Biological and Cultural Tests for Control of Plant Diseases: An Overview of 1991 Reports

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Like earlier volumes, the recently published volume 6 of *Biological and Cultural Tests for Control of Plant Diseases* reports the results of numerous tests to control plant diseases by nonchemical means. The new volume contains 109 separate reports: 32 on vegetables, 21 on peanuts and soybeans, 10 on small grains, 9 on corn and sorghum, 12 on other field crops (dry bean, cotton, sugarcane, tall fescue), 14 on turfgrasses, 6 on ornamentals (ornamental cabbage and kale, carnation, crabapple, rhododendron, zinnia), and 5 on deciduous fruits and nuts. Disease control through use of plant resistance, biological agents, cultural practices, or combinations of these methods is reported. The volume also contains a special report by G. E. Harman on the requirements for successful control of soilborne plant pathogens with biological agents and on the technological problems that have slowed commercial application.

Plant resistance. Seventy-five reports included some evaluation of host resistance to control plant disease. Most of these studies (>93%) indicated significant disease control with use of certain cultivars, plant hybrids, inbred lines, plant introductions, or other selections. Reductions in the level of disease were reported for 72 host-pathogen combinations (Table 1). Although host resistance was the sole control procedure evaluated in most of these reports, host resistance also was evaluated in combination with planting date (pp. 29 and 70), row spacing (p. 65), pesticide use (pp. 32, 65, and 77), spray schedules (pp. 10, 23, and 37), soil amendments of calcium silicate slag (pp. 86 and 88), and biological agents (p. 57).

Plant resistance for disease control was evaluated in five additional tests. Sixty-six dry bean cultivars, including Great Northern, pinto, navy, black, small white, and kidney types, were evaluated for reactions to common blight (p. 78) and to rust (p. 81). Significant differences in the yields of several processing tomato cultivars were also reported; however, the foliar disease ratings did not differ significantly (p. 34). Ten of 48 crabapple cultivars remained free of apple scab, rust, fire blight, and powdery mildew during a 6-year evaluation period and showed promise as disease-resistant selections for the southeastern states (p. 106). Although there were no significant differences in the disease ratings of 18 creeping bentgrass cultivars evaluated for Pythium root rot resistance, variation in the rate of disease development indicated that some plant resistance may exist (p. 92).

Biological agents. Evaluation of biological agents for control of plant diseases was included in 17 reports (Table 2). Most of these reports also included one or more standard fungicide treatments for comparison. Compared with controls, biological agents suppressed disease or increased yield, or both, in nearly 65% of the studies. A variety of biological agents were evaluated, with five bacterial genera and four fungal genera represented. In addition to identified agents, over two dozen numbered biological agents (organism unspecified) were studied. Several of these agents had significant disease-suppressive or yield-enhancing capabilities, and registrations are being pursued for commercial production. The effects of biological agents on disease severity were also evaluated in combination with solarization (p. 49) and planting date (p. 80). Of particular interest to researchers may be the potential interaction between biological agents and commercial seed protectant dye (p. 85).

Cultural practices. Fifteen reports focused on evaluation of cultural practices for disease control. Five of these reports (pp. 90, 91, 93, 101, and 105) dealt with the effects of nitrogen source, organic fertilizers, composts, or other soil amendments on disease development: four on turfgrass diseases (brown patch, dollar spot, and red thread) and one on Fusarium wilt of carnation. Several commercial composts were as effective as a high rate of the fungicide standard in suppressing diseases of turfgrass.

In other reports, shading inoculated soil with straw significantly increased the incidence of take-all of wheat and led to lower yields than when soil was left unshaded (p. 76). Symptoms of bacterial canker developed somewhat faster in pruned than in nonpruned tomato plants inoculated with *Clavibacter michiganensis* subsp. *michiganensis* (p. 33). When applied for control of root-knot nematode, a "biological nematicide" composed of a crustacean chitin-protein complex plus fertilizer and organic buffers increased the marketable head weight of lettuce over that of a fertilizer check without significantly affecting the number of galls on roots (p. 13). Inoculating whole or cut seed potatoes with *Rhizoctonia solani* increased the incidence of premature senescence; plants from whole seed potatoes had lower plant vigor scores than those from cut seed potatoes (p. 24). A 3-year rotation to Sudan grass reduced soil populations of *Verticillium dahliae* and the incidence of Verticillium wilt on potato while leading to higher total yields than cover crops of pea or rape or a fallow control (p. 26). Rape, however, was more effective than Sudan grass for reducing the incidence of *Rhizoctonia*. A 1-year rotation to other vegetable crops, on the other hand, provided insufficient control of Alternaria blight of carrot (p. 8). There were significant interactions between soil fumigation and soil solarization treatments on soil populations of *Pythium* spp. and *Fusarium* spp. (p. 9) and between nitrogen level and cutting height on the severity of brown patch of tall fescue (p. 97). Regular use of fungicide sprays provided better control of early blight and Septoria leaf spot on tomato than did crop rotation (p. 36). Most other cultural practices were also less effective than pesticide sprays in reducing defoliation of tomato caused by early blight (p. 35).

