INVASION OF SOYBEAN RUST AND ITS MANAGEMENT, FROM BRAZILIAN EXPERIENCES

Claudia Vieira Godoy

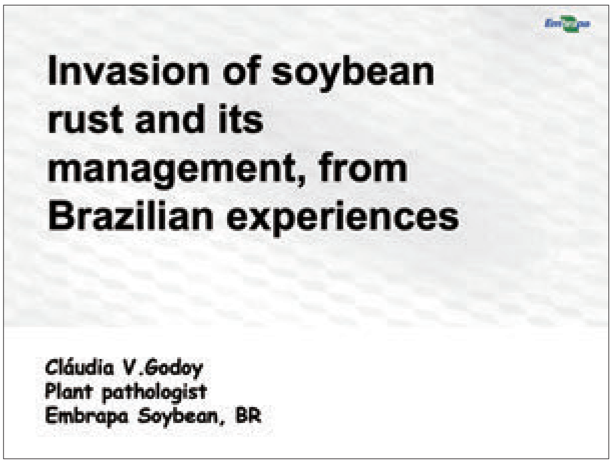
Researcher, Empresa Brasileira de Pesquisa Agropecuária,

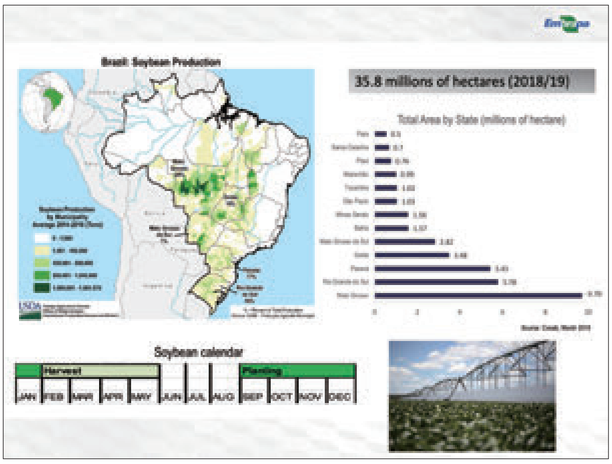
Centro Nacional de Pesquisa de Soja (Embrapa Soybean), Brazil

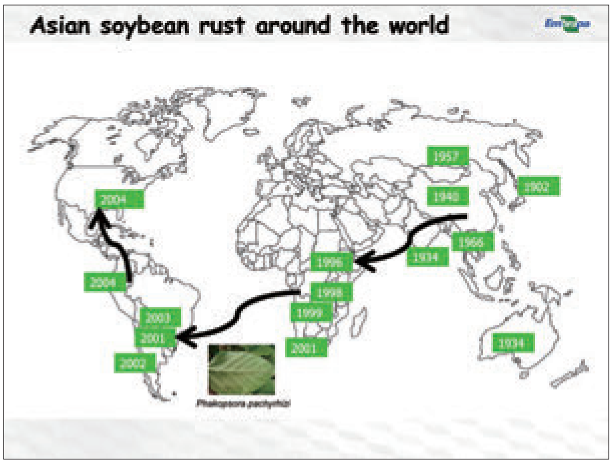
Claudia Vieira Godoy is a researcher at the Soybean Research Center of the Brazilian Agricultural Research Corporation (Embrapa). She earned her Ph.D. from the University of São Paulo. During her Ph.D. course, she worked as a visiting researcher at Gottfried Wilhelm Leibniz Universität in Hannover, Germany, and at Université Paris-Sud in France. She then worked as a researcher at Zeneca/ Syngenta Crop Protection from 1999 to 2002. In 2002, she began her career at Embrapa as a plant pathology researcher, focusing on epidemiology and control of soybean diseases. Since 2004, she has been acting as coordinator of the Anti-rust Consortium, a task force created to control soybean rust. In 2012-2013, she worked as a visiting researcher at USDA/ University of Illinois.

