t e c h n i c a l   l e a f l e t

Rhizoctonia Root Rot

UPDATED VERSION 2013

SESVANDERHAVE

sugar beet seed

Preface

The battle against Rhizoctonia: an evolving story

This is the updated version of SESVanderHaves' Technical Leaflet on Rhizoctonia. New developments, new insights and new solutions in the battle against Rhizoctonia make this essential reading. This, in part is due to the collaboration of SESVanderHave and the sugar beet industry at the first SESVanderHave Technical Days in Strasbourg, August 2011.

Rhizoctonia is an increasing problem for sugar beet growers everywhere. This disease can significantly affect crop yield, as well as industrial quality. Therefore, to prevent the sugar beet crop from losses we must understand how to protect it. However, this is not straightforward, changes in agricultural practice are encouraging the proliferation on Rhizoctonia. Changes in crop rotations and reduced tillage exacerbate Rhizoctonia root and crown rot.

Reduction of damage caused by Rhizoctonia requires an integrated approach to harness the synergies from combining best agricultural practice, breeding and crop protection.

This updated Technical Leaflet provides a comprehensive reference on Rhizoctonia and its control. SESVanderHaves' emphasis on R&D ensures that new breeding technology anticipates and delivers genetic solutions which are in tune with integrated control strategies for pests and diseases – driving crop yields and performance.

Sharing knowledge and ideas is essential to keep ahead of pests and diseases. The SESVanderHave Technical Days on Rhizoctonia provided a platform to achieve this, both through an extensive set of presentations and field trials - allowing all participants to improve their understanding of Rhizoctonia & its control. We hope this will lead to a better control of the disease around the world; keeping the industry and growers productive and profitable in the face of threats from pests & disease.

That is the aim of SESVanderHave.

Klaas Van der Woude
R&D Director SESVanderHave

Acknowledgements

We would like to thank everyone who participated in the first 'SESVanderHave Technical Days on Rhizoctonia root rot in sugar beet: integrated management' in Strasbourg in 2011, as well as the staff of the Cristal Union agronomy department for their support during the field trials visit.

Figure 1. The first 'SESVanderHave Technical Days' owe their success not only to the quality of the speakers and field technicians but also to the enthusiasm of the participants.

Introduction

Rhizoctonia root rot is caused by the soil-borne fungus *Rhizoctonia solani*. In sugar beet, the disease causes a dark brown rot of the root and crown. Outbreaks of the fungus responsible for Rhizoctonia root rot generally start when the rows begin to canopy (i.e. during the month of June for the majority of beet-growing regions). However, symptoms of the disease are often not apparent until late summer or early autumn. The grower usually doesn't notice that his beets are diseased until he lifts them.

The phytopathogenic fungus *Rhizoctonia solani* was discovered in 1858 by Julius Kühn. The strain responsible for Rhizoctonia root rot in sugar beet (AG 2-2 IIIB) can affect a wide range of plants: maize, soya, vegetables, ryegrass, weeds, etc.

Today, the disease is found in many regions of the world and in all types of soil. The extent of the damage it causes in sugar beet can vary but the losses are sometimes considerable, even dramatic.

In recent years, a resurgence of the disease has been observed in several beet-growing areas. The higher frequency of host plants in the rotation (e.g. maize in Germany, soya and/or maize in the USA) is one of the main reasons.

Figure 2. Typical symptoms of Rhizoctonia root rot (Source: INRA-Dijon).

The fungus responsible for Rhizoctonia root rot can also be involved in damping off (or 'black foot')

In sugar beet, *Rhizoctonia solani* not only causes Rhizoctonia root rot. In the USA, Europe and Japan, it is also part of the complex of fungi responsible for damping off. However, the strain of *Rhizoctonia solani* that causes this disease (AG4, AG2-2) is not always the same as the one responsible for Rhizoctonia root rot (AG 2-2) (Fürher Ithurrart & Büttner, 2002). In any given soil, one of the two strains may be present or they may co-exist, in such a way that the two diseases may (but need not) occur consecutively in the same plot.

Phoma (*Phoma betae*), Pythium (*Pythium ultimum*) and Aphanomyces (*Aphanomyces cochlioides*) are the main members of the complex of soil-borne fungi responsible for damping off. However, the complex can also include other fungi (e.g. *Rhizoctonia solani*). These fungi attack the young plant at the same time, so it is often difficult to identify the pathogenic agent with certainty.

The complex causes blackening of the roots in young plants ('black foot' or 'black root' are alternative names for 'damping off') and constriction of the beet crown. In some cases, the part just under the cotyledons may also turn black. The plant is weakened or may be killed completely. The result is poor beet development and/or a reduced plant population in the field. Symptoms may appear until the four-leaf stage. After that, the plant is no longer susceptible to the disease.

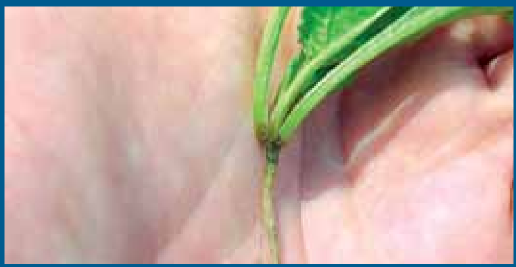


Figure 3. Typical symptoms of black foot (damping off).

The spread of the fungal complex is encouraged by warm, wet weather – conditions that are often present in late sowing. Black foot is widespread and may cause severe damage if not controlled properly.

The fungicide treatments contained in seed coatings (e.g. Hymexazole) provide an effective solution to some of the pathogenic agents that cause this disease.

Geographical distribution

Europe

The disease is found in many areas of Europe. In recent years, it has occurred almost simultaneously in France, Germany, Belgium and the Netherlands. It has been diagnosed to date in most European countries with the exception of Scandinavia and the UK, where the disease is virtually unknown, the climate there being colder and rotations longer.

In **France**, 3% of the land area is thought to be affected by the disease. Its presence is:

– Strong in Limagne and Alsace

– Moderate to the south of Paris and in Picardy

– Very limited in other regions

The disease appears to have a particularly strong presence in regions where maize is commonly included in rotations, and in regions with clay soils and relatively short rotations.

In **Germany**, Rhizoctonia root rot is present in around 15,000 ha (approx. 4% of the total beet-growing area). It occurs mainly in two regions: (1) Niederbayern, (2) Aachener / Bucht / Niederrhein. The role played by the significant proportion of maize in rotation and the type of soil (clay texture) partly explains this geographical distribution.

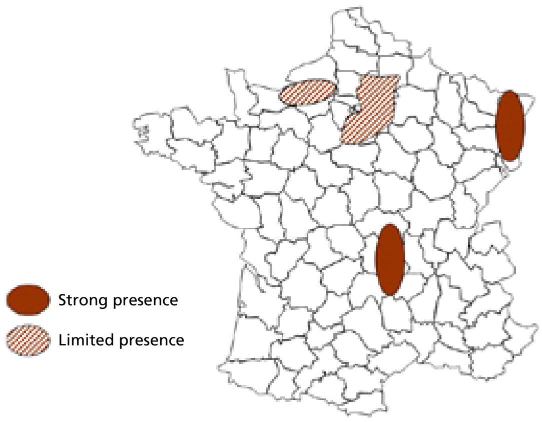


Figure 4. Beet-growing regions affected by Rhizoctonia root rot in France.
Source: ITB[1] (SESVanderHave Technical Days 2011)

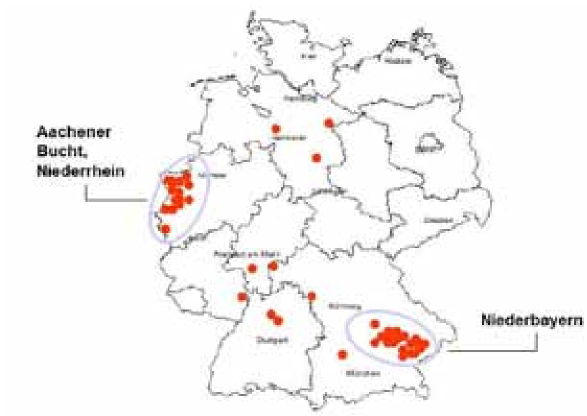


Figure 5. Geographical distribution of R. solani in beet-growing regions in Germany.
Source: IfZ[2] (SESVanderHave Technical Days 2011).

(1) *ITB, Institut Technique de la Betterave (France)*
(2) *IfZ, Institut für Zuckerrübenforschung (Germany)*

In **Belgium**, the main areas where Rhizoctonia root rot is found are centred around the former sugar mill in Moerbeke, i.e. in a region of sandy and sandy/loamy soils. Other less significant centres have been demonstrated around Tienen and in the north and south of the province of Hainaut.

Figure 6. Locations affected by Rhizoctonia root rot in Belgium in 2011. Source: IRBAB/KBIVB[3] (SESVanderHave Technical Days 2011).

In the **Netherlands**, the disease causes significant problems particularly on sandy soils in the east of the country. However, a rise in cases has also been observed on clay soils. *Rhizoctonia solani* is currently found on 80% of plots in East Brabant, the Achterhoek and Limburg (IRS, 2006). However, the severity of the damage varies widely.

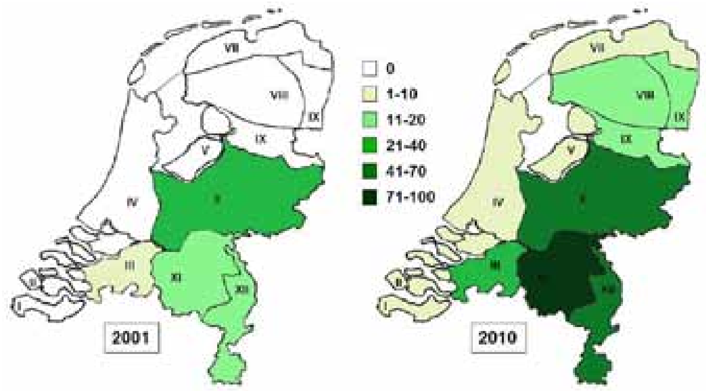


Figure 7. The usage of varieties tolerant to beet necrotic yellow vein virus and Rhizoctonia root rot in the different agricultural regions of the Netherlands gives an indication of the geographical distribution of Rhizoctonia root rot in the country.
Source: IRS[4] (SESVanderHave Technical Days 2011).

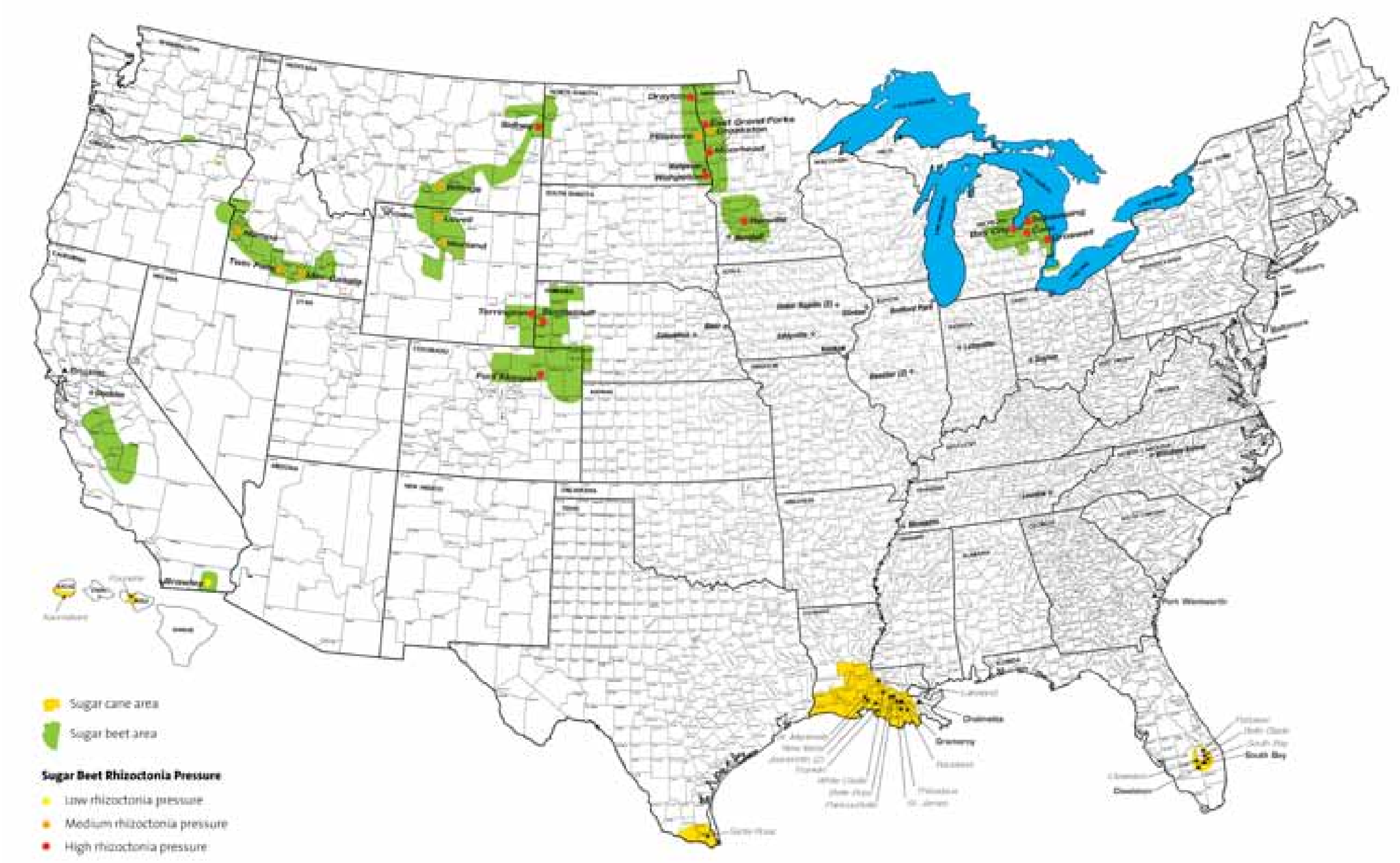
Figure 8. Principal beet-growing regions where Rhizoctonia root rot is present in Spain.
Source: AIMCRA[5] (SESVanderHave Technical Days 2011).

In **Spain** in the beet-growing region in the north of the country (Castille-León), two principal areas are affected by Rhizoctonia root rot: the larger of these is Salamanca (where 15% of 7,000 ha are affected), followed by the smaller region of León (30% of 2,300 ha). In the south of the country (Andalucia), where sowing takes place in the autumn, *R. solani* causes a different problem in beets grown after tomatoes: damping off.

(3) *IRBAB, Institut Royal Belge pour l'Amélioration de la Betterave; KBIVB, Koninklijk Belgisch Instituut tot Verbetering van de Biet (Belgium)*
(4) *IRS, Instituut voor Rationele Suikerproductie (the Netherlands)*
(5) *AIMCRA, Asociación de investigación para la mejora del cultivo de la remolacha azucarera (Spain)*

North America

Rhizoctonia root rot is common in North America, where it has become one of the most significant root rots. In 2003, the disease was present in over 35% of the area sown to beet in the USA (Büttner et al., 2006). It has increased over the last 10 years: today, the use of azoxystrobin by localised foliar application – a method for the control of Rhizoctonia root rot – is widely practiced in the Red River Valley, Michigan and Western regions..



Elsewhere

Rhizoctonia root rot and other root rot diseases are also present in other beet-growing countries such as Chile, China and Iran.

Epidemiology

Life cycle

In the absence of a host plant, *Rhizoctonia solani* can persist for many years in the soil in the form of small brown or black survival structures called "sclerotia". In some cases, it can also survive in the form of mycelium on decomposing plant debris.

When the soil temperature reaches a certain level (around 15°C), secretions produced by the host plants activate the sclerotia which begin to generate a mass ("mycelium") of long filaments ("hyphae"). This makes contact with the roots and attaches to their surface.

The mycelium then proliferates on the root and produces special T-shaped structures called "infection cushions". Using specific enzymes capable of digesting cell walls, these enable the fungus to invade and colonise the inter- and intra-cellular spaces of the root tissue.

As it develops, the fungus diverts the plant's cell resources and uses them for its own growth. The fungal mycelium gradually invades the cells, killing them and producing survival structures inside them. The plant starts to die as its xylem vessels are attacked.

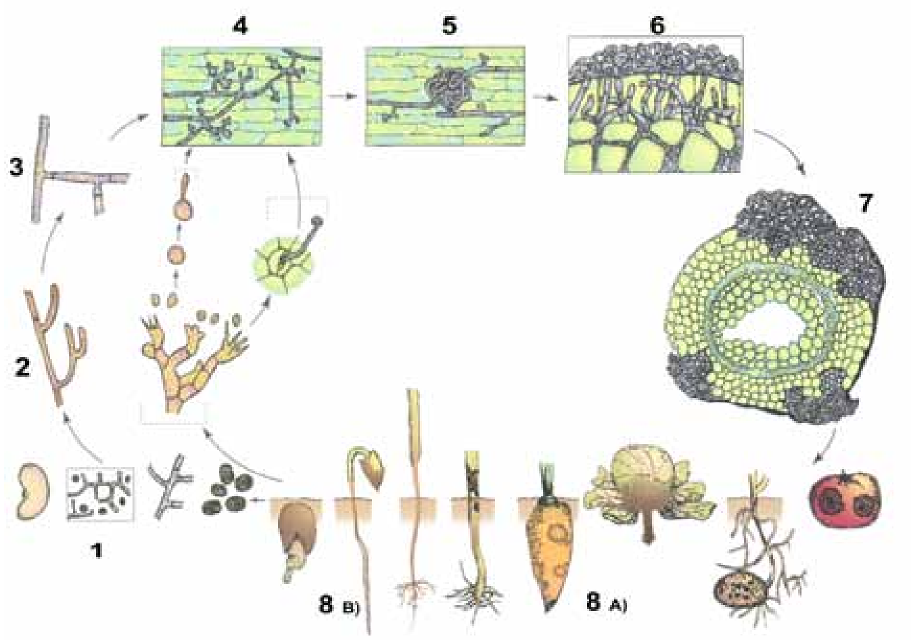


Figure 9. The life cycle of Rhizoctonia solani: the (1) mycelium and sclerotia overwinter in plant debris, soil or host plants (seed, debris, mycelium, sclerotia). The (2) young hyphae develop gradually into (3) an older mycelium which (4) colonises the surface of the plant and (5) produces infection cushions. This enables the (6) mycelium to invade the host. (7) Necrosis and sclerotia form in and on the tissues of the host plant, which may lead to (8a) crown and root rot, or even (8b) damping off. (Agrios, 2006; with the kind permission of Professor G. Agrios).

Dispersal and growth factors

Rhizoctonia solani sclerotia can be dispersed by the wind, water (rainfall, drainage and irrigation) and soil movement (erosion, cultivation, uprooting).

However, the fungus' ability to disperse may not be as crucial as it appears. Many phytopathologists believe that *Rhizoctonia solani* is already present in most agricultural soils in the regions where sugar beets are grown. Consequently, an outbreak of the disease is thought to depend more on a combination of several **environmental factors**:

- presence of a host plant and/or host plant residue (e.g. maize stubble)
- abundant rainfall
- increased temperatures in spring and summer[6]

Another critical factor is **poor soil structure**; this reduces drainage and encourages the development of a humid microclimate in the soil. Several studies have shown that compaction significantly increased damage by Rhizoctonia root rot, especially in heavy soils (Buddemeyer & Petersen, 2004).

(6) *The ideal air temperature for development of the fungal mycelium ranges from 20 to 25°C. The fungus continues to develop at 35°C.*

Strains of Rhizoctonia - the importance of AG2-2 IIIB

A wide range of *Rhizoctonia solani* strains exist all over the world, defined by scientists as **anastomosis groups** (or AGs). An anastomosis group identifies a group of fungi of the same species which are capable of fusing their hyphae and exchanging genetic material. In practice, these groups are differentiated mainly by their host plants and the conditions of temperature and humidity required for development. There are a total of 13 AGs in the case of *R. solani*, several of which are capable of infecting sugar beet. However, sugar beet is mainly affected by two of them: AG2-2 IIIB and AG4. While AG4 is almost exclusively associated with early outbreaks of *R. solani* (damping off), AG2-2 IIIB is the main target for Rhizoctonia root rot in sugar beet, and in most of the world's beet-growing areas[7].

(7) *Some clarification is required here:*
- AG2-2 IIIB can also cause damping off if the outbreak is very early.
- AG2-2 IV can also cause Rhizoctonia root rot but it is less virulent and occurs mainly in the USA, and often in combination with AG2-2 IIIB.

AG2-2 IIIB has a **broad host spectrum**. It can therefore infect other crops such as maize and soya, as well as many vegetables (e.g. beans, carrots). Ryegrass is also thought to spread the fungus (Westerdijk et *al*., 2004). A number of weeds are also potential hosts (e.g. goosefoot).

There is a strong correlation between the **presence of maize and soya in rotations** and the damage caused by *Rhizoctonia solani*. In France and Germany for example, maize production mirrors the severest Rhizoctonia root rot infections. In the USA, maize and/or soya are commonly included in rotations in the majority of beet-growing regions.

	Generic name	Species or genus	Chenopodiaceae	Poaceae	Asteraceae	Apiaceae	Fabaceae
Main crops	Sugar beet	*Beta vulgaris*	x				
	Maize	*Zea mays*		x			
	Rice	*Oryza sativa*		x			
	Black salsify	*Scorzonera hispanica*			x		
	Carrots	*Daucus carota*				x	
	Beans	*Phaseolus vulgaris*					x
	Ryegrass	*Lolium perenne*		x			
Weeds	Goosefoots	*Chenopodium*	x				
Ornamental plants	Chrysanthemums, bulbs						

Table 1. The AG2-2 IIIB strain has a broad host spectrum (according to Westerdijk, 2005; Fürher Ithurrart, 2003 & IRS, 2006).

Note: a strain of *Rhizoctonia solani* attacks potatoes (AG3), but it is not the same as the one responsible for the disease in sugar beet (AG2-2 IIIB). Consequently, potatoes are not a host plant of the fungus that causes Rhizoctonia root rot in sugar beet.

Symptoms

Even though outbreaks of the fungus responsible for Rhizoctonia root rot can occur early in the season (during canopy closure), the disease is not generally apparent until late summer or early autumn.

In foliage

The damage associated with Rhizoctonia root rot infestation always appears in the form of defined patches in the field (a). These patches often tend to spread along the rows (ITB, 2008). Although small at the start of the season, they grow gradually and, in particularly virulent outbreaks, can affect entire rows or even the whole field.

The first symptoms observed are a sudden wilting of the foliage which gradually evolves into a chlorosis and ultimately necrosis of the leaves. However, the dead foliage remains attached to the crown, where it forms a rosette of brown leaves. New leaves may appear in the middle of this, just before the plant dies (b and c).

a/

b/

c/

Figure 10. The characteristic foliar symptoms of Rhizoctonia root rot (clockwise: a, b and c). (Source c: ITB)

In roots

In the roots and crown, a dark brown or black dry rot is observed, on the surface and/or inside, depending on the virulence of the outbreak (a and b). There is a clear difference between healthy and diseased tissue (c). In some cases, the entire beet may disappear.

Figure 11. Main root symptoms of Rhizoctonia root rot (clockwise: a, b and c) (Source a: INRA-Dijon; b and c: ITB).

Diagnosis

IRBAB/KBIVB (BetaConsult) in Belgium and IRS (BetaKwik) in the Netherlands have joined together to develop a decision-making aid for growers which includes a pest and disease identification tool:

- IRBAB /KBIVB http://www.irbab-kbivb.be/nl/actuality/beta_consult/
- IRS: http://www.irs.nl/overzicht.asp?sOnderdeel=betakwik

Diagnosing the disease on the basis of roots is fairly easy. However, it is possible to confuse its symptoms with those of other root rots (Pythium, Aphanomyces) or even with lightning damage. If in doubt, growers should consult a specialised laboratory. Molecular analysis may also make it possible to assign the fungus to a specific anastomosis group (AG).

Economic importance

Rhizoctonia root rot is present in many of the world's beet-growing regions. However, outbreaks vary widely in their severity and infections in the field are often limited. In general, losses in terms of recoverable white sugar are usually in the order of 5-10%. However, losses of up to 50-60% are not uncommon and total crop failure is a possibility.

The damage caused by the fungus can have significant economic consequences (Büttner et al., 2006), due to:

- major losses in yield (e.g. up to 100% in France according to ITB; up to 45% in Belgium according to IRBAB; between 25 and 100% in the Netherlands according to IRS; up to 60% [in Germany] according to IfZ)
- a reduction in sugar content
- an increase in soil tare (soil sticks to the root via the mycelium)
- higher levels of sodium (Na), potassium (K) and amino nitrogen (N_{amino}), leading to poorer industrial quality
- problems with beet storage in silos

Control

No fungicides are currently approved in Europe for the effective control of Rhizoctonia root rot. Growers are therefore advised to control the disease by means of **integrated control**, i.e. by combining **agronomic measures** and using **Rhizoctonia tolerant varieties**.

Agronomic measures

Think about the rotation

✓ **Extend rotation:** Ideally, there should be a gap of 3 to 5 years between two successive beet crops in the same plot, to reduce the potential infectivity of the soil.

✓ **Avoid host plants:**

- as far as possible, avoid maize, soya, rye-grass and vegetables such as carrots and salsify; introduce a wheat or barley type straw cereal before sowing
- exercise careful weed control (some weeds can be host plants, e.g. goosefoot)

✓ In France, the potential benefit of **intercropping with brown mustard** is currently being studied by ITB and INRA. It appears that this helps to reduce the inoculum in the soil before the beet is sown, due to a biofumigation effect (ITB, 2007).

Biofumigation

By introducing a cleansing intercrop into rotation, it is possible to produce a biofumigation effect on the pathogenic agent *R. solani*.

The principle is fairly simple and involves sowing an intercrop densely enough to produce a substantial quantity of biomass. The parts of the crop above ground level are chopped at the start of flowering and immediately incorporated in the soil, where they will release glucosinolates from the breakdown of the biomass. These glucosinolates (mainly sinigrin) are hydrolysed into compounds that are toxic to the pathogenic agent, known as isothiocyanates (ICTs). Although ICTs have very short persistence in the soil, they have a relatively long-lasting impact on its potential infectivity. This tends to support the idea that, besides their direct effect on the primary foci of infection of *R. solani*, ICTs also have an indirect impact by changing the microbial structure of the soil (some antagonists of *R. solani* are not themselves susceptible to ITCs, e.g. Trichoderma and Pseudomonas).

Figure 12. Glucosinolate concentrations are highest at the start of flowering (a). Both chopping and burying are necessary in order to optimise the biofumigation effect.
Source: INRA and ITB (SESVanderHave Technical Days 2011).

Brown mustard (*Brassica juncea*) and white mustard (*Sinapsis alba*), together with radish (*Raphanus sativus*), were included in a three-year trial conducted by INRA and ITB. Brown mustard was found to have the most promising effect.

Planting a winter cover crop is a practice that is now virtually mandatory in many European countries. Since we know that planting a particular species during the winter may have repercussions for the spring crop (particularly in terms of disease and pest management), it may be useful to take time to think this decision through as well.

This control method is very attractive at first sight, but it also has limits. It appears that brown mustard has to be sown for several winters in a row in order to have a truly useful impact. Efficacy can be variable due to the volatility of the isocyanate compounds. Finally, some believe that there is a practical and economic limitation on this technique: planting a mustard in between maize and sugar beet is not always easy because the maize is sometimes harvested too late to allow the mustard to be sown early enough – and to give it sufficient time to develop.

Attend to soil structure and the management of crop residue after harvesting

- ✓ Maintain good soil structure: apply organic fertiliser regularly, sow a cover crop in the winter and limit soil compaction by using appropriate cultivation techniques (avoid the use of heavy machinery and working in unfavourable conditions such as standing water, use relatively wide tyres with appropriate pressure, etc.).
- ✓ Avoid piles of maize straw building up in the bottom of ploughed furrows; this stops the residue breaking down quickly and causes it to act as a source of inoculum for outbreaks of *R. solani* in the spring.

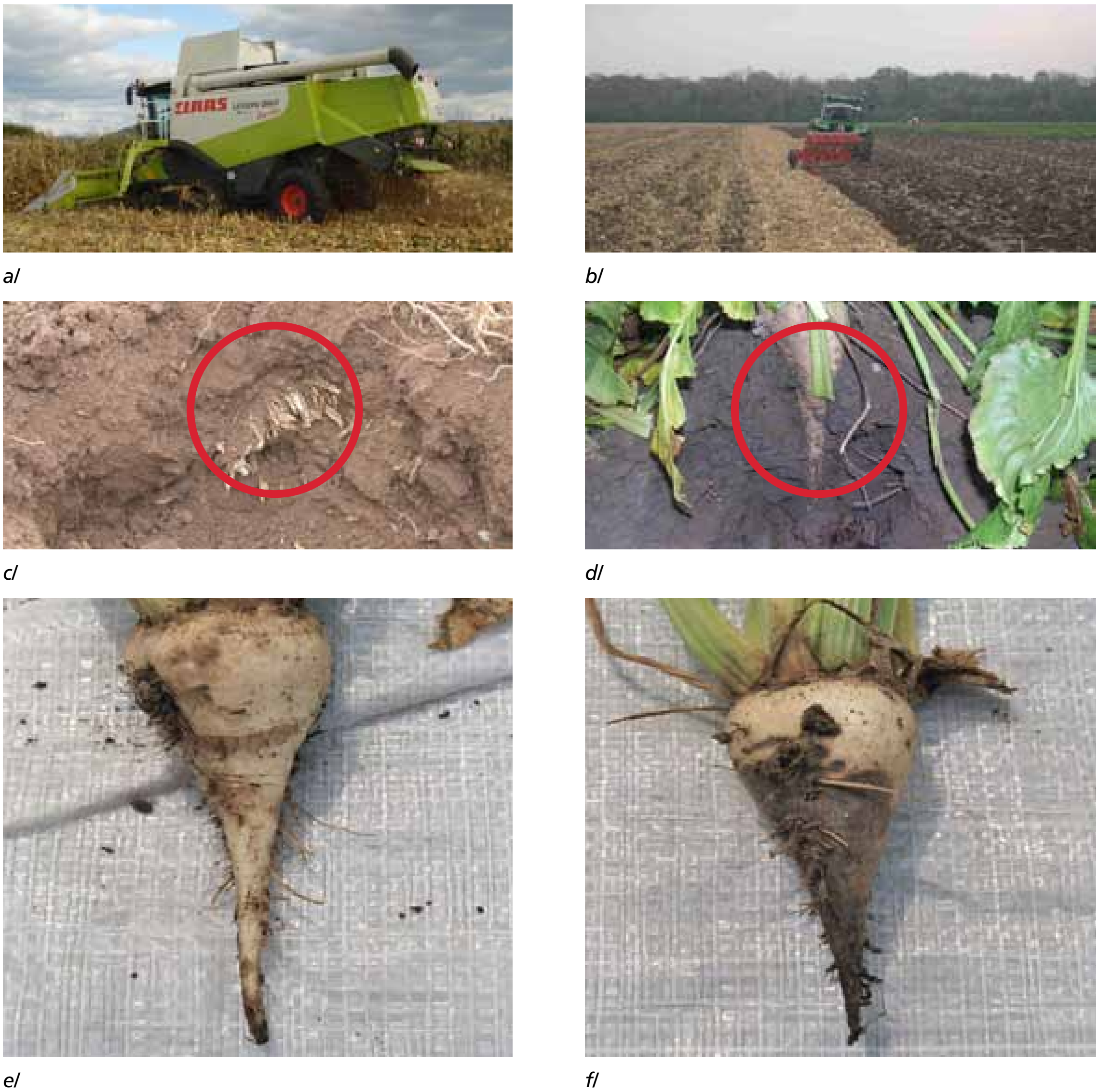
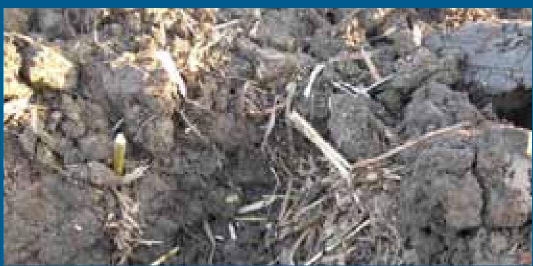


Figure 13. After a maize harvest (a), followed by 'traditional' soil preparation (b), piles of maize stubble can build up at the bottom of ploughed furrows (c). Located just below the beet roots, these piles will act as sources of inoculum for R. solani in the following spring (d). The rot typically starts at the tip of the root (e) and may extend along the entire length of the beet (f).

The work done by the Cristal Union agronomy department (Erstein sugar factory, in Alsace) illustrates the importance of this factor. In this region, where maize/sugar beet rotation is widespread, Rhizoctonia root rot has become a critical issue over the years and one that must be managed if yields are to be protected.

In addition to (1) relying on genetic tolerance and (2) exploring the possibility of chemical control adapted to the level of tolerance of the variety, (3) the management of crop residue and cultivation techniques is a key component of integrated control of Rhizoctonia root rot. In practice, this involves a pass with a disc harrow (cover crop) after harvesting the maize and a pass with a plough without a skimmer, preferably in the autumn. This type of preparation allows the maize stubble to be incorporated evenly into the soil and allows air to circulate rather than promoting a warm, humid microclimate. This ensures rapid residue breakdown and minimises fungal development in the spring.

a/



b/

Figure 14. The use of a disc harrow (cover crop) and a plough without a skimmer (a) allows harvest residue to be incorporated evenly into the soil (b).

Other:

- ✓ Ensure good plant growth in order to increase the plants' chances of withstanding the disease: pay attention to sowing, fertiliser, liming, weed control, etc.
- ✓ If possible, avoid hoeing because this may throw potentially contaminated soil on to the beet crowns, encouraging the proliferation of the fungus.
- ✓ Minimise storage of diseased beets by delivering to sugar factories as quickly as possible. If beets are already affected, storing diseased roots appears to increase the severity of the attack. However, contamination of neighbouring roots is thought to be limited (ITB).
- ✓ Choosing a variety that is less susceptible to Rhizoctonia root rot may reduce potential infectivity in a sugar beet/maize rotation.

Chemical control

No fungicide is currently registered in Europe for the control of Rhizoctonia root rot in sugar beet: control is based largely on the use of tolerant varieties and appropriate agronomic measures.

However, in the United States, where Rhizoctonia root rot has become a major problem over the last ten years, foliar application of azoxystrobin in sugar beet has become a common practice with proven effectiveness. In Michigan, for example, over 82% of plots infected with Rhizoctonia root rot are treated with azoxystrobin (1 or 2 applications), for a cost of around €30 to €40 per hectare. In the Red River Valley, 33% of crops currently receive such treatment.

The Michigan Sugarbeet Research and Education Advisory Council (REACH) is at the forefront of developments in this field. Azoxystrobin is generally applied to susceptible varieties by spraying at the 6-8 leaf stage, at a rate of 260 g ai/ha. This traditional treatment regime and a number of variations (application at the 2-4 leaf stage, application in the furrow on sowing, lower dose rate, multiple applications, etc.) have been studied over a number of consecutive years: all crops have shown better yields than the untreated control. At a cost of €30 to €40 per hectare, it is a cost-effective solution.

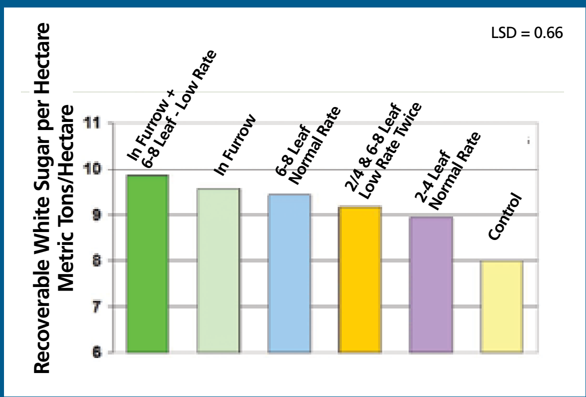


Figure 15. Comparison of recoverable white sugar per hectare for different treatment regimes using azoxystrobin. Source: Michigan Sugar Beet REACH (SESVanderHave Technical Days 2011).

In Europe, following the results demonstrated in the USA, some thought has been given to applying for an extension of approval for Amistar extra® (which contains azoxystrobin) to control Rhizoctonia root rot in sugar beet. This product is currently approved for the control of foliage diseases in sugar beet but, in trials, has already demonstrated its usefulness in the control of Rhizoctonia root rot in certain countries.

New seed treatments based on different active ingredients are currently in development in the USA: azoxystrobin, penthiopyrad, ipoconazole, etc. These products are intended to control damping off problems. However, their usefulness in the control of Rhizoctonia root rot remains unclear.

Rhizoctonia tolerant varieties

Breeding

The source of genetic resistance to Rhizoctonia root root in sugar beet (*Beta vulgaris*) comes essentially from America (e.g. USDA ARS FC germplasm). It differs from Rhizomania resistance in that it is controlled by several genes rather than a single gene. However, this also makes it more difficult to introduce into elite breeding material. The term used is 'quantitative resistance' (oligogenic to multigenic).

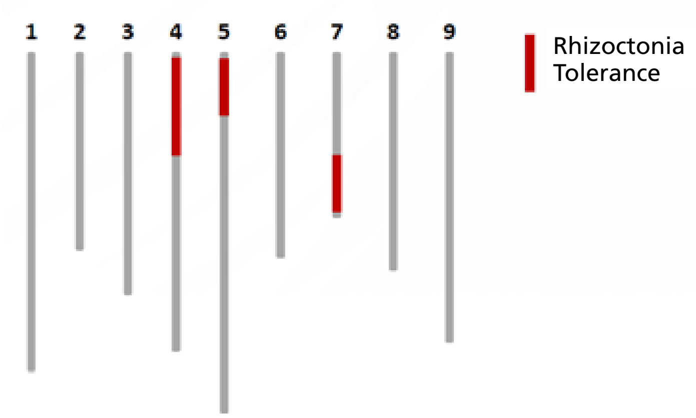


Figure 16. Locations on the 9 sugar beet chromosomes of the areas likely to harbour genes playing a role in tolerance to Rhizoctonia root rot (Lein et al., 2008).

To produce a variety with Rhizomania/Rhizoctonia dual tolerance, pure-bred elite plant lines (with high sugar content, good root yield, good extractability, etc.) are first crossed with a resistant wild species. The resulting populations are then back-crossed several times with the elite parent. After each crossing, the most promising plants are systematically selected for the next back-crossing. This selection is carried out on the basis of trials in a greenhouse, where the plants are grown in an infected environment in order to evaluate their level of resistance. Today, the development of molecular markers makes it possible to identify the approximate location of resistance genes in a plant's genome almost instantaneously. This type of technique is used in combination with greenhouse trials to accelerate genetic selection.

The main challenge is to produce hybrids that not only carry a large number of genes for resistance to Rhizoctonia root rot but are also adapted to European conditions to produce low bolting, good root yield, high sugar content, etc.

Figure 17. Glasshouse trials make it possible to assess the behaviour of different genotypes in response to Rhizoctonia root rot.

Advantages and disadvantages

The main advantage of varieties with Rhizomania/Rhizoctonia dual tolerance is that **they provide an effective and accessible method of control where there is a high likelihood of Rhizoctonia root rot outbreaks in the coming year.** Compared with a Rhizomania-only variety, these varieties will perform much better in terms of yield, sugar content, soil tare and extractability in areas with a high pressure of infection.

However, it is vital to note that, in order to obtain optimum results, **the sowing of a variety with dual tolerance must be combined with agronomic control measures.**

Varieties with Rhizomania/Rhizoctonia dual tolerance nevertheless have certain disadvantages:

- They are only tolerant to Rhizoctonia root rot, not resistant, as such: yields are not guaranteed under extreme infections.
- Tolerant varieties remain susceptible to the fungus at the young plant stage: this means that a variety with Rhizomania/Rhizoctonia dual tolerance does not offer protection against damping off.
- Tolerant varieties carry a yield penalty in healthy soil compared with 'standard' Rhizomania material.

Violet root rot

Violet root rot is caused by the soil-borne fungus *Helicobasidium purpureum*.

The symptoms of the disease generally appear even later than those of Rhizoctonia root rot, so it is often not diagnosed until the time of lifting. The first signs are areas of wilting in the fields. Next, starting at the tip of the root, a purple coloured rot develops and spreads to colonise the surface of the root as well as the inside to different degrees.

Figure 18. Symptoms of violet root rot.

The life cycle of *Rhizoctonia violacea* is similar to that of *Rhizoctonia solani*. Its survival spores are even more resistant and can remain in the soil for at least 7 years. It also has a relatively broad host spectrum: alfalfa, clover, potato, carrot, etc. The spread of this fungus is encouraged by poor soil structure, the presence of host plants and a warm, humid climate.

The disease is widespread in Europe, in all types of soil. Less well-known than Rhizoctonia root rot, the damage it causes is less extensive but, in the event of high pressure of infection, may represent a significant loss to the grower. In addition, the disease can continue to spread in storage once the beets have been lifted, so it should not be ignored.

No chemical control method is currently available. It is important to note that varieties with Rhizomania/Rhizoctonia dual tolerance do not offer a solution to violet root rot. The only advice that can be given is to avoid resowing sugar beet too soon in a contaminated plot and also to avoid growing other host plants.

Future developments

The effectiveness of varieties with Rhizomania/ Rhizoctonia dual tolerance combined with appropriate agronomic measures, is clear. In recent years, the market share associated with this type of variety has increased steadily in Belgium, the Netherlands, Germany and France as growers recognise the benefits such dual tolerance provides. By contrast in the United States, the option of using chemical control limits the uptake of Rhizoctonia tolerant varieties amongst growers.

Although, with the exception of the Netherlands, the use of Rhizoctonia-tolerant varieties still appears to be relatively limited (e.g. 1.5% in France), this is largely due to the yield penalty associated with the first generation of this type of genetics. However, this masks the importance of these varieties in the regions severely affected by the disease, where their usage can be as high as 30 to 40% (e.g. Alsace).

Year	Country	Surface (ha)	RHRT %
2012	Belgium	62.400	9%
	France	376.000	1%
	Germany	353.400	4%
	Netherlands	72.459	23%
	Spain North	31.000	10%
	United Kingdom	115.000	0%

Tabel 2. Market share in 2012 of varieties tolerant to Rhizoctonia root rot in the principal European countries in which they are sold.

The good news is that the breeding work is producing good results. Breeding advances should soon make it possible to reduce the yield penalty, or to incorporate Rhizoctonia tolerance as standard alongside Rhizomania and beet cyst nematode tolerance. In the Netherlands, simultaneous outbreaks of beet cyst nematode and Rhizoctonia root rot in the same field have already been observed in several areas, so a variety with Rhizomania/nematode/Rhizoctonia triple tolerance is eagerly awaited. In Alsace, there is growing demand for varieties with tolerance to Rhizomania, Cercospora and Rhizoctonia root rot. In the United States, there is a need to offer resistance to Rhizoctonia, Rhizomania and Aphanomyces (Red River Valley) or to Rhizoctonia, Rhizomania and beet cyst nematode (Michigan) in a single variety. The work being done at USDA to identify resistance at the young plant stage should also lead to significant advances in the near future. It is largely advances in marker-assisted breeding that will allow us to achieve these aims. However, these new tools do not eliminate the need for extensive testing, both glasshouse trials (bio-assays) and field trials, which remain essential to develop future molecular markers and verify field performance.

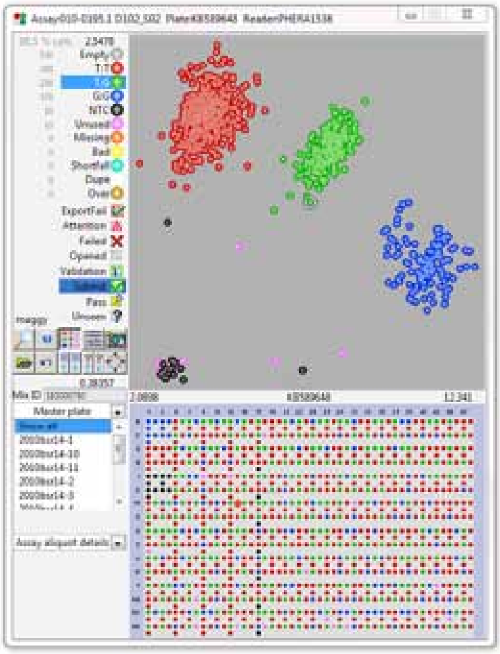


Figure 19. Molecular markers play an increasingly important role in breeding progress, but depend on assessing tolerance in the field and in the glasshouse (bio-assays).

Conclusion

- Severe threat to crop – 40-100% damage in severe cases
- Distribution – discreet infections in many countries mean the national infection levels remain low, although there are significant hot spots in many countries.
- Maize and soy in the rotation combined with poor soil structure/waterlogging increase risk of infection.
- Fungicides offer some protection where usage is permitted (USA).
- The main threat is strain AG2-2 IIIb.
- SESVanderHave genetics with tolerance to Rhizoctonia will help you continue growing sugar beet.

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All of the presentations from the "1st SESVanderHave Technical Days on Rhizoctonia root rot in sugar beet: integrated management" are available here: www.rhizoctonia.info

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