Breeding for Disease Resistance of Vegetable Crops in Japan

Part I Cucurbits

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Cucurbits, widely grown throughout the world, are important fruit vegetables in Japan, particularly cucumber, watermelon and melon are grown everywhere in the country, being produced and consumed almost all the year round in recent years.

A major problem involved in cucurbits cultivation is the occurrence of diseases owing to the humid climate of Japan in the monsoon zone. Recent increase of glasshouse and plastic house cultivation has accerelated the occurrence of diseases, resulting in the unstable production. As the disease control constitutes a major portion of crop management, there is an increasing concern about the breeding for disease resistance aiming at stabilizing production, reducing production cost and avoiding pollutions caused by agricultural chemicals. The breeding of cucurbits for disease resistance is urgently needed, because this aspect is behind the progress made with other vegetables. In this paper, present works on breeding for disease resistance of cucumber and melon are described, although some works are under way on watermelon too.

Cucumber

1) Downy mildew

This disease caused by *Pseudoperonospora cubensis* (Berkely et Curtis) Rostowzew is the most important one for cucumber, occurring every year everywhere, and at any season.

Varietal resistance can be assessed by inoculation tests, but it can also be identified by field observations because of the serious occurrence of the disease in the spring cultivation.

It is known that varieties of Far East origin are generally resistant. Shimizu et al.[12] reported that sprawling varieties of South China group such as Aojihai and Shimoshirazu are most resistant, followed by varieties of North China group. Based on the gene analysis research with pedigrees of the cross between resistant Aojihai and susceptible Sagamihanjiro, it was found that the resistance is determined by three recessive genes, and the character of Sagamihanjiro producing fruits at each node of main branches is also related to three recessive genes, and that there exists a considerable genetic correlation between the resistance and the short fruit type of Aojihai.

Since spring varieties are generally susceptible in Japan, the breeding for resistant spring varieties is initiated by crossing with summer varieties such as sprawling group and North China group.

2) Powdery mildew

This disease in Japan is caused by *Sphaerotheca fuliginea* (Schlechtendahl) Pollaci, whereas no disease due to *Erysiphe cichoracearum* Dc. was found. Varietal

resistance to the disease can be determined by inoculation tests as well as by field observations on natural infection.

Fujieda & Akiya[3] developed a resistant variety Natsufushinari by using three varieties: Sūyō, Ochiai No. 1 and Manshu-aki. The resistance was found to be due to a pair of recessive genes. Since these three varieties used in the breeding showed no resistance to the disease, it was presumed that the resistance was originated either by the fixation of recessive resistant gene or natural mutation occurred in the course of the breeding. Natsufushinari is now being utilized as a breeding material for developing resistant varieties in U.S.A., U.S.S.R. and other countries.

3) Mosaic

Mosaic diseases occurring most frequently in Japan are due to cucumber mosaic virus (CMV) and watermelon mosaic virus (WMV). The former is consisted of different strains. As mosaic diseases are transmitted by aphids, the diseases give a big trouble to the cucumber cultivation from late spring to autumn when the aphids are active.

Mosaic diseases occurring in fields are mostly caused by CMV, with partial infections by WMV in usual cases. Apparent varietal differences are observed in the disease occurrence in fields. Sprawling varieties such as Jihaiao, Shimoshirazu etc. are less infected. Some of the summer type hybrid group and of North China group are also less infected. Inoculation of CMV to seedlings has shown the same result as the above field observation (Misawa & Goto[9]). However, varietal resistance to WMV is not yet clearly known.

4) Scab

This disease, caused by *Cladosporium cucumerinum* Ellis *et* Arthur, used to occur in cool areas of northern region, but since 1954 it has spread to many places of the country, creating a serious trouble. However, the occurrence is becoming less in recent years.

Kanazawa et al.[5] developed a seedling inoculation test method and screened a large number of Japanese varieties for the resistance. Although highly resistant varieties were not found, fairly resistant ones were identified among varieties grown in cool areas: Kagafushinari, and Karihafushinari. By repeating the selection for the resistance with Kagafushinari, they developed a resistant strain, D108–304, which is more resistant than the original variety. Although the resistance of D108–304 exhibits a incomplete dominance in F_1, the strain can be used as a resistant parent for F_1 hybrid, because D108–304 is a gynoecious strain with good quality.

