Summary of the USDA Fungicide Efficacy Trials to Control Soybean Rust in Paraguay 2003-2004

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Executive Summary

The Asian soybean rust, caused by *Phakopsora pachyrhizi*, is one of the most devastating diseases of soybean worldwide, causing yield losses of up to 80 % in experimental plots. With the spread of the pathogen in South America the disease has become an increased threat to soybean production in the continental U.S. Fungicides, although not commonly used on soybean in the U.S., will be the primary management tool available to producers. 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, including those listed in the Section 18 Emergency Exemption requests submitted to the EPA. Fungicide efficacy trials were located in the Parana River basin of southern Paraguay during the 2003–2004 growing season. A total of 48 fungicide treatments were evaluated. The majority of the plots received either two or three fungicide applications, but there were single application treatments as well. All compounds controlled soybean rust when compared to the untreated control; disease severity was less in all the plots treated with fungicides. Yield increases were also seen with each of the fungicides in the Section 18 Emergency Exemption request.

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 identification of Asian soybean rust in Paraguay in 2001 (Morel and Yorinori, 2002) and its spread to over 95% of the soybean production in Brazil through the 2004 growing season has heightened the awareness of this disease in the U. S. A. The rapid spread of *P. pachyrhizi* and the potential for severe yield losses makes this the most destructive foliar disease of soybean. Yield losses of 20% to 60% reported in Asia with losses of 80% reported from experimental fields in Taiwan (Hartman *et al*., 1992). Losses in Brazil from the 2003-2004 growing season were estimated at 10% of the annual crop, an increase from the 5% yield loss estimate reported in the 2002-2003 growing season (Yorinori, pers. comm.). Soybean rust, if introduced into the U.S., could have a major impact on both total soybean production and production costs.

In the near future the primary tool to control of soybean rust will be fungicides (Miles, *et al.* 2003a). Fungicides have been used effectively in Southern Africa and South America to manage the disease. Cultural practices have not been shown to be effective in controlling the pathogen; recommendations were inconsistent and varied by location. The most effective practices were those that maximized yields in the absence of the disease or were to plant during seasons were the disease could be avoided. Incorporation of resistance into commercial cultivars is several years away and will be made more difficult by the need to use non-race specific resistance.

Fungicide Efficacy. Many fungicides have been evaluated to control soybean rust. Early research from Asia indicated that mancozeb was effective (Hartman *et al*., 1992). Other compounds available at the time were compared to mancozeb and were effective, but results varied by test (Miles *et al*., 2003b). Fungicide trials in India (Patil and Anahosur, 1998) and Southern Africa (Levy, 2004) identified several triazole compounds and

Table 1. Fungicides that are registered and labeled or on a Section 18 Emergency Exemption request for use on soybeans in the U.S.A. to manage Asian soybean rust.

Compound	Product	Company	U. S. A. registration status: Soybeans	U. S. A. registration status: Soybean rust
Azoxystrobin	Quadris®	Syngenta	Yes	Labeled
Chlorothalonil	Bravo® Echo®	Syngenta Sipcam Agro	Yes Yes	Labeled
Myclobutanil	Laredo®	DAS		Section 18[a] Approved 4/04
Propiconazole	Tilt® Propimax® Bumper®	Syngenta DAS Makhteshim-Agan		Section 18[a] Approved 4/04
Pyraclostrobin	Headline ®	BASF		Section 18[a]
Pyraclostrobin + boscalid	Pristine ®	BASF	(Yes[b])	Section 18[a]
Tebuconazole	Folicur®	Bayer		Section 18[a] Approved 8/04
Tetraconazole	Eminent®	Sipcam Agro		Section 18[a]
Trifloxystrobin + propiconazole	Stratego®	Bayer		Section 18[a]

a. http://plantsci.sdstate.edu/draperm/SoybeanRustSection18

b. Boscalid has been registered for use on soybean, but will not be labled for use against soybean rust.

triazole mixes. More recent trials in Africa and South America have identified additional triazoles, (e.g. tebuconazole and tetraconazole), as well as several strobilurins and strobilurin mixes including azoxystrobin, pyraclostrobin, pyraclostrobin + boscalid and trifloxystrobin + propiconazole (Miles *et al*., 2003c). Additional triazoles are commercially available in Brazil; among these are epoxiconazole, cyproconazole and metconazole. These fungicides have been shown to be very effective when mixed with one of the strobilurin compounds.