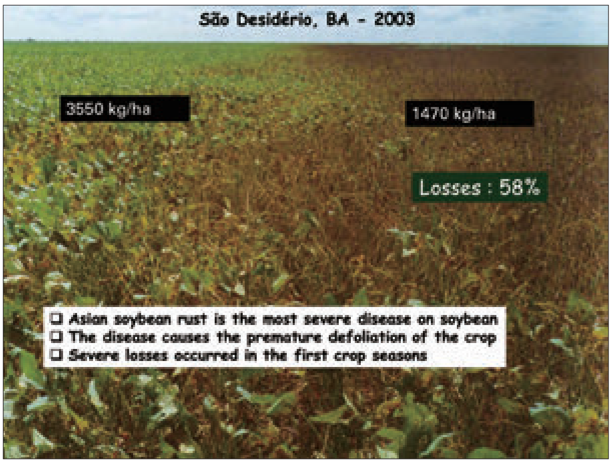
ABSTRACT

The cultivated soybean area in 2018/19 in Brazil reached 35.8 million hectares (Conab, 2019). One disease that threatens the sustainability of the crop and represents a breakthrough in the history of soybean in Brazil is Asian soybean rust, caused by the fungus Phakopsora pachyrhizi. The disease was first reported in Paraguay in 2001 and in the west of the state of Paraná, Brazil, spreading, within three years, throughout South America (Yorinori et al. 2005). Epidemics of the disease were common in the country, where the fungus can survive year-round. Management and regulatory measures were adopted to reduce the inoculum between crop seasons (soybean-free period) and to curb late sowing of soybeans. Varieties with resistant genes have been available in the Brazilian market since 2009. Fungicide applications are recommended for these varieties due to the variability of the fungus' ability to overcome the resistance genes. The most important soybean rust control strategy in Brazil has been the early sowing of short-cycle varieties after the soybean-free period, escaping the higher inoculum pressure period. The use of fungicides is one of the strategies adopted in the management of the disease. Fungicide application costs in soybean were estimated at US$ 2.9 billion in 2018/19, with an average of 2.75 fungicide applications per soybean crop season. Since 2003/04, uniform field trials have been carried out in different producing regions in order to compare the efficacy of registered fungicides and those in the registration phase. Besides the fungicides'efficacy, the results allowed accompanying changes in the sensitivity of the fungus to the different modes of action over the years, along with bioassays and molecular analyses. Reduced fungicide efficacy in the uniform field trials was reported for the demethylation inhibitors (DMIs) in 2007, the quinone outside inhibitors (QoIs) in 2013, and for the succinate dehydrogenase inhibitors (SDHIs) in 2016. At least six CYP51 mutations (Y131F/H; F120L; K142R; I145F; I475T) and overexpression are involved in the sensitivity reduction towards DMIs (Schmitz et al., 2014). For QoI, the F129L mutation was reported at high frequency (~ 90%) in 2013/14 isolates (Klosowski et al., 2016) and remained stable in the subsequent crop seasons. SDHI fungicides were used on soybean in Brazil for the first time in 2013/14 and strains of P. pachyrhizi with a lower sensitivity were found in monitoring studies in 2015/16, with a mutation in the C-I86F gene (Simões et al., 2018). With the P. pachyrhizi resistance to single-site fungicides, the efficacy of multi-site fungicides (mancozeb, chlorothalonil, and copper) has also been evaluated in the uniform field trials and their use in Brazil to control Asian rust has increased. Even though all major single-site mode of action fungicides used for soybean rust control (DMI, QoI, and SDHI) have experienced adaptation by P. pachyrhizi in Brazil, they still contribute to disease control when associated with other management strategies.

