Beetle Resistance


Field studies were conducted in 1993 and 1994 to evaluate the effects of induced resistance in cucumber by plant growth-promoting rhizobacteria (PGPR) on numbers of the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber, and the striped cucumber beetle, *Acalymma vittatum* (F.). Cucumber plant growth and yields were significantly (P<0.05) greater, and populations of cucumber beetles were significantly lower, on PGPR-treated cucumber than on nontreated cucumber. On dates when peak beetle populations were present, PGPR treatment resulted in significantly (P<0.05) greater cucumber beetle control than weekly applications of esfenvalerate insecticide. In no-choice greenhouse cage experiments with 3 cucumber cultivars, beetles infected with the cucurbit wilt pathogen, *Erwinia tracheiphila*, were released and allowed to feed on PGPR-treated or nontreated cucumber Plants. The incidence of cucurbit wilt disease was significantly (P<0.05) lower on PGPR-treated cucumber plants than on nontreated plants. These results indicate that PGPR-induced resistance may be more effective than insecticides for control of cucumber beetles and cucurbit wilt disease on cucumber. Possible mechanisms for PGPR-induced resistance against cucumber beetles are discussed.


One hundred and ten markers were analysed for linkage in 218 F2 plants derived from two divergent cultivars ('Vedrantais' end 'Songwhan Charmi') of *Cucumis melo* (L.). Thirty-four RFLPs, 64 RAPDs, one isozyme, four disease resistance markers and one morphological marker were used to construct a genetic map spanning 14 linkage groups covering 1390cM of the melon genome. RAPD and RFLP markers detected similar polymorphism levels. RFLPs were largely due to base substitutions rather than insertion/deletions. Twelve percent of markers showed distorted segregation. Phenotypic markers consisted of two resistance genes against *Fusarium* wilt (Fom-1 and Fom-2), one gene (nsv) controlling the resistance to melon necrotic spot virus, one gene (Vat) conferring resistance to *Aphis gossypii*, and a recessive gene for carpel numbers (3 vs 5 carpels: p).

Seventy-six *Cucurbita pepo* L. cultivars and breeding lines were evaluated under field conditions for infestation levels and defoliation (leaf area consumed by beetles) by adult diabroticite beetles in 1992 and 1994. Striped and spotted cucumber beetles, *Acalymma vittatum* (F.) and *Diabrotica undecimpunctata howardi* Barber, respectively, were most common, but some western and northern corn rootworms, *D. virgifera virgifera* LeConte and *D. barberi* Smith and Lawrence, respectively, also were present. In general, pumpkin, delicata, acorn winter squash, scallop, and yellow straightneck summer squash types were the least infested and defoliated, Caserta/yellow, zuccini, caserta/zucchini, caserta, and precocious yellow straightneck types were the most infested and defoliated. The number of beetles per plant was correlated (r greater than or equal to 0.72) with leaf defoliation and proportion of plants infested, indicating that beetle infestation is a good predictor of damage. The cultivars and breeding lines that were the least infested and defoliated can be used in breeding programs to develop desirable genotypes with reduced beetle preference. Conversely, those genotypes that were highly preferred have potential as trap crops for these beetle pests.


The influence of tissue age, pathogen infestation, intrapopulation contamination, and polymerase chain reaction (PCR) conditions were assessed as sources of error in random amplified polymorphic DNA (RAPD) analysis. DNA from young, uninfected tissue provided the most consistent results. Plants infected with *Sphaerotheca fuliginea* Schl. (ex Fr.) Poll. showed variation in RAPD banding patterns compared to those of uninfected plants. Differences in banding patterns were detectable when DNA from two inbred lines were mixed at dilution ratios of greater than or equal to 20:1 but not greater than or equal to 50:1. Differing lots of commercially available 10x reaction buffer, MgCl₂ stock solutions, and Taq DNA polymerase affected RAPD banding patterns and overall yield. For reproducibility of RAPD assays, it may be necessary to optimize reactions for specific lots of PCR reagents from either commercial or in-house sources.


Ten muskmelon (*Cucumis melo* L.) cultivars were tested for their susceptibility to bacterial wilt, caused by *Erwinia tracheiphila* (Smith) Bergey, Harrison, Breed, Hammer and Huntoon and vectored by the striped cucumber beetle *Acalymma vittatum* (F).  ‘Superstar’, ‘Rising Star’, ‘Pulsar’, ‘Caravelle’, ‘Cordele’, ‘Legend’, ‘Makdimon’,
'Galia’, ‘Rocky Sweet’, and ‘Passport’ were used in field studies to determine the number of striped cucumber beetles, feeding damage, and incidence of bacterial wilt. ‘Makdimon’ and ‘Rocky Sweet’ hosted significantly more beetles than the other cultivars. These two cultivars and ‘Legend’ and ‘Cordele’ had much more feeding damage and a significantly higher incidence of bacterial wilt than the others. A greenhouse experiment was conducted with seven of the cultivars to test their susceptibility to bacterial wilt when directly inoculated with the causal agent. All cultivars were equally susceptible to the disease when it was introduced directly into the plant. Selective feeding by striped cucumber beetles was probably most responsible for ‘Makdimon’, ‘Rocky Sweet’, ‘Legend’, and ‘Cordele’ having greater incidences of bacterial wilt that then other cultivars.


