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Screening the Cucumber Germplasm Collection for Resistance to Gummy Stem Blight in North Carolina Field Tests

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***Abstract*. Gummy stem blight (Didymella blight*)*, caused by *Didymella bryoniae* (Auersw.) Rehm and its anamorph *Phoma cucurbitacearum* (Fr.:Fr.) Sacc., is the second most important disease of cucumber (*Cucumis sativus* L.) in North Carolina after root knot nematodes *Meloidogyne sp*. Both *Didymella blight* and Phoma blight, caused by *Phoma exigua* Desm., have similar symptoms and control practices, and are generally referred to as gummy stem blight. In order to determine whether resistance existed to North Carolina isolates of *D. bryoniae*, 851 cultigens [cultivars, breeding lines, and plant introduction (PI) lines] were evaluated in the field. Plants were inoculated with one selected isolate (highly pathogenic in preliminary greenhouse tests) at the vine tip-over stage. They were rated for foliage lesion size and number on a 0 to 9 visual scale (0 = no disease, 9 = plant killed) and average ratings for 10 plants per plot were analyzed. The ratings ranged from 2.0 (highly resistant) to 8.5 (highly susceptible) with a mean of 6.2. The most resistant breeding lines and PI accessions were PI 200815, PI 390243, 'LJ 90430', PI 279469, and PI 432855. The most resistant cultivars were 'Homegreen #2', 'Little John', 'Transamerica', and 'Poinsett 76'. The most susceptible cultigens in the study were PI 288238, PI 357843, PI 357865, and PI 167134. Two popular cultivars in North Carolina, 'Calypso' and 'Dasher II', were moderately resistant.**

Gummy stem blight of cucumber is caused by *Didymella bryoniae* [synonyms: *Mycosphaerella citrullina* (C.O. Sm.) Gross., and *Mycosphaerella melonis* (Pass.) Chiu and J.C. Walker] and its anamorph *Phoma cucurbitacearum* (Farr et al., 1989) (synonyms: *Ascochyta cucumis* Fautr. and Roum., and *Phyllosticta cucurbitacearum* Sacc.). The pathogen attacks several other genera of *Cucurbitaceae* such as melon (*Cucumis melo* L.), watermelon (*Citrullus lanatus* Matsum. & Nakai) and squash (*Cucurbita pepo* L.). The pathogen is attracted to plants by volatile compounds produced by *Cucumis* and *Cucurbita* species (Pharis et al., 1982). The incidence and severity of damage due to gummy stem blight on cucumber is second only to those of root knot nematode in North Carolina (St. Amand and Wehner, 1991). Gummy stem blight is a serious disease of greenhouse cucumber in The Netherlands, where it causes fruit rot (black rot) (Punithalingam and Holliday, 1972; Van Steekelenburg, 1985a). Cucumber plants may be infected at any growth stage from seedling to mature fruit, and infection can occur on all plant parts, including roots (Thinggaard, 1987). Didymella blight and Phoma blight have similar symptoms and control practices and, together, cause gummy stem blight. Although chemical control is available, resistant cultivars would be preferable.

Infection caused by *D. bryoniae* is dependent on relative humidity (RH), with more infection occurring at 95% than at 50% RH. Greatest infection is also produced by free-standing water on leaves. In the case of older leaves, wounding is essential for infection (Van Steekelenburg, 1985b). St. Amand and Wehner (1995a) reported that susceptibility of cucumber plants increased with increased guttation. Detached-leaf and greenhouse seedling tests both indicated that old leaves were more susceptible to the pathogen than young leaves. Field tests also revealed that leaves and stems were more susceptible after the vine tip-over stage (about eight true leaves) (St. Amand and Wehner, 1995a). Cucumber beetles (*Diabrotica undecimpunctata howardi* Barber and *Acalymma vittatum* Fabricius) and powdery mildew [*Erysiphe cichoracearum* DC. or *Sphaerotheca fuliginea* (Schlect.) Poll.] may predispose the plant to infection or contribute to pathogen spread (Bergstrom et al., 1982).

Van Steekelenburg (1985a) reported that late-morning transition to day temperature settings in the greenhouse caused a higher incidence of main stem lesions and internal fruit rot from *D. bryoniae* on cucumber compared with early-morning transition. This was attributed to longer duration at high humidity, and to water condensation on fruits. St. Amand and Wehner (1995a) reported that dawn inoculation during field or greenhouse tests increased leaf susceptibility compared with dusk inoculation, possibly because of free water and nutrients provided by guttation.

The typical symptoms of gummy stem blight on cucurbits are circular, tan to dark brown spots that appear first at the leaf margins and rapidly spread over the entire leaf. Circular, black or tan spots also appear on the cotyledons and stems of young plants. Stem cankers develop in the cortical tissue, and a brown, gummy exudate is produced on the surface. On fruits, the disease causes a soft rot with black discoloration of the epidermis (exocarp). Small, water-soaked spots develop that later enlarge to an indefinite size, with a gummy exudate. In the lesions of different organs, pycnidia of the anamorph stage (*P. cucurbitacearum*) and perithecia of the teleomorph (*D. bryoniae*) are observed as abundant black dots (Zitter et al., 1996).

Seedling tests for gummy stem blight have been developed (Abad and Wehner, 1992; Van Steekelenburg, 1981; Wyszogrodzka et al., 1986), and disease ratings from seedling tests described by St. Amand and Wehner (1995a) were found to be highly correlated (r = 0.82 to 0.96) to disease ratings in field tests.

There have been no reports of race specialization for *D. bryoniae*. In eight geographically diverse isolates tested for differences in pathogenicity to cucumber, there was no significant interaction of cultivar with isolate, and no differences were observed among the eight isolates for pathogenicity based on cluster analysis (St. Amand and Wehner, 1995b). However, two isolates (one from The Netherlands and one from Spain) were found to be more pathogenic than the isolates from the United States. Resistance in cucumber to *D. bryoniae* appeared to be non-specific or horizontal in pattern, indicating that breeders could use a single pathogenic isolate of *D. bryoniae* when screening for resistance.

The objective of this experiment was to test all available plant introduction (PI) accessions from the U.S. National Plant Germplasm System, cultivars, and breeding lines (hereafter collectively referred to as cultigens) of cucumber for gummy stem blight resistance under field conditions in North Carolina.

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Materials and Methods

The experiment was conducted in 1989 at the Horticultural Crops Research Station in Clinton, N.C., using recommended horticultural practices as summarized by Schultheis (1990).

