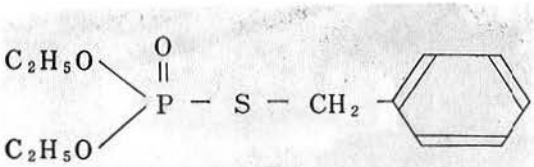

was developed as a fungicide by Ihara Agricultural Chemicals Co. It is an interest discovery because many compounds of this type are well known as insecticides.

Kitazin shows excellent curative effects on the rice plant which has suffered from blast disease. A spray at 500 ppm concentration shows the same effect as organomercuric fungicide. Kitazin has a low toxicity to humans and animals and also to fish and shellfish. The phytotoxicity on rice plant is also low, but rarely a problem appears under some conditions, causing brown spots. Kitazin has a certain insec ticidal activity, it is supposed from the chemical structure.

The raw chemical is produced by Ihara Chemical Co. and the dust and the emulsion are sold by Ihara Agricultural Chemicals Co., Toa Noyaku Co., Yashima Chemical Co. and Mikasa Chemical Co.

The non-mercuric chemicals described above generally exhibit the same or more effectiveness for rice blast control than mercuric chemicals. Although they are effective enough when they are looked at only for their effectiveness, many problems are still left. For example, blasticidin S causes eye trouble, kasugamycin is liable to cause formation of resistant fungi, PCP-Ba and Rabcon occasionally cause necrosis on leaves, and so on. Because each of the non-mercuric blast controllers used at present has merits and demerits, application of proper mixtures may be preferable for becoming the problems rather than using only one chemical to substitute for mercuric chemicals. The cost of non-mercuric chemicals being used at present is still 20~30% higher than mercuric chemicals. But, the cost will be reduced by large scale production in the future.

On Breeding Tomatoes for Disease Resistance

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In Japan since 1951, the study on breeding tomatoes for disease resistance has been carried out mainly at Okitsu Branch, Horticultural Research Station, Ministry of Agriculture and Forestry. The steps in progress of the actual breeding work are differentiated by the sorts of diseases. However, the screening methods, which are fundamental to the breeding of varieties with resistance to diseases, has arrived at a certain conclusion, satisfactory, to some extent, to the practice of breeding, and after several revisions, it has brought about some breeding-systems, both reasonable and practical, through experiments, owing to which several strains resistant to Fusarium wilt or leaf-mold have been found; besides, several new strains with their two complex resistances are expected to be produced in the near future.

An outline of the research conducted up to the present is as follows:

A. Screening method for resistance

1) For the screening method for Fusarium wilt resistance in tomatoes, the seedling-test method standardized by F. L. Wellman in 1939, has been adopted after some experimental modification suitable to the conditions for investigations in Japan. In this method, young plants are to be set on incubation-beds under glass after inoculation by dipping

Fig. 1 Screening for Fusarium wilt resistant tomato strains by inoculation of seedlings in incubation-bed under glass.

washed root-systems into the inoculum prepared by the solution-culture method. The test may fail at the start, if management to accelerate the rooting of young plants is not thought over sufficiently. It seems that better results from incubation can be acquired on a bed composed mainly of sand than on a bed composed of loam soil. In such a seedling test, investigators are required to be careful to distinguish the abnormality seen in tomato plants immediately after transplanting from epinasty and yellowing as early symptoms of the disease.

The experimental data concerning ages of plants to be tested indicate that the most preferable results may be obtained when plants are inoculated from 30 to 40 days after germination. The tomato varieties and strains, recognized to be immune from the

Fig. 2 Screening for leaf-molt resistant tomato strains by inoculation of seedlings in a growth cabinet under adjusted temperature and hnmidity.

wilt by means of the seedling test, exhibit their resistance ability even if tested under natural conditions on the heavily contaminated soils. When tested by seedling inoculation, the resistant tomato varieties are found to be highly resistant to isolates of the pathogen in Japan.

2) For the screening method for leaf-mold resistance in tomatoes, the seedling inoculation technique, improved on the standardized method devised by L. J. Alexander and others from the standpoint of simplifying incubation-apparatus, has been adopted. After inoculating with conidial suspension of *Cladosporium fulvum,* tomato plants of 4 or 5 true leaves are incubated for 3 or 5 days under cover of vinyl-film in a glasshouse. In such a way, so many typical lesions are formed on leaves of a susceptible variety in about 15 days after inoculation, that the screening of resistant plants is easily performed.

The possibility of screening the resistance of complex races of *C. fulvum* through a single inoculation test is indicated by experiments, in which it is proved capable to select some individuals resistant to two races from segregating progeny by mixed inoculum of 3 isolates containing actually 2 races.

