

Differences in tolerance to soil borne pathogens in sugar beet varieties 2012

Provning av betsorters toleransnivå mot jordburna patogener 2012

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Sammanfattning

Sockerbetor kan angripas av flera jordburna patogener. Den viktigaste i Sverige är *Aphanomyces cochlioides*. Denna patogen kan ge upphov till både tidiga rotbrandsangrepp samt senare angrepp i form av deformerade rötter. Plantbortfall under uppkomsten kan förhindras genom att fröet betas med Tachigaren med den verksamma beståndsdelen hymexazol. Denna betning räcker i cirka fyra till sex veckor.

Sedan några år tillbaka provas nya sorter i Sverige på naturligt infekterad mark. Resultaten från dessa försök har visat att det finns stor variation mellan sockerbetssorter vad gäller tolerans mot jordburna patogener. Under 2012 provades totalt 24 sorter i ett försök i Skåne; 15 AT-sorter (*Aphanomyces*-toleranta), 4 NT-sorter (Nematodtoleranta), 2 NE sorter (nematode escapes), 3 standardsorter RZ (Rhizomaniatoleranta) och 3 sorter av okänd typ. I försöket gjordes bedömningar av plantantal och rotbrandsangrepp under uppkomst samt kroniska rotskador efter skörd.

De tidiga rotbrandsangreppen var generellt låga under 2012, främst beroende på den kalla väderleken efter sådd. Vid den andra bedömningen av tidiga rotbrandsangrepp (DSI) fanns det signifikanta skillnader mellan sorterna. Högst DSI hade OK129 och lägst HI1273.

Det fanns signifikanta skillnader i plantantal mellan sorterna vid 20, 50 och 100 % uppkomst. Den första räkningen av plantor gjordes den 2 maj. Det fanns en tendens till att sorter med snabb uppkomst också hade relativt låga sjukdomsindex.

Sorter som konsekvent hade höga DSI i båda bedömningarna var Rosalinda, Sabrina och Alexina. Sorter som konsekvent hade låga sjukdomsindex i båda bedömningarna var Muse, Stinger, HI1185, HI1273, MA2085 and MA2100. Vid den andra bedömningen hade Rosalinda och Sabrina signifikant högre sjukdomsindex än Stinger.

Sockerskörden för Mixer, den toleranta kontrollen, var 11,1 ton/ha. Sockerskörden för den mottagliga sorten Rosalinda var 10,6 ton/ha (prob. 0,0073, LSD 5 % = 1,5).

Högst skörd hade AT-sorten HI1203 med, 11,6 ton/ha, följd av Stinger, 11,3, MA2085 11,3 och Marcella KWS också med 11,3 ton/ha.

Sockerskördarna för NT-sorterna (HI1179, HI1185, Alexina KWS, Cactus) var 10,1; 10,5; 9,9 och 10,2 ton/ha, respektive. Då det inte fanns några betcyst-nematoder på försöksplatsen förväntas skörden för dessa sorter ligga ca 5–7 % under den för standardsorter.

En sort klassificeras som tolerant om den kombinerar tidig och snabb uppkomst med lågt sjukdomsindex och hög skörd.

En sort klassificeras som mottaglig om den kombinerar långsam uppkomst med högt sjukdomsindex och låg skörd.

Sorter som har klassificerats i gruppen ”medel/information otillräcklig” behöver testas ytterligare för att säkert kunna avgöra deras toleransnivå.

Klassificering av sorter som toleranta eller känsliga för Aphanomyces cochliformis 2012

Tolerant	Medel/Information otillräcklig	Mottaglig
AT- sorter		
Mixer	MA2100 (lågt DSI*1 och 2)	1K187
HI1273	SY Muse /lågt DSI2)	2K300
HI1203	Frazze	2K330
MA2085	Smash	
Stinger	SR735	
Marcella KWS	SR618	
	MA2095	
	2K310	
NT och NE		
	Cactus (snabb tidig uppkomst)	Rosalinda
		HI1179
		Alexina KWS
		Sabrina KWS
		HI1185
Standard och sorter av okänd typ		
	ST-S-Aph121 (lågt DSI1 och 2)	
	ST-S-Aph122 (lågt DSI1 och 2)	
	ST-S-Aph123 (lågt DSI1 och 2)	
	Barents (lågt DSI1 och 2)	

*DSI = sjukdomsindex

Summary

One of the most important soil borne pathogens in Sweden is *Aphanomyces cochlioides*. The disease occurs in two phases, one early causing damping-off after emergence and one later chronic phase which may cause severe root deformations. New varieties are routinely tested every year in Sweden on naturally infested soil. Disease severity during emergence, plant number and yield was assessed in one trial 2011, at Skibaröd in Skåne.

