Efficacy testing of hymexazol in sugar beets, Sweden 2012

HUSEC project code: HUE85-87
NBR project code: 424-2012

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HUSEC and NBR trial IDs:	HUSEC HUE85 HUE86 HUE87	NBR = 51-424 Ormastorp = 52-424 Svalöv = 53-424 Skibaröd	
Method:	Field trials with randomised complete block design. Green house experiments		
Purpose of trials:	Evaluation of efficacy of hymexazol against *Aphanomyces cochlioides* on sugar beet.		
Trial quality:	According to GEP standards and EPPO guidelines PP 1/152(2) and PP 1/181(3).		

Contents

Summary

Several soil borne pathogens can cause substantial damage to sugar beet roots. One of the most important pathogens is *Aphanomyces cochlioides*. In warm and wet soils, *A. cochlioides* infect young seedlings two to three weeks after emergence. Early infections are controlled by treating the seed with hymexazol (active substance in Tachigaren). The standard dose used on all commercial sugar beet seed in Sweden is 14 g a. i./unit. The seed treatment is effective for four to six weeks.

This project included three field trials with 3.5; 7; 14; 18; 28 and 56 g hymexazol compared with 7 g thiram and an untreated control (in total eight entries).

When the plant number in the field trials was counted at 20% emergence, the seed treatments with 56 g hymexazol showed significantly slower emergence than all other entries. However, final plant number was not affected. The seed treatments with 7; 14 and 18 g hymexazol showed a significantly faster emergence than in the untreated control and 28 and 56 g hymexazol.

No phytotoxic following seed treatment with hymexazol in terms of chlorosis or necrosis was observed on the plants in the field. No stunting was observed on the plants treated with 28 or 56 g hymexazol.

In total, 27 trials with 0; 14; 18 and 30 g hymexazol have been analysed 2004–2012. The results show that a seed treatment with hymexazol has a significant positive impact on all yield parameters; root weight, sugar content, sugar yield, amino-N and K+Na.

The average yield in trials with high infection levels of *A. cochlioides* (17 trials in total), showed a significant positive impact on all yield parameters; increased root weight, sugar content, sugar yield, cleanness and lower amino-N and K+Na is shown. The increase in sugar yield was 5% for 30 g hymexazol corresponding to 530 kg sugar per hectare. The plant number in treatments with hymexazol was also significantly increased compared to untreated (prob. = <0.0001, LSD 5% = 3.3). The plant number for 14, 18 and 30 g hymexazol is increased with 6,700; 6,900 and 9,000 plants/ha, respectively, compared to the untreated check.

Sammanfattning

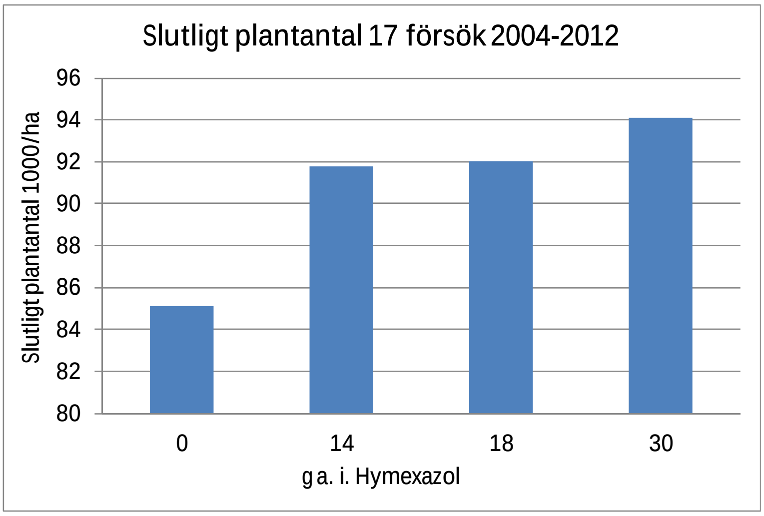
Ett flertal jordburna patogener kan ge upphov till stora skador och skördeförluster i sockerbetor. En av de allvarligaste är *Aphanomyces cochlioides*. Det är framförallt under regniga och varma vårar som problemen kan bli stora med betydande plantbortfall. De tidiga skadorna ger också upphov till kroniska skador på rötterna. Senare på tillväxtsäsongen, framförallt vid mycket regn, reduceras tillväxten. De tidiga angreppen kan minskas genom att fröet betas med hymexazol. Hymexazol är verksamt cirka fyra veckor efter uppkomst.

I denna försöksserie testades sex doser av hymexazol (3,5; 7; 14; 18; 28 och 56 g) i tre fältförsök utlagda i Skåne (Svalöv, Skibaröd och Ormastorp). Som kontroll användes helt obetat men pelleterat frö samt ett led endast betat med 7 g tiram.

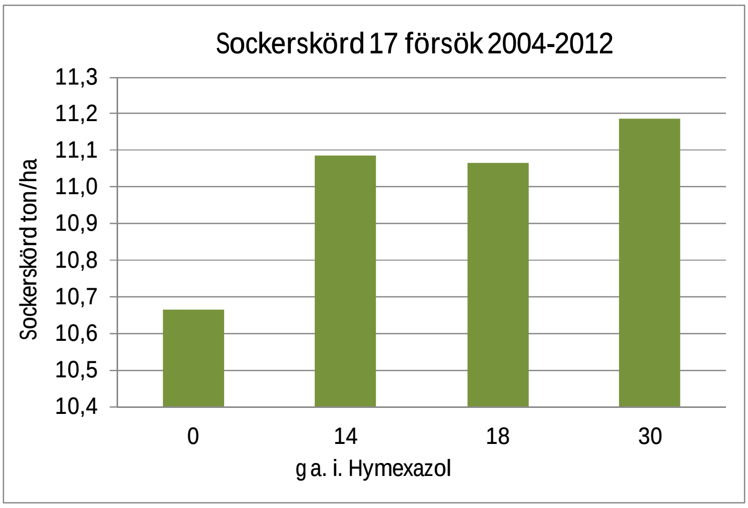
Vid räkningen av plantor vid 20 % uppkomst i fältförsöken hade behandlingen med 56 g hymexazol signifikant färre plantor än obehandlat. Vid full uppkomst fanns det inga signifikanta skillnader mellan behandlingarna. Höga doser av hymexazol försenar alltså uppkomsten något men det slutliga plantantalet påverkas inte.

