Summary of the USDA Fungicide Efficacy Trials to Control Soybean Rust in Paraguay 2002-2003

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Executive Summary

The Asian soybean rust, caused by *Phakopsora pachyrhizi*, is one of the most devastating diseases of soybean world wide, causing yield losses of up to 80 % in experimental plots. With the spread into South America the pathogen has become a threat to soybean production in the continental U.S. Fungicides, although not commonly used on soybean in the U.S., will be the primary method of control. The objectives of these trials were to evaluate soybean rust control and yield benefits from fungicides that are or could be registered for use in the continental U.S. Fungicide efficacy trials were located in the Parana River basin of southern Paraguay during the 2002–2003 growing season. A total of 20 fungicide treatments were evaluated in plots that received either two or three fungicide applications. A total of five locations were included in the trial, data from three locations were summarized. All compounds controlled soybean rust when compared to the untreated control; disease severity was less in all the plots treated with fungicides. Seed weights and yield varied but were inconsistent to draw conclusions about the effectiveness of fungicides in terms of preventing yield losses since disease severity was low. To make future trials more effective, experimental locations need to be identified where irrigation and inoculation can be provided. If natural inoculation and rainfall are relied upon to provide disease severities sufficient to evaluate fungicides then the number of locations and years of testing will need to be increased.

Introduction

The Asian soybean rust, caused by *Phakopsora pachyrhizi*, can drastically reduce yields. In experimental plots, yield losses up to 80% have been reported. The pathogen has been limited to the Eastern hemisphere until it was found in Hawaii in 1994 (Fig.1). Currently, the distribution of *P. pachyrhizi* includes Africa, Asia, Australia, South America, and Hawaii. The rapid spread of *P. pachyrhizi* in less than a decade and its potential for severe yield losses makes this the most destructive foliar disease of soybean. Soybean rust could have a major impact on both total soybean production and production costs in the U.S.

The most current recommendations for chemical control of soybean rust have come from Zimbabwe and South Africa (C. Levy, pers. comm.). Three fungicide applications were recommended, with the first application 50 days after planting or at early flowering. Second and third applications were 20 and 40 days after the first or at 70 and 90 days after planting, to provide protection during pod fill. If the disease was not severe then the recommendation was for two applications were recommended to prevent early leaf drop and yield loss. Punch (flusilazole/carbendazim) and Shavit (triadimenol) were found to be the most effective compounds for controlling soybean rust.

There are only a few fungicide compounds currently registered for foliar application on soybean in the U.S. Among them are Bravo® and Echo® (chlorothalonil), and Topsin® M (thiabendazole), and Quadris® (azoxystrobin). Efficacy data is limited on all three classes of compounds. Chlorothalonil and thiabendazole have been reported to be as effective or less effective than Dithane® M45 (mancozeb). Quadris, a strobilurin, has limited data from efficacy trials in Brazil and Africa but does control soybean rust. Additional fungicides are needed for resistance management strategies as well as economic and supply limitations. The objectives of these trials in Paraguay were to evaluate soybean rust control and yield benefits from fungicides that are or could be registered for use in the continental U. S.

Methods

Fungicide efficacy trials were located in the Parana river basin of southern Paraguay during the 2002–2003 growing season in cooperation with W. Morel, Ministerio de Agricultura y Granaderia, Centro Regional de Investigacion Agricola (CRIA), Capitan Miranda, Paraguay. A total of 20 fungicide treatments were evaluated in plots that received either two or three fungicide applications (Table 1). The first application was at growth stage R1 (first flower) with subsequent applications spaced 20 days apart. Field design was a complete randomized block with 4 replications per location. Initially, two locations were planned. With the low rust severity in the early planted soybeans additional locations were added. Product was applied at 66 psi using 400 ml of water per plot. Plots were 9.6 m in length and six rows wide at a row spacing of 0.4 m. Applications were made using a hand held spray boom with pressurized CO_2 bottles. The boom had four flat fan nozzles, spaced 0.4 m apart. One pass was made per plot, per application on four rows of the plot. The center three rows of the six-row plot were used for data collection. Three rows each 5 m in length were cut from each plot to evaluate yields. Seed was weighed and graded; all results were adjusted to 13% moisture.

