SOYBEAN RUST - BEWARE OF RESISTANCE TO TRIAZOLE FUNGICIDES

Prof. M.D. Laing and Dr P. M. Caldwell

Discipline of Plant Pathology, SASA, University of KwaZulu-Natal,

Private Bag X01, Scottsville 3209.

Asian soybean rust (SBR), caused by the fungus *Phakopsora pachyrhizi*, was limited to causing significant losses only in Asia and Australasia. Mysteriously, after 1992, the fungus started to move around the world. It appears to have arrived in Africa via monsoon winds from India, and was clearly established in Uganda, Kenya and Rwanda by 1996. Then it appeared in Zimbabwe and Zambia in 1988, slowly followed by its appearance in 1999 in Nigeria, in Mozambique in 2000, and finally arrived in South Africa (SA) in 2001. Subsequently, wind currents took SBR spores to South America, and between 2001 and 2004, SBR was detected in many South American countries, moving north following the continental wind patterns. By 2004 it was seen in Louisiana and in the following two years spread to 15 states in the USA. One of the main reasons that the fungus moved so far so fast was that none of the popular soybean cultivars grown globally are resistant to SBR. Hence management of the disease globally has depended upon fungicides. In 2008, Brazil reportedly used more than US$8 billion on their soybean crop to control SBR.

In South Africa, high yield losses were initially avoided in the SA soybean industry through the use of systemic fungicides, following emergency fungicide registrations. This was followed by an intensive research programme by many researchers and chemical companies to secure long term fungicide registrations. As a result, over the past 7 years, numerous fungicides have been registered for the control of SBR in SA. At present SBR can be controlled with 1-2 sprays, applied after flowering, using the registered fungicides on the market in SA (Table 1).

Table 1. Table of registered fungicides for the control of soybean rust in South Africa.

Product name / Produknaam	**Active Ingredient** **Aktiewe bestanddeel**	**Fungicide Group**	**Company** **Maatskappy**
Abacus®	pyraclostrobin/ epoxiconazole	Strobilurin + Triazole	BASF
Bayfidan® 250DC	triadimenol	Triazole	Bayer
Capitan® 250EW	flusilazole	Triazole	DuPont
D-Zole® 250 EC	difenoconazole	Triazole	Universal Crop Protection

Folicur® 250EW	tebuconazole	Triazole	Bayer
Impact®	flutriafol	Triazole	Cheminova
Lyric® 250 EW	flusilazole	Triazole	DuPont
Lyric® C	carbendazim/ flusilazole	Benzimidazole + Triazole	DuPont
Pronto® 250 EC	difenoconazole	Triazole	Meridian Agritech
Punch® C	carbendazim/ flusilazole	Benzimidazole + Triazole	DuPont
Punch-Xtra®	carbendazim/ flusilazole	Benzimidazole + Triazole	DuPont
Scope® 250	difenoconazole	Triazole	Villa Crop Protection
Score® 250EC	difenoconazole	Triazole	Syngenta
Shavit® 25EC	triadimenol	Triazole	Makhteshim-Agan
Tebucure®	tebuconazole	Triazole	Universal Crop Protection
Tristar® EC	triadimenol	Triazole	Meridian Agritech

Source / Bron: Registrar, Act No. 36 1947, personal communication November 2006.

These fungicides can be classified into two primary groups of systemic fungicides, specifically the triazoles and strobilurins. A third group, the benzimidazoles, are ineffective against rusts but are included with some of the fungicides registered against SBR.

Because of their high level of efficacy, and “reach-back” curative action, triazoles have been used most frequently against SBR. At present, no cases of resistance by *P. pachyrhizi* to triazole fungicides has been detected in SA. However, if soybean farmers continue to use triazoles alone, without alternating or mixing with other groups of effective fungicides with different modes of action, then this aggressive pathogen is likely to evolve resistance to triazoles.

Fungicide resistance problems by wheat rust to triazole fungicides in Europe are a well-known problem, so triazole fungicide resistance by SBR can be expected. Multisite fungicides (protectants) do not face resistance problems, but single site fungicides (systemics) all face resistance problems. For example, single site benzimidazole fungicides, such as benomyl, was used extensively to control eyespot on wheat in

Europe in the 1970s. However, once resistant strains of the fungus had developed, none of the benzimidazole fungicides could be used again because the resistant strains of eyespot were as fit as susceptible strains. Similarly, metalaxyl is also a single site fungicide and some fungi (e.g., late blight and downy mildew) have also evolved resistant strains with equal fitness. In the case of *Botrytis*, strains with resistance to iprodione show a reduced fitness (less able to reproduce), which means that the fungicide can be re-used after a break of several crops.