Cultigens used. All available PI accessions (720) from the U.S. National Plant Germplasm System were tested, along with 41 breeding lines and 90 cultivars from the North Carolina State University collection, for a total of 851 cultigens originating from 45 countries. Most of the cultigens tested were from Turkey (164), the People's Republic of China (P.R. China) (102), former Yugoslavia (63), Iran (54), India (46), Japan (43), former Soviet Union (USSR) (41), former Czechoslovakia (31), and the United States (16). The PI accessions were obtained from the North Central Regional Plant Introduction Station in Ames, Iowa. Other cultigens were obtained from commercial sources, public breeding programs, or the National Seed Storage Laboratory (NSSL) in Fort Collins, Colo. An additional 33 cultigens were tested, but data are not presented in this paper because of poor seed germination or plant growth.

Inoculum preparation. One isolate of *P. cucurbitacearum*, which was collected in 1988 from cucumber fields in North Carolina and proved to be highly pathogenic in preliminary greenhouse tests, was used for field inoculation. The isolate was increased in malt extract agar medium at room temperature (≈23 °C) under 16 h of fluorescent light [40 to 90 $mol\cdot m^{-2}\cdot s^{-1}$ photosynthetic photon flux (*PPF*)] per day for 7 d (Van Der Meer et al., 1978). Conidia were collected by flooding plates with 5 to 10 mL of acidified sterile distilled water and scraping the surface of the agar with a rubber spatula. The liquid from each plate was filtered through four layers of cheesecloth to remove mycelia, pycnidia, and dislodged agar. The spore suspension was standardized to a concentration of $\approx 1 \times 10^6$ spores per mL using a hemacytometer. Before inoculation, Tween 80® (surfactant) was added at the rate of 0.5 $ml\cdot L^{-1}$ of the spore suspension.

Table 1. Gummy stem blight rating (GSB) of cucumber cultigens at Clinton, N.C., listed in order of decreasing resistance.[z]

Cultigen name	Seed source	GSB rating
PI 200815	Burma	2.0
Homegreen #2	USDA–Wis.	2.0
AR 79-75	Univ. Arkansas	2.3
Transamerica	Ferry-Morse	2.3
PI 390243	Japan	2.5
LJ 90430	USDA–La Jolla	2.5
PI 279469	Japan	2.8
PI 432855	P.R. China	2.8
Poinsett 76	Cornell Univ.	2.8
PI 267746	India	3.0
PI 279463	Japan	3.0
Gy 5	N.C. State Univ.	3.0
Gy 6	N.C. State Univ.	3.0
PI 390239	Japan	3.0
Regal	N.C. State Univ.	3.0
Cracker Lee	NSSL	3.0
PI 390245	Japan	3.3
TMG-1	P.R. China	3.3
PI 163217	India	3.3
PI 432864	P.R. China	3.3
Olympian	Hollar Seed	3.3
PI 163218	India	3.3
PI 426170	Philippines	3.5
PI 163223	India	3.5
PI 390257	Japan	3.5
PI 390259	Japan	3.5
PI 390260	Japan	3.5
Aodai-Nazare	Asgrow Seed	3.5
PI 418963	P.R. China	3.5
Dasher II	Petoseed	3.5
M 41	N.C. State Univ.	3.5
Slice	Clemson Univ.	3.5
Gy 4	N.C. State Univ.	3.5
PI 306785	Canada	3.5
PI 249562	Thailand	3.8
PI 302443	Taiwan	3.8
PI 279467	Japan	3.8
PI 432863	P.R. China	3.8
Balam Model	Nepal	3.8
Sumter	Clemson Univ.	3.8
PI 267935	Japan	3.8
PI 171608	Turkey	3.8
PI 188807	Philippines	4.0
PI 288332	India	4.0
PI 432858	P.R. China	4.0
AR H-19	Univ. Arkansas	4.0
Boston Pickling	NSSL	4.0
Burpees Sunnybrook	Burpee Seed	4.0
Cross Country	Ferry-Morse	4.0
PI 267942	Japan	4.0
PI 390246	Japan	4.0
PI 432876	P.R. China	4.0
Gy14A	N.C. State Univ.	4.0

Table 1. Continued.

Cultigen name	Seed source	GSB rating
Gy57u	Cornell Univ.	4.0
Marketmore 80F	Cornell Univ.	4.0
PI 163216	India	4.0
Gy 54	Clemson Univ.	4.0
Redlands Long White	New World Seeds	4.0
PI 179678	India	4.0
PI 358813	Malaysia	4.0
Balam Khira	Nepal	4.0
SC 57M	Clemson Univ.	4.0
PI 422182	Czechoslovakia	4.0
Calypso	N.C. State Univ.	4.0
PI 419017	P.R. China	4.3
PI 432871	P.R. China	4.3
Fancipak	Asgrow Seed	4.3
PI 234517	U.S.–S.C.	4.3
PI 255935	Netherlands	4.3
PI 279466	Japan	4.3
Clinton	N.C. State Univ.	4.3
Picarow	Agway Inc.	4.3
PI 105340	P.R. China	4.3
PI 163222	India	4.3
PI 390258	Japan	4.3
PI 390264	Japan	4.3
PI 414159	U.S.–Hawaii	4.3
Centurion	Northrup King	4.3
Pixie	Clemson Univ.	4.3
PI 390266	Japan	4.3
AC 1811	Abbott & Cobb	4.3
Dublin	Stokes	4.3
Pick	Clemson Univ.	4.3
Prolific	Sakata Seed	4.3
PI 163213	India	4.3
PI 419214	Hong Kong	4.3
Brice	Burrell	4.3
PI 165509	India	4.5
PI 171604	Turkey	4.5
PI 432897	P.R. China	4.5
PI 483343	Korea	4.5
Addis	N.C. State Univ.	4.5
PI 164816	India	4.5
PI 321011	Taiwan	4.5
PI 482464	Zimbabwe	4.5
PI 263082	P.R. China	4.5
PI 321007	Taiwan	4.5
PI 390265	Japan	4.5
PI 489754	P.R. China	4.5
PI 220860	Korea	4.5
Dual	Clemson Univ.	4.5
Marketsett	Clemson Univ.	4.5
Wautoma	USDA–Wis.	4.5
WI 2757	USDA–Wis.	4.5
PI 183127	India	4.5
PI 267741	Japan	4.5
Sumter	Clemson Univ.	4.5

Field test. Fertilizer was incorporated before planting at a rate of 90N–39P–74K kg·ha^{-1}, with an additional 34 kg·ha^{-1} N applied at the vine-tip-over stage (four to six true leaves). Seeds were planted on raised, shaped beds with centers 1.5 m apart. Plots 1.5 m long were seeded, and later thinned to five plants at the first true leaf stage. A 1.5 m alley was present at either end of each plot. Irrigation was applied when needed to provide a total of 25 to 40 mm per week, and a tank mix of 2.2 kg·ha^{-1} of naptalam {2-[(1-naphthalenylamino) carbonyl] benzoic acid} and 4.4 kg·ha^{-1} of bensulide {*O,O*-bis(1-methylethyl) *S*-[2-[(phenylsulfonyl) amino] ethyl] phosphorodithioate} was applied preplant for weed control. The field was surrounded by border rows for uniform competition.