Maine No. 2, a resistant variety of U.S.A., shows apparently a high resistance in Japan, giving almost complete dominance in F_1 of the crosses with Japanese varieties. The variety is regarded as a promising breeding material for scab resistance, although it is susceptible to downy mildew and mosaic.

5) Fusarium wilt

It is a soil borne disease caused by *Fusarium oxysporum* Schlechtendal f. *cucumerinum* Owen. In glasshouses and plastic houses, where continuous cropping is practiced, the disease occurs seriously.

Komada & Ezuka[8], found out that Aofushinari showed a stable resistance to pathogens collected from various parts of Japan, by comparing a large number of varieties grown in the disease garden supplied with the pathogens artificially. They reported also that the seedling test, in which seedlings were grown in pots filled with perlite and inoculated by applying spore suspension of the pathogen to the pots, gave clear varietal differences, consistent with field observation.

Toshimitsu & Noguchi[18] reported that the resistance of Aofushinari is related to three pairs of multiple gene. Ezuka & Komada[2] pointed out that varieties resistant to

Fusarium wilt are susceptible to downy mildew, while those resistant to downy mildew are susceptible to *Fusarium* wilt, and therefore the selection for resistance to one disease, carried out in hybrid pedigrees, will apt to result in an extreme susceptibility to another disease.

6) Angular leaf spot

Occurrence of this disease, caused by *Pseudomonas lachrymans* (E. F. Smith et Bryan) Carsner, has increased since 1971. In recent years, open field cultivations as well as plastic house and glasshouse cultivations suffer seriously from this disease.

At present, breeding for resistant varieties is under way in the Vegetable and Ornamental Crops Research Station. In 1974 difference in the resistance was found with Japanese varieties, and in 1975 a comparative study is being made between varieties and strains which are regarded as resistant in U.S.A. and Japanese varieties.

Melon

1) Powdery mildew

This disease of melon is caused by the same pathogen which causes cucumber powdery mildew. Takada et al.[15] reported that the resistance was found among varieties of India, Nepal, and Burma, and resistant varieties developed in U.S.A. (breeding material was introduced from India) also showed to be resistant, based on the natural field infection to *Cucumis melo* L, collected from various parts of the world. They pointed out that among the resistant varieties of U.S.A., Georgia 47, C68, and PMR 5, all resistant to race 1 and race 2 of *Erysiphe cichoracearum* D.C. were always resistant in Japan, whereas PMR 45 which is resistant to only race 1, showed the resistance in spring cultivation, but was susceptible in the autumn cultivation.

They developed Hiratsuka No. 2, No. 4, and No. 5 from the cross Pearl × C68, and Hiratsuka No. 3 from the cross Pearl × Georgia 47. Tamai et al.[17] also bred Iyo No. 1 from the cross Earl's Favorite × PMR 5. Ashizawa et al.[1] developed Kurume No. 1 from the selection of Cantaloupe varieties introduced from Okinawa (presumably PMR 5 or related variety). As all these varieties have powdery mildew resistance and better quality than resistant parents used in the crosses, they are expected to be used as resistant parents for F_1 hybrids.

2) Mosaic

Major mosaic diseases of melon mostly caused by CMV and WMV attack summer to autumn cultivation.

Kanazawa[6] found, based on observations of natural field infection, that oriental melon (var. *makuwa* Makino) and oriental pickling melon (var. *conomon* Makino) were resistant. Of the former group, Mi tang ting (of Continental China) and Kankoku No. 1 (South Korea), and Shirouri No. 2 (Japan) of the latter group were highly resistant. Since natural field infections are considered to be caused usually by concurrent infection of CMV and WMV, the inoculation test was made separately. The result of the test with CMV was quite consistent with the result of field observation, whereas no apparent varietal difference was observed by the inoculation test with WMV, which caused the disease with all varieties. Therefore, the varietal resistance observed by the field test is supposed to indicate the resistance to CMV.

