

(c) *Effect of Chemicals on Crossing Over*

The effect on crossing over of 21 chemicals when sprayed on test plants was assessed in a study involving over 27,000 observations. These chemicals (mutagens, hormones, anti-metabolites, metabolic inhibitors, etc.) were chosen for their known pronounced biological activities. Solutions of the chemicals were prepared in concentrations known to be active on other systems, adjusted to pH 6.0, and sprayed at weekly intervals on test plants for 3 weeks. The effects of the chemicals on recombination frequency are shown in Figure 5. A slight, but not significant, increase was caused by 3-indolylacetic acid and benzthiazoleoxyacetic acid. Barbituric acid, streptomycin, and ribonucleic acid apparently lowered crossover frequency. However, as decreased crossing over was not of interest, these substances were not re-tested.

(d) *Effect of Grafting on Crossing Over*

In an attempt to determine the influence of the root system on crossing over, a series of grafting experiments were made which yielded a total of 13,000 observations. The test plants were grafted on another tomato variety (Suttons Best of All), on other *Lycopersicon* species (*L. pimpinellifolium*, *L. peruvianum*, and *L. hirsutum*), and on related genera (*Capsicum annuum*, *Solanum tuberosum*, and *Datura stramonium*). Grafted and ungrafted controls were included. Grafting on *S. tuberosum* produced the only significant result which was a pronounced decrease in recombination frequency.

(e) *Genetic Modification of Crossing Over*

Influence of the genetic background on frequency of crossing over between the two test loci was examined by a series of backcrosses to eight different parental stocks including *L. pimpinellifolium*, several cherry fruit size ecotypes of *L. esculentum*, and several commercial varieties (*L. esculentum*). The results reported here pertain to stocks which have been backcrossed to the parental line three times.

The crossover frequencies were recorded for 20 plants, i.e. an average of 2.5 plants per line. The total number of progeny scored was 19,671, approximating the goal of 1000 observations for each plant. The mean recombination values given in Table 1 range from 9.7% in *L. pimpinellifolium* to 21.0% in the Ponderosa variety.

The statistical analysis was based on normal deviates derived from the scoring system as indicated earlier. Thus the variate

$$y_{ij} = S_{ij}(\hat{g})[I_{ij}(\hat{g})]^{-\frac{1}{2}},$$

is defined for the j th plant in the i th stock, where \hat{g} is that value which satisfies

$$\sum_{i,j} S_{ij}(\hat{g}) \cong 0.$$

The analysis of variance for the data is also given in Table 1. It is clear that the different genetic backgrounds cause highly significant differences in crossover frequency. The analysis also suggests that differences among plants within lines persist.

