Control of Foliar Diseases with Epidermal Coating Materials

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ABSTRACT

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Several waxes and plastic polymers were evaluated as protectants from foliar pathogens on maize (*Zea mays*), sorghum (*Sorghum bicolor*), and wheat (*Triticum aestivum*). These products reduced anthracnose, leaf blight, rust, downy mildew, and powdery mildew in varying amounts. The potential of these products for disease control is reviewed and discussed.

Many foliar diseases are currently managed with sequential applications of fungicidal sprays. Some of these fungicides, however, cause such nontarget effects as enhancement of other diseases and increased mite populations. In addition, intensive use of some fungicides has resulted in the development of fungicide-resistant strains of targeted pathogens (18). It may be possible to use foliar sprays of polymers to establish a physical and/or chemical barrier to penetration by pathogenic fungi because most foliar diseases reach epidemic levels after the leaf area is fully developed. Waxes, silicones, and other plastic polymers have been used as antitranspirants and to delay desiccation of agricultural products. If these substances were effective, they might give growers an economical alternative to protectant fungicides and reduce the amount of fungicide required for effective disease management.

There is little information on the effects of foliar sprays of waxes, silicones, latexes, polyterpenes, high-molecular-weight alcohols, and various other products on control of foliar pathogens of crop plants. In addition, there may be some possible synergistic effects of these compounds both as antitranspirants and disease control agents.

Physical barriers are important plant disease defense mechanisms (4,6,11). For example, the cuticle may prevent penetration by some fungal pathogens either on the basis of physical properties or by the production of inhibitory substances. In addition, Dickinson (11) suggested that the waxy surface may present the first barrier simply by repelling the film of free water required for germination by many fungal pathogens.

Various workers (12,19,21–23) have reported a relationship between cuticle thickness and penetration. Nutman and Roberts (23) observed that varietal susceptibility of coffee (*Coffea arabica* L.) to *Colletotrichum coffeanum* Noack sensu Hindort was related to cuticular differences. Louis and Day (19) determined that penetration of bean (*Phaseolus vulgaris* L.), tomato (*Lycopersicon esculentum* Mill.), and other host plants by *Botrytis cinerea* Pers. ex Fr. was related to cuticle thickness. Plants were not susceptible when the cutin in the cuticle reached about 0.1 mg/cm^2 of the surface.

According to Davis and Smoot (6), water repellency of the plant surface influenced deposition of inoculum. Wetting of plants was influenced not only by the amount and physical configuration of the surface wax but also by its chemical composition.

In addition to its role as a physical barrier, the cuticle may contain substances that inhibit growth of fungi. The occurrence of either naturally occurring fungal inhibitors in plant tissues or inhibitory compounds formed as a response to invasion is well documented (11–13,15–17,19,20).

The "antitranspirants" may contribute to increased efficiency of water utilization by crop plants. There are three types of antitranspirants: 1) compounds with stomatal regulating properties, 2) reflective materials that reduce transpiration by reflection of solar radiation from plant parts, and 3) film-forming compounds. Film-forming waxes, latex compounds, various plastics, silicones, polyterpenes, and high-molecular-weight alcohols have been used as antitranspirants. The longevity of the effectiveness of these film-forming compounds ranges from a few days to a few weeks, depending on the nature of the compound, the plant-growth rate, and environmental conditions. Phytotoxicity associated with the antitranspirants is usually caused by the carrier, eg, the emulsifier.

In these experiments, polymers and

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waxes were evaluated for leaf blight and downy mildew of sorghum (*Sorghum bicolor* (L.) Moench), southern rust and downy mildew of maize (*Zea mays* L.), and powdery mildew and leaf rust of wheat (*Triticum aestivum* L.).

MATERIALS AND METHODS

Sorghum diseases. Sorghum cultivar Tx7078 seeds were planted in 12-cm plastic pots. Ten seeds per pot and four pots served as a replicate of each treatment. In all experiments, conditions in the growth chamber were: 1) continuous fluorescent "Vita Light" (Durra-test Corporation, North Bergen, NY) 40 cm above the seedlings, and 2) temperature of 21 C and relative humidity (RH) 70. In all cases, inoculation was at the two-leaf stage of growth.

The *Peronosclerospora sorghi* (Weston & Uppal) C. G. Shaw downy mildew inoculation device consisted of an inoculation chamber as described by Craig (5). The inoculated sorghum seedlings were grown for 8 days until chlorotic leaf areas were apparent. For anthracnose, an isolate of *Colletotrichum graminicola* (Ces.) G. W. Wils. was obtained from diseased sorghum leaves collected in the field. The isolation, sporulation, and infection systems followed Pastor-Corrales' (24) techniques and conditions. In studies with leaf blight, an isolate of *Exserohilum turcicum* Leon. & Sug. was obtained from diseased sorghum leaves, and culture growth conditions, sporulation, and infection techniques followed Tuleen's (25) description.