To reduce the risks of fungicide resistance development, and to extend the life of fungicides, it is advisable for SA farmers to follow the recommendations of the global Fungicide Resistance Action Committee (FRAC), specifically:

1. Alternate fungicides with different modes of action e.g., triazole / strobilurin / triazole; or triazole / protectant / triazole. The idea here is that the each fungicide will kill off mutants that develop resistance against the previously used partner fungicide.
2. Use a premix, e.g., triazole plus strobilurin or protectant. The idea here is that fungi would have to develop resistance against two different fungicide groups at the same time, which is much less likely.
3. Reduce exposure to two applications of each systemic fungicide per season. The idea here is to reduce the number of chances the fungus has to develop resistant mutants.
4. Use a full dose, not a reduced dose, of the fungicide. The idea here is that reduced doses give the fungus a chance to adapt to the fungicide because fewer spores and fungal colonies will be completely eliminated, whereas a full dose will kill more spores and colonies.

A further consideration is to start fungicide treatments relatively early, before the disease epidemic is in full swing, and before millions of spores are flying around, because the more spores there are at the time of spraying, the greater the chances there are that resistant mutants will be selected.

SBR arrived in Brazil in 2003, and severe SBR outbreaks resulted in heavy applications of triazoles alone. This led to warnings by concerned chemical companies and scientists of the risks of SBR fungicide resistance developing against the triazoles. Sure enough, in the first quarter of 2008, a lower than expected efficacy of triazoles was observed in Mato Grosso and Mato Grosso do Sul, Brazil. However, no sensitivity change was detected in the triazole-strobilurin mixtures which continued to perform very well.

According to Dr Claudia Godoy of Embrapa Soya in Londrina, Brazil, this reduced efficiency of triazoles is mainly due to over-exposure of SBR to triazole fungicides used by themselves. Folicur® (tebuconazole) is cheap in Brazil and is sold in competition with a number of generic brands. Dr Godoy reports that many farmers in the Mato Grosso province of Brazil used up to four applications of tebuconazole per season, despite the FRAC recommendation of only two applications per season. Although tebuconazole is a recommended fungicide, its single site mode of action makes it vulnerable to resistance.

It is this situation that South Africa needs to avoid in order to retain the excellent control of SBR provided by triazoles.

The use of a strobilurin-triazole mixture is a major strategy to manage resistance, promoted by the agrochemical industry, for reducing risk of resistance towards both fungicide groups. These two active ingredients are complimentary in their action because strobilurins inhibit fungal respiration and consequently inhibit spore germination, whereas triazoles inhibit germ tube elongation, fungal penetration and mycelial growth.

Of the 16 fungicides registered in SA, Abacus is the only triazole + strobilurin product registered in SA currently. Unfortunately, carbendazim is not effective against rusts such as SBR, so the mixing of triazoles with carbendazim does not protect against resistance development of rusts, the way it does against grey leaf spot of maize (*Cercospora zeae-maydis*).

If the FRAC recommendation of only two applications of a single product per season are to be followed, then a logical rotation of fungicides would be:

Option 1 – Low Risk Area with up to 2 sprays required

Spray 1 triazole or triazole + benzimidazole (choice of 15 fungicides)

Spray 2 strobilurin + triazole (Abacus)

Option 2 – Medium Risk Area with up to 3 sprays required

Spray 1 triazole or triazole + benzimidazole (choice of 15 fungicides)

Spray 2 strobilurin + triazole (Abacus)

Spray 3 Spray 4 strobilurin + triazole (Abacus)

Option 3 – High Risk Area with up to 4 sprays required

Spray 1 triazole or triazole + benzimidazole (choice of 15 fungicides)

Spray 2 strobilurin + triazole (Abacus)

Spray 3 triazole or triazole + benzimidazole (choice of 15 fungicides)

Spray 4 strobilurin + triazole (Abacus)

If the FRAC recommendations are followed, the over-use of single product fungicides, and especially triazoles, will be minimized and resistance by soybean rust to fungicides will be avoided or delayed. The agrochemicals and soybean industries need to commit

to protecting effective systemic fungicides, upon which the soybean industry will be dependant until fully rust resistant soybean varieties can be bred.
