Spread of Peanut Stripe Virus from Peanut to Soybean and Yield Effects on Soybean

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ABSTRACT

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Spread of peanut stripe virus (PStV) from peanut to soybean and the yield effects on soybean were determined in field tests at Byron, GA, in 1988 and 1989. Infection was determined by visual symptoms and confirmed by indirect ELISA. Initial spread of PStV to soybean was observed 38 and 35 days after inoculation of the peanuts in 1988 and 1989, respectively. After another 26 and 21 days, PStV had spread 24.4 and 16.8 m, respectively. The highest number of plants with PStV was in the southeastern and southwestern sections of the fields in both years. Secondary spread occurred in both years. Infection of six soybean cultivars caused no significant decrease in plant height, seed weight, or seed yield for any cultivar.

Peanut stripe virus (PStV) was first observed in the United States in 1982 by Demski et al (1) on peanuts (*Arachis hypogaea* L.) introduced from the Peoples Republic of China. They reported that PStV is seed-transmitted in peanuts up to 37%. Lynch et al (5) found that PStV produced a 5–7% yield reduction in peanuts. A serologically related strain of PStV was reported to cause a 53% reduction in soybean (*Glycine max* (L.) Merr.) yield in greenhouse trials in China (9). Green and Lee (3) in Taiwan reported that PStV produced up to 90% yield reduction and up to 50% reduction in seed weight in soybeans. Warwick and Demski (8) did not detect any PStV seed transmission in 15,000 soybean seeds harvested from infected plants in greenhouse studies.

No studies concerning the spread of PStV from peanuts to other crops have been conducted with U.S. cultivars, nor have the possible yield effects of PStV in legumes other than peanuts been evaluated. The sale of soybean seed from the southeastern U.S. to Mexico in 1986 was stopped because of possible PStV infection. Understanding the potential risks associated with PStV is necessary to overcome the fears of growers and consumers. Our results deal with the effects of PStV on soybean yield and the spread of the virus from infected peanuts into susceptible soybeans. A preliminary report of some of these data has been published (2).

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MATERIALS AND METHODS

Experimental plots. Two experiments were conducted at the USDA Fruit and Tree Nut Research facility at Byron, GA. Plots were planted 7 June 1988 and 5 June 1989 (peanuts) and 12 June 1989 (soybeans). The experiments were performed in different ends of the same block of land in the 2 yr. The experimental areas were fertilized according to the Georgia Agricultural Cooperative Extension Service recommendations for soybeans. Glyphosate at 11.6 L/ha was applied at a preplant stage, metolachlor at 4.7 L/ha was used preemergent, and benzothiadiazin at 4.7 L/ha was used postemergent at the V3 leaf stage (second trifoliolate) for control of weeds. Insecticides were not applied because economic thresholds of insect populations were not reached during either growing season. Soybean seeds were sprayed with a Karo syrup/water adherent solution (30 ml of syrup and 450 ml of water), treated with micronutrients according to Georgia Agricultural Cooperative Extension Service recommendations, and overtreated with *Rhizobium* according to package directions.

Based on preliminary greenhouse studies, the following susceptible soybean cultivars were selected for the field tests: Bragg, Braxton, Centennial, Ransom, Tracy M, and Wright. These cultivars were recommended and grown in Georgia (7).

Soybean yield trials were in strip-plot randomized complete block designs. Six soybean cultivars with six replications each were used in rows 6.1 m long and 91 cm apart. Subplots consisted of four rows of each cultivar either inoculated with PStV or left uninoculated. Each subplot was buffered with *Phaseolus vulgaris* L. 'Top Crop' to minimize spread of the virus within the test. In 1988, six rows of buffer crop were used on each side of each replication. In 1989, four rows of buffer crop plus a 1.8-m alley were used on each side of each replication with 5.5 m of buffer crop on each end of each replication in both years.

Tests to monitor virus spread consisted of peanut cv. Argentine infected with PStV in the middle of a field of Tracy M soybeans. In 1988, eight 5.5-m-long rows of peanuts surrounded 51 49-m-long rows of Tracy M. In 1989, the peanut plots of the same size as the previous year were surrounded by 55 26-m-long rows of soybeans. Row widths were 91 cm. To determine directional spread of the virus, the soybean fields were divided into 12 pie-shaped sectors of 30° each in which due north was designated 0° and measurements moved in a circle in a clockwise fashion.

Plots were seeded at a rate of 39 soybean seeds per meter and 20 peanut seeds per meter, and stands were not adjusted after germination. Irrigation was supplied by overhead sprinklers as needed to obtain a 2.5-cm rainfall equivalent each week.

