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Soybean Rust Incidence and the Response of Soybeans to Foliar Fungicides in 2006

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Disease Incidence and Losses in 2006

The spread of soybean rust northward through states along the Atlantic Coast began on soybeans in Alabama, Georgia, and Florida. The disease was first reported in South Carolina on 21 August, North Carolina on 14 September, and Virginia on 9 October. The epidemic of 2006 was far reaching in that disease outbreaks occurred on soybeans as far north as Illinois and Indiana and east to Virginia (Fig. 1).

No significant losses of yield were expected as a result of soybean rust in Virginia due to low incidence and late appearance of disease. Essentially, all soybean fields were either at or beyond R6 (full seed stage) when the disease was detected. Nematodes had the greatest impact on yield based on diagnostic tests performed in the plant disease clinic at the Tidewater Agricultural Research and Extension Center (AREC) and field observations in Eastern Virginia (Table 1). Soybean cyst, southern and northern root-knot and stubby root nematodes accounted for the greatest losses of yield. Leaf spot diseases (frogeye leaf spot, anthracnose, *Cercospora* blight) showed low incidence in 2006 as a result of dry weather stress in July and August. Soybean yields averaged 31 bu/A in 2006 on 500,000 acres.

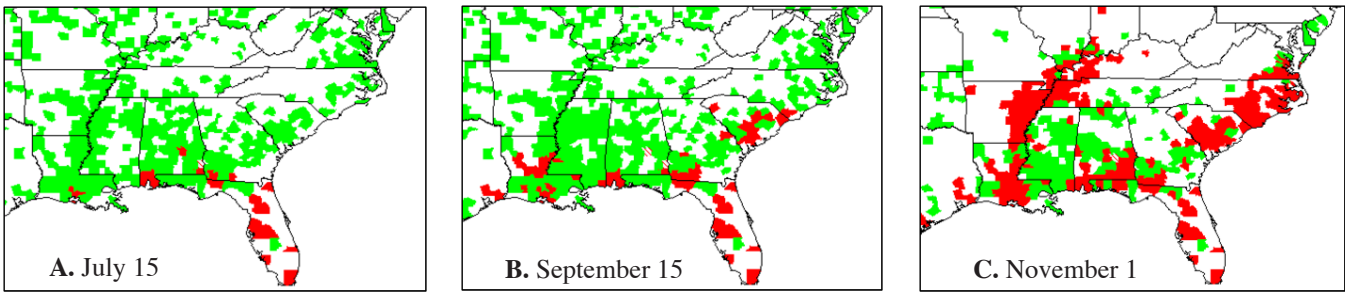

Fig. 1. Counties confirmed with soybean rust on 15 July, 15 September, and 1 November 2006

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Table 1. Estimated loss in yield as a result of soybean diseases in 2006.

Disease	Causal agent(s)	Percent loss
Seedling diseases	---various---	0.8
Downy mildew	*Peronospora manshurica*	Trace
Soybean rust	*Phakopsora pachyrhizi*	0.0
Frogeye leaf spot	*Cercospora sojina*	0.4
Phytophthora root & stem rot	*Phytophthora sojae*	0
Anthracnose	*Colletotrichum truncatum*	0.5
Pod & stem blight	*Diaporthe phaseolorum var. sojae*	0.1
Stem canker	*Diaporthe phaseolorum var. caulivora*	Trace
Sudden death syndrome	*Fusarium solani f.sp. glycines*	Trace
Sclerotinia stem rot	*Sclerotinia sclerotiorum and S. minor*	0
Southern blight	*Sclerotium rolfsii*	0.1
Root & lower stem rot	*Rhizoctonia solani*	Trace
Purple seed stain	*Cercospora kikuchii*	0.1
Cercospora blight	*Cercospora kikuchii*	0.6
Brown spot	*Septoria glycines*	0.2
Red crown rot	*Cylindrocladium parasiticum*	0.2
Brown stem rot	*Phialophora gregata*	0.1
Charcoal rot	*Macrophomina phaseolina*	Trace
Viruses	*SMV, PeMoV, BPMV, etc.*	0.1
Bacterial pustule	*Xanthomonas campestris pv. glycines*	Trace
Bacterial blight	*Pseudomonas syringae pv. glycinea*	0.2
Southern root knot nematode	*Meloidogyne incognita*	1.8
Soybean cyst nematode	*Heterodera glycines*	2.2
Other nematodes	---various---	0.5
Total loss (%)		8.1*

* The loss estimate equals 1.366 million bushels based on production of 15.5 million bushels in 2006. At a value of $6.00/bu, the loss in revenue at the farm gate was $8.2 million in 2006.

Sentinel Plots

Ten regional sentinel plots and 40 commercial fields were scouted from flowering up to beginning senescence for early detection of soybean rust in 2006. A total of 363 samples of 100 leaflets were processed by microscopic examination; 212 sentinel plot and commercial samples at the Tidewater AREC, 97 sentinel plot and commercial samples at the Eastern Shore AREC, and 54 sentinel plot samples by the Virginia Tech Department of Plant Pathology, Physiology, and Weed Science (PPWS) in Blacksburg. Sentinel plots were located at the Tidewater AREC (Suffolk), Southampton County (Courtland), Eastern Shore AREC (Painter), Northampton County, Shenandoah County, Southern Piedmont AREC (Blackstone), New Kent County, Northern Piedmont AREC (Orange), Eastern Virginia AREC (Warsaw), and Virginia Tech – Kentland Farm (Blacksburg).

Leaf samples were collected and shipped overnight by site cooperators to the Tidewater AREC, Eastern Shore AREC, or the department of PPWS for processing. Upon receipt, the samples were placed in moist chambers at room temperature (70º to 77°F), incubated for 3 to 5 days, and examined under a stereomicroscope for pustules of soybean rust.

Weekly examinations of leaf samples from 10 sentinel plots and field scouting in 40 commercial fields resulted in detection of the first outbreaks of soybean rust in Chesapeake on 9 October and in the sentinel plot at Suffolk on 10 October. Thereafter, intensive scouting

up to 15 November confirmed incidence of the disease in a total of 18 counties (Suffolk, Chesapeake, Virginia Beach, Isle of Wight, Southampton, Greensville, Brunswick, Mecklenburg, Sussex, Surry, Prince George, King and Queen, New Kent, James City, Gloucester, Middlesex, Accomack, and Northampton). These findings represented the first report of soybean rust, caused by *Phakopsora pachyrhizi,* in Virginia. Photographs of leaflets were taken to illustrate the small size of lesions and the need for a microscope to find rust pustules (uredinia) and spores for disease detection (Fig. 2).

Further confirmation of positive samples with pustules on leaflets was obtained by ELISA and PCR tests in the laboratory. ELISA tests were run on 164 samples and PCR tests were run on six samples. The initial finds of soybean rust on 9 October were also confirmed by submitting leaf samples to the USDA Animal Plant Health Inspection Service lab in Rockville, Md.