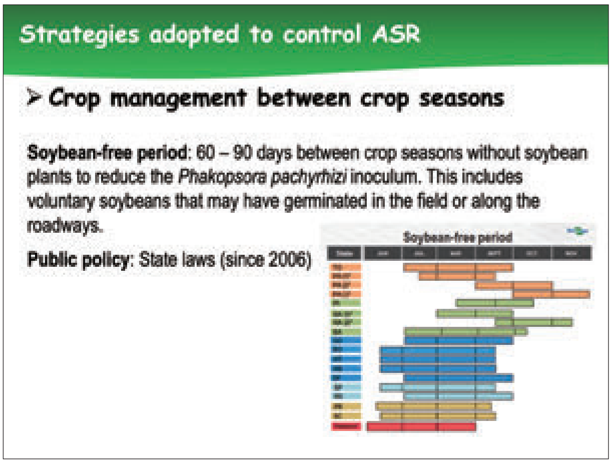

Invasion of soybean rust and its management, from Brazilian experiences
Cláudia V.Godoy
Plant pathologist
Embrapa Soybean, BR


Brazil: Soybean Production
35.8 millions of hectares (2018/19)
Total Area by State (millions of hectare)
Soybean calendar
Harvest
Planting
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

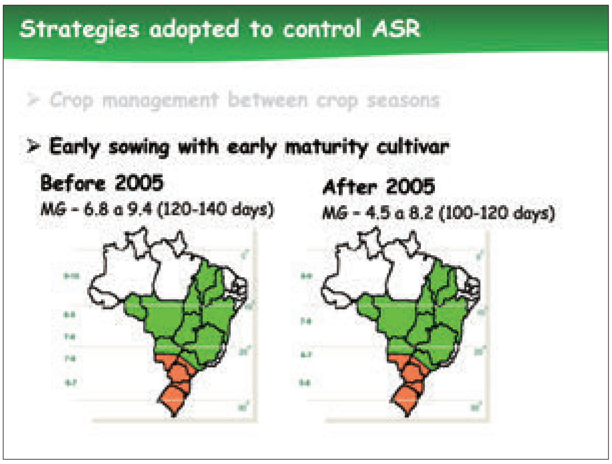

Asian soybean rust around the world
2004
2004
2003
2001
2002
1957
1940
1902
1966
1934
1996
1998
1999
2001
1934
Phakopsora pachyrhizi

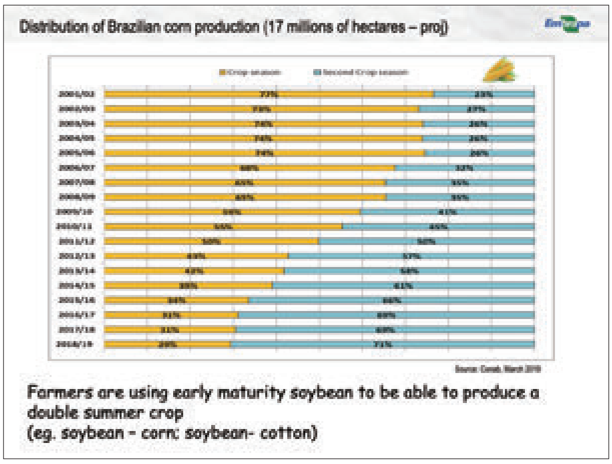

São Desidério, BA - 2003
3550 kg/ha
1470 kg/ha
Losses : 58%
❑ Asian soybean rust is the most severe disease on soybean
❑ The disease causes the premature defoliation of the crop
❑ Severe losses occurred in the first crop seasons

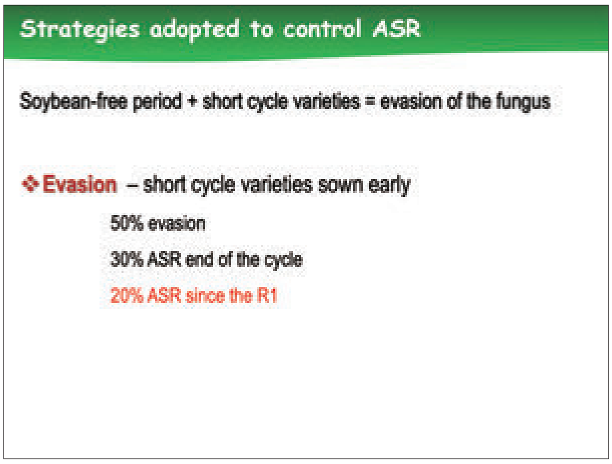

Strategies adopted to control ASR
❑ Restrict the sowing under irrigation between crop seasons to avoid the green bridge
J.T. Yorinori
Primavera do Leste, Mato Grosso - July 2003

