# ABSTRACT: 452

## BREEDING SOYBEAN FOR DISEASE RESISTANCE IN BRAZIL

**OLIVEIRA M F & ARIAS C A A**

*National Soybean Research Center, Embrapa Soybean, CP 231, 86001-970, Londrina, PR, Brazil*
*E-mail: marcelo@cnpso.embrapa.br*

As a major crop, soybean has received the most attention from public and private plant breeding companies in Brazil, especially concerning biotic stresses caused by diseases. Genetic resistance, when available, remains the most economic and practical solution for the farmers. Diseases long present in Brazil such as frogeye-leaf-spot (*Cercospora sojina*), stem canker (*Diaphorte phaseolorum* f. sp. *meridionalis*) and bacterial pustule (*Xanthomonas axonopodis* pv. *glycines*) have been controlled by introgression of resistant genes into cultivars. Among the remaining fungal diseases, Asian soybean rust (ASR - *Phakopsora pachyrhizi*) is a priority because of its large economic impact both in the cost of chemical control and direct yield losses. New cultivars resistant to ASR are now available as a useful tool for this disease management but market participation of these cultivars is just beginning. White mold (*Sclerotinia sclerotiorum*) has increased in several regions but no effective resistance source is available for breeding purposes. Root rot caused by *Phytophthora* remains important in the states of southern Brazil but there are commercial, high-yielding, resistant cultivars. Increased occurrence of target spot (*Corynespora cassiicola*) has been reported in several soybean regions and some resistant genotypes have already been selected and are being used in breeding programs. Among the nematodes, the soybean cyst nematode (SCN) and gall nematodes (*Meloidogyne javanica* and *M. incognita*) have been managed with moderate resistant cultivars. SCN has increased in importance and more than 50 Brazilian soybean cultivars were developed from sources that normally provide resistance to race 3 or to races 1 and 3. Gall nematode is dispersed in all Brazilian regions and there are cultivars with resistance to one or both species of *Meloidogyne*. The crop management system involving a second crop has increased the problems with the lesion nematode (*Pratylenchus brachyurus*) and the preliminary studies are showing that the inheritance is relatively complex. Among the viruses, soybean mosaic virus is apparently under control and there are some resistant cultivars. Despite the problems observed with the stem necrosis virus in some regions in recent years, there are tolerant cultivars.

INVITED SPEAKER





# Breeding soybean for disease resistance in Brazil





Author: Soybean Breeding Team
Speaker: Marcelo Fernandes de Oliveira

# Soybean Diseases in Brazil

Among the main factors that limit the achievement of high yields in soybeans are diseases.

Approximately 40 diseases caused by fungi, bacteria, nematodes, and viruses have been identified in Brazil.

The economic importance of each disease varies from year to year and from region to region, depending on climatic conditions of each crop.

The annual production losses due to diseases are estimated at about 15% to 20%, however, certain diseases may cause loss of almost 100%

# Diseases – Soybean cicle

DAMPING OFF
-Anthracnose
-Phytophthora
-Rhizoctonia
-Sclerotium
-Fusarium
-Pythium

EARLY
-Brown Spot (*Septoria*)
-Cercospora Blight
-Bacterial Blight
-Rust
- Phytophthora

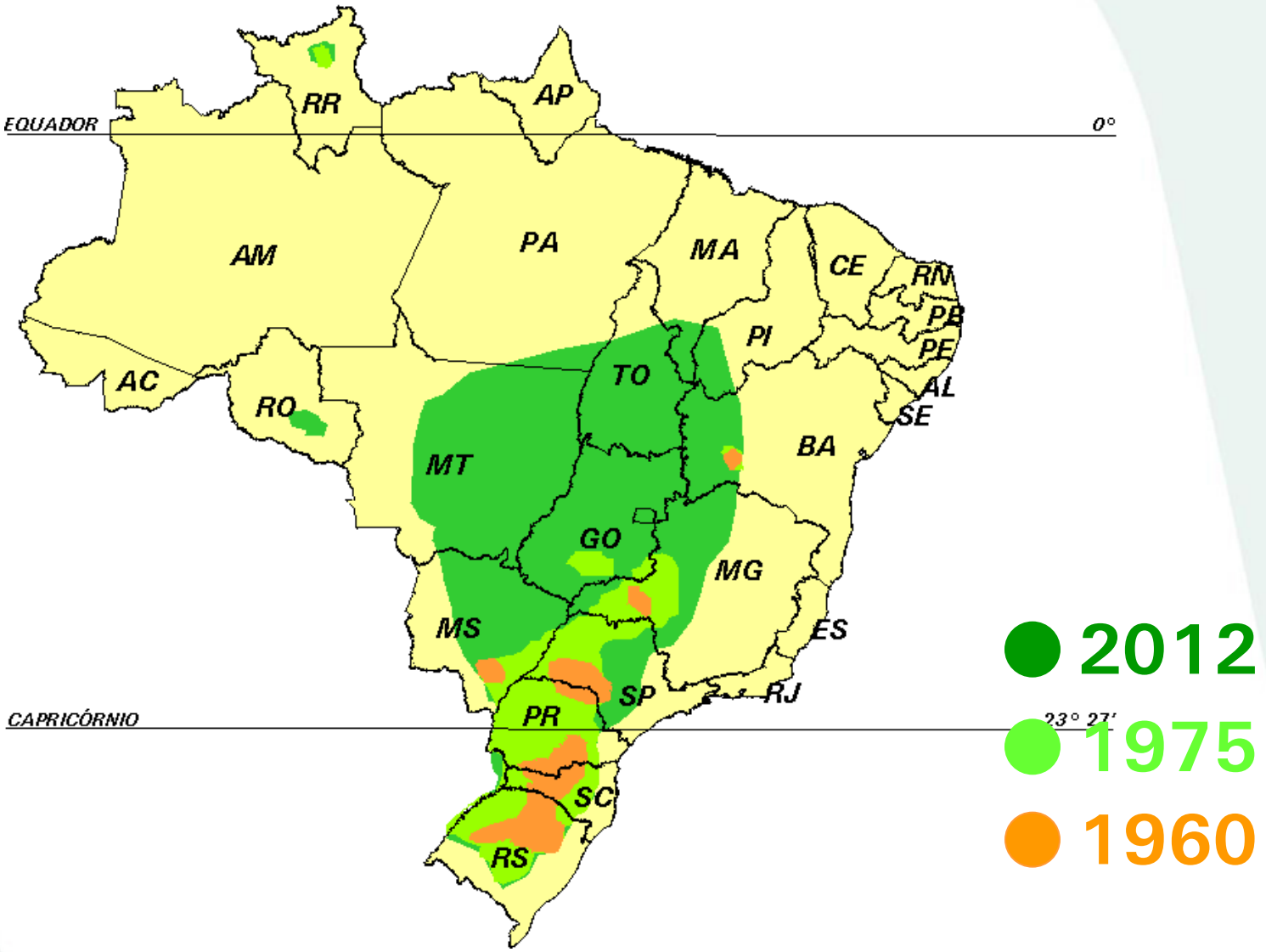
MIDDLE
-Powdery Mildew
-Rust
- Phytophthora
-Anthracnose
-Rhizoctonia
-Target Spot
-Sudden Death
-Sclerotinia Stem Rot
-Viruses
-Bact.Pustule

