Impact of stem mining weevils on yield in winter oilseed rape

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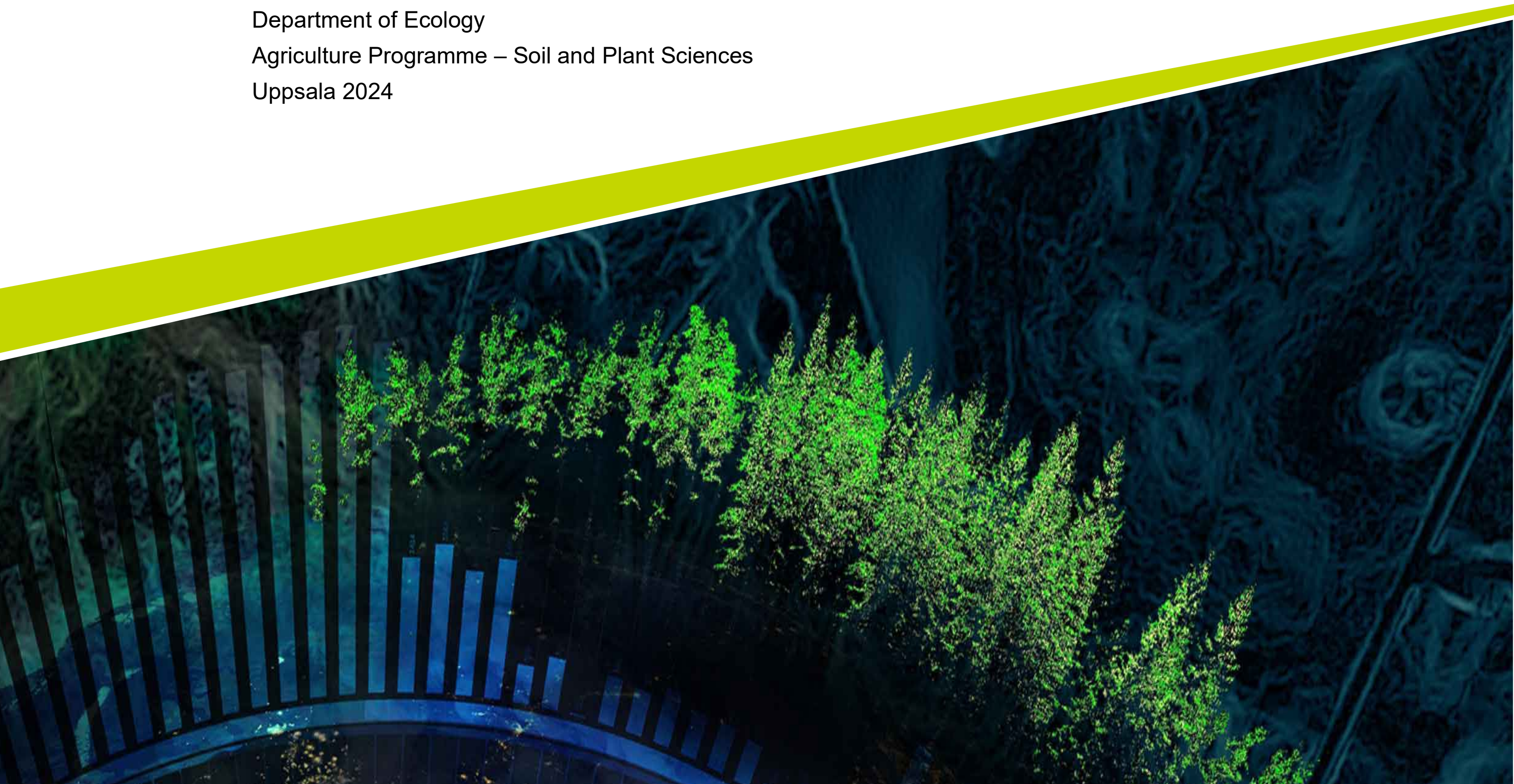

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Skördepåverkan av stjälkminerande rapsvivlar i höstraps.

Rebecka Alaton

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Abstract

Larvae of stem mining weevils (*C. sulcicollis* and *C. pallidactylus*) cause damage inside the stem of winter oilseed rape when feeding. Both weevil species have a single generation annually but they differ in where they owerwinter. *C. sulcicollis* colonizes the oilseed rape fields in autumn and overwinter there. The weevil can therefore be controlled by insecticide treatment in autumn, whereas *C. pallidactylus* overwinters in the edge of forests, under bushes or similar and colonizes oilseed rape fields in the spring. *C. pallidactylus* usually starts to appear in winter oilseed rape fields in the beginning of May in south of Sweden, and a bit later in the middle of Sweden.

The main purpose of this master thesis is to evaluate how stem mining weevils impact the yield of winter oilseed rape. Insecticide treatments in autumn and spring were performed in two different locations with the aim to vary crop injury by the pests and thereby understand the impact of the pests on yield. The field trial study was conducted in the growing season 2022/2023 at two separate fields in the county of Östergötland. Weevil incidence was determined with yellow water traps. Measuring of length of damage inside the stem and grading of damage index was performed in May and June. The damage in May was caused by *C. sulcicollis* and the damage in June by both weevil species. The next generation of stem mining weevils was counted with the help of emergence traps. Plots in the field trial were harvested separately and analysed for oil content, chlorophyll content, moisture content and thousand seed weight. Profitability calculations were made for the insecticide and control treatments.

The sites of the field trials in this experiment were chosen with the expectation that pest level would be high, which was indeed the case. Especially pest level of *C. sulcicollis* was very high in the field trials. The results showed a mean yield increase varying between 170 to 180 kg ha^{-1} in one of the field trials when insecticides were applied in autumn, in spring and as a combination of the two compared to control. The autumn treatment decreased the damage inside the stem caused by *C. sulcicollis*, however no response on damage to insecticide treatment was observed later in the season when *C. pallidactylus* is expected to cause damage as well. In the second trial no yield increase or decrease in damage as a result of insecticide treatment was observed. The plant density was low after winter as a result of the lack of growth regulator treatment at this site, which may have contributed to the trial results. The field trials did not show any significant difference between the four treatments in profitability, even though the yield increase in one of the field trials covered the financial costs that spraying entails. Further research is needed to understand the reasons behind the yield increase without stem damage decrease when spring treatment is performed. In addition, more research is needed to evaluate insecticide treatment at different pest levels in order to be able to set profitability threshold values.