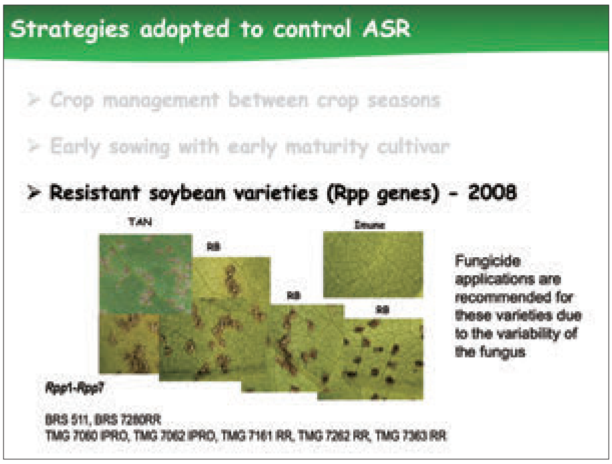

Strategies adopted to control ASR
➢ Crop management between crop seasons
Soybean-free period: 60 – 90 days between crop seasons without soybean plants to reduce the Phakopsora pachyrhizi inoculum. This includes voluntary soybeans that may have germinated in the field or along the roadways.
Public policy: State laws (since 2006)
Soybean-free period

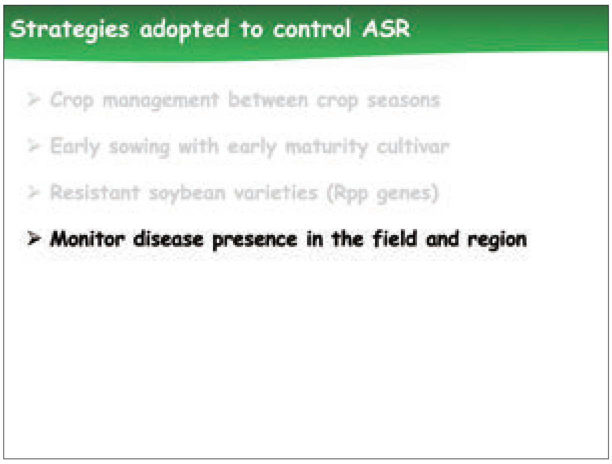

voluntary soybeans

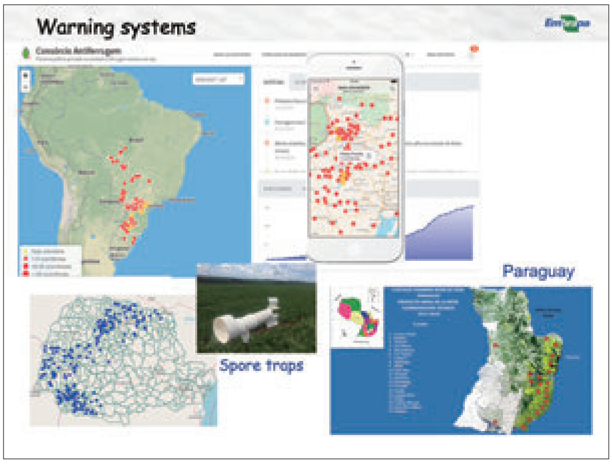

Strategies adopted to control ASR
➢ Crop management between crop seasons
➢ Early sowing with early maturity cultivar
Before 2005
MG - 6.8 a 9.4 (120-140 days)
After 2005
MG - 4.5 a 8.2 (100-120 days)