Labeled and Section 18 compounds. There are three fungicides that are registered for use on soybean, labeled for soybean rust and are commercially available in the U.S.A. (Table 1). These fungicides are Bravo®, Echo® and Quadris®. Quadris® is an azoxystrobin; Bravo and Echo are both chlorothalonils. There has been a Section 18 Emergency Exemption request for seven compounds or mixtures of compounds submitted to the EPA by the Departments of Agriculture of Minnesota and South Dakota (http://plantsci.sdstate.edu/draperm/SoybeanRustSection18). At least 24 other soybean-producing states have followed with requests of their own. Not included on any of the lists are the sulfur, lime, elemental compounds, various oils, and other organic products that may not be a viable management tool in large commercial operations.

Timing and Number of Applications. The most recent experiments evaluating the timing and number of applications for chemical control of soybean rust have come from Zimbabwe and South Africa (Levy *et al*., 2002). Early experiments evaluated the number of applications needed to protect the crop. There were no differences in yields when fungicide application started 28 days after planting (DAP) with five applications, or when application started 48 DAP with four applications. There was a slight yield loss when the first treatment was applied 68 DAP, with three applications in the season. Delaying fungicide application until 88 DAP, with two applications, and 108 DAP, with a single late application, resulted in significant yield losses. Flowering of the cultivars used in the study started between 50 and 60 DAP. When fungicides were applied during the vegetative growth stages, 28 DAP, yields did not increase compared to applications that protected the crop from flowering through grain fill, 48 and 68 DAP.

Experiments that evaluated the timing of applications in post-flowering soybean were completed using two cultivars, Sonata and Soprano, treated with 50 g flusilazole + 100 g carbendazim (Punch Xtra®) in single applications at either 50, 60, 70, 80 or 90 DAP, and two-application treatments at 50+70 DAP, 60+80 DAP or 70+90 DAP. A three-application treatment, 50+70+90 DAP, simulated the recommendation being made to farmers, and a four-application treatment was included to provide total rust control. A single, properly timed application can protect yields when compared to treatments with two or more applications (Levy, 2004). The timing of the application was critical, as applications 10 days earlier or later showed significant yield losses. All treatments with two applications had yields similar to treatments with three or four applications. Late applications had slightly less protection in "Soprano", the indeterminate cultivar when compared to the determinant cultivar "Sonata".

Recommendations. In Southern Africa, the recommendation was made to use a program with two or three fungicide applications (Levy, 2004). Three applications were considered necessary in high disease situations, while two applications were recommended when disease severities were light. For best yield protection the first application was recommended at 50 DAP, at or just ahead of flowering. Subsequent applications 20 days apart were sufficient to control the disease. These recommendations were made in an attempt to limit the exposure of the crop to the disease due to difficulties in obtaining exact timing of a single application. This recommendation was supported by limited data from Paraguay where a single application at flowering had less yield protection than two applications, one at flowering followed by another 20 days later (Miles, unpublished data).

The production practices in Brazil are changing from a single late fungicide application (growth stage R5) used to protect against late season diseases to a two-application program with the first application at growth stage R3 or earlier. These recommendations differ from the recommendations in Southern Africa. As the scenario plays out in South America we will learn more about the timing and number of fungicides applications to manage soybean rust.

The number and timing of applications are critical for the control of soybean rust. The most efficient were applications during early reproductive growth that allowed protection through to crop maturity. The exact number of applications will depend on the length of the reproductive phase of the crop, duration of the compound and severity of the epidemic. Fungicide applications in early vegetative stages, although effective in reducing disease severity, have not been shown to be effective in protecting yield.

Methods

Fungicide efficacy trials were located in the Parana River basin of southern Paraguay during the 2003–2004 growing season in cooperation with W. Morel,

Table 2. Products evaluated in the 2003-2004 Paraguay efficacy trials.