Keywords: Ceutorhynchus pallidactylus, *Ceutorhynchus sulcicollis,* insecticides, integrated pest management, pest control, stem mining weevils, winter oilseed rape.

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1. Introduction

1.1 Background

Chemical pesticides are used in agriculture to control pests and weeds in order to prevent crop losses (Tudi et al. 2021). A sustainable use of pesticides is a target for all member states of the European Union (EU) (European Commission n.d.b). EU has set a target to reduce the use and risk of chemical pesticides by 50 % by 2030 (European Commission n.d.b). The European Commission includes integrated pest management (IPM) in the Directive 2009/128/EC as a central tool for sustainable plant protection (European Parliament 2009). Plant protection products should only be used to levels that are economically and ecologically justified with careful consideration of the risk to human health and the environment. IPM must be implemented by all professional users of pesticides. Decision making of whether and when to apply pesticides should be based on the result of monitoring of pests and scientifically sound threshold values (European Commission n.d.a). The Swedish Board of Agriculture is responsible for national pest control recommendations in Sweden (Jordbruksverket 2023a).

Oilseed rape (*Brassica napus* L.) is attacked by several harmful insects with the degree of harm varying between years and locations (Williams 2010). Insecticide applications can be considered essential to secure yields but are often used for prophylactic purposes before the pest is reaching threshold values (Peterson et al. 2018). Oilseed rape in Europe has an average frequency of 3,5 applications of insecticides per season (Zheng et al. 2020). The larvae of blue stem weevil (*Ceutorhynchus sulcicollis* Paykull) and cabbage stem weevil (*Ceutorhynchus pallidactylus* Marsham) cause damage inside the stem of oilseed rape. At present, no threshold values for chemical control of these two pests are available to Swedish farmers (Jordbruksverket 2023a). To set insecticide recommendations for these weevils, their lifecycle, prevalence, and effect of harm on the crop and yield of oilseed rape must be considered.

1.2 Aims and objectives

The effect on yield caused by stem mining weevils in Swedish winter oilseed rape cultivation has not been sufficiently investigated. The main purpose of this master thesis is to evaluate how stem mining weevils (*C. sulcicollis* and *C. pallidactylus*) impacts yield of winter oilseed rape. Insecticide treatments in autumn and spring were performed in two different locations with the aim to vary crop injury by the pests and thereby understand the impact of the pests on yield. The result is intended to be a foundation for pest control recommendations. To gain an understanding of the influence of stem mining weevils the following research objectives are formulated:

Determine the difference in plant damage, frequency of stem mining weevils, yield and economic outcome in relation to temporally varying insecticide treatments.

Evaluate the associations between the frequency of stem mining weevils, plant damage and crop yield.

1.3 Cultivation of winter oilseed rape

Winter oilseed rape cropping has increased over several years in Sweden, today reaching over 110 000 hectares which is the largest acreage that has been measured (Jordbruksverket 2023b). It is the second most common winter crop, after winter wheat, which is grown in Sweden. Cultivation of winter oilseed rape takes place to the highest degree in the three counties Skåne, Västra Götaland and Östergötland (Jordbruksverket n.d.). The cruciferous plant is a valuable source of vegetable oil and oil extraction meal as a by-product. In addition to being used for human consumption, oilseed rape is also processed into animal feed and transportation fuel (Friedt & Snowdon 2010). The crop has also agronomic benefits. Being a leaf crop with taproot it contributes to soil fertility and acts as an important component in crop rotations which often are dominated by cereals (Friedt et al. 2018). As a break crop in cereal production, oilseed rape´s taproot improves the texture of the subsoil which leads to increased nutrient and water uptake. As a rotational crop it also suppresses diseases by being a non-host for pathogens associated with other crops and releasing pathogen-suppressing compounds (Angus et al. 2015).

1.4 The biology of stem mining weevils

The stem mining weevils *Ceutorhynchus pallidactylus* and *Ceutorhynchus sulcicollis* belongs to same family of weevils but differ in their appearance and biology. The body of *C. pallidactylus* is 2.5 – 3.5 mm long, slightly larger than *C. sulcicollis* which is 2.0 – 3.3 mm long (Ekbom 1996). Both weevils have a globular body shape with a narrow, long snout. The elytra of *C. sulcicollis* are shiny dark blue and the rest of the body parts are black or brown (Figure 1A; Ekbom 1996). *C. pallidactylus* has a greyish body with brown-red legs (Figure 1B). The elytra is covered with fine whitish hair, concentrated to the centre, forming a white spot close to the pronotum (Ekbom 1996; Juran et al. 2011). Eggs, larvae and pupa are difficult to distinguish between the species (Gustafsson 1991). The eggs are circa 0.5 mm long, narrow in shape and shiny white. The larvae are white with brownish-yellow head capsule and without feet. In the last larvae stage, the larvae can be up to 5 mm long. The pupas are white (Gustafsson 1991).