Maize diseases. Ten maize cultivar SA 0254 seeds were planted in 24-cm plastic pots (with four replicates for each treatment and disease). The maize seedlings were grown in growth chambers under the same conditions as the sorghum seedlings and were inoculated at the two- to three-leaf stage of growth.

Inoculation techniques for downy mildew and their conditions were based on Craig's (5) technique. For *Puccinia polysora* Underw. southern corn rust inoculation, the maize seedlings were placed under diseased maize plants (48 hr) and transferred to a humidity chamber (RH 95) for 48 hr. The percent rust area of the leaves was assessed 2 wk after inoculation.

Wheat diseases. Ten wheat cultivar TAM-101 seeds were planted in 12-cm plastic pots with four replicates. At the two-leaf stage of growth, the wheat seedlings were placed in wheat fields. Half of the seedlings were placed in a field with an epidemic of powdery mildew (*Erysiphe graminis* DC.) and the other half in a field with leaf rust (*Puccinia recondita* Rob. ex Desm.). The wheat seedlings were returned to the growth chamber after 24 hr. Disease severity was measured 8 days later.

Polymer treatments. The polymers used in these experiments were generally of two different groups: 1) commercial antitranspirants—Vapor Gard (Miller Chemical & Fertilizer Co., Hanover, PA), Wilt Pruf (Nursery Specialty Products), and Folicote (Crystal Soap & Chemical Co. Inc., Lansdale, PA); and 2) industrial use (floors, etc.) and storage fruit systems—Wax Plat-14 (S. C. Johnson & Son, Inc., Racine, WI), Sta Fresh 960, 460, 350, and Polyethylenemultion (FMC Co., Lakeland, FL), Super Gard (Purex Co. Ltd., Carson, CA), Rhoplex AC-33 (Rohm and Haas Co., West Philadelphia, PA), Brogdex-505C (Brogdex Co., Pomona, CA), and HA 863 (Hopkins Agricultural Chemical Co., Madison, WI).

The surfactants and spreaders used were polyethylene and octyl phenoxy polyethoxy ethanol (PLYAC, Hopkins Agricultural Chemical Co.) and pinolene (NU-FILM-17, Miller Chemical & Fertilizer Co.).

For all crop diseases, polymers were sprayed on seedling leaves with a 450-ml hand sprayer to full leaf coverage. The polymers were mixed with distilled water (1:10, v/v) and with two drops of surfactant. The treatment was made 2 hr before inoculation with each pathogen.

RESULTS

In each trial, some of the polymers controlled the foliar diseases (Tables 1–3). Foliar disease control with the polymers was variable; some were effective in controlling one disease and not effective for others (Tables 1–3). Rhoplex AC-33 gave excellent control of sorghum anthracnose (Table 1). Wilt Pruf controlled leaf blight, and Sta Fresh 460 strikingly reduced the level of downy

Table 1. The effect of polymers on disease severity of foliar diseases on Tx7078 sorghum seedlings

	Disease severity[v]			
Polymer	**Anthracnose**[w] **(%)**	**Leaf blight**[w] **(%)**	**Sorghum downy mildew**[w] **(%)**	**Phytotoxicity**[x]
Untreated control	28.7 a[y]	6.7 a[y]	34.4 a[y]	−
Wilt Pruf	30.9 a	1.2 c	n[z]	−
Wax Plat-14	30.2 a	7.1 a	n	+
Sta Fresh 960	21.3 ab	3.6 b	9.1 bc	+
Polyethylenemultion	12.4 b	n	8.8 c	+
Sta Fresh 460	11.2 bc	3.5 b	2.2 d	−
Super Gard	10.2 bc	6.5 a	n	−
Folicote	5.3 cd	2.4 bc	11.5 b	−
Rhoplex AC-33	2.1 d	2.2 bc	n	−
Brogdex-505E	n	n	11.8 b	+
Sta Fresh 350	n	n	10.4 bc	−

[v] Based on the percent leaf area damage for anthracnose, leaf blight, and number of local lesions per leaf for sorghum downy mildew.

[w] The pathogens were *Colletotrichum graminicola, Exserohilum turcicum*, and *Peronosclerospora sorghi*, respectively.

[x] + Denotes phytotoxicity.

[y] Values followed by the same letter do not differ significantly at $P = 0.05$ according to Duncan's multiple range test.

[z] Not tested.

