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Efficacy of Foliar Applications of Particle Films and Genotype for Managing Thrips, Diseases, and Aflatoxin in Peanut

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Abstract

The kaolin-based particle film Surround has been shown to suppress various insect pests and foliar diseases while reducing canopy temperature and improving water use efficiency in certain agricultural production systems. The usefulness of Surround was examined against important production constraints in peanut, including tomato spotted wilt, leaf spots, and aflatoxin contamination. Field experiments were conducted during 2001 using multi-varietal trials with or without spray treatment of Surround (75 lbs/acre) + NuFilm-17 (8 oz/acre). The effects of Surround application were evaluated for control of thrips and tomato spotted wilt on genotypes Georgia Green, C11-2-39, C34-24, and Sunoleic 97R; for control of leaf spots on AgraTech 201, GK 7 High Oleic, and C-99R; and for control of aflatoxin contamination on *Aspergillus*-inoculated plots of genotypes Georgia Green, AgraTech 201, and GK 7 High Oleic. In these experiments, Surround applications had little or no effect on thrips populations, tomato spotted wilt severity and incidence, leaf spot severity, drought stress, aflatoxin contamination, chlorophyll content, specific leaf area, and pod yield. In all experiments, host genotype effects were more effective in reducing disease and increasing yield than was Surround protection. Although foliar applications of particle films may be useful for producing certain vegetables and fruits, its benefits for addressing peanut production constraints are limited.

Introduction

Surround WP (Engelhard Corp., Iselin, NJ) is a kaolin-based crop-protectant that has recently become available for use on fruits and vegetables. Application of Surround on plants creates a particle film that acts as a physical barrier that has been demonstrated to suppress some pests and diseases (5,6,11,12). The reflectivity of particle films can reduce temperatures of fruit tree foliage and fruit and can result in improved leaf carbon assimilation (3,4). Because plant stress is reduced, photosynthesis and transpiration can be improved during heat and drought conditions, without an apparent effect on plant productivity (5).

The characteristics and benefits of particle films suggest a potential for reducing both biotic and abiotic stresses commonly encountered in peanut production. In the southeastern U.S. peanut production regions, these stressors include the thrips (primarily *Frankliniella fusca*) (15) vector of *Tomato spotted wilt virus* (TSWV), which causes tomato spotted wilt; leaf spots (early leaf spot, caused by *Cercospora arachidicola* S. Hori, and late leaf spot, caused by *Cercosporidium personatum* (Berk. & M. A. Curtis) Deighton that require fungicide sprays to control disease and limit yield losses in susceptible cultivars; and drought stress that can predispose dryland-produced peanut to aflatoxin contamination (7). A compound with potential for multiple benefits would be of value to peanut producers.

The objective of these experiments was to assess the potential benefits of Surround applications in peanut production. The effects of Surround particle film was evaluated for its potential to (a) interfere with thrips feeding and population number to reduce the severity and incidence of TSWV, (b) reduce leaf spot development, and (c) alleviate drought stress to reduce aflatoxin contamination in peanut.

Assessing Potential for Managing Thrips & Tomato Spotted Wilt

The effects of Surround applications on thrips and tomato spotted wilt were evaluated in genotypes Georgia Green (resistant commercial standard), C11-2-39, C34-24 (experimental genotypes), and Sunoleic 97R (susceptible commercial standard). Tests were planted on 14 May (Test 1) and 6 June 2001 (Test 2). In each test, two-row plots (15 ft long) were arranged in a split-plot design with four replications, with spray treatments as main plots and genotypes as sub-plots.

Fig. 1. Peanut plots with and without application of kaolin-based particle film.

In these and all subsequent experiments, spray treatments were applied to the foliage (Fig. 1) using a hand-held CO_2-powered sprayer at 35 psi. Applications were made to simulate coverage that would be expected from standard production spray equipment. Surround WP was applied at the rate of 75 lbs/acre plus NuFilm-17 (Miller Chemical Co., Biglerville, PA) at the rate of 8 oz/acre to improve adhesion and distribution of Surround on peanut foliage. Application dates for Test 1 were 25 and 30 May, 7, 13, 21 June, and 2 July 2001. Application dates for Test 2 were 21 June and 2, 13, and 20 July 2001. Application intervals varied depending on the degree of coverage as affected by plant growth and rain intensity.