Medelvärdet för sockerskörden i de tre fältförsöken 2012 visade att 7 och 18 g hymexazol gav signifikant högre sockerskörd jämfört med obehandlat. Ökningen på 6 %-enheter motsvarade ca 800 kg socker.

Tre av doserna (14, 18 och 30 g) har sedan 2004 testats i totalt 27 fältförsök. I 17 av dessa blev infektionsnivån hög vilket resulterade i att det slutliga plantantalet i de tre doserna blev 6 700; 7 900 och 9 000 fler jämfört med den obetade kontrollen (se figur nedan).



Skörderesultaten från 27 försök 2004–2012 visar att hymexazol i doserna 14, 18 och 30 g har en signifikant positiv inverkan på sockerhalt, rotskörd, sockerskörd, blåtal och K+Na. I medeltal över alla 27 försöken ger 14 och 18 g hymexazol knappt 250 kg högre sockerskörd än obehandlat. Om bara de 17 försök med hög infektionsnivå tas med i beräkningarna resulterar 14 och 18 g i 430 kg högre sockerskörd och 30 g i 530 kg.



Introduction

Several soil borne pathogens can cause substantial damage to sugar beet roots. One of the most important pathogens in Sweden is *Aphanomyces cochlioides*. In warm and wet soils, *A. cochlioides* infect young seedlings two to three weeks after emergence (Harveson and Rush, 1993; Windels, 2000). The hypocotyl rots and the seedling dies. Early seedling infections of *A. cochlioides* may result in low plant numbers and permanent damage to the root, resulting in severe deformations. The pathogen infects sugar beet roots through the whole growing period thus causing a general growth reduction. *A. cochlioides* is found in most soils in Sweden and approximately 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.).

Early infections can be controlled by treating the seed with hymexazol, the active ingredient of Tachigaren. Hymexazol is the only registered product that is effective against *A. cochlioides*. The standard dose used on all sugar beet seed in Sweden is 14 g/unit.

Materials and methods

General field trial information

Three field trials were conducted in 2012 according to GEP (Good Experimental Practice) standards and the following EPPO guidelines: PP 1/152 (2) Design and analysis of efficacy evaluation trials; PP 1/181 (3) Conduct and reporting of efficacy evaluation trials including GEP.

Experimental design: Randomised complete block design with four replicates. The trials were located as indicated in Figure 1 and Table 1. The single net plot size was 2.88 x 9 m = 25.92 m^2. The gross plot length was 13 m which made it possible to dig up plants for evaluation of root rot.

Table 1. Trial series in HU-1234 2011. General information

Trial ID HUSEC	**Location**	**Coordinates WGS 84**	**Soil type**
HUE87	Skibaröd	N55.811848° E13.564889°	Medium humus rich light sand
HUE86	Svalöv	N55.90037° E13.07533°	Humus poor rich fine sand
HUE85	Ormastorp	N55.97421° E12.89388°	Humus rich fine sand soil

Trial ID HUSEC	**Previous crop**	**Variety**	**Sowing date**	**Seed distance, seeds/m**
HUE87	Winter wheat	Harpoon	19 April	5,3
HUE86	Winter wheat	Harpoon	18 April	5,3
HUE85	Winter wheat	Harpoon	4 April	5,3