Spore Traps

Five spore traps were monitored weekly for early detection of airborne rust spores moving into Virginia by wind currents. Spore traps were located at the Tidewater AREC (Suffolk), Eastern Virginia AREC (Warsaw), Northern Piedmont AREC (Orange), Eastern Shore AREC (Painter) and Virginia Tech (Blacksburg). A freshly greased microscope slide was placed in each trap weekly from 12 June up to 10 October. Slides were replaced weekly and sent to John Rupe (University of Arkansas) for microscopic examination and count of rust spores. Table 2 summarizes the trapping dates when rust spores were found on slides at specific locations, and Table 3 provides a monthly summary of findings in 2006. The viability of spores could not be determined, nor could the identity be positively confirmed as *P. pachyrhizi*. However, the morphological traits of spores counted did conform to spores of the soybean rust fungus.

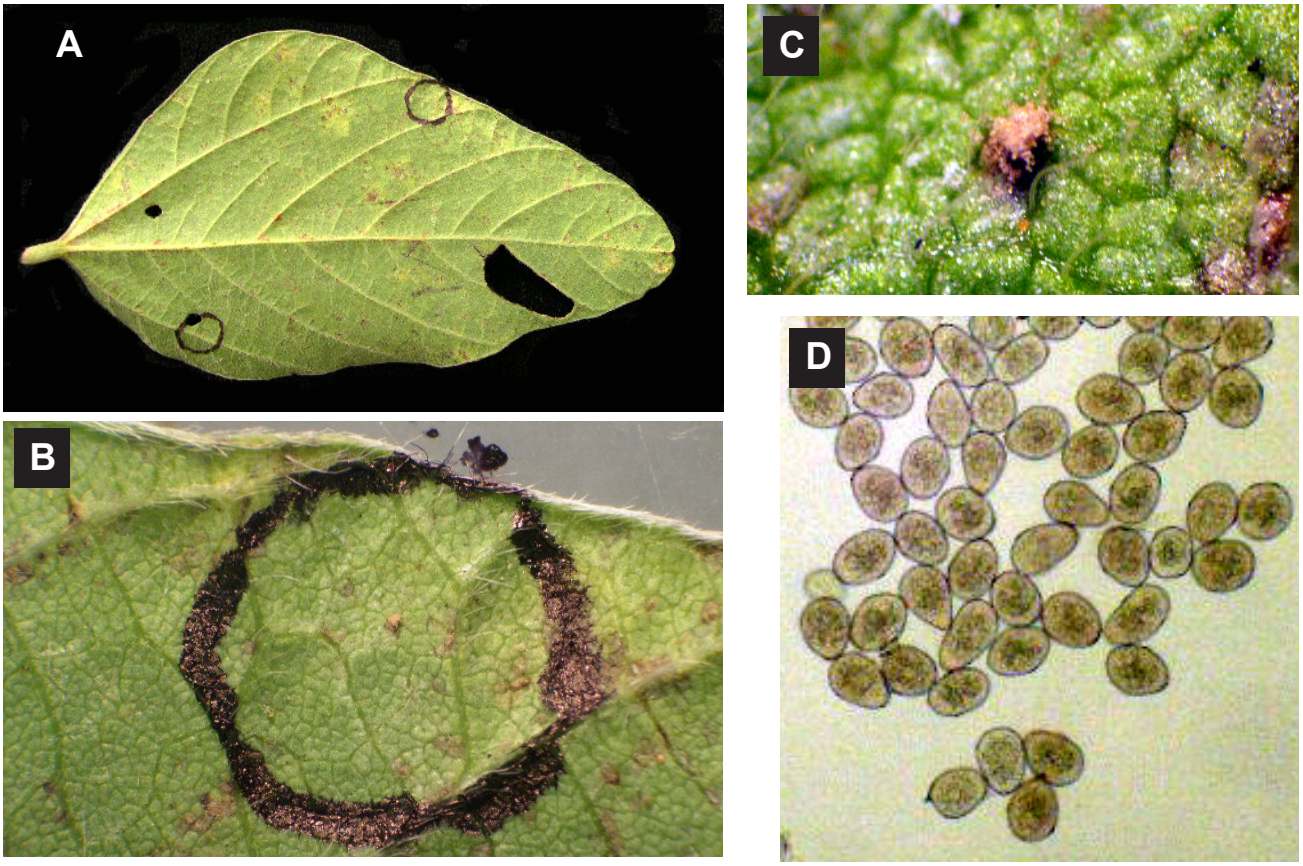

Fig. 2. Relative size and appearance of rust pustules (circled) and rust spores: A) leaflet with two single rust pustules circled, B) rust pustule viewed at low magnification under stereoscope, C) rust pustule with spores visible at high magnification under stereoscope, D) mature rust spores with high magnification under microscope.

Table 2. Occurrence of rust spores resembling *Phakopsora pachyrhizi* in spore traps, 2006

Trap location	No. positive rust spores	Trap dates
TAREC, Suffolk	3	Jul 3 – 10
NPAREC, Orange	1	Jul 10 – 17
ESAREC, Painter	1	Aug 3 – 10
Virginia Tech, Blacksburg	4	Aug 7 – 14
ESAREC, Painter	2	Aug 14 – 21
NPAREC, Orange	1	Aug 14 – 21
EVAREC, Warsaw	2	Aug 14 - 21
ESAREC, Painter	1	Aug 17 – 24
NPAREC, Orange	1	Sep 15 – 25
NPAREC, Orange	3	Sep 25 – Oct 2

Table 3. Monthly summary of rust spores believed to be *Phakopsora pachyrhizi* in spore traps, 2006.

Month	Slides submitted	Slides w/rust spores	Total spores
June	9	0 (0%)	0
July	18	2 (11%)	4
August	22	6 (27%)	11
September	12	2 (17%)	4
October	3	0 (0%)	0

Seasonal Air Temperatures and Rainfall in 2006

Much of eastern Virginia experienced below-normal temperatures in May and above-normal temperatures in August and September. July and August were especially dry as a result of widely scattered thundershowers in eastern Virginia. These conditions caused moderate to severe drought stress in some fields especially in August when maximum temperatures ranged from 90° to 100ºF on 19 of 31 days. Overall, dry weather and above normal temperatures in July and August were believed to be responsible for reduced yields and the late appearance of soybean rust in South Carolina, North Carolina, and Virginia in 2006. Tropical Storm Ernesto brought heavy rainfall (8.04 in.) as it passed through eastern Virginia on 31 August and 2 September. This event was a major contributor to ending the drought in August and increasing total rainfall above normal for September and the entire growing season.

The optimum temperature range for leaf infection and development of rust pustules is 60° to 77ºF. Infection can occur at temperatures as low as 59º and as high as 84ºF, but will require a longer period of time at these temperatures. In addition to a favorable temperature, the fungus requires moisture (leaf wetness or ≥ 95% relative humidity (RH) for spore germination and infection of leaflets. Only 11, 30, and 31 August were considered favorable for infection according to hourly measurements of air temperature and RH, and daily rainfall at the Tidewater AREC. Weather data from this site indicated that 24 of 30 days in September and 23 days of 31 days in October provided favorable conditions for the disease.