Company	Product Name-rate	Applications	Active Ingredient	Use rate	Product rate
DAS	Systhane 20EW-100 g	2 vs. 3	myclobutanil	100g ai/ha	500 ml/ha
DAS	Systhane 20EW-125 g	2 vs. 3	myclobutanil	125g ai/ha	625 ml/ha
DAS	Dithane DF	2 vs. 3	mancozeb	2400g ai/ha	3.2 k /ha
DAS	Propimax EC-125g	2 vs. 3	propiconazole	125g ai/ha	287 ml/ha
DAS	Propimax EC-190g	2 vs. 3	propiconazole	190g ai/ha	437 ml/ha
Syngenta	Tilt 3.6EC	2 vs. 3	propiconazole	126g ai/ha	4 oz/A
Syngenta	Quadris 2.08SC	2 vs. 3	azoxystrobin	110g ai/ha	6.2 oz/A
Syngenta	Quilt 200SE-14 oz/A	2 vs. 3	azoxystrobin + propiconazole	a	14 oz/A
Syngenta	Quilt 200SE -20 oz/A	R1 only	azoxystrobin + propiconazole	a	20 oz/A
Syngenta	Quilt 200SE-10.5 oz/A	3	azoxystrobin + propiconazole	a	10.5 oz/A
Syngenta	Bravo 720 SC	2 vs. 3	chlorothalonil	1262g ai/ha	1.5 pints/A
BASF	Headline (BAS 500F)	2 vs. 3	pyraclostrobin	0.15lb ai/a	9.2 fl oz/A
BASF	Pristine (BAS 516F)	2 vs. 3	pyraclostrobin + boscalid	a	8.4 oz/A
BASF	Endura	2 vs. 3	boscalid	0.2lb ai/a	4.6 oz/A
Bayer	Stratego 250 EC	2 vs. 3	trifloxystrobin + propiconazole	a	600 ml/ha
Bayer	Folicur 3.6 F	2 vs. 3	tebuconazole	94g ai/ha	392 ml/ha
Bayer	Stratego followed by Folicure	2 vs. 3	trifloxystrobin + propiconazole	a	600 ml/ha
			tebuconazole	94g ai/ha	392 ml/ha
Sipcam Agro	Eminent 125SL	2 vs. 3	tetraconazole	100g ai/ha	13 fl.oz./A
Sipcam Agro	Echo 720	2 vs. 3	chlorothalonil	1440g ai/ha	2 pints/A
ISAGRO	Domark 230 ME-60g	2 vs. 3	tetraconazole	60g ai/ha	260 ml/ha
ISAGRO	Domark 230 ME-85g	2 vs. 3	tetraconazole	85g ai/ha	370 ml/ha
ISAGRO	Domark 230 ME-100g	2 vs. 3	tetraconazole	100g ai/ha	430 ml/ha
ISAGRO	Domark 230 ME-115g	2 vs. 3	tetraconazole	115g ai/ha	500 ml/ha
ISAGRO	Domark 230 ME-100g	R1 only	tetraconazole	100g ai/ha	430 ml/ha
	Domark 230 ME-100g	R3 only	tetraconazole	100g ai/ha	430 ml/ha
Control	Priori Xtra	2 vs. 3	azoxystrobin + cyproconazole	a	200 ml /ha
Control	No-fungicide control				

a. Product is a mixture of two active ingrediants so individual rates are not presented.