Inoculation and ratings. Field plots were inoculated on 26 June and 3 July with a suspension of the selected isolate (highly pathogenic in preliminary greenhouse tests) at the vine tip-over stage until a fine film of inoculum suspension covered the leaves. A Solo backpack sprayer (Solo, Newport News, Va.) was used to spray the inoculum on the leaves and stems at 100–140 kPa (15–20 psi) until run-off. We observed natural occurrence of gummy stem blight with typical lesions in the field, and there was a low incidence of anthracnose [*Colletotrichum lagenarium* (Ross.) Ellis & Halst]. The weather conditions during the season with high humidity helped in the uniform spread of gummy stem blight.

Field plots were rated on 13 and 20 July for foliar lesions, using a 0 to 9 visual rating scale (0 = no disease, 1 to 2 = a trace of infection, 3 to 4 = few small lesions, 5 to 6 = 20 to 50 % of leaves covered with small lesions, 7 to 8 = plant wilted and covered with 50% or more with lesions, 9 = plant killed). The rating system was modeled after the categories developed by Thompson and Jenkins (1985). Ratings were averaged over the five plants in a plot.

Data collection and analysis. The experiment was a randomized complete-block with 884 cultigens, two replications, and two ratings. Prior to analysis, data were checked for

Table 1. Continued.

Cultigen name	Seed source	GSB rating
Galaxy	Clemson Univ.	4.5
PI 164670	India	4.5
PI 308916	USSR	4.5
PI 436608	P.R. China	4.8
PI 197087	India	4.8
PI 279468	Japan	4.8
PI 419136	P.R. China	4.8
PI 211984	Iran	4.8
PI 390268	Japan	4.8
PI 422183	Czechoslovakia	4.8
PI 483339	Korea	4.8
PI 483340	Korea	4.8
M 22	N.C. State Univ.	4.8
PMR 551	Cornell Univ.	4.8
PI 426169	Philippines	4.8
PI 432883	P.R. China	4.8
PI 212985	India	4.8
MSU 9429M	Mich. State Univ.	4.8
Pickalot	Burpee Seed	4.8
PI 227207	Japan	4.8
PI 164433	India	5.0
PI 390255	Japan	5.0
PI 432873	P.R. China	5.0
PI 164734	India	5.0
PI 172839	Turkey	5.0
PI 212233	Japan	5.0
PI 308915	USSR	5.0
PI 330628	Pakistan	5.0
PI 390241	Japan	5.0
PI 390262	Japan	5.0
PI 391570	P.R. China	5.0
PI 432856	P.R. China	5.0
PI 432869	P.R. China	5.0
PI 432875	P.R. China	5.0
PI 432878	P.R. China	5.0
PI 478365	P.R. China	5.0
PI 483342	P.R. China	5.0
PI 500365	Zambia	5.0
PI 265887	Netherlands	5.0
PI 267745	Brazil	5.0
PI 422172	Czechoslovakia	5.0
PI 432862	P.R. China	5.0
PI 432885	P.R. China	5.0
M 21	N.C. State Univ.	5.0
PI 181752	Syria	5.0
PI 263049	USSR	5.0
PI 267744	U.S.–N.Y.	5.0
PI 436648	P.R. China	5.0
Burpless 33	Hastings	5.0
Gy 2	N.C. State Univ.	5.0
Magnolia	NSSL	5.0
Maximore 102	Abbott & Cobb	5.0
Spartan Salad	Mich. State Univ.	5.0
PI 370022	India	5.0

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 422170	Czechoslovakia	5.0
PI 385967	Kenya	5.0
A&C	Niagara	5.0
PI 176950	Turkey	5.3
PI 209069	U.S.–Iowa	5.3
PI 264228	France	5.3
PI 379279	Yugoslavia	5.3
PI 418962	P.R. China	5.3
PI 422185	Czechoslovakia	5.3
Royal	Harris-Moran	5.3
PI 263046	USSR	5.3
PI 263083	P.R. China	5.3
PI 358814	Malaysia	5.3
PI 368556	Yugoslavia	5.3
PI 419183	P.R. China	5.3
PI 422190	Czechoslovakia	5.3
PI 432859	P.R. China	5.3
PI 432874	P.R. China	5.3
PI 432886	P.R. China	5.3
PI 489753	P.R. China	5.3
PI 193496	Ethiopia	5.3
PI 271326	India	5.3
PI 357861	Yugoslavia	5.3
PI 418964	P.R. China	5.3
PI 432854	P.R. China	5.3
PI 451976	Japan	5.3
M 27	N.C. State Univ.	5.3
Medalist	Harris-Moran	5.3
Poinmarket	Clemson Univ.	5.3
PI 092806	P.R. China	5.3
PI 267086	USSR	5.3
PI 267088	USSR	5.3
PI 271331	India	5.3
PI 279464	Japan	5.3
PI 326597	Hungary	5.3
PI 432877	P.R. China	5.3
General Lee	Ferry-Morse	5.3
PI 390267	Japan	5.3
PI 432892	P.R. China	5.3
PI 436610	P.R. China	5.5
PI 478366	P.R. China	5.5
PI 483341	Korea	5.5
HMX 4490	Harris-Moran	5.5
Polaris	Clemson Univ.	5.5
PI 173889	India	5.5
PI 197085	India	5.5
PI 306179	Poland	5.5
PI 326596	Hungary	5.5
PI 391572	P.R. China	5.5
PI 432881	P.R. China	5.5
PI 478364	P.R. China	5.5
PI 269481	West Pakistan	5.5
PI 321010	Taiwan	5.5
PI 427089	P.R. China	5.5