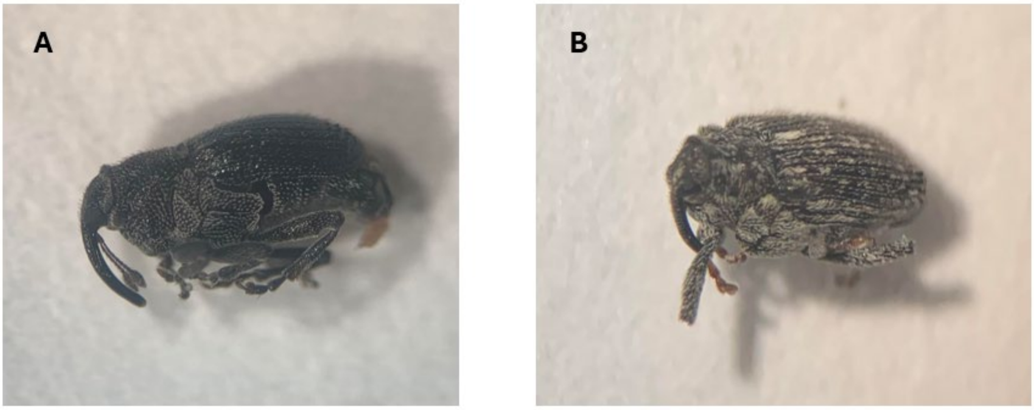


Figure 1. Ceutorhynchus sulcicollis (A) and Ceutorhynchus pallidactylus (B). Photos by Rebecka Alaton.

Both weevil species have a single generation annually (Ekbom 1996). Fully formed weevils hatch in July and feed on still green oilseed rape or other cruciferous plants. After a period of maturation feeding, *C. sulcicollis* moves into summer dormancy in forest edges until September when reappearing in winter oilseed rape fields. Immigration usually culminates in the end of September, but can vary with temperature (Gustafsson 1991). *C. sulcicollis* stays in the field for wintering unlike *C. pallidactylus*, which instead seeks a place in the edge of forests, under bushes or similar. Immigration occurs when air temperature is over +15°C and *C. pallidactylus* usually starts to appear in winter oilseed rape field in the beginning of May in the south of Sweden, and a bit later in the middle of Sweden. *C. sulcicollis* on the other hand, starts being active in the field earlier in spring, as soon as the temperature is high enough (Ekbom 1996). This is, according to Hayn (1970, see

Gustafsson 1991), when the average daily temperature in the air for two consecutive days exceeds +5°C and a daily maximum temperature of +11°C is reached.

The weevils can start laying eggs already a couple of days after waking up (Gustafsson 1991). The weevils oviposit on the underside of leaf petioles, into the stem epidermis and the larvae then mine into the stem, inducing damage to the stem structure. The fully grown larvae bores out of the stem to pupate under the soil surface, normally in July. The time from egg to adult varies between 50 to 68 days for *C. sulcicollis* and between 37 to 51 days for *C. pallidactylus*, depending on the weather (Ekbom 1996).

1.5 Direct and indirect damage to the crop by stem mining weevils

The plant shows several physiological symptoms when stem weevil larvae feeds inside the stem (Kelm & Klukowski 2000). The stem injury reduces plant growth, leaf area, the leaves are lost sooner and the flowering is delayed (Kelm & Klukowski 2000). The physical properties of injured stems are deteriorated compared to uninjured plants when mechanical properties are studied. Several parameters, such as the energy of cutting and the force of inflection, was higher in uninjured plants (Kelm & Klukowski 2000). The inside of the stem often becomes brown, even at low attacks, and sullied with excrements from larvae. In case of larger quantities of larvae the outer supporting tissues and root crown can be attacked (Gustafsson 1991). Wounding of plant tissue by stem mining weevils can also increase the severity of secondary infections, by fungal pathogens such as *Phoma lingam* (Krause et al. 2006).

The stem mining weevils do not attack the pods, however, there is a negative correlation between the length of the feeding tunnels in the stem and the oilseed rape yield (Zaller et al. 2008). A statistical evaluation of this relation showed a significant decrease of yield with one tonne when average damage length per plant increases from 0 to 50 % (Zaller et al. 2008). The damage in the study can possibly be caused by *Ceutorhynchus napi* (Gyllenhal) as well, but *C. pallidactylus* constituted 80 % of total abundance of stem mining weevils in the region (Zaller et al. 2008). *C. napi* is present in Central Europe but not in Sweden (Eickermann et al. 2014; SLU Artdatabanken n.d.). Similarly to *C. pallidactylus* the species immigrates to oilseed rape in the spring, and, in contrast to *C. pallidactylus* and *C. sulcicollis*, the females oviposit eggs into the top of the stems (Eickermann et al. 2014). Pest control trials can be used to clarify the effect of reducing the number of stem mining weevils present and thus the impact on several parameters of the crop, including yield.

1.6 Chemical control trials to understand impact on yield by stem mining weevils

Chemical control has shown an effect on stem weevil damage in oilseed rape and pest control trials can also be used to understand yield impact (Grantiņa et al. 2011). A systemic insecticide can significantly decrease the damage, caused by stem-mining weevils, by 43 - 51 % compared to untreated area (Grantiņa et al. 2011). The systemic insecticide stops the hatched larvae´s feeding and further development. Insecticide treatment when the plant was in the stem elongation phase resulted in a significant yield increase of 0.5 to 0.7 t ha^{-1} or approximately 19 % compared to untreated control (Grantiņa et al. 2011). Danish chemical control trials (SEGES Innovation P/S 2023) against *C. pallidactylus* demonstrated yield increase (300 - 400 kg ha^{-1}) in three of four trials when weevil frequency was high (74 - 99 *C. pallidactylus* weekly in yellow water traps). No yield increase was obtained in four trials when weevil frequency was low (0 - 8 *C. pallidactylus* weekly in yellow water traps). Major damage (in mean 83 % of the lowest 60 cm of the stem) was observed in the untreated control in the trials with high weevil frequency. Damage length was reduced to 43 % of the lowest 60 cm of the stem by one treatment, and to 20 % when insecticide treatments were performed twice with three weeks in between (SEGES Innovation P/S 2023). Yield increase by insecticide treatment has been reported in the Czech Republic as well (Spitzer et al. 2014). A yield increase by 4 – 5 % in comparison with the untreated control was discovered, but only in three of 15 insecticide experiments. The authors suggest that the currents threshold values should be revised since the damage appears to be overestimated. Most of the damage was caused by *C. pallidactylus*, but some *C. napi* was also detected (Spitzer et al. 2014).