Restricted (non-systemic) inoculation of cucurbits, green bean, tobacco, and other plants with certain viruses, bacteria, or fungi has been shown to induce persistent, systemic resistance to a wide range of diseases caused by diverse pathogens. The non-specificity of this response has fueled speculation that it may also affect plant suitability for arthropod herbivores, and there is limited evidence, mainly from work with tobacco, which suggests that this may indeed occur. Young cucumber plants were immunized by restricted infection of a lower leaf with tobacco necrosis virus (TNV), and upper leaves were later challenged with anthracnose fungus, Colletotrichum lagenarium, to confirm induction of systemic resistance to a different pathogen. As has been reported before, immunization with TNV gave a high degree of protection from C. lagenarium reducing the number of lesions and the area of fungal necrosis by 65-93%. However, there was no systemic effect on population growth of twospotted spider mites, Tetranychus urticae Koch, on upper leaves, nor did restricted TNV infection of leaf tissue on one side of the mid-vein systemically affect mite performance on the opposite, virus-free side of the leaf.


Recently developed breeding lines and cultivars with different field resistances to the wireworm, and the Dabrotica, Systena (WDS) complex were tested in the laboratory for antibiosis to the banded cucumber beetle (BCB) Diabrotica balteata LeConte. Resistance (antibiosis) was measured by the reduction in number and weight of adults emerging from the different tissues. Resistance was highest in whole roots (periderm intact). The cortex was intermediate in antibiosis while least antibiosis was recorded in the stellar tissue. Antibiosis of peridermal and cortical tissues were more pronounced early or late
in the season than during mid-season. Field resistance classification to the WDS complex was correlated with BCB larval development on cortical tissue.


Four sets of nearly isogenic bacterial wilt \([Erwinia tracheiphila (E.F. Smith)]\) Holland resistant and susceptible gynoecious cucumber \((Cucumis sativus \text{ L.})\) lines, along with their companion segregating generations were evaluated under replicated field conditions for flowering date, fruit quality, fruit number, and length: diameter ratio \((L:D)\). In addition to flowering earlier, susceptible lines were higher-yielding and had longer fruits than their resistant counterparts. Although differences in fruit quality were not significant, susceptible lines were preferred by a panel of seven judges. Compared to susceptible lines, hybrid progeny were later-flowering and in some instances lower-yielding.

**Baker, P. B. and Robinson, R. W. 1985. Evaluations of selected Cucurbita accessions for cucumber beetle complex resistance. The Station. 31:2-8.**

The objective of this study was to select plants from field plantings of numerous lines and cultivars that expressed resistance to the striped and spotted cucumber beetles by antixenosis (nonpreference), for use in squash breeding programs. Although there was some variation from one season to another and in different plantings in the same year, there was generally a good agreement in different test of the same cultivar or line. Zucchini-type varieties of \(Cucurbita pepo\) (‘Ambassador’, ‘Dark Green Zucchini’, ‘Black Jack’, ‘President’) were more susceptible to cucumber beetles than Scallop-type cultivars (‘Scallop’, ‘Scallopini’, ‘Peter Pan’, ‘Patty Green Tint’), Table-queen cultivars (‘Table King’, ‘Table Ace’, Royal Acorn’, ‘Table Queen’), and Straightneck-type cultivars (‘Slendergold’, ‘Early Prolific Yellow Straightneck’). There is considerable opportunity for \(Cucurbita\) breeders to develop improved cultivars by selecting for reduced cucurbitacin content and thus for cucumber beetle resistance.


A decline in Midwestern muskmelon production during the past 30 years has resulted in fewer cultivars with resistance to bacterial wilt, \(Erwinia tracheiphila\). Levels of resistance in 187 cultivars were assessed in field and greenhouse experiments. Resistance was most common in obsolete muskmelon cultivars and least common in current commercial hybrids. Commercially available cultivars which had resistant plants tended to be older cultivars. Of the 12 cultivars with highest frequency of resistant plants, half are obsolete. No cultivar tested was sufficiently resistant for commercial production,
but resistant plants were observed in many cultivars. Burrell’s Gem, Early Wonder, and Jewel had the highest frequency of resistant plants.