A total of 27 varieties were tested in the trial; 15 AT varieties (*Aphanomyces* tolerant), 4 NT varieties (Nematode tolerant), 2 NE varieties (nematode escape), 3 standard RZ (Rhizomania tolerant) varieties and 3 varieties of unknown type.

Early root rot infections were generally low 2012, because of the cool temperatures after drilling. In the second assessment, there were significant differences between the varieties. The variety with the highest score was 0K129 and the lowest HI1273.

There were significant differences in plant number between the varieties at 20%, 50% and 100% emergence. The first assessment of plant number was done on 2012-05-02. There was some tendency that varieties with high emergence rate also had relatively low DSI2.

Varieties that had consistently high DSI in both evaluations were Rosalinda, Sabrina, Alexina. Varieties that had consistently low DSI in both evaluations were Muse, Stinger, HI1185, HI1273, MA2085 and MA2100. In the second evaluation of disease severity Rosalinda and Sabrina had significantly higher DSI than Stinger.

The sugar yield for Mixer, the tolerant control variety, was 11.1 ton/ha. The sugar yield for the susceptible variety Rosalinda was 10.6 ton (prob. 0.0073, LSD 5% = 1.5).

The AT variety HI1203 had the highest sugar yield in the trial, 11.6 ton/ha, followed by Stinger, 11.3, MA2085 11.3 and Marcella KWS also 11.3.

The sugar yield for the NT varieties (HI1179, HI1185, Alexina KWS, Cactus) were 10.1, 10.5, 9.9 and 10.2 ton/ha, respectively. Since there were no beet cyst nematodes in the trial at Skibaröd, the yield level for these varieties are expected to be approximately 10% lower than for standard varieties.

A variety is classified as tolerant if it combines fast and early emergence with low DSI and high yield.

A variety is classified as susceptible if it combines slow emergence with high DSI and low yield.

Varieties classified in the group moderate/lack of information needs further testing to determine their level of tolerance more precise.

Classification of varieties in to two groups, tolerant or susceptible to Aphanomyces

Tolerant	Moderate/lack of information*	Susceptible
AT varieties		
Mixer	MA2100 (low DSI1 and 2)	1K187
HI1273	SY Muse /low DSI2)	2K300
HI1203	Frazze	2K330
MA2085	Smash	
Stinger	SR735	
Marcella KWS	SR618	
	MA2095	
	2K310	
NT and NE		
	Cactus (fast early emergence)	Rosalinda
		HI1179
		Alexina KWS
		Sabrina KWS
		HI1185
Standard and unknown type varieties		
	ST-S-Aph121 (low DSI1 and 2)	
	ST-S-Aph122 (low DSI1 and 2)	
	ST-S-Aph123 (low DSI1 and 2)	
	Barents (low DSI1 and 2)	

*Further testing needed

Introduction

One of the most important soil borne pathogens on sugar beet in many countries e.g. Sweden, USA and Poland is *Aphanomyces cochlioides*. This pathogen is the major cause of damping-off and root rot on sugar beets in Sweden. The seedlings are infected shortly after emergence and this may result in black and threadlike hypocotyls. In severe cases the seedling dies. Surviving seedlings suffer from deformed roots that cause problems during harvest (Harveson and Rush, 1993; Windels, 2000). Infected fields suffer from problems with reduced plant number and root yield.

A. cochlioides can be found in most soils in Sweden and around 25% of the fields have a medium to high risk of *Aphanomyces* root rot. Identification of fields with high risk is important for disease control (Olsson *et al.*, 2010). Control methods include seed treatment with hymexazol, growing tolerant varieties and applying lime to the soils. New varieties are by routine tested every year in Sweden on naturally infested soil.

Materials and methods

Field trial

One field trial was drilled on naturally infested soil at Skiberöd 2012. Mixer was used as tolerant control and Opta with and without hymexazol as susceptible control. A total of 27 varieties were tested in the trial; 15 AT varieties (*Aphanomyces* tolerant), 4 NT varieties (Nematode tolerant), 2 NE varieties (nematode escape), 3 standard RZ (Rhizomania tolerant) varieties and 3 varieties of unknown type.

Assessments

The number of plants in each plot was counted three times (at 20%, 50%, 100% emergence). Plant vigour was assessed twice.

Damping-off was assessed twice in early spring. The first assessment took place when the plants had developed cotyledons and the second assessment two weeks later. 20 randomly chosen plants were dug up in the sample area and each plant was assessed for symptoms of damping-off and classified into one of six groups: 0 (healthy), 10, 25, 50, 75 and 100% (almost dead seedling). This scale is based on discoloration of the root system. Values above 50 indicate that the rot has spread along the hypocotyl. A value of 75 means that the rot has spread up to the cotyledons.