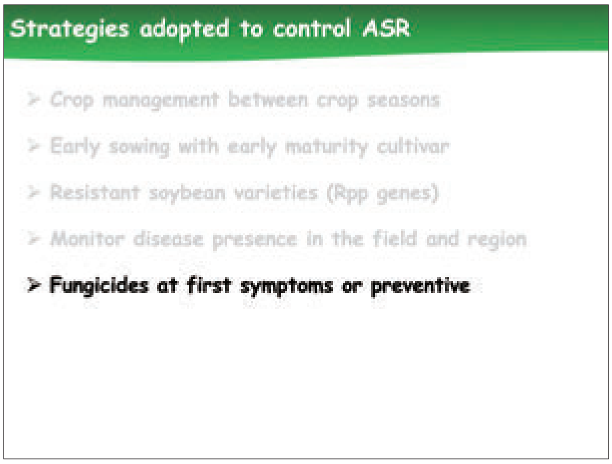

Distribution of Brazilian corn production (17 millions of hectares – proj)
Farmers are using early maturity soybean to be able to produce a double summer crop
(eg. soybean - corn; soybean- cotton)

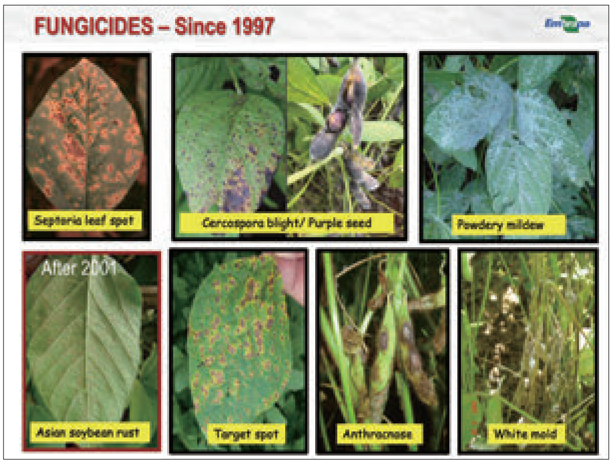

Strategies adopted to control ASR
Soybean-free period + short cycle varieties = evasion of the fungus
Evasion – short cycle varieties sown early
50% evasion
30% ASR end of the cycle
20% ASR since the R1

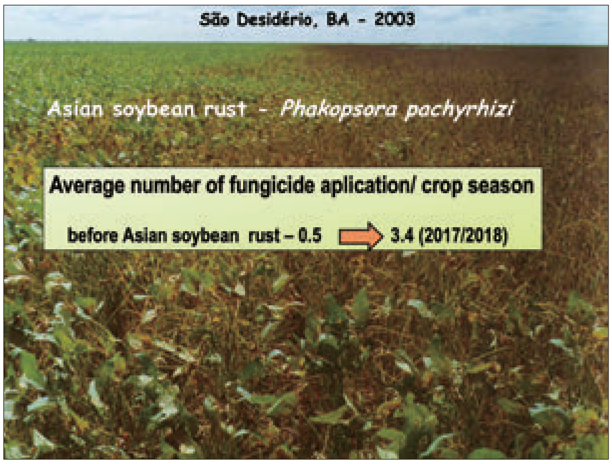

Strategies adopted to control ASR
Crop management between crop seasons
Early sowing with early maturity cultivar
Resistant soybean varieties (Rpp genes) - 2008
TAN
RB
Fungicide applications are recommended for these varieties due to the variability of the fungus
Rpp1-Rpp7
BRS 511, BRS 7280RR
TMG 7060 IPRO, TMG 7062 IPRO, TMG 7161 RR, TMG 7262 RR, TMG 7363 RR

