5.35	2.06	1.47	1.4	0.01

(Table 1 - continued)

Generation	u_s	u_p	Deviation	No. of evaluations	
			$\bar{X}_p - \bar{X}_s$	Standard	Population
M_2	5.75 ± 0.4	5.8 ± 0.005	0.05	668	7,226
M_3	5.95 ± 0.15	6.0 ± 0.005	0.05	59	2,550
M_4	6.35 ± 0.36	7.05± 0.15	0.7	196	990
M_5	5.3 ± 0.30	5.70± 0.10	0.4	133	1,884
M_6	4.7 ± 0.13	5.35± 0.05	0.65	128	1,677

Table 2:--After chronic application of gamma-rays.

Generation	Standard		Population		F	F_{tab}	LDS
	$\bar{X}_s$	S^2	$\bar{X}_p$	S^2			
M_2	6.0	1.57	5.7	1.01	1.55	1.4	0.05
M_3	5.9	1.66	6.0	2.22	1.33	1.3	0.01
M_4	5.1	1.37	5.0	2.40	1.75	1.1	0.01

(Table 2 - continued)

Generation	u_s	u_p	Deviation	No. of evaluations	
			$\bar{X}_p - \bar{X}_s$	Standard	Population
M_2	6.0 ± 0.16	5.7 ± 0.02	-0.3	59	5,065
M_3	5.9 ± 0.02	6.0 ± 0.006	0.1	180	5,749
M_4	5.1 ± 0.03	5.0 ± 0.008	-0.1	811	3,235

Gilbert, J. C., and Jack Tanaka

The use of Hawaiian tomato lines in crosses with mainland lines to obtain greater heterosis in the F_1.

The Hawaiian tomato lines and varieties used in these hybrids originated in a breeding program which was started by Frazier in the 1940's from very diverse germplasm but remained a "closed system" for some 20 years thereafter (Island of Oahu). There was no exchange of genes between this series of lines and those in Florida and other southeastern states during this period.

Of 10 F_1 hybrids entered from Hawaii in the S.T.E.P. trials in the last 8 years, 8 have been successful and only 2 dropped out for poor scores. Of these, one had a parent with fruit size below commercial requirements in this area and the other was a cross made between a southeastern line and a rootknot resistant inbred recently derived from a combination of a Hawaiian and a southeastern variety. The latter, then, was not a typical hybrid of the type described above but was 3/4 S.E. and 1/4 Hawaiian in its recent ancestry. It was dropped because of light production.

The success of F_1 hybrids made between these Hawaiian lines and present southeastern tomatoes as seen in the Southern Tomato Exchange Program is in contrast to the work of Quinones (Proc. Amer. Soc. Hort. Sci. 70:366-372, 1957) in which no heterosis effects on yields of hybrids with unrelated parents could be shown.

Although Quinones in Minnesota studied hybrids made between northern varieties and unrelated Hawaiian varieties as compared with other hybrids in which both parents were northern varieties, we feel that the lack of yield improvement in the unrelated crosses may have been due to the introduction of genes for subtropical adaptability into hybrids which were then compared with northern x northern crosses in trials conducted in the north. The Hawaiian varieties used as the unrelated parents had been selected for 15 years at low elevations in a latitude about the same as Mexico City. They do not have a good record of performance in northern trials. We thus feel that the case for greater heterosis in commercial tomato hybrids with "unrelated" parents is still open.

Gilbert, J. C., Jack Tanaka, and J. T. Chinn Longevity in heavy yielding tomatoes.

Starting in 1956, F_1 hybrids made between rootknot nematode resistant Hawaiian varieties and breeding lines and recent southeastern tomato lines have been grown annually in yield trials on Oahu in fields where tomato pathogens (except bacterial wilt) commonly found in subtropical areas were usually present. These include Fusarium wilt, rootknot nematodes, Alternaria diseases, Stemphylium solani, tobacco mosaic virus, Rhizoctonia, Pythium, and other soil fungi as well as spider mites, broad mites, serpentine leaf miners and melon flies (Dacus cucurbiteae). Spotted wilt virus has occurred sporadically.

The ten year record of the hybrids here shows no year in which the hybrids failed to outlive their parents by a wide margin. The inbreds regularly die out in these fields after one cropping cycle while the hybrids send out new growth, begin flowering again and set a new crop of fruits, even though they have already produced a heavier yield than the inbreds in the first cropping cycle. Since the inbreds are also rootknot and multiple disease resistant in many cases, this greater longevity of the hybrids could be attributed to a combination of hybrid vigor and a somewhat larger number of disease resistances than in either parent.

Tomato plant longevity and extended cropping may not be of interest in areas with a more limited season (except for greenhouse culture), but they are of interest among tropical growers with no seasonal limitations. Over 90% of the tomatoes grown in Hawaii are F_1 hybrids of this type, even though rootknot resistant inbreds have also been available in commercial types since 1955. The same hybrid may be used from sea level up to 3,000 feet at all times of the year. This is a more extended range than available from the inbreds here. Although the multiple resistant hybrids may be still producing marketable fruits at 9 months of age, they are usually limited to 6-8 months because of trellising problems.

Ibarbia, E. A., and V. N. Lambeth Predicting quality attributes of F_1 hybrids from parental values in the tomato.

Uncertainty as to the precise mode of inheritance of quality attributes such as soluble solids, pH, and titratable acidity has raised the question as to the extent of genetic gain to be realized from F_1 hybrids. In an exploratory study, eight commercial hybrids resulting from crossing of lines of broad genetic base were compared with their midparents for the three previously mentioned quality attributes in the tomato.

Except in one instance, that of the cross Pink Mozark x Tomboy for soluble solids, the values of the F_1 progenies were not statistically different from those of their respective midparents for the three quality attributes (Table 1). In four crosses out of eight for soluble solids content, two for pH, and two for titratable acidity, the two parents differed significantly (5%) for the quality attribute. It did not appear to matter in the F_1 progenies, however, whether there was significant disparity or not between the two parents going into the cross.

The fact that F_1 values approximated or equaled those of the midparents may suggest that under the particular conditions of this experiment, F_1 hybrids would be expected to show phenotypic values about equal to the mean of their two respective parents. Should this generalization continue to hold in future, more extensive experiments, the breeder's job of predicting F_1 performance may

Table 1:--Significance of differences between parents and between midparents and F_1 for soluble solids, pH and titratable acidity in 8 crosses in tomatoes.

Combination	Soluble solids				pH				Titratable acidity			
	$\bar{P}$	$\overline{MP}$	$\bar{F}_1$	$\overline{MP-F_1}$	$\bar{P}$	$\overline{MP}$	$\bar{F}_1$	$\overline{MP-F_1}$	$\bar{P}$	$\overline{MP}$	$\bar{F}_1$	$\overline{MP-F_1}$
Tomboy x Ozark Wonder	6.01* / 6.45	6.23	5.93	-.30	4.36* / 4.54	4.44	4.45	+.01	.456* / .366	.411	.404	-.007
Pink Shipper x Tomboy	6.01 / 6.01	6.01	5.77	-.24	4.45 / 4.36	4.41	4.44	+.03	.463 / .456	.459	.393	-.066
Pink Mozark x Tomboy	5.38* / 6.01*	5.70	6.31	+.61*	4.36 / 4.36	4.36	4.44	+.08	.523 / .456	.487	.427	-.060
Mammoth Wonder x Tomboy	6.62* / 6.01*	6.31	6.37	+.06	4.55* / 4.36*	4.45	4.42	-.03	.453 / .456	.454	.425	-.029
Red Tomboy x Delicious	5.64* / 6.43*	6.03	5.97	-.06	4.38 / 4.45	4.41	4.42	+.01	.396 / .458	.427	.429	+.002
76-1-60-8 x Delicious	6.19 / 6.43	6.31	5.89	-.42	4.53 / 4.45	4.49	4.49	0	.392 / .458	.425	.412	-.013
89-3-60-7 x Delicious	5.98 / 6.43	6.20	6.03	-.17	4.41 / 4.45	4.43	4.46	+.03	.457 / .458	.457	.460	+.003
Red Tomboy x 89-3-60-7	5.64 / 5.98	5.81	5.93	+.12	4.38 / 4.41	4.39	4.47	+.08	.396* / .457	.426	.427	+.001

* Significant at 5% level. Under the column heading $\bar{P}$, the significance (*) is between the two parent means which appear immediately above or below the asterisk.

$\bar{P}$ - parent mean; $\overline{MP}$ - mid parent mean; $\bar{F}_1$ - hybrid mean.

lie in visually examining the midparental means. The comparable F_1 and midparental values may also indicate that additive gene effects may be the situation as would be found in a case where inheritance is of a quantitative nature. In an earlier work, Lower (Diss. Abstr. 24:3508) indicated that variation exhibited by pH and total titratable acidity was of a quantitative nature. The exceptional case in cross Pink Mozark x Tomboy may be a situation where some genes showed considerable dominance or non-additive effects. One of the parents, Pink Mozark, however, is not yet quite stable.

Ibrahim, Helmi, S. Shannon, and R. W. Robinson Influence of the high pigment gene on anthocyanin content.

The high pigment gene influences many seemingly unrelated physiological processes, bringing about increases in carotenoids, chlorophyll, ascorbic acid, fruit firmness and stem brittleness. Still another effect of this gene was discovered more recently by E. A. Kerr, who observed that hp seedlings differ from normal by producing pink pigments in the subterranean portion of their hypocotyls. In view of the diverse pleiotropic effects of hp, the biochemical nature of these pink pigments aroused our interest.

It was determined by paper chromatography that the pigments consisted of anthocyanins. The anthocyanins of both hp and + plants were acylated diglucosides. Hydrolysis of the anthocyanin pigments revealed that petunidin was the major anthocyanidin in both hp and +, and both had lesser amounts of malvidin and traces of delphinidin. Both hp and + had the same aglycones, sugars, and acyl groups. Thus hp appears to have a quantitative rather than a qualitative effect on anthocyanin content.

Kerr, E. A. Further data on the linkage relations of nc.

In TGC 17 possible linkage of nc with both ah and a was reported. Crosses in 1967 proved that there were no mistakes in the classification of the a and ah parent stocks. Further tests with the remnants of backcross seeds again indicated linkage between nc and ah. There was random segregation of nc—a although there were more a segregates than expected. The total population still indicates linkage between nc and a, but this is believed to be fortuitous. Data for the total populations grown in 1966 and 1967 are:

++ 111, + ah 70, nc + 38, nc ah 74, CO 36.9

++ 84, + a 69, nc + 34, nc a 66, CO 40.7

With great sympathy, seed of nc has been sent to R. W. Robinson for more critical study of its linkage relationships on chromosome 9.

Kerr, E. A. "Paprica" is on chromosome 2.

In 1965 R. Frankel sent me seed under the number 745 which he described as follows:

' "paprica" Mutant - tough epidermis mutant induced by neutron irradiation, indeterminate, two-locular, oval shape, poor quality.'

When grown in the greenhouse the fruits were very puffy with a large air space in each locule. This puffiness was absent when grown under field conditions. In 1967 it was noticed that, in two F_2 populations between "paprica" and round tester stocks, almost all elongated fruits were wrinkled.

They appeared to be puffy fruits whose outer wall had been drawn in until it was tightly pressed against the locular jelly.

No tests were made with stocks known to be o. However, the parent "paprica" stock was a San Marzano type which gave 25% elongated fruits in F_2. Since no round "paprica" fruits were observed in populations totalling 300 plants and all plants bearing elongated fruits bore some "paprica" fruits, it is assumed that "paprica" is located on chromosome 2 very close to o. It may even be an allele of that gene.

Kerr, E. A. Possible location of high pigment hp on chromosome 8.

Many tests for linkage with hp have been made at Vineland and elsewhere. Vague suggestions of linkage have been obtained from F_2 populations involving genes on chromosomes 1, 2, 3, 5, 6, 8, 10 and 11, but further tests were either negative or indefinite. Part of the difficulty has been reduced emergence and identification of hp plants. At Vineland there apparently has been confusion in tests with genes on chromosome 8. Fruit color of l plants appears to be, or is, more intense than that of normal segregants. The gene gf was obtained from Philippine #2 which also contains crn. Some of our stocks of gf are "contaminated" with crn. This undoubtedly has resulted in some segregants being wrongly classified.