A disease index was calculated using the following equation developed by Larsson and Gerhardson (1990):

$$DSI = ((n_0 * 0 + n_{20} * 20 + n_{50} * 50 + n_{75} * 75 + n_{100} * 100) / \text{plant number})$$

n = number of beets in each class.

After harvest, the roots in each plot were assessed for symptoms of chronic root rot using a scale from 1–7 (table 1). The assessment of chronic root rot was

carried out at the central tare house in Örtofta (Agri Provtvätt, Örtofta Sockerbruk, Nordic Sugar).

Statistical analyses

The experimental design was lattice design with four varieties in each of six miniblocks and four replications. All variables measured in the field trial were analyzed using analysis of variance (Proc GLM and MIXED, SAS) and pair wise differences were analyzed with Fischer's LSD test.

Table 1. Scale 1–7 for assessment of chronic symptoms of root rot

Score	Evaluation
1	Big healthy roots without deformations
2	Big healthy roots, some with deformations
3	Roots of normal size, several with slight deformations
4	Roots with reduced size, most with slight deformations
5	Roots with reduced size, most with medium deformations
6	Roots with reduced size, most with severe deformations
7	Very small roots, all with severe deformations

Results and discussion

The sugar beet fields were drilled in the end of March in Sweden. The weather was very cold after emergence which resulted in low infestation levels.

The occurrence of *A. cochlioides* in the soil at Skibaröd was verified by isolations of the pathogen from plants collected in the field.

Plant number

Plant numbers at 20, 50 and 100% emergence, at Skibaröd are shown in figure 1. There were significant differences between the varieties at 20, 50% and 100% emergence (figure 1).

The first assessment of plant number was done on 2012-05-02. There was some tendency that varieties with high emergence rate also had relatively low DS12 (figure 2).