To examine the concomitant effects of Surround spray on leaf physiology, relative chlorophyll content of leaves and specific leaf area were determined in Test 1. Relative chlorophyll content was measured with a Minolta SPAD chlorophyll meter (Minolta Corp., Ramsey, NJ). The SPAD chlorophyll meter measures absorbance by plant tissues of wavelengths in the visible spectrum, which is determined by the relative internal concentration of chlorophyll a and b (Minolta Corp., Ramsey, NJ). SPAD values are unit-less and indicate the relative amount of chlorophyll in a plant leaf (Minolta Corp., Ramsey, NJ). On 10 August 2001, six randomly selected plants in each plot in Test 1 were sampled for SPAD chlorophyll content and specific leaf area. One SPAD chlorophyll measurement was taken per leaflet (four total per plant, avoiding the midrib) then averaged to correct for possible non-homogeneous distribution of chlorophyll throughout the leaf (9). Leaves measured by the SPAD meter were collected and immediately placed on ice for transport to the laboratory and then stored at 39° F until further processing.

In the laboratory, leaf area was determined after hydrating leaves in distilled water for at least 3 h in order to insure all leaves were standardized to full turgor prior to leaf area measurement (10). Leaf area was measured using a LI-COR LI-3000A leaf area meter (LI-COR Inc., Lincoln, NE). Leaves were then oven-dried at 60°C for 72 h prior to weighing. Specific leaf area was calculated as the ratio of leaf area to leaf dry weight (without the petiole). The effect of spray treatment, genotype, and their interaction on chlorophyll content and specific leaf area was statistically tested using SAS JMP (SAS Institute Inc., Cary, NC).

Thrips feeding damage was assessed visually and scores of 0 to 5 were assigned based on the severity of thrips feeding damage, with 0 = no visual damage, 1 = up to 20% of leaf surface covered with thrips feeding scars, 2 = 21 to 40% damage, 3 = 41 to 60% damage, 4 = 61 to 80% damage, and 5 = the highest level of damage, with 80 to 100% of the leaf surface covered with thrips feeding scars (17). Feeding damage was assessed and thrips were collected from Test 1 on 14 June and from Test 2 on 9 July 2001. Ten partially unfolded terminal quadrifoliates were collected randomly from each plot, placed in 70% ethanol and refrigerated until thrips could be counted. Thrips were sorted according to life stage (immature and adult) and counted.

Tomato spotted wilt severity was visually assessed in both plantings based on symptoms using a 0-to-10 scale. A score of 0 indicated no symptoms, 1 to 3 expressed increased degrees of chlorosis (Fig. 2), 4 to 7 expressed increased levels of stunting with the chlorosis (Fig. 3), 8 and 9 expressed increased levels of necrosis with the chlorosis and stunting, and a score of 10 indicated severely stunted, dead plants. Severities were assessed on 24 August and 25 September 2001. At each evaluation, plots were assessed twice, and ratings were averaged to obtain a plot score.

Fig. 2. Chlorosis in peanut due resulting from infection by tomato spotted wilt virus.

Fig. 3. Stunting in peanut resulting from infection by tomato spotted wilt virus.

The final incidence of TSWV was estimated by detection of TSWV by enzyme linked immunosorbent assay (ELISA) of root samples. Samples for ELISA were collected when the plots were dug for yield evaluations on 8 October for Test 1 and 24 October for Test 2. Ten whole plants with roots were randomly sampled from each plot. Plants were trimmed and only the collar regions with roots were brought to the laboratory. About 100 mg of bark tissue from the upper part of the main and lateral roots were peeled off and used for ELISA, which was conducted using a TSWV-specific kit (Agdia Inc., Elhart, IN). An ELISA reading three times higher than the average reading of the negative control (comparable tissue from non-infected peanut) was considered as a TSWV positive sample.

Assessing Potential for Managing Leaf Spots

The effect of Surround applications on leaf spot severity was assessed in genotypes AgraTech 201, GK 7 High Oleic, and C-99R. Two-row plots (15 ft long) were planted on 25 May 2001 in a split-plot design with eight replications, with spray treatments as main plots and genotypes as sub-plots. Surround treatments were applied on 8 and 23 August 2001. Leaf spot severity (% infection or defoliation) of whole plots was evaluated on 24 August and 25 September 2001. At each evaluation date, severities were visually assessed twice in each plot, and ratings were averaged to obtain a plot score. Plants were dug 12 October 2001 for yield evaluation.