In 1967, two backcross populations were classified at the pricking-out stage for hp. One of these segregated for gf and the other for l. The data are as follows:

++ 56, + l 44, hp + 21, hp l 28, CO 38.5

++ 40, + gf 30, hp + 23, hp gf 28, CO 43.8

These data are fairly convincing, but unfortunately 4 F_2 populations segregating for the same genes gave irratic results. A backcross population made with the marker hp—l—tp will be grown before hp is definitely assigned to chromosome 8.

Khush, G. S., and C. M. Rick
Approximating centromere positions.

In a study recently completed of 74 induced deficiencies for key loci, as well as of various other aberrations, we have been able to obtain better approximations of centromere positions than those previously established for most of the tomato complement. Key information was also thereby provided for orientation of the linkage maps; i.e., the parts of the linkage map associated with the short vs. long arms. Since the data and proofs are to be presented in detail in a manuscript submitted for publication, our findings are summarized in the linkage maps issued in this Report.

Khush, G. S., and C. M. Rick
Where is lg?

In our efforts to find the arm locations of markers of chromosome 10 and to determine the position of the centromere on the linkage map, we tested lg, u, h and ag with a secondary trisomic for 10L. The genes ag and h gave trisomic ratios and were thus delimited to 10L, while u gave a disomic ratio and must therefore be on 10S. The centromere must therefore lie between u and h. Since these data are discussed in a paper submitted for publication, the

data need not be presented here. However, the data on the BC progeny of the secondary trisomic x lg is presented below, as they show that lg is independent of chromosome 10.

2n		2n + 1 (secondary)		2n + 1 (primary triplo-10)	
Normal	Recessive	Normal	Recessive	Normal	Recessive
98	87	26	26	23	29

The data show that the segregation amonst the three fractions of the progeny is clearly disomic. Had lg been on chromosome 10, no or very few primary trisomics with recessive phenotype would have appeared. Thanks to the appearance of so many primary trisomics in the progeny of this secondary, it was possible to detect the error in the original mapping. The genes lg and pe, which are only 8 cM apart, must therefore belong to some other chromosome. Since lg is an excellent seedling marker it should be tested with other chromosomes, especially 12 and 5.

Khush, G. S., and R. W. Robinson
Linkage relations and arm locations of chromosome 9 markers.

Since our report on the cytological locations of nv and ah on 9L, we have obtained new deficiencies for the loci of these markers. These deficiencies have permitted us to localize the loci of these markers to much smaller regions than previously reported. The locus of nv is now known to be in the region embracing the 2nd, 3rd and 4th chromomeres of heterochromatin of 9L, and ah is situated very near the junction of heterochromatin and euchromatin of 9L. An unlocated marker, lut, was also allocated to the euchromatin of 9L by means of the induced deficiency technique. The pseudo-dominant lut plant was deficient for most of the euchromatin of 9L except a small terminal segment. Our F_2 linkage data (539 ++ : 264 ah + : 170 + lut : 22 ah lut) show a distance of about 32 units between ah and lut. Another marker, marm, was delimited to 9L by means of tertiary trisomic test (Canad. Jour. Genet. Cytol. 9:610-631). Two markers of the Verkerk Series, 377-20 and 242, were found to be closely linked to ah, were tested with a secondary trisomic for 9L, and gave disomic ratios. Both of the markers must therefore lie on 9S. Since 377-20 is identical in phenotype to wd and gives similar linkage values with ah, we are convinced that 377-20 and wd are allelic. Also, a very tight linkage between ao and nv suggest possible allelism between ao and ah. However, 242 is a new marker for 9S. The position of the centromere must therefore lie between wd and nv.

Kruse, J. (Submitted by H. Stubbe)
Morphological characterization of the Gatersleben Mutant Collection.

A study has been made of the morphological characters of X-ray induced mutants in the Gatersleben Tomato Mutant Collection containing mutants described previously by H. Stubbe. These studies consisted in a detailed investigation of the mutant characters and their comparative description (growth habit, leaves, flowers, fruits and inflorescences). For these derivations and comparisons, some mutants which were described in former TGC Reports were used. A synopsis is given (in a separate publication) by arranging the mutants in morphological series.

It was found that most of the mutants are reduced forms. A smaller number are marked by progressive characters. Generally the progressive as well as the regressive characters are quantitative ones. Some forms show qualitative characters new within the genus Lycopersicon.

The most frequent deviations concern characters of growth habit and of leaves. The manifoldness of growth habit is chiefly determined by the variation of plant size, frequency of branching and the degree of ramification. A fundamental variation of ramification could be observed only in one case (mut. mortalis).

The variations in the form of the leaves are caused by the change of leaf size, the relative leaf length, the form of the leaflets, the degree of the pinnation, and the number of the major and minor leaflets.

Extremely ramified inflorescences have been observed besides the common reduction-types. They are partially characterized by the presence of leaves and by the total reduction of flowers (e.g. mut. falsiflora).

In the material studied only a few forms with altered flowers and fruits have been observed.

The ontogeny of some organs has been analyzed for a better understanding of the reductions and of the drastically changed structures which had been difficult to explain. Furthermore, the morphological characters of the cultivated tomato were compared with those of some wild species of the genus Lycopersicon (espec. L. hirsutum). In this way it could be shown that the lowest leaflets of the tomato leaf are a pair of major leaflets.

The expression of the mutant characters is modified by many factors, some of which are discussed with respect to their effect on the tomato mutants.

On the basis of these detailed morphological descriptions, a classification of these 250 mutants was elaborated. Its practical use, however, is limited by the difficulty of reproducing exactly the environmental conditions every year. This grouping is based in each stage on the numerous variations within one character. Thus an overlapping of the single groups is avoided. The characters of the growth habit form the major divisions, while the subdivision is based on leaf characters. A further arrangement of the mutants is possible by using other characters,e.g. of fruits or flowers.

The results will be published in detail in the journal "Die Kulturpflanze".

Lesley, J. W., Margaret Lesley, and R. K. Soost Evidence of linkage of Crinkled (Crk) and anthocyaninless (ah).

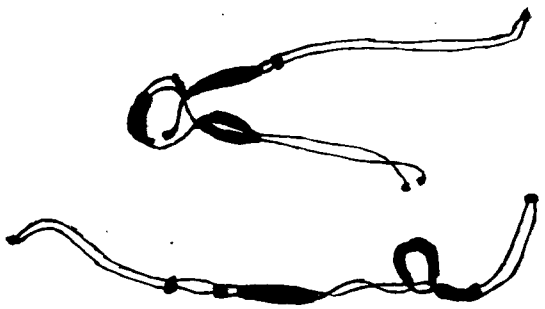
Six additional F_2 and F_3 families from Crinkled parents contained 201 Crk : 100 Crk^+, thus confirming the previous finding (TGC 17:36-38, 1967) that Crinkled is dominant and homozygous lethal. As previously noted, Wo and Crk seem to be independent, indicating that Cu and Crk are different. F_2 and backcross families of Crinkled and alleles in chromosomes 2, 6, 9 and 11 segregated as shown in the Table. The expected F_2 ratio is Crk x^+ 6, Crk x 2, Crk^+ x^+ 3, Crk^+ x 1.

Evidence of linkage with anthocyaninless ah is shown in the Table. This comes from only two families both having Crk and ah in the "trans" or repulsion phase. The data are homogeneous and linkage is in accordance with phase. The ratio ah^+ : ah is 123 : 52 and deviates significantly from 3 : 1 (Chi square = 6). A deficiency of Crk^+ ah^+ and excess of Crk^+ ah occurred. If Crk is in chromosome 9 it will be a useful marker in one of the least frequented chromosomes. It was not easily scored with c, potato leaf, in the two-leaf stage, but probably could be distinguished in this stage except with mutants causing extreme leaf distortions. Although distinctly slow-growing, Crk is quite fertile.

Backcross and F_2 from Crinkled (Crk) x mutant alleles, trans (repulsion) with respect to Crk and x, a mutant allele.

Parent	Type	Mutant allele	Chrom. of mutant	Crk x^+	Crk x	$Crk^+ x^+$	$Crk^+ x$	Chi^2_L	P
66.048.25 x 66.002.1	BC	Wo	2	16	15	17	16	0	
66.148.8 66.111.24	selfed F_2) selfed F_2)	d_1	2	57	16	25	9	0.2	.9
66.148.8 66.111.24	selfed F_2) selfed F_2)	c	6	46	30	25	9	1.5	.2
66.148.8 66.111.24	selfed F_2) selfed F_2)	a	11	56	19	28	6	0.9	.3
67.014.7	selfed F_2	ah	9	74	24	30	22	6.1	.01
67.014.8	selfed F_2	ah	9	14	3	5	3	0.8	.3
Combined ah-Crk		ah	9	88	27	35	25	6.7	<.01
ah-Crk expected				87.6	29	43.8	14.6		

Pericentric inversion.



Meiosis in Crk is similar to that in Wo except that in F_1 Wo x Crk occasional cells indicate a pericentric inversion (Fig.) in a chromosome resembling 9.

Makó, J. (Submitted by B. Gyórffy) Frequencies of transmission of extra chromosomes to the progeny through egg cell and through pollen grain.

Sesquidiploid hybrid plants were produced by crossing between the autotetraploid L. pimpinellifolium and the diploid L. peruvianum. We obtained individuals with different chromosome numbers (1-10) and with different frequencies in the first and second generation progenies (TGC 13:36-37). Since these arose from uncontrolled natural pollination, we could not estimate the rate of transmission of extra chromosomes through the pollen grains.

In the 2n=25 aneuploids the separation of chromosomes in the first meiotic anaphase was regular, and 50% of the pollen grains contained the extra chromosome; the same distribution was assumed for the egg cells.

In the present experiment, we used two aneuploid individuals (2n=25) conspicuously different in their morphology, and it was very likely that not the same chromosome of L. pimpinellifolium was present as an extra chromosome in these two aneuploids in addition to the whole genome of L. peruvianum.

The aneuploid x normal and reciprocal crosses were performed under greenhouse conditions. The distribution of the extra chromosome in the offspring determined in the meiosis is presented in the Table. The results indicate that the extra chromosome was transmitted with higher frequency through the egg cells than through the pollen grains.

The proportion of the stainable and unstainable pollen grains was very variable among the individuals independently of chromosome number, but on the average the pollen sterility of the aneuploid plants with 2n=25 chromosomes was higher (16.2%).

Crosses	Number of plants			2n=25
	Total	2n=24	2n=25	%
1. 2n=25 x 2n=24	656	492	164	25.0
reciprocal	218	207	11	5.0
2. 2n=25 x 2n=24	289	210	79	27.3
reciprocal	154	144	10	6.5

Monaco, L. C. Planting of non processed tomato seeds.

The cleaning of tomato seeds required before planting has usually been considered an important restriction to the use of tomato for mutation studies. The mucilage covering the seeds has to be removed by physical, chemical or, more frequently, by biological means. This disadvantageous aspect of the tomato may be eliminated by the use of uncleaned seeds.

During our study to evaluate the efficiency of EMS as mutagen for tomato pollen, the need for a simpler way of handling the tomato seeds became evident. Ripe fruits were harvested and the seeds planted without any cleaning. The fruits were cut in halves and the seeds squirted directly into drills in a sterilized mixture of soil. The seeds were then covered with sand and left overnight for fermentation to start. The next day the flats were watered and then stacked to keep moisture at a level with temperature maintained at 25°C. The germination of seeds without fermentation before planting was always above 90%. Some variation was observed in the time of germination in different samples and this variation is assumed to be due to differences in the stage of ripeness of the fruits. For the few families found segregating for induced mutation, the fruits could be harvested and the seeds cleaned and stored in the usual manner for later study.

de Nettancourt, D., and R. Ecochard

Effects of chronic irradiation upon fruit-setting in a clonal population of L. peruvianum.

