Performance of prothioconazole solo or added to mancozeb in the control of Asian soybean rust

Erlei Melo Reis[1], Mateus Zanatta[2], Andrea Camargo Reis[2]

[1]Universidad de Buenos Aires, Facultad de Agronomía, Escuela para Graduados, Buenos Aires, Argentina; [2] Instituto Agris, Passo Fundo, RS, Brasil
Autor para correspondência: Erlei Melo Reis (erleireis@upf.br)
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ABSTRACT

Reis, E.M.; Zanatta, M.; Reis, A.C. Performance of prothioconazole solo or added to mancozeb in the control of Asian soybean rust. ***Summa Phytopathologica,*** v.46, n.4, p.345-347, 2020.

The evolution of the reduction in Asian soybean rust (caused by *Phakopsora pachyrhizi*) control by site-specific fungicides has been reported season after season. In a field experiment, the effect of prothioconazole solo and added to multisite mancozeb was evaluated for rust control. Treatments were evaluated in a factorial design of four prothioconazole doses and three mancozeb doses. In a set of treatments, three applications were performed in one soybean cycle and four applications in another one. The first applications were performed at GS V8, 11 days before rust detection, with 2.56% leaflet incidence, while the other applications were at 12 to 14-day interval. Rust severity was quantified, control was calculated in relation to the unsprayed treatment, and soybean grain yield was estimated as kg/ha. Fifty-one to 61% control was obtained with three sprayings and 68% to 70% control with four sprayings of prothioconazole alone. Over 80% control was obtained with at least 0.3 L/ha prothioconazole + 2.0 kg/ha mancozeb, corresponding to 75 g a.i./ha prothioconazole + 1500 g a.i./ha mancozeb. Reduction in *P. pachyrhizi* control by the use of the site-specific fungicide alone was confirmed, while the addition of mancozeb can recover the efficacy of the site-specific fungicide.

Keywords: Chemical control, *Glycine max, Phakopsora pachyrhizi,* fungicide resistance, triazolinedione.

RESUMO

Reis, E.M.; Zanatta, M.; Reis, A.C. Desempenho do protioconazol isolado ou adicionado ao mancozebe no controle da ferrugem asiática da soja. ***Summa Phytopathologica,*** v.46, n.4, p.345-347, 2020.

Tem sido relatada a evolução da redução do controle da ferrugem asiática da soja causada por *Phakopsora pachyrhizi* pelos fungicidas sítio-específicos safra após safra. Em experimento conduzido no campo, foi avaliado o efeito do protioconazol isolado e adicionado ao multissítio mancozebe no controle da ferrugem. Os tratamentos foram avaliados em delineamento fatorial de quatro doses do protioconazol e três doses do mancozebe. Num grupo de tratamentos foram feitas três aplicações no ciclo da soja e em outro quatro. As primeiras aplicações foram realizadas no estádio GS V8, 11 dias antes da detecção da ferrugem com 2,56% de incidência foliolar e as demais aos com 12 a 14 dias de intervalo. A severidade da ferrugem foi quantificada, o controle calculado em relação ao tratamento sem aplicação e o rendimento de grãos estimado em kg/ha. Cinquenta e um a 61% de controle foi obtido com três aplicações e 68 a 70% com quatro aplicações de protioconazol isolado. Controle superior a 80% foi obtido com no mínimo 0,3 L/ha de protioconazol + 2,0 kg/ha mancozebe, correspondendo a 75 g i.a./ha de protioconazol + 1500 g i.a./ha de mancozebe. A redução do controle de *P. pachyrhizi* pelo uso isolado do fungicida sítio-específico foi confirmada e a adição do mancozebe pode recuperar a eficácia do sítio-específico.

Palavras-chave: Controle químico, *Glycine max, Phakopsora pachyrhizi,* resistência a fungicidas, triazolintiona.

Soybean [*Glycine max* (L.) Merr.] growing area in Brazil has increased season after season, reaching 35.8 million hectares in the 2018/19 season (2).

Since the 2002/03 season, Asian Soybean Rust (ASR) control has employed only site-specific fungicides: (i) triazoles or inhibitors of cell membrane synthesis, (ii) strobilurins and more recently another class of chemicals, (iii) carboxamides or respiration inhibitors (7). After five seasons of use of site-specific chemicals alone, such as demethylation inhibitors (DMIs), a reduction has been reported in *P. pachyrhizi* sensitivity to these chemicals (6, 7, 10). In the following seasons, ready-mix site-specific co-formulations of DMIs + quinone outside inhibitors (QoIs) or QoIs + succinate dehydrogenase inhibitor (SDHI) were used. Among the three groups (DMI, QoI and SDHI) of site-specific fungicides, prothioconazole (Prot), a DMI released to the market in the 2012/13 season in combination with trifloxystrobin, has been the most efficient and thus the most used fungicide for rust control in the 2016/17 season (7).

