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BREEDING FOR MULTIPLE DISEASE RESISTANCE IN CUCURBITS (WATER MELON, MUSK MELON, CUCUMBER AND SQUASH) - A REVIEW

B.R. Choudhary and M.S. Fageria

Department of Horticulture (Rajasthan Agricultural University),
S.K.N. College of Agriculture, Jobner - 303 329, India

ABSTRACT

Cucurbits are highly prone to several diseases. The indiscriminate use of chemicals to control these disease leads to severe health hazards, adds to the cost of production besides toxic residual effects. Thus, the development of multiple disease resistant varieties are only solution to overcome these hazards. So far a large number of multiple disease resistant genotypes have been identified but promising ones includes Poinsette of cucumber, Arka Manik of watermelon and Punjab Chappan Kaddu-1 of summer squash. In this article the important sources of disease resistance, genetics of disease resistance and breeding methods followed have been reviewed.

Cucurbits in India comprise of more than fifteen vegetables being cultivated in different parts of the country round the year. They are consumed in different forms and cultivated throughout the world and have tremendous economic importance in human diet. Cucurbits are affected by several fungal diseases like mildews, anthracnose, *Fusarium* wilt, fruit rot, scab, bacterial diseases like angular leaf spot and bacterial leaf spot and viruses.

Usually these diseases are controlled by frequent applications of chemical which are toxic, expensive and have high residual effects. Therefore, it is necessary to develop varieties possessing resistance against one or more diseases. This article includes important sources of disease resistance, genetics of disease resistance and breeding methods followed to breed resistance varieties in cucurbits.

SOURCES OF RESISTANCE

The sources of disease resistance may be a cultivated variety, wild related species, exotic germplasm or spontaneous and induced mutations which are summarised below.

CUCUMBER: Powdery mildew resistant genotypes in cucumber includes, PI 197087 (Barnes, 1966); Poinestee, Yomaki (Imam and Morkes, 1975); Sparton Salad (Omara, 1979); PI 197088, *Cucumis ficifolia*, *C. anguria*, *C. dinteri* and *C. sagittatus* (Munger *et al.*, 1979); *C. ficifolia*, accessions IVT 1801 and PI 280231, *C. anguria* PI 147065, *C. anguria* var. *anguria*, *C. dinteri* PI 374209 and *C. sagittatus* PI 282441 (Lebeda, 1984). Resistance to downy mildew has been reported in Chinese Long (Imam and Morkes, 1975) and Poinsette (Seshadri, 1986). Accessions PI 197087 (Barnes and Epps, 1952) and PI 175111 (Abul Hayja and Peterson, 1978) have been found to be moderately resistant to anthoracnose, TMG-1 is a good source of resistance to CMV (Provvidenti, 1985). Varieties Tokyo Long Green, Chinese Long, Wisconsim and Table Green are also found to be resistant to CMV. *Cucumis anguria* carry resistant against CGMMV (Den-Nij, 1982) whereas, Table Green and Sarinam against WMV (Takeda and Gilbert, 1975 & Provvidenti, 1985).

MUSKMELON: Varieties Edisto (Copeland, 1957), PMR-45 and PMR-450 (Bohn and Whitaker, 1964); Georgia-47 and C-68 (Takada *et al.*, 1975); Campo and PMR-6 (Norton and Cosper, 1985); Arka Rajhans, RM-43 and Pusa Sharbati were found to be resistant to powdery mildew. Resistance to powdery mildew has also been observed in Campo, Jacumba, Levlita, PM-5 and PMR-6

(Choudhury and Sivakami, 1972) and in two accessions PI 164323 and PI 180283 (Khan, 1973).

Resistance to downy mildew has been reported from Edisto (Copeland, 1957); Seminole (Whitner, 1960); Buduma Type - 1, 2 and 3, Phoontee, Goomuk, Nakkadosa, Ex-2, Annamalai, Edisto and Harvest Queen (Sambandam *et al.*, 1979) and from *Cucumis callosus* (Zink *et al.*, 1983). WMR-29, MR-1, Punjab Rasila, Cinco, DMDR-1 and DMDR-2 were also found to be resistant to downy mildew. Variety Punjab Rasila showed tolerance against downy mildew (Nandpuri *et al.*, 1993). Singh *et al.* (1996) reported resistance to mildew in line EC 163888 and Snapmelon collections like SP-1, SP-2, SP-3, KP-2, KP-7 and KP-9.