In the early 1970s, a study was begun to find resistance to feeding in muskmelon, Cucumis melo L., by banded cucumber beetles, Diabrotica balteata Le conte. Bitter seedlings were observed to be more susceptible to feeding than nonbitter seedlings. We noticed reduced damage levels in both bitter and nonbitter seedlings in 1974. Genetic study of resistant materials showed that in addition to the recessive form of the bitter gene, bibi, a 2nd recessive gene, cbl cbl, conditioned reduced seedling susceptibility. Subsequent tests involving spotted (Diabrotica undecimpunctata howardi Barber), striped [Acalymma vittata (Fabricius)], and banded beetles on leaf disks of several C. melo cultivars showed that homozygous double recessive, bibi cblcbl, plants were more resistant to all 3 species of cucumber beetles than nonbitter, bibi Cbl-and bitter Bi-Cbl-plants. This double recessive resistance provides muskmelon breeders with germplasm which can be incorporated into breeding lines and hybrids.


Electrophoretic analyses of extracts of cucumber leaves infected with Colletotrichum lagenarium Fusarium oxysporum f. sp. Cucumerinum, Pseudomonas lachrymans, Erwinia tracheiphila, tobacco necrosis virus or cucumber mosaic virus revealed the presence of a protein band with an Rf value of 0 50-0 60 (based on mobility of bromophenol blue) on 10% polyacrylamide gel. This band was not evident in extracts of healthy or mechanically wounded leaves. The protein was not detected in uninfected leaves of infected plants, but it was detected in similar amounts in infected leaves and in secondarily challenged leaves of infected plants even though symptoms were not apparent on the latter. The protein had a molecular weight of approximately 16 000 d, was adsorbed on DEAE-cellulose, did not react with Schiff’s reagent, and did not have ribonuclease activity. When injected into cucumber leaves, it did not inhibit germination of conidia a C. lagenarium or induce resistance against disease caused by the fungus.


A strong linkage (~1 crossover unit) was detected between the gene Bw for resistance to bacterial wilt incited by Erwinia tracheiphila (E.F. Smith) Holland and the gene M for pistillate vs. perfect flowers in cucumber (Cucumis sativus L.).

In Cucumber (Cucumis sativus L.) no linkage was detected between genes for scab resistance, Ccu or bacterial wilt resistance, Bw and the 10 seedling market genes: nonbitter cotyledon, bi; glabrous, gl; glabrate, glb; light sensitive, ls; revolute leaf, cr; mottled cotyledon, mc; and 2 yellow cotyledon genes, yc-1 and yc-2. All 12 traits were inherited monogenically. Methods were developed for the screening of scab and bacterial wilt resistance in the seedling stage.


Antibiotic and nonpreference mechanisms are related in cucumber through the action of the bi gene and the absence of cucurbitacins. Cucurbitacins attract cucumber beetles and cause feeding whereas they have an antibiotic effect on two-spotted mites.


Fifty-three varieties within the plant family Cucurbitaceae were evaluated for plant resistance to Diabrotica undecimpunctata howardi Barber. Varieties were tested for foliage resistance and seedling resistance. Varieties were placed in 4 groups, based on common crop names for statistical analysis: (1) cucumbers, (2) summer squash, (3) winter squash, and (4) pumpkins, muskmelons, and watermelons. Varieties were scored on the amount of damage sustained, were given a damage index rating, and were listed as resistant, intermediate, or susceptible. Pumpkins, muskmelons, and watermelons were more susceptible than the other groups. However, greater differences occurred among varieties within a group than occurred between groups in both the seedling and foliage stages. Also it was found that resistance in one stage of plant growth did not preclude varietal resistance in another stage.


The inheritance of resistance to bacterial wilt in cucumber was studied in the cross Marketer x P.I. 200818 by observing the reaction of P1, F1, F2 and B1 seedling populations in the greenhouse to inoculations with Erwinia tracheiphila (E.F.Sm.)
Holland. The results show that resistance to bacterial wilt in the P.I. 200818 cucumber is due to a single dominant gene.


152 cucumber (*Cucumis sativus*) lines were screened for resistance to bacterial wilt (*Erwinia tracheiphila*). Partial resistance was identified in three plant introductions from Burma.

A Hybrid Cucumber Resistant to Bacterial Wilt. 1939. Phytopathology. 29:996-998.

This article reports moderate resistance to bacterial wilt (*Erwinia tracheiphila*) in progeny of a cross between Tokio Long Green and Vickery Forcing cucumber (*Cucumis sativus*). The progression of wilt through these plants is confined to the initially-inoculated leaf or shoot.