END OF CICLE
-Brown Spot
-Cercospora Blight
-Charcoal Rot
-Rust



**Nematodes (galls, cyst, lesions)**

# Soybean in Brazil



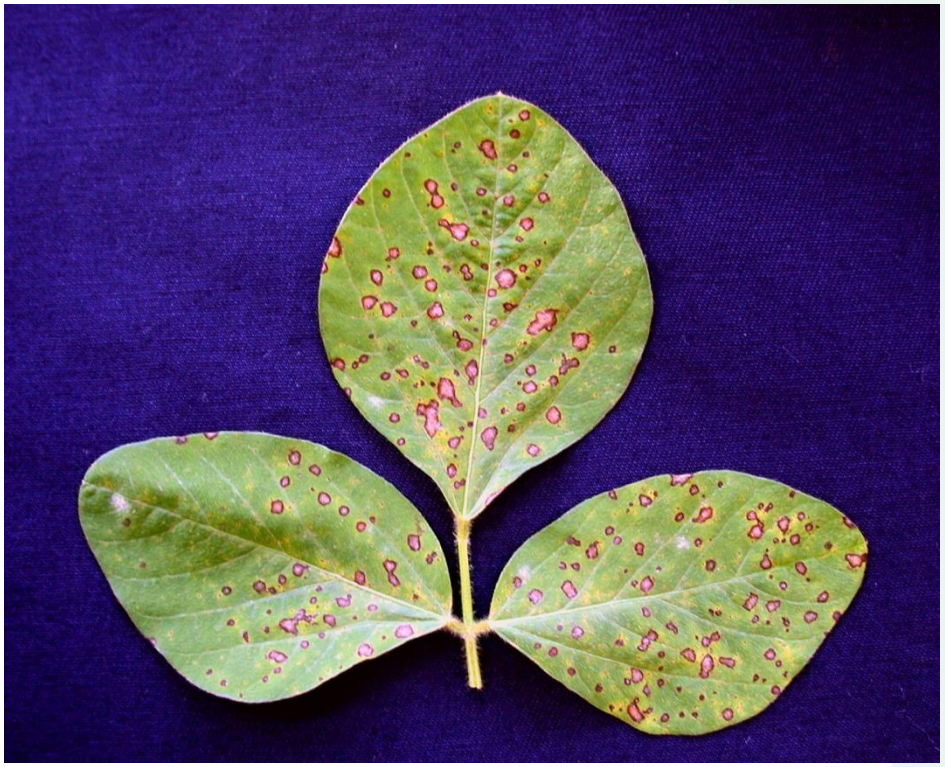
# In Brazil, major diseases can be divided into decades

- "frog-eye leaf spot" (Cercospora sojina Hara) in the 1970s
- Stem Canker (Diaporthe phaseolorum f.sp. meridionalis) in the 1980s
- Soybean cyst nematode - *Heterodera glycines* in the 1990s
- "Asian Soybean Rust" (Phakopsora pachyrhiri) in the 2000s

# Disease: “obligatory” resistance

- Frogeye leaf spot (*Cercospora sojina*)