Flowering plants from a self-incompatible clone of L. peruvianum (clone 6006 kindly provided by the Institute of Horticultural Plant Breeding in Wageningen) were exposed during 90 days to different dose-rates of gamma-rays ranging from 2 to 17 rad/hour. Irradiation was continuous except for a daily interruption of 7 hours.

Whereas irradiation at dose-rates higher than 7.50 rad/hour seriously inhibited bud formation and floral development, chronic exposure at dose-rates ranging from 3 to 7 rad/hour increased the number of seeds per plant. This stimulation is not due to a higher number of seeds per fruit but to a very significant rise in the number of fruits per plant (more than 50 fruits per plant in the case of 7.50 rad/hour as compared to 5.25 in the control series). Irradiation treatment did not significantly increase the number of flowers per plant and did not appear to stimulate pollen tube germination in the style (observed by means of UV microscopy 24 hours after pollination). It is therefore concluded that the recorded increase in fruit-setting essentially resulted from a radio-induced inhibition of the processes which control floral abscission in the absence of cross-pollination.

Three plants with reduced self-incompatibility and one completely parthenocarpic individual were observed in the M_2 progeny but no evidence was obtained that irradiation could induce a permanent type of self-compatibility in L. peruvianum.

Pelham, J. (Submitted by L. A. Darby)

Disturbed segregation of genes on chromosome 9 - Gamete promoter, Gp, a new gene.

The backcross families in pedigrees to produce TMV resistant varieties, using an accession of Tm-2^2 (from L. J. Alexander) as the donor parent, have repeatedly shown constant disturbed segregations for the resistance gene. Instead of the 1:1 and 3:1 monohybrid ratios expected, approximately 3:1 and 9:1 ratios were obtained for the backcrossing and selfings, respectively.

Hoffman's anthocyaninless, ah, mapped close to Tm-2 on chromosome 9, normally gives a good 3:1 F_2 ratio, but the F_2 from a cross of Tm-2^2 with ah segregated 119 tm-2^2 + : 11 + ah with one recombinant, Tm-2^2 ah. These 131 F_2 plants were all progeny-tested by selfing; the results are classified in the Table.

Parental phenotype	Class	F_3 progeny	No. of F_3 families	Deduced parental genotype
Resistant purple	a	All resistant All purple	68	$\frac{Gp \text{ or } +}{Gp \text{ or } +}$ $\frac{Tm\text{-}2^2 +}{Tm\text{-}2^2 +}$
	b	Segregating resist. : suscept. purple : green approx. 9 : 1	6	$\frac{Gp \quad Tm\text{-}2^2 \quad +}{+ \quad + \quad ah}$
	c	Segregating resist. : suscept. purple : green 3 : 1	41	$\frac{Gp}{Gp}$ or $\frac{+}{+}$ $\frac{Tm\text{-}2^2 +}{+ \quad ah}$
	d	Segregating resist. : suscept. purple : green approx. 1 : 1	1	$\frac{+ \quad Tm\text{-}2^2 \quad +}{Gp \quad + \quad ah}$
	e	All resistant Segregating purple : green 3 : 1	3	$\frac{Gp}{Gp}$ or $\frac{+}{+}$ $\frac{Tm\text{-}2^2 +}{Tm\text{-}2^2 ah}$
Susceptible green	f	All susceptible All green	11	$\frac{Gp \text{ or } +}{Gp \text{ or } +}$ $\frac{+ \quad ah}{+ \quad ah}$
Resistant green	g	All green Segregating resist. : suscept. 3 : 1	1	$\frac{Gp}{Gp}$ or $\frac{+}{+}$ $\frac{Tm\text{-}2^2 \quad ah}{+ \quad ah}$

A total of 47 susceptible green-stemmed plants from 24 families in classes b, c, d, and f were crossed with wild type (susceptible purple stem) plants, and the segregation of ah observed in the F_2 progenies. Nearly one-half of the individuals in each family were ah/ah instead of the expected one-quarter.

A resistant purple-stemmed plant in class d was crossed with wild type. Ten F_1 plants segregated with nearly a half of each F_2 progeny ah/ah; five F_1 plants gave rise to purple-stemmed progeny which segregated 3 resistant : 1 susceptible.

It is suggested that a gene, Gamete promoter (Gp), strongly promoting the gametes which bear it, has been introduced into these breeding lines on chromosome 9. The deduced genotypes of the different classes of plants in the F_2 progeny of the Gp $Tm\text{-}2^2$ x ah cross are presented in the Table. Initial calculations suggest a gene order Gp $Tm\text{-}2^2$ ah with Gp and $Tm\text{-}2^2$ separated by as much as 20 units.

This gene has probably been introduced into L. esculentum from L. peruvianum the source of $Tm\text{-}2^2$. The action of Gp in the wild species is to be investigated.

Plant breeders working with Tm-2^2 should beware of the effects of Gp. The combined effect of the plant breeder selecting for resistance and of Gp promoting itself would, in the absence of double crossovers, result in a large section of chromosome 9 being kept intact.

Perquin, M. D. G., and J. J. C. M. Claassen (Submitted by R. Ecochard and D. de Nettancourt) Progeny tests of irradiated tomatoes under sub-optimal growing conditions.

A number of X_3 and X_4 progenies from variety Money Maker, line 83 NUNHEM, have been tested for their yielding capacity under sub-optimal growing conditions (low light intensity, day temperature 18, night temperature 15°C) in a winter greenhouse. Under these conditions, one M_3 line (PK_{23}) was found to set more seeded fruits and larger fruits than the best control plants. Pollen of the PK_{23} line and of the control plants was collected from the winter greenhouse and from a growth-chamber (12,000 Lux, day temperature 23, night temperature 17°C) and a series of pollinations was made on excised styles which had been harvested in the winter greenhouse and incubated on agar at 23°C. Twenty-four hours after pollination, pollen tube growth in the style was examined by means of UV microscopy following the technique of Martin (TGC 9:38). The results obtained (Table 1) indicated that the pollen of PK_{23}, harvested from the winter greenhouse, germinated and grew significantly faster than the control pollen harvested in the same greenhouse. No differences could be detected between PK_{23} and the control lines in those cases when the pollen had been collected from plants growing in the climate cell. These preliminary results appear to suggest that at least some of the beneficial effects of irradiation on tomatoes cannot be detected unless progeny tests are conducted under sub-optimal growing conditions.

Table 1:--Number of pollen tubes having reached at least one-half of style length 24 hours after pollination (measurements are based on 15 styles per cross).

Styles \ Pollen	Winter greenhouse		Climate cell	
	Control	PK_{23}	Control	PK_{23}
Control	4.8 ± 0.8		13.8 ± 6.7	
Winter greenhouse PK_{23}		22.0 ± 10.7		16.2 ± 7.3

Provvidenti, R., W. T. Schroeder, and R. W. Robinson Possible sources of Tm-2 not linked with the nv allele.

Two additional sources of TMV resistance were compared with Tm-2 and Tm-2^2 stocks for their responses to virus strains and temperature, using the technique reported in TGC 17:47-49, 1967. One source,

127832-4G-1-1, was selected by Alexander and McRitchie from Lycopersicon peruvianum (P. I. 127832). The other source, Perou 2, was obtained by P. Pecaut from L. peruvianum through selection from P. I. 126926 and subsequent crossing with L. esculentum.

Genotypes	Symptoms at following temperatures (C)									
	TMV normal strains					TMV aberrant strains				
	20	25	30	35	40	20	25	30	35	40
+/+	M	M	M	M	M	M	M	M	M	M
$Tm\text{-}2^2/Tm\text{-}2^2$	Sl	Sl	Sl	N	N	Sl	Sl	Sl	Sl	N
Tm-2 nv/Tm-2 nv	Sl	Sl	Sl	Sl	Sl	M	M	M	M	M
127832-4G-1-1	Sl	Sl	Sl	Sl	Sl	M	M	M	M	M
Perou 2	Sl	Sl	Sl	Sl	Sl	M	M	M	M	M
(Perou 2 x Tm-2 nv) F_1				Sl					M	

TMV strains

Normal: Alexander V. Boyle and U-1
Aberrant: NY66-4, NY66-5 and Alexander IV

M - Mosaic; Sl - Symptomless; N - Necrosis (a shock reaction, usually followed by mosaic and leaf distortion).

Respective viruses were recovered from all symptomless plants using Chenopodium quinoa as local lesion host.

The data in the above table indicate that 127832-4G-1-1 and Perou 2 behaved identically to Tm-2 nv with respect to resistance but did not have the $Tm\text{-}2^2$ allele. Both lines, particularly Perou 2 because of its closer relationship to L. esculentum, provide a most useful source of this resistance without the virescence incited by nv.

Reeves, A. F. Digenic determination of the citrine character. The citrine character first appeared in F_2 segregation in one of Jack Hanna's breeding lines, No. VFN/36-11-10. Ten seedlings out of 63 were uniformly tinted bright whitish-yellow and maintained this color at all stages. Citrine plants grow rather slowly but have comparatively normal morphology and will fruit under field and greenhouse conditions. Citrine plants from the original F_2 family, and others subsequently grown, bred true when selfed. The character is especially useful since it is uniformly expressed under all tested conditions and in all stages of growth.

The above described mutant has been notorious for its scarcity in all F_2 combinations. Except for the high yields in combinations with sy (18.1 and 19.7%), the percentage of citrine is 5.1, which closely approximates that expected for digenic duplicate interaction. It had earlier been noted

that a uniform pale green mutant also segregates in these F_2's. On the assumption that this pale green character was determined by one of the two genes, two of these plants were selfed and backcrossed to the citrine stock. These data are shown in Table 1.

Table 1

Family	Pale green	Citrine	Total
66L1595 F_3	7	3	10
1596 F_3	87	35	122
	94	38	132
66L1897 BC	10	5	15
1898 BC	1	6	7
1899 BC	6	11	17
	17	22	39

Het. X^2 for BC families = 6.06. Significant only at .05 level.

As an additional test, 48 pale green F_3 plants were selfed. Thirty-five of these segregated for the yellow citrine character, giving a total of 551 pale green : 180 yellow.

With this encouragement, an F_2 of citrine x per was grown, the normal appearing plants selected and selfed, and their progeny grown for classification. The data for these F_3 families are given in Table 2.

Table 2

	No. of F_3 families	%
All +	42	43.75
25% yellow	9	9.37
25% pale green	14	14.58
Pale green & yellow	31	32.29
	96	99.99

Table 3 shows the expected ratios of F_3 families under various assumptions of gene action and linkage. It can be seen that the actual data can fit only two of these conditions, both of which assume that there are two interacting genes causing the yellow phenotype. From the available data, it cannot be determined whether or not these two genes are linked. One indication that they are not linked, however, is the fact that the coupling F_2 families show less than 6.25% yellow plants.

Table 3

Assuming:	Percent of F_3 families with: all +	25% yellow	25% pale green	pale green & yellow
Two separate genes, independent	11	22	22	44
" " " , linked at 30 units	19.7	16.9	16.9	46.5
" " " , " " 25 "	21.9	14.6	14.6	48.8
" " " , " " 20 "	24.2	12.1	12.1	51.4
" " " , " " 10 "	28.8	6.4	6.4	58.3
" " " , " " 0 "	32.9	0.7	0.7	65.8
Two interacting genes, independent	33.3	16.7	16.7	33.3
" " " , linked at 30 units	33.3	14	14	38.7

The question is now raised as to the phenotype of those plants homozygous for the second gene. These would be the "normals" in the F_3 families having 25% yellow plants. Some of these "normal" plants had a somewhat yellowish growing point, but not consistently so. Until further studies are made, we assume that the second gene has no visible expression of its own and can be called an "enhancer".

To return to those F_2's of citrine x sy, one possible explanation for the high yield of citrine is that the enhancer interacts with sy (and perhaps also other chlorophyll mutants), as well as with the pale green gene, to produce the yellow phenotype. Crosses are being made to test this theory.

An indication of linkage between citrine and La (on chromosome 7) was obtained in 1966 and confirmed this year (Table 4).