Virus inoculation. The virus isolate (PStV-blotch) (7) was obtained from J. W. Demski, University of Georgia, and maintained on soybean cv. Tracy M because this was a better source of inoculum for soybean. Inoculum was prepared by grinding leaves of infected Tracy M soybean 31 days after infection in 0.025 M phosphate buffer, pH 7.2, in a Waring blender (1 g of leaves per 39 ml of buffer). After filtering through cheesecloth, the filtrate was kept on ice until used. For each inoculation, filtrate mixed with Carborundum was sprayed onto 7- to 14-day-old (V1 stage or unifoliolate) seedlings with artists' airbrushes. In 1988, peanuts used to determine virus spread into soybeans were planted at the same time as the soybeans and inoculated at the same time as the yield trials (17 June). In 1989, peanuts were planted before the soybeans so that they had been inoculated before the soybeans began to emerge (19 June). The soybeans were inoculated on 26 June. The percent infection of soybeans and peanuts was estimated based on the presence of visual symptoms

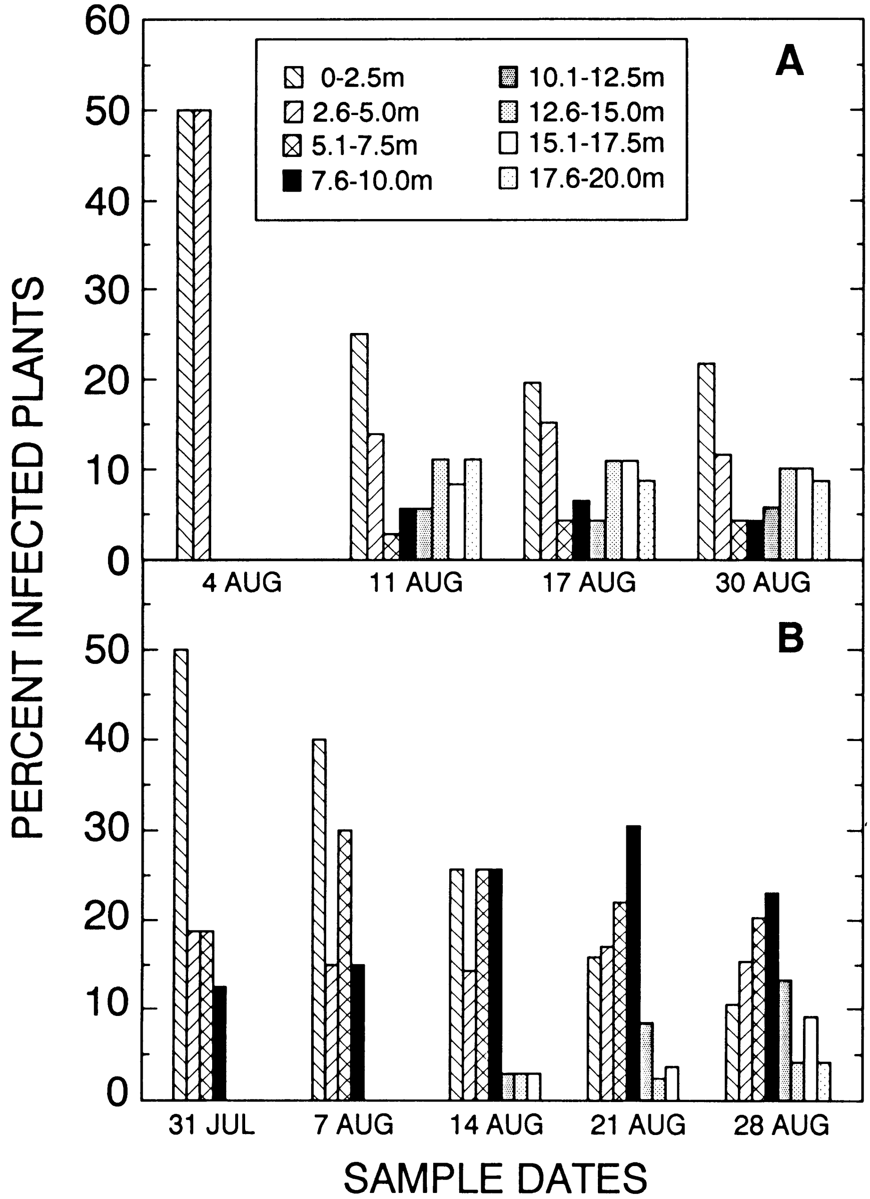

Fig. 1. Pattern of peanut stripe virus spread from infected peanut to soybean as measured by the percentage of infected soybean plants at 2.5-m intervals from peanut plants for each sampling date in (**A**) 1988 and (**B**) 1989. Data are shown for the first five dates of the eight data collection dates in 1989, but the last three dates were very similar to that of 28 August. Plots were planted 7 June 1988 (peanuts and soybeans) and 5 June 1989 (peanuts) and 12 June 1989 (soybeans). Peanut plants were inoculated by airbrush 17 June 1988 and 19 June 1989.