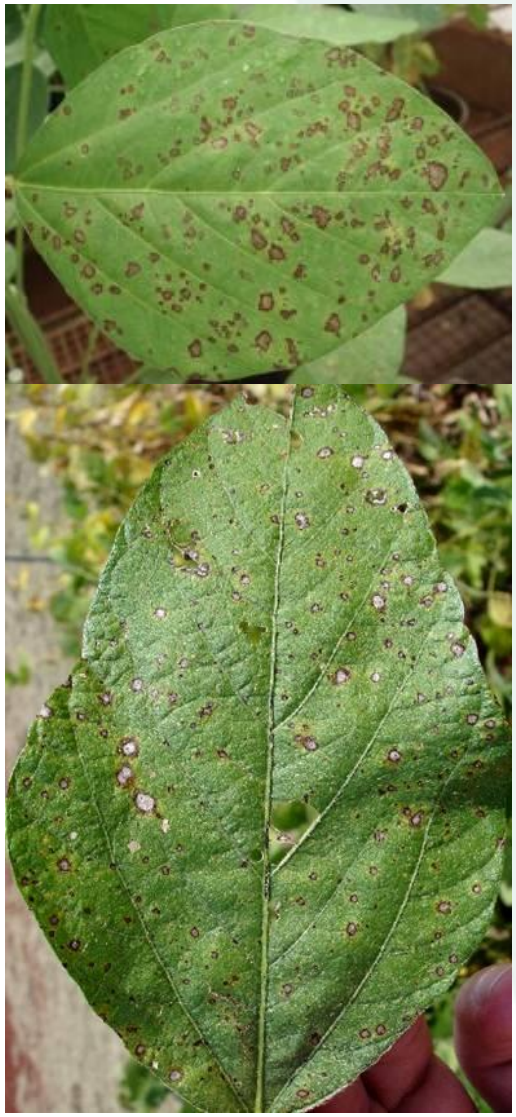
# Frogeye leaf spot

- First identified in 1971, the "frog-eye“ leaf spot came to cause major damage in the South and in the Cerrado.
- It is currently under control due to the use of resistant cultivars

- 25 races have been identified in Brazil

  South races 2,4,7,9, 15 and 17

  Northest races  2,4,7,9, 15, 17, 23, 24 and 25



# Frogeye leaf spot

- resistance controlled by one or a few genes (oligogenic),

  cv Davis (gene Rcs 3) – resistance to all races report until now

  cv Santa Rosa and Cariri – (allelic to Rcs 3) resistance was broken by the race Cs-15

  cv Parana (allelic to Rcs 3) –

  resistance was broken by races

  Cs-23, Cs-24 e Cs-25






The evaluation of resistance to "frog-eye" can be performed by artificial inoculation under conditions of a green house or using molecular markers.



# Frogeye leaf spot

- Currently, the soybean cultivars recommended for the Central Region of Brazil with information on response to disease: 88% are resistant "frog-eye leaf spot
- South ?

# Disease: “obligatory” resistance

- Stem canker - (*Diaphorte phaseolorum* f. sp. *meridionalis*)





# Stem canker

- First identified in season 1988/89, in the southern state of Parana and Mato Grosso in the restricted area

- 96/97 harvest, caused nationally loss estimated at $ 0.5 billion.

- Losses until 100%



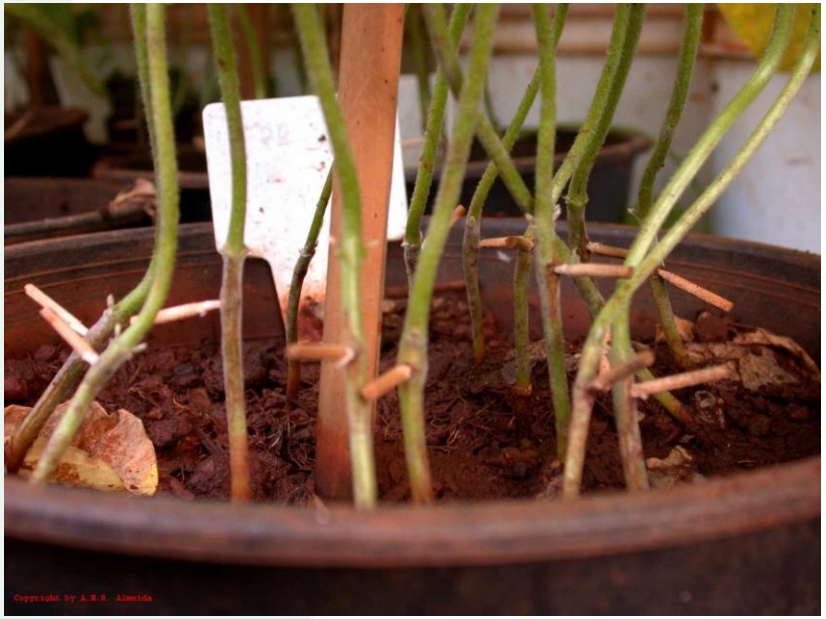
# Stem canker



- The use of resistant cultivar is the most economical and efficient control
- Their resistance is conditioned by up to three genes.
- Source of resistance Tracy M (Rdc1 and Rdc2); Bragg (Rdc2); Crockett (Rdc3) and Dowling (Rdc4)
- 85% of cultivar are resistant to the stem canker

# Stem canker

- The evaluation of resistance of stem canker can be performed by artificial inoculation under conditions of a green house or using molecular markers.





# Disease: “obligatory” resistance

- Bacterial pustule (*Xanthomonas axonopodis* pv. *glycines*)
- Wildfire – (*Pseudomonas syringae* pv *tabaci)*