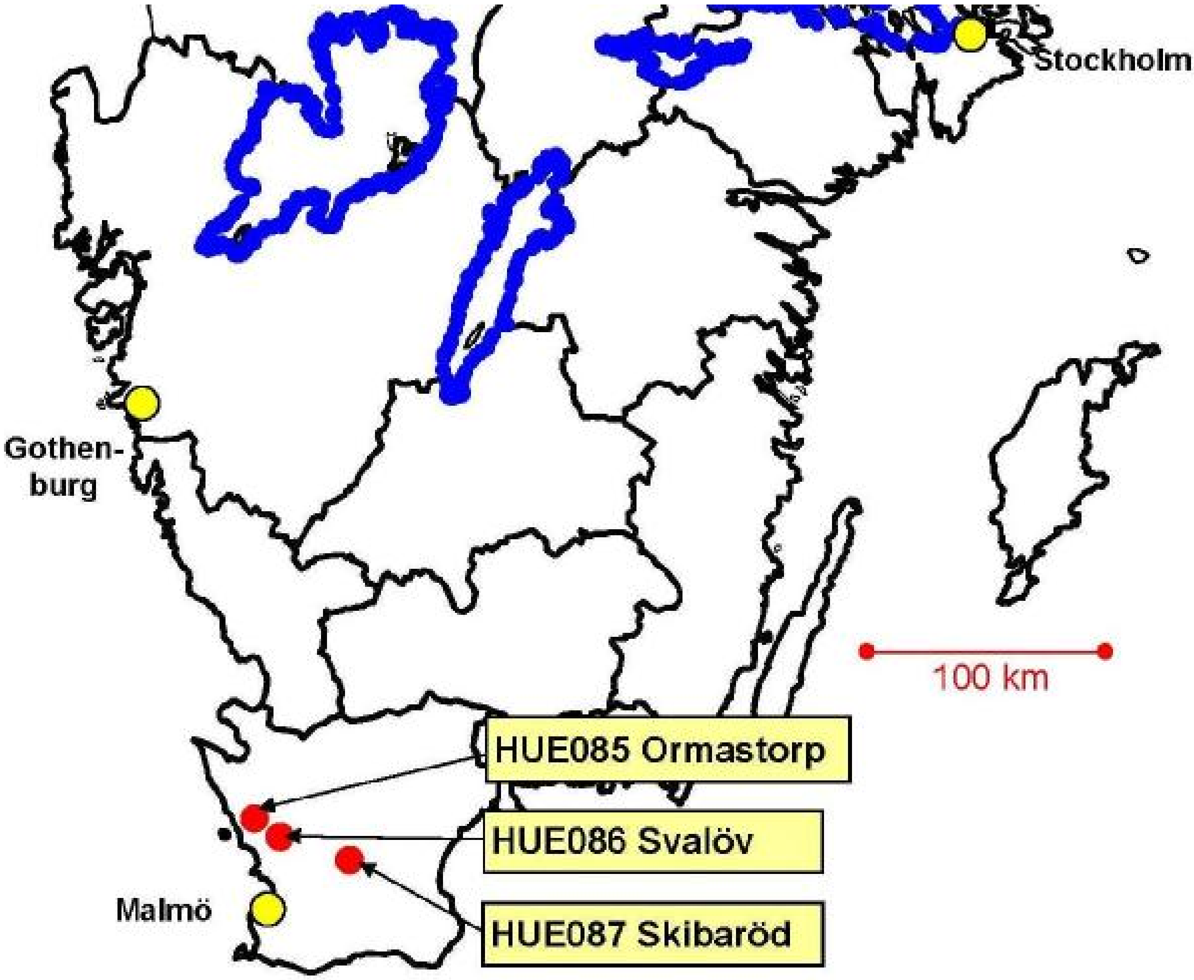


Figure 1. Location of the three trials in series HU-1234 2012.

Treatment information

Table 2. Treatment information of trial series HU-1234 in 2012

Trtm No.	Treatment Fungicide	g a. i. /unit	Insecticide g a. i. /unit
1	Untreated	0	Imidacloprid 60
2	Thiram	7	Imidacloprid 60
3	Hymexazol	3,5	Imidacloprid 60
4	Hymexazol	7	Imidacloprid 60
5	Hymexazol	14	Imidacloprid 60
6	Hymexazol	18	Imidacloprid 60
7	Hymexazol	28	Imidacloprid 60
8	Hymexazol	56	Imidacloprid 60

Treatments 1, 2, 3, 4, 5, 6, 7, 8 were tested in three field trials.

In late autumn 2011, soil samples were taken from a number of different locations in the south of Sweden and tested for root rot potential in a bioassay. Sugar beet seeds were sown in pots with test soil and then put in greenhouse under conditions favorable for infection of soil borne pathogens. The soils are classified into one of four risk groups (Ewaldz, 1992); no risk; low; medium and high (table 3). Three field trial locations were chosen on the basis of the result from the soil tests. The results of the analyses of soil type on each locality are shown in the appendix.

Table 3. The risk of infection in soils analyzed for disease severity index (Ewaldz, 1992)

Index	Risk	Evaluation
0 – 20	No risk	-
20 – 50	Low	Normally no problems
50 – 70	Medium	Growing sugar beets could be hazardous
70 – 100	High	Under favourable conditions, damping-off is highly likely

Plant number

The number of plants in the harvest rows, rows three and four, was counted three times during emergence (20%, 50% and final emergence).

Plant vigour and row coverage

Plant vigour was assessed once in each trial using a scale from 0 to 100 where values below 50 indicate plants in severely reduced growth (50% yield reduction), 50–79 indicates somewhat reduced growth that probably will affect yield. Values between 80 and 90 indicates that the plants only show minor damage that seldom has any effect on yield and values above 90 are nearly healthy plants.

Disease severity index

Assessment of disease severity index on field collected seedlings were performed twice in early spring. The first assessment was done when the plants had developed cotyledons and the second two weeks later. In the sample area 20 randomly chosen plants were dug up 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% (roots totally rotten, plant dead). A disease index (DSI) was calculated using the following equation developed by Larsson and Gerhardson (1990):

DSI = $((n_0 * 0 + n_{20} * 20 + n_{50} * 50 + n_{75} * 75 + n_{100} * 100)/\text{plant number})$
where n = number of beets in each class.

The results are shown in the appendix. Pieces of roots were put on agar plates and fungi were determined to genera and species based on morphology.

Harvest

After harvest, the beets in each plot were assessed for symptoms of chronic root rot using a scale from 1–7. The evaluation of chronic root rot was carried out at the tare house in Örtofta (Agri Provtvätt, Örtofta Sockerbruk, Nordic Sugar).

Table 4. Assessment of chronic symptoms of Aphanomyces 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

Green house experiment I

The trial plan is shown in table 5. Soil was collected from a field naturally infected with soil borne fungi, predominantly *Aphanomyces cochlioides*. The soil was divided between six pots per treatment and replication and put in a green house in a randomized complete block design. Ten seeds of the susceptible variety Harpoon were sown in each pot. The pots were checked daily for dying sugar beet seedlings which were all marked by a tooth pick. After four weeks all remaining plants were washed from soil and inspected for symptoms of damping-off using the scale described above (Larsson and Gerhardson, 1990). A DSI was calculated according to Larsson and Gerhardson (1990).