Ministerio de Agricultura y Ganadería, Centro Regional de Investigación Agrícola (CRIA), Capitán Miranda, Paraguay. A total of 23 fungicide treatments were evaluated in plots that received either two or three fungicide applications (Table 2). The first application was at growth stage R1 (first flower) with subsequent applications spaced 20 days apart. There were three treatments that received a single application; Quilt® (20 oz/A) and Domark® (100g ai/ha), both applied at growth stage R1, and Domark® (100g ai/ha) applied at growth stage R3. Field design was a split plot with 4 replications per location. The main effects were fungicide treatment, product and rates, with early and late applications as the subplot. The early application was either a single application at R1 or the standard two-application protocol. The late application was either a single application at R3 or the standard three-application protocol. Fungicides were hand applied with a CO_2 powered spray wand at 66 psi, using 400 ml per plot. Plots were 9.6 m in length and four rows wide at a row spacing of 0.4 m. The boom had four flat fan nozzles, spaced 40 cm apart. One pass was made per plot, per application on four rows of the plot. The center two rows of the four-row plot were used for data collection. Three rows, each 6 m in length, were cut from each plot to evaluate yields. Seed was weighed and graded; all results were adjusted to 13% moisture. Each plot was bordered by a pair of soybean rows that were left untreated to act as both a buffer between plots and as a source of inoculum for the plots. Three locations were used in the study. Yomo was planted to the cultivar “Mercedes 70”, a maturity group 7.0, on November 1, 2003, which is in the normal planting season for Paraguay. Sato 1 and Sato 2 were planted in early February, to the cultivar “Nidera 7500”, a maturity group 7.5. The late planting date is the normal planting for a double crop after corn or wheat and in previous years had more severe soybean rust than soybean planted earlier (Morel, pers. comm.). Both cultivars used in the study were glyphosate resistant, were determinant and were common cultivars used by producers. Two other fields planted in December and January were planned but were dropped due to poor emergence that was the result of drought in January.

Results and Discussion

The three locations differed in final soybean rust severity, yield and 1000 seed weight (Table 3). Sato 2 had the most severe soybean rust, while Yomo had the least. Mean yields were similar at both the Sato locations and were significantly lower than the yield at Yomo. The low yields at the Sato locations were due to the effect of the late planting date. Yomo also had the highest 1000 seed weights followed by Sato 1, with Sato 2 the lowest. There were significant location by treatment interactions that were due to the lack of separation for final disease severity in Yomo and the lack of separation for yield and 1000 seed weight at Sato 2. When the two application schedules were

Table 3. Mean final soybean rust (SBR) severity, yield and 1000 seed weights from each location in the 2003-2004 Paraguay fungicide efficacy trials.

	Final SBR Severity (%)		Yield @ 13% (KG/ha)		1000 Seed Wt (g)	
Sato 1	15	B	1129	B	130	B
Sato 2	27	C	1014	B	121	C
Yomo	6	A	5655	A	155	A

Means with different letters were significantly different (LSD, p=0.05).

compared, there was a significant interaction between the number of applications and the fungicide treatment for yield and 1000 seed weights. These interactions were due to a lack of separation among treatments within locations rather than differences in rank. These interactions limit the value of the cross-location means and result in the need to evaluate each location separately (Table 4).

Sato 1. All fungicide treatments reduced soybean rust severity at Sato 1 (Table 4). The mean soybean rust severity was 34% in the no fungicide control plots, which was significantly more severe than any of the fungicide plots. Dithane®, Bravo® and Echo® were next with means ranging from 25 to 27% severity. The remaining treatments had less than 20% soybean rust severity, with Endura®, Headline® and Pristine® the only fungicides that differed from Priori Xtra®, the fungicide with the lowest severity. There were no differences in soybean rust severity between the 2 and 3-application treatments.

When the mean yields are compared, two treatments had mean yields that were significantly greater than the control: Headline® and the high rate of Propimax® (190g ai/ha). The mean yields from this location were low; the location was planted late, and was under drought conditions through the vegetative stages. The low yields and lack of statistical difference among treatments at this location contribute to the statistically significant fungicide by location interaction. Significant differences were detected among treatments for 1000 seed weights. The mean 1000 seed weight was lowest for the no fungicide control, followed by Dithane®, Endura® and Tilt® 250 EC treatments. The greatest seed weights were seen with the strobilurins and strobilurin-triazole mixes, with Quadris® (6.2 oz rate) and Stratego® 250 EC having a mean1000 seed weight of 138 g. The single R1 application of Quilt® at 20 oz/A was the only strobilurin treatment that was not included among the treatments with high seed weights. The only triazole in this higher seed weight grouping was Domark®, but only at the 85 or 100 g/ha rates. There were no differences in soybean rust severity, yield or 1000 seed weights when comparing fungicides applied two vs. three times.

