

# Male-Sterile Tomatoes

This is the thirteenth article in a series of brief progress reports on the application of the science of genetics to commercial agriculture.

## unfruitful mutants offer several advantages for the production of hybrid seed

Charles M. Rick

**Male-sterile tomatoes** offer advantages in the production of hybrid seed—from which substantially higher yields than those of parent varieties have been reported.

Because tomatoes are naturally self-pollinated, they are highly inbred and resemble corn in respect to the vigor of hybrids between inbred lines. Dominant disease resistance or other desirable dominant characters of one or both parents can be combined in the hybrids. These advantages have not been fully exploited because large-scale production of hybrid tomato seed by the usual methods is too costly.

To cross-pollinate the flowers of two different tomato plants it is necessary to take precautions against self-pollination of the female parent. This is accomplished in fertile plants by removing the anthers—pollen-bearing organs—before the flower bud opens, by a tedious hand operation. Corn, to the contrary, can be emasculated very simply and quickly by merely pulling out the tassel before it sheds pollen. The risk of self-pollination of the female parent in tomatoes can be



Fertile flower at left; male-sterile flower at right. Note that male-sterile anthers—in center of flower—are shorter and more slender.

circumvented by using male-sterile plants, in which the anthers are effectively sterilized by the action of a single gene.

### Mutants

Male-sterile mutants occur naturally in tomato varieties as one of the types of extremely unfruitful plants—the so-called, bull, male, or rogue plants.

These very unfruitful plants appear at variable rates, with a mean of about one per every 1,000 fruitful plants—rates so low that they do not appreciably decrease total yields. In spite of this very low frequency, they are very easily found, even at a considerable distance, since they grow many times larger and higher than surrounding fruitful plants, which are weighted to the ground by their fruit load. In the late harvest season it is a very simple procedure to collect and examine a large number of unfruitful plants in a short time; about 200 have been collected and studied to date.

Inherited male sterility causes unfruitfulness in 5% to 10% of the unfruitful plants—that is, 0.005% to 0.01% of all plants. Abnormal chromosome numbers and many other inherited defects account for the sterility of the other plants.

Fourteen different male-sterile mutants have been discovered in the varieties Earliana, Early Santa Clara, Pearson and San Marzano. These differ somewhat from each other in the contents of their anthers and, to some extent, in external appearance. Mutants in at least three other varieties have been found by other workers.

It is not necessary to breed the male sterility from mutants into desired varie-

ties, but it is entirely feasible to obtain a male-sterile mutant in any variety merely by searching for it, provided a sufficiently large planting—20 to 30 acres—is available for inspection.

Male-sterile plants show the following characteristics: 1, pollen is nonviable or absent; 2, anthers are reduced in size to varying degrees and are often modified in color; and 3, the whole flower may be slightly smaller than that of normal plants. In all other features the plants appear to be normal.

If viable pollen is applied to flowers of male-sterile plants, fruits and seeds are produced in normal fashion. Many similar examples of male sterility are known in corn, onions and many other plants.

### Inheritance

Male sterility is inherited very simply, being controlled in each mutant thus far investigated by a single recessive gene.

The hybrid between a male-sterile and a fertile plant— $F_1$ , first generation—would be expected to be fertile. Self-pollination of this hybrid yields a second generation— $F_2$ —consisting of approximately 75% fertile and 25% sterile plants; and the backcross between the  $F_1$  hybrid and the sterile plants produces ap-

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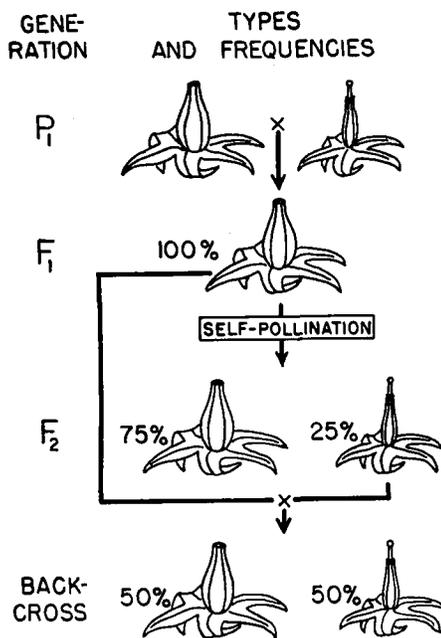


Diagram of inheritance of male-sterile condition. Flowers with plump anthers represent fertile type; those with shrunken anthers represent sterile type.

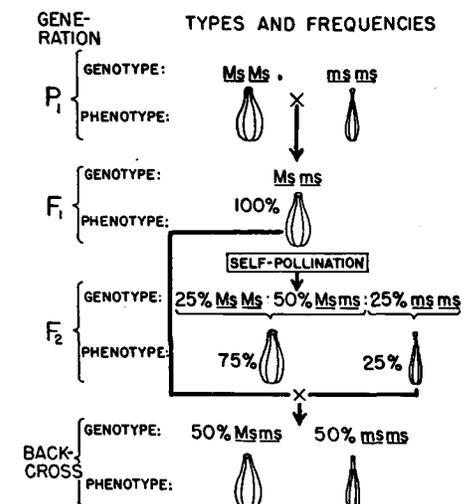


Diagram of inheritance of male-sterile condition. Plump anthers represent fertile type, shrunken anthers represent male-sterile type.

3. Most striking is the fact that yield was not significantly reduced at pH's as low as 3.5. The pH of the heavy sulfur strip averaged 3.7 at harvest in 1949 and total yield was no different from the checks on either side at pH 7.0.