Table 4 summarizes seasonal temperatures at locations where fungicide trials were conducted on soybeans in 2006. All locations, except Warsaw, reported above normal rainfall for the period from May through October. Weather data in Suffolk, Capron, and Skippers were obtained from the Peanut/Cotton InfoNet (*www.ipm.vt.edu/infonet*). The Virginia Agricultural Experiment Station Mesonet (*www.ahnrit.vt.edu/research/weather.html*) collected weather data at the Eastern Shore AREC at Painter and the Eastern Shore AREC at Warsaw. Normal rainfall records were obtained from annual reports by the Virginia Agricultural Statistics Service.

Table 4. Weather summary for trial locations, 2006.

Location	2006 Air Temperatures (F)					Rainfall (in.)	
	Month	Avg.	Max	Min.		2006	Normal
Tidewater AREC, Suffolk	MAY	64.8	76.8	53.0		3.07	3.82
	JUN	72.8	82.5	64.4		9.20	4.33
	JUL	77.4	87.6	68.7		2.72	5.87
	AUG	77.4	88.8	67.7		2.50	5.71
	SEP	67.7	78.4	58.4		7.83	4.52
	OCT	57.9	68.9	47.5		7.44	3.52
	Mean	**69.7**	**80.5**	**59.9**	**Total**	**32.76**	**27.77**
Foxhill Farms, Capron	MAY	64.3	77.3	51.6		2.31	--*
	JUN	72.6	82.9	63.7		5.16	--
	JUL	77.1	87.5	68.1		6.17	--
	AUG	77.2	88.4	67.8		4.70	--
	SEP	67.3	78.1	58.7		7.89	--
	OCT	56.9	68.8	46.2		5.36	--
	Mean	**69.2**	**80.5**	**59.3**	**Total**	**31.59**	
Hawkins Farm, Skippers	MAY	74.5	86.5	62.7		0.41	4.01
	JUN	74.9	86.1	64.9		6.80	3.44
	JUL	79.1	91.1	68.2		4.19	4.49
	AUG	77.5	89.9	65.0		3.28	4.53
	SEP	66.1	78.9	55.9		7.59	3.41
	OCT	57.7	70.0	46.5		5.61	3.14
	Mean	**71.6**	**83.8**	**60.5**	**Total**	**27.88**	**23.02**
Eastern Shore AREC, Painter	MAY	63.6	73.1	53.5		2.32	3.48
	JUN	72.1	80.1	64.1		6.41	3.34
	JUL	78.0	86.3	69.8		4.68	4.29
	AUG	77.3	86.4	68.3		3.13	3.80
	SEP	67.3	75.8	58.9		13.97	3.16
	OCT	58.6	67.2	48.8		7.31	3.08
	Mean	**69.5**	**78.1**	**60.6**	**Total**	**37.82**	**21.15**
Eastern VA AREC, Warsaw	MAY	64.1	75.1	52.7		2.56	4.55
	JUN	72.2	82.1	62.8		4.81	3.67
	JUL	78.2	88.0	69.4		4.06	4.2
	AUG	77.9	88.6	68.0		2.11	4.17
	SEP	66.5	75.6	58.0		6.67	4.16
	OCT	56.4	67.1	45.8		2.47	3.37
	Mean	**69.2**	**79.4**	**59.4**	**Total**	**22.68**	**24.12**

* Records of normal rainfall for Capron unavailable.

Fungicide Trials

Plots were 30 feet long and 12 feet wide. Row spacing ranged from 12 to 36 inches, depending upon location. A randomized complete block design was used with four or five replications of treatments. Fungicides were applied with either a CO_2-pressurized backpack sprayer in a 6-foot spray swath, or a Lee Spider sprayer in a 12-foot spray swath. Both sprayers were equipped with 8002VS nozzles spaced 18 inches apart and delivered a volume of 16.5 gallons per acre at 30 psi. Disease and yield data were collected from the central 4.75-foot by 30-foot long section in each plot. Standard practices for soybean production were followed after planting each trial. Plots were harvested with a self-propelled, small-plot combine. Samples of 100 seeds from each plot were weighed and seed numbers with purple seed stain, Phomopsis seed decay, and other diseases were recorded.

Results

Tidewater AREC, Trial 106 (Phipps and Partridge). The field site was planted to S57-P1 on 25 May. The soil type was Nansemond fine sandy loam that was planted to soybean in 2005 and corn in 2004. Plots were eight 30-foot rows spaced 18 inches apart. Roundup Ultra Max at 22 fluid ounces per acre was used on 10 July for weed control. All treatments were applied using a Lee Spider sprayer. The timing of fungicide application was designed to evaluate one spray at R3 (21 August). Plots were harvested on 6 November. None of the treatments caused symptoms of chemical injury on leaves, stems, or pods. Brown spot, frogeye leaf spot and bacterial blight occurred at low levels and were not believed to reduce yield (Table 5). Cercospora blight was the most likely disease to reduce yield based on the percentages of leaf area with symptoms up to 10 October when leaflets began to show senescence. Soybean rust was not detected at the test site. Sprays of Headline, Absolute, Quilt with crop oil, Quadris with crop oil, and Stratego with Induce provided the most effective control of Cercospora blight and significantly delayed defoliation. The same treatments also significantly reduced the incidence of purple seed stain.

Table 5. Soybean fungicide trial #106, Suffolk.

Treatment and rate/A[z]	Cercospora blight[y] 19 Sep	Cercospora blight[y] 10 Oct	Defoliation[x] (10 Oct)	Yield[w] (bu/A)	P-value of yield[v]	Seed/lb	Purple seed stain[u]
Untreated	1.53	32.5 b	48.8 a	35.1	--	2871	5.0 ab
Topsin 4.5FL 20 fl oz	0.53	28.8 bc	30.0 bc	34.3	.7901	2800	3.5 b-e
MFC-T methyl 4.5F 20 fl oz	0.53	28.8 bc	28.8 b-d	34.5	.8355	2705	3.8 b-d
MFC 4.5F 20 fl oz + MFX-0650 1 oz	0.55	23.8 cd	37.5 ab	32.3	.3184	2769	4.3 a-c
MFC 4.5F 20 fl oz + MFX-0650 2 oz	1.25	22.5 d	23.8 cd	34.1	.7383	2732	4.0 a-d
Quadris 2.08SC 6 fl oz + COC 20.5 fl oz	0.28	13.8 ef	16.3 de	34.7	.8955	2789	2.5 c-e
Quilt 1.67SC 14 fl oz + COC 20.5 fl oz	0.50	16.3 e	23.8 cd	36.4	.6283	2843	2.8 b-e
Stratego 250EC 10 fl oz + Induce 2.56 fl oz	0.53	13.8 ef	25.0 b-d	37.8	.3374	2770	1.8 de
Folicur 3.6F 4 fl oz	0.30	38.8 a	36.3 a-c	36.9	.5178	2747	6.3 a
Absolute 500SC 5 fl oz	0.50	10.0 f	10.0 e	35.6	.8461	2768	1.8 de
Headline 2.09SC 6 fl oz	0.03	8.8 f	10.0 e	37.7	.3418	2676	1.3 e
LSD	**n.s.**	**5.1**	**12.9**	**n.s.**		**n.s.**	**2.3**

[z] All treatments were applied on 21 Aug.
[y] Percentage of leaf area with disease symptoms.
[x] Defoliation rating scale: 0=none, 100=no leaves on plants.
[w] Yield of soybeans with 13.5% moisture. One bushel equals 60 lb.
[v] *P*-values are for comparison of each treatment to untreated using orthogonal contrast procedure.
[u] Percentage of 100 seeds with symptoms of each disease.
Means followed by the same letter(s) in a column are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$), "n.s." = not significant. Arcsine transformation of percentage data was made in analysis to determine statistical significance.