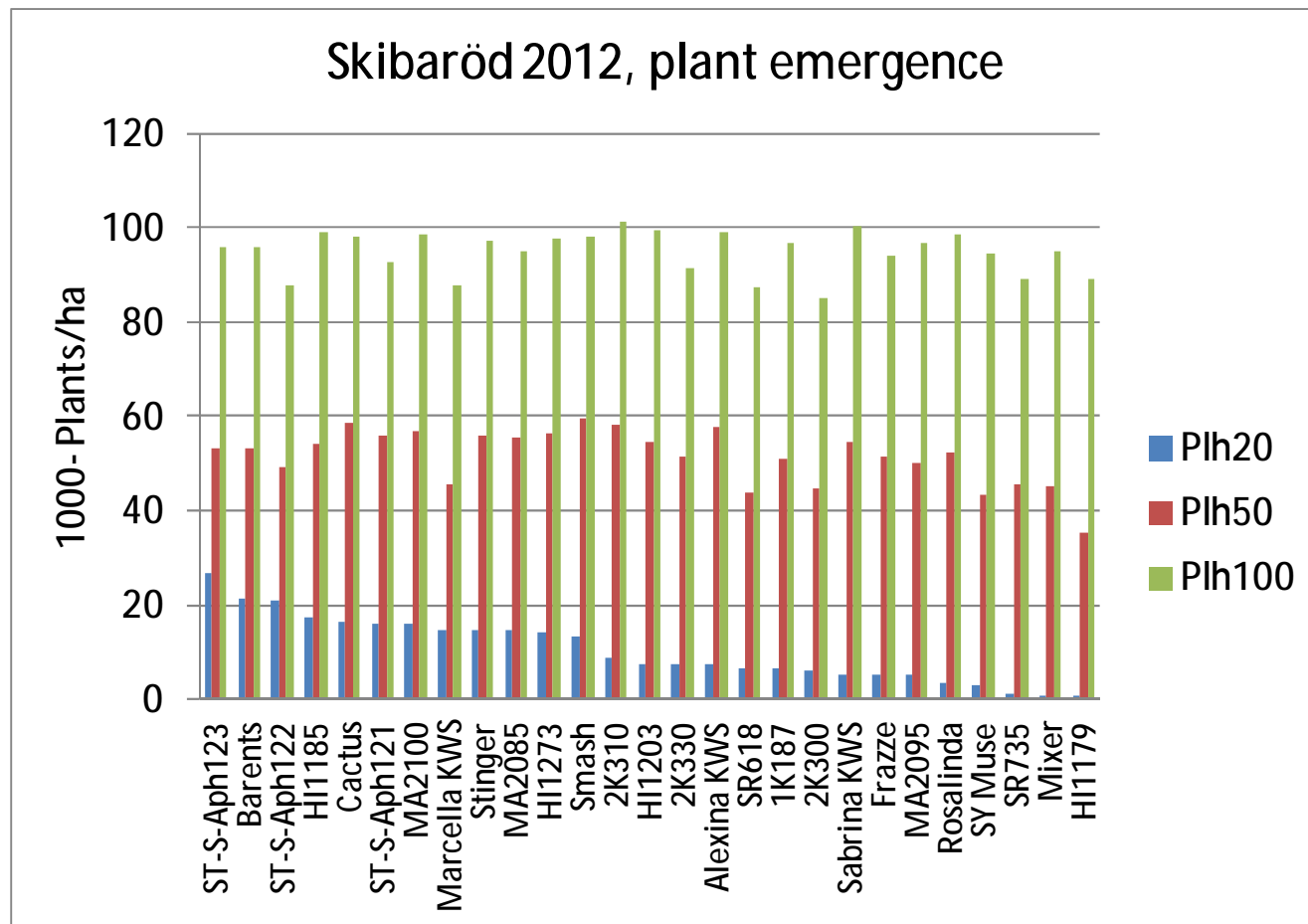


Figure 1. Plant countings at 20, 50 and 100% emergence in the trial at Skibaröd 2012. Plh 20%, LSD 5%= 5.1; Plh 50% LSD 5%= 12.2; Plh 100%, LSD 5% = 10.2. Prob. < 0.0001 for plh20 and plh50, prob. = 0.0003 for plh100. 2011-05-02, 2012-05-04 and 2012-06-04.

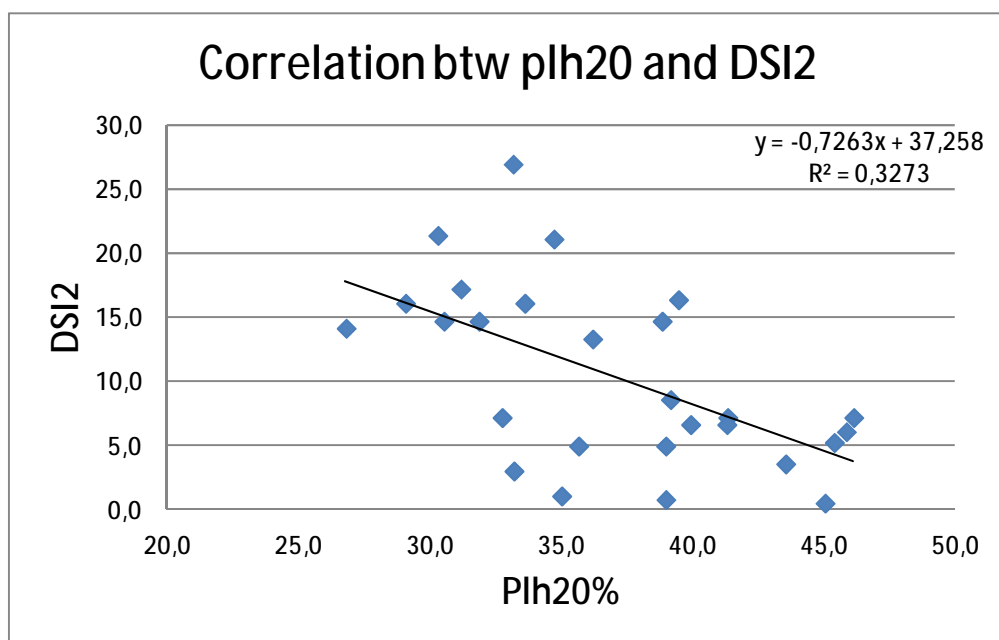


Figure 2. Correlation between 20% emergence and DSI2.

Disease severity – early phase

Varieties that had consistently high DSI in both evaluations were Rosalinda, Sabrina, Alexina.

Varieties that had consistently low DSI in both evaluations were Muse, Stinger, HI1185, HI1273, MA2085 and MA2100.

In the second evaluation of disease severity Rosalinda and Sabrina had significantly higher DSI than Stinger (figure 3).