During 1973 - 1975 chemical control of *C. sulcicollis* trials were set up and new methods for weevil frequency counts were investigated in Sweden (Björkman 1975). A tool that can be pushed forward between the sowing rows and that catches weevils falling from the plants was constructed and was also used monitoring in chemical control trials between 1980 and 1990 (Gustafsson 1991). The effect of insecticide treatment performed in 1973-1975 was evaluated based on the impact on weevil frequency (Björkman 1975). Successful results, with control effect between 97 - 100 %, were achieved in several locations (Björkman 1975). Similarly, results from Estonia shows significantly lower numbers of weevil larvae in winter oilseed rape when insecticide against *C. sulcicollis* has been applied (Sulg et al. 2022). The later field trials in Sweden, those between 1980 and 1990, includes yield as a evaluating parameter (Gustafsson 1991). Insecticide treatment, both autumn and spring treatment, increased yield with 2 - 5 % in some locations, although these differences were not statistically significant. Insecticide treatment significantly decreased the observed level of damage by stem mining weevils in all field experiments (Gustafsson 1991).

1.6.1 Pest control thresholds

The Swedish Board of Agriculture monitors *C. sulcicollis* and *C. pallidactylus* in several locations, however, no economic threshold for insecticide application has been established (Jordbruksverket 2023a). Threshold values for *C. pallidactylus* varies among European countries from 10 to 30 adult weevils per yellow water trap within three consecutive days, however, it is unclear how these values were determined (Alford et al. 2003, see Eickermann et al. 2015). No threshold values for *C. sulcicollis* have been found.

2. Material and method

The field study was conducted in growing season 2022/2023 at two separate fields, Helleberga and Säby, in the county of Östergötland. The locations were chosen in consultation with the Plant Protection Centres of the Swedish Board of Agriculture to find a placement where stem mining weevil incidence was expected to be high. High numbers of stem mining weevils are desired to be able to evaluate the effect of insecticide treatment, and the effect of stem mining weevils on yield. The sites were also chosen based on having limited numbers of cabbage stem flea beetle (*Psylliodes chrysocephala)* in the yellow water traps in autumn, to minimize the risk of confounding damage from this pest.

2.1 Experimental design

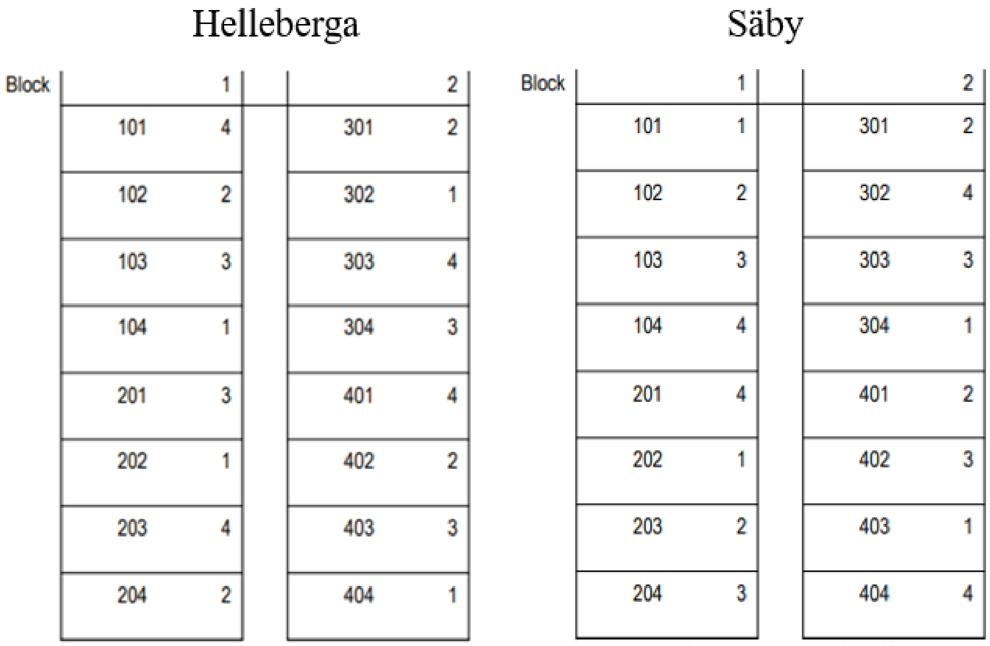
The field trial was sown with winter oilseed rape seeds and managed by Hushållningssällskapet Östergötland, regarding insecticide treatments and harvest, and in other aspects by the farmers in line with management practices for the rest of the field. The trial area had plot length, i.e. 12 m with a plot width that was double compared to the standard, i.e. 6 m (Figure 2). Wider plots reduces the risk of the pests moving between plots. The field experiment used a randomized complete block design with four replicates of four treatments. Plots were immediately adjacent to each other. The four treatments were; insecticide treatment in autumn, insecticide treatment in spring, insecticide treatment in autumn and spring (combination) and control (no insecticide treatment) (Table 1). The insecticides that were used was Nexide CS and Mavrik. The application time of the insecticides was in October and May. The timing was chosen when the number of *C. sulcicollis* (autumn) or *C. pallidactylus* (spring) weevils in yellow water traps was decreasing, indicating that flight immigration had culminated. The autumn treatment was intended to control *C. sulcicollis* and the spring treatment to control *C. pallidactylus*. For product names and rates, see table 1.

Table 1. The four treatments in the field trials.

Treatment number	Treatment name	Insecticide	Rate (l/ha)	Application time
1	Autumn	Nexide CS[1]	0,06	13th of October
2	Spring	Mavrik[2]	0,2	16th of May
3	Combination	Nexide CS[1] + Mavrik[2]	0,06 + 0,2	13th of October + 16th of May
4	Control	-	-	-

Active substance is gamma cyhalotrin with the concentration 60 g/l.
Active substance is taufluvalinate with the concentration 240 g/l.