Table 5. Treatment information of trial series HU-1234 in 2012, green house experiment I

Trtm No.	Treatment Fungicide	g a. i. /unit	Insecticide g a. i. /unit
1	Untreated	0	Imidacloprid 60
2	Hymexazol	14	Imidacloprid 60
3	Hymexazol	18	Imidacloprid 60
4	Hymexazol	28	Imidacloprid 60

Conditions in the green house

Pots were watered daily to maintain high soil moisture and optimal conditions for infection. The plants were grown with 16 h day/8 h night cycle, with a day-time temperature of 24°C, a night-time temperature of 19°C and with extra light (Osram, HQI-T 400W) supplied for the 16 h of day-time.

Statistical analysis

All variables were analysed using Proc GLM in SAS, SAS Institute Inc. All shown treatment means are adjusted means (LSmeans) unless otherwise stated. In case of no missing values in the data set, LSmeans are equal to the aritmethic means.

Results

Field trials

The growing conditions after drilling 2012 were cold which led to somewhat low disease development. See Appendix 2 for details in daily temperatures.

The pre-testing of soils for the field trials showed that the DSI before drilling was 83 at Ormastorp, 71 at Skibaröds gård and 79 at Svalöv. Table 10 shows the results of isolations that were done on plants from the soil test.

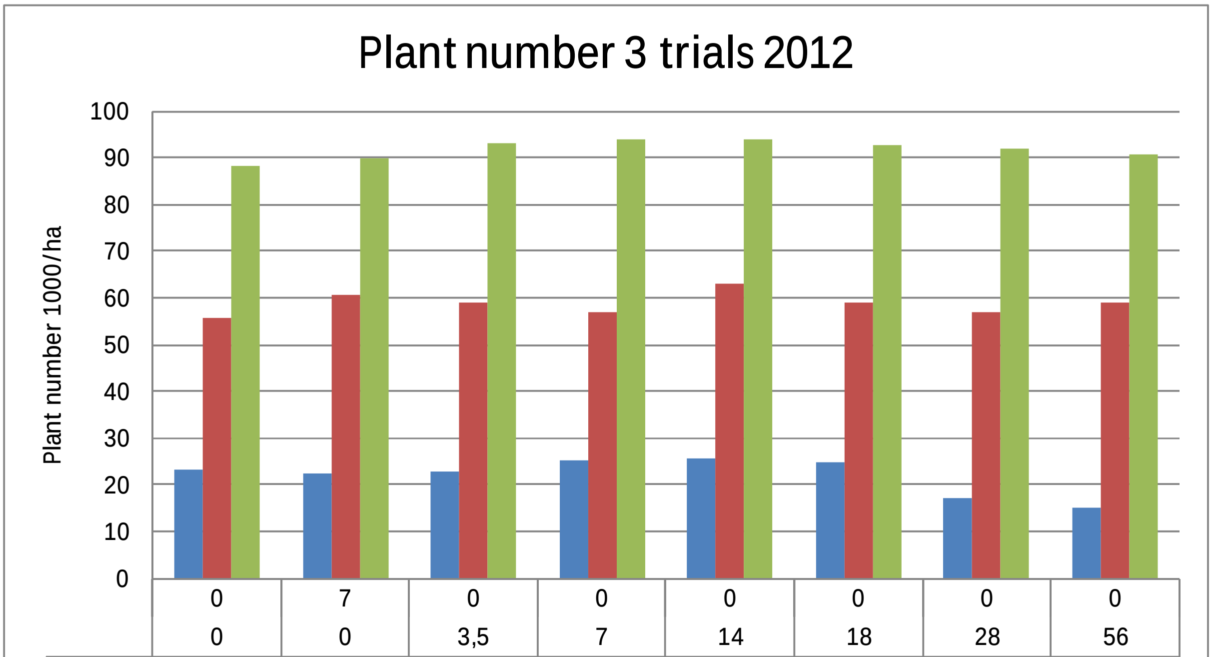
Table 10. Soil borne pathogens and fungi isolated from soil test

Location	**% plants found with infected roots**
Ormastorp	*70% Aphanomyces cochlioides, 20% Pythium spp.*
Skibaröds gård	*90% A. cochlioides*
Svalöv	*50% A. cochlioides*

Plant number

When the plant number was counted at 20% emergence in the field trials, the seed treatments with 56 g hymexazol showed significantly slower emergence than all other treatments, mean 3 trials 2012, prob = 0,0045, LSD 5% = 6.1 (figure 1). There were no significant differences in final plant number between the seed treatments.

Three doses of hymexazol, 14; 18 and 30 g, (in 2012 28 g was used instead of 30 g) has now been tested in a total of 27 field trials 2004–2012. The increase in plant number for 14, 18 and 30 g hymexazol in the trials displaying high infestation levels (17 trials 2004–2012) was 6 700; 7 900 and 9 000 compared to the control.



	0 0	7 0	0 3,5	0 7	0 14	0 18	0 28	0 56
plh20	23,0	22,2	22,8	25,3	25,5	24,8	17,1	15,1
plh50	55,9	60,8	59,1	56,8	62,9	59,1	57,0	59,0
plh100	88,3	90,1	93,2	93,8	93,8	92,5	91,8	90,6

Figure 1. Plant number at 20% emergence, average over three trials 2012.
Plh20%: prob = 0,0045, LSD 5% = 6.1; Plh50%: prob = ns; Plh100%: prob = ns.