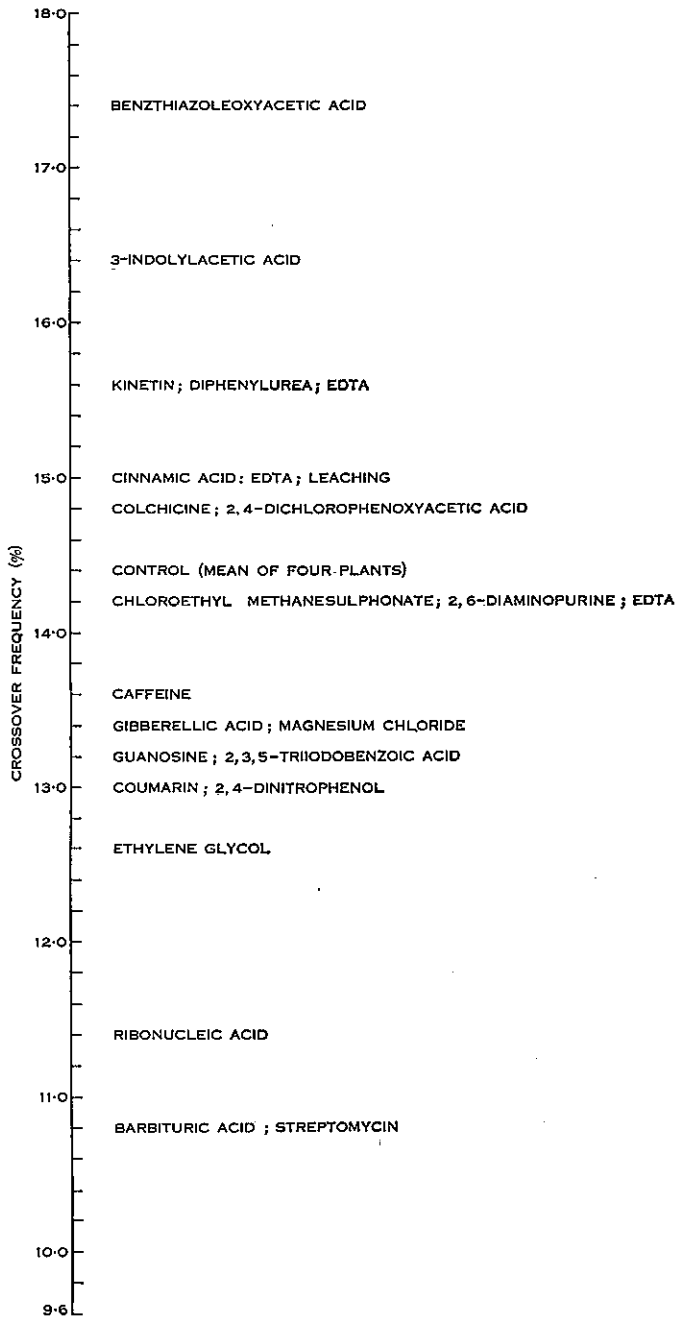


Fig. 5.—Effect of chemicals on crossing over shown by their position on a scale of recombination frequency.

IV. DISCUSSION

From the experimental data obtained, it is evident that the problem of increasing crossing over in plants by the manipulation of environmental stimuli remains unsolved. The maximum crossover frequency in the tomato appears to be a characteristic of the genotype brought about by apparently unknown and uncontrollable factors. Such treatments as did have a significant effect decreased crossover frequency. The depressing agents discovered included sodium ions, certain chemicals, and grafting on potatoes. The only treatment successful in raising the level of crossing over was the addition of nutrients to the soil when the crossover frequency had first been depressed by age.

TABLE 1
CROSSOVER FREQUENCIES FOR DIFFERENT TOMATO STOCKS INTO WHICH THE TEST LOCI HAVE BEEN BACKCROSSED

Tomato Stock	Plant Number				Mean Crossover Frequency (%)
	1	2	3	4	
<i>L. pimpinellifolium</i>	9.7	9.7			9.7
Florida cherry	14.8	16.6			15.7
Phillipine cherry	20.8	18.0			19.4
Red cherry	14.6	15.3			15.0
2n-ex-haploid	19.3	18.3	18.2		18.6
Goldball	15.9	19.0	16.7	17.0	17.2
Suttons Best of All	13.8	18.3			16.1
Ponderosa	18.6	23.3	21.2		21.0

Analysis of Variance

Source of Variation	Degrees of Freedom	Mean Square	Probability
Between stocks	7	15.230	$P < 0.005$
Between plants within stocks	12	1.588	$0.05 < P < 0.1$

With respect to the tomato plant, the results suggest that an upper limit to crossing over is set by the genotype, is reached in young healthy plants, and cannot be further increased. Tomato breeders should, therefore, maintain crossing material in good nutrition and use flowers from the first clusters where possible.

The upper limit of crossing over may, however, be changed by altering the genetic background. This fact suggests that it may be wise to screen tomato breeding stocks for recombination frequency, and, in the long run, to select for increased

frequency. As a corollary to the postulate of a genetically fixed maximum crossover frequency, experimental treatments are likely to be effective only when crossing over has dropped below this maximum. This prediction is yet to be properly tested.

V. ACKNOWLEDGMENT

We are indebted to Mr. J. R. Twine for the inorganic analyses.

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