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 432870	P.R. China	5.5
PI 435946	USSR	5.5
PI 436609	P.R. China	5.5
PI 464873	P.R. China	5.5
Khira Patna	Nepal	5.5
Mandarin	Vaughan	5.5
Marketmore 76	Cornell Univ.	5.5
Poinsett	Clemson Univ.	5.5
Poona Khira	Nepal	5.5
PI 175120	India	5.5
PI 179921	India	5.5
PI 212896	India	5.5
PI 321009	Taiwan	5.5
PI 357839	Yugoslavia	5.5
PI 368560	Yugoslavia	5.5
PI 422179	Czechoslovakia	5.5
PI 422186	Czechoslovakia	5.5
PI 432882	P.R. China	5.5
Chipper	Clemson Univ.	5.5
Danish Common	U.S.–Wyo.	5.5
PI 432865	P.R. China	5.5
PI 109483	Turkey	5.5
PI 211983	Iran	5.5
PI 357858	Yugoslavia	5.5
PI 406473	Netherlands	5.5
Shamrock Resistant	Iowa AES	5.5
SMR 12	Wisconsin AES	5.5
PI 283900	Czechoslovakia	5.5
PI 427090	P.R. China	5.5
Sprint 440	Asgrow Seed	5.5
PI 432895	P.R. China	5.5
PI 432880	P.R. China	5.8
PI 206953	Turkey	5.8
PI 390244	Japan	5.8
PI 401732	Puerto Rico	5.8
PI 179259	Turkey	5.8
PI 263081	P.R. China	5.8
PI 271328	India	5.8
PI 280096	USSR	5.8
PI 390253	Japan	5.8
PI 432879	P.R. China	5.8
PI 432888	P.R. China	5.8
PI 432893	P.R. China	5.8
Gy 3	Clemson Univ.	5.8
PI 163214	India	5.8
PI 181756	Lebanon	5.8
PI 200818	Burma	5.8
PI 222720	Iran	5.8
PI 227209	Japan	5.8
PI 306180	Poland	5.8
PI 379286	Yugoslavia	5.8
PI 419040	P.R. China	5.8
PI 430585	P.R. China	5.8
PI 432851	P.R. China	5.8
PI 432852	P.R. China	5.8
PI 432861	P.R. China	5.8
PI 432872	P.R. China	5.8
PI 458856	USSR	5.8
PI 188749	Egypt	5.8
PI 222783	Iran	5.8
PI 275412	Netherlands	5.8
PI 314425	USSR	5.8
PI 357853	Yugoslavia	5.8
PI 391568	P.R. China	5.8
PI 458853	USSR	5.8
PI 487424	P.R. China	5.8
PI 175692	Turkey	5.8
PI 204692	Turkey	5.8
PI 222782	Iran	5.8
PI 390247	Japan	5.8
PI 211977	Iran	6.0
PI 279465	Japan	6.0
PI 342950	Denmark	6.0
PI 177364	Iraq	6.0
PI 109275	Turkey	6.0
PI 164743	India	6.0

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 169381	Turkey	6.0
PI 169398	Turkey	6.0
PI 178888	Turkey	6.0
PI 183224	Egypt	6.0
PI 267742	Hong Kong	6.0
PI 344353	Turkey	6.0
PI 344445	Iran	6.0
PI 357859	Yugoslavia	6.0
PI 390263	Japan	6.0
PI 419010	P.R. China	6.0
PI 458847	USSR	6.0
PI 483344	Korea	6.0
Discover	Asgrow Seed	6.0
Earliest of All	NSSL	6.0
Ohio MR 200	Heinz–Ohio AES	6.0
Picklers Special	U.S.–Wyo.	6.0
PI 135123	New Zealand	6.0
PI 165046	Turkey	6.0
PI 263080	USSR	6.0
PI 264666	Germany	6.0
PI 281448	Korea	6.0
PI 357856	Yugoslavia	6.0
PI 422167	Czechoslovakia	6.0
PI 422173	Czechoslovakia	6.0
PI 422176	Czechoslovakia	6.0
PI 435947	USSR	6.0
Straight 8	NSSL	6.0
PI 113334	P.R. China	6.0
PI 137844	Iran	6.0
PI 137848	Iran	6.0
PI 137851	Iran	6.0
PI 164679	India	6.0
PI 164819	India	6.0
PI 164952	Turkey	6.0
PI 167223	Turkey	6.0
PI 169401	Turkey	6.0
PI 178886	Turkey	6.0
PI 183056	India	6.0
PI 197086	India	6.0
PI 262990	Netherlands	6.0
PI 263084	P.R. China	6.0
PI 288994	Hungary	6.0
PI 357849	Yugoslavia	6.0
PI 360939	Netherlands	6.0
PI 370449	Yugoslavia	6.0
PI 390238	Japan	6.0
PI 390261	Japan	6.0
PI 418989	P.R. China	6.0
PI 422171	Czechoslovakia	6.0
PI 422180	Czechoslovakia	6.0
PI 422218	Israel	6.0
PI 432850	P.R. China	6.0
Early Russian	NSSL	6.0
Minn. Dwarf Cuke XII	Minnesota AES	6.0
PI 264667	Germany	6.0
PI 368553	Yugoslavia	6.0
PI 422174	Czechoslovakia	6.0
PI 426629	Pakistan	6.0
PI 470254	Indonesia	6.0
Sumter	Clemson Univ.	6.0
PI 169378	Turkey	6.0
PI 176526	Turkey	6.0
PI 197088	India	6.0
PI 321008	Taiwan	6.0
PI 419108	P.R. China	6.0
PI 458845	USSR	6.0
PI 466922	USSR	6.0
Muronium	NSSL	6.0
PI 177360	Turkey	6.0
Gy 1	N.C. State Univ.	6.0
PI 357854	Yugoslavia	6.0
PI 304805	U.S.–N.Y.	6.0
PI 183445	India	6.3
PI 264226	France	6.3
PI 288993	Hungary	6.3
PI 339241	Turkey	6.3

normality, error variance homogeneity, and additivity by residual plot analysis. Residual plots had a random distribution, indicating that the statistical model was valid and its assumptions were met (Fernandez, 1992). Rating scale data were not transformed because assumptions for the analysis of variance were met (Little, 1985). Data were analyzed using the GLM procedure of SAS (SAS Institute, Cary, N.C.).

