Investigations on Variati

possibilities for the development of a hybrid carrot with root size uniformity under study

J. E. Welch and E. L. Grimball, Jr.

Male sterility has been reported in several crop plants including tomato, flax, corn, onion, sorghum, barley, and sugar beet.

The possibility of utilizing this character in the production of hybrid seed—such as carrot—for commercial planting is under investigation.

Present varieties of carrots lack uniformity when growing—environmental—conditions deviate from the optimum.

By studying the combining ability of paired inbred lines, one in each combination possessing the male-sterile character, it is theoretically possible to obtain extremely uniform carrot varieties which are also superior to those now available in general appearance, productivity, quality, and nutritional value. The feasibility of using inbred lines of corn in producing seed for commercial planting is due to monoecism—having the stamens and the pistils in separate flowers but on the same plant—and the ease in making cross-pollinations. In perfect-flowered—having both stamens and pistils in the same flower—plants like the carrot it is impractical to employ inbred lines in this way without male sterility.

An apparently male-sterile carrot plant was found in a collection of several dozen being grown for inbreeding in a greenhouse planting in the winter of 1945–46 at the U. S. Regional Vegetable Breeding Laboratory in South Carolina. This plant was grown from a root selected in a commercial stock of the variety Tendersweet in the spring of 1945.

Caging of certain umbels—flower clusters—took place a day or so before the first flowers normally would open, and the caged umbels were observed daily for the appearance of exserted stamens—the stage at which blowflies are introduced into the cages as pollinating agents.

The first flies were placed in the cage on February 25, 1946, even though no stamens were evident. A few days later microscopic examination showed that the anthers—the pollen containers—of this plant were shriveled and brown in color before any petals unfolded. No exserted stamens were found.

On March 9, 1946, an umbel of the variety Nantes Strong Top, grown from a root selected from a commercial stock in the spring of 1945, was placed in a test tube of water and introduced into the cage with the apparently male-sterile plant. This procedure was continued with fresh umbels from the Nantes plant. Later the two entire plants were isolated in a single large cage.

The seed on the selectively caged umbels were harvested separately from the other umbels because some seed had set on the male-sterile plant outside the small cage by open pollination before the whole plants were enclosed. The pollen parents of these seeds were unknown. Female fertility of the male-sterile plant appeared normal.

On September 6, 1946, a portion of the hybrid seed was planted under good conditions. The 67 roots which were produced were harvested on January 6th and 28th, 1947, and held at 32°–35° F until they were planted in the field between February 21 and March 18, 1947, at five different locations. The histories and internal characteristics of all roots were recorded.

Classification of flower types of these F_1 plants—progeny of the first cross-breeding—between June 6–July 7, 1947, showed 39 male-sterile and 15 normal.

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Courtesy of USDA

Upper left: **young normal carrot flower showing first stamens to appear.** ***Upper right:*** **corresponding male-sterile flower.** ***Lower left:*** **normal carrot flower completely opened.** ***Lower right:*** **corresponding male-sterile flower. A millimeter scale is shown at the left.**

FUNGI

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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.

BROCCOLI

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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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