Vigour

There were significant differences in vigour between the treatments at Skibaröd, prob = 0,0196, LSD 5% = 9,7 (figure 2).

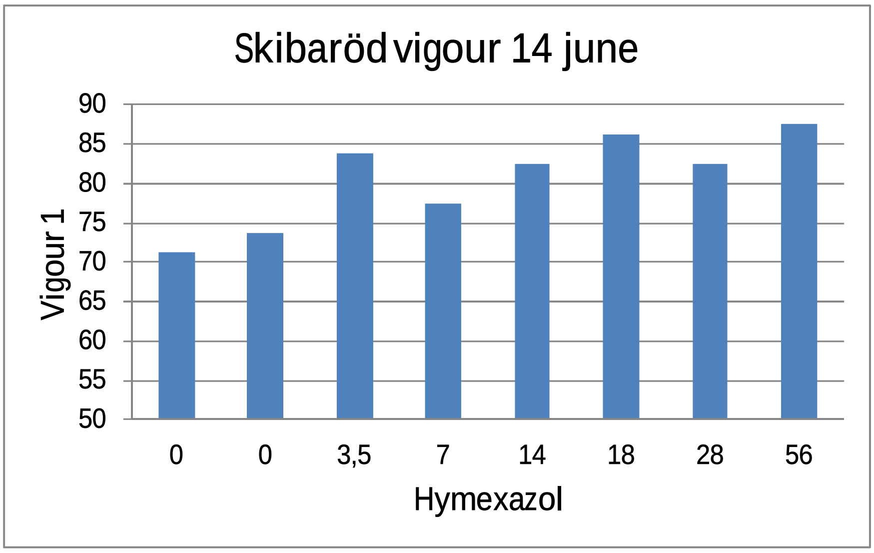


Figure 2. Evaluation of vigour at Skibaröd 2012, 14 June.

Picture 3. Treatment 1, untreated control, in the field trial at Skibaröd 2012, 14 June.

Picture 4. Treatment 8, with 56 g hymexazol in the field trial at Skibaröd 2012, 14 June.

Disease severity

The cold weather after emergence resulted in low infections of *A. cochlioides*. There were no significant differences in DSI 1 and 2 between the seed treatments in 2012. *Aphanomyces cochlioides* was reisolated from the plants collected in the three field trials. In addition, *F. culmorum* was isolated from plants collected at Svalöv.

The average DSI 1 and 2 in 27 field trials 2004–2012 showed that the seed treatments (14, 18 and 30 g hymexazol) had significantly lower DSI than the untreated control.

Sugar yield 2012

Two of the locations showed that there was an increase in sugar yield for seed treatment with hymexazol, Svalöv (prob. = 0,0248, LSD 5% = 0.9) and Ormastorp (prob. = ns).

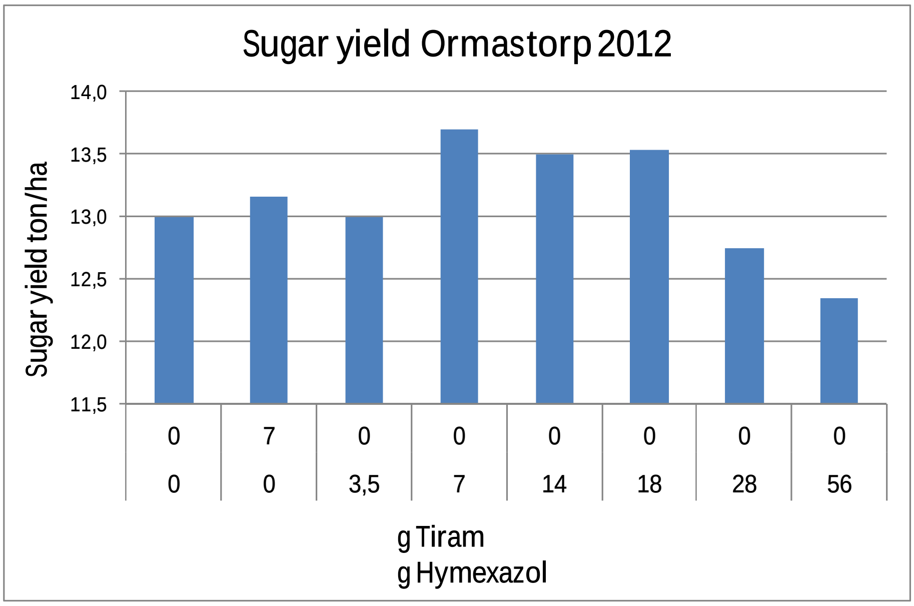


Figure 3. Sugar yield in the field trial at Ormastorp 2012, prob. = ns.

