

# Mosaic Resistance

## transferred from wild tobacco to cultivated varieties through science of genetics

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

Roy E. Clausen

**Varieties of cultivated tobacco** are almost invariably susceptible to mosaic, a virus disease, which also may infect tomatoes and some other crop plants.

Tobacco mosaic causes distortion of growth, mottling of the leaves, and other effects which may reduce the cash value of the crop as much as 50%.

A wild species of tobacco—*Nicotiana glutinosa*—appears to be uniformly resistant to mosaic infection. The resistance, however, is really a form of hypersensitivity. This is evidenced by the production of small spots of dead plant tissue at the site of infection. At the same time the killing of the plant tissue apparently prevents multiplication of the virus and blocks further spread of the disease.

In cultivated varieties of tobacco, little effect is produced at the site of infection, but the disease spreads throughout the plant system. Its ill effects are manifested mainly on new growth, which becomes deformed and characteristically mottled in appearance.

The transfer of the mosaic resistance character of wild tobacco—*Nicotiana glutinosa*—to the cultivated tobacco varieties—*Nicotiana tabacum*—is difficult because it must be made across the barrier separating the two species. The transfer can be made, however, by employing the principles of the sciences of genetics and cytology, in conjunction with the new techniques for doubling chromosome number.

The science of genetics is concerned with the way genes—the factors which control heritable characters such as disease resistance, maturity and yield—are passed from parent to offspring. Cytology is concerned with the chromosomes—the structures in which the genes are located.

Each one of the thousands of cells which make up a single plant contains a constant number of paired chromosomes.

The wild tobacco is a 12 pairs—24-chromosome—species while the cultivated tobacco is a 48-chromosome species.

When cultivated varieties are crossed with wild tobacco, the first generation hybrid exhibits the resistant necrotic type—the small spots of dead plant tissue—of reaction. These first-generation hybrids are completely sterile, so they are of no value for further breeding purposes.

The hybrid sterility may, however, be overcome by treatment with colchicine.

Applied to germinating hybrid seeds this treatment causes doubling of chromosome number in a portion of the young seedlings; which has the effect of converting the sterile hybrid into a fertile, seed-producing type which then may be used for further breeding operations.

With the fertile hybrid as a base of operations, the method of recurrent backcrossing to cultivated varieties may be employed—selecting in each succeeding generation those plants which, on artificial infection, exhibit the resistant reaction to the virus.

By eventual self-fertilization cultivated varieties have been established which appear to be identical in practically all respects with susceptible varieties except for their resistance to mosaic infection.

### Difficulties Involved

This brief description of procedure minimizes some of the difficulties actually arising in practice. Since different species are involved, they differ in chromosome number. The dissimilarity in the chromosome numbers is responsible for sterility of the first generation hybrid. That dissimilarity also tends, in subsequent generations, to obstruct incorporation of *glutinosa*—the wild tobacco—elements in the *tabacum*—cultivated species—germinal system. Without that incorporation the program would be unsuccessful.

By practicing self-fertilization—instead of recurrent backcrossing after the first cross of the fertile hybrid type to *tabacum*—the very dissimilarity of chromosomes which leads to sterility in the first generation hybrid, leads to rapid elimination of *glutinosa* chromosomes in the hybrid material. Eventually only a single *glutinosa* chromosome remains—the one which has been kept there by selection because it carries the factor for mosaic resistance.

The result is production of a cultivated variety which contains 23 pairs of unaltered *tabacum* chromosomes and one pair of *glutinosa* chromosomes, instead of the original 24 pairs of *tabacum* chromosomes. Such a variety exhibits the essential features of the original cultivated variety virtually unaltered, but it is resistant to mosaic infection because of the *glutinosa* chromosome.

Once a single resistant variety is established, its resistance may be transferred to other cultivated varieties by recurrent backcrossing. Thus at the present time a whole series of mosaic resistant strains of special varieties has been established, and production of such strains has become a purely routine task.

There is still some debate as to the commercial value of mosaic resistant strains as compared with the original susceptible varieties.

Since an entire *glutinosa* chromosome was originally introduced into cultivated varieties by these operations, it is to be expected that other features of difference may have been transferred in the chromosome along with the mosaic resistance, for a single chromosome carries a large number of germinal elements.

Some tobacco growers have professed to see differences in leaf size and shape, in rate of growth, in yield, and possibly in quality in the resistant as compared with the susceptible strain. Such differences are certainly to be expected. It is surprising to find them so slight and so difficult to detect. In this respect, there is still a possibility of effecting improvement by eliminating these differences without sacrificing the resistance.

Long-continued backcrossing has led to exchange of germinal material between this *glutinosa* chromosome and the corresponding *tabacum* chromosome. This process may eventually produce *tabacum* chromosomes which contain only a small segment of *glutinosa* material containing the resistance factor. Thus the amount of germinal material which has been introduced from wild species into these resistant cultivated varieties may be reduced, leading to further improvement in them.

The operations described in this account represent an extension of plant breeding methods which may lead to important improvements, hitherto impossible under customary procedures.

Frequently wild species related to cultivated plants may have features which could with advantage be transferred to the cultivated species, but sterility of the hybrid has prevented transfer. With the application of the colchicine and other techniques for doubling chromosome number it is sometimes possible to over-

Continued on page 16

## MOSAIC

Continued from page 7

come the hybrid sterility and to effect the transfer.

Virus diseases are of importance in every phase of California crop production. Usually they can be controlled effectively only by production of resistant varieties or by practice of rigid sanitary precautions. Since sanitary measures depend principally on destruction of infective material, they often have little chance of complete success, because many weeds and wild species may harbor the virus. Consequently plant breeding often is the only really practicable method of control.