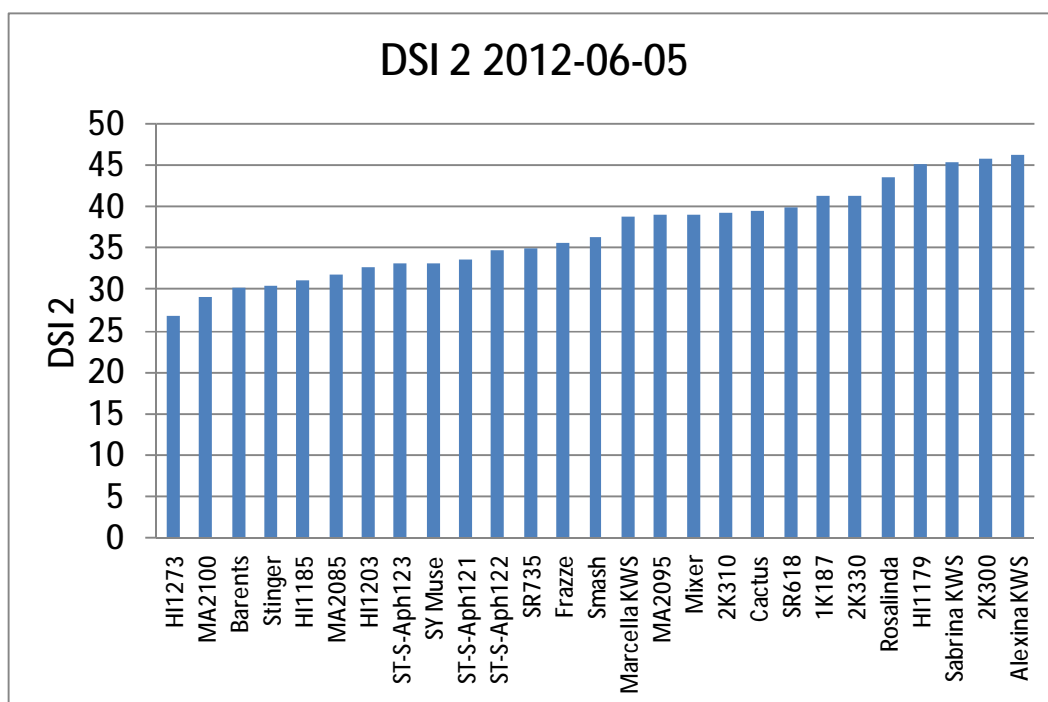


Figure 3. Disease severity2 2012-06-05 at Skibaröd. LSD 5% = 11.3, Prob. < 0.0001.

Sugar yield

The sugar yield for all 27 varieties in the trial is shown in figure 4.

The sugar yield for Mixer, the tolerant control variety, was 11.1 ton/ha. The sugar yield for the susceptible variety Rosalinda was 10.6 ton (prob. 0.0073, LSD 5% = 1.5).

The AT variety HI1203 had the highest sugar yield in the trial, 11.6 ton/ha followed by Stinger, 11.3, MA2085 11.3 and Marcella KWS also 11.3.

The sugar yield for the NT varieties (HI1179, HI1185, Alexina KWS, Cactus) were 10.1, 10.5, 9.9 and 10.2 ton/ha, respectively (figure 4). Since there were no beet cyst nematodes in the trial at Skibaröd, the yield level for these varieties are expected to be approximately 5-7% lower than for standard varieties.

The sugar yields for 15 AT varieties plus the susceptible control (the NT varieties excluded) are shown in figure 5.

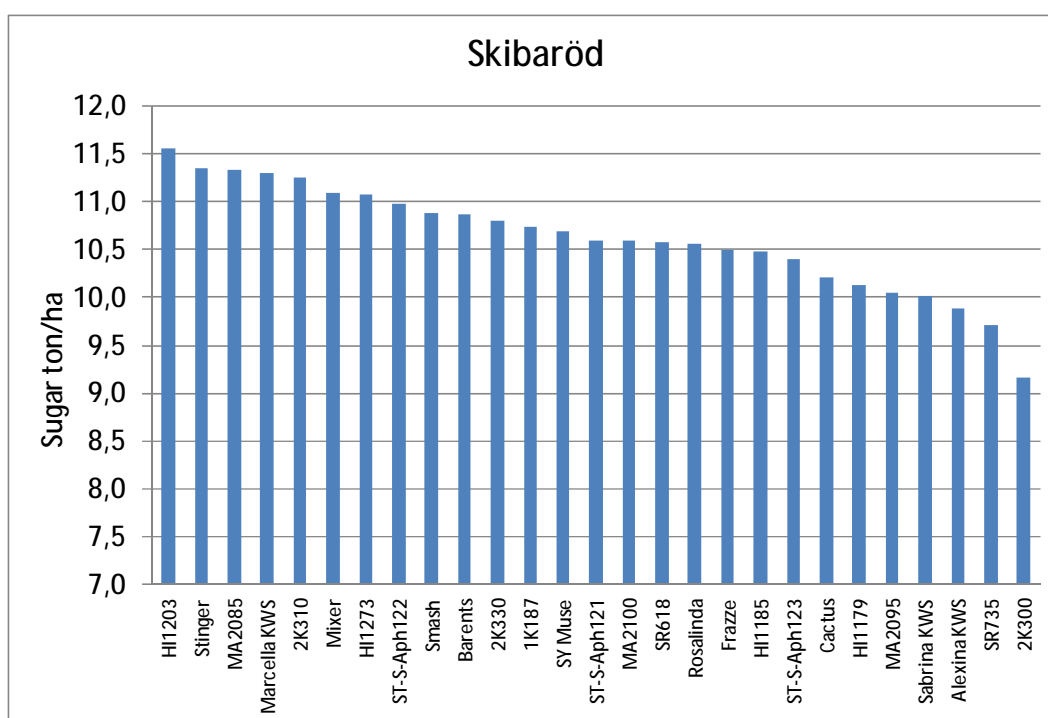


Figure 4. Sugar yield for 27 varieties at Skibaröd 2012. Prob = 0.0073, LSD = 1.5.

