Pathogenic Fungi

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

disease-causing parasitical plants may overcome resistance of host plant developed by genetic means

H. N. Hansen

Fungi are plants and, as in crop plants, their heritable characters—such as color, virulence and growth pattern—may change from generation to generation.

Although fungi belong in the plant kingdom, they differ from the higher plants in many important respects.

For one thing, fungi have no chlorophyll—the green coloring matter in plants which enable them to employ sunlight in the process of making food available to the living cells. In the manner of all parasites fungi are dependent for sustenance on organic matter, either living or dead, already elaborated—made assimilable—by some other organism.

Such pathogenic fungi—disease causing fungi—as the mildews and the rusts have become so highly specialized that they grow only on living plants where their parasitic action causes immense annual losses in many agricultural and horticultural crops.

Other pathogenic fungi such as those that cause root rots and wilts are less highly specialized and can grow on both living and dead material. These usually are soil inhabitants and cannot be reached easily by fungicides.

When, for some reason, control of plant diseases by the application of fungicidal dusts or sprays or by the modification of cultural practices becomes unsatisfactory it may be possible to transfer disease resistance from one plant to another by crossbreeding and the proper manipulation of the genes—those factors which control the hereditary characters.

Transfer Temporary

Disease control achieved by genetic means is effective for a time only which is well illustrated by two examples from California agriculture.

In the late twenties and early thirties the cantaloupe growers in the Imperial Valley were greatly handicapped by a powdery mildew disease that, in some years, caused the loss of nearly half their crop.

Since fungicidal treatment and modified cultural practices did not give adequate control, an intensive breeding program was initiated that eventually resulted in the production of a highly resistant variety that was released to the growers in the mid-thirties.

Within two years after release of the resistant variety mildew reappeared on the supposedly resistant plants and increased to such an extent that during the following year fungicides and other nongenetic methods had to be used in order to produce a crop.

Upon investigation of this apparent breakdown of resistance in the cantaloupe it was found that there were present in the state at least two biologically distinct races of the mildew fungus and that evidently resistance had been developed to only one of them.

Another example is that of the ornamental garden flower, the snapdragon, which had begun to lose popularity because of the wide distribution of the highly destructive disease caused by a rust fungus.

The College of Agriculture found a gene resistant to this parasitic fungus and introduced it into many horticultural varieties of snapdragons.

Here again resistance appeared to

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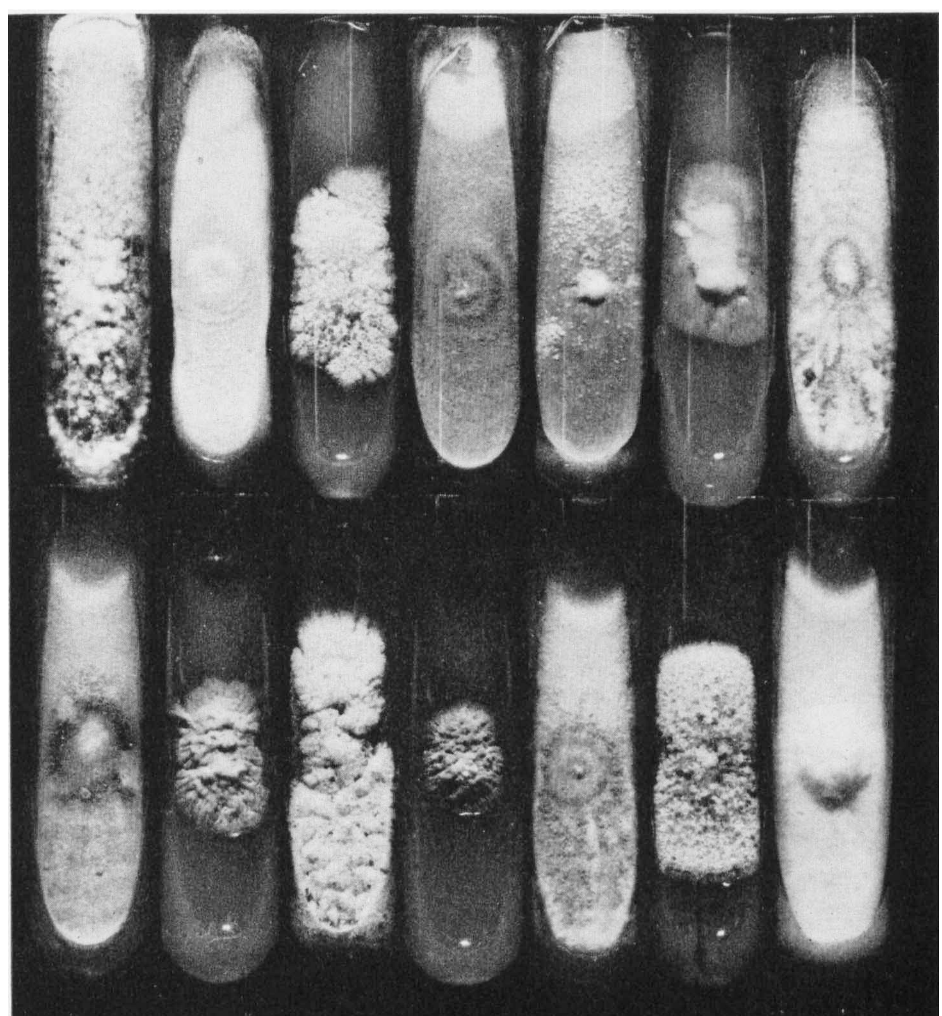

Fourteen cultures of a fungus pathogenic on squash. Numbering from top left to right, 1 and 2 are the parents and the rest some of the progeny from one mating. Cultures 4, 5, 7, 8, 12 and 14 are all much more virulent than either parent.