Results and Discussion

The cultigens were ranked based on the mean gummy stem blight rating averaged over the two rating dates (Table 1). The nine most resistant cultigens were PI 200815, ‘Homegreen #2’, AR 79-75, ‘Transamerica’, PI 390243, LJ 90430, PI 279469, PI 432855, and ‘Poinsett 76’. The four most susceptible cultigens were PI 288238, PI 357843, PI 357865, and PI 167134. The ratings ranged from 2.0 (highly resistant) to 8.5 (highly susceptible), with a mean of 6.2 and a coefficient of variability of 17% for the 851 cultigens tested in the study.

When rating for resistance on a continuous scale, it is difficult to separate cultigens into classes such as resistant and susceptible. However, plant breeders often use those terms for quantitative traits. In keeping with that practice, cultigens with ratings of 3.0 or lower were classified as highly resistant, >3.0 to <6.0 as moderately resistant, and ≥6.0 as susceptible. The categories were somewhat arbitrary, but were based on the range/LSD value of 3.1, meaning that there were 3.1 LSD units from the most susceptible to the most resistant cultigen. Based on those classifications, 16 cultigens were highly resistant, 269 were moderately resistant, and 566 were susceptible (Table 1).

No conclusions could be made concerning the resistance of feral accessions from particular countries because the assortment of cultigens from a given country included any combination of improved cultivars, breeding lines, land races, and feral accessions. A comparison among countries for only feral accessions was not possible because that information was not available from either the Germplasm Resources Information Network (GRIN) or the North Central Regional Plant Introduction Station for most cultigens.

The degree of heterozygosity for most of the cultigens tested was unknown but may be high in some PI accessions. The PI accessions found to be resistant in this study were likely to have useful genes for resistance. However, those accessions found to be susceptible may still carry recessive alleles for resistance that were not discovered because of the small sample size and the possibility of heterozygosity.

Van der Meer et al. (1978) screened cultigens for resistance to gummy stem blight resistance using a seedling test, and reported that PI 200818 (Burma), PI 339241 (Turkey), ‘Leningradsky’, ‘Wjarnikovsky’ (USSR), and ‘Rheinische Vorgebirge’ (Germany) were the most resistant. Wyszogrodzka et al. (1986) also reported that ‘Homegreen #2’ and PI 200818 were the most resistant among 49 cucumber cultigens tested for the pathogen in fields in Florida and Wisconsin. However,

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 419041	P.R. China	6.3
PI 432866	P.R. China	6.3
PI 103049	P.R. China	6.3
PI 167079	Turkey	6.3
PI 167197	Turkey	6.3
PI 175679	Turkey	6.3
PI 183231	Egypt	6.3
PI 217644	India	6.3
PI 257486	P.R. China	6.3
PI 288996	Hungary	6.3
PI 338234	Turkey	6.3
PI 342951	Denmark	6.3
PI 357830	Yugoslavia	6.3
PI 372587	Netherlands	6.3
PI 436649	P.R. China	6.3
Chinese Long Green	Oris	6.3
PI 169383	Turkey	6.3
PI 205996	Sweden	6.3
PI 209067	U.S.–Iowa	6.3
PI 211978	Iran	6.3
PI 214049	India	6.3
PI 285605	Poland	6.3
PI 314426	USSR	6.3
PI 379283	Yugoslavia	6.3
PI 401734	Puerto Rico	6.3
PI 436673	P.R. China	6.3
Extra Early Majestic	U.S.–Wyo.	6.3
Slice Max	Sakata Seed	6.3
PI 169388	Turkey	6.3
PI 339246	Turkey	6.3
PI 390249	Japan	6.3
PI 489752	P.R. China	6.3
PI 114339	Japan	6.3
PI 285610	Poland	6.3
PI 432889	P.R. China	6.3
PI 169399	Turkey	6.5
PI 176952	Turkey	6.5
Early Green Cluster	NSSL	6.5
PI 175688	Turkey	6.5
PI 192940	P.R. China	6.5
Everbearing	NSSL	6.5
PI 171611	Turkey	6.5
Pi 176924	Turkey	6.5
PI 178885	Turkey	6.5
PI 255938	Netherlands	6.5

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 261609	Spain	6.5
PI 289698	Australia	6.5
PI 304803	U.S.–N.Y.	6.5
PI 339243	Turkey	6.5
PI 357845	Yugoslavia	6.5
PI 357848	Yugoslavia	6.5
PI 357868	Yugoslavia	6.5
PI 432867	P.R. China	6.5
PI 432887	P.R. China	6.5
PI 458855	USSR	6.5
Crystal Salad	NSSL	6.5
Pacer	Harris-Moran	6.5
PI 135345	Afghanistan	6.5
PI 169380	Turkey	6.5
PI 171606	Turkey	6.5
PI 172841	Turkey	6.5
PI 172843	Turkey	6.5
PI 173893	India	6.5
PI 177363	Syria	6.5
PI 181755	Lebanon	6.5
PI 209068	U.S.–Iowa	6.5
PI 211982	Iran	6.5
PI 257487	P.R. China	6.5
PI 257494	Iran	6.5
PI 267087	USSR	6.5
PI 288990	Hungary	6.5
PI 351140	USSR	6.5
PI 354952	Denmark	6.5
PI 372893	Netherlands	6.5
PI 379282	Yugoslavia	6.5
PI 391569	P.R. China	6.5
PI 451975	Canada	6.5
PI 164465	India	6.5
PI 209066	U.S.–Iowa	6.5
PI 211117	Israel	6.5
PI 212059	Greece	6.5
PI 220171	Afghanistan	6.5
PI 255933	Netherlands	6.5
PI 263079	USSR	6.5
PI 271334	India	6.5
PI 321006	Taiwan	6.5
PI 344352	Turkey	6.5
PI 357842	Yugoslavia	6.5
PI 357847	Yugoslavia	6.5
PI 379287	Yugoslavia	6.5