Laboratory studies. A leaf leachate study indicated that soybean resistance to frogeye leaf spot was not due to the presence of inhibitory substances (p. 59). In a related study, the sensitivity of several fungal pathogens of soybean to cercosporin indicated *Cercospora* spp. may have a competitive advantage in colonizing soybean seed (p. 60).

Comment. Public concern for food safety has prompted a call for reduced use of pesticides in food production and plant management practices. Additional research on the use of plant resistance, biological agents, and cultural practices

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to control plant diseases and of integrated pest management systems that combine methodologies is needed to achieve this goal. Like earlier volumes of *Biological and Cultural Tests for Control of Plant Diseases*, volume 6 provides many excellent examples of research addressing this need.

Editor's note: We solicit readers' opinions on the value of publishing overviews of future volumes of *Biological and Cultural Tests for Control of Plant Diseases*. Opinions may be sent to the editor-in-chief.

Table 1. Reports of significant disease control with plant resistance[a]

Host	Disease	Pathogen	Page(s)
Apple	Alternaria leaf blotch	*Alternaria mali*	1
	Powdery mildew	*Podosphaera leucotricha*	3
Bean, dry	White mold	*Sclerotinia sclerotiorum*	82,83
Bean, snap	Gray mold	*Botrytis cinerea*	6
Cabbage	Black rot	*Xanthomonas campestris* pv. *campestris*	7
Cabbage, ornamental	Black rot	*Xanthomonas campestris*	104
Celery	Bacterial blight	*Pseudomonas cichorii*	10
	Early blight	*Cercospora apii*	10
Corn, field	Gray leaf spot	*Cercospora zeae-maydis*	39–41
	Maize dwarf mosaic	Maize dwarf mosaic virus	42
	Stalk and ear rots	*Fusarium moniliforme*	44
		Botryodiplodia theobromae	44
		Macrophomina phaseolina	44
Corn, sweet	Bacterial wilt	*Erwinia stewartii*	38
	Rust	*Puccinia sorghi*	38
	Southern corn leaf blight	*Bipolaris maydis*	43
Crabapple	Apple scab	*Venturia inaequalis*	107
	Frogeye leaf spot	*Botryosphaeria obtusa*	107
Cucumber	Downy mildew	*Pseudoperonospora cubensis*	11
	Powdery mildew	*Sphaerotheca fuliginea*	11
Kale	Black rot	*Xanthomonas campestris*	104
Kentucky bluegrass	Dollar spot	*Sclerotinia homoeocarpa*	94
	Leaf spot	*Drechslera poae*	95
	Necrotic ring spot	*Leptosphaeria korrae*	96
Lettuce	Downy mildew	*Bremia lactucae*	12
Muskmelon	Downy mildew	*Pseudoperonospora cubensis*	14
	Fusarium wilt	*Fusarium oxysporum* f. sp. *melonis*	15
Oats	Barley yellow dwarf	Barley yellow dwarf virus	68
Peanut	Rhizoctonia limb rot	*Rhizoctonia solani*	54
	Sclerotinia blight	*Sclerotinia minor*	47
	Southern blight	*Sclerotium rolfsii*	51
	Spotted wilt	Tomato spotted wilt virus	52
	White mold	*Sclerotium rolfsii*	54
Pepper	Blight	*Phytophthora capsici*	16
Perennial ryegrass	Dollar spot	*Sclerotinia homoeocarpa*	98
	Red thread	*Laetisaria fuciformis*	100,102
Potato	Bacterial soft rot	*Erwinia* spp.	25
	Common scab	*Streptomyces scabies*	25
	Early blight	*Alternaria solani*	17–20,23,25
	Late blight	*Phytophthora infestans*	21–23
	Verticillium wilt	*Verticillium dahliae*	25
Pumpkin	Downy mildew	*Pseudoperonospora cubensis*	28
	Powdery mildew	*Sphaerotheca fuliginea*	28
	Scab	*Cladosporium cucumerinum*	28
	Watermelon mosaic	Watermelon mosaic virus, strain II	28
Raspberry	Anthracnose	*Elsinoë veneta*	4
	Gray mold	*Botrytis cinerea*	4,5
Rhododendron	Botryosphaeria dieback	*Botryosphaeria dothidea*	108
Rice	Leaf blast	*Pyricularia oryzae*	69
	Sheath blight	*Rhizoctonia solani*	69
Sorghum, grain	Head smut	*Sporisorium reilianum*	45
	Maize dwarf mosaic	Maize dwarf mosaic virus	46
Soybean	Brown stem rot	*Phialophora gregata*	56
	Iron deficiency chlorosis	(Alkali soil)	56
	Northern root-knot nematode	*Meloidogyne hapla*	66
	Pyrenochaeta leaf blotch	*Pyrenochaeta glycines*	61
	Sclerotinia stem rot	*Sclerotinia sclerotiorum*	63
	Soybean cyst nematode	*Heterodera glycines*	56,64,66,67
St. Augustinegrass	Gray leaf spot	*Pyricularia grisea*	103
Sugarcane	Ringspot	*Leptosphaeria sacchari*	86,87
	Sugarcane rust	*Puccinia melanocephala*	88
Sweetpotato	Soil rot (pox)	*Streptomyces ipomoea*	29
	Southern root knot	*Meloidogyne incognita*	30
	Stem rot (Fusarium wilt)	*Fusarium oxysporum* f. sp. *batatas*	31
Tall fescue	Leaf spot and blight	*Drechslera dictyoides*	89
Tomato	Anthracnose	*Colletotrichum coccodes*	32,37
	Early blight	*Alternaria solani*	37
	Septoria leaf spot	*Septoria lycopersici*	37
Triticale	Scab	*Fusarium graminearum*	75
	Take-all	*Gaeumannomyces graminis*	77
Wheat	Leaf rust	*Puccinia recondita* f. sp. *tritici*	71–73
	Powdery mildew	*Erysiphe graminis* f. sp. *tritici*	73
	Scab	*Fusarium graminearum*	74,75
	Septoria leaf and glume blotch	*Septoria tritici* and *S. nodorum*	73
	Barley yellow dwarf	Barley yellow dwarf virus	70