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break down within a couple of years and snapdragons became as badly infected as before.

Investigation of this apparent breakdown of resistance revealed the presence of more than one biologic race of the rust fungus in the state.

The temporary nature of the resistance in the cantaloupes and snapdragons apparently was due not to a genetic breakdown in the host plants but rather to genetic changes in their respective pathogens.

Fungi Readily Mutable

Fungi differ from higher plants again in that during the greater part of their existence they are haploid—having a definite number of single chromosomes, where each higher plant has a definite number of pairs of chromosomes which are the structures in which the genes are located.

Since each fungus nucleus has only one set of single chromosomes there can be no dominant or recessive genes and all are immediately effective. This haploid condition also makes the fungi much more responsive to environmental changes so that they apparently mutate much more frequently than do the higher plants. It is this mutability that enables the pathogenic fungi to adjust themselves to new or different environments and to overcome or by-pass such obstructions as resistant genes in their favorite host plant.

In addition to the variants arising by direct mutation there are those that arise by genetic segregation. There are in many fungi natural mechanisms that insure cross fertilization and greatly increased variability and therefore greatly increased adjustability.

The accompanying illustration—page 4—shows 14 cultures of a fungus that is pathogenic on members of the squash family.

The two at the upper left are the parents, female and male, and the other 12 are some of the progeny from a single mating. There are striking physical and cultural differences between parents and offspring and between the individuals. There is a color range from deep brown to white, with shades of blue, green and yellow in between.

Aside from these observable differences there are also differences in pathogenicity or virulence.

Each of the two parents is moderately pathogenic. With either one of them present it is possible to grow plants of the squash family to maturity. With the progeny, it is a quite different story. If the specimens shown in the photo are numbered from one—top left—to 14, then numbers three, 10 and 13 are much like the parents in their pathogenicity. Numbers six, nine and 11 are nonpathogenic but numbers four, five, seven, eight, 12 and 14 are so highly pathogenic and virulent that they will kill young squash plants in less than 10 days.

It is evident that effective use of genetic means of combating plant diseases must recognize the existence and the whereabouts of pathogenic fungi—their behavior under various conditions, their range of variability and the significance of this variability in their inheritance.

To this end the College of Agriculture is conducting continuous and intensive investigations of plant pathogenic fungi.

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The balance of the plants—of the 67 planted—either had not flowered when the last notes were taken or were lost before classification.

No difficulty was encountered in distinguishing between male-sterile and normal plants. The abnormal specimens appeared like the parental male-sterile plant found in the winter 1945–46 greenhouse planting. The mode of inheritance of the male-sterile character is unknown, because so far only a relatively small segregating population has been studied. Further breeding tests will be required before a genetical explanation can be proposed.

To determine whether male-sterile plants produce any self-fertile pollen, umbels of four segregants—apparent male-sterile plants—were caged with blowflies.

Three of these plants set a few seeds. If enough plants can be grown from these seeds, proof should be obtained as to whether these were really selfed seeds or were cross-pollinated from normal plants by thrips, ants, or some other very small insects that penetrated the fine-mesh cloth cage covering. Umbels were not allowed to touch the cloth, thus eliminating the possibility of insects outside the cages pollinating enclosed flowers pressed against the inside of the cloth. Isolated plantings of single male-sterile plants and other plantings with several male-sterile plants would give further information on the possibility of viable pollen production.

At the time the F_1 population involving male sterility was being classified, several dozen plants in other carrot-breeding lines were examined for flowering habit. Four plants were found to possess varying degrees of apparent male sterility. Each plant produced some exserted stamens, but the number was only a small percentage of those which would normally be exhibited. Two of the specimens shed pollen, the viability of which was not determined, but no pollen production by the remaining two plants was observed. All four set an abundance of open-pollinated seed. This partial male sterility was not encountered in classifying the F_1 population which segregated for the male-sterile character.

The mode of inheritance in the carrot of the male-sterile character, for which segregation data were presented, and the partially male-sterile types with which no controlled crosses were made will not be known until additional breeding tests are completed.

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The above article is based on work conducted while Dr. Welch was Associate Horticulturist, U. S. Regional Vegetable Breeding Laboratory, U.S.D.A. Charleston, South Carolina. Investigations are being continued at the University of California under Research Project No. 906.

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yield, especially of side shoots, by the August 1st and September 1st plantings compared to that of July 1st than were the midseason strains. The effect of planting dates on decreased side-shoot production in the Late strain was not very great in 1945–46 but more pronounced than in any other strain in 1946–47.

It was apparent that the strains used in this work fall into the four groups suggested. There is a fairly close similarity between the two years in the dates by which any given strain has reached the stage at which 75% of the center heads had been harvested. When the planting was delayed until September 1st, there was much less difference between the dates at which the various strains reached this stage of harvest than was the case in the July 1st planting. The cool fall weather tends to obliterate the differences between strains.

Side-shoot harvesting started soon after the first center heads were cut. The dates at which the first marketable heads were found did not differ greatly between the very early and early strains. The tendency for the very early strains to cease production of harvestable material sooner than the others was clearly shown in the July 1st and August 1st plantings.

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