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 390240	Japan	6.5
PI 390256	Japan	6.5
PI 422184	Czechoslovakia	6.5
PI 432868	P.R. China	6.5
Tablegreen 72	Cornell Univ.	6.5
PI 209065	U.S.–Iowa	6.5
Marketer	Associated	6.5
Wis. SMR 18 a	Wisconsin AES	6.5
PI 169387	Turkey	6.5
PI 175121	India	6.5
PI 206955	Turkey	6.5
PI 288237	Egypt	6.5
PI 355053	Iran	6.5
PI 478367	P.R. China	6.5
PI 422169	Czechoslovakia	6.8
PI 109481	Turkey	6.8
PI 109484	Turkey	6.8
PI 165029	Turkey	6.8
PI 202801	Syria	6.8
Snake	Clemson Univ.	6.8
Armstrong Early Cluster	Sunseeds	6.8
PI 164284	India	6.8
PI 171602	Turkey	6.8
PI 176518	Turkey	6.8
PI 176525	Turkey	6.8
PI 261608	Spain	6.8
PI 267747	U.S.–Okla.	6.8
PI 269482	West Pakistan	6.8
PI 357835	Yugoslavia	6.8
PI 357852	Yugoslavia	6.8
PI 368548	Yugoslavia	6.8
PI 370447	Yugoslavia	6.8
PI 390951	USSR	6.8
PI 432896	P.R. China	6.8
Early Cluster	NSSL	6.8
EC 128264	NSSL	6.8
Long Green	Northrup King	6.8
White Wonder	Northrup-King	6.8
PI 165506	India	6.8
PI 169400	Turkey	6.8
PI 172847	Turkey	6.8
PI 176957	Turkey	6.8
PI 178884	Turkey	6.8
PI 179260	Turkey	6.8
PI 179676	India	6.8
PI 283901	Czechoslovakia	6.8
PI 356809	USSR	6.8
PI 419009	P.R. China	6.8
PI 422191	Czechoslovakia	6.8
PI 222243	Iran	6.8
PI 171609	Turkey	6.8
PI 211728	Afghanistan	6.8
PI 249550	Iran	6.8
PI 264229	France	6.8
PI 285606	Poland	6.8
PI 285607	Poland	6.8
PI 368557	Yugoslavia	6.8
PI 432857	P.R. China	6.8
PI 432860	P.R. China	6.8
PI 169328	Turkey	6.8
PI 182190	Turkey	6.8
PI 267197	P.R. China	6.8
PI 422198	Czechoslovakia	6.8
Wis. SMR 18 b	Wisconsin AES	6.8
PI 176951	Turkey	6.8
PI 227210	Japan	6.8
PI 283902	Czechoslovakia	6.8
PI 344351	Turkey	7.0
PI 167043	Turkey	7.0
PI 167198	Turkey	7.0
PI 175695	Turkey	7.0
PI 222985	Iran	7.0
PI 223841	Philippines	7.0
PI 249561	Thailand	7.0
PI 271753	Netherlands	7.0
PI 339247	Turkey	7.0

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 368555	Yugoslavia	7.0
PI 391571	P.R. China	7.0
PI 401733	Puerto Rico	7.0
PI 458848	USSR	7.0
PI 466921	USSR	7.0
PI 169351	Turkey	7.0
PI 169389	Turkey	7.0
PI 172844	Turkey	7.0
PI 175694	Turkey	7.0
PI 176521	Turkey	7.0
PI 176524	Turkey	7.0
PI 177359	Turkey	7.0
PI 181753	Syria	7.0
PI 211943	Iran	7.0
PI 218199	Lebanon	7.0
PI 222244	Iran	7.0
PI 222987	Iran	7.0
PI 227208	Japan	7.0
PI 228344	Iran	7.0
PI 229808	Canada	7.0
PI 250147	West Pakistan	7.0
PI 264231	France	7.0
PI 264668	Germany	7.0
PI 326595	Hungary	7.0
PI 339244	Turkey	7.0
PI 344347	Turkey	7.0
PI 344437	Iran	7.0
PI 357840	Yugoslavia	7.0
PI 357844	Yugoslavia	7.0
PI 370450	Yugoslavia	7.0
PI 379281	Yugoslavia	7.0
PI 390953	USSR	7.0
Ashley	Clemson Univ.	7.0
Model	NSSL	7.0
Spacemaster	Cornell Univ.	7.0
PI 109063	Turkey	7.0
PI 137836	Iran	7.0
PI 164950	Turkey	7.0
PI 169315	Turkey	7.0
PI 174172	Turkey	7.0
PI 182192	Turkey	7.0
PI 220790	Afghanistan	7.0
PI 227664	Iran	7.0
PI 271754	Netherlands	7.0
PI 326594	Hungary	7.0
PI 344432	Iran	7.0
PI 357837	Yugoslavia	7.0
PI 357869	Yugoslavia	7.0
PI 419135	P.R. China	7.0
PI 422188	Czechoslovakia	7.0
PI 432853	P.R. China	7.0
Beit Alpha MR	Sunseeds	7.0
Palmetto	NSSL	7.0
PI 169395	Turkey	7.0
PI 172845	Turkey	7.0
PI 212599	Afghanistan	7.0
PI 271327	India	7.0
PI 288991	Hungary	7.0
PI 357860	Yugoslavia	7.0
PI 432894	P.R. China	7.0
PI 436672	P.R. China	7.0
Chicago Pickling	NSSL	7.0
PI 432890	P.R. China	7.0
PI 169352	Turkey	7.0
PI 109482	Turkey	7.3
PI 169353	Turkey	7.3
PI 296387	Iran	7.3
PI 351139	USSR	7.3
Cubit	NSSL	7.3
PI 169350	Turkey	7.3
PI 172842	Turkey	7.3
PI 172851	Turkey	7.3
PI 175681	Turkey	7.3
PI 178887	Turkey	7.3
PI 263085	P.R. China	7.3
PI 275410	Netherlands	7.3

among the 1208 cultigens tested in a seedling test for the pathogen (Wyszogrodzka et al., 1986), no cucumber cultigen was found to be resistant. Our results agree with those of Wyszogrodzka et al. (1986) for the cultivar Homegreen #2, which was resistant. However, PI 200818, which Van der Meer et al. (1978) and Wyszogrodzka et al. (1986) reported to be resistant, was susceptible in our study with a mean disease rating of 6.3. PI 200815 (Burma) was the most resistant of the 851 cultigens tested in our study. PI 339241, which was reported to be resistant in The Netherlands (Van Der Meer et al., 1978), was susceptible both in our test and in that of Wehner and St. Amand (1993).