Tidewater AREC, Trial 206, Suffolk (Phipps and Partridge). The variety, planting date, cultural practices, and location of this trial were the same as the previous trial. All fungicides were applied with a Lee Spider sprayer in a single application at beginning seed (R_3) on 21 August. Headline, Absolute, and Stratego were the most effective treatments in control of Cercospora blight (Table 6). Soybean rust was not detected in the trial. The same treatments suppressed the rate of defoliation significantly according to ratings on 10 October. None of the treatments caused visible evidence of plant injury. Portions of the trial were harvested on 27 November, 30 November, and 7 December due to delays caused by wet weather. None of the fungicide treatments significantly increased yield.

Table 6. Soybean fungicide trial #206, Suffolk.

Treatment and rate/A[z]	Cercospora blight[y] 10 Oct	Defoliation[x] (10 Oct)	Yield[w] (bu/A)	P-value of yield[v]	Seed/lb	Purple seed stain[u]
Untreated	30.0 a	31.3 a	39.9	--	2858	3.5 b-d
Folicur 3.6F 4 fl oz	18.8 c	26.3 a	41.1	.7195	2821	4.0 a-d
Absolute 500SC 5 fl oz	10.0 d	11.3 f	39.0	.7955	2756	2.8 b-d
Stratego 250EC 10 fl oz + Induce 2.6 fl oz	11.3 d	13.8 ef	39.3	.8757	2784	2.0 cd
Domark 230ME 4 fl oz	18.8 c	20.0 cd	44.8	.1481	2705	1.8 cd
Domark 230ME 5 fl oz	17.5 c	18.8 c-e	42.1	.5120	2740	6.0 ab
Folicur 3.6F 4 fl oz	25.0 ab	17.5 de	43.0	.3584	2707	7.3 a
Headline 2.09EC 6 fl oz	6.3 d	11.3 f	39.5	.9057	2700	1.0 d
Laredo 2EC 7 fl oz	22.5 bc	23.8 bc	42.8	.3918	2743	4.5 a-c
Quadris 2.08SC 6 fl oz	20.0 bc	23.8 bc	39.8	.9820	2760	2.5 cd
LSD	**6.1**	**5.1**	**n.s.**		**n.s.**	**3.3**

[z] All treatments were applied on 21 Aug.
[y] Percentage of leaf area with disease symptoms.
[x] Defoliation rating scale: 0=none, 100=no leaves on plants.
[w] Yield of soybeans with 13.5% moisture. One bushel equals 60 lb.
[v] *P*-values are for comparison of each treatment to untreated using orthogonal contrast procedure.
[u] Percentage of 100 seeds with symptoms of disease.
Means followed by the same letter(s) in a column are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$), "n.s." = not significant. Arcsine transformation of percentage data was made in analysis to determine statistical significance.

Tidewater AREC, Trial 306, Suffolk (Phipps and Partridge). The field site was planted to S57-P1 on 24 May. The soil type was Dragston fine sandy loam that was planted to corn in 2005. Plots were eight 30-foot rows spaced 18 inches apart. Roundup Ultra Max at 22 fluid ounces per acre was applied for weed control. All treatments were applied using a Lee Spider sprayer at R_3 on 21 August. Plots were harvested on 20 November with a small-plot combine. None of the treatments caused symptoms of chemical injury on leaves, stems or pods. Soybean rust was not detected in the trial. Brown spot and frogeye leaf spot occurred at low levels throughout the growing season and were not believed to reduce yield (Table 7). Cercospora blight was the most likely disease to suppress yield in the untreated check based on percentages of leaf area with symptoms of disease on 10 October. All fungicide treatments resulted in significant suppression of Cercospora blight. Treatments with Quadris 6 fluid ounces per acre and Quilt 14 fluid ounces per acre + Quadris 1.5 fluid ounces per acre significantly reduced levels of defoliation on 10 October. A tank mix of Headline 4.7 fluid ounces + Folicur 3.1 fluid ounces per acre was the only treatment to increase yield significantly compared to the untreated check. All treatments resulted in significant reductions in the incidence of purple seed stain.

Table 7. Soybean fungicide trial #306, Suffolk.

Treatment and rate/A[z]	Cercospora blight[y] (10 Oct)	Defoliation[x] (10 Oct)	Yield[w] (bu/A)	P-value of yield[v]	Seed/lb	Purple seed stain[u]
Untreated	25.0 a	45.0 a	40.1	--	2789	6.8 a
Quadris 2.08SC 6 fl oz	8.8 b	12.5 c	40.8	.8020	2735	1.8 b
Quilt 1.67SC 14 fl oz + Quadris 2.08SC 1.5 fl oz	8.8 b	13.8 c	40.5	.9092	2801	1.0 b
Headline 2.09SC 6 fl oz	13.8 b	23.8 bc	41.8	.5548	2771	0.8 b
Quilt 1.67SC 14 fl oz + COC 20.5 fl oz	13.8 b	20.0 bc	41.6	.6168	2747	2.5 b
Alto 0.83SL 4 fl oz + Quadris 2.08SC 5.5 fl oz + Induce 5.12 fl oz	13.8 b	32.5 ab	41.2	.7155	2817	1.5 b
Quilt 1.67SC 14 fl oz + Quadris 2.08SC 1.5 fl oz + COC 20.5 fl oz	12.5 b	21.3 bc	42.3	.4412	2806	1.5 b
Headline 2.09SC 4.7 fl oz + Folicur 432SC 3.1 fl oz	11.3 b	22.5 bc	47.6**	.0148	2767	1.3b
LSD	**7.6**	**15.6**	**n.s.**		**n.s.**	**2.5**

[z] All treatments were applied on 21 Aug.
[y] Percentage of leaf area with disease symptoms.
[x] Defoliation rating scale: 0=none, 100=no leaves on plants.
[w] Yields are soybeans with 13.5% moisture. One bushel equals 60 lb. **Denotes yield significantly different from untreated ($P \leq 0.05$).
[v] *P*-values are for comparison of each treatment to untreated using orthogonal contrast procedure.
[u] Percentage of 100 seeds with symptoms of disease.
Means followed by the same letter(s) in a column are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$), "n.s." = not significant. Arcsine transformation of percentage data was made in analysis to determine statistical significance.