Assessing Potential for Managing Aflatoxin Contamination

The effects of Surround applications on drought stress and aflatoxin contamination were evaluated in genotypes Georgia Green, AgraTech 201, and GK 7 High Oleic. Two-row plots (5 ft long) were planted on 4 May 2001 in a split-plot design with five replications. Genotypes were main plots and spray treatments were subplots.

Plots were inoculated 10 July 2001 (60 days after planting) with a mixture of *Aspergillus flavus* and *A. parasiticus* using the methods of Will et al. (18). Drought and heat stresses were induced for the 40 days preceding harvest by covering the entire test area with a mobile greenhouse (Atlas Greenhouse System Inc., Alapaha, GA) on 2 August 2001. Surround treatments were applied on 8 and 23 August 2001. Drought stress ratings (0 to 5 scale, where 0 = no stress and 5 = terminal wilting) and tomato spotted wilt severity ratings (as described previously) were visually assessed on 29 August 2001. Pods were dug on 10 September 2001, hand-picked from the plant, and dried. Peanuts were shelled, ground, and then aflatoxin concentration was measured by the immunoaffinity column fluorometer method (16).

Effects on Chlorophyll and Leaf Morphology

Genotypes differed for SPAD chlorophyll measurement and specific leaf area. Georgia Green had a significantly higher SPAD chlorophyll measurement, regardless of spray treatment, and Sunoleic 97R had significantly lower specific leaf area than the other three genotypes (Fig. 4).

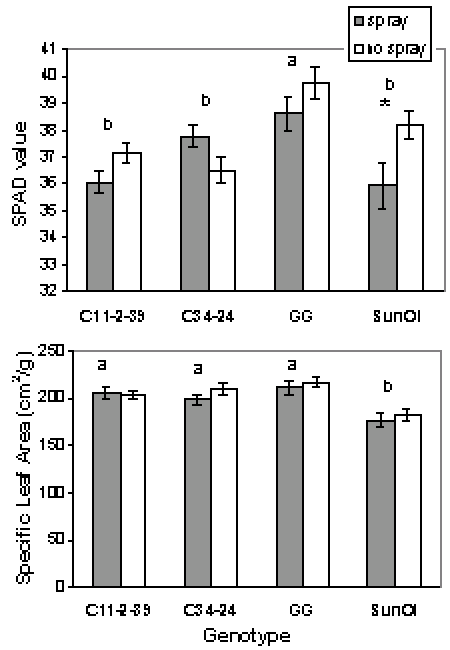

Fig. 4. Effects of Surround spray treatment on SPAD chlorophyll value and specific leaf area for four peanut genotypes. Asterisk indicates significant differences between spray treatments; letters denote differences among varieties across spray treatments. CG = Georgia Green, SunOl = Sunoleic97R. Bars represent the standard error of the mean of four replications.

Negative effects associated with Surround treatment were not consistently observed. Surround spray treatment reduced SPAD chlorophyll measurements in Sunoleic 97R. Thus, for the variety Sunoleic 97R with relatively thick leaves (low specific leaf area), Surround treatment significantly reduced SPAD chlorophyll measurement. Kaolin sprays applied to upper leaf surfaces have been reported to change the optical properties of leaves, tending to increase reflectivity and decrease transmissivity and absorptivity of spectral curves for many plants (1,2). The heightened light reception through kaolin's reflectivity properties has the potential to increase photosynthetic activity (13). However, previous work has shown that this change in spectral properties often shows no effect on net photosynthesis (1,5). In our study, it appears the Surround-treated leaves of Sunoleic 97R may be compensating for heightened light reception by decreasing chlorophyll production, suggesting a greater photosynthetic efficiency for these leaves. Because kaolin increases water-use efficiency in many crops (1,13), these results indicate some peanut varieties may respond to a kaolin spray treatment with increased physiological efficiency.

Effects on Thrips and Tomato Spotted Wilt

Genotype and spray treatments affected thrips feeding damage. Feeding damage was greatest on C34-24 and C11-2-39 (Table 1). Sampling date and genotype affected isolation of immature and total thrips, but there was no interaction of treatments with sampling date. More thrips were isolated on 14 June than on 9 July. A greater number of thrips were isolated from C11-2-39, and fewer thrips were isolated from Georgia Green and Sunoleic 97R. Feeding damage was lower with Surround treatment, however, thrips isolation did not differ among the spray treatments (Table 1).

Table 1. Thrips feeding damage and isolation from peanut genotypes, and effect of Surround treatment in 2001.