Table 4

	++	La +	+ citrine	La citrine	Total	χ^2
66L567	311	280	46	14	651	11.76
67L305	302	382	40	16	740	14.4

In assigning names and symbols to these two genes, we shall call the gene with the pale green phenotype lime (symbol lm), and the second gene, lime enhancer (symbol lme); thus reserving the name citrine for the yellow phenotype produced by the two genes together.

Reeves, A. F., R. W. Zobel, and C. M. Rick Further tests with mutants of the Stubbe Series I, II, III, and IV.

As a progress report of our tests, the present note summarizes information on six genes belonging to series I-IV. The format of presentation, abbreviations, etc. correspond to those we have used in previous reports. Information on the

testers used for each gene is presented in Table 1, and segregations that provided the evidence of linkage in Table 2. Pertinent information concerning loci is given in the following section.

var: Such weak linkages as reported here are ordinarily not regarded with much confidence, but a position on 7S has been established by Khush and Rick (Chromosoma, in press) by means of induced deficiencies. This relationship is also strengthened by our finding (see Rick, Reeves, and Zobel in this Report) of a linkage between atv and var. The populations of var x lg-5 were not large enough to distinguish between 9:7 and 1:1 ratios.

co: Although the data suggest a locus on 1 closer to scf than inv, they are inconclusive about order.

tab: The recovery of several a—hl—tab recombinants together with the intensities recorded for the a—tab and hl—tab intervals give strong evidence of the order: tab—hl—a with a locus for tab at about position 23.

lu: Linkage with chromosome 1 is based solely on the 2-point test with inv, but all phenotypes were clearly expressed and the departure from random association is highly significant. Independence with au suggests a locus on 1L at 77.

pla: In a 4-point test with marm—ah—pum, the distances indicate a locus between the pum—ah region and marm--a relationship that is also consistent with the finding of pla—marm, pla—pum, and pla—pum—ah but no other multiple recombinants. A locus is approximated at 13.

ses: Close linkage with au and very loose association with inv point to a locus at about 25 on 1S.

Table 1:--Summary of exploratory tests.

Stubbe group

Chsm	I	II		III		IV
	var	co	tab	lu	pla	ses
1	au,pr(S) y(S)	inv(L) scf(L)	au,inv scf	au inv(L)	inv scf	au(L),scf(L) inv(S)
2	d(S),Wo^m	aw,d,Wo^m	d,Wo^m	d,Wo^m	d	d,Wo^m
3	r,sf,sy rv,wf	sf,sy	sf,sy	sf,sy		ru,sf,sy
4	cm,di,e, ra,w-4	e,ful	e(S),ful(S) clau	e,ful		e,ful
5	mc(S),tf		tf	tf		tf
6	c,yv	c,yv	c,yv	c,yv	c(S),m-2(S) yv(S)	c,yv
7	La(L),lg-5 not(L)	La(S),lg-5(S) not(S)	deb(S),La lg-5,var(S)	not		not,La(L)
8	bu,dl,l(S)	dl	dl,l	dl,l	dl,l	dl,l
9	ah	ah	ah	ah marm	ah(L),marm(L) pum(L)	ah,lut(S)
10	ag,h,t^v,u	ag,h	ag,h	ag,h		ag,h
11	a,hl,neg	a,hl	a(L),hl(L)	a,hl	a	a,hl
12		fd				alb

S = Segregations that suggested linkage.

L = Segregations that significantly indicated linkage.

Table 2:--Linkage tests.

Combination	++	+t	m+	mt	χ^2	Co.
var—La	37	66	21	20	3.5	40
	38	106	24	24	8.1	39
	54	135	24	46	n.s.	44
	142	303	77	93	9.0	41
—not	216	87	90	17	6.2	39.0
	(rogued to var)		85	14	6.2	40
—lg-5	98+ :	71 lg		(vs 9:7)	0.2	
	75+ :	79 lg		(" " ")	3.56	
co—scf	717	397	231	7	98.5	16.0
—inv	772	342	201	37	21.6	37.5
tab—a	267	179	89	10	18.7	30.5
—hl	256	140	97	2	41.4	13.5
lu—inv	94	40	52	2	13.7	20
pla—marm	127	33	47	2	6.2	26.5
	389	183	122	13	26.2	30.0
—ah	119	41	49	0	14.0	0
	401	171	134	1	48.8	9.5
—pum	124	36	49	0	11.8	0
	409	163	133	2	43.1	13.5
ses—au	476	213	199	1	76.8	7.5
—scf	675	230	248	43	13.5	40.5
—inv	724	181	245	46	2.3	46

Rick, C. M., A. F. Reeves, and R. W. Zobel Inheritance and linkage relations of four new mutants.

atv (atroviolacea). Brief mention of this mutant is made in Occ. Pap. Calif. Acad. Sci. 44:66 (1963). Derived from a segregant in a natural population of Galápagos pimpinellifolium, it is characterized by strong anthocyanin pigmentation. Especially under cool conditions the purple coloration of stems, leaf veins, and even green fruits becomes intense. The intermediate intensity in heterozygotes leads to difficulty in classification and likely accounts for the irregular segregations presented below. Linkage tests have been completed against chrs. 1 (au), 2 (Wo^m,d), 3 (rv,sf,sy,wf), 4 (e), 5 (tf), 7 (La,lg-5,not,var), 8 (l,dl), 10 (h), and 11 (j), linkage being revealed with all tested markers of 7. Although this association with 7 is highly significant, the linkage intensities reported below are contradictory with respect to the locus of atv. Our difficulty in distinguishing between atv/atv and atv/+ doubtless accounts for the confusion. The linkage with var strengthens the support for a locus on 7.

aud (auroid). This mutant first appeared in fam. no. 64N117, a breeding line being grown by Dr. P. G. Smith and A. Millet. Five plants were mutant and 158 normal. All foliar parts are bright yellow and maintain this color under all tested conditions. It is reasonably vigorous and fertile in greenhouse and field. Because it closely resembles au, this new mutant is called auroid and symbolized aud. It differs from au in not being elongate in the seedling stage and in not developing blanched areas in the leaf laminae. The segregation pooled from 8 families was 1215+ : 347 aud, $\chi^2 = 6.61^*$, het.

χ^2 = 18.47*. Linkage tests were completed against chr. 3 (sy,sf), 4 (clau,e), 6 (c,yv), 7 (not), 8 (l,dl), 9 (ah,marm), 10 (ag), 11 (a,hl), and 12 (alb,fd), only the last revealing linkages. No recombinants were recovered from the F_2 with fd, and a linkage of 27 units with alb was indicated. Also reported below are the results of a test between alb and fd, the pooled data giving a value of 32 units. The data thus tentatively place aud close to fd but their orientation is still uncertain.

fsc (fuscatinervis). A single, weak, virescent plant appeared in our stock of VF145-22-8 and became the progenitor of this line. Characterized by retarded growth and by prominent veins of darker coloration, it was first called "dark venoid", hence the name fuscatinervis. The difference in vein coloration is apparent in the field, but growth there is essentially normal except for the fact that artificial selfing is usually required for seed production. Data pooled from 8 families show an extreme deficiency of recessives (3393+ : 356 fsc; χ^2 = 480.6***; het. χ^2 = 13.15 (n.s.). Linkage tests have been completed against chrs. 1 (scf,inv), 4 (e), 6 (c), 7 (La,not), 8 (l,dl), 9 (ah), 10 (ag,h), 11 (a,hl), and 12 (alb). Three separate tests with ah gave significant indications of linkage, the intensity of the pooled data being 24.5. Further localization awaits tests with other markers.

icn (incana). A breeding line (64N327) in the cultures of Dr. P. G. Smith and A. Millet yielded one stunted plant and 23 normal. The progeny of the exceptional plant bred true for a small slow seedling with cotyledons tending to be whitish, true leaves characteristically whitish with irregular margins and prominent purpling. Mature plants are vigorous and fruitful. A highly significant deficiency of recessives is revealed by the data pooled from 4 families: 1283+ : 287 icn, χ^2 = 37.85***; het. χ^2 = 7.32 (n.s.). Linkage tests were made with chr. 1 (au), 2 (Wo^m,d), 5 (tf), 6 (c,yv), 10 (ag,h), and 12 (fd), giving unequivocal evidence of a relationship with chr. 10. In a 3-point test with ag—h, independence was found with ag but linkage of some 23 units with h. A locus to the left of h is also supposed by the fact that 8/12 icn—h segregants were also ag. Since icn is thus likely located on 10S, it should be useful as a seedling marker of that arm.

Combination	++	+t	m+	mt	Adj. χ^2 cont.	Co.
atv—La	39	80	49	10	37.9	25
—lg-5	208	34	78	2	7.0	25.5
—not	89	16	516	13	29.9	25.5
—var	211	102	162	30	16.9	36.5
aud—alb	174	65	60	4	11.4	27.0
—fd	132	16	71	0	6.8	0
fd—alb (pooled)	1186	410	263	24	40.8	32.0
fsc—ah (pooled)	1004	528	148	11	50.0	24.5
icn—ag	208	93	37	13	n.s.	
	556	172	128	55	n.s.	
—h (pooled)	710	319	221	12	74.6	23.0

Robinson, R. W., and S. Shannon

Linkage relations of the crimson fruit color gene.

The tight cluster of genes around the sp locus is of interest because of its implications on the nonrandomness of gene distribution in the tomato and its significance to tomato breeders.

It has been a hindrance to tomato breeders trying to combine crimson fruit color with determinate habit, but it also promises to be very useful by providing them with a seedling marker (c) for plant habit (sp) and fruit color (og^c).

This study was made to learn more about the distribution of these genes on chromosome 6. Two breeding lines were parents of the cross c sp + x + + og^c. The F_2 segregation of 1870++ : 16 + sp : 15 c + : 639 c sp indicated 1.2 ± 0.1% crossing over between c and sp. The 31 crossover plants were progeny tested, classifying for the crimson fruit color gene (og^c) on the basis of flower color at low temperature, and their genotypes were determined to be 16 + sp + /c sp + : 15 c + og^c/c sp +.

The most probable order of these genes on chromosome 6, therefore, is c - sp-og^c. If this is correct, then the og locus is probably very close to the position assigned to the B locus by Ito and Currence (TGC 14:14-15, 1964). The close proximity of these two genes, and their action on the same biochemical system, suggests the possibility that they might constitute a multiple allelic series at the same locus.

Robinson, R. W., and M. L. Tomes

Ripening inhibitor: a gene with multiple effect on ripening.

An F_4 line, developed by H. M. Munger from a cross between Fireball and his breeding line 54-149, appeared extremely variable for maturity. The explanation became apparent later, when it was determined that a spontaneous mutation had occurred in a previous generation and the line was segregating for a gene inhibiting the ripening process.

Fruit of the mutant are green when normal fruits turn red, and they later develop a lemon yellow color. In storage tests at 7 constant temperatures ranging from 35 to 95°F, mutant fruits developed yellow color more rapidly with each increase in temperature and did not develop red color at any temperature. Chromatography tests indicated that carotenoid synthesis was inhibited. Mutant fruits had no phytofluene, little or no lycopene and gamma carotene, and reduced contents of phytoene and beta carotene.

One of the most intriguing features of this mutant is that so many aspects of the ripening process are affected. Mature fruit of the mutant are as firm as green fruit of normal plants. Mutant fruit appear to be much less subject to fruit rots than normal. Their storage life is extraordinary, for they may remain in sound condition for several months after harvest. They also have a distinctive flavor.

The F_1 of crosses between the mutant and 5 marker gene stocks produced normal fruit, and each F_2 segregated in close agreement with a 3:1 ratio, the pooled F_2 segregation being 363 normal : 127 mutant. It is proposed that the gene be named ripening inhibitor (rin).