Tidewater AREC, Trial 406, Suffolk (Phipps and Partridge). The variety, planting date, cultural practices, and location of this trial were the same as the previous trial. All fungicides were applied with a Lee Spider sprayer in a single application at beginning seed (R_3) on 21 August. Plots were harvested on 20 November with a small-plot combine. None of the treatments caused symptoms of chemical injury to leaves, stems or pods. Soybean rust was not detected in the trial. All fungicide treatments resulted in significant suppression of Cercospora blight. Application of Enable 7.1 fluid ounces per acre w/crop oil on 25 July followed by an application of Headline 7.1 fluid ounces per acre on 8 August or 11 August were significantly superior to other treatments in suppression of Cercospora blight (Table 8). All fungicide treatments showed significantly lower defoliation than the untreated check on 10 October. The highest level of leaf health and retention was observed in plots treated with Enable 7.1 fluid ounces per acre with crop oil on 25 July followed by an application of Headline 7.1 fluid ounces per acre on 8 August. Treatments with Enable followed by Headline resulted in the greatest reduction in purple seed stain.

Table 8. Soybean fungicide trial #406, Suffolk.

Treatment, rate/A and application date	Cercospora blight[z] (10 Oct)	Defoliation[y] (10 Oct)	Yield[x] (bu/A)	P-value of yield[w]	Seed/lb	Purple seed stain[v]	Phomopsis seed blight[v]
Untreated	22.5 a	53.8 a	38.8	--	2838 a	12.0 a	2.5
Laredo 2EC 7 fl oz (8/21)	17.5 ab	32.5 b	38.0	.7821	2776 a-c	10.0 ab	1.8
Laredo 2EC 5 fl oz (8/21)	13.8 b	23.8 bc	39.0	.9255	2747 a-c	8.8 a-c	2.3
Enable 2F 7.1 fl oz + Crop Oil 0.5% v/v (7/25) Headline 2.08EC 7.1 fl oz (8/8)	7.5 c	15.0 c	43.1	.1344	2695 c	3.0 de	2.8
Laredo 2EC 7 fl oz (8/21)	13.8 b	32.5 b	40.3	.5814	2827 ab	6.3 b-d	1.5
Laredo 2WC 5 fl oz (8/21)	15.0 b	32.5 b	40.1	.6455	2760 a-c	5.0 c-e	2.3
Enable 2F 7.1 fl oz + Crop Oil 0.5% v/v (7/25) Headline 2.08SC 7.1 fl oz (8/11)	7.5 c	20.0 bc	37.5	.6620	2733 bc	1.8 e	2.8
LSD	**5.8**	**15.3**	**n.s.**		**96**	**3.9**	**n.s.**

[z] Percentage of leaf area with disease symptoms.
[y] Defoliation rating scale: 0=none, 100=no leaves on plants.
[x] Yields are weight of soybeans with 13.5% moisture. One bushel equals 60 lb.
[w] *P*-values are for comparison of each treatment to untreated using orthogonal contrast procedure.
[v] Percentage of 100 seeds with symptoms of each disease.
Means followed by the same letter(s) in a column are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$), except seed weight means were analyzed at $P \leq 0.10$ for significant differences. "n.s."=not significant. Arcsine transformation of percentage data was made in analysis to determine statistical significance.

Southampton County, Trial 506, Foxhill Farms (Phipps and Partridge). The field site was planted to cotton in 2004 and 2005. Seed of DP 5634RR were planted in rows spaced 36 inches apart on 28 May with Temik 15G 5 pounds per acre in furrow. Standard practices for production of glyphosate-resistant soybeans were followed after planting. Plots were 12 feet wide by 30 feet long and treatments were replicated in four randomized complete blocks. A single application of treatments was applied with a backpack sprayer at beginning pod stage (R_3) on 17 August. Low levels of frogeye leaf spot, brown spot, and Cercospora blight were observed in disease ratings on 10 September (Table 9). Observations at beginning senescence of foliage showed moderate levels of Cercospora blight on foliage in untreated plots on 11 October. All fungicide treatments reduced Cercospora blight. The greatest level of disease suppression was observed in plots treated with Headline 6 fluid ounces per acre, Absolute 5 fluid ounces per acre, Stratego 10 fluid ounces per acre with Induce, and Quilt 14 fluid ounces per acre with crop oil. These same treatments also showed the lowest level of defoliation and fewer Cercospora lesions on stems and pods. No soybean rust was detected in the field. Domark 5 fluid ounces per acre and Absolute 5 fluid ounces per acre were the only treatments that increased yields significantly compared to the untreated check according to orthogonal contrasts. The incidence of purple seed stain was suppressed significantly by all treatments except the triazole fungicides (Domark, Laredo, Folicur).

Table 9. Soybean fungicide trial #506, Capron.

Treatment and rate/A[z]	Cercospora blight[y] (11 Oct)	Defoliation[x] (11 Oct)	Yield[w] (bu/A)	P-value of yield[v]	Seed/lb	Purple seed stain[u]
Untreated	22.5 a	62.5 a	39.6	--	2519	3.8 a
Quadris 2.08SC 6 fl oz + COC 20.5 fl oz	11.3 c-e	43.8 bc	44.5	.2144	2487	0.0 d
Quilt 1.67SC 14 fl oz + COC 20.5 fl oz	8.8 d-f	38.8 c	44.2	.2420	2465	0.5 b-d
Stratego 250EC 10 fl oz + Induce 2.56 fl oz	8.8 d-f	38.8 c	42.8	.4199	2460	0.3 cd
Absolute 500SC 5 fl oz	7.5 ef	35.0 c	46.8*	.0739	2421	0.3 cd
Headline 2.08EC 6 fl oz	6.3 f	37.5 c	43.6	.3108	2422	0.0 d
Folicur 432SC 4 fl oz	12.5 b-d	51.3 b	43.3	.3531	2447	2.3 ab
Laredo 2EC 7 fl oz	16.3 b	51.3 b	41.7	.5922	2450	2.8 a
Domark 230ME 5 fl oz	15.0 bc	51.3 b	49.5**	.0171	2452	2.0 a-c
LSD	**4.6**	**8.8**	**n.s.**		**n.s.**	**1.8**

[z] All treatments applied on 17 Aug.
[y] Percentage of leaf area with disease symptoms.
[x] Defoliation rating scale: 0=none; 100=no leaves on plants.
[w] Yields are weight of soybeans with 13.5% moisture. One bushel equals 60 lb; * and ** denote yields significantly different from untreated at $P \leq 0.10$ and $P \leq 0.05$, respectively.
[v] *P*-values are for comparison of each treatment to untreated using orthogonal contrast procedure.
[u] Percentage of 100 seeds with symptoms of disease.
Means followed by the same letter(s) in a column are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$), "n.s." = not significant. Arcsine transformation of percentage data was performed for statistical significance.