Results

A summary of three locations was analyzed since the earliest planted location was lost and data from last location has not been received. Disease severity at all three locations was generally low as the control plots averaged 27% severity at growth stage R6 (full pod set) (Table 2). There were differences among treatments; all had less disease severity ratings than the control. There was a significant location by treatment interaction. There was a significant difference between two and three fungicide applications, with three applications having less disease severity at two of the three locations.

When 1000 seed weights were compared there was a significant treatment by location interaction (Table 3). Part of this interaction may be due to the lack of significant differences at the Yasu location. At the Sato and TRP locations, there were compounds that increased 1000 seed weights compared to the control. There were also compounds that differed in rank between the two locations and contributed to the treatment by location interaction. The Yasu location had the greatest 1000 seed weights, was the highest yielding and had the least amount of disease. However, at Yasu there were no differences among treatments when 1000 seed weights were compared. It would seem that rust had no impact at this location. The Sato location had similar rust severity to that seen at Yasu, but was lower yielding and had lower 1000 seed weights. While the TRP location had lowest seed weights and the most severe rust.

If only the data from Sato and TRP locations are used, then BAS 500, AMS 21619, Echo 720 and Quadris consistently had rankings better than Dithane, followed by Folicur and BAS 516. These compounds appeared to provide more yield protection in the presence of rust. Stratego, Systhane and Enable, at the higher rate, were inconsistent.

Two compounds, Folicur and BAS 516 had significantly greater yields (kg/ha) then that of the control (Table 4). The yields of seven other compounds were statistically similar to the highest yielding treatment, but were not different from the control. Mean yields did not differ when two or three applications were used. There was no treatment by location interaction for yield.

Discussion and Conclusions

The 2002–2003 growing season was hot and dry at these three locations in Paraguay. Soybean rust was not a major factor in soybean production in the areas where the trials were located. As a result, in the three location summarized, disease was not severe enough to determine the efficacy of the fungicides in the trial. All compounds controlled soybean rust as seen in the reduced severities when compared to the untreated control. However, the effects of the fungicides on yields are not as clear. There were no significant yield differences observed when two and three applications were compared, even when there were reductions in disease severity observed with the third application. Among the fungicides, Folicur and BAS 516 appear to provide the best yield protection when mean yields from the three locations were compared. However, the high mean yield seen with Folicur may be due to the high yield at the Yasu location where rust did not impact yields.

The data can be used to show trends, i.e. all compounds reduced visual disease severity, but comparisons within the inconsistent yield data should be made with caution. Rust severity was not great enough and did not develop early enough to separate the fungicides with confidence. If anything, the trial points to the need to do fungicide efficacy trials in areas where inoculation and irrigation are available. If natural inoculation and rainfall are relied upon to provide disease severities sufficient to evaluate fungicides then the number of locations and years of testing will need to be increased.

Table 1. List of fungicides evaluated in the efficacy trial located in Paraguay during the 2002 - 2003 growing season.

Company	Product/Formulation	Chemical name
BASF	BAS 500 00F (Headline)	pyraclostrobin
	BAS 510 70 % WG (Endura)	boscalid
	BAS 516 UDF 38%WG (Pristine)	pyraclostrobin + boscalid
Bayer	AMS 21619 480SC	new chemistry
	Folicur 3.6F	tebuconazole
	Stratego 250EC	trifloxystrobin + propiconazole
Dow	Dithane DF	mancozeb
	Eagle20EW	myclobutanil
	Enable 2F 75 g ai	fenbuconazole
	Enable 2F 100 g ai	fenbuconazole
	Laredo 2 EC	myclobutanil
	Propimax EC	propiconazole
Nichino America,	Moncut	flutolanil
Sipcam Agro	Echo 720,	chlorothalonil
	Eminent 125SL	tetraconazole
Syngenta	Tilt	propiconazole
	Bravo	chlorothalonil
	Quadris 6 oz rate	azoxystrobin
	Quadris 9 oz rate	azoxystrobin
Control	No Spray	

Table 2. Mean rust severity (%) at growth stage R6 in each fungicide treatment from the three locations of the fungicide efficacy trial located in Paraguay during the 2002-2003 growing season.