The effect of pH on potatoes is now being studied to determine whether sulfur toxicity, rather than low pH, is responsible for some of the crop failure after sulfur applications.

A second set of sulfur soil trials in September 1948—at rates of application similar to those of the February 1948 experiments—brought out the fact that oxidation of elemental sulfur in the soil by the sulfur bacteria is dependent upon abundant soil moisture.

In the absence of any appreciable rainfall, the soil remained dry until the pre-planting irrigation in February. The pH of all treatments remained neutral until February and then dropped abruptly. The strips receiving the 2,500-pound application dropped from pH 6.8 to 4.5 in 40 days.

Many older potato fields have a reaction of about pH 6.0—due to the application of ammonium sulfate fertilizers which tend to change the soil reaction to the acid side. In the experimental field initial pH was 7.5 and 2,500 pounds of sulfur were effective on scab with no harmful effects on potato yields. It is not likely that 2,500 pounds of sulfur per acre could be safely applied to fields with pH 6.0. Many instances of poor stands and yields have been reported where sulfur applications have been too great.

Since it apparently takes two years to renovate scabby land with sulfur, it seems advisable not to crop the land to potatoes the first year after the treatment. No control of scab could be expected and the infestation of the fungus would be building up in the soil. The danger of encountering sulfur damage on the potatoes would also be eliminated.

A rotation program of potatoes with cotton as a first year crop after soil treatment is being studied but is not recommended as a control until experiments show its effectiveness.

As the potato scab problem is studied further, it may be possible with knowledge of a field's soil type and reaction to prescribe an amount of sulfur necessary to cope with scab but without affecting a field's productiveness.

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*The tests on scab resistant varieties in Kern County were conducted by G. N. Davis, Associate Professor of Truck Crops, Davis.*

*The February 1948 investigations on 12 acres of scab infested land were made possible by the cooperation of the S. A. Camp Co., Shafter.*

## HYBRIDS

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proximately equal numbers of fertile and sterile plants.

By backcrossing in this manner, male-sterile plants can be propagated indefinitely and in as large numbers as desired. It is also expedient for special purposes to propagate the male-sterile mutant as a clone by rooting cuttings.

One curious and exceptional mutant—designated as *ms<sub>3</sub>*—produces small quantities of fertile pollen in occasional flowers and can therefore be propagated by self-pollination to produce 100% male-sterile progenies.

Male-sterile mutants are useful for any project that demands large-scale cross-pollination. Their use eliminates not only the need for costly emasculation but also the possibility that contamination by self-pollination might occur if flowers of fertile plants were not properly emasculated.

Hybrid seed production is being facilitated also by the invention by an Australian worker of a simple mechanical pollen collector.

Certain hybrids are very difficult to obtain and may require the pollination of great numbers of flowers. In transferring desired characters from species of wild forms to cultivated tomatoes, it is important that accidental self-pollination of fertile plants be avoided. The contamination of such crosses is misleading and can be prevented by utilizing, as female parents, male-sterile plants planted together in a plot well isolated from other tomatoes.

Male-sterile mutants also serve efficiently to measure rates of natural cross-pollination because all fruits and seeds that they produce must issue from pollen transferred to them from surrounding plants.

Tests in progress show that rates vary to a great extent from one locality to another and are influenced by the distance between parent plants and by the varieties used as parents. These studies suggest that natural cross-pollination itself—chiefly by wild solitary bees—might be utilized in combination with male-sterile plants to supplant, or at least supplement, hand pollination as well as hand emasculation.

Differences in size and color of anthers affect the usefulness of many mutants. In hybrid seed production utilizing natural cross-pollination, those mutants with anthers most closely resembling the normal type are most desirable because they enjoy the highest rates of cross-pollination. In regard to ease of identification and pollination, mutants whose anthers are most reduced are preferable.

Mutants of intermediate effect—those designated *ms<sub>6</sub>* and *ms<sub>7</sub>*—might satisfy both requirements because they are sub-

ject to relatively high rates of cross-pollination and at the same time, are readily identified and pollinated.

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## OLIVES

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duced total yield and at the same time pay for the cost of thinning, the income per tree was calculated from the yield records and size grades.

After thinning and harvesting costs the early-thinned trees gave a return of \$11.56 per tree in comparison with \$7.06 per tree from the check trees, an increase of \$4.50 per tree or approximately \$225 an acre.

The trees that were thinned later in the summer, on July 19th and August 16th, failed to show any appreciable benefits. While fruit sizes in the later thinned trees were greater than in the unthinned trees, apparently the yield was reduced to such an extent by the later thinning that the increased fruit sizes failed to offset this reduced yield.

Another fruit thinning experiment with olives was conducted in an orchard near Davis in 1949.

Two Mission variety trees were used, about 25 years old and of moderate size, growing in a border row. Both trees were heavily loaded with fruit, and the thinning was performed on June 30th.

Individual branches on the same tree were given different amounts of thinning to determine how localized the thinning effect was. Fruits and leaves were counted following thinning to obtain a leaf-fruit ratio. Each treatment was given to three branches. The figures given in the table on page 4 are the averages for the three branches used. The thinned branches of one of the trees were girdled to see if girdling is necessary to localize the thinning effect.

The thinning effect was quite pronounced even when single branches on the same tree were used as the units for thinning and regardless of whether the branches were girdled.

All trees in these experiments were of moderate size with the fruiting area well distributed around the tree. In extremely large trees, especially those planted close together, where the fruiting areas are in the upper parts hand-thinning may not be feasible. It is likely that only those trees which show a very heavy fruit set by about June 25th will respond to thinning—it probably would not pay to thin the trees unless they are definitely overloaded.

The thinning operation is most important when it can lift fruit from the Sub-

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