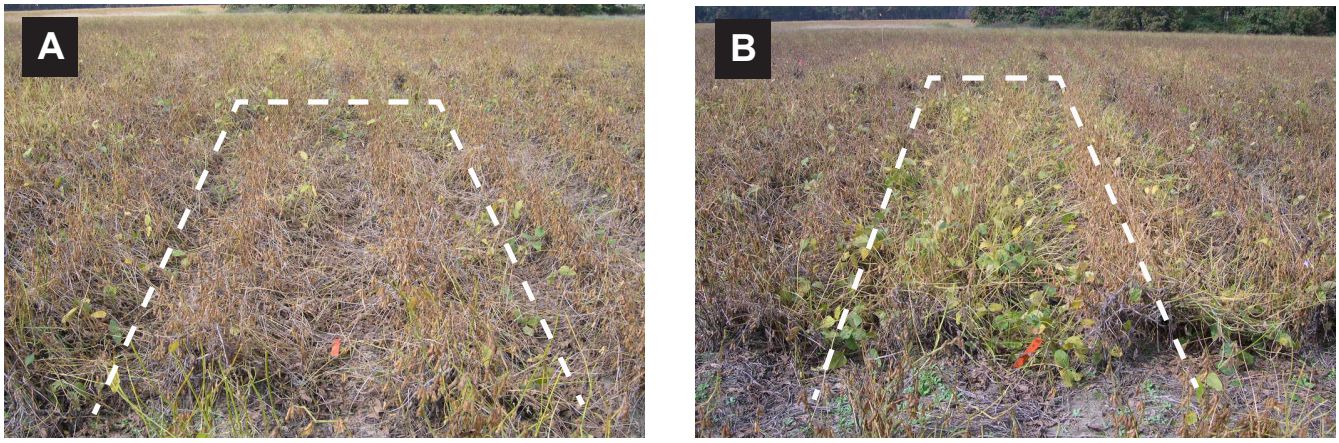

Fig. 3. Soybean plots on 19 October at Fox Hill Farms; A) Untreated check, B) Headline 6 fluid ounces per acre applied on 17 Aug.

Greensville County, Trial 606, Hawkins Farm (Phipps and Partridge). Soil at the field site was Emporia loamy fine sand planted to soybean in 2005 and cotton in 2004 and 2003. Seed of Pioneer 95B96RR were planted in rows spaced 12 inches apart on 18 May. Standard practices for production of glyphosate-resistant soybeans were followed after planting. Plots were 12 feet wide by 30 feet long and treatments were replicated in four randomized complete blocks. A single application of treatments was made with a backpack sprayer at beginning pod stage (R_3) on 17 August. Low levels of frogeye leaf spot, brown spot, and Cercospora blight were observed on 11 September (not shown). Only the incidence of Cercospora blight increased to levels with potential for causing a loss of yield according to ratings on 11 October. Untreated plots showed significantly greater defoliation than fungicide treated plots on 11 October (Table 10) and 19 October (Fig. 4). Soybean rust was detected in the field at low levels of incidence on 23 October. Treatments with Absolute 5 fluid ounces per acre and Headline 6 fluid ounces per acre provided the best protection against defoliation. Soybeans were harvested on 7 December. The treatment with Absolute increased yield an average of 8.3 bushels per acre above the yield of untreated plots, but the response to treatment was significant only at P=0.1295 according to a comparison by orthogonal contrast. No significant differences in purple seed stain or Phomopsis seed blight were detected in harvested grain.

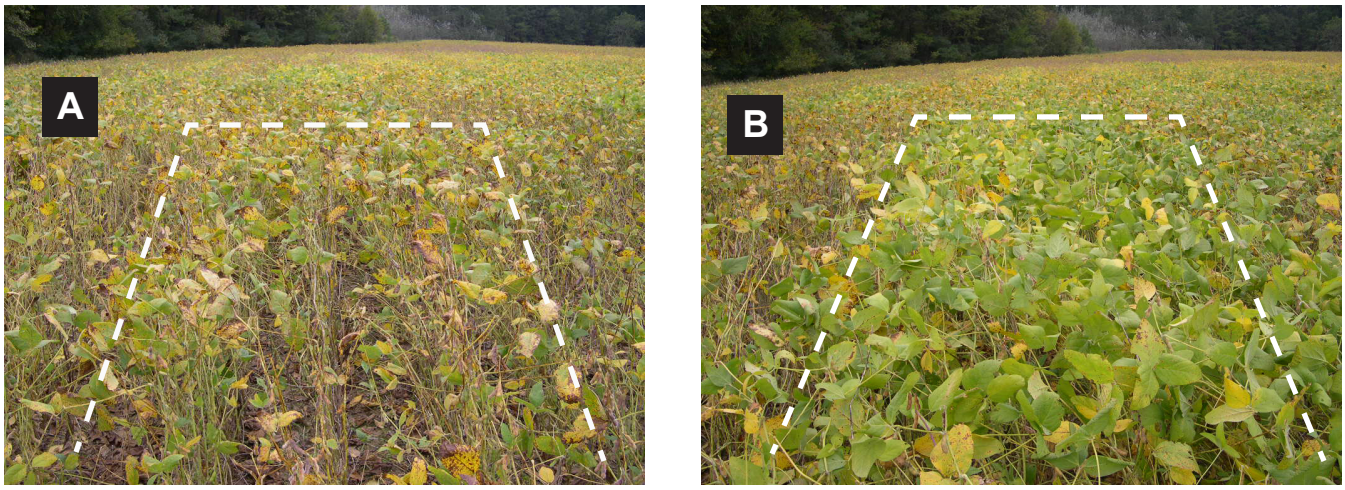

Fig. 4. Soybean plots on 19 October at Hawkins farm; A) Untreated check, B) Headline 6 fluid ounces per acre applied on 17 Aug.

Table 10. Soybean fungicide trial #606, Skippers.

Treatment and rate/A[z]	Cercospora blight[y] (11 Oct)	Defoliation[x] (11 Oct)	Yield[w] (bu/A)	P-value of yield[v]	Seed/lb	Purple seed stain[u]
Untreated	36.3 a	66.3 a	32.4	--	2962	6.8
Quadris 2.08SC 6 fl oz + COC 20.5 fl oz	16.3 de	28.8 c	36.3	.4752	2796	4.8
Quilt 1.67SC 14 fl oz + COC 20.5 fl oz	12.5 ef	17.5 de	37.9	.3090	2725	2.0
Stratego 250EC 10 fl oz + Induce 2.56 fl oz	13.8 d-f	18.8 de	32.7	.9658	2754	1.3
Absolute 500SC 5 fl oz	10.0 fg	16.3 e	40.7	.1295	2739	1.8
Headline 2.08EC 6 fl oz	7.5 g	15.0 e	31.8	.9062	2684	1.0
Folicur 432SC 4 fl oz	21.3 c	30.0 c	35.6	.5500	2685	5.5
Laredo 2EC 7 fl oz	26.3 b	48.8 b	35.0	.6305	2817	3.3
Domark 230ME 5 fl oz	17.5 cd	26.3 cd	38.1	.2944	2663	5.8
LSD	**4.2**	**8.4**	**n.s.**		**n.s.**	**n.s.**

[z] All treatments applied on 17 Aug.
[y] Percentage of leaf area with disease symptoms.
[x] Defoliation rating scale: 0=none; 100=no leaves on plants.
[w] Yield of soybeans with 13.5% moisture. One bushel equals 60 lb.
[v] *P*-values are for comparison of each treatment to untreated using orthogonal contrast procedure.
[u] Percentage of 100 seeds with symptoms of disease.
Means were compared for significant different by Fisher's Protected LSD ($P \leq 0.05$), "n.s." = not significant. Arcsine transformation of percentage data was performed for statistical significance.