A growth regulator was applied to the field experiment in Helleberga but not in Säby. The commercial part of the field in Säby was treated with growth regulator together with an insecticide which was not intended to be a part of the experiment, hence the field trial was unintentionally without growth regulator. The plant density was low in Säby after winter as a result of the lacking growth regulator treatment, but sufficient for the trial to continue. For photographs from end of May and June, see Figures 3 and 4.



Helleberga

Block	1		2
101	4	301	2
102	2	302	1
103	3	303	4
104	1	304	3
201	3	401	4
202	1	402	2
203	4	403	3
204	2	404	1

Säby

Block	1		2
101	1	301	2
102	2	302	4
103	3	303	3
104	4	304	1
201	4	401	2
202	1	402	3
203	2	403	1
204	3	404	4

Figure 2. Trial design for Helleberga (left) and Säby (right). Plot number (101-404) to the left and treatment number (1-4) to the right. 1 = insecticide treatment in autumn, 2 = insecticide treatment in spring, 3 = insecticide treatment in autumn and spring (combination), 4 = control (no insecticide treatment. Hushållningsssällskapet 2022, see Appendix 1 and 2.

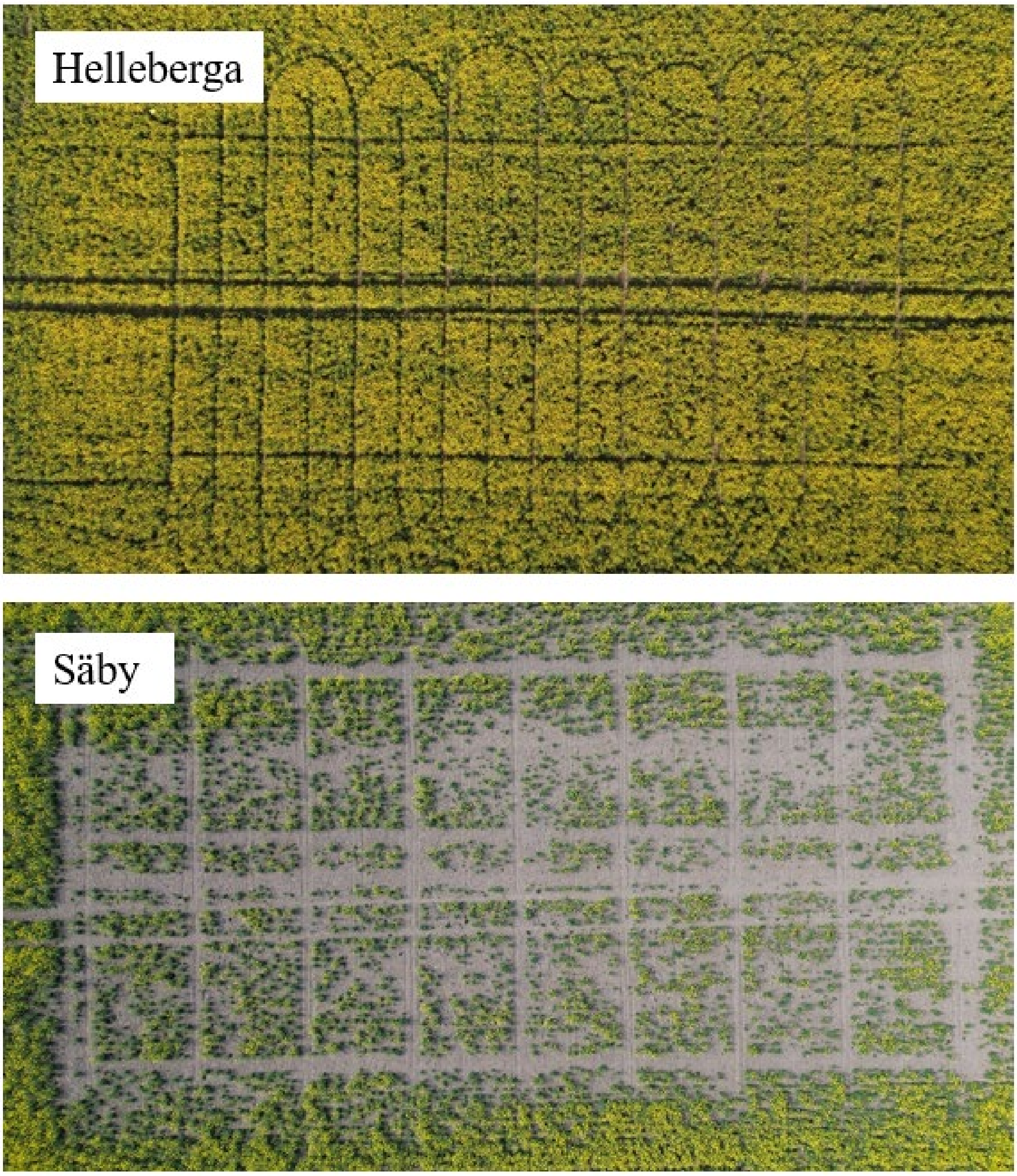


Figure 3. Drone photographs of the field trials from 22th and 25th of May. Photos: Plant Protection Centres of the Swedish Board of Agriculture.

Figure 4. The field trials photographed 28th of June (Helleberga) and 17th of May (Säby). Photos: Rebecka Alaton

2.2 Data collection

2.2.1 Weevil catches in yellow water traps in the field trials and in Sweden

Weevil incidence in the field trials was determined with two (autumn) or one (spring) yellow water trap placed in the corner of each experiment. Total catches of *C. sulcicollis* and *C. pallidactylus* was counted over several weeks in autumn and spring respectively. Weevils were collected in the autumn between 22nd of August and 18th of November and in spring between 17th of April and 12th of June. Weevil incidence was monitored in the same way by the Plant Protection Centres between 2017 – 2023 in other locations in Östergötland, Västra Götaland and in Mälardalen. In total, *C. sulcicollis* was monitored in 292 fields and *C. pallidactylus* in 191 fields. This data was used to compare the sum of catches of the two weevil species in the field trials with other locations in Sweden to be able to assess the trials´ relative level of weevil frequency.