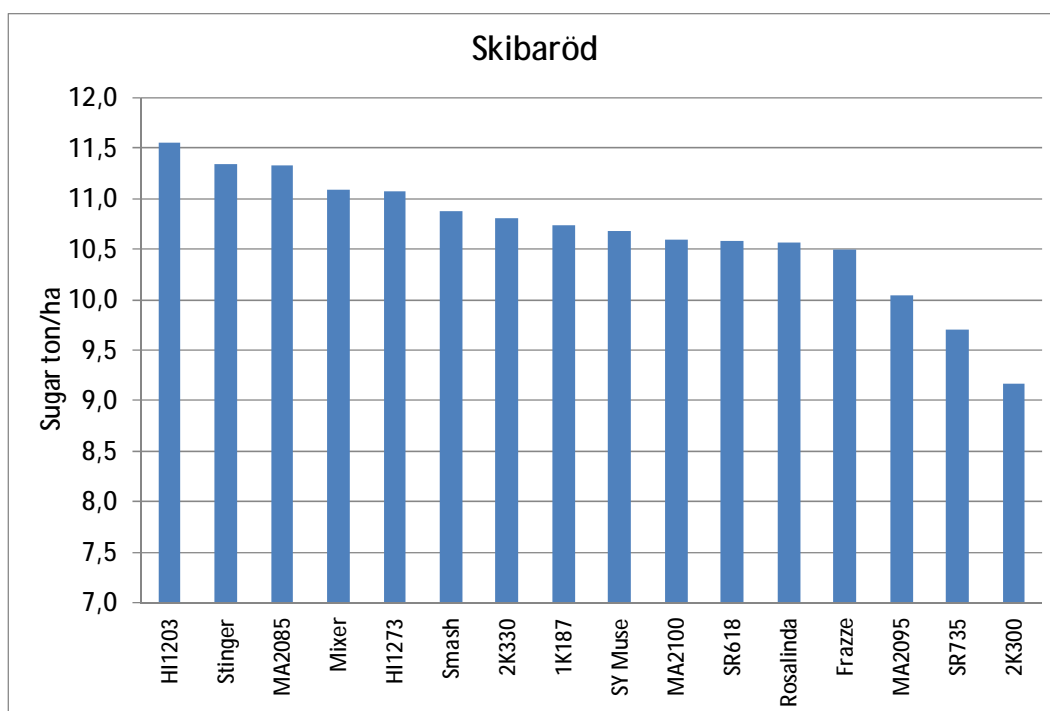


Figure 5. Sugar yield for 15 AT varieties at Skibaröd 2012. The NT varieties are excluded from the statistical analysis. Prob = 0.0462, LSD = 1.7.

Chronic root rot 2012

The assessment of chronic root rot 2012 is shown in figure 6. The assessment of chronic root rot at the tare house showed that weak symptoms were found in the tolerant control Mixer.

The variety HI1185 had very low DSI in both evaluations in the spring. However, when chronic root rot was evaluated this variety had severe symptoms in all repetitions (picture 1 and 2). This was also so for MA2085. The DSI in the spring was very low but chronic root rot relatively high (picture 3).



Picture 1. Chronic root rot in HI1185.



Picture 2. Chronic root rot in HI1185.



Picture 3. Chronic root rot in MA2085.