The hypothesis raised in this study is that the efficacy of the site-specific fungicides available in the market is not greater than 68% for ASR control. Thus, the anti-resistance strategy (addition of a multisite fungicide to a site-specific fungicide) used to control late blight (*Phytophthora infestans* De Bary) in tomato and potato, as well as downy mildew (*Plasmopara viticola* De Toni), may also be a useful tool to recover the effectiveness of these three MOA to fight *P. pachyrhizi*, especially prothioconazole.

The objective of this study was to evaluate the actual efficacy of

prothioconazole, a site-specific fungicide, solo and added to mancozeb, in the control of *P. pachyrhizi* in the soybean crop.

The experiment was conducted in the Webber Seeds Farm, Coxilha County, Rio Grande do Sul State (28º09'33.8''S latitude, 52º18'20.1''W longitude, and 710 m a.s.l.) in the 2016/17 growing season. The used soybean cultivar was 'DuPont Pioneer 96Y90-RR', sown on December 7th, 2016, and under soybean monoculture.

Treatments were conducted according to a factorial design with four Prot (Proline 250 g/L SC) doses (0.3, 0.4, 0.5, 0.6 L/ha) added to three mancozeb doses (0.0, 2.0, 3.0 kg/ha) (Unizeb Gold 750 WG) and an unsprayed treatment. Plots were arranged in a randomized complete block design with four replicates.

Fungicides were applied with a CO_2 pressurized backpack sprayer equipped with Hypro® LD 015F110 nozzles spaced at 0.5 m and delivering 150 L/ha water.

Foliolar ASR severity was estimated per plot, according to a diagrammatic scale for ASR severity evaluation proposed by Godoy et al. (5).

The first fungicide application was performed on February 2nd, 2017, at GS V8, and rust was detected after 11 days, on February 13th, 2017, with 2.56% leaflet incidence which was, therefore, below the economic damage threshold (LDE). The LDE, calculated according to Danelli et al. (3), was 16% leaflet incidence (LI).

Regarding the control for three solo Prot applications, general mean was 57%, not reaching the minimum control of 80% for maximum yield (8).

There was an increase from 74% to 78% for 2.0 and 3.0 kg/ha mancozeb doses, respectively. The increasing Prot doses resulted in 65%, 69%, 73% and 72% control, respectively (Table 1).

Considering four sprayings, control with Prot solo was 69%. According to the mancozeb doses, four sprayings led to 88% to 89% control with the addition of 2.0 and 3.0 kg mancozeb, respectively. Prot control increased from 77%, 85%, 83% to 83% with increasing doses, respectively (Table 1).

Regardless of the Prot dose, the highest control, 88% and 89%, was obtained with the addition of 2.0 or 3.0 kg/ha mancozeb, first application performed with 2.75% LI and four applications with a 12-14-day interval.

Plant defoliation was not evaluated because it is a function of severity, as demonstrated with the positive relationship between severity and defoliation caused by ASR (8).

Soybean grain yield, considering three applications in the treatment with Prot solo, was 4,397 kg/ha. For 2.0 and 3.0 kg/ha mancozeb doses, the yield increased from 4,397 (Prot solo) and 4,810 to 4,857 kg/ha, respectively. For Prot doses, soybean grain yield increased from 4,497, 4,660, 4,668 to 4,916 kg/ha, respectively (Table 2).

Analyzing the effect of four applications, there were no differences in grain yield for Prot doses ranging from 5,244, 5,449, 5,550 to 5,569 kg/ha. However, for 0, 2.0 and 3.0 kg/ha mancozeb addition, grain yield increased from zero, 5,119 to 5,550 and 5,569 kg/ha, respectively. Addition of 2.0 kg mancozeb to Prot resulted in a 431 kg/ha increase in grain yield (Table 2).

Considering the reduction in *P. pachyrhizi* sensitivity to DMIs and QoIs (1, 6, 9, 10), Prot co-formulation with trifloxystrobin (Trif), still the best option at the present, is under high directional selection pressure due to their use without multi-site MOA for ASR control. The present data confirm a gradual reduction in Prot efficacy, season after season, which needs the earliest possible addition of a multisite fungicide to maintain its longer effective life (1, 6, 7).

Table 1. Effect of prothioconazole (Prot) doses added to mancozeb doses on the control of Asian soybean rust severity (%) with three and four sprayings

Three sprayings					
Prot dose (L/ha)	Mancozeb (kg/ha)			Mean	
	0.0	2.0	3.0		
0.3	51	70	75	65	c
0.4	57	71	78	69	bc
0.5	60	79	81	73	a
0.6	61	76	78	72	ab
Mean	C 57	B 74	A 78		
Four sprayings					
0.3	68	81	82	77	b
0.4	69	92	93	85	a
0.5	69	90	91	83	a
0.6	70	90	88	83	a
Mean	B 69	A 88	A 89		

Means followed by the same lowercase letter in the columns and uppercase letters on the lines are not different, according to Tukey's test at 0.05. Severity in unsprayed plots: 70%.