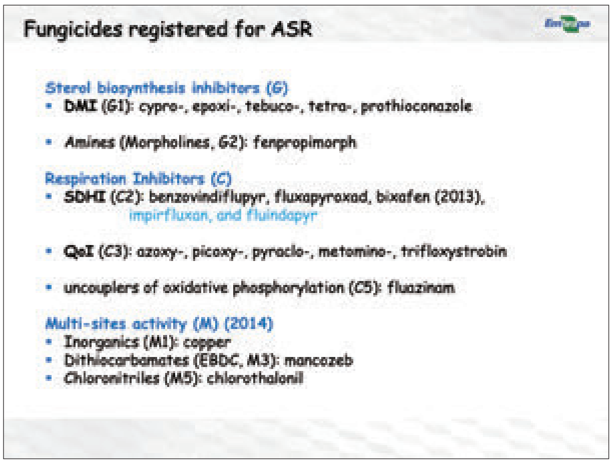

Strategies adopted to control ASR
Crop management between crop seasons
Early sowing with early maturity cultivar
Resistant soybean varieties (Rpp genes)
Monitor disease presence in the field and region


Warning systems
Paraguay
Spore traps


Strategies adopted to control ASR
Crop management between crop seasons
Early sowing with early maturity cultivar
Resistant soybean varieties (Rpp genes)
Monitor disease presence in the field and region
Fungicides at first symptoms or preventive


FUNGICIDES – Since 1997
Septoria leaf spot
Cercospora blight/ Purple seed
Powdery mildew
After 2001
Asian soybean rust
Target spot
Anthracnose
White mold

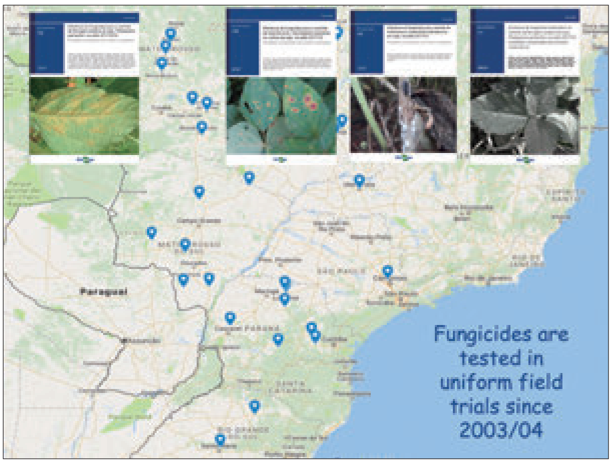

São Desidério, BA - 2003
Asian soybean rust - Phakopsora pachyrhizi
Average number of fungicide aplication/ crop season
before Asian soybean rust – 0.5
3.4 (2017/2018)

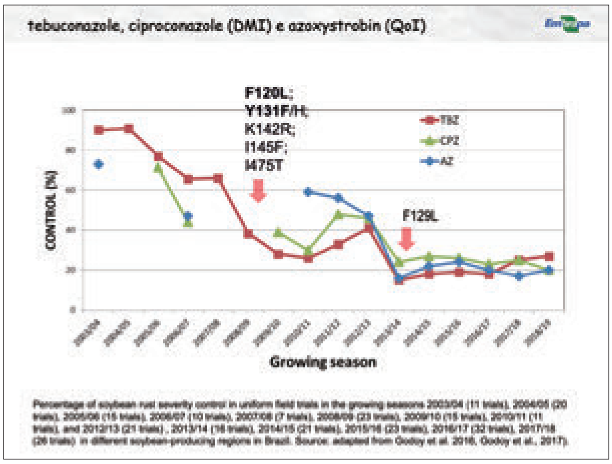

Fungicides registered for ASR

Sterol biosynthesis inhibitors (G)
- DMI (G1): cypro-, epoxi-, tebuco-, tetra-, prothioconazole
- Amines (Morpholines, G2): fenpropimorph