Resistance to *Fusarium* wilt has been observed in Delicious-51 (Munger, 1954) and *C. melo* var. *reticulatus*, *indorus*, *chito* and *flexuosus* (Zink *et al.*, 1983). Line PI 140471 was found resistant to gummy stem blight (Norton, 1982). Resistance to CMV has been reported in Freeman (Karchi *et al.*, 1975) and resistance to WMV in PI 414723 (Webb and Bohn, 1962), B 66-5 (Webb, 1967) and *C. metuliferus* (Provvidenti and Robinson, 1977). Pitrat and Lecoq (1985) reported resistance to zuchini yellow mosaic virus in PI 161375.

Thomas and Webb (1981) developed five multiple disease resistant lines W_1, W_3, W_4, W_5 and W_6 which carry resistance against downy mildew, powdery mildew, Alternaria blight and WMV-1.

WATERMELON: Arka Manik had high level of resistance against mildews and anthracnose (Nath *et al.*, 1973) whereas, Asahi Yamato and Sugar Baby were moderately resistant (Robinson and Shail, 1975 & Waraitch *et al.*, 1977). Resistance to anthracnose was found in Black Stone, Charleston Gray and Cargo (Robinson and Shail, 1975 & Suvanjrakorn and Norton, 1980). Citron was found resistant against *Fusarium* wilt (Orton, 1911). Genotypes Calhoun Gray, Somkylee and Summit were highly resistant while Dixielle, All Sweet, Crimson Sweet, Charleston Gray and Lousiana Queen were moderately resistant to *Fusarium* wilt (Elmstrom and Hopkins, 1981).

Cucurbita spp: Sowell and Corley (1973) have reported resistance to powdery mildew in *C. moschata*. Resistance to bacterial wilt has been reported in *C. pepo*, *C. maxima*, *C. andreana* and *C. lundellina* (Watterson *et al.*, 1971). *C. pepo*, *C. maxima* and *C. moschata* carries resistance against squash mosaic virus (Salama and Sill, 1968) and *C. ecuadorensis* and *C. foetidissima* against WMV and CMV (Provvidenti *et al.*, 1978).

GENETICS OF DISEASE RESISTANCE

The knowledge of genetics of disease resistance is prerequisit to choose an appropriate breeding method to transfer resistance. The inheritance of disease resistance was first studied by Biffen (1908). Then a lot of research work have been done on this aspect in different crops.

The information on inheritance of various diseases of cucurbits has been given below:

CUCUMBER: Robinson (1978) and Munger *et al.* (1979) reported complex nature of genetic of powdery mildew caused by *Sphaerotheca fuliginia*. According to El-Jack (1984) resistance to powdery mildew has a partially dominant gene in line SS 717 for resistance. The resistance to angular leaf spot caused by *Pseudomonas lachrymans* is controlled polygenically (Dessert *et al.*, 1982). Wang (1984) found monogenic recessive resistance in cultivar Surinam against watermelon mosaic virus.

MUSKMELON: Powdery mildew is a major limiting factor in the production of

muskmelon throughout the world. Resistance to *Erysiphae cichoracearum* race-1 and race-2 was reported to be monogenically dominant. Resistance to powdery mildew (*Sphaerotheca fuliginia*) was studied in Campo and PMR-6 varieties and showed that they have the same locus/loci confering resistance. Inheritance of resistance to *E. cichoracearum* race-2 had indicated that resistance is partly dominant and controlled by Pm-2 (Bohn and Whitaker, 1964). Nath *et al.* (1973) observed that resistance to powdery mildew was dominant over susceptibility, whereas Choudhury and Sivakami (1972) found recessive nature susceptibility.

Resistance to downy mildew in line PI 124111 is controlled by two independently dominant genes (Cohen *et al.*, 1985) whereas, resistance in PI 124112 was attributed by two partially dominant genes (Kenigsbuch and Cohen, 1992). Resistance to *Fusarium* wilt is conferred by a single dominant gene (Risser, 1973).

The genetics of resistance to CMV is complex. The resistance to WMV-1 is conferred by a single dominant gene in line PI 180283 (Kaan, 1973) and in *Cucumis metuliferous* (Provvidenti and Robinson, 1977).