	Sato[b]		TRP[b]		Yasu[b]		
Fungicide treatment[a]	Rust severity (%)	Rank within location	Rust severity (%)	Rank within location	Rust severity (%)	Rank within location	Mean rust severity
BAS 500 00F	0.7	20	4.1	20	1.6	13	2.1
Stratego 250EC	2.6	18	6.5	19	1.2	14	3.4
Echo 720	2.8	17	8.0	18	1.6	12	4.1
Eminent 125SL	10.1	7	8.3	16	0.8	19	6.4
Quadris (9 oz/A)	2.6	19	8.3	17	5.5	9	5.5
Quadris (6 oz/A)	3.2	16	8.5	15	12.7	4	8.1
BAS 516 UDF	4.1	15	9.0	14	2.8	10	5.3
AMS 21619 480SC	6.0	12	9.3	13	0.9	15	5.4
Dithane DF	9.8	8	9.9	12	11.7	6	10.4
Laredo 2 EC	8.1	10	9.9	11	0.9	16	6.3
Bravo	7.3	11	10.2	10	14.7	2	10.7
Enable 2F (100g ai/ha)	9.3	9	10.2	9	0.8	18	6.8
Enable 2F (75g ai/ha)	14.6	2	10.5	8	0.9	17	8.6
BAS 510	14.0	3	11.0	7	7.7	8	10.9
Folicur 3.6F	5.5	14	11.5	6	0.6	20	5.9
Systhane 20EW	5.6	13	12.0	5	1.9	11	6.5
Tilt	10.3	6	14.1	4	12.6	5	12.3
Propimax EC	13.1	5	14.7	3	9.8	7	12.5
Moncut	13.4	4	15.7	2	14.5	3	14.5
Control	27.6	1	26.9	1	25.6	1	26.7
Location mean[b]	6.4	A	10.9	B	6.4	A	
Mean of 2 applications[c]	10.4	AB	11.6	A	6.7	C	
Mean of 3 applications[c]	6.7	C	10.2	B	6.2	C	
Mean yield at each location, Kg/ha @13%[b]	2023.2	B	1655.8	C	3730.6	A	

a. All fungicide treatments significantly different from control (p=0.05).
b. Differences between locations significant at (p=0.001), means with different letter were significantly different. There was a significant location by treatment interaction (p=0.0001) seen as differences in ranking within each location.

c. Significant (p=0.05) location by number of applications interaction.

Table 3. Mean 1000 seed weights of each fungicide treatment from the three locations of the fungicide efficacy trial done in Paraguay during the 2002-2003 season.