2.2.2 Damage grading of oilseed rape plants

At two occasions, 17th of May and 28th of June, 20 randomly selected oilseed rape plants from each plot was dug up and collected. Grading was then performed directly in the laboratory or, as for the second grading occasion, in the field. The first grading should only measure damage caused by *C. sulcicollis* since larvae of *C. pallidactylus* are not expected to be present in the stems this early in the season (Gustafsson 1991). In the second grading, damage from both weevils are expected.

2.2.3 Measuring of plant and damage length

Plant stems were cut to measure damage length inside the plant caused by the stem mining larvae, see Figure 5. To be able to set damage length in relation to the length of the plant, the length of the main shoot was also measured. Measuring of plant and damage length was performed at both of the two grading occasions.

Figure 5. Stems were cut to measure damage by stem mining weevils. Photo: Ola Lundin.

2.2.4 Damage index

Each plant in both grading occasions was given a damage index between 1 and 4, according to Gustafsson (1991; table 2), where 1 is no damage, 2 is low damage, 3 is moderate damage (Figure 6) and 4 is high damage.

Table 2. Damage index for stem mining weevils (Gustafsson 1991).

Damage index	Description
1	No damage
2	Low damage - single mines, most of the pith undamaged, (only one or a few larvae)
3	Moderate damage – severe discoloration of the pith, however, not all the way to the vascular tissue, (usually several larvae)
4	High damage – the entire pith destroyed in at least 2-3 cm length. Damage also to the vascular tissue, (high prevalence of larvae)

Figure 6. Damage index 3. Photo: Plant Protection Centres of the Swedish Board of Agriculture.

2.2.5 Common pollen beetle and brassica pod midge

In the second grading, damage by common pollen beetle (*Brassicogethes aeneus*) and brassica pod midge (*Dasineura brassicae*) was graded in order to evaluate if the spring treatment could have affected these pests. Common pollen beetle was graded as the number of undeveloped pods, observed as podless stalks (Figure 7A) (Nilsson 1995). Common symptoms of brassica pod midge are dried and prematurely ripen pods (Figure 7B) (Williams 2010). The number of affected pods by both pests were counted on a high, intermediate and low positioned shoot on 10 random plants in each plot.

Figure 7. Damage of common pollen beetle (Brassicogethes aeneus) seen as podless peduncles (A). Damage of brassica pod midge (Dasineura brassicae) seen as premature, yellow and splitted pods (B). Photos: Ola Lundin.

2.2.6 Emergence traps

The next generation of stem mining weevils, which hatch out of the ground, were counted with the help of emergence traps. The purpose of the traps was to relate stem damage to one of the weevil species since the larvae are difficult to identify. The traps were made of sawed-off ventilation pipes that were hammered into the ground with nets strung on top. Sticky traps were placed inside the pipe and replaced weekly from 26th of June to 24th of July. One emergence trap was placed in each plot. The number of *C. sulcicollis* and *C. pallidactylus* were counted on each sticky trap in the lab.

Figure 8. Emergence trap. Photo: Plant Protection Centres of the Swedish Board of Agriculture.

2.2.7 Yield samples

Plots in the field trial were harvested separately and data for yield, oil content, chlorophyll content, moisture content and thousand seed weight were collected. A profitability calculation was made for each plot based on the income from the harvest and the expenditure on insecticide treatment. Other economic factors were considered equal between treatments. The driving damage in field was assumed to be negligible. Information was obtained from Lantmännen (2023) on drying costs and price adjustments according to quality (oil content and chlorophyll content). The calculation also included driving costs and the cost for insecticides, these were found as guideline values (Jordbruksverket 2023a). The sale price for oilseed rape was chosen as a mean of the last five years (Jordbruksverket 2023a). See table 3 for price adjustments.

Table 3. Price adjustments. Cuurrency is expressed in Swedish crowns (kr).

Price adjustment	
Sale price (kr/kg)	5,25
Oil content adjustment	+1,5 % per percent >40%, -1,5 % per percent <40%
Nexide 0,06l/ha (kr/ha)	54,60
Mavrik 0,02l/ha (kr/ha)	90,00
Driving cost (kr/ha)	175
Chlorophyll content	-0,2% per ppm <20 ppm

2.3 Statistical analysis

Statistical analysis was performed using general linear mixed models (package lme4) in R Statistical Software (version 4.2.1; R Core Team 2023). The two experiments were analysed separately. Treatment was consistently the explanatory variable and the response variable was damage length as percentage of the length of the main shoot, mean value of damage index per plot, damage by common pollen beetle, damage by brassica pod midge, mean *C. pallidactylus* per trap week, mean *C. sulcicollis* per trap week, yield or partial net profit. Block and plot inside block were random factors for the analysis of damage length, common pollen beetle damage and brassica pod midge damage. Only block was a random factor for the analysis where mean or single values per plot values are used, this applies to damage index, emergence traps, yield and partial net profit analysis. After running ANOVAs, models were checked for homoscedasticity. From the obtained diagnostic plots I could verify that the models fit the assumptions of normality and equal variances in different groups. In the last step, Tukey´s Honestly Significant Difference (Tukey´s HSD) post-hoc test was performed for pairwise comparisons in cases where the overall treatment effect was statistically significant (p<0.05). This was done to find out exactly where statistically significant differences lie. Correlation tests were performed to evaluate the association between mean *C. pallidactylus* per trap week, mean *C. sulcicollis* per trap week, sum of weevils, damage length in May and June as percentage of the length of the main shoot, mean value of damage index in May and June per plot and yield. The correlations were analysed for statistical significance ($p<0.05$).