[a]Includes cultivars, commercial hybrids, breeding lines, and other selections.

Table 2. Reports on use of bacteria and fungi as biological control agents

Agent/disease	Pathogen	Host	Page(s)
BACTERIA			
Bacillus spp.			
Seedling diseases and damping-off	*Rhizoctonia solani* and *Pythium* spp.	Cotton	85
		Peanut	50
		Soybean	57*,62*[a]
White mold	*Sclerotinia sclerotiorum*	Bean, dry	84
Enterobacter aerogenes			
Crown and root rot	*Phytophthora cactorum*	Apple	2*
Erwinia herbicola			
White mold	*Sclerotinia sclerotiorum*	Bean, dry	84*
Pseudomonas spp.			
Damping-off, root rot, and seedling diseases	*Rhizoctonia solani*, *Fusarium* spp., and *Pythium* spp.	Bean, dry	79
		Cotton	85
		Peanut	50
		Soybean	57,58
Streptomyces spp.			
Seedling diseases	*Rhizoctonia solani* and *Pythium* spp.	Peanut	50
FUNGI			
Gliocladium spp.			
Rhizoctonia stem and root rot	*Rhizoctonia solani*	Zinnia	109*
Sclerotinia blight	*Sclerotinia minor*	Peanut	49
Seedling diseases	*Rhizoctonia solani* and *Pythium* spp.	Cotton	85
		Peanut	50
Verticillium wilt	*Verticillium dahliae*	Potato	27
Binucleate *Rhizoctonia* spp.			
Seedling diseases	*Rhizoctonia solani* and *Pythium* spp.	Peanut	50
		Cotton	85
Sporidesmium sp.			
Sclerotinia blight	*Sclerotinia minor*	Peanut	48*
Trichoderma spp.			
Sclerotinia blight	*Sclerotinia minor*	Peanut	48,49
Seedling diseases	*Rhizoctonia solani*, *Fusarium* spp., and *Pythium* spp.	Bean, dry	80*
		Cotton	85
		Peanut	50
		Soybean	58
NUMBERED BIOLOGICAL AGENTS			
Brown patch	*Rhizoctonia solani*	Bentgrass	91*
Dollar spot	*Sclerotinia homoeocarpa*	Bentgrass	91
Pythium blight	*Pythium aphanidermatum*	Ryegrass	99*
Rhizoctonia limb rot	*Rhizoctonia solani*	Peanut	53*,55*
Sclerotinia blight	*Sclerotinia minor*	Peanut	48*
White mold	*Sclerotium rolfsii*	Peanut	53*,55*

[a] Asterisk indicates significant disease suppression and/or yield increase with biological agent.