3) On the screening method for Cucumber Mosaic Virus resistance, some experimental results are obtained, indicating that it is practicable to test tomato stocks for their

resistance to virus disease under natural infection. So as to be constantly successful in this method, apparently, the test-field needs to be examined about the uniform severe attacking of winged aphids living on weeds infected by Cucumber Mosaic Virus of certain tomato stocks. According to some experiments it is conclusive that Super Marmande, a French variety, HES 5060, a breeding line from Hawaii University, and P. I. accessions of *Lycopersicon hirsutum* contain individuals having hereditary resistance.

4) In the screening method for bacterial wilt resistance, it was indicated by experiments that screening of constant resistance can be achieved by way of testing on a extremely infested field. By comparison of the adult plant test conducted from spring to summer with the seedling test started in late summer, it is apparent that we can evaluate the resistance by either of the two methods, even though readings of disease-rate is inclined, to some degree, to be higher in the seedling test than in the other. Such difference in disease readings could be eliminated by adjusting the ages of plants to be set on the disease-field. In carrying out the breeding program, we are able to screen the progenies by the seedling test on the same field immediately after the selection of the preceding generation which has undergone the adult-plant test, and to grow the selected plants in a glasshouse until full ripening. Thus, it is possible that the period required to breed races may be shortened by finishing selection through two generations a year. The presence of certain strains of *Pseudomonas solanacearum* having different virulence to different kinds of host plants has already been found. From the result of experiment regarding the reactions of these strains against several varieties of egg-plants, it was indicated that the degree of virulence against different host-varieties is found in parallel with the rate of diseased plants, and that inoculated plants with mixed inoculum of several strains show the strongest reaction against the most virulent strain. The predominance of some of these strains in soil seems to be selective according to the environmental conditions of a given field. In conducting an artificial inoculation test, therefore, breeders need to try through preliminary experiments what strains must be used under a given field condition.

B. Breeding system to resistance and breeding procedure of new tomato selections

1) In breeding tomatoes for resistance to Fusarium wilt, it is quite reasonable to cross the superior commercial character of Japanese varieties with American varieties recently released having profitable size of fruits and resistant to diseases, through true-breeding. A breeding-system established for this purpose consists of the following fundamental processes; selection for disease resistance in F_2 and F_3 by means of the

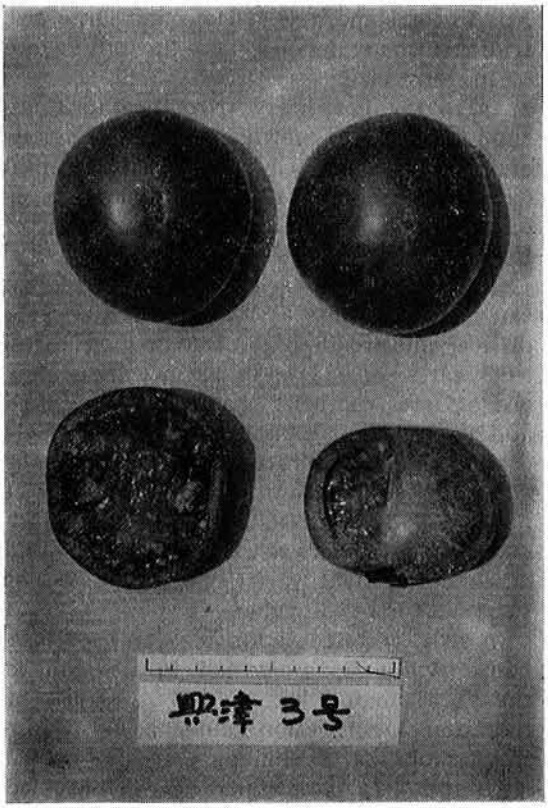

Fig. 3 Tomato Okitsu No. 3
(Resistance to Fusarium wilt)

seedling test performed in glasshouse beds, and the procedure of selection and fixation concerning commercial characters through descendant generations.

Through true-breeding combined with the modified Wellman's screening method, six promising tomato selections were released as candidates for new strains in 1960. From a hybrid of practically immune Homestead crossed with susceptible June Jink the selections Tomato Okitsu No. 1 and No. 2, from a hybrid of Homestead × Fruit the selections Tomato Okitsu No. 3 and No. 4 and from a hybrid of F_3 selected individual of Homestead × June Pink, out-crossed with Sioux, the selections Tomato Okitsu No. 5 and No. 6 were derived respectively.

All these strains have matured fruits of pink color. Okitsu No. 5 and No. 6 are of uniform-coloring in unriped fruits and the others are green-based. Okitsu No. 4 and No. 6 bear somewhat fasciate and large size fruits of many locules, and the others are of medium size.

As to the hereditary resistance to Fusarium wilt of the newly released selections and their resistant parents, the experimental data fundamentally support the hypothesis of simple dominance in the inheritance of immunity from the wilt.