Wehner and St. Amand (1993) evaluated a total of 83 cultigens (cultivars, breeding lines, and PI accessions) for resistance to a mixture of *D. bryoniae* isolates in the field for 4 years in North Carolina. The most resistant *C. sativus* cultigens in their study were PI 164433, 'Slice', PI 390264, M 17, and M 12. They found several highly resistant accessions of related *Cucumis* species, including PI 299568 (*C. myriocarpus* Naud.), PI 282450 (*C. zeyheri* Sond.), PI 299572 (*C. myriocarpus*), and PI 233646 (*C. anguria* L.). The most susceptible cultivars were 'Colet', 'Meresto', 'Supergreen', 'Dura', 'Pioneer', 'Marketmore 76', 'Pickmore', and 'Addis'. Only a few cultigens were common to both studies. The cultigens that were reported to be resistant or susceptible in the study by Wehner and St. Amand (1993) were moderately resistant (rating 3.0–6.0) in our study [('Slice' (3.5), PI 390264 (4.3), PI 164433 (5.0), 'Marketmore 76' (5.5), 'Addis' (4.5), 'Calypso' (4.0), and 'Dasher II' (3.5)]. Differences in rating between the studies possibly may be attributed to the use of a mixture of isolates in the study by Wehner and St. Amand (1993), whereas we used a highly pathogenic isolate. A second explanation could be isolate × environment interactions. Even though variability in virulence of the pathogen has been reported (Van Steekelenburg, 1982), *D. bryoniae* races have not been mentioned in the literature.

St. Amand and Wehner (1999a) reported that heritability estimates for gummy stem blight were low to moderate, ranging from 0.12 to 0.49 for leaf ratings and from –0.03 to 0.12 for stem ratings in two cucumber populations. Wyszogrodzka et al. (1986) reported that the realized heritability for foliar resistance in one cycle of mass selection within

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 296121	Egypt	7.3
PI 344444	Iran	7.3
PI 390954	USSR	7.3
PI 422177	Czechoslovakia	7.3
PI 422199	Czechoslovakia	7.3
Double Yield	NSSL	7.3
Longfellow	NSSL	7.3
PI 167358	Turkey	7.3
PI 169384	Turkey	7.3
PI 172838	Turkey	7.3
PI 175697	Turkey	7.3
PI 176517	Turkey	7.3
PI 183677	Turkey	7.3
PI 193497	Ethiopia	7.3
PI 206425	Turkey	7.3
PI 221440	Afghanistan	7.3
PI 224668	Korea	7.3
PI 296120	Egypt	7.3
PI 338235	Turkey	7.3
PI 338236	Turkey	7.3
PI 339245	Turkey	7.3
PI 344442	Iran	7.3
PI 357836	Yugoslavia	7.3
PI 357862	Yugoslavia	7.3
PI 368550	Yugoslavia	7.3
PI 368552	Yugoslavia	7.3
PI 368558	Yugoslavia	7.3
PI 368559	Yugoslavia	7.3
PI 422168	Czechoslovakia	7.3
PI 422189	Czechoslovakia	7.3
PI 422197	Czechoslovakia	7.3
Arlington White Spine	NSSL	7.3
Nappa 63	NSSL	7.3
SR551F	Cornell Univ.	7.3
PI 165499	India	7.3
PI 171607	Turkey	7.3
PI 174160	Turkey	7.3
PI 206043	Puerto Rico	7.3
PI 223437	Afghanistan	7.3
PI 344440	Iran	7.3
PI 355055	Iran	7.3
PI 379284	Yugoslavia	7.3
PI 385968	Kenya	7.3
PI 414157	U.S.–Ore.	7.3
PI 414158	U.S.–Hawaii	7.3
PI 422200	Czechoslovakia	7.3
PI 458854	USSR	7.3
Delicatesse	NSSL	7.3
Early Michigan	Burgess Seed	7.3
Klondike	NSSL	7.3
PI 169304	Turkey	7.3
Dharampur-I	Nepal	7.3

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 172849	Turkey	7.5
PI 182189	Turkey	7.5
PI 211962	Iran	7.5
PI 211985	Iran	7.5
PI 211986	Iran	7.5
PI 226510	Iran	7.5
PI 251028	Afghanistan	7.5
PI 274902	Great Britain	7.5
PI 288995	Hungary	7.5
PI 343452	USSR	7.5
PI 357864	Yugoslavia	7.5
PI 370448	Yugoslavia	7.5
Danish Mustard	U.S.–Wyo.	7.5
Sieger	U.S.–Wyo.	7.5
PI 167389	Turkey	7.5
PI 169382	Turkey	7.5
PI 169386	Turkey	7.5
PI 204569	Turkey	7.5
PI 209064	U.S.–Iowa	7.5
PI 233932	Canada	7.5
PI 263078	USSR	7.5
PI 264664	Germany	7.5
PI 267743	Hong Kong	7.5
PI 339250	Turkey	7.5
PI 344348	Turkey	7.5
PI 344350	Turkey	7.5
PI 344434	Iran	7.5
PI 357846	Yugoslavia	7.5
PI 137846	Iran	7.5
PI 169377	Turkey	7.5
PI 169391	Turkey	7.5
PI 169393	Turkey	7.5
PI 175683	Turkey	7.5
PI 176516	Turkey	7.5
PI 177361	Turkey	7.5
PI 206954	Turkey	7.5
PI 217946	Pakistan	7.5
PI 251519	Iran	7.5
PI 257286	Spain	7.5
PI 263047	USSR	7.5
PI 264665	Germany	7.5
PI 284699	Sweden	7.5
PI 285604	Poland	7.5
PI 285609	Poland	7.5
PI 292010	Israel	7.5
PI 292011	Israel	7.5
PI 292012	Israel	7.5
PI 343451	USSR	7.5
PI 344441	Iran	7.5
PI 355052	Israel	7.5
PI 356832	Netherlands	7.5
PI 356833	Great Britain	7.5