Sato 2. Soybean rust was more severe at the Sato 2 location than at Sato 1 (Table 4). The mean soybean rust severity in the no fungicide control plots was 60%, which was significantly more severe than in any of the fungicide treatments. The group of fungicides with the next most severe soybean rust included: Quadris® (at 6.2 oz), Bravo®, Echo® and Dithane®, with means of 40 to 47% severity. The lowest soybean rust severity was seen among the treatments that were triazoles. Folicur®, Eminent®, Domark®, Systhane® and the high rate of Propimax® all had less than 20 % soybean rust severity. Of the strobilurin fungicides, only Priori Xtra® and Quilt® applied at a high rate in a single application at growth stage had soybean rust severity below 20%. The fungicides that were strobilurin-triazole mixes tended to have less severe soybean rust than fungicides that were only a strobilurin. The yields at Sato 2 were low, ranging from 713 Kg/ha for the non-treated control plots to a high of 1164 Kg/ha for Domark® at 100 g/ha. However, most of the treatments had significantly higher yields than the no fungicide control. Among the treatments with lower yields were Echo® and Endura®, followed by Folicur®. The low yield for Folicur® cannot be explained by disease severity, as the treatment had the least severe soybean rust among all treatments at this location. Most of the fungicide treatments had mean yields similar to Domark® (100 g/ha). Mean 1000 seed weights ranged from 96 g for the no fungicide control plots to

133 g for Domark® (100 g/ha). Among the treatments with the lowest 1000 seed weight were Echo®, Endura®, Tilt® and Quadris® (6.2 oz rate), followed by Dithane® and Bravo®. Among the treatments with the greatest seed weights were the triazoles, (Domark®, Systhane®, Eminent®, Propimax® and Folicur®) as well as the strobilurins; Headline®, Priori Xtra®, Stratego® and Quilt®. There were no significant differences in soybean rust severity or yield when two vs. three applications were compared. There were significant differences detected between the two and three-application protocols among 1000 seed weights. This effect was due to increased seed weights with three applications of most of treatments. Exceptions included, Dithane®, all propiconazole treatments (Tilt®, Propimax®, and Stratego®) and both Bravo® and Echo®, where weights were either lower than or similar to the mean weight of the two-application treatment (Table 5).

Yomo. Soybean rust severity was very low at this location. Mean severities ranged from 4 to 8%, with the non-protected control among the least severe at 5% (Table 6). Mean yields were greater at this location than at the other two locations where the trial was done this year. Yields ranged from 4650 Kg/ha up to 7505 Kg/ha. However, only Headline® and Quilt® at 14 oz/a were significantly greater than the control. The location was limited in size, so the experiment was reduced to two replications from the four planned. Further confounding the results were hot dry growing conditions, which reduced soybean rust development and promoted charcoal rot and insects. This location, with its high yield and low soybean rust severity, contributes to the significant location interactions and results in a confounding of the data when comparing treatment means across locations. This location should not be used to compare fungicide efficacy for soybean rust control.

Conclusions

Each of the fungicides used in this study reduced the severity of soybean rust at the two locations where the disease developed. Among the treatments, Dithane®, Bravo® and Echo® reduced the soybean rust severities the least. This result is not un-expected. These three fungicides are not absorbed into the leaf, but are protectant fungicides that provide control by limiting infection and spore germination on the leaf surface; once an infection occurs these products do not interfere with fungal development. The experimental protocol used in this trial was to apply fungicides at 20-day intervals; this interval is too long for these products. Labeled recommendations for these fungicides are to apply at 7 to 14 day intervals, depending on rainfall. The late-planted Sato locations had frequent, almost weekly, rains after flowering, which were enough to reduce the effectiveness of the products when combined with the long interval between applications.