Fungicide treatment	Sato			TRP			Yasu			Treatment mean	
	1000 seed wt (g) at 13%	Rank within location		1000 seed wt (g) at 13%	Rank within location		1000 seed wt (g) at 13%	Rank within location			
BAS 500 00F	162.4	1		147.3	1		167.1	7	*	158.9	
AMS 21619 480SC	160.9	2		146.4	3		162.4	19	*	156.5	
Echo 720	160.6	3		144.9	6		165.3	12	*	156.9	
Stratego 250EC	160.4	4		137.4	15	*	166.5	10	*	154.8	*
Quadris (9 oz/A)	159.3	5		144.3	7		168.4	3	*	155.6	*
Quadris (6 oz/A)	158.9	6		140.4	10		167.5	5	*	157.3	
Dithane DF	158.1	7		142.9	8		167.0	8	*	156.0	*
BAS 516 UDF	158.0	8		141.5	9		169.6	2	*	156.4	*
Folicur 3.6F	157.6	9		146.0	4		171.1	1	*	158.3	
Tilt	157.5	10		136.0	18	*	167.4	6	*	153.6	*
Eminent 125SL	157.5	11		139.0	13	*	164.8	16	*	153.8	*
Bravo	156.5	12		139.0	14	*	168.1	4	*	154.5	*
Systhane 20EW	156.3	13		145.4	5		165.0	14	*	155.5	*
Enable 2F (75g ai/ha)	156.0	14		137.1	16	*	165.1	13	*	152.8	*
Enable 2F (100g ai/ha)	156.0	15		146.9	2		166.9	9	*	156.6	
Laredo 2 EC	154.6	16	*	139.9	12	*	165.0	15	*	153.2	*
Propimax EC	153.9	17	*	134.5	19	*	164.6	17	*	151.0	*
BAS 510	152.4	18	*	140.4	11		163.9	18	*	152.2	*
Moncut	149.3	19	*	136.8	17	*	161.8	20	*	149.3	*
Control	148.5	20	*	133.5	20	*	165.8	11	*	149.3	*
Location mean[b]	156.7	B		141.0	C		166.2	A			
Mean yield at each location, Kg/ha @13%[b]	2023	B		1656	C		3731	A			

a. Significant differences among treatments within each location, (*) indicates treatments not significantly different from the control within the location. There was a significant treatment by location interaction (p=0.1).

b. Differences among means were significant (p=0.05), means with different letters differed significantly.

Table 4. Mean yield and percent defoliation of soybean plots treated with twenty fungicide treatments at three locations in Paraguay during the 2003-2004 growing season

Fungicide treatment	Yield (K/Ha) at 13 % Moisture[a]		Defoliation[b] (%) at Sato							
			Mean		2 Applic.		Rank	3 Applic.		Rank
Folicur 3.6F	2703	A	86	A	80.0		8	91.3	A	19
BAS 516 UDF	2671	AB	77		80.0		6	73.8		3
Stratego 250EC	2581	ABC	78		70.0		1	86.3	A	13
BAS 500 00F	2551	ABC	73		71.3		2	73.8		2
AMS 21619 480SC	2545	ABC	85		90.0	A	15	80.0		7
Dithane DF	2514	ABCD	74		71.3		3	77.5		6
Enable 2F,100g ai/ha	2513	ABCD	81		85.0	A	11	75.0		4
Echo 720,	2510	ABCD	81		80.0		7	81.3		8
Quadris, 9 oz/A	2502	ABCD	79		71.3		4	86.3	A	14
Quadris, 6 oz/A	2448	BCD	81		81.3		9	81.3		9
Enable 2F,75g ai/ha	2446	BCD	80		76.3		5	86.3	A	15
Bravo	2417	CD	81		86.3	A	12	76.3		5
BAS 510	2396	CD	91	A	92.5	A	20	88.8	A	17
Moncut	2395	CD	86	A	90.0	A	16	81.3		10
Propimax EC	2391	CD	80		90.0	A	17	70.0		1
Tilt	2389	CD	88	A	90.0	A	18	86.3	A	16
Systhane 20EW	2387	CD	82		81.3		10	82.5		11
Control	2383	CD	93	A	91.3	A	19	94.3	A	20
Laredo 2 EC	2366	CD	88	A	87.5	A	14	89.3	A	18
Eminent 125SL,	2288	D	84		86.3	A	13	82.5		12
Mean of 2 applications[c]	2469				82.6					
Mean of 3 applications[c]	2470							82.2		

a. Mean of two application schedules at three locations, four replications per location. No significant location or application interactions.
b. Mean of four replications from the Sato location. Significant treatment by application schedule interaction seen.

Means separated using LSD, means with same letter are statistically the same.