Treatment	Feeding damage[x]	Number of thrips collected per quadrifoliate		
		Immature	Adult	Total
Date of sampling				
14 June 2001	--[y]	8.4 a	1.6 a	9.9 a
9 July 2001	--	1.8 b	0.3 b	2.1 b
LSD (0.05)	--	1.8	0.4	2.1
Genotype				
Sunoleic 97R	2.3 b	4.2 b	0.6 b	4.8 b
Georgia Green	1.9 b	4.0 b	0.9 ab	4.9 b
C11-2-39	2.6 ab	8.1 a	1.3 a	9.4 a
C34-24	3.3 a	4.1 b	1.0 ab	5.1 b
LSD (0.05)	0.8	2.6	0.6	2.9
Spray treatment				
Non-treated	3.2 a	5.4	1.0	6.4
Surround	1.8 b	4.8	0.9	5.7
LSD (0.05)	0.6	NS[z]	NS	NS

[x] Thrips feeding damage was assessed on a 0 to 5 scale, with 0 indicating no visual damage and 5 indicating the highest level of feeding damage or scarring from thrips feeding. Damage was assessed on 14 June 2001.

[y] Treatment means within a column were differentiated by Fisher's LSD.

[z] NS = not significant at $P = 0.05$

Genotypes differed for tomato spotted wilt ratings and frequency of TSWV positive plants. In spite of the greater levels of thrips feeding damage on C11-2-39 and C34-24, these genotypes had the lowest tomato spotted wilt ratings at both evaluation dates and lowest incidence of TSWV positive plants (Table 2). These results are consistent with previous studies demonstrating the resistance of C11-2-39 to TSWV (8). In addition to their lower tomato spotted wilt severity ratings and TSWV incidence, these two genotypes also had greater yield (Table 2).

Although thrips feeding was reduced by spray treatment, Surround had no effect on thrips isolation, tomato spotted wilt severity and incidence, or yield (Table 2). The lack of relationship between the amount of damage from thrips feeding and TSWV transmission was observed previously (17).

Application of the particle film Surround provided no control of tomato spotted wilt in these two experiments. Surround was sprayed on the plant when the first quadrifoliate expanded, however, thrips larvae often feed in the shoot terminals (14). Because the Surround is a protectant compound, terminals did not maintain adequate coverage as the leaves unfolded. Sprouts with folded terminals were available for thrips feeding shortly after germination, therefore, Surround treatment did not provide an effective barrier to feeding and subsequent transmission of TSWV by thrips at any stage of growth. Although feeding behavior of thrips was modified by Surround treatment, as evidenced by reduced feeding damage, this modification was not adequate to prevent tomato spotted wilt development.

Table 2. Tomato spotted wilt severity ratings and incidence of Tomato spotted wilt virus (TSWV) infection in peanut genotypes, and effect of Surround treatment in 2001.

Treatment	Severity rating on date of evaluation[v]		TSWV incidence[w] (%)	Yield (g per plot)	
	24 Aug.	25 Sept.		Test 1	Test 2
Date of planting[x]					
Test 1	3.5	3.7	92.8 a	--	--
Test 2	3.6	3.3	65.9 b	--	--
LSD (0.05)	NS	NS	7.8	--	--
Genotype					
Sunoleic 97R	4.8 a[y]	6.2 a	96.3 a	3091 b	1833 c
Georgia Green	3.9 b	4.3 b	88.1 a	3897 ab	2949 b
C11-2-39	3.1 c	1.9 c	69.9 b	4532 a	3343 ab
C34-24	2.5 c	1.6 c	63.1 b	4665 a	3824 a
LSD (0.05)	0.6	0.7	11.0	809	618
Spray treatment					
Non-treated	3.5	3.4	75.9	4113	2995
Surround	3.6	3.7	82.8	3982	2980
LSD (0.05)	NS[z]	NS	NS	NS	NS

[v] Severity of tomato spotted wilt was evaluated based on a 0 (no disease) to 10 scale.

[w] TSWV incidence was based on enzyme linked immunosorbent assay of tissue sampled from both Test 1 and Test 2.

[x] Test 1 was planted 14 May 2001, Test 2 was planted on 6 June 2001.

[y] Treatment means within a column were differentiated by Fisher's lsd.

[z] NS = not significant at P = 0.05.