No linkage was detected between rin and c, d, l, r, s, sf, sp, u, wf, or y, but a gene conditioning large sepals appeared completely linked with rin. The large sepal character segregated in each of the 5 F_2 populations, although none of the marker gene parents had this phenotype. Furthermore, the linkage was in coupling phase, indicating that the large sepal gene was contributed by the rin parent. This was substantiated when the original breeding line that rin was found to segregate in was replanted. It was found to segregate for large sepals also. It is unlikely that the large sepal character is a pleiotropic effect of rin, for the large sepal gene proved to be allelic with mc. Apparently rin and mc mutated together in the same plant, suggesting that there may have been a small deficiency involving

both closely linked loci rather than two separate and simultaneous mutations on chromosome 5.

Other crosses showed rin to be distinct from Nr (Never ripe) and gr (green ripe).

Shannon, S., R. W. Robinson, and Manuel D. de la Guardia
A spectrophotometric method for identifying plants with the crimson fruit color gene.

A reliable, objective method has been developed to identify plants having the unusual flower color associated with the crimson fruit color gene. The orange and yellow flower pigments were easily extracted by blending petals and anthers with acetone (1:200) for 2 minutes in an omnimixer. The filtered extracts were scanned with a Beckman DB spectrophotometer and their absorption spectra were recorded from 400 to 540 mμ. Extracts of flowers from High Crimson plants held for 5 days in a 10°C growth chamber had a low peak or prominant shoulder at 504 to 508 mμ which was not present in extracts of flowers from + plants treated in the same manner. The pigment has been separated by thin layer chromatography and is a carotenoid with an absorption spectrum similar to lycopene.

The pigment did not develop in flowers of High Crimson plants held at 25° or 30°C but did develop in flowers on these same plants less than one week after they were transferred to a 10°C chamber. This technique has provided a more positive identification of progeny segregating for the crimson character, especially in cases where the visual classification is uncertain. Only a single flower from individual plants is needed for the test.

Temperature has quite a different effect on the formation of this flower pigment than it has on the formation of lycopene in the fruit. Mature green fruit of High Crimson, a genetic line with the old gold gene, and several varieties and breeding lines with normal fruit color were ripened at different temperatures. Lycopene formation was sharply reduced in fruit of crimson and old gold as well as + types at 8°C or lower, whereas temperatures of 5° to 10° enhanced formation of the orange pigment in flowers of crimson and old gold.

Soressi, G. P. Development of hybrid tomato seed making simultaneous use of the genetic markers brown seed and spongy seed.

Brown seed (bs) character behaves as an endosperm trait while spongy seed (ss) is a typical plant character. Two schemes are proposed for their use.

for their use.

Scheme No. 1

	Line A		Line B	
♀	bs/bs (partially sterile with long style)	x	ss/ss	♂

Line A = seed parent : homozygous for bs, having partially selfing flowers with stigma protruding sufficiently beyond the anther cone (genetic or induced characters)

Line B = pollinator : homozygous for ss, with normal pollen fertility

Scheme No. 2

	Line C		Line D	
♀	bs/bs (long style; normal pollen fertility)	x	ss/ss; a/a (long style; normal pollen fertility)	♂

Line C = homozygous for bs character; flowers with stigma protruding sufficiently beyond the anther cone and with normal pollen fertility

Line D = homozygous for ss character and for any seedling marker such as green stem (a); flowers with stigma protruding sufficiently beyond the anther cone and normal pollen fertility

(C and D lines both function as seed parent and pollinator)

Stages in hybrid tomato seed production according to the two proposed schemes.

Sowing: Seed of both male and female lines can be distributed in separate rows or can be sown after the required proportions of seed are mixed to obtain the best results by the pollinating method adopted.

Pollination: The above two schemes increase the natural cross-pollination.

Harvest: Whatever the planting design, it is always possible to realize hand or mechanical harvest of the total yield to send to the cannery provided that the seeds can be extracted for selection. These seeds will be of three types:

a) brown seed (bs) : derived from selfed seed-parent and used in maintaining the line.

b) normal seed : produced by the seed-parent but hybrid as result of cross-pollination.

c) spongy seed (ss) : obtained from the pollinator plants and used in maintaining this line.

Using the second scheme, some spongy seeds will be hybrid, but they can be distinguished at the seedling stage because the recessive genetic marker green stem (a) appears in the self-fertilized seedlings.

Selection: All these seeds can be mechanically separated in three different classes by using electronic selecting machines which function on the basis of colour difference.

Soressi, G. P. Frequency of mono- and polycotyledon seedlings in F_2 selected progenies.

Polycotyledon seedlings usually occur in some varieties at rates of 1-3%. Progenies with 20-90% of multiple cotyledon types were selected from crosses between L. pimpinellifolium and var. Rutgers by Reynard (TGC 2, 1952). Thompson, on the other hand, could not increase by selection the frequency of tri- and tetracotyledons (TGC 13, 1963). In F_2 progenies from EMS treated seeds, one family of cv. Sioux with some single cotyledon seedlings was observed while a second case of cv. San Marzano had an unusually high frequency of polycotyledons.

The cotyledon of the monocotyledon seedling is often larger than the normal one, frequently has two midribs, and is more or less split. Monocotyledon seedlings grow more slowly than normal; the leaf spreads toward one side; calyx, corolla and anther cone are often distorted; fruit-set is nearly normal, but there are very few seeds per fruit when plants are freely self-fertilized in our field conditions. The polycotyledons were also slightly later than normal and had poorly seeded fruit, possibly because the style was longer than the anther cone.

The expression of the condition studied is variable and gives the impression of a continuous variation from monocot to tetracot seedlings. Field self-pollination of selected mono- and polycots and three different crosses gave the following results:

	No. of seedlings	1 cot.	2 cot.	3 cot.	4 cot.	% monocot	% polycot
Polycot self.	133	-	12	57	64	-	91.0
" "	280	-	67	103	110	-	76.1
" "	746	-	265	265	216	-	64.5
" "	219	-	130	48	41	-	40.6
" "	73	-	41	32	-	-	43.8
" "	141	-	104	26	11	-	26.2
Monocot self.	71	41	30	-	-	57.7	-
" "	173	78	95	-	-	45.1	-
" "	48	14	34	-	-	29.2	-
Dicot, possibly heterozygous for monocot	486	51	435	-	-	10.5	-
F_2 (monoc.x Red Top)	1,281	145	1,136	-	-	11.3	-
F_2 (monoc.x Sioux)	943	101	842	-	-	10.7	-
F_2 (monoc.x Dwarf)	153	14	139	-	-	9.1	-

Soressi, G. P. Gametophyte factor linked with potato leaf character.

To test linkage relationship, the reticulate virescent-2 (rv-2) mutant was crossed with Jenkins' multiple tester carrying br, c, j—lv, and wt genes. The F_2 did not segregate seedlings with potato leaf character in the expected ratio of 3:1, but at a very low rate as follows:

No. of seeds	No. of seedlings	+		c		c
		+	rv-2	+	rv-2	%
4,000	3,861	2,938	825	85	13	2.54

The highly significant deviation from the expected 25% is tentatively ascribed to a gametophyte factor placed on the chromosome carrying the +/c pair. The symbol proposed is x-2.

Tomes, M. L. Flesh pigment mutants—new mutant program.

On the basis of chemical analyses and phenotypic appearance, it was suggested that Verkerk's 509-105αα and 377-2αα probably were identical (Tomes and Verkerk, TGC 15:61-62; Tomes, TGC 16:37-38). A cross between these two gave an F_1 with the mutant phenotype, and a small F_2 population of 57 plants failed to segregate for flesh color. Thus, these two mutants are identical or allelic. Inheritance studies at Wageningen, noted in TGC 15, had shown 377-2αα to be distinct from r, t, and at. Additional crosses have shown it to be distinct from B as well.

Studies with another mutant from Wageningen, Hildering's I 1-20, for which a flesh pigment analysis was given in TGC 16, have shown I 1-20 to be distinct from r and at. In both crosses the F_1 produced normal red-fleshed fruits, and red-fleshed recombinants were recovered in both F_2's.

Verkerk, K., and R. B. Contant
Comparison of mutant frequency in fruit-halves of the tomato after seed irradiation.

Kedar and Verkerk (in press) have shown that fertilization of ovules in flowers of regular-shaped tomato varieties such as 'Money Maker' proceeds from the blossom half to the stem half of the ovary. After pollination with pollen mixtures of different germination speed and/or pollen tube growth, the blossom half ovules may be predominantly fertilized by the more active pollen, while a relatively larger proportion of the stem half ovules is fertilized by the slower growing pollen. In the same way, certation might occur when normal and mutated pollen grains have different rates of pollen tube growth; if such differences would be associated with genes expressing themselves in the diploid organism, one might find a higher mutant frequency in one of the fruit halves than in the other half; this would provide a means of increasing the average mutant frequency in M_2 populations.

This problem was approached by harvesting blossom and stem halves separately of two adjacent fruits on the second cluster of 1070 M_1 plants raised from seed treated with high doses of fast neutrons. Of each M_1 plant progeny, 12 seeds from the blossom halves and 12 from the stem halves were sown, of which an average 9.80 and 9.82 seeds, respectively, germinated and produced a seedling that could be screened. In 357 segregating M_1 progenies, a total of 837 mutants were scored in the blossom halves, against 825 in the stem halves. The average mutant frequencies therefore were 23.9 and 23.4% in the blossom and stem halves, respectively; this shows that on the basis of total mutant frequency there was no evidence of certation. Even when the mutants were classified according to the severity of phenotypic disturbance,

no differences in mutant frequency between the two fruit halves were found. The distribution of mutated seeds over the two fruit halves differed significantly from random in only 2 out of 357 mutated progenies. The pooled data from two successive sowings of these progenies are, for the blossom/stem halves, respectively: mutated progeny no. 1: scored 23/22 seedlings, of which 9/1 mutants; mutated progeny no. 2: scored 24/24 seedlings, of which 12/5 mutants. Both mutations were very detrimental, no. 1 having small dark green cotyledons and retarded growth, no. 2 being lethal at the cotyledon stage. It needs to be verified whether either of these exceptions represents a case of true pleiotropy of the marker genes in question.

In conclusion, no advantage is to be gained from harvesting a particular fruit half following seed irradiation. Before definite conclusions are drawn it remains to be studied whether or not such certation effects occur when irradiated pollen is used for pollination of control plants of the same variety.

Verkerk, K., and R. B. Contant

M_1 fertility after irradiation of tomato seeds with fast neutrons.

Seed set in plants is normally reduced with increasing doses of radiation. This may be ascribed to a reduction in the amount of pollen per anther and/or to effects on pollen and/or egg cell vitality. This question was studied in tomato plants grown from seed irradiated with (1) a medium and (2) a high dose of fast neutrons. In all, 72 irradiated plants (I) were grown alongside an equal number of control plants (C) and crossed in pairs in both directions C x I and I x C, while also the artificial selfings C x C and I x I were made; 4 flowers were pollinated per cross or selfing. Results in terms of (a) the mean percentage of fruit set and (b) the average number of seeds per fruit are shown below:

Combination	% fruit set		Number of seeds per fruit	
	Dose 1	Dose 2	Dose 1	Dose 2
Control x Control	81	79	43	35
Control x Irradiated	44	42	16	13
Irradiated x Control	85	85	33	20
Irradiated x Irradiated	49	43	12	5

It is concluded that virtually the entire effect of seed irradiation on fruit set is due to a reduced number and/or vitality of the male gametes, while the female gametes do not appear to contribute to the reduction in fruit set (I x I = C x I versus I x C = C x C). Furthermore, the number of seeds per fruit was reduced by 63% at dose 1 (67% at dose 2) when the male parent had been irradiated and by only 25% (48%) when the female parent had been irradiated; the difference between C x I and I x C was highly significant ($P < 0.005$). There was no significant interaction between irradiated egg cells and pollen at either of the two doses though possibly a slight tendency at the higher dose. In the crosses with pollen from irradiated plants, the quantity of pollen per pollination was about 1/3 of that in crosses or selfings involving normal pollen. From other data it is known that this may account for a seed set reduction of 30%; as the actual reduction was 63-67%, a large part of the effect must have been due to reduced vitality of the pollen of the

irradiated plants. The irradiated plants possessed more leaves below the first cluster, associated with later flowering, than the control plants.