Table 2. The effect of polymers on disease severity of foliar diseases on 65A 0254 maize seedlings

	Disease severity[v]		
Polymers	**Sorghum downy mildew**[w] **(%)**	**Southern rust**[w] **(%)**	**Phytotoxicity**[x]
Untreated control	21.6 a[y]	25.4 a[y]	−
Wilt Pruf	12.5 ab	0.4 d	−
Wax Plat-14	10.4 bc	n[z]	+
Folicote	6.6 cd	5.6 c	−
Sta Fresh 460	6.2 cd	12.2 bc	−
Sta Fresh 960	5.4 cd	n	+
Polyethylenemultion	5.0 cd	n	+
Brogdex 505E	4.1 cde	n	+
Super Gard	0.5 e	21.0 ab	−
Vapor Gard	n	6.2 c	−
HA-863	n	0.2 d	−
Rhoplex AC-33	n	0.3 c	−

[v] Based on percent leaf area damage for anthracnose, leaf blight, and number of local lesions per leaf for sorghum downy mildew.

[w] The pathogens were *Peronosclerospora sorghi* and *Puccinia polysora*, respectively.

[x] + Denotes phytotoxicity.

[y] Values followed by the same letter do not differ significantly at $P = 0.05$ according to Duncan's multiple range test.

[z] Not tested.

Table 3. The effect of polymers on disease severity of foliar diseases on TAM-101 wheat seedlings

	Disease severity[u]	
Polymers	**Powdery mildew[v] (%)**	**Leaf rust[v] (%)**
Untreated control	73.1 a[w]	82.1 a[w]
Water[x]	55.1 b	n
Water[y]	n[z]	80.3 a
Wilt Pruf[x]	1.7 c	26.2 bc
Rhoplex AC-33[x]	58.5 b	n
Super Gard[x]	25.3 bc	n
Sta Fresh 460[x]	5.7 c	n
Benomyl[x]	1.0 c	3.1 d
Wilt Pruf[y]	n	29.0 bc
Sta Fresh 460[y]	n	12.4 c
Vapor Gard[y]	n	14.3 c

[u] Based on the percent leaf area damage for anthracnose, leaf blight, and number of local lesions per leaf for sorghum downy mildew.

[v] The pathogens were *Erysiphe graminis* f. sp. *tritici* and *Puccinia recondita* and *P. tritici*, respectively.

[w] Values followed by the same letter do not differ significantly at $P = 0.05$ according to Duncan's multiple range test.

[x] Surfactant = PLYAC, common name, polyethylene and octyl phenoxy polyethoxy ethanol.

[y] Surfactant = NU-FILM-17, common name, pinolene.

[z] Not tested.

mildew of sorghum. At the same time, Wilt Pruf was ineffective in controlling anthracnose (Table 1). Similar levels of control were obtained with these polymers for control of foliar downy mildew and southern rust of maize (Table 2). Super Gard gave excellent control of sorghum downy mildew of maize but failed to control southern rust of maize. Wilt Pruf was highly effective in reducing the severity of rust but failed to control downy mildew of maize. Some polymers were phytotoxic to the seedlings (Tables 1 and 2), but others (Wilt Pruf, Super Gard, Folicote, Rhoplex AC-33, and Vapor Gard) have controlled most foliar diseases without phytotoxic effects (Tables 1–3). The effects of the surfactants were not significantly different from untreated control.

DISCUSSION

Little is known about commercial use of epidermal coating materials as foliage disease control agents, although these products have been used to reduce transpiration (1,10). Use of epidermal coatings for foliage disease control should enhance the natural interruption of fungal pathogen development by the waxy layer on leaf surfaces. Mechanisms for interrupting pathogen development on host leaves are related to: 1) thickness of the natural waxy layer (3,12,13), 2) repelling of the film of free water on the leaf surface (7,14,22), 3) chemical substances in the cuticle (2,6,20), and 4) disorientation of pathogen germ tubes by changes in surface structures (4,15,26).

The significant differences in foliage disease development among polymer-treated seedlings (Tables 1–3), compared with untreated controls, provides confidence for continuing research on the polymers as disease control agents. Because of rising costs and the development of fungicide-tolerant strains to some fungal pathogens, it is evident that improved integrated strategies of foliar disease management are imperative (8,9). In addition, the ultimate fate of the compound in the agroecosystem must be evaluated in order to test whether there is a low probability of deleterious environmental effects. The potential for these products seems high because: 1) some of the polymers (antitranspirants) are biodegradable; 2) previous work indicates that they are stable over a range of temperatures, humidity, and radiation; 3) antitranspirants are commercially available; 4) the agrotechnical aspects (spray system, surface coverage, sprayers, droplet size, etc.) are available for field trials; and 5) delivery systems are available.

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