The first requirement in a program of plant breeding is location of a source of resistance—either in some variety of the same species or in some related species. Often this part of the program entails extensive exploration, particularly in regions where the crop is grown under relatively primitive conditions. When such a strain or species has been discovered—no matter how unpromising it may be in other respects—it may be possible to transfer its resistance to improved varieties. Such a procedure may be effective in combating virus diseases in tomatoes, just as it has been in producing mosaic resistant tobacco varieties.

*Roy E. Clausen is Professor of Genetics and Geneticist in the Experiment Station, Berkeley.*

## SURPLUS

Continued from page 4

largely for overseas civilian relief, have temporarily replaced large prewar exports to European countries. However, even with such diversion to exports and the high level of domestic consumer purchasing power and demand, wine stocks have accumulated and prices of grapes, raisins and wines have dropped sharply in the past two years. At the same time farm wages and other production costs have fallen but little.

Present indications are that lower prices for the 1949 grape crop will push growers' incomes below the 1948 level. Moreover, there is danger that prices growers receive for their grapes may be painfully low for several years unless a favorable combination of the following conditions develops; 1, smaller grape production in the state; 2, maintenance of a high level of domestic demand; 3, control or elimination of surplus grapes; and 4, a big increase in commercial exports.

*S. W. Shear is Associate Agricultural Economist in the Experiment Station and on the Giannini Foundation, Berkeley.*

See: "Raisin Marketing" by H. R. Wellman, *California Agriculture*, March, 1949, page 2. "Fruit Prices" by S. W. Shear, *California Agriculture*, May, 1949, page 2.

## DONATIONS FOR AGRICULTURAL RESEARCH

Gifts to the University of California for research by the College of Agriculture accepted in May, 1949

### BERKELEY

American Potash Institute, Inc.	\$2,300.00
Division of Plant Nutrition	
Dr. William H. Boynton	\$156.73
Veterinary Science	
Carbide and Carbon Chemicals Corporation	1 lb. Experimental Fungicide 974; 1 lb. Crag Potato Fungicide 658; 1 lb. Crag Turf Fungicide 531; 1 qt. Crag Fruit Fungicide 341-C
Division of Plant Pathology	
Colloidal Products Corporation	50 lbs. DDT Depositor; 75 lbs. Colloidal 77 depositor builder
Division of Entomology & Parasitology	
Dow Chemical Company	1 drum 50# insecticide
Division of Entomology & Parasitology	
E. T. Doyle, Tobacco By-Products and Chemical Corporation	174 lbs. 14% dry nicotine concentrate
Division of Entomology & Parasitology	
E. I. Du Pont de Nemours & Co.	50 lbs. Fertilizer compounds; 12 1-pt. bottles of Spreader-Sticker
Division of Plant Pathology	
Eston Chemicals, Inc.	10 lbs. Alkron 25WC
Division of Entomology & Parasitology	
General Chemical Company	10 gallons of Compound 923, 50% Emulsion Concentrate; 50 lbs. Compound 923, 25% Wettable Powder; 24 lbs. Genithion P-25
Division of Entomology & Parasitology	
Mr. Alton L. Hall	25 lbs. spent lime
Division of Poultry Husbandry	
Hercules Powder Co.	1,000 lbs. 20% Toxaphene dust; 300 lbs. Toxaphene 75% emulsifiable
Division of Entomology & Parasitology	
Julius Hyman & Company	2 gallons of Compound 497 Emulsifiable Concentrate; 100 lbs. of 2½% 118 Dust
Division of Entomology & Parasitology	
Pennsylvania Salt Mfg. Co.	18 lbs. of Penfluor W-25
Division of Entomology & Parasitology	
Rohn & Haas Company	1 lb. amberlite IRA-400
Division of Poultry Husbandry	
Mr. Bart Rolph, Assistant Supt. Golden Gate Park	600 routed Chrysanthemum cuttings
Division of Plant Pathology	
Sherwin-Williams Co.	1 gal. Dimite; 4 lbs. Aphamite; 1 qt. Emulsifiable Chlordane; 2 lbs. 2% IMC Dust; 1 gal. XP-40 A—Preemergence Weed Killer
Division of Entomology & Parasitology	
Sugar Research Foundation, Inc.	\$1,000.00
Division of Food Technology	
Sugar Research Foundation, Inc.	\$702.00
Division of Plant Nutrition	

### DAVIS

American Potash Institute, Inc.	\$1,000.00
Division of Pomology	
California Committee on the Relation of Electricity to Agriculture	\$3,375.00
Division of Agricultural Engineering	
Messrs. Hart, Cole and Goss	\$2,029.41
Division of Animal Husbandry	
Lederle Laboratories Division American Cyanamid Co.	3 grams folic acid
Division of Poultry Husbandry	
Merck & Company	5 lbs. vitamin B12 concentrate
Division of Poultry Husbandry	
National Turkey Federation	\$1,400.00
Veterinary Science	

### LOS ANGELES

Mr. Claude G. Bewley, Howard & Smith	200 experimental cement composition pots
Division of Ornamental Horticulture	
Kellogg Supply Company	100 lbs. aero granular cyanamid
Division of Ornamental Horticulture	
Mr. Gene Marzolf, Northrup, King and Co.	45 lbs. grass seed
Division of Ornamental Horticulture	
Panaka, Inc.	One 100-lb. bag Panaka minerals
Division of Ornamental Horticulture	
Southern California Golf Association	\$3,470.00
Division of Ornamental Horticulture	
Roy F. Wilcox and Company	150 Azalea plants in 2¼" pots and 50 Saintpaulia plants in 2¼" pots
Division of Ornamental Horticulture	

### RIVERSIDE

Allied Chemical & Dye Corporation, General Chemical Division	\$600.00
For investigations in new insecticides	