These effects of irradiation, and especially the large difference in sensitivity of the male and female gametes to reduction in functionality, are probably mainly physiological, as very similar phenomena are commonly observed in plants weakened by various unfavorable environmental causes.

Twenty-five of the cross-pairs C x I and I x C yielded at least 20 seeds per fruit. The corresponding selfed offsprings (I x I) were sown; only 5 segregated for a visible seedling mutation. The genetic composition of each of the 5 F_1 families (C x I and I x C), i.e., the ratio of ++ and +α individuals, was deducted from the F_2 analysis, using the mutations as markers. From the results it appears that in 20 out of 23 cross pollinations the contribution to fertilization by + and α gametes from the irradiated parent was about equal, irrespective of the direction of the cross (C x I versus I x C). The remaining three cases were obviously due to unsatisfactory emasculation. The general conclusion is that both pollen and egg cells carrying a recessive mutation for a seedling character have the same ability to take part in fertilization as normal gametes. In other words, any selection occurring at the haploid level is not as a rule associated with mutated genes governing characters of the diploid organism. There may of course be rare exceptions for specific genes. In 3 out of the 5 cross-pairs which contained a mutation, the segregation ratios in the selfed heterozygous F_1 plant progenies did not deviate significantly from 1 : 3, irrespective of the direction of the cross. However, in the other two cross combinations, the F_2 showed a highly significant deficit of homozygous recessives (ratio approximately 1 : 6); in one case, but not in the other, the same deficit was also found in the selfed offspring (I x I) of the corresponding M_1 plant. The discrepancy needs further study. Considering that the + and α carrying gametes were shown to have equal fertilizing ability, the above result indicates that at least in one case the homozygous recessive F_2 individuals are less likely to develop into viable seeds. There was no apparent relation with the severity of the mutant phenotypes.

Verkerk, K., and R. B. Contant

Further studies on the genetics of obl and ep and associated characters.

The genetic analysis of two 'Money Maker' mutants, ep (easy peeling) and obl (oblate fruit) was reported by Verkerk and Contant in 1967 (TGC 17). Both F_1 hybrids, (ep x obl) and (obl x ep), were grown again, together with their F_2's, the mutant lines and the original variety 'Money Maker' with an aim to clarify a few questions unsolved in the first analysis. No significant differences in ease of peeling were detected between the two reciprocal F_1's nor between these and 'Money Maker', nor between the two F_2 families. Therefore, the suggestion that plasmatic modifying factors might be involved is not confirmed. The test employed consisted of counting the number of skin fragments from fruits of comparable size and degree of ripeness when peeled with a blade at normal temperature; the fruit skin of the homozygous ep genotype peeled in 3-5 pieces compared with approximately 14 pieces in the other genotypes.

The F_2 segregation ratios confirmed the monogenic recessive nature of ep and obl and there was no evidence of linkage.

The original mutant line ep contained an anatomical abnormality 'corky root' which on the basis of F_1 and F_2 analysis in 1966 seemed to be governed by a single dominant gene, not linked with either ep or obl. However, in the present experiment (1967) none of the F_1 plants had corky roots while the F_2's

of (ep x obl) and (obl x ep) segregated corky : normal, 36 : 60 and 1 : 15, respectively. Furthermore, the F_3 of selected F_2 plants with corky root segregated in a ratio consistent with 1 : 3, suggesting the action of a single recessive (instead of dominant) gene. It seems that either the expression of the heterozygote genotype is highly dependent on conditions, or that the genetic situation is more complex.

As in 1966, the obl character was associated with greater plant size and vigor than of round-fruited plants in the F_2; average height to the 5th cluster was 150.6 ± 2.5 cm in the former and 128.5 ± 1.7 cm in the latter.

The skin of obl fruits was on the average twice as strong as that of round fruits measured on 10 x 30 mm pieces of skin with an Instrom apparatus (tearing force 1200 and 600 g, respectively). In spite of considerable variation, the two classes of skin strength could be clearly distinguished. Routine determinations are most easily done by eye, especially in easy peeling fruit where the skin is easily detached without adhering flesh. None of the 112 F_2 plants observed showed a recombination of round fruit with strong skin desired for its greater resistance to skin cracking.

The mechanism involved in easy peeling, on which a first report was given by Verkerk, Contant, Rombouts and Berkholst (TGC 17, 1967), has been further studied. In extensive experiments by Rombouts and Berkholst, the previous findings of high cellulase and high pectinase activities in the outer 2 mm of the fruit wall could not be confirmed; neither could the differences in ease of peeling be attributed to cellulase inhibitors. The mutant may, from the results of a first analysis, contain less calcium in the outer fruit wall. The anatomical study will be extended; so far, there is still no evidence of consistent anatomical differences.

The easy peeling trait is manifest under widely varying growing conditions, from out-of-doors culture in Italy (Rome) to winter cultivation in greenhouses in Holland. It is noted that very easy peeling in over-mature fruit is often associated with a somewhat irregular fruit color, due to bruising. Oblate fruits, which have a stronger skin, are less prone to skin cracking and bruising.

Mutant obl resembles 'San Marzano' in fruit shape; the genetics of this trait in 'San Marzano' is unknown. In order to establish whether a connection exists with obl, crosses have been made in both directions between obl, 'San Marzano' and 'Money Maker'; F_1 and F_2 analysis will follow in 1968.

Verkerk, K., and R. B. Contant

Performance of mutant tomato lines selected for earliness and yield.

Field selection under summer conditions In TGC 17:16-18 (1967) the first results were summarized of attempts to select for earliness, yield and other valuable characteristics in the M_3 and subsequent generations obtained from fully fertile M_2 plants containing a visible but not grossly detrimental mutation. Selection experiments on the M_3 were carried out in the greenhouse and in the field during spring-autumn of 1966. The same mutant lines which were superior in the greenhouse experiment also showed the greatest promise in the field. The main results of the field trial are summarized in the Table; line 'W' was not included in this trial; of the unirradiated 'Money Maker' there were two independent selections.

'Glorie' and its mutant lines were consistently earlier than 'Money Maker' and its mutant lines; this confirms a known fact. The most promising mutant line from 'Glorie', 'L', was 5-6 days earlier and higher yielding in the first two harvests than 'Glorie'; the mutant was characterized by good fruit-shape and -size, even growth, unbranched clusters with many fruits and a medium vigor; some plants were sterile. Variation was much greater than in the original variety, as is demonstrated by the superior performance of the 12 plants selected.

The dark-leaved and very vigorous mutant line 'V' from 'Money Maker' was more productive and somewhat earlier than 'Money Maker', but had rather variable fruit-set and fruit-shape whereas the clusters were branched and very irregular; immature fruits are orange-yellow, but the color of the ripe fruit is normal; some plants were sterile. Line 'T' was the earliest flowering of the 'Money Maker' mutants tested. It had, however, rather low vigor and although early yields were much higher than from 'Money maker', later yields may be unfavorable, as they were in the summer greenhouse trial. Cluster- and fruit-shape were unsatisfactory; the clusters were branched, except the lowest; the foliage was compact and somewhat curled, the lowest leaves showing early senescence.

Finally, some plants from the multi-branched bushy mutant line 'C' were retained for their attractive sturdy growth and small size; although their yield was low, they may be of use in breeding for mechanical harvesting.

Limited amounts of seed from the plants selected in this field experiment (M_4 generation) are available. It should be noted that confirmative field and greenhouse trials are needed before it can be definitely established whether these selections are indeed superior breeding stock.

Greenhouse experiment under winter/spring conditions Following the encouraging results of the greenhouse and field experiments in the summer of 1966, two identical large greenhouse yield trials were sown in November and December, respectively, in which 'Glorie' and 'Money Maker' were compared with the M_3 generation of the mutant lines 'L' and 'M' from 'Glorie' and 'S', 'T', 'V' and 'W' from 'Money Maker', and with the offspring (M_4 generation) of the highest yielding plants from these lines. A total of 31 lines were involved, each represented by 2 x 8 replications of 3 plants each (= 48 plants); each plant was neighbored by a plant of the corresponding control variety. Results are summarized below.

On the whole, the M_4 selections showed no significant improvement over the M_3 lines from which they were derived. The major response to selection was apparently reached in the M_2 and M_3 generation; the efficiency of subsequent selection is affected by the high non-genetical variability normally found in tomato. In the following, any reference to a particular line is also meant to include its M_4 selections.

Mutant line 'V' flowered on the same day as 'Money Maker' but was less productive, especially during the first 6 weeks of harvesting; it also had the lowest number of leaves below the successive clusters and was significantly shorter than 'Money Maker' or any of the other mutant lines; this corresponds with the lack of vigor noted in the 1966 summer trials.

Mutant line 'W' from 'Money Maker', which had been the best yielder in the summer trial, was earlier and higher yielding in the first harvests but lagged behind its control in later harvests. These effects were mainly caused by the high incidence of blossom-end rot. This physiological disease also badly affected line 'S' which had on an average slightly less fruits per plant than 'Money Maker'. Only B_1, selected from line 'B' which had yielded fairly well in the summer trials, included in the place of another selection which had failed to germinate, outyielded the control by 4-12% (not significant); this line was not earlier than 'Money Maker'.

First flowering was relatively late in the T-selections but not in the parent generation; however, early yields were rather high, though this advantage was lost later. It should be noted for comparison that in the summer trials, 'T' was particularly early. Line 'T' was also markedly taller than 'Money Maker' or any of the other lines.

'Glorie' and its derivatives flowered 2-5 1/2 days later than 'Money Maker' but, even so, slightly exceeded 'Money Maker' at the early harvesting dates;

later, they were of equal yielding capacity. The 'Glorie' group had more flowers per inflorescence, 25-30% more fruits per cluster and per plant, a correspondingly lower average weight per fruit, a 5% greater plant height and more leaves below the first cluster than the 'Money Maker' group.

The yield of 'M' and its best selection exceeded that of 'Glorie' by 12-15%; this superiority was consistent, though not significant for any one selection. With regard to flowering date, plant height and number of leaves between successive clusters, the differences within the 'Glorie' group were slight.

In conclusion, only B_1 and the M-selections outyielded their respective controls, though the differences were not statistically significant. The low performance of 'W' was at variance with the positive results obtained in the summer experiment; this was attributed chiefly to blossom-end rot which had not occurred in summer. This demonstrates that also in mutant material, selection for spring/summer and for winter/spring conditions must from the outset (M_2 generation) be separated. For the same reason the above mentioned field selection is treated separately.

The interaction between mutant line and season is being further studied by sowing a number of new selections (M_5 generation) of lines 'L', 'M', 'S' and 'W' together with the original varieties, at two-month intervals during winter and spring 1968. This will also serve to verify the good performance of 'W' under summer conditions.

Comparison of different selection procedures During 1966-67, 64 new M_1 plant progenies have been selected which carry non-deleterious macromutations. These were sown again, together with an equal number of M_2's from the same radiation treatments, but without a visible mutation, and with an equal number of control plant progenies. An equal number of individuals will be taken from (a) the mutant M_2 plants; (b) the non-mutated M_2 plants from the same progenies; (c) the M_2 plants in the non-segregating irradiated progenies; (d) the control progenies. Selection for earliness and yield will be practiced in the M_3 and subsequent generations. The chief aim is to establish in which of these populations the advance under selection will be most rapid.

Table:--First two harvests of 'Glorie', 'Money Maker' and selected mutant lines.

Line	Number of plants	First harvest (29.9.1966)		Second harvest (10.10.1966)	
		Number of fruits per plant	Total weight per plant	Number of fruits per plant	Total weight per plant
Glorie	27*	7.4	481	10.3	559
	9**	7.6	522	-	-
L	63*	7.2	499	11.8	655
	12**	9.1	697	-	-
Money Maker	I 55*	2.0	165	2.7	196
	II 13*	2.6	238	3.1	230
V	164*	3.1	233	5.6	375
	3**	5.0	517	-	-
T	31*	5.1	348	7.1	397
	10**	7.0	470	-	-

* Total number

** Highest yielding selections

Zobel, R. W. Linkage and phenotype studies with lz-3.