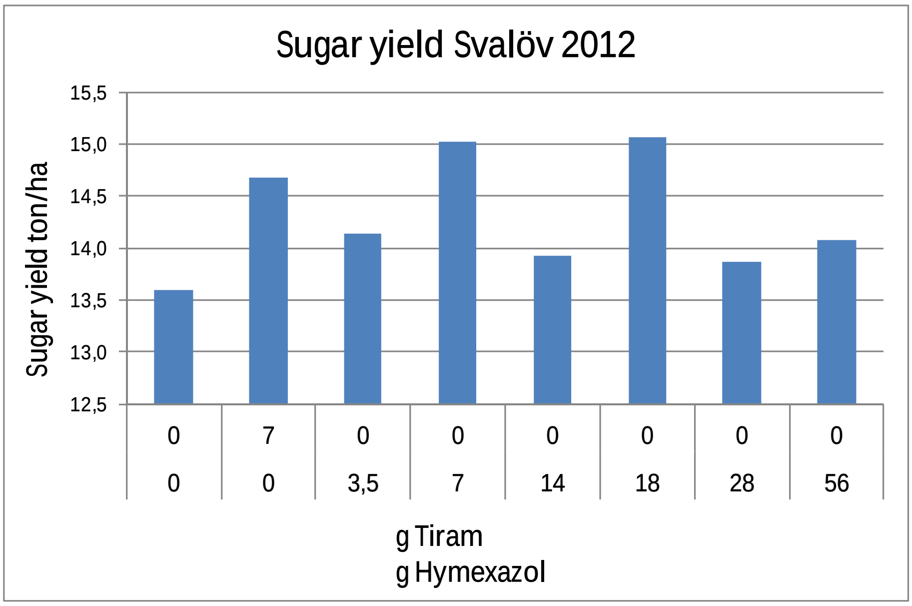


Figure 4. Sugar yield in the field trial at Svalöv 2012. Svalöv, prob. = 0,0248, LSD 5% = 0.9.

Chronic root rot symptoms was low in all the trials compared to 2011. This may be an effect of the rain during 2012 which was less in 2012 than 2011 (appendix 2).

Sugar yield 2004–2012

In total, 27 trials with 0, 14, 18 and 30 g hymexazol have been studied since 2004. The results show that a seed treatment with hymexazol has a significant positive impact on all yield parameters; sugar content, sugar yield, amino-N and K+Na.

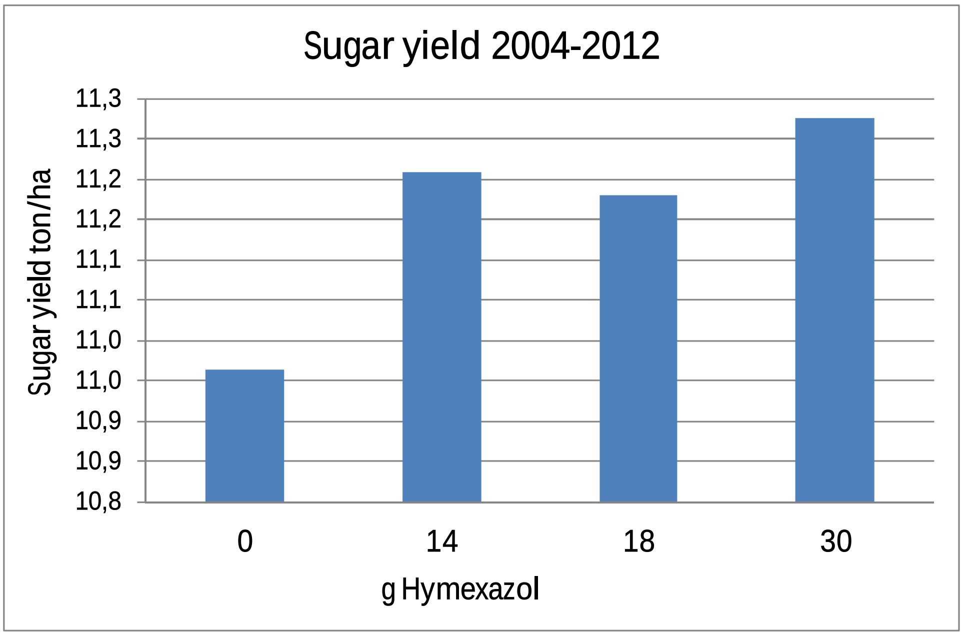


Figure 5. Sugar yield in 27 trials 2004–2012.

The average of trials with high infestation levels of *A. cochlioides* (17 trials in total), shows a significant positive impact on all yield parameters; increased root weight, sugar content, sugar yield, cleanness and lower amino-N and K+Na is shown. The increase in sugar yield is 5% for 30 g hymexazol corresponding to 530 kg sugar per hectare.

The plant number for treatment with hymexazol is also significantly increased compared to untreated (prob. = <0.0001, LSD 5% = 3.3). The plant number for 14, 18 and 30 g a. i. hymexazol is increased with 6,700; 6,900 and 9,000 plants/ha compared to untreated.

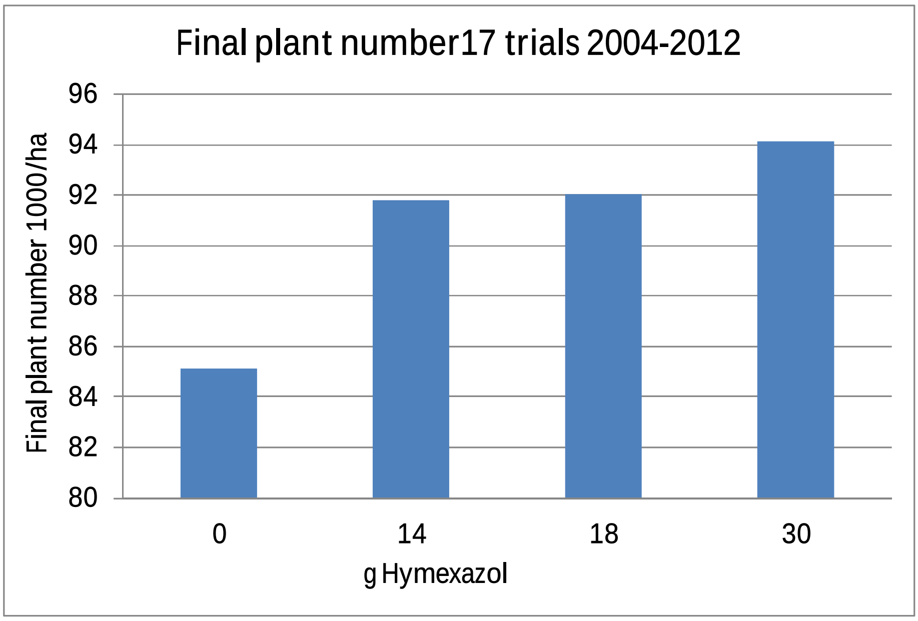


Figure 6. Plant number in 17 trials 2004–2012 with high infection level of A. cochlioides.