Eastern Shore AREC, Painter (Rideout and Waldenmaier).

The trials were conducted on a Bojac fine sandy loam soil (organic matter <1%). Standard practices for weed and insect control were followed in both trials. Conventional-tillage, full-season soybeans (cultivar S39N4RR) were planted on 26 May and no-till double-cropped soybeans (cultivar V622NRR) were planted on 19 July following wheat. Emergence in the double-cropped trial was affected by heavy rainfall throughout the growing season. Both trials were also inundated with 9 inches of rainfall and strong winds from Tropical Storm Ernesto on 1 September. Plots consisted of two 30-foot rows spaced 2.5 feet apart bordered by two non-treated rows. Treatments were arranged in a randomized complete block design with five (full-season trial) or four replications (double-cropped trial). Treatments were applied with a CO_2-pressurized backpack sprayer which delivered 20 gallons per acre at 42 psi. The spray boom had four 8002VS nozzles spaced 18 inches apart. Treatments were applied to the full-season soybeans on 7 August when soybeans were at reproductive stage R_3 and no-till soybeans on 8 October at stage R_5. Soybean harvest was delayed due to excessive rainfall through November and the early part of December. Soybeans were harvested and weighed on 11 December in full-season plots and 12 December in double-cropped plots. A 100-seed sample was collected from each plot during harvest to assess seed weight and percent discolored seeds.

Results

Full-season Soybean Trial – In the full season trial, canopy growth was greater than average throughout the summer. Large canopy growth coupled with excessive moisture promoted development of downy mildew; however, no significant differences in disease development according to treatment were observed. No other significant diseases were noted in this trial. Winds from Tropical Storm Ernesto bent the stems and removed some foliage. Frequent rainfall throughout the fall delayed harvest for nearly two months. No differences in yields according to treatment were observed (Table 11). Similarly, no differences in 100-seed weight or percent discolored seed were noted.

Double-cropped Soybean Trial – This trial was planted late to favor development of soybean rust. Seedling emergence was negatively impacted by excessive rainfall throughout August and September. Excessive rainfall suppressed plant development throughout the growing season. Trace

amounts of soybean rust were detected in this trial on November 1, just prior to a killing frost. Disease severity was not sufficient to constitute an assessment. Yields in this trial were poor and no significant differences were detected according to treatments (Table 11). No differences were observed in 100-seed weights or percent discolored seed.

Table 11. Soybean yields and percent discolored seed from a full-season and a double-cropped soybean fungicide trial conducted at the ESAREC in Painter in 2006.

	Full season		Double cropped	
Treatment (Rate/A)	**Yield (bu/A)**	**Discolored Seed (%)**	**Yield (bu/A)**	**Discolored Seed (%)**
Nontreated Control	40.8 a[z]	34.4 a	3.7 a[z]	54.7 a
Quadris 2.08SC 6 floz +COC 1% v/v	38.2 a	35.6 a	4.2 a	51.5 a
Quilt 1.67SC 14 floz + COC 1% v/v	37.7 a	26.0 a	4.2 a	50.6 a
Stratego 250EC 10 floz + Induce 0.1% v/v	33.4 a	34.0 a	4.7 a	52.9 a
Absolute 500SC 5 floz	38.1 a	31.2 a	4.5 a	43.3 a
Headline 2.08EC 6 floz	35.8 a	35.2 a	5.7 a	47.1 a
Folicur 3.6F 4 floz	31.7 a	28.4 a	4.3 a	51.9 a
Laredo 2EC 7 floz	39.3 a	30.0 a	5.2 a	52.2 a
Domark 230ME 5 floz	39.9 a	30.4a	5.6 a	51.0 a

[z] Means within each column followed by the same letter are not significantly different ($P \leq 0.05$, Fisher's LSD).

Eastern Virginia AREC, Warsaw (Stromberg). Summary for 2006 Soybean Fungicide Trials – FULL SEASON

Soybean cultivar Vigoro V48N5RR

Full-season soybeans planted on 6 June

Herbicides: Python 0.9 oz/A + Dual 1.0 pint/A PPI
RoundUp 1 qt/A postemergence on 25 July

Fertilizer: 0-60-60 per acre

Insecticide: Warrior T 3.84 oz/A on 21 August for corn ear worm and stink bugs

Fungicide applications:
Treatments 2-9 applied at R_{1-2} on 24 July
Treatments 10-17 applied at R_3 on 2 August
2nd applications, treatments 11, 14, 15, 16, and 17 applied on 23 August

Disease ratings: upper and lower canopy.

Table 12. Soybean fungicide trial in full-season planting, EVAREC, Warsaw.

Treatment, rate/A and application date[z]	Brown spot (Lower leaves)[y] 30 Aug	Upper leaves[y] Phyto-toxicity 30 Aug	Brown spot 20 Sep	Target spot 20 Sep	Yield[x] bu/A	100 seed wt (g)/
Non-treated	25.5 a	0.0 c	13.8 a	3.0 a	51.4 c	19.4 d
Quadris 6.0 fl oz COC 20.5 fl oz (7/24)	2.3 b	0.0 c	2.8 b	1.0 b	56.4 abc	21.0 abc
Quilt 14.0 fl oz COC 20.5 fl oz (7/24)	2.0 b	2.5 bc	1.8 b	1.5 b	54.8 bc	21.3 ab
Stratego 10.0 fl oz Induce 2.56 fl oz (7/24)	2.0 b	0.0 c	2.8 b	0.8 b	58.1 abc	21.0 abc
Absolute 5.0 fl oz (7/24)	2.3 b	3.3 bc	1.3 b	0.6 b	58.7 abc	21.3 ab
Folicur 4.0 fl oz (7/24)	2.3 b	20.0 a	1.8 b	0.6 b	54.9 bc	20.9 abc
Laredo 7.0 fl oz (7/24)	2.8 b	3.8 bc	3.8 b	0.4 b	57.1 abc	20.0 bcd
Domark 5.0 fl oz (7/24)	2.8 b	0.0 c	2.8 b	0.8 b	57.0 abc	19.7 cd
Headline 6.0 fl oz (7/24)	1.8 b	0.0 c	2.0 b	1.3 b	63.7 ab	21.5 ab
Headline 6.0 fl oz + NIS 0.125% v/v (8/2)	1.3b	0.0 c	1.5 b	0.4 b	63.4 ab	21.0 abc
Headline 6.0 fl oz + NIS 0.125% v/v (8/2) Caramba 8.2 fl oz (8/23)	1.3 b	3.3 bc	0.8 b	0.9 b	63.0 ab	21.0 abc
Headline SBR 7.8 fl oz (8/2)	1.8 b	3.8 bc	1.3 b	0.6 b	64.6 ab	21.4 ab
Headline Caramba CoPack 11.9 fl oz (8/2)	1.0 b	3.3 bc	0.8 b	0.2 b	68.1 a	21.7 a
Headline Caramba CoPack 11.9 fl oz (8/2) Caramba 8.2 fl oz (8/23)	1.0 b	6.3 bc	0.8 b	0.4 b	63.4 ab	22.4 a
Headline Caramba CoPack 11.9 fl oz (8/2) Headline Caramba CoPack 9.6 fl oz (8/23)	1.0 b	10.8 b	1.3 b	1.3 b	66.9 ab	21.4 ab
Headline 6.0 fl oz +NIS 0.125% v/v (8/2) Headline Caramba CoPack 9.6 fl oz (8/23)	1.3 b	1.0 c	1.5 b	0.6 b	64.5 ab	21.4 ab
Headline SBR 7.8 fl oz (8/2) Headline SBR 5.9 fl oz (8/23)	1.0 b	1.5 c	1.3 b	0.2 b	67.4 a	21.5 ab