Two lazy type mutants have been reported in the TGC to date; both are strongly prostrate. Under greenhouse conditions lz-3 is relatively vigorous, but is so consistently lacking in its will to grow upright that it has to be constantly tied to supports; in the field the plants are erect but very weak. This mutant was found in an F_1 of another mutant found in a commercial field of VFN8 by Dr. C. M. Rick. It segregates 3:1 and is easily scored. It is a very nice seedling mutant as the cotyledons become concave and turn up about the time the first true leaves start to form. The mutant is a darker green than normal plants but does not interact epistatically with any of the chlorophyl mutants except possibly sunny (sy). Another character, "bald" roots, was found during the course of some root studies. Roots branch rarely and have no small rootlets, and apparently the number of root hairs is reduced. Grafting this mutant to normal root stock yields a normal VFN8 type plant. Further extensive studies are underway on this and several other root mutants.

On the basis of the linkage data in the accompanying table, we have placed lz-3 on chromosome 1 near inv. As can be seen there we have found only one recombinant with inv;it was also scf. The F_3 from this recombinant was all inv—lz-3—scf. The only other gene that lz-3 showed significant linkage with was um, a gene that originally was placed on chromosome 7 but which now appears to be on chromosome 1. Since um shows strong relationships with other genes on chromosome 1, we feel that this lack of recombination with um is not a chance deviation in our data. Data for chromosome 3 was not reported because the F_2 showed extremely abnormal segregation and appeared to be contaminated with some other seeds. From our data we believe the chromosomal arrangement is inv—8—lz-3—32—scf.

Linkage summary

Chromosome	Tester	++	+ t	m +	m t	Adj. χ^2 cont.	Co.
1	au	157	34	39	11		
	scf*	194	52	39	5	1.68	38.0
		427	149	114	10	17.42	30.0
		154	48	42	3	5.57	28.0
	inv*	177	69	44	0	14.68	< 16.0
		421	155	123	1	38.65	10.0
		142	60	45	0	14.36	<15.0
(7?)	um	130	48	31	2	5.6	-
		257	98	116	4	29.9	-
2	Wo	24	167	2	48		
	d	150	41	35	15		
4	clau	140	37	30	18		
	e	141	36	38	10		

Chromosome	Tester	++	+ t	m +	m t	Adj. cont. χ^2	Co.
5	tf	160	31	29	21		
6	c	127	45	26	6		
	yv	142	30	22	10		
7	not	142	36	25	8		
		259	96	102	18		
10	ag	131	41	22	10		
	h	145	27	27	5		
11	a	155	22	41	7		
	hl	161	16	41	7		
12	fd	235	50	59	7		
* Combined total	scf	775	249	195	18	25.8	31.0
Combined total	inv	740	284	212	1	72.4	7.0

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PART III

ADDITIONS TO STOCK LIST

STOCKS AVAILABLE

Andrásfalvy, A.

1. 4 different F_1's ♀—L. hirsutum glabratum x L. hirs. typicum) ♂ x (L. esc [d, c, l, r, y, a]
2. one of above F_1's—♀ x (L. esc. [a] x S. pennellii)
3. two F_1 plants with almost normal anthers ♀, and one clone with mostly aborted anthers (L. esc. [d, c, l, r, y, a] x L. hirs. typ.) x S. penn.
4. sl mutant similar to those found in Pearson and recently in VFN8; supposedly located on chromosome 3 (linkage with wf found)
5. light green mutant
6. different ms stocks with substituted normal loci derived from wild sources: S. penn., L. hirs. typ., L. hirs. glab., L. minutum, L. pimpinellifolium
7. stock of extruded pistil, derivative of a L. hirs. typ. cross; segregates female sterile progenies with apparently normal pollen
8. stock with reduced pistils, derivative of a L. hirs. typ. cross; transferred apparently as a dominant feature by pollen; seedling similar to veined cotyledon (vc) mutant
9. many F_1 or F_2 progenies of ms mutants with various testers (see TGC 18 Res. Note)
10. tetraploid stock of Budai Korai (early sp var.) carried over by seeds for 8 generations

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FINANCIAL STATEMENT

(to December 31, 1967)

		Total
Balance from 1966		$188.50
Receipts		
Assessments	$293.50	
Sale of back issues	94.00	
Interest on savings	.56	388.06
Assets		576.56
Expenditures		
TGC Report No. 17, 1967		
Multilithing	322.04	
Miscellaneous		
Postage	61.18	
Newsletter duplicating	4.01	
Invoice pad	.60	387.83
Balance		$188.73

MEMBERSHIP STATUS

(to January 31, 1968)

Assessments paid for	1967	95
	1968	134
	1969	52
	1970	14
	1971	12
	1973	1
	1978	2
Total members		310

APPENDIX

Interim Report of the Committee on Varietal Pedigrees 1965-1967

Listings of previous reports: TGC 9: 1959 - an attached supplement between pages 36 and 37.
TGC 11:36-51, 1961.
TGC 16:53-67, 1966.

COMMITTEE ON VARIETAL PEDIGREES

Alexander, L. J.
Andrásfalvy, András (Hungary)
Chmielewski, Tadeusz (Poland)
Circulli, M. (Italy)
Darby, L. A. (England)
Daskaloff, C. (Bulgaria)
Foskett, A. L.
Frankel, Rafael (Israel)
Frazier, W. A.
Gabelman, W. H.
Gilbert, J. C.
Graham, T. O.
Groszmann, H. (Australia)
Hernandez, T. P.
Honma, Shigemi
John, C. A.
Kemp, G. A.
Kooistra, E. (Holland)
Lambeth, V. N. (Chairman)
Lana, E. P.
Leeper, Paul
Meszoly, G. (Hungary)
Odland, M. L.
Pecaut, M. (France)
Peto, Howard B.
Robinson, R. W.
Stark, F. C.
Strobel, James W.
Sumeghy, J. B. (Australia)
Tomes, M. L.

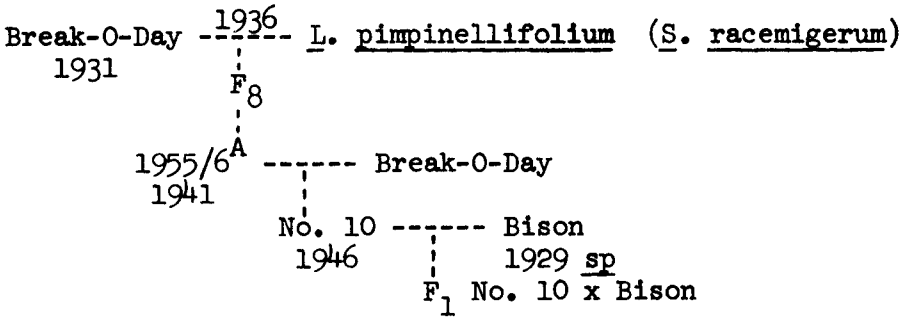
Tomato Pedigrees, Characteristics and Reference Publications 1965-1967

Robinson, R. W., S. Shannon, W. T. Schroeder, R. Provvidenti and W. B. Robinson. 1967. NEW YORKER - an early tomato variety with a bonus. Farm Research #32(4):6-7.
Pedigree: F_9 sel. of cross - Fireball x F_2 of [Rhode Island Early x Geneva 11]
Characteristics: sp, u, Ve, Ph

Gilbert, James C. Hawaii AES. 1967. Correspondence.
ANAHU-R
Pedigree: 7th generation selection of backcross [Anahu x Hawaii 5794-8 (TMV series)] x Anahu
Characteristics: u, sp, Mi, I, Sw, Sm, Tm, spider mite

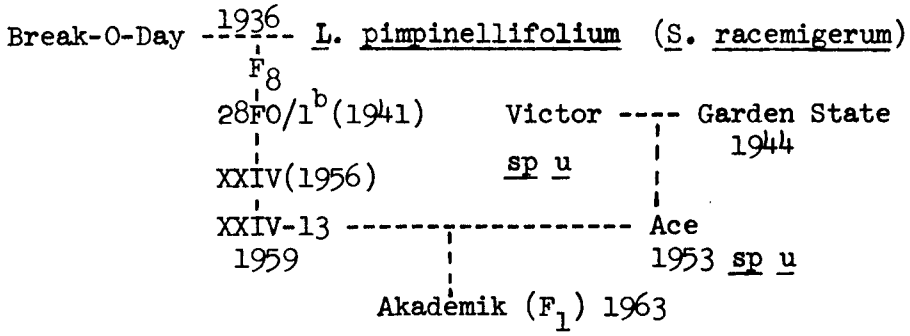
Gilbert, James C. Hawaii AES. 1967. Correspondence.
HEALANI
Pedigree: 8th generation selection of hybrid N-51 (Hawaii 6351 x STEP 305 Fla.)
Characteristics: u, sp, Mi, I, Sw, Sm, Tm, physiological browning

Daskaloff, C. Institute of Genetics and Plant Breeding. Sofia, Bulgaria. 1967. Correspondence.
F_1 hybrid No. 10 x BISON (1948).
Pedigree:



This hybrid is widely grown in Bulgaria.

Daskaloff, C. Institute of Genetics and Plant Breeding. Sofia, Bulgaria. 1967. Correspondence.
AKADEMIK (F_1) 1963.
Pedigree:



This hybrid also widely grown in Bulgaria.

Strobel, J. W., J. M. Walter, N. C. Hayslip. 1967. Tropi-Red a determinate tomato with excellent color and multiple disease resistance. Fla. Agr. Exp. Sta. Circ. S-182.
TROPI-RED
Pedigree: (see p. 66)
Characteristics: Sm, Ve, I, sp, U, R, gray wall

Strobel, J. W. 1967. Tropi-Gro - a determinate tomato with a new combination of disease resistance. Fla. Agr. Exp. Sta. Circ. S-183.
TROPI-GRO
Pedigree: (see p. 66)
Characteristics: Sm, Ve, I, sp, U, R, gray wall

Mohr, H. C. 1960. Plainsman. TAES L-479.
PLAINSMAN
Pedigree: 7th generation selection of cross [(Firesteel x Carter's Fruit) x Rutgers]
Characteristics: sp, heat tolerance

(Strobel, J. W., et al) (see p. 65)

Leeper, Paul W. 1961. Chico. TAES L-557.
CHICO
Pedigree: 9th generation sel. of [(STEP 54 x Southland) F_{10} x sel. of USDA 53 SM 11]
Characteristics: Sm, fusarium, pear, fruit cracking and rots.

Young, P. A. 1962. Pinkdeal. TAES L-566.
PINKDEAL (STEP 329)
Pedigree: sel. of (Hotset x S 1547, a Jacksonville line)
Characteristics: heat tolerant, crack resistant, catfacing, puffing.

Young, P. A. 1963. Young. TAES L-608.
YOUNG (CP1951, STEP 428)
Pedigree: sel. of (Homestead x Hotset)
Characteristics: fusarium wilt (multigenic), crack resistance, puffing, catfacing.

Young, P. A. 1963. Summer Cherry. TAES L-609.
SUMMER CHERRY (STEP 437, S1447E)
Pedigree: sel. of (S1119, a Jacksonville line x P.I. 190256)
Characteristics: cherry, heat tolerant, catfacing, puffing and blossom end rot, u(u_1).

Leeper, Paul W. 1964. La Bonita. TAES L-614.
LA BONITA
Pedigree: Multiple crosses involving Weshaven, P#1, STEP 54, Southland, and lines from which Roma was selected. 10th generation sel. of (W211-1S'57 x W21-3S'56)
Characteristics: plum, I, Sm, sp.

Leeper, Paul W. 1966. La Pinta. TAES L-691.
LA PINTA (M-60)
Pedigree: F_{11} sel. of [P#1 x (STEP 54 x Southland) x (STEP 54 x Southland)]
Characteristics: y, I, Sm, sp.

Leeper, Paul W. 1966. Chico Grande. TAES L-693.
CHICO GRANDE
Pedigree: F_{11} sel. of [(STEP 54 x Southland) x Chico]
Characteristics: I, Sm, blocky pear, crack resistant, fruit rot.