Fuzishita[4] found out that *C. figarei* is immune to CMV and WMV, and is now working to solve cross-incompatibility of *C. figarei* × *C. melo*.

3) Gummy stem blight

This disease, caused by *Mycosphaerella melonis* (Passerini) Chiu et Walker attacks cucurbits in general but melon suffers most seriously.

Based on the natural field infection, Kanazawa[6] found out that oriental pickling melon of Japan and oriental melon of Japan, Continental China and Korea (South) were

generally resistant, particularly Shirouri No. 2 (Japan) of oriental picklin melon, and Mi tang ting (Continental China) and Gin-yose (Japan) of oriental melon were highly resistant. Mi tang ting was regarded as most promising breeding material by taking into account other superior characters such as better flavor and higher sugar content of fruit.

It is not easy to carry out the inoculation of *Mycosphaerella melonis* because it hardly produces pycnospora in the artificial culture. However, Kishi et al.[7] found that a large amount of pycnospora can be obtained by the culture on potato sucrose agar media (agar: 10%, and sucrose: 2 to 5%) under ultraviolet radiation at 24°C. Takada[16] conducted seedling inoculation test in which pycnospora produced by the method of Kishi were inoculated to stems of seedlings by use of a needle, and found that varietal difference could easily be identified by that inoculation test. The result of the test was well consistent with field observation.

4) Fusarium wilt

This disease is caused by *Fusarium oxysporum* Schlachtendahl *f. melonis* (Leach et Current) Snyder et Hansen.

Suzuki[14] examined varietal resistance of melon used for glasshouse cultivation in Japan by sowing seeds to the soil to which spore suspension of the pathogen was applied, and reported that Ooi and Emerald Gem were relatively resistant.

Shiina et al.[11] examined varietal resistance of cantaloupe varieties of U.S.A. and Japanese melon varieties by transplanting them to the field inoculated with the pathogen, and recognized Georgia 47, Delicious 51, Harvest Queen, Iroquois, Penth Weet's, Golden Gopher (all of them are U.S.A. varieties) and Ooi (Japanese variety) as resistant ones. Some of the varieties which are regarded as resistent in U.S.A. showed the susceptibility in this test, suggesting differences in virulency of the pathogen between U.S.A. and Japan.

Sugahara & Igarashi[13] bred a new variety, Kurume No. 2, which has a combined resistance to powdery mildew and *Fusarium* wilt, from the cross of SC-108 and BC-5, a strain of Earl's Favorite type. In F_1 hybrids between Kurume No. 2 and susceptible varieties, it is inferred that the resistance to powdery mildew may be same as that of the resistant parent, whereas the resistance to *Fusarium* wilt may be intermediate between both parents. Thus, Kurume No. 2 is expected to be used as a parent for F_1.

Seko & Odagiri[10] developed a commercial variety, Fukamidori (F_1 hybrid) in 1973. The variety is now regarded as most promising, being suitable for any season of cultivation, with good quality and resistance to both *Fusarium* wilt and Gummy stem blight. For the breeding of this variety, Georgia 47 was utilized. It is very likely that Georgia 47 might have contributed to the resistance of the variety.

Sources of resistant genes

As cucumber of Japan belongs to a group with relatively high resistance to diseases, utilization of resistant commercial varieties developed in other countries is considered to be less effective. On the other hand, it is not easy to find out new resistance genes which have simple genetic mechanism. Furthermore, there are strong preferences of consumers for quality and shape of fruit, and which makes it difficult to utilize wild species in breeding for resistance.

As for melon, there is an increasing demand for less expensive melon in place of high grade melon produced by glasshouse cultivation. To meet this consumption demand, it is required to develop new varieties which can be grown in open fields or with simple facilities and which are resistant to diseases, and hence with low cost of production.

For this purpose, commercial varieties of U.S.A. and European countries are effectively utilized as breeding materials for disease

resistance. The resistance genes of oriental melon and oriental pickling melon in Asia as well as wild species or related species found in South Asia and Africa can also be utilized.

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