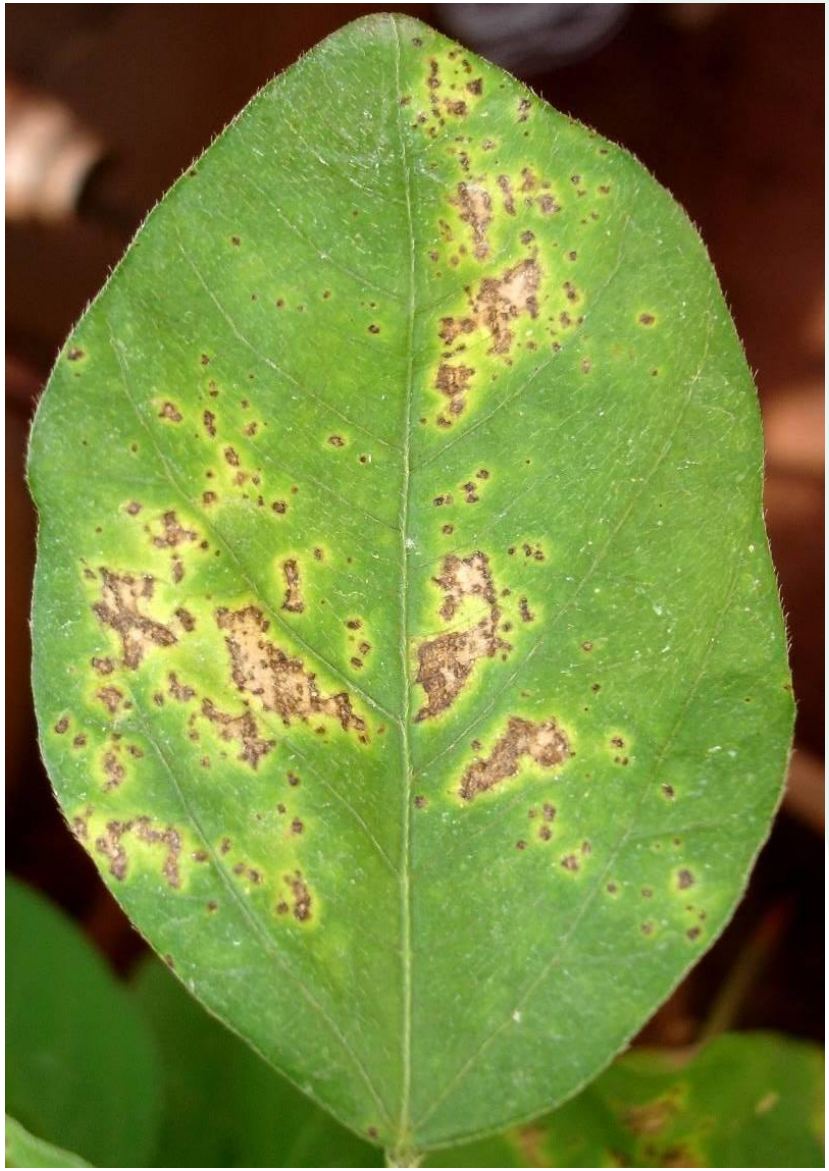


# Bacterial pustule

-Losses until 40%

- Control:
  Resistance variaties







# Bacterial pustule

- One recessive gene (rxp) found in cv CNS
- This allele also controls resistance to the disease wildfire
- Major problem from Parana to Savanas regions





# Bacterial pustule

- The evaluation of resistance of bacterial pustule can be performed by artificial inoculation under conditions of a green house or field

# “Desirable” Resistance

- Phytophthora Root Rot – *Phytophthora sojae*





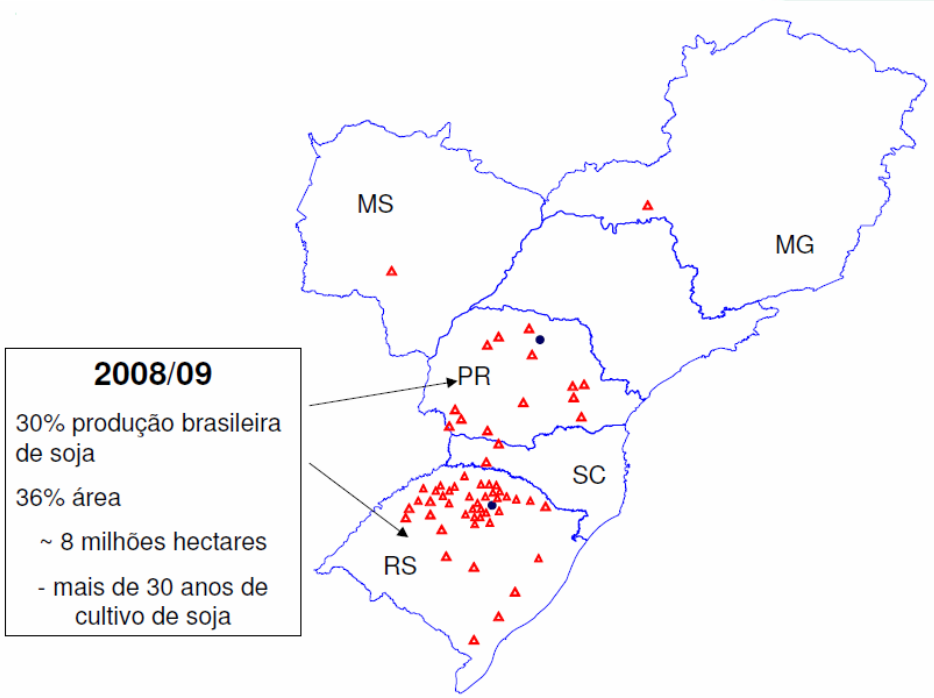


# Phytophthora Root Rot

- Decreased production between 65% and 93% comparing genotypes S and R
- Over 55 races of the pathogen have been described in US
- Brazil and Argentina in