Leeper, Paul W. 1966. El Monte. TAES L-692.
EL MONTE (M-73)
Pedigree: F_7 sel. of [(STEP 54 x Southland) x Red Top) x STEP 388 Fla.]
Characteristics: I, Sm, sp.

Harrison, A. L. 1967. Nematex. TAES L-698.
NEMATEX
Pedigree: Very complex; includes Michigan State Forcing, P.I. 128657, San Marzano, Earlina 498, STEP 57, Texto 2 and many unnamed breeding lines from Nebraska, Florida, and Texas.
Characteristics: Mi, I, Sm, sp, ad, crack resistant.

Lambeth, Victor N. 1966. Release of Greenhouse Tomato Line 399. Mo. AES. SR 74/1M/66.
LINE 399
Pedigree: F_8 selection of (Tucker's Forcing x Crack-proof Pink)
Characteristics: y, I, Cf (Cf_{sc}) for forcing.

Lambeth, Victor N. 1967. Tuckcross 520. Mo. AES. SR 86.
TUCKCROSS 520
Pedigree: F_1 of [Mo. line 399 x Prospector (P42, (Purdue)]
Characteristics: I, Cladiosporium fulvum (most races), tolerant blotchy ripening, for forcing.

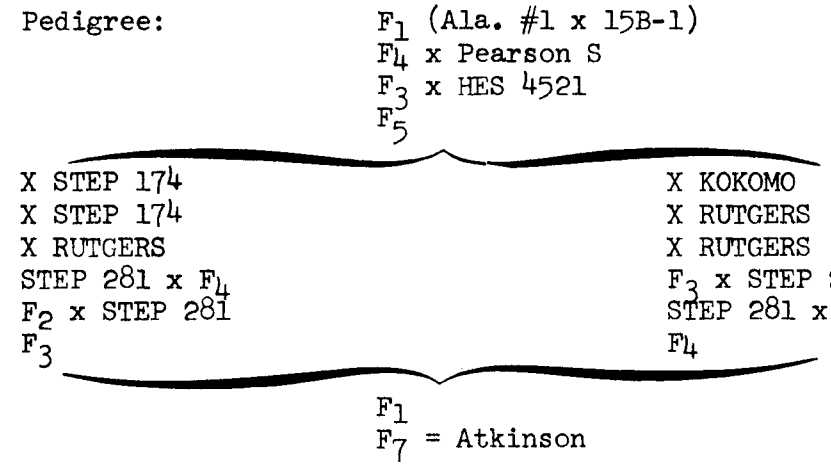
Hafen, Leslie, E. C. Stevenson, and M. L. Tomes. 1966. Prospector - A New Greenhouse Tomato Variety. Correspondence.
PROSPECTOR (P42)
Pedigree: F_{10} selection of [Manalucie x F_1 (Vagabond x Ohio WR7)]
Characteristics: I, Cf (most races), for forcing.

Alexander, L. J. 1965. Ohio WR25 and WR29: Two new disease-resistant, uniform ripening, pink, greenhouse tomato varieties. Ohio AES. Res. Bull. 971.
OHIO WR25
Pedigree: ({ [(Ohio WR Globe x Sioux) x Ohio WR7]-1-2-2 x Ohio W-R 7} x Ohio W-R 7)-BK-1-1-BK-BK. (bulk selected).
Characteristics: C, h, P, R, u, Wt, y, I, resistant to blotchy ripening and fruit pox, tolerant to high Mn.

OHIO WR29
Pedigree: ({ [(Ohio WR Globe x Sioux) x Ohio W-R7]-29-2-1 x Ohio WR 7} x Ohio WR 7)-BK-1-11-11-BK
Characteristics: C, h, P, u, R, Wt, y, I, resistant to blotchy ripening and fruit pox, tolerant to high Mn.

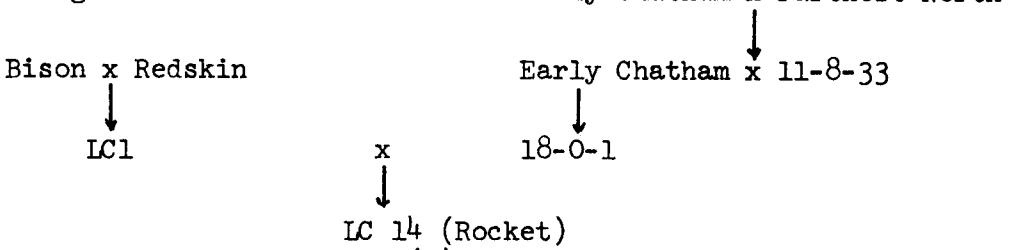
Foskett, R. L. 1966. Red Cushion, a new miniature tomato for home use. Colorado Horticulture Circular No. 14.
RED CUSHION
Pedigree: F_6 generation (Premier x Hardin's Miniature)
Characteristics: dwarf, sp, cherry.

Greenleaf, W. H. 1967. Atkinson, a Rootknot and Fusarium Wilt Resistant Tomato Variety of the Rutgers Class. Hort. Science 2(2):60.
ATKINSON
Pedigree:



Pedigree of Atkinson. The pedigree of Atkinson is presented with due regard to the direction in which the crosses were made, with the female parent always written first in the sequence of crosses. There is a possible error in the pedigree where 3 successive backcrosses to Rutgers could replace the two to STEP 174 plus one to Rutgers. However, the odds are 4:1 in favor of the pedigree as presented, based on the expected frequency of F_2 lines segregating determinate plants after these respective backcrosses.
Characteristics: I, Mi, Se, moderate ad.

Allen, H. T., and C. Walkof. 1967. Rocket tomato. Can. J. Plant Sci. 47: 117-118.
ROCKET
Pedigree:



Characteristics: sp, pg (?), sets fruit below 15°C.

Ounsworth, L. F. 1966. Harbon Tomato. Can. J. Plant Sc. 46:331.
HARBON
Pedigree: F_9 sel. from (Harrow x U. Cal. VF36).
Characteristics: sp, apple green, Ve, Fusarium, processing.

Kamimura, Shoji. 1966. Tohoku #6. Correspondence dated 31 Jan. 1966.
TOHOKU #6
Pedigree: sel. of Roma x All Red.
Characteristics: sp, u.

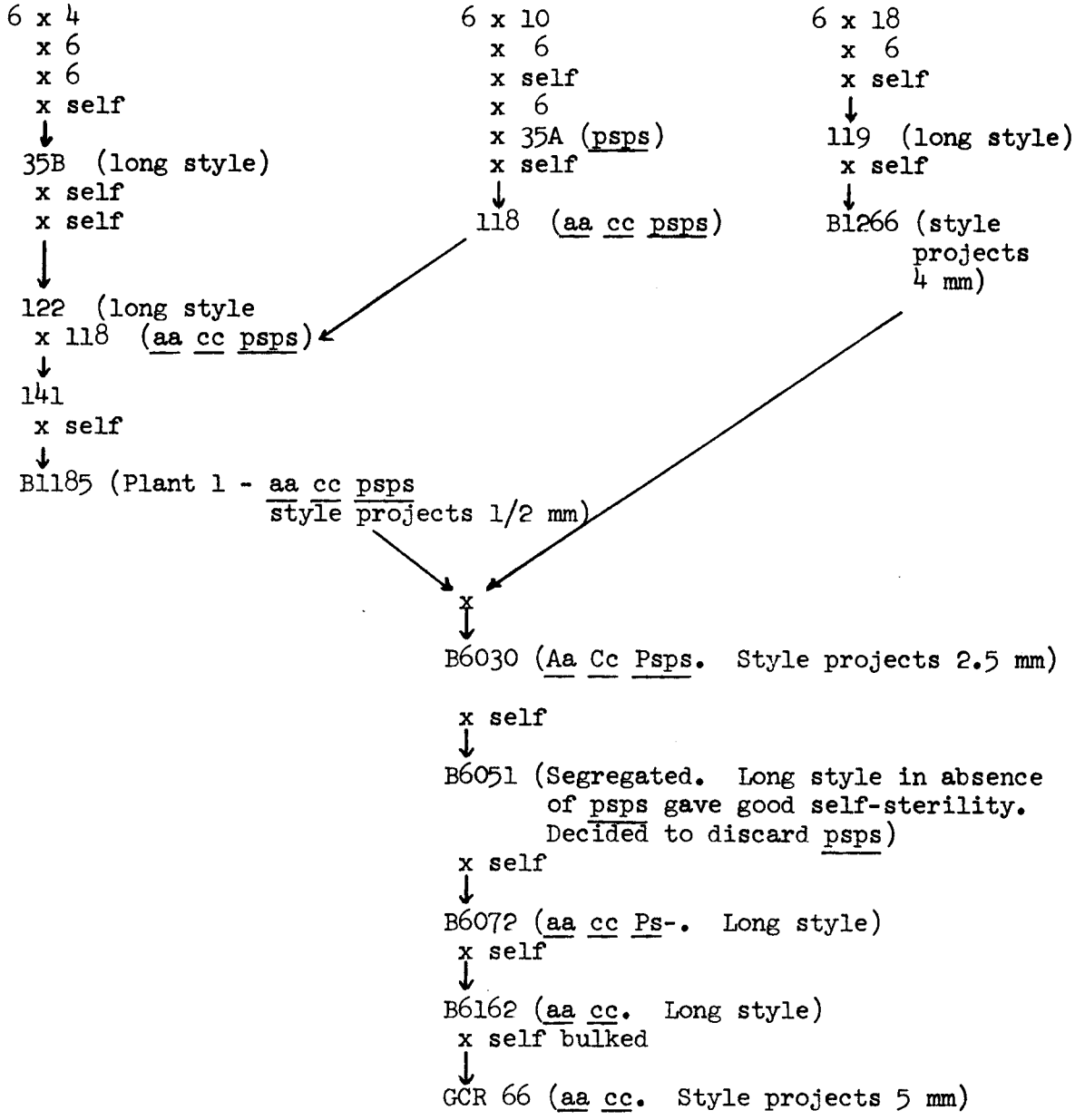
Smith, J. W. M. 1966. A new tomato rootstock seed parent. Euphytica 15: 395-404. (Submitted by L. A. Darby)
SEED PARENT GCR66
Pedigree: (see p. 70)
Characteristics: aa, cc, long style (5 mm), highly self-sterile.
Use: Only as seed-parent producing an interspecific F_1 hybrid (with L. hirsutum var. glabratum) to serve as a rootstock (Identistock) for grafted tomato plants.

Hafen, Leslie, E. C. Stevenson, and M. L. Tomes. 1967. Pioneer Greenhouse Tomato. Correspondence.
PIONEER
Pedigree: F_8 selection of [Manalucie x F_1 (Vagabond x Ohio WR 7)]
Characteristics: I, Cf (all known races), for forcing.

(Smith, J. W. M.) (see p. 69)

Parent: 6 = 'Ailsa Craig'
4 = 'John Baer' carrying psps
10 = 'John Baer' carrying aa cc psps
18 = L. pimpinellifolium type with very long style

Pedigree:



Single plant selections were always made in segregating families.

Darby, L. A. Correspondence dated 11/16/67.
SEED PARENT GCR 115
Pedigree:

Parents: GCR 66 - aa cc. Style projects 5 mm.
B2001 - VeVe II. Breeding line 122 ex. M.W. Martin, Utah.

Pedigree: GCR 66 x B2001
↓
B6268 (Style projects 3 mm)
x self
↓
B6272 (Segregated. Plant 18 selected
aa cc Ve- I- Style projects 4.7 mm)
x self
↓
B6286 (All VeVe. Segregated I-i. Plant 1 selected
aa cc Ve Ve I- Style projects 5 mm)
x self
↓
B6465 (All aa cc VeVe II. Style projects 5 mm)
x self
↓
B6483 (All aa cc VeVe II. Style projects 5 mm)
x self bulked
↓
GCR 115

Single plant selections were always made in segregating families.
Characteristics: aa, cc, long style (5 mm), Ve, I
Use: Same use and limitations as GCR 66. Gives rootstock "Identistock KVF" = "Rootstock KVF".