Table 1. Results of ordinary runs analysis for 1988 and 1989 testing for randomness of spread of peanut stripe virus (PStV) from infected peanut to soybean at each sampling date

Sampling date[a]	Plants (no.)	No. of runs Total	Expected	SD	Z^b
1988					
4 August	2	5	4.00	0.011	136.36
11 August	37	73	73.97	0.238	6.43
17 August	47	93	93.95	0.302	5.13
30 August	69	133	137.90	0.444	−5.41
1989					
31 July	16	33	31.98	0.024	63.33
7 August	20	41	39.98	0.196	7.76
14 August	35	71	69.94	0.345	4.52
21 August	82	157	163.67	0.811	−7.61
28 August	143	265	284.99	1.41	−13.82
5 September	221	401	440.58	2.18	−17.93
11 September	247	435	490.98	2.44	−22.93
19 September	259	444	514.69	2.56	−27.42

[a] Data are inclusive from first sample date through listed sample date.
[b] Z = "Z" test statistic considered to be nonrandom spread if $-Z \leq -1.645$ at $P = 0.05$.

within the rows to be harvested.

Agronomic characters. Data on plant height was determined at the R6 stage (maximum seed size) in soybeans. Plants from the two interior rows of the inoculated and uninoculated plots were measured (symptoms could not be visualized well at this stage so plants were measured without recording symptoms). Total seed yield and 100-seed weights were determined and adjusted to 11% moisture for soybeans. Soybean plants from 4.6 m of each of the interior two rows were harvested mechanically in 1988 and by hand in 1989. Soybeans were threshed with a plot combine.

The soybeans in the virus spread tests were surveyed weekly after the appearance of the first symptoms of the virus. Plants with virus symptoms were recorded by position in the field and leaf samples taken for testing with PStV polyclonal antiserum using the indirect ELISA method. Furthermore, some sampling was done to determine if asymptomatic virus spread had occurred.

For ELISA, sap from leaf samples was extracted in approximately 3 ml of carbonate coating buffer on a roller mill (Piedmont Machine and Tool Inc., Pell City, SC). A direct antigen-coating ELISA method (4) using phosphatase-labeled affinity purified antibody to rabbit IgG (H+L) produced in goat (Kirkegaard and Perry Laboratories Inc., Gaithersburg, MD) was used.

RESULTS

Virus spread tests. PStV spread from infected peanuts to soybeans in both years, but the amount and pattern of spread varied. Disease incidence did not reach 1% either year. Virus symptoms were first observed in soybeans 38 and 35 days after inoculation of the peanuts in 1988 and 1989, respectively. By 14 August each year (58 and 56 days after inoculation of the peanuts, respectively), virus had spread to the edge of the field, or about 24.4 and 16.8 m, respectively. By 11 August 1988, the highest percentage of infected plants (25%) was found between 0 and 2.5 m from the inoculum source (Fig. 1). Also, the middle three sections (5.1–7.5, 7.6–10.0, and 10.1–12.5 m) had a lower percentage of infection than sections further from the inoculum source. Initially, in 1989, the highest percentage of infection (50%) was found 0–2.5 m from the inoculum source. By 21 August, the section 7.6–10.0 m away had the highest percentage of infection (30.5%).

Ordinary runs analysis (6) (Table 1) indicated nonrandom spread of the virus at the last sampling date (30 August 1988). However, nonrandom spread of the virus was seen by the fourth sampling date (21 August) in 1989. The highest percentage of samples testing positive for PStV in each test was in the southeastern and southwestern areas (121–240° =

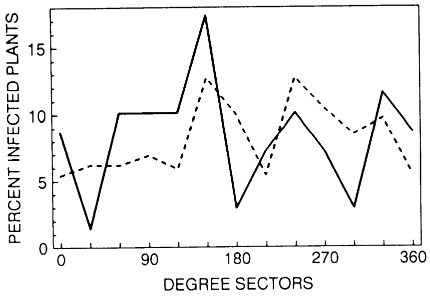

Fig. 2. Direction of peanut stripe virus spread from infected peanuts to soybeans as measured by the percentage of infected soybean plants for each 30° sector of the field 11 and 13 wk after inoculation of the peanuts in 1988 (—) and 1989 (- - - - -), respectively. The field was divided into 12 sectors each with due north = 0°. Sectors were designated in a circle moving clockwise.