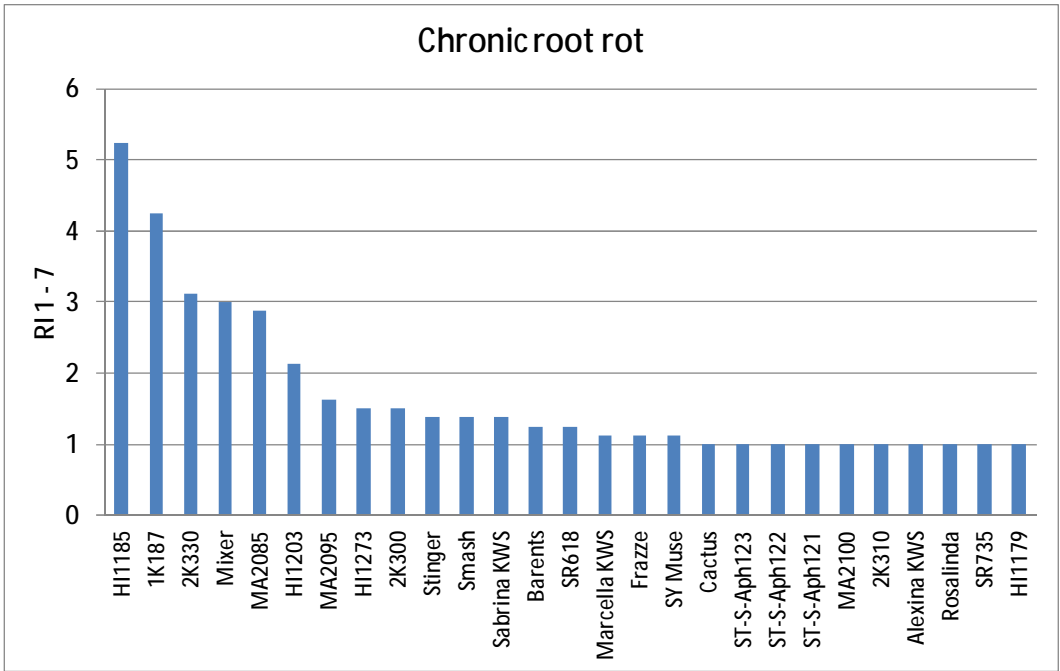


Figure 6. Chronic root rot in the 27 varieties tested at Skibaröd 2012.
Prob < 0.0001, LSD = 1.0.



Picture 4. Chronic root rot in 1K187.



Picture 5. Chronic root rot in 2K330.

Varieties tested in 2011 and 2012

Six varieties were tested both in 2011 and 2012; Mixer, HI1185, 1K187, MA2085, Muse and Stinger. With the exception of 1K187, they had all DSI values below 40. Chronic root rot was high in HI1185 and 1K187 both years (table 1).

Chronic root rot was low in Muse and Stinger in both 2011 and 2012. Frazze had higher chronic root rot in 2011 than in 2012. In 2012, Frazze was comparable to Muse and Stinger.

Table 1. DSI and RI in six varieties tested in 2011 and 2012

Variety	Type	2011		2012		2011	2012
		DSI1	DSI2	DSI1	DSI2	RI	RI
Mixer	RZAT	30.3	30.5	35.7	39.0	1.8	3.0
HI1185	RZNT	32.7	29.0	32.0	31.2	3.3	5.3
1K187	RZAT	24.9	33.9	35.4	41.3	4.0	4.3
MA2085	RZAT	31.2	30.5	34.5	31.9	1.0	2.9
Frazze	RZAT	37.0	26.7	37.5	35.7	2.3	1.1
Muse	RZAT	34.7	26.6	32.5	33.2	1.3	1.1
Stinger	RZAT	33.0	31.0	32.5	30.5	1.5	1.4

HI1185 and 1K187 both showed reduced yield compared to Mixer in 2011 and 2012 (table 2).

Muse had higher sugar yield than Mixer in 2011 and 2012. Frazze showed reduced yield compared to Mixer in 2012.

Table 2. Sugar yield in four varieties tested in 2011 and 2012

Variety	Type	Sugar yield 2011		Sugar yield 2012	
		ton/ha	Rel	ton/ha	Rel
Mixer	RZAT	13.9	100	11.1	100
HI 1185	RZNT	13.6	98	10.5	94
1K187	RZAT	12.8	92	10.7	97
MA2085	RZAT	13.7	99	11.3	102
Frazze	RZAT	13.9	100	10.5	95
Muse	RZAT	14.7	105	12.7	101
Stinger	RZAT	13.3	95	12.3	98

Summary of results 2012

Table 3 shows a summary of important characteristics; fast and early emergence (above 10,000 plants/ha in the first counting), low DSI2 (<35), sugar yield (>11.0 ton/ha) for the varieties tested in 2012.

Three varieties, HI1273, Stinger and MA2085, showed fast and early emergence in combination with low DSI2 and high yield.

One variety, HI1203, showed low DSI2 in combination with high yield.

Other varieties that showed higher sugar yield than the control Mixer were HI1203, Marcella KWS, 2K310 and Stinger.