  90's race 1 – gene Rps7
- 2007 Rio Grande do Sul -

  Rps 1a,7 race 3





- Phytophthora Root Rot – major genes








Source of resistance – Rps 1c and Rps 1k



- Phytophthora Root Rot – minor genes – field resistance








# Field Resistance

| Genótipo | Resistência parcial | | Resistência completa | |
|---|---|---|---|---|
| | Nota | Reação | % plantas mortas | Reação |
| BRS 243RR | 1,3 | Alta resistência | 0 | Resistente |
| Test. resist. | 1,8 | Alta resistência | 0 | Resistente |
| BR04-46450 | 2,3 | Alta resistência | 100 | Suscetível |
| BR02-03841 | 2,8 | Alta resistência | 88 | Suscetível |
| BR04-93979 | 3,0 | Alta resistência | 70 | Suscetível |
| BRS 283 | 3,5 | Alta resistência | 60 | Intermediária |
| BRI04-02770 | 3,5 | Alta resistência | 100 | Suscetível |
| BRS 284 | 5,7 | Moderada suscetibilidade | 100 | Suscetível |
| BR03-71454 | 5,8 | Moderada suscetibilidade | 70 | Suscetível |
| BRS 282 | 6,5 | Alta suscetibilidade | 100 | Suscetível |
| BRS 268 | 8,7 | Alta suscetibilidade | 100 | Suscetível |

# “Desirable” Resistance

- Stem necrosis virus (Cowpea mild mottle virus – CPMMV)







- The stem necrosis virus of soybean (CPMMV) was initially identified in the southwest of Goiás, in 2000/01.
- Now It was diagnosed at fields of MT, BA's, MA's and recently, the PR
- The virus is transmitted by whiteflies (not by seeds).



- cv. CD 206 (susceptible) e cv. BRSMT Pintado (resistant)

# “Desirable” Resistance

- Gall nematodes - *Meloidogyne javanica*, *M. incognita*, *M. Arenaria*









# Root-knot nematades

- They have been observed more frequently in the northern Rio Grande do Sul, Paraná, São Paulo and southern Minas Gerais
- In Central Brazil, the problem is growing, with severe damage to crops in Mato Grosso do Sul and Goias
- Brazil losses range from 18 to 56%

.

M. Javanica – Pedrinhas

Sao Paulo 2012/2013







# Root-knot nematades



- Control:

  -Crop rotation

  -Soil management

  - Genetic Resistance

  - Almost 100% of the 71 cultivars are descendants of Bragg (main source of resistance genes Meloidogyne spp

CD 201: - Resistant M. incognita, M. javanica

PI 230977 has an additional resistance gene not present in Gordon and PI80466

## ➢High yielding with resistance to gall nematodes

- Center-North

•BRS 279 RR MRjRi
•BRS Candeia MRjRi
•BRS 8160 RR MRjRi
•BRS 8560 RR MRjRi
•BRS Baliza RR MRji
•BRS Favorita RR RjMRi
•BRS Pétala RjMRi
•BRS Raimunda RjMRi
•BRS Silvânia RR MRji
•BRS Valiosa RjMRi
•BRSGO 204 Goiânia Rji
•BRSGO 8061 MRjRi
•BRSGO 8560 RR MRjRi
•BRSGO 8860 RR MRjRi
•BRSGO Gisele RR MRji
•BRSGO Indiara MRjRi
•BRSGO Luziânia RjMRi
•BRSGO Mineiros MRji
•BRSGO Paraíso MRjRi
•BRSMG 740SRR MRjRi
•BRSMG 811CRR MRjRi
•BRSMG 850GRR MRjRi
•BRSMG Garantia Rji

- Center-South

•BRS 211 Rji
•BRS 213 MRjRi
•BRS 216 MRji
•BRS 230 MRi
•BRS 232 MRi
•BRS 239 Rji
•BRS 240 MRji
•BRS 241 MRj
•BRS 256 RR Rji
•BRS 257 MRjRi
•BRS 260 MRjRi
•BRS 282 Rji
•BRS 283 MRj
•BRS 284 MRj
•BRS 285 Ri
BRS 316 RR RjMRi
BRS 319 RR RjMRi
BRS Cambona Ri
BRS Taura RR MRj
BRS Tertúlia RR MRj





# “Desirable” Resistance

- Soybean cyst nematode - *Heterodera glycines*





# Soybean cyst nematode

- first identified in the Cerrado Region in 1991/92, became one of the most important disease in Brazil
- in the 1996/97 season had already been reported in more than 60 municipalities in the states of Rio Grande do Sul, Paraná , São Paulo, Goiás, Minas Gerais, Mato Grosso and Mato Grosso do Sul
- In Brazil, 11 races have been found, showing high genetic variability of the nematode



- In some regions the losses reached up to 100% of yield.

# Soybean cyst nematode

- Controle:
  - Prevention: clean machinary.
  - Crop rotation
  - Soil
  - Cultivar resistance



Most of cultivar are resistance to races 1 and 3, the predominant cultivated area

# Soybean cyst nematode

- Resistant SCN Sources:
- At least 3 recessive genes (rhg1, rhg2 and rhg3)
  - Hartwig, Pickett, Peking, Centennial, Forrest, Padre, Sharkey, Bryan, Gordon, Bedford, Epps, Nathan, Foster, Carver, Stonewall, Cornell and Thomas, PI 437654 (4+ and 14+) and PI 88788
  - Hartwig has been broke by races 4+ and 14+



SCN Screening in Minas Gerais State



Nursery – screening for SCN in Mato Grosso State













# ➢High yielding with resistance to SCN

## Center-North

- BRSMG Liderança: R3
- BRSMG 251 Robusta R3
- BRSMG Renascença: R3,
- BRSGO Raíssa R3
- BRS 8460RR: R3
- BRSMG 811CRR R3
- BRS Iara R3
- BRSMG 250 Nobreza R1,3
- FMT Tucunaré: R1,3
- FMT Cachara: R1,3
- FMT Matrinxã: R1,3
- BRS Piraíba: R1,3
- BRSGO Araçú R1,3
- BRSMG 810C: R1,3
- BRS Ipameri R3,14
- BRS 263 Diferente: R1,3,14
- BRSMT Pintado: R1,3,5,6,9,10,14
- BRS Jiripoca : R1,3,5,6,9,10,14
- BRSGO Chapadões: R1,2,3,4,5,6,9,10,14