Table 2. Comparison of peanut stripe virus inoculated (I) and uninoculated (U) controls in six soybean cultivars with respect to seed yield, plant height, seed weight, and percent infection

	Seed yield (kg/ha)[a]		Plant height (cm)		Seed weight (g/100 seeds)		Percent infection
Cultivar	**U**	**I**	**U**	**I**	**U**	**I**	**I**
1988 experiment							
Bragg	2,612*[b]	3,106	102	96	17.1	17.0	84.2
Braxton	2,489*	2,942	100	94	18.8	18.8	79.6
Centennial	2,609	2,731	87	88	16.2	16.0	84.4
Ransom	2,764	2,859	90	82	18.3	18.3	90.0
Tracy M	1,886*	2,195	85	78	18.9	18.7	73.2
Wright	2,568*	3,043	91	86	15.8	15.5	81.5
Mean	2,488*	2,812	92	87	17.5	17.3	82.5
1989 experiment							
Bragg	2,547	2,267	90	88	16.2	16.4	40.2
Braxton	2,424	2,165	89	87	19.0	18.1	38.0
Centennial	2,179	2,104	84	78	14.4	15.1	49.6
Ransom	2,293	2,294	81	75	16.0	15.4	32.0
Tracy M	1,866	1,991	76	72	17.2	17.1	55.0
Wright	2,435	2,335	86	84	15.4	15.3	45.0
Mean	2,290	2,192	84*	81	16.3	16.2	43.3

[a] Adjusted to 11% moisture.
[b] Asterisks indicate significant difference between inoculated and uninoculated plots within cultivar based on analysis of variance and least squares means test at $P = 0.05$.

37.6% in 1988 and 40.8% in 1989), with a smaller concentration of positive plants in the northwest area (Fig. 2). In 1988, sectors with the largest percentages of positives were at 121–150° (17.4%), 211–240° (10.1%), and 301–330° (11.6%). In 1989, the high sectors were at 121–150° (12.7%), 211–240° (12.7%), and 301–330° (10.4%) (Fig. 2). In 1988, sector 1–30° contained the lowest percentage of samples testing positive for PStV (1.4%), and in 1989, the sectors containing the lowest percentage of infected plants were 181–210° and 331–360° (5.4%). The total number of positive samples was 69 of 112 in 1988 and 259 of 487 in 1989.

Agronomic performance. Twelve comparisons (six genotypes × two experiments) between uninoculated and inoculated soybean plants were made for each of three agronomic characters (Table 2). Analysis of variance indicated significant main effects over all cultivars for plant height in 1989 and seed yield in 1988. There was a cultivar by treatment interaction for seed yield in 1988 with a significant difference between inoculated and uninoculated in four of six cultivars by least squares means analysis ($P = 0.05$). Infection percentages of the inoculated plants were estimated at 73–90% in 1988 and 32–55% in 1989, based on visual symptoms (Table 2).

DISCUSSION

Soybean growers now have some information indicating that PStV does not adversely affect the yield of seed of U.S. cultivars. Our preliminary data with 2,691 seed from infected soybean plants from the field and the Warwick and Demski greenhouse data (8) indicate no seed transmission of PStV in soybean. Based on the yield results, even if soybeans are infected by PStV spread from peanuts, there will be no losses in yield.

The reports of yield losses in soybeans in China and Taiwan (3,9) could be attributable to different genotypes used, virus strain differences, different growing conditions, and/or differences in the time of infection. Our studies involved an isolate of PStV (blotch) from peanut and those in China and Taiwan used soybean isolates. Our studies used cultivars common in Georgia, and these may vary greatly from those in Asia. We were also not able to demonstrate yield effects of PStV (blotch) in a preliminary test with lima beans. Although the environmental conditions and the harvest procedures differed in the 2 yr, we cannot offer an explanation for the apparent increase in seed yield in infected plants in four of the 1988 yield plots.

Spread of the virus from peanuts into soybeans occurred in a southerly direction, following the prevailing winds as recorded in the Byron station weather data. Spread was greater in 1989 when the peanuts were inoculated before the soybeans emerged than in 1988 when the peanuts were planted at the same time as the soybeans and were inoculated when the soybeans were at the first trifoliolate stage. Our efforts to collect data on vector populations in the 2 yr were not successful and we could not correlate differences in the amount of spread of the virus to environmental differences. There was statistical evidence for secondary spread in the soybeans (i.e., clustering/nonrandom spread) in both years.

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