Generally these selections have shown satisfactory results as regards resistance to disease and productivity. But in some cases, as an early spring crop in warmer areas, they are of later maturity, and have less yield and poorer fruit characteristics than some of the leading F_1 varieties. These inferior characteristics seem to prevent the direct utilization of the resistant selections. Various F_1 hybrids between these selections and other commercial varieties were tested as for their practical value.

In 1961, the Federation of Shimizu Glasshouse Associations decided to recommend the F_1 (Tomato Okitsu No. 6 × Yōzu) for the tomato cultivation under a glasshouse in the suburbs of Shimizu City and named it "Shūkō." In 1964, Shūkō variety occupied nearly 150 hectares of glasshouse and has shown excellent commercial effect owing to its disease resistance. This is the first case of commercial utilization of the F_1 hybrid resistant to Fusarium wilt in Japan.

Since 1962, Agricultural Experiment Stations in several prefectures and some Seed Companies have released successively new resistant F_1 hybrid, using the selections. The number of these F_1 hybrids amounted to above twenty at 1967. The development of these new varieties demonstrates that the utilization of the first generation hybrid between resistant selections and commercial varieties is one of the very practicable and profitable methods in tomato breeding.

2) To breed up excellent tomato varieties highly resistant to leaf-mold and adaptable to the growing condition under glass or plastic film in Japan, it is necessary to carry out breeding under a definite system, in which using American and Canadian varieties of small or medium sizes as a source of resistance and Japanese commercial varieties as recurrent parents, the backcross method is adopted, and then selection and fixation are conducted successively, regarding both disease resistance and commercial characters of selffed progenies of the backcrossed generation.

In case of two races of the pathogen, the breeding program may be divided into two series; namely, in the first, fixation of resistance to common race is carried out by selfing selected plants from B_1F_1 generation inoculated with mixed inoculum; in the second fixation of resistance to both common and other races by selfing selected plants from the B_2F_1 generation.

Improved Bay State and Waltham Mold-Proof Forcing were immune to leaf-mold caused by a common race of *C. fulvum* in Japan, in comparison with other resistant varieties introduced from foreign countries. They were hybridized as resistant parents with leading Japanese varieties in the fall of 1957, and their hybrids were backcrossed to their susceptible parents in the spring of 1958. In the later generations of the hybrids, screening for the resistance has been repeated against the common leaf-mold fungus. In the fall of 1960, all of B_1F_3 lines derived

from a backcross Fāsto × F_1 (Fāsto × Improved Bay State) were ascertained to be apparently immune to the common race of the causal fungus, and moreover the homozygosity of their immunity was confirmed.

As the standard variety for the selection of commercial characteristics, Fāsuto was used, because it is one of the leading varieties for the winter crops cultivated under glass in the warmer regions of Japan, having good fruit-characteristics and adaptability for greenhouses. The selection work for these principal commercial characteristics of fruits had been almost completed about B_1F_5 generation in the fall of 1960, and it seems that the fixation in relatively early descendants is due to the application of the backcross method.

After eliminating some undesirable characteristics through 3 generations, two promising fixed lines were finally selected out of the progenies, and released as "Tomato Okitsu No. 7 and No. 8" in 1964.

The released strains are immune to leaf-mold caused by usual isolates of *C. fulvum* and it is supposed from genetical observation of immunity in early segregating generations of hybrids that it is controlled by two dominant genes. These strains produce pink fruits of relatively large size, come to maturity late or nearly late, and are adaptable for winter or spring cultivation under glasshouses. As compared with the leading variety Fāsto, however, they are taller, have rather larger leaflets, are more vigorous in growth, and yield fruits of regular shape, malformed ones being rare.

It seems that the utilization of the first generation hybrid between resistant selections and commercial varieties is useful as the released strains resistant to Fusarium wilt are.

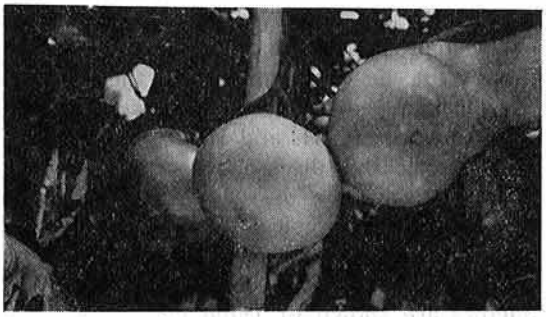

Fig. 4 Tomato Okitsu No. 7 (Resistance to leaf-mold)

As the next program, since 1963, in Okitsu Branch, Horticultural Research Station, it is carrying out breeding work to gain excellent tomato strains highly mixed resistant to Fusarium wilt and leaf-molt, from the progeny of hybrid between Tomato Okitsu No. 1~6, and No. 7 or 8 and several promising lines will soon be selected.

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