For the trials in which very low infection levels were observed there were no significant differences in yield between the treatments.

Phytotoxicity

When the plant number in the field trials was counted 2012 at 20% emergence, the seed treatments with 7, 14, 18 g hymexazol showed a significantly faster emergence than in the untreated control and 28 and 56 g hymexazol.

56 g hymexazol was significantly slower in emergence at 20% than all the other treatments.

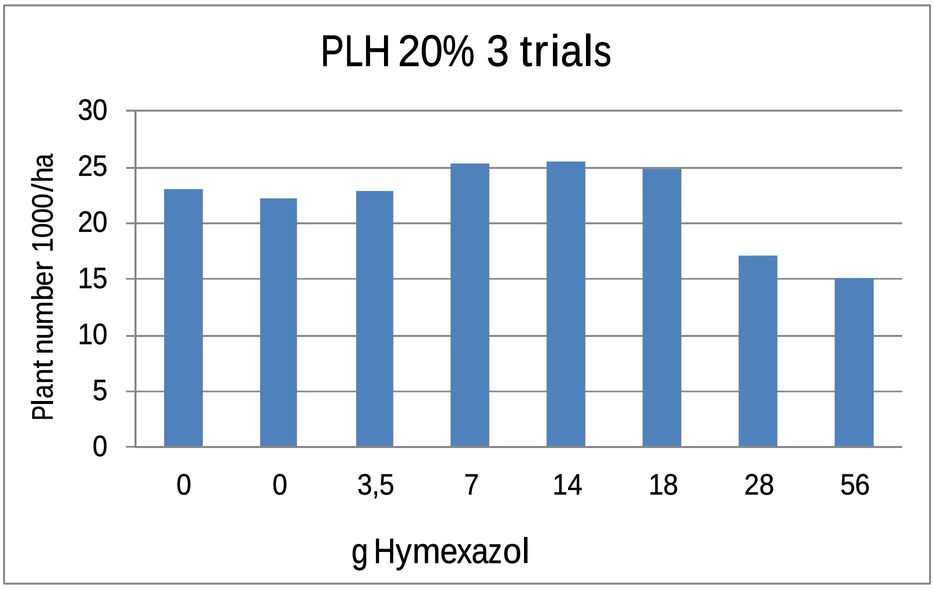


Figure 7. Plant number in 3 field trials 2012 prob. = 0,0045, LSD 5% = 6.1.

Green house experiment I

The green house experiment 2012 (figure 8) showed that 14; 18 and 30 g hymexazol had lower DSI, 63, 60 and 60 respectively, than the untreated control, DSI = 68, prob = ns.

A total of nine green house experiments have been performed since 2005 with 14; 18 and 30 g hymexazol. The average DSI from nine green house trials showed that all treatments, 14; 18 and 30 g hymexazol, had significantly lower DSI than the untreated control, Prob < 0.0001, LSD = 2.6. There was no significant difference between the three doses of hymexazol.

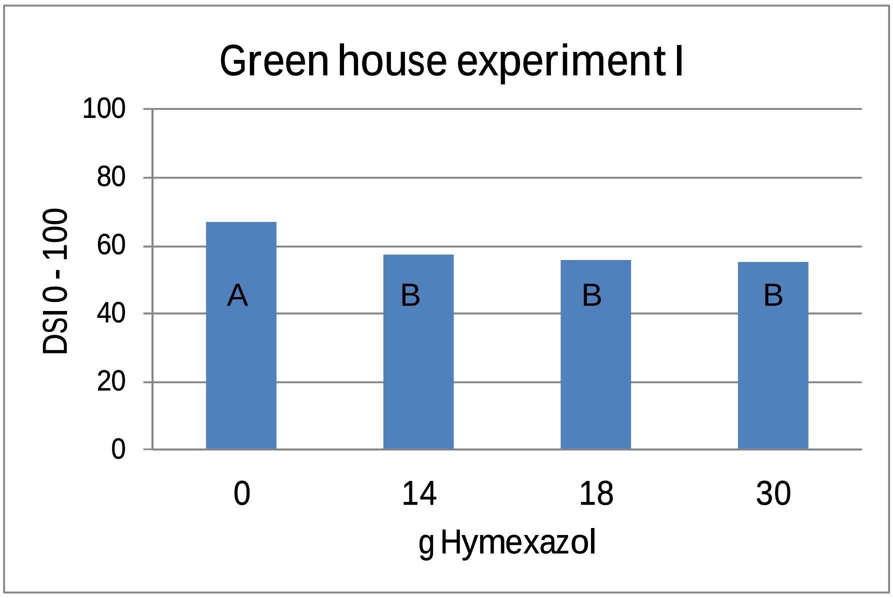


Figure 8. Average DSI in nine green house experiments 2005–2012 in 0, 14, 18 and 30 g hymexazol, Prob < 0.0001, LSD = 2.6.

Conclusions

When the plant number in the field trials was counted at 20% emergence, the seed treatments with 56 g hymexazol showed significantly slower emergence than all other entries. However, final plant number was not affected. The seed treatments with 7, 14 and 18 g hymexazol showed a significantly faster emergence than in the untreated control and 28 and 56 g hymexazol.