Effects on Leaf Spots

Genotype and spray treatments affected leaf spot severity, but no interaction existed between treatments. C-99R was more resistant to leaf spots than AgraTech 201 and GK 7 High Oleic at both evaluation dates, and had significantly greater yield (Table 3). Leaf spot severities were less in Surround-treated plots early in the epidemic at the first evaluation date. There were no differences in late-season leaf spot severity or in yield between Surround-treated and non-treated plots. Leaf spot was not well controlled by Surround application. It was difficult to obtain a uniform coverage by Surround due to the hydrophobic surface of the mature peanut leaves.

Susceptible peanut genotypes require regular fungicide applications for the control of leaf spots. Addition of Surround to tank mixes may provide some benefit since treatments resulted in slightly reduced disease at the early stage of crop development, however, the effectiveness and economics of the practice would need to be assessed.

Table 3. Leaf spot severity and yield of peanut genotypes and effect of Surround particle film treatment in 2001.

Treatment	Leaf spot severity on date[x]		Yield (g per plot)
	24 Aug.	24 Sept.	
Genotype			
AgraTech 201	10.2 a[z]	93.5 a	1000 a
GK 7 High Oleic	10.5 a	87.9 b	1072 a
C-99R	3.7 b	40.1 c	2890 b
LSD (0.05)	2.2	3.0	313
Spray treatment			
Non-treated	9.4 a	77.9	1630
Surround	6.9 b	75.8	1678
LSD (0.05)	1.8	NS[z]	NS

[x] Disease severity was assessed as a percent of foliage infected or defoliated.

[y] Treatment means within a column were differentiated by Fisher's LSD.

[z] NS = not significant at $P = 0.05$.

Effects on Drought Stress and Aflatoxin Contamination

Neither genotype nor spray treatment affected drought stress rating or aflatoxin contamination (Table 4). Significant correlations exist between visual stress ratings and aflatoxin contamination (7). Because Surround applications did not reduce symptoms of drought stress in this experiment, it was expected that no differences in aflatoxin contamination were observed. Aflatoxin values are associated with a large experimental source of variation. Numerically, aflatoxin levels among genotypes varied greatly (though not statistically significant) whereas the aflatoxin levels of sprayed and non-treated plots were nearly equal. Based on these results, a reduction in aflatoxin contamination in peanut attributable to Surround application is unlikely.

Table 4. Drought stress, aflatoxin contamination, tomato spotted wilt severity, and yield of peanut genotypes and effect of treatment with Surround particle film in 2001.

Treatment	Drought Stress[w]	Aflatoxin (µg/g)	Tomato spotted wilt[x]	Yield (g/plot)
Genotype				
Georgia Green	1.9	1555	3.0 a[y]	1515 a
Agra Tech 201	1.7	4752	3.8 ab	1218 b
GK 7 High Oleic	2.0	2895	4.0 b	1085 b
LSD (0.05)	NS[z]	NS	1.0	267
Spray treatment				
Non-treated	1.9	3018	4.1 a	1217
Surround	1.9	3116	3.1 b	1327
LSD (0.05)	NS	NS	0.8	NS

[w] Drought stress rated as 0 = no stress, 5 = terminal wilting.

[x] Tomato spotted wilt rated as 0 = no disease, 10 = stunted, dead plants.

[y] Treatment means within a column were differentiated by Fisher's LSD.

[z] NS = not significant at $P = 0.05$.

Development of tomato spotted wilt in this experiment allowed another opportunity to assess effects of Surround on development of that disease. Tomato spotted wilt severity differed by genotype and spray treatment. Georgia Green had the lowest tomato spotted wilt ratings and the greatest yield. In contrast to the first two tests for the control of tomato spotted wilt, severity ratings were lower in Surround-treated plots in this test (Table 4).

In conclusion, in these studies, only limited benefits were observed from Surround application for the control of tomato spotted wilt and leaf spots, and no effects on aflatoxin contamination were observed. Based on the results obtained, we determined that additional study would not provide information that could lead to significant control of these peanut stresses.

Current peanut production practices require routine application of pesticides, therefore, if multiple benefits had been observed in these studies, particle film applications could be adopted into the management regime. These results show that Surround applications had little or no effect on the incidence or severity of TSWV, leaf spot severity, aflatoxin contamination, or yield. In these studies, host genotype effects were more effective in reducing disease and increasing yield than was particle film application. Although foliar applications of particle films may be useful for producing certain vegetables and fruits, its use appears to have little value in peanut production systems.

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