[z] Treatments 2-9 applied at R1-2 on 24 July; treatments 10-17 applied at R3 on 2 August ; 2nd applications, treatments 11, 14, 15, 16, and 17 applied on 23 August.
[y] Data are percent of leaf area with symptoms.
[x] Yield of soybeans with a mean of 10.6% moisture. One bushel equals 60 lb. Soybeans were harvested 1 Nov.
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL

Eastern Virginia AREC, Warsaw (Stromberg). Summary for DC-Soybean Fungicide Trial 2006 – DOUBLE CROPPED

Cultivar: Vigoro V48N5RR
Planted on 12 July 2006 no-tillage into wheat stubble
Herbicides: Gramoxone 1 pint/A on 10 July 2006 (burndown).
Dual 1 pint/A + RoundUp 1 qt/A on 23 August 2006
Insecticide: Warrior T 3.84 oz/A on 21 August 2006 for corn ear worms and stinkbug

Fungicides:

Treatments 2-9 applied at R1 on 15 August 2006

Treatments 10-17 applied at R3 on 28 August 2006

2nd applications 11, 14, 15, 16, and 17 applied on 11 September 2006

Disease ratings: upper and lower canopy.

Table 13. Soybean fungicide trial in double-cropped planting.

	Lower leaves[y]		Upper leaves[y]			
Treatment and rate/A[z]	**Brown spot 20 Sep**	**Target spot 20 Sep**	**Brown spot 20 Sep**	**Downy mildew 20 Sep**	**Yield bu/A[x]**	**100 seed wt (g)/**
Non-treated	4.3 a	0.5 a	0.5 a	4.0 a	31.7 a	18.6 a
Quadris 6.0 fl oz +COC 20.5 fl oz (8/15)	1.0 b	0.0 a	0.3 a	2.8 ab	30.2 a	19.1 a
Quilt 14.0 fl oz + COC 20.5 fl oz (8/15)	1.1 b	0.0 a	0.5 a	1.3 b	30.3 a	18.5 a
Stratego 10.0 fl oz + Induce 2.56 fl oz (8/15)	1.1 b	0.1 a	0.5 a	2.0 b	30.3 a	18.8 a
Absolute 5.0 fl oz (8/15)	0.5 b	0.0 a	0.3 a	1.5 b	30.5 a	18.6 a
Folicur 4.0 fl oz (8/15)	1.0 b	0.3 a	0.5 a	1.0 b	31.1 a	18.8 a
Laredo 7.0 fl oz (8/15)	1.2 b	0.0 a	0.3 a	1.5 b	30.8 a	18.7 a
Domark 5.0 fl oz (8/15)	1.3 b	0.6 a	0.2 a	2.3 b	30.6a	18.6 a
Headline 6.0 fl oz (8/15)	0.8 b	0.3 a	0.3 a	2.8 ab	29.7 a	19.3 a
Headline 6.0 fl oz + NIS 0.125% v/v (8/28)	0.5 b	0.1 a	0.3 a	2. b	31.0 a	19.4 a
Headline 6.0 fl oz + NIS 0.125% v/v (8/28) Caramba 8.2 fl oz (9/11)	0.8 b	0.3 a	0.3 a	1.3 b	30.5 a	19.4 a
Headline SBR 7.8 fl oz (8/28)	0.8 b	0.3 a	0.3 a	1.8 b	30.8 a	19.5 a
Headline Caramba CoPack 11.9 fl oz (8/28)	1.1 b	0.1 a	0.8 a	1.5 b	30.7 a	19.6 a
Headline Caramba CoPack 11.9 fl oz (8/28) Caramba 8.2 fl oz (9/11)	0.7 b	0.1 a	0.5 a	1.5 b	30.8 a	19.6 a
Headline Caramba CoPack 11.9 fl oz (8/28) Headline Caramba CoPack 9.6 fl oz (9/11)	0.5 b	0.0 a	0.5 a	1.5 b	31.1 a	19.6 a
Headline 6.0 fl oz + NIS 0.125% v/v (8/28) Headline Caramba CoPack 9.6 fl oz (9/11)	0.7 b	0.0 a	0.3 a	1.5 b	31.6 a	19.4 a
Headline SBR 7.8 fl oz (8/28) Headline SBR 5.9 fl oz (9/11)	0.7 b	0.0 a	0.3 a	1.5 b	30.3 a	19.2 a

[z] Treatments 2-9 applied at R1-2 on 15 August; treatments 10-17 applied at R3 on 28 August ; 2nd applications, treatments 11, 14, 15, 16, and 17 applied on 11 September.
[y] Data are percent of leaf area with symptoms.
[x] Yield of soybeans with a mean of 13.9% moisture. One bushel equals 60 lb. Soybeans were harvested 1 Nov.
Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL

Summary: Soybean Rust Incidence and the Response of Soybeans to Foliar Fungicides in 2006

1. Ten regional sentinel plots and ca. 40 commercial fields were scouted from flowering to senescence for detection of soybean rust in 2006.

2. Sentinel plots were located at the Tidewater AREC (Suffolk), Southampton County (Courtland), Eastern Shore AREC (Painter), Northampton County, Shenandoah County, Southern Piedmont AREC (Blackstone), New Kent County, Northern Piedmont AREC (Orange), Eastern Virginia AREC (Warsaw), and Virginia Tech – Kentland Farm (Blacksburg).

3. The first outbreak of soybean rust, caused by *Phakopsora pachyrhizi*, was in Chesapeake on 9 October and Suffolk on 10 October; thereafter, the disease was confirmed in 18 counties and cities in Eastern Virginia. No loss of yield to soybean rust was expected since the disease appeared when soybeans were at growth stage R_6 (full pod) or later.

4. High temperatures and below normal rainfall until the arrival of tropical storm Ernesto on 30 August suppressed yield and were unfavorable for soybean rust; thereafter, cooler temperatures and frequent rainfall in September and October were favorable for disease spread and development.

5. Cercospora blight, caused by *Cercospora kikuchii*, was the primary foliar disease that appeared to be responsible for yield losses of soybeans in 2006.

6. Fungicide treatments with Headline, Absolute, Quilt, and Stratego provided superior control of Cercospora blight. Significant yield increases ($P \leq 0.05$ or 0.10) were obtained with sprays of Absolute, Domark, and Headline either alone or Headline tank mixed with Folicur or Caramba.

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