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 357833	Yugoslavia	7.5
PI 357851	Yugoslavia	7.5
PI 379280	Yugoslavia	7.5
PI 379285	Yugoslavia	7.5
PI 432848	P.R. China	7.5
Bush Champion	Burpee Seed	7.5
Challenger	Niagara	7.5
Crystal Apple	NSSL	7.5
Mincu	Minnesota AES	7.5
Wis. SMR 18 c	Wisconsin AES	7.5
Sunny South	NSSL	7.5
PI 118279	Brazil	7.5
PI 135122	New Zealand	7.5
PI 164951	Turkey	7.5
PI 169334	Turkey	7.5
PI 211589	Afghanistan	7.5
PI 357834	Yugoslavia	7.5
PI 357855	Yugoslavia	7.5
PI 369717	Poland	7.5
PI 391573	P.R. China	7.5
PI 432891	P.R. China	7.5
Early White Spine	NSSL	7.5
PI 220791	Afghanistan	7.5
PI 368554	Yugoslavia	7.5
Delcrow	NSSL	7.5
PI 167050	Turkey	7.8
PI 169402	Turkey	7.8
PI 169403	Turkey	7.8
PI 204568	Turkey	7.8
PI 211975	Iran	7.8
PI 264227	France	7.8
PI 344439	Iran	7.8
PI 357831	Yugoslavia	7.8
PI 175686	Turkey	7.8
PI 176520	Turkey	7.8
PI 176522	Turkey	7.8
PI 179263	Turkey	7.8
PI 181942	Syria	7.8
PI 206952	Turkey	7.8
PI 255934	Netherlands	7.8
PI 357863	Yugoslavia	7.8
PI 422192	Czechoslovakia	7.8
PI 458851	USSR	7.8
Burpee Pickler	Burpee Seed	7.8
PI 169397	Turkey	7.8
PI 175691	Turkey	7.8
PI 175693	Turkey	7.8
PI 176953	Turkey	7.8
PI 204690	Turkey	7.8
PI 275411	Netherlands	7.8
PI 285608	Poland	7.8
PI 293432	Lebanon	7.8
PI 344433	Iran	7.8
PI 344435	Iran	7.8
PI 370019	India	7.8
PI 400270	Japan	7.8
PI 422181	Czechoslovakia	7.8
PI 458846	USSR	7.8
PI 458849	USSR	7.8
Davis Perfect	NSSL	7.8
Monopol	Wageningen	7.8
Producer	NSSL	7.8
PI 137853	Iran	7.8
PI 222099	Afghanistan	7.8
Giant White Arnstadt	U.S.–Wyo.	7.8
PI 339248	Turkey	8.0
PI 105263	Turkey	8.0
PI 137839	Iran	8.0
PI 137847	Iran	8.0
PI 167052	Turkey	8.0
PI 169319	Turkey	8.0
PI 169394	Turkey	8.0
PI 172840	Turkey	8.0
PI 175696	Turkey	8.0
PI 283899	Czechoslovakia	8.0
PI 285603	Poland	8.0

Table 1. Continued.

Cultigen name	Seed source	GSB rating
PI 293923	Israel	8.0
PI 357857	Yugoslavia	8.0
PI 137835	Iran	8.0
PI 169392	Turkey	8.0
PI 171603	Turkey	8.0
PI 172846	Turkey	8.0
PI 174166	Turkey	8.0
PI 174167	Turkey	8.0
PI 174170	Turkey	8.0
PI 181874	Syria	8.0
PI 181940	Syria	8.0
PI 227235	Iran	8.0
PI 255936	Netherlands	8.0
PI 263048	USSR	8.0
PI 288992	Hungary	8.0
PI 344067	Turkey	8.0
PI 357841	Yugoslavia	8.0
PI 357866	Yugoslavia	8.0
PI 370643	USSR	8.0
PI 379278	Yugoslavia	8.0
PI 432849	P.R. China	8.0
PI 458850	USSR	8.0
PI 458852	USSR	8.0
PI 175689	Turkey	8.0
PI 171600	Turkey	8.0
PI 171613	Turkey	8.0
PI 174164	Turkey	8.0
PI 174173	Turkey	8.0
PI 227013	Iran	8.0
PI 246930	Afghanistan	8.0
PI 392292	USSR	8.0
Coolgreen	Asgrow Seed	8.0
Packer	Associated	8.0
PI 220169	Afghanistan	8.0
PI 181910	Syria	8.3
PI 182188	Turkey	8.3
Favor II	NSSL	8.3
PI 319216	Egypt	8.3
PI 344438	Iran	8.3
PI 357867	Yugoslavia	8.3
PI 368551	Yugoslavia	8.3
PI 137856	Iran	8.5
PI 169385	Turkey	8.5
PI 169390	Turkey	8.5
PI 171601	Turkey	8.5
PI 172848	Turkey	8.5
PI 172852	Turkey	8.5
PI 174177	Turkey	8.5
PI 175690	Turkey	8.5
PI 176523	Turkey	8.5
PI 176954	Turkey	8.5
PI 204567	Turkey	8.5
PI 222986	Iran	8.5
PI 226461	Iran	8.5
PI 226509	Iran	8.5
PI 248778	Iran	8.5
PI 255937	Netherlands	8.5
PI 288238	Egypt	8.5
PI 357843	Yugoslavia	8.5
PI 357865	Yugoslavia	8.5
PI 167134	Turkey	8.5
Mean (all cultigens)		6.2
LSD (5%)		2.1
CV (%)		17
Range (High–Low)		6.5
Range/LSD		3.1

[z]Some countries listed as the origin of some accessions (e.g., Czechoslovakia, USSR, Yugoslavia) no longer exist as political units. Ratings were assessed visually 1 and 2 weeks after inoculation and were based on the percentage leaf area affected using a 0 to 9 scale (0 = no disease, 1 to 2 = a trace of infection, 3 to 4 = few small lesions, 5 to 6 = 20% to 50% of leaves covered with small lesions, 7 to 8 = plant wilted and covered with 50% or more with lesions, 9 = plant killed). Values are means of two replications.

'Homegreen #2' was 0.14 to 0.35. Estimates of gain from selection were twice as large for selection based on half-sib families as for mass selection for all traits in both populations. A moderate amount of additive genetic variation was observed for gummy stem blight resistance on the leaves, but little or none on the stems. The phenotypic correlation between leaf and stem ratings was low, while the genetic correlation between leaf and stem ratings was either negative or could not be measured (St. Amand and Wehner, 1999a).

Estimated genetic gain for leaf and stem resistance to gummy stem blight in five crosses of resistant × susceptible cucumber inbreds ranged from low to moderate (St. Amand and Wehner, 1999a). Breeding methods that make best use of additive variance were suggested, because most of the variance for resistance was additive, and dominance effects contributed mostly to susceptibility (St. Amand and Wehner, 1999b).

The most resistant cultigens identified in this study should be retested to determine whether plants with higher resistance can be selected from within each cultigen. If different genes control the trait in different cultigens, plant breeders may be able to improve resistance to gummy stem blight by combining genes from the most resistant plants in the most resistant cultigens. Use of different sources of resistance may also improve the performance of cultivars in different production areas of the world. The inheritance of resistance should be studied in the resulting inbred lines. Finally, linkage relationships with important marker genes should be measured to facilitate incorporation of gummy stem blight resistance into elite cultivars.

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