## Center-South

- BRS 262: R1,3
- BRS Invernada: R1,3
- BRS 231: R1,3,14



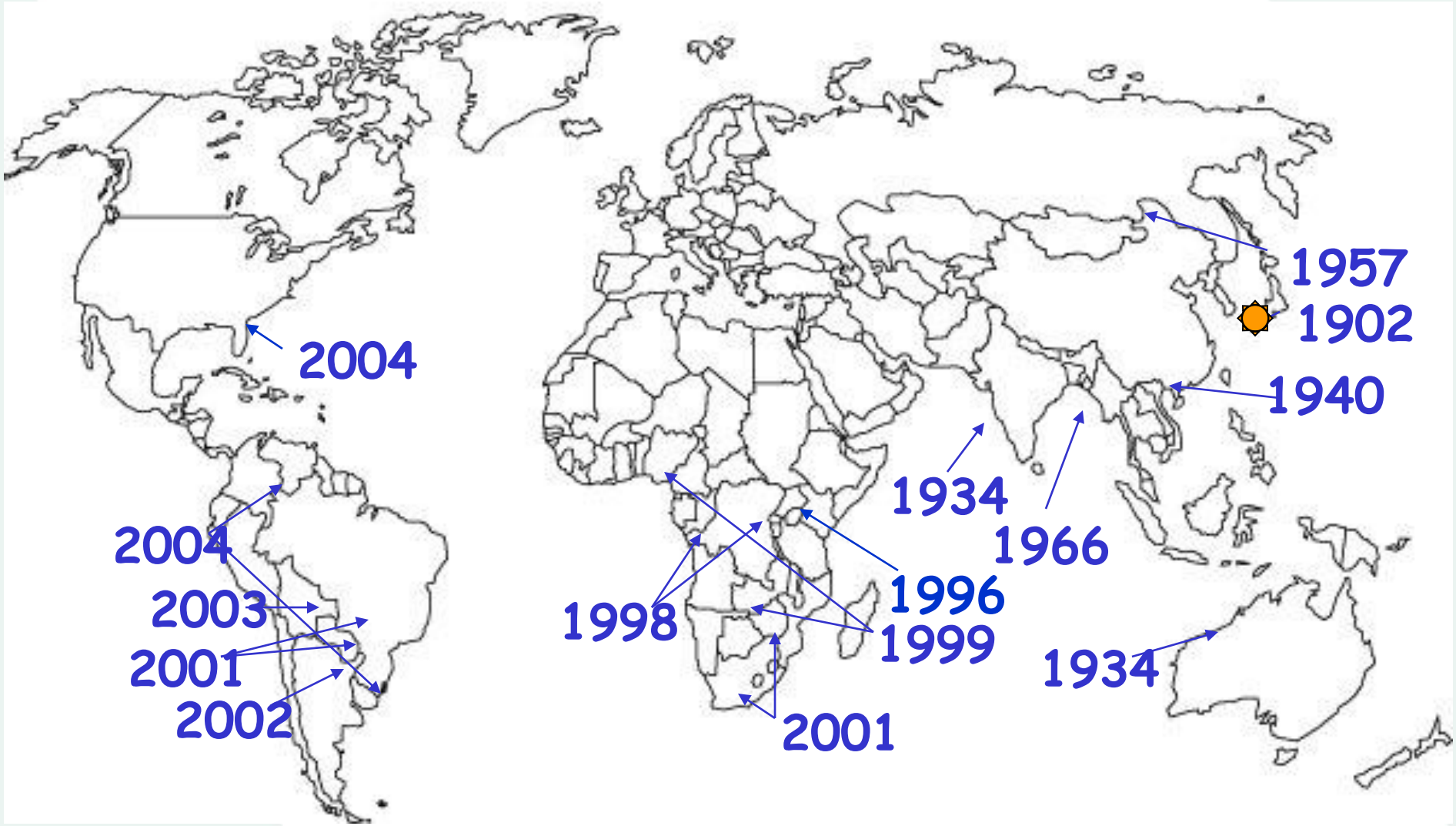
# “Desirable” Resistance

- Asian Soybean Rust - *Phakopsora pachyrhizi*



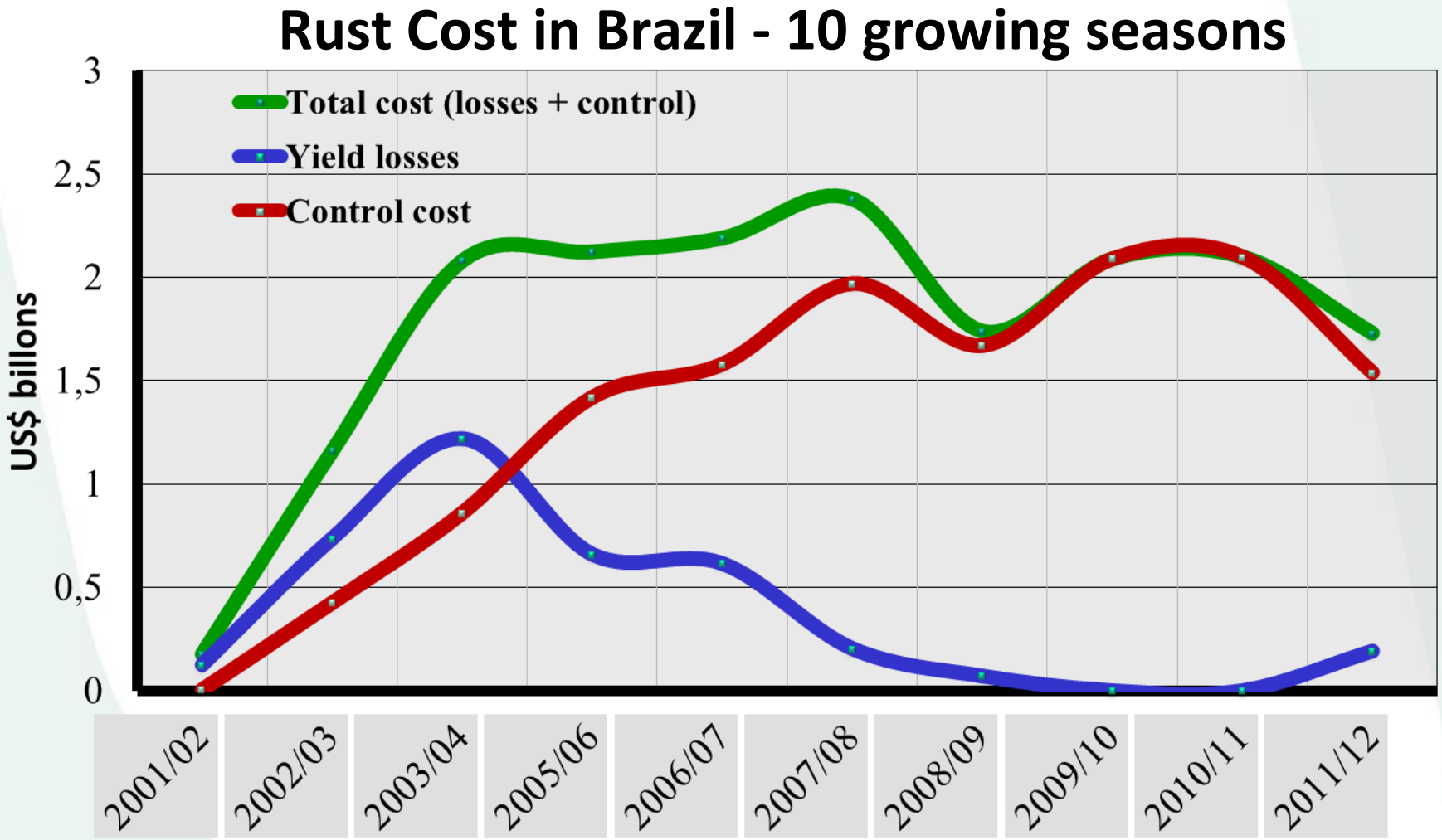


# Asian Rust Occurence



# Asian rust is a priority in the Brazilian breeding programs because:

- have high potential for economic impact



# Asian rust is a priority in the Brazilian breeding programs because:

- Ocurr