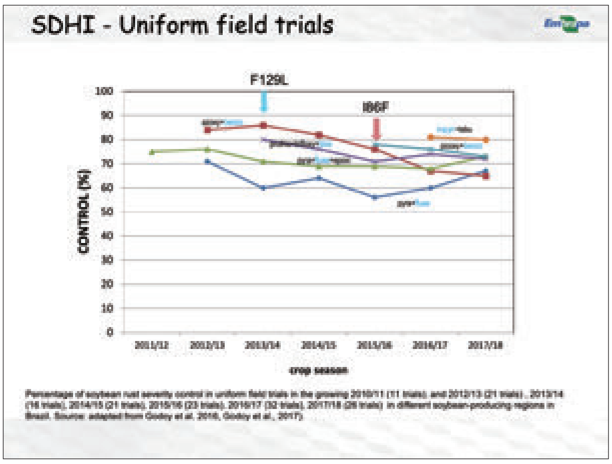
Respiration Inhibitors (C)
- SDHI (C2): benzovindiflupyr, fluxapyroxad, bixafen (2013), impirfluxan, and fluindapyr
- QoI (C3): azoxy-, picoxy-, pyraclo-, metomino-, trifloxystrobin
- uncouplers of oxidative phosphorylation (C5): fluazinam

Multi-sites activity (M) (2014)
- Inorganics (M1): copper
- Dithiocarbamates (EBDC, M3): mancozeb
- Chloronitriles (M5): chlorothalonil

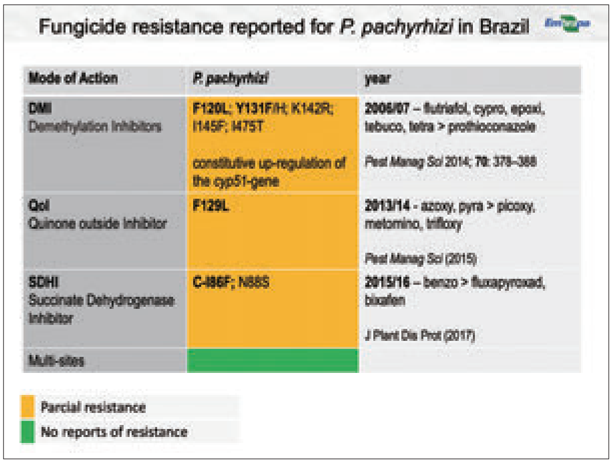




Percentage of soybean rust severity control in uniform field trials in the growing seasons 2003/04 (11 trials), 2004/05 (20 trials), 2005/06 (15 trials), 2006/07 (10 trials), 2007/08 (7 trials), 2008/09 (23 trials), 2009/10 (15 trials), 2010/11 (11 trials), and 2012/13 (21 trials), 2013/14 (16 trials), 2014/15 (21 trials), 2015/16 (23 trials), 2016/17 (32 trials), 2017/18 (26 trials) in different soybean-producing regions in Brazil. Source: adapted from Godoy et al. 2016, Godoy et al., 2017).