Both the triazole and strobilurin fungicides as well as the mixes of the two were effective in reducing soybean rust severity. Each of the fungicides evaluated in these trials will be an effective tool in the management of the disease. However, the protocol used in these trials was not designed to determine relative efficacy of the products. The 20-day interval between applications will bias any conclusions. Only products with long residuals or a high "curative" ability can be identified with this protocol. Each of the products evaluated in the trial have different properties. As a group, the triazoles have short residual periods but can kill rust infections within a leaf. Under a 20-day application schedule they may be dissipated from the plant tissue, unless high rates are used. This effect was seen, where higher rates tended to have less severe soybean rust than a lower rate of the same product. The strobilurin products have a longer residual, moving slower through the leaf tissue but are not as effective in controlling infections that are established. If infection levels are to high when the strobilurin fungicides are first applied, they may not protect yields.

Additional research on the timing of application and rotation of triazoles and strobilurin fungicides is needed. With the single site mode of action from each group of fungicides it is necessary to limit their use to one application per season for each class. The relative curative ability of the triazoles and the interaction between application rates and residual effects need to be evaluated.

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Table 4. Summary of the final soybean rust severity (SBR), yield and 1000 seed weights for each the fungicides evaluated in the Sato 1 and Sato 2 locations in the 2003-04 Paraguay efficacy trials.

Sato 1	Final SBR Severity (%)		Yield (Kg/ha)		1000 seed weight (g)	
Bravo 720 SC	25.8	B	983	C	128	C D E F
Eminent 125SL	9.6	E F	984	C	131	A B C D E F
No-fungicide control	34.2	A	987	C	116	G
Domark 230 ME (100g ai/ha)	10.4	D E F	1023	B C	130	A B C D E F
Quadris 2.08SC (6.2 oz/A)	12.1	D E F	1024	B C	138	A
Quilt 200SE (20 oz/A)-R1	12.5	D E F	1032	B C	128	B C D E F
Systhane 20EW (100g ai/ha)	10.8	D E F	1054	B C	127	C D E F
Quilt 200SE (14 oz/A)	12.9	D E F	1068	A B C	134	A B C
Echo 720	27.5	B	1088	A B C	128	B C D E F
Tilt 250 EC	13.8	C D E F	1110	A B C	125	D E F G
Endura + Penetrator	19.6	C	1121	A B C	124	E F G
Priori Xtra	7.9	F	1138	A B C	133	A B C D E
Domark 230 ME (100g ai/ha)-R3	10.0	D E F	1142	A B C	135	A B C
Dithane DF	26.3	B	1146	A B C	122	F G
Domark 230 ME (100g ai/ha)-R1	10.4	D E F	1148	A B C	134	A B C
Systhane 20EW 125g ai/ha	10.4	D E F	1148	A B C	131	A B C D E
Stratego 250 EC	10.8	D E F	1149	A B C	138	A
Domark 230 ME (85g ai/ha)	8.8	F	1154	A B C	135	A B C
Folicur 3.6 F	10.4	D E F	1165	A B C	133	A B C D E
Quilt 200SE(10.5 oz/A)- 3 app	12.9	D E F	1168	A B C	132	A B C D E
Stratego 1st app, Folicur 2nd & 3rd	11.3	D E F	1173	A B C	137	A B
Pristine (BAS 516F)	15.0	C D E	1220	A B C	135	A B C
Propimax EC (125g ai/ha)	13.3	D E F	1259	A B C	127	C D E F
Domark 230 ME (60g ai/ha)	12.5	D E F	1265	A B C	128	C D E F
Propimax EC (190g ai/ha)	12.1	D E F	1300	A B	127	C D E F
Headline (BAS 500F)	15.8	C D	1350	A	133	A B C D
Mean of 2 applications	14.8		1129		130	
Mean of 3 applications	15.1		1131		130	