Table 2. Effect of prothioconazole (Prot) doses added to mancozeb doses on soybean **grain yield** (Kg/ha) to control Asian soybean rust with three and four sprayings

Three sprayings								
Prot doses (L/ha)	Mancozeb doses (kg/ha)						Mean	
	0.0		2.0		3.0			
0.3	4224		4611		4656		4497	b
0.4	4410		4751		4820		4660	ab
0.5	4442		4760		4831		4678	ab
0.6	4510		5118		5120		4916	a
Mean	B 4397		A 4810		A 4857			
Four sprayings								
0.3	5087		5333		5313		5244	a
0.4	5096		5676		5721		5498	a
0.5	5126		5587		5636		5450	a
0.6	5167		5606		5606		5459	a
Mean	B 5119		A 5550		A 5569			

Means followed by the same lowercase letter in the columns and uppercase letters in the lines are not different, according to Tukey's test at 0.05. Gain yield of unsprayed plots: 3156 Kg/ha.

Recently, Braga et al. (1) reported that the sensitivity reduction factor of 17 *P. pachyrhizi* isolates to prothioconazole ranged from 1.25 to 26, confirming the sensitivity reduction.

A triple co-formulation containing Prot + Trif + mancozeb applied to the whole soybean area in all sprayings is likely to reduce *P. pachyrhizi* directional selection towards resistance. On the contrary, the increase in the treated area and number of sprayings/area/season, without the addition of a multisite fungicide, could accelerate the reduction in the effective life of Prot, currently considered the most powerful fungicide against *P. pachyrhizi*. Similarly, Prot + Trif and

QoI + SDHI co-formulations and others do not comply with FRAC (4) recommendations since they are not individually efficient for rust control (>80%).

Regarding the reduction in *P. pachyrhizi* sensitivity towards DMIs, QoIs and SDHIs, even solo or in double or triple mixtures, the present results suggest the development, as early as possible, of ready liquid co-formulation containing prothioconazole + mancozeb, or prothioconazole + trifloxystrobin + mancozeb, in compliance with FRAC recommendations regarding the fungicide resistance strategy against fungi to keep their effective life the longest possible (4)

REFERENCES

1. Braga, K. Fantin, L.H.; Minchio, C.A.; Scolin, L.B.; Paduan, F.N.; Canteri, M.G. Sensibilidade de populações de *Phakopsora pachyrhizi* ao fungicida protioconazol. ***Summa Phytopathologica***, v.46, n.2, p.150-154, 2020.
2. Conab. Acompanhamento da safra brasileira: grãos, Brasília, DF, v. 2, V.7 - Safra 2019/20, Primeiro levantamento. Outubro 2019. ISSN 2318-6852. Disponível em: https://www.conab.gov.br/info-agro/safras/graos/boletim-da-safra-de-graos?limitstart=0. Acesso em: 16 janeiro 2020.
3. Danelli, A.L.D.; Reis, E.M.; Boaretto, C. Critical-point model to estimate yield loss caused by Asian soybean rust. ***Summa Phytopathologica***, Botucatu, v.41, n.4, p.262-269, 2015.
4. Fungicide Action Committee. Update EPPO Resistance Panel Berlin, 19 September 2017.
5. Godoy, C.V., Koga, L.J.; Canteri, M.G. Diagrammatic scale for assessment of soybean rust severity. ***Fitopatologia Brasileira*****,** Brasília, DF, 31:063-068. 2006.
6. Reis, E. M.; Deuner, E.; Zanatta, M. *In vivo* sensitivity of *Phakopsora pachyrhizi* to DMI and QoI fungicides. ***Summa Phytopathologica***, Botucatu, v. 41, n. 1, p. 21-24, 2015.
7. Reis, E.M.; Reis, A. C.; Zanatta, M.; Silva, L. H. C. P; Siqueri, F. V.; Silva, J. R. C. Evolução da redução da sensibilidade de *Phakopsora pachy*rhizi a fungicidas e estratégia para recuperar a eficiência do controle. 3. ed., rev. e ampl. – Passo Fundo: Berthier. 2017. 104 p.
8. Reis, E.M.; Zanatta, M.; Reis, A.C. Relationship between soybean plant defoliation and Asian soybean rust severity. ***Summa Phytopathologica***, Botucatu, v.45, n.3, p.252-254, 2019.
9. Reis, E.M.; Zanatta, M.; Reis, A.C. Eficiência do controle de doenças para igualar ao custo da aplicação terrestre de fungicida. ***Summa Phytopathologica***, Botucatu, 2018 (in press).
10. Xavier, S.A.; Koga, L.J.; Barros, D.C.M.; Canteri, M.G.; Lopes, I.O.N.; Godoy, C.V. Variação da sensibilidade de populações de *Phakopsora pachyrhizi* a fungicidas inibidores da desmetilação no Brasil. ***Summa Phytopathologica***, Botucatu, v. 41, n. 3, p. 191-196, 2015.