3. Result

3.1 Yellow water traps

The prevalence of *C. sulcicollis* and *C. pallidactylus* in the field trials, as sum of catches in yellow water traps, was high in comparison to sum of catches in Mälardalen, Östergötland and Västra Götaland (figure 9A and 9B). Catches of *C. sulcicollis* in Helleberga (435,5 weevils) and Säby (667 weevils) are included in the top 4 % with the highest sum of catches in Östergötland. Säby is also one of the locations with the highest catches of *C. pallidactylus* in Östergötland (1693 weevils), included in the top 3%, while Helleberga in placed in the highest third (108 weevils).

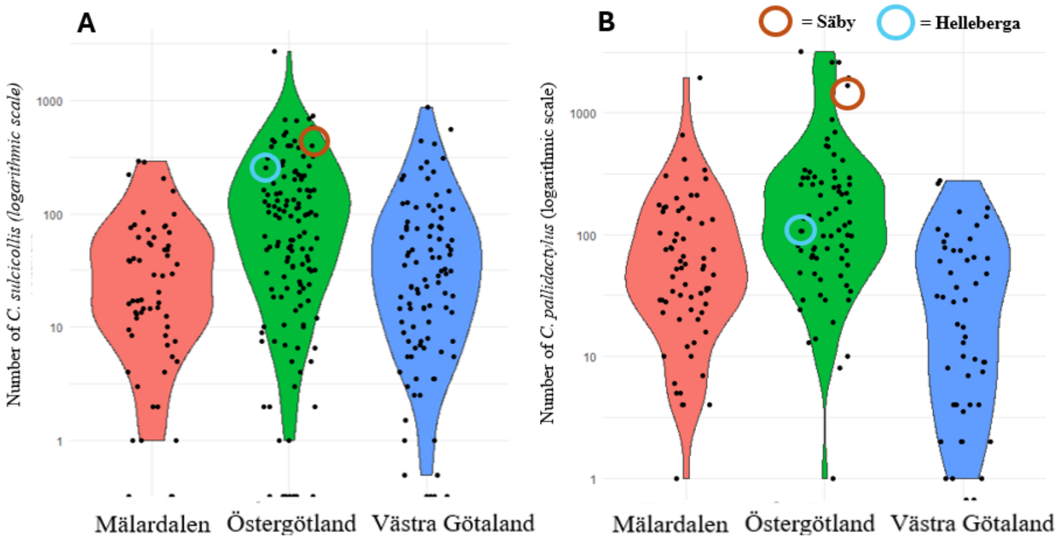


Figure 9. Violin plots of number of C. sulcicollis (A) and C. pallidactylus (B) caught in yellow water traps in Mälardalen, Östergötland and Västra Götaland between 2017 - 2023. Säby is circled in red and Helleberga is circled in blue. Y-axis is in logarithmic scale. The width of the violin shows the probability density of the data at different values.

3.2 Statistical analysis of the field experiment

Results from statistical analysis of the results from the experiment is compiled in table 4.

Table 4. Results from statistical analysis for response variables in Helleberga and Säby. Results show degrees of freedom (DF), chi-square (χ^2) and p-value. Degrees of freedom (DF) includes both locations. p-value < 0.05 display statistical difference indicated by bold numbers.

		Helleberga		Säby	
Response variable	DF	χ^2	p-value	χ^2	p-value
Damage length May	3	23.90	**2.6e-05**	1.00	0.80
Damage length June	3	1.31	0.73	0.15	0.99
Damage index May	3	26.48	**7.6e-06**	0.74	0.86
Damage index June	3	5.02	0.99	0.92	0.82
Damage common pollen beetle	3	2.82	0.42	4.10	0.25
Damage brassica pod midge	3	0.24	0.97	5.63	0.13
Number of *C. sulcicollis*	3	5.34	0.15	4.67	0.20
Number of *C. pallidactylus*	3	11.66	**0.0087**	5.41	0.14
Yield	3	24.31	**2.2e-05**	6.73	0.081
Partial net	3	8.75	**0.033**	5.52	0.14

3.3 Stem damage in May

Insecticide treatment in autumn decreased damage length, as percentage of the shoot length, compared to control in Helleberga when plants were graded in May (Figure 10A; Table 4). The percent of damage length was higher in Säby, compared to Helleberga, but no difference between treatments was observed in Säby (Figure 10B; Table 4).

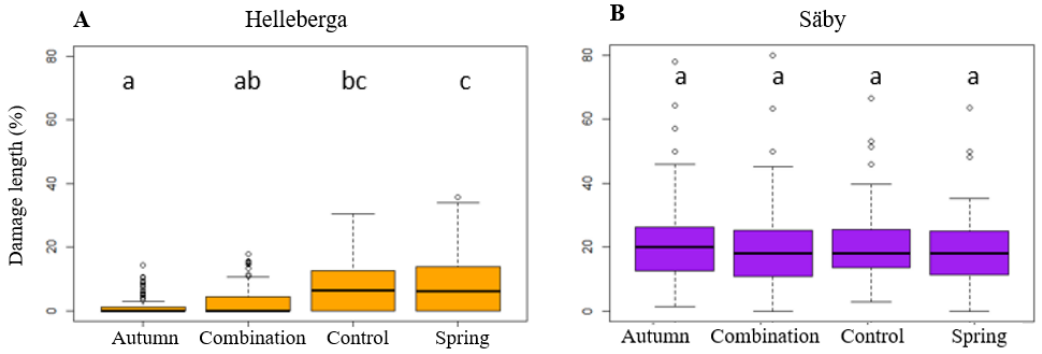


Figure 10. Box plots of damage length, as percentage of the shoot length in May depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is bold line in between. Bars represent 10th and 90th percentiles. Outliers are shown as dots. Different letters indicate significant differences between treatments.

The mean of damage index was lower for both autumn and combination treatment compared to control and spring treatment, in Helleberga (Figure 11A; Table 4). Observed values were higher in Säby and there were no differences between treatments (Figure 11B; Table 4).