Sato 2	Final SBR Severity (%)		Yield (Kg/ha)		1000 seed weight (g)	
No-fungicide control	60.0	A	713	E	96	J
Echo 720	46.7	B	824	D E	108	I
Endura + Penetrator	35.8	C D	825	D E	111	H I
Folicur 3.6 F	12.9	I	854	C D E	126	A B C
Propimax EC (190g ai/ha)	28.3	E F	909	B C D E	123	B C D E F
Quilt 200SE(10.5 oz/A)- 3 app	22.5	F G H	916	B C D E	121	C D E F G
Tilt 250 EC	28.3	E F	942	A B C D E	114	G H I
Dithane DF	43.8	B	946	A B C D E	117	F G H
Stratego 250 EC	27.5	F	975	A B C D	126	A B C
Stratego 1st app, Folicur 2nd & 3rd	26.3	F G	975	A B C D	125	A B C D
Bravo 720 SC	40.8	B C	981	A B C D	118	E F G H
Quadris 2.08SC (6.2 oz/A)	39.6	B C	989	A B C D	114	G H I
Pristine (BAS 516F)	35.0	C D E	1018	A B C D	118	D E F G
Quilt 200SE (20 oz/A)-R1	19.6	G H I	1019	A B C D	120	C D E F G
Eminent 125SL	14.2	I	1023	A B C D	129	A B
Domark 230 ME (100g ai/ha)-R3	16.6	H I	1042	A B C D	132	A
Domark 230 ME (100g ai/ha)-R1	18.8	H I	1055	A B C D	127	A B C
Systhane 20EW 125g ai/ha	18.3	H I	1063	A B C	130	A B
Domark 230 ME (60g ai/ha)	14.2	I	1073	A B C	124	B C D E
Systhane 20EW (100g ai/ha)	17.1	H I	1086	A B C	124	B C D E F
Domark 230 ME (85g ai/ha)	15.4	I	1088	A B	128	A B
Propimax EC (125g ai/ha)	19.6	G H I	1108	A B	126	A B C
Quilt 200SE (14 oz/A)	22.9	F G H	1124	A B	126	A B C
Headline (BAS 500F)	29.2	D E F	1136	A B	128	A B
Priori Xtra	15.8	H I	1137	A B	127	A B C
Domark 230 ME (100g ai/ha)	15.4	I	1164	A	133	A
Mean of 2 applications	26.9		1001		122	
Mean of 3 applications	27.4		1028		122	

Means with different letters are significantly different (LSD, p=0.05)

Table 5. Mean 1000 seed weights (g) from the two and three applications of each fungicide evaluated at Sato 2 in the 2003-2004 Paraguay efficacy trial.

Fungicide treatment	Two applications[a]		Three applications[a]	
Domark 230 ME (100g ai/ha)	132.5	A B C D	136.3	A
Systhane 20EW 125g ai/ha	129.5	A B C D E F	132.8	A B C
Eminent 125SL,	129.3	A B C D E F G	129.0	A B C D E F G
Domark 230 ME (85g ai/ha)	128.2	B C D E F G	134.5	A B
Headline (BAS 500F)	128.0	B C D E F G	130.6	A B C D E
Priori Xtra	127.3	B C D E F G H	129.2	A B C D E F G
Propimax EC (125g ai/ha) a	126.4	C D E F G H	118.8	I J K L M N O
Stratego 250 EC	126.4	C D E F G H	118.3	K L M N O
Folicure 3.6 F	126.1	C D E F G H I	131.6	A B C D
Quilt 200SE (14 oz/A)	125.9	C D E F G H I	121.9	G H I J K L M
Stratego 1st app, Folicure 2nd	125.4	D E F G H I J	126.0	C D E F G H I
Domark 230 ME (60g ai/ha)	124.1	E F G H I J K	128.8	B C D E F G
Systhane 20EW (100g ai/ha)	123.6	E F G H I J K L	129.6	A B C D E F
Propimax EC (190g ai/ha)	123.0	F G H I J K L M	117.4	K L M N O P
Pristine (BAS 516F)	118.4	J K L M N O	115.7	M N O P Q
Bravo 720 SC	117.6	K L M N O P	112.7	O P Q
Dithane DF	116.6	L M N O P	112.9	N O P Q
Quadris 2.08SC (6.2 oz/A)	114.2	N O P Q	120.1	H I J K L M N
Tilt 250 EC	113.7	N O P Q	113.8	N O P Q
Endura + Penetrator	110.9	P Q R	108.8	Q R
Echo 720,	108.5	Q R	104.8	R S
No fungicide control	95.6	T	100.0	S T
Single application treatments[b]				
Domark 230 ME (100g ai/ha)-R1	127.1	C D E F G H		
Domark 230 ME (100g ai/ha)-R3			132.1	A B C D
Quilt 200SE (20 oz/A)-R1	120.3	H I J K L M N		
Quilt 200SE 10.5 oz/A -3 apps			121.2	H I J K L M N
Mean	121.6		122.0	

a. Means separated using Students LSD (p=0.05), different letters indicate significant differences.