all years with more or less severity (reproduction / dispersion ability)



**RB**



**RT**



**TAN**

# Soybean Rust

**Major genes: Rpp1, Rpp2, Rpp3, Rpp4 and Rpp5**

**Resistant cultivar before 2003**

**BRS 134**

**BRSMS Bacuri**

**CS 201**

**FT-2**

**FT-3**

**FT-17**

**FT-2001**

**Campos Gerais**

**KIS 601**

**Ocepar7**



# RESISTANCE









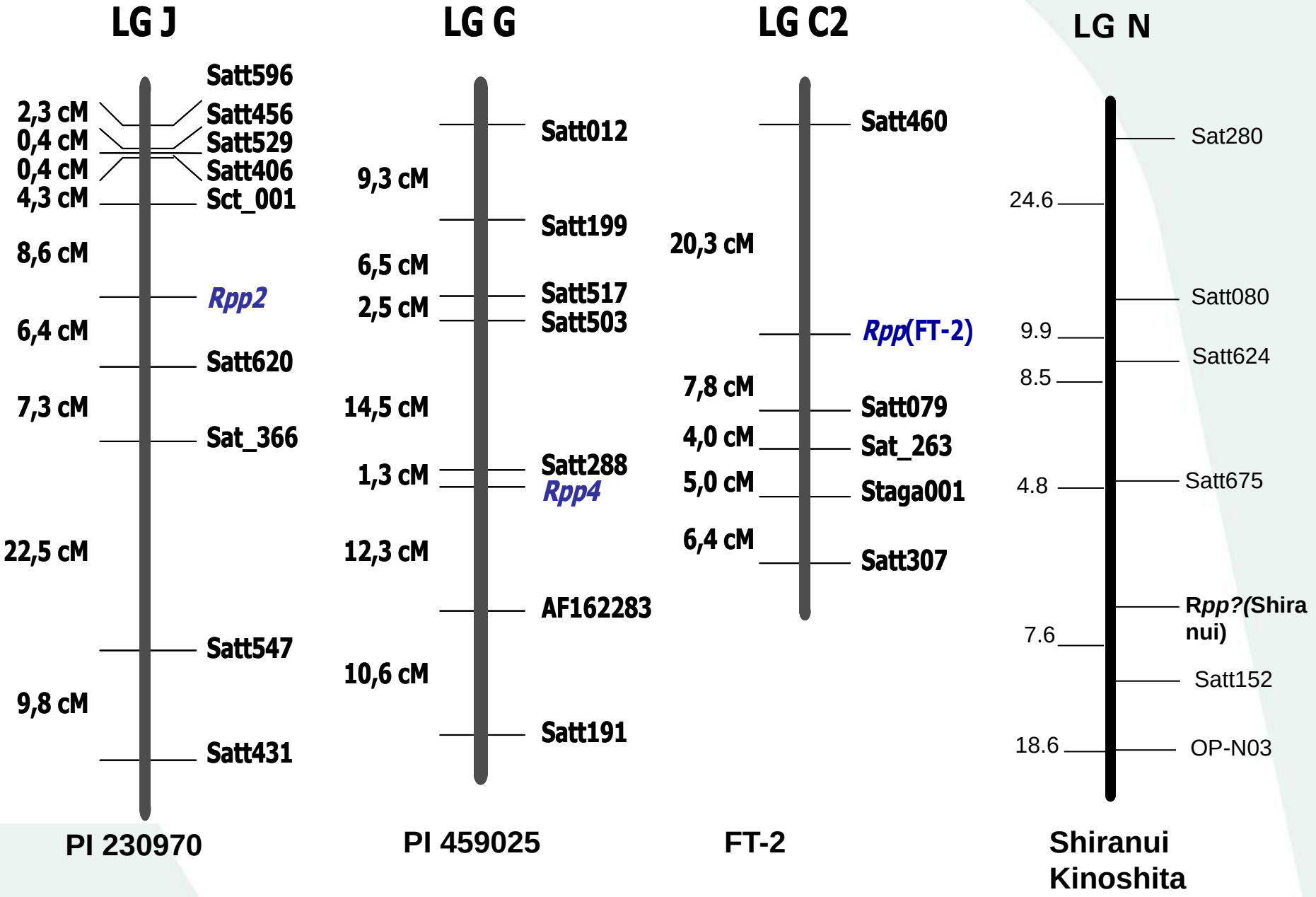
## ➢Embrapa’s varieties with rust resistance gene