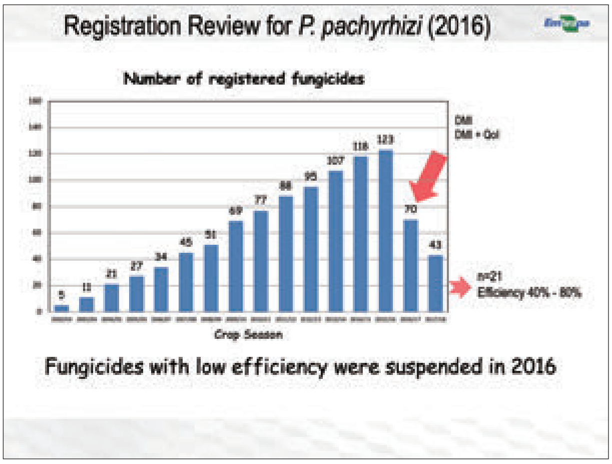


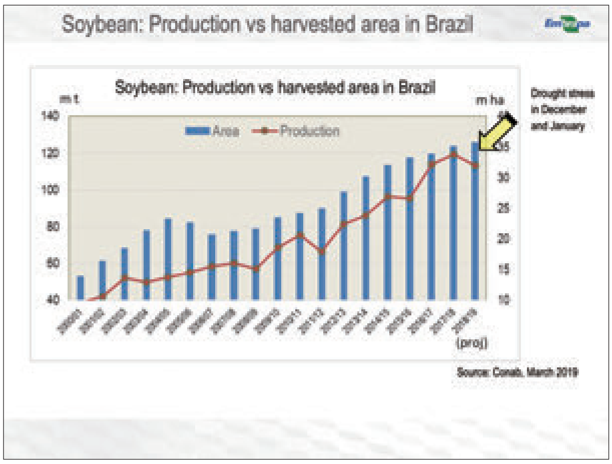
Percentage of soybean rust severity control in uniform field trials in the growing 2010/11 (11 trials) and 2012/13 (21 trials), 2013/14 (16 trials), 2014/15 (21 trials), 2015/16 (23 trials), 2016/17 (32 trials), 2017/18 (26 trials) in different soybean-producing regions in Brazil. Source: adapted from Godoy et al. 2016, Godoy et al., 2017)

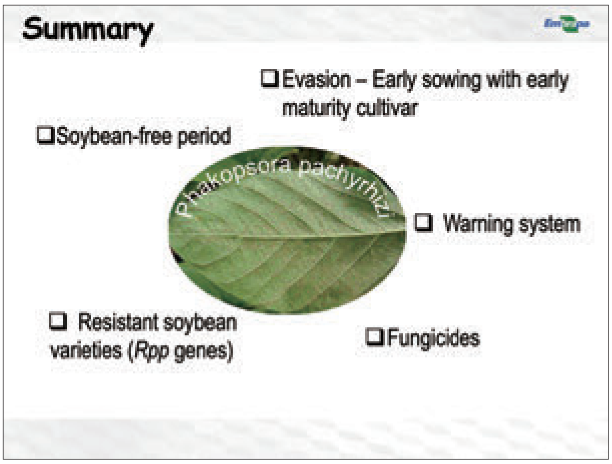

Fungicide resistance reported for *P. pachyrhizi* in Brazil

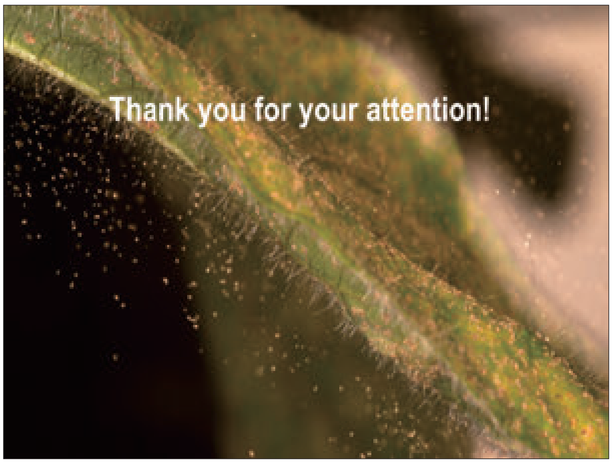
Mode of Action	*P. pachyrhizi*	year
DMI Demethylation Inhibitors	F120L; Y131F/H; K142R; I145F; I475T constitutive up-regulation of the cyp51-gene	2006/07 – flutriafol, cypro, epoxi, tebuco, tetra > prothioconazole *Pest Manag Sci* 2014; **70**: 378–388
QoI Quinone outside Inhibitor	F129L	2013/14 - azoxy, pyra > picoxy, metomino, trifloxy *Pest Manag Sci* (2015)
SDHI Succinate Dehydrogenase Inhibitor	C-I86F; N88S	2015/16 – benzo > fluxapyroxad, bixafen J Plant Dis Prot (2017)
Multi-sites		

Parcial resistance (orange)
No reports of resistance (green)








Thank you for your attention!