b. Fungicides applied once at growth stage R1 or R3, mean of 4 plots per location not the 8 plots per location when 2 and 3 application treatments were combined for comparison with other treatments across locations.

Table 6. Mean final soybean rust severity, yield and 1000 seed weights for each the fungicides evaluated at the Yomo location in the 2003-04 Paraguay efficacy trials.						
Fungicide treatment	**Final soybean[a] rust severity (%)**		**Yield (Kg/ha)[a]**		**1000 seed[a] weight (g)**	
Systhane 20EW 125g ai/ha	**6.7**	A B	**4650**	G	**138**	0 B C D
Priori Xtra	**5.8**	B C	**4678**	G	**124**	D
Domark 230 ME (100g ai/ha) R1 [b]	**5.0**	B C	**4771**	F G	**128**	D
Propimax EC (125g ai/ha)	**8.3**	A	**4781**	F G	**137**	B C D
Quilt 200SE (20 oz/A) R1 [b]	**6.7**	A B	**4899**	E F G	**138**	B C D
Propimax EC (190g ai/ha)	**5.8**	B C	**4900**	E F G	**120**	D
No fungicide control	**5.0**	B C	**5071**	D E F G	**123**	D
Tilt 250 EC	**5.0**	B C	**5304**	C D E F G	**159**	A B C
Domark 230 ME (100g ai/ha)	**5.8**	B C	**5360**	C D E F G	**170**	A B C
Folicure 3.6 F	**5.0**	B C	**5386**	C D E F G	**133**	B C
Systhane 20EW (100g ai/ha)	**6.7**	A B	**5390**	C D E F G	**148**	A B C
Quilt 200SE 10.5 oz 3 app	**5.8**	B C	**5402**	C D E F G	**146**	A B C
Bravo 720 SC	**5.8**	B C	**5439**	C D E F G	**130**	C
Stratego 1st app, Folicure 2nd & 3rd	**5.0**	B C	**5504**	B C D E F G	**151**	A B C
Pristine (BAS 516F)	**5.0**	B C	**5773**	B C D E F G	**128**	D
Eminent 125SL	**4.2**	C	**5784**	B C D E F G	**191**	A
Domark 230 ME (100g ai/ha) R3 [b]	**6.7**	A B	**5801**	B C D E F G	**169**	A B C
Dithane DF	**5.8**	B C	**6330**	A B C D E F G	**167**	A B C
Echo 720	**5.8**	B C	**6425**	A B C D E F	**150**	A B C
Endura + Penetrator	**5.8**	B C	**6463**	A B C D E F	**181**	A B
Stratego 250 EC	**5.0**	B C	**6477**	A B C D E	**158**	A B C
Quadris 2.08SC (6.2 oz/A)	**5.0**	B C	**6650**	A B C D	**175**	A B C
Domark 230 ME (85g ai/ha)	**5.8**	B C	**6719**	A B C D	**180**	A B C
Domark 230 ME (115g ai/ha)	**5.0**	B C	**6894**	A B C	**168**	A B C
Headline (BAS 500F)	**5.8**	B C	**7141**	A B	**197**	A
Quilt 200SE (14 oz/A)	**5.8**	B C	**7507**	A	**195**	A
	Mean		**Mean**		**Mean**	
Mean of 2 applications	**5.7**		**5762**		**154**	
Mean of 3 applications	**5.7**		**5549**		**156**	

a. Means with different letters are significantly different (LSD, p=0.05)

b. Fungicides applied once at growth stage R1 or R3, mean of 4 plots per location not the 8 plots per location when 2 and 3 application treatments were combined for comparison with other treatments across locations.