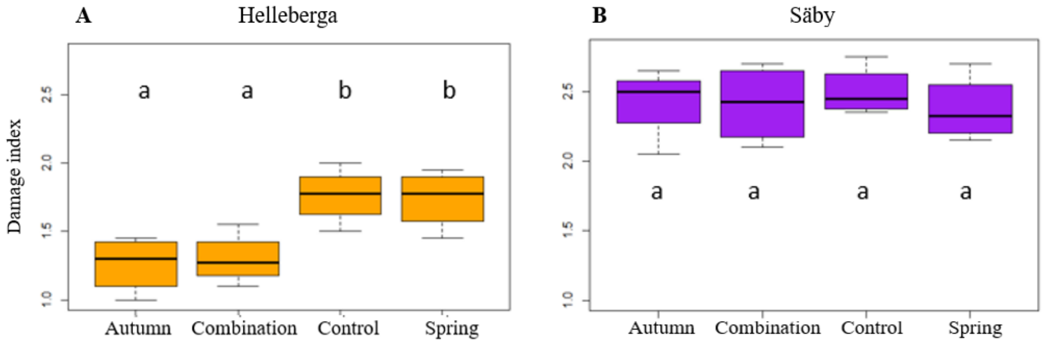


Figure 11. Box plots of mean damage index in May depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Different letters indicate significant difference between treatments.

3.4 Stem damage in June

By the time the second grading occurred, both the damage length and the level of the damage had increased. No difference between treatments was observed regarding damage length (Figure 12A; Figure 12B; Table 4) and damage index (Figure 13A; Figure 13B; Table 4). Like the results in May, the extent of damage was higher in Säby compared to Helleberga.

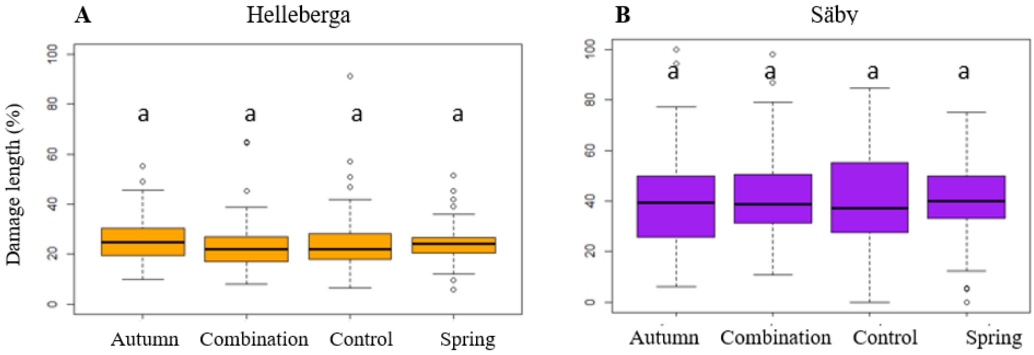


Figure 12. Box plots of damage length, as percentage of shoot´s length in June depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Outliers are shown as dots. Different letters indicate significant differences between treatments.

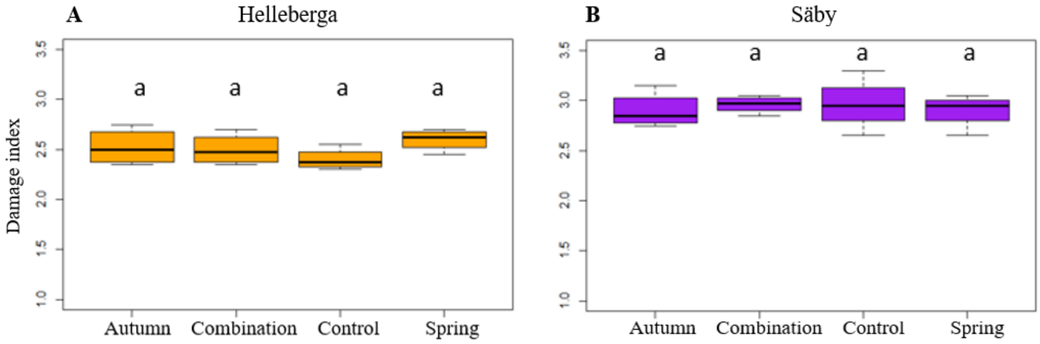


Figure 13. Box plots of mean damage index in June depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Different letters indicate significant differences between treatments.

3.5 Common pollen beetle and brassica pod midge

Damage caused by common pollen beetle and brassica pod midge did not differ with treatment (Figure 14A; Figure 14B; Figure 15A; Figure 15B; Table 4).

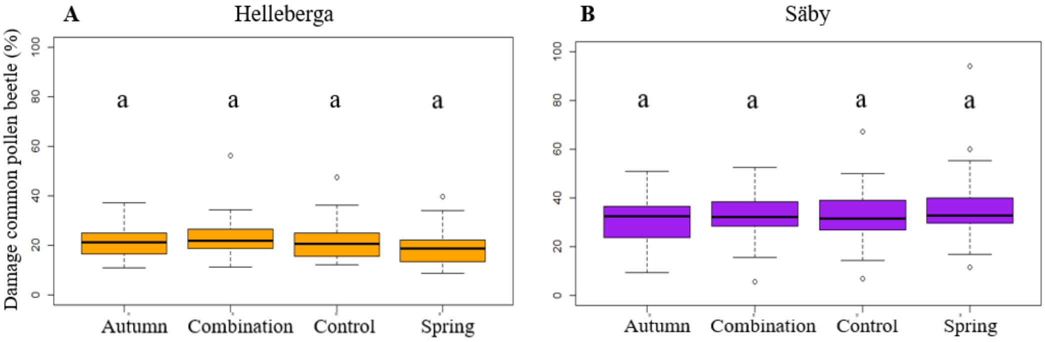


Figure 14. Box plots of damage caused by common pollen beetle depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Outliers are shown as dots. Different letters indicate significant differences between treatments.