WATERMELON: Resistance to most of the diseases in watermelon is controlled by a single dominant gene. Resistance to *Fusarium* wilt may be recessive (Walker, 1941) and dominant (Welch and Melhus, 1942). Netzer and Weintall (1980) reported that resistance to *F. oxysporum f. sp. niveum* race-1 is controlled by a single dominant gene in cultivars Gray and Summit. Robinson *et al.* (1975) suggested that powdery mildew of watermelon caused by *S. fuliginia* is controlled by the Pm gene.

Cucurbita spp: Scientists, Rhodes (1964), Contin and Munger (1977), Contin (1978) and Vashistha (1986) noticed that resistance to *E. cichoracearum* and *S. fulginia* in *Cucurbita lundelliana* and *C. martinezii* was controlled by a single dominant gene. Resistance to powdery mildew in *C. martinezii* was controlled by a partial dominant gene (Contin and Munger, 1977).

BREEDING METHODS

Though cucurbits are cross pollinated but they do not show inbreeding depression on selfing. Therefore, breeding methods suitable for both self and cross pollinated crops can be successfully used for incorporating resistance in cucurbits. The breeding methods used to transfer disease resistance are almost the same as those used improvement of other horticultural characters. Generally, back cross method and inter and intra-species hybridization followed by back crossmethod has been used to transfer oligogenic type of resistance (Norton, 1982 & Munger and Washek, 1983). When resistance is governed by single dominant gene, it is very easy to exploit it in heterosis breeding whereas, pedigree method is generally followed when resistance is polygenic in nature. For accumulating more number of resistant genes into a single cultivar, double or three way crosses are followed.

The screening of collected germplasm under both field and laboratory conditions is the first step in the breeding programme. Simultaneous screening for more than one diseases can also be done (Williams, 1977). Alternatively one can use a line already having resistance to one or two diseases and incorporate resistance for other disease in the same line from other sources. Peterson *et al.* (1982) developed Wisconsin 2757 of cucumber adopting the same technique which shows resistance against as high as nine disease. Singh (1986) suggested that development of hybrid varieties should be based on parental lines each having resistance to one or more diseases.

Khush (1977) also suggested that development of single cross F_1 hybrid and this

could be crossed with other resistant donors to make double or top crosses to combine resistance to given diseases. If more donors are available for single parasite, it is desirable to use good combiners for yield components, plant types, etc. (Gardner, 1985). Bosch *et al.* (1990) also advocated to go for three way and four way crosses and then selecting resistant plants in segregating generations for more than one disease. The pedigree method may be used to handle the segregating populations. Barnes (1961) reported that plants having promising complimentary characters in F_3 to F_5 generations may be crosses for developing multiple disease resistant varieties.

Interspecific hybridization is an another approach, where individuals from two distinct species of the same genus are crossed. The resistance from wild species or genera may be transferred to commercial varieties. A population was developed among the species of *Cucurbita pepo*, *C. maxima* and *C. lundellina* possessing resistance to powdery mildew as a bridge species among the interspecific crosses for developing multiple disease resistant varieties to powdery mildew, downy mildew and squash mosaic virus in *C. pepo*. This was called inter breeding gene poll method.

Recurrent or reciprocal recurrent selections are often used in simultaneously improving horticultural traits while incorporating disease resistance (Sharma, 1997). Biotechnological techniques have also been used successfully to develop multiple disease resistance genotypes, eg. transgenic line ZW20 in squash is resistant to zucchini mosaic virus and CMV.

The development of stable resistance in a variety is of great importance. For this, horizontal resistance is supposed to be more stable than vertical resistance. A variety with horizontal resistance had the maximum potential for general adaptability (Sleptsova and Balashova, 1985).

ACHIEVEMENTS

The most promising multiple disease resistant varieties developed in cucurbits are as follows. Poinsettee of cucumber is resistant to powdery mildew, downy mildew, anthracnose and angular leaf spot. Homegarden, Perlita and Planers Jumbo of muskmelon are resistant to both the mildews. Arka Manik of watermelon carries multiple resistance against powdery mildew, downy mildew and anthracnose. Summer squash variety Punjab Chappan Kaddu-1 shows resistance against powdery mildew and CMV.

CONCLUSION

So far a very few promising multiple disease resistant varieties has been developed. However, the information pertaining to the reliable sources of disease resistance, genetics of disease resistance and adoption of suitable breeding methods including biotechnological approaches may help a breeder in developing more number of superior varieties coupled with multiple disease resistance.

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