No phytotoxic effect due to seed treatment with hymexazol in terms of chlorosis or necrosis was observed on the plants in the field. No stunting was observed on the plants treated with 28 or 56 g hymexazol.

In total, 27 trials with 0, 14, 18 and 30 g hymexazol have been analyzed 2004–2012. The results show that a seed treatment with hymexazol has a significant positive impact on all yield parameters; root weight, sugar content, sugar yield, amino-N and K+Na.

On average of trials with high infection levels of *A. cochlioides* (17 trials in total), hymexazol seed treatment show a significant positive impact on all yield parameters; increased root weight, sugar content, sugar yield, cleanness and lower amino-N and K+Na is shown. The increase in sugar yield is 5% for 30 g a. i. hymexazol corresponding to 530 kg sugar per hectare.

The plant number in treatments with hymexazol is also significantly increased compared to untreated (prob. = <0.0001, LSD 5% = 3.3). The plant number for 14, 18 and 30 g a. i. hymexazol is increased with 6,700; 6,900 and 9,000 plants/ha compared to untreated.

References

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Borgeby in December 2012

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Appendix 1

Pictures from green house experiment with soil from Glumslöv naturally infected with A. cochlioides

Untreated

7 g thiram

3,5 g hymexazol

7 g hymexazol

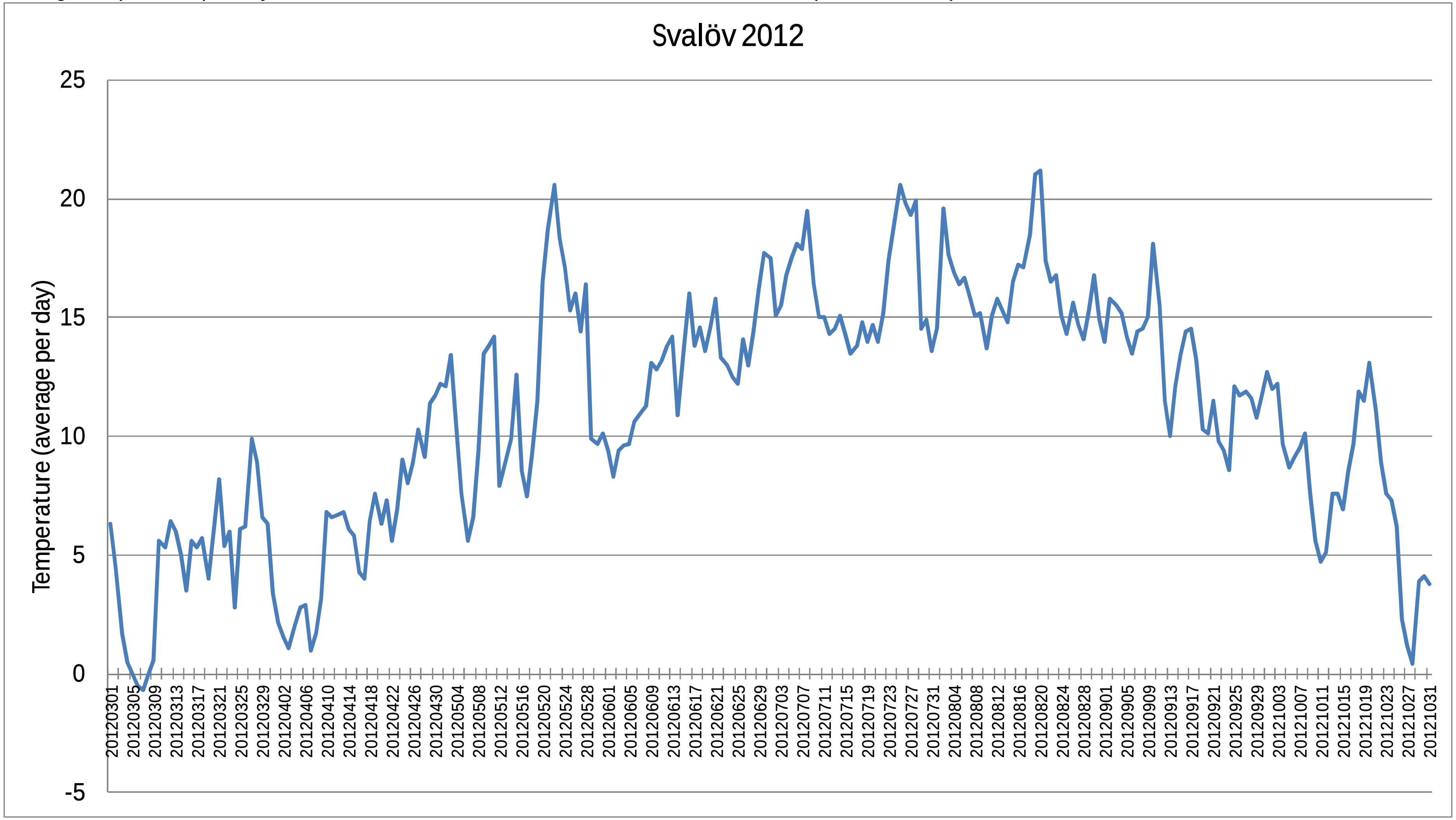
14 g hymexazol

28 g hymexazol

56 g hymexazol

Appendix 2

Average temperature per day 1 March to 31 October in Svalöv 2012, data from Lantmet (www.ffe.slu.se)



Accumulated rain (mm) 1 March to 31 October in Svalöv 2011 and 2012, data from Lantmet (www.ffe.slu.se)