- BRSMS Bacuri
- BRSGO 7560: Abura
- BRSMG 771 : Abura / BRSMS Bacuri
- BRSMG 780RR : Abura / BRSMS Bacuri
- BRSMG 791RR : PI 230970, BRS 134

•42 new sources for soybean asian rust

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | Abura | 13 | PI 203406 | 25 | PI 398781 | 37 | PI 417503 |
| 2 | BR86-448 | 14 | PI 224270 | 26 | PI 407912 | 38 | PI 423956 |
| 3 | FT87-17893 | 15 | PI 230971 | 27 | PI 407980 | 39 | PI 423966 |
| 4 | GC84051-9-1 | 16 | PI 274453 | 28 | PI 408205 | 40 | PI 424473 |
| 5 | GC84058-18-4 | 17 | PI 339866 | 29 | PI 408251 | 41 | PI 471904 |
| 6 | GC84058-21-4 | 18 | PI 340050 | 30 | PI 416764 | 42 | Shiranui |
| 7 | Hyuuga | 19 | PI 379618 TC1 | 31 | PI 416810 | 43 | PI 200492 (Rpp1) |
| 8 | IPB77-257 | 20 | PI 398507 | 32 | PI 416819 | 44 | PI 230970 (Rpp2) |
| 9 | Nova Santa Rosa | 21 | PI 398513 | 33 | PI 417074 | 45 | PI 562312 (Rpp3) |
| 10 | PI 197182 | 22 | PI 398526 | 34 | PI 417115 | 46 | PI 459025 (Rpp4) |
| 11 | PI 200455 | 23 | PI 398561 | 35 | PI 417125 | 47 | FT-2 |
| 12 | PI 200487 (Kinoshita) | 24 | PI 398777 | 36 | PI 417421 | 48 | BRS 134 |

# How many genes?




Silva et al (2007) Molecular Mapping of Two Loci That Confer Resistance to Asian Rust in Soybean. TAG (Submetido)

| Source | Segregation with *Rpp2* | Segregation with *Rpp4* | Conclusion |
|---|---|---|---|
| PI 197182 | 1:0 | 15:1 | Loco Rpp2 |
| PI 230971 | 1:0 | 13:3 | Loco Rpp2 |
| PI 417125 | 1:0 | 15:1 | Loco Rpp2 |
| GC 84058-21-4 | 15:1 | 15:1 | Novo gene |
| PI 408251 | 15:1 | 15:1 | Novo gene |
| PI 379618 TC1 | 15:1 | 15:1 | Novo gene |
| Nova Santa Rosa | 15:1 | 15:1 | Novo gene |
| PI 203398 (Abura) | 15:1 | 15:1 | Novo gene |
| PI 423966 | 15:1 | 15:1 | Novo gene |
| PI 416764 | 15:1 | 15:1 | Novo gene |
| PI 417115 | 15:1 | 15:1 | Novo gene |
| PI 416819 | 15:1 | 15:1 | Novo gene |
| GC 84058-18-4 | 15:1 | 15:1 | Novo gene |
| PI 398526 | 13:3 | 13:3 | Novo gene |
| PI 339866 | 13:3 | 15:1 | Novo gene |
| PI 340050 | 13:3 | 15:1 | Novo gene |
| PI 417503 | 13:3 | 15:1 | Novo gene |
| PI 417421 | 13:3 | 15:1 | Novo gene |
| PI 203406 | 13:3 | 15:1 | Novo gene |
| FT 87-17893 | 13:3 | 15:1 | Novo gene |
| PI 417074 | 13:3 | 15:1 | Novo gene |
| PI 408205 | 13:3 | 15:1 | Novo gene |
| GC 84051-9-1 | 15:1 | 13:3 | Novo gene |
| PI 416810 | 15:1 | 13:3 | Novo gene |
| PI 200487 | 15:1 | 13:3 | Novo gene |

# Thank you !




***marcelofernandes.oliveira@embrapa.br***