Table 3. Summary of important characteristics for the 27 varieties in the trial at Skibaröd 2012. Varieties with high scores are marked in green

			Variety type	Fast early Emergence >10,000 pl/ha	Low DSI2 <35	Yield >11,0 ton/ha
1	Mixer		RZAT			+
2	Rosalinda		RZNE			
3	HI1078	Frazze	RZAT			
4	HI1050	Smash	RZAT	+		
5	SY Muse		RZAT		+	
6	HI1179		RZNT			
7	HI1185		RZNT	+	+	
8	HI1273		RZAT	+	+	+
9	HI1203		RZAT		+	+
10	SR735		RZAT			
11	SR618		RZAT			
12	0K129	Alexina KWS	RZNT			
13	0K110	Marcella KWS	RZ	+		+
14	1K187		RZAT			
15	2K300		RZAT			
16	2K330		RZAT			
17	2K310		RZ			+
18	ST-S-Aph121		Unknown	+	+	
19	ST-S-Aph122		Unknown	+	+	
20	ST-S-Aph123		Unknown	+	+	
21	ST12023	Barents	RZ	+	+	
22	MA2085		RZAT	+	+	+
23	MA2095		RZAT			
24	MA2100		RZAT	+	+	
25	Stinger		RZAT	+	+	+
26	Sabrina KWS		RZNE			
27	SN215	Cactus	RZNT	+		

Table 4 shows varieties, marked in red, that have low scores for important characteristics; early emergence (below 5,000 plants/ha in the first counting), DSI2 (>40), sugar yield (<10 ton/ha) and RI for the varieties tested in 2012.

Table 4. Summary of important characteristics for the 27 varieties in the trial at Skibaröd 2012. Varieties with low scores are marked in red

		Variety	Slow early	High	Yield	RI
		type	Emergence	DSI2	<10 ton/ha	>3
			<5,000 pl/ha	>40		
1	Mixer	RZAT	-			
2	Rosalinda	RZNE	-	-		
3	HI1078 Frazze	RZAT				
4	HI1050 Smash	RZAT				
5	SY Muse	RZAT	-			
6	HI1179	RZNT	-	-		
7	HI1185	RZNT				-
8	HI1273	RZAT				
9	HI1203	RZAT				
10	SR735	RZAT	-		-	
11	SR618	RZAT				
12	OK129 Alexina KWS	RZNT		-	-	
13	OK110 Marcella KWS	RZ				
14	1K187	RZAT		-		-
15	2K300	RZAT		-	-	
16	2K330	RZAT		-		-
17	2K310	RZ				
18	ST-S-Aph121	Unknown				
19	ST-S-Aph122	Unknown				
20	ST-S-Aph123	Unknown				
21	ST12023 Barents	RZ				
22	MA2085	RZAT				
23	MA2095	RZAT			-	
24	MA2100	RZAT				
25	Stinger	RZAT				
26	Sabrina KWS	RZNE		-	-	
27	SN215 Cactus	RZNT				

Classification of varieties

A variety is classified as tolerant if it combines fast and early emergence with low DSI and high yield (table 5).

A variety is classified as susceptible if it combines slow emergence with high DSI and low yield.

Varieties classified in the group moderate/lack of information needs further testing to determine their level of tolerance more precise.

Table 5. Classification of varieties in to two groups, tolerant or susceptible to Aphanomyces

Tolerant	Moderate/lack of information*	Susceptible
AT varieties		
Mixer	MA2100 (low DSI1 and 2)	1K187
HI1273	SY Muse (low DSI2)	2K300
HI1203	Frazze	2K330
MA2085	Smash	
Stinger	SR735	
Marcella KWS	SR618	
	MA2095	
	2K310	
NT and NE		
	Cactus (fast early emergence)	Rosalinda
		HI1179
		Alexina KWS
		Sabrina KWS
		HI1185
Standard and unknown type varieties		
	ST-S-Aph121 (low DSI1 and 2)	
	ST-S-Aph122 (low DSI1 and 2)	
	ST-S-Aph123 (low DSI1 and 2)	
	Barents (low DSI1 and 2)	

*Further testing needed

Conclusions

The first assessment of plant number was done on 2012-05-02. SR735, Mixer and HI1179 had the slowest emergence rate with less than 2,000 plants/ha. Three varieties had more than 20,000 plants/ha 2012-05-02; ST-S-Aph123, Barents and ST-S-Aph122.

The final plant number (2012-06-04) was high in all varieties, above 85,000 plants/ha.

Early root rot infections were generally low 2012, because of the cool temperatures after drilling. In the second assessment, there were significant differences between the varieties. Seven varieties had DSI above 40; Alexina KWS, 2K330, Sabrina KWS, HI1179, Rosalinda, 2K330 and 1K187.

The variety with the highest DSI2 score was Alexina KWS (46.1) and the lowest HI1273 (26.8; prob. <0.0001, LSD 5% = 11.3).

The results in this trial indicate that 7 varieties (HI203, Stinger, MA2085, Marcella KWS, 2K310, Mixer and HI1273) may be new promising varieties for *A. cochlioides* infected soils. These varieties show a yield level comparable to the tolerant control Mixer or above.

Varieties that may be susceptible to *A. cochlioides* are 1K187 (AT) and HI1185 (RZ variety). These two varieties were also tested for tolerance to *Aphanomyces* in 2011 and the results in 2011 and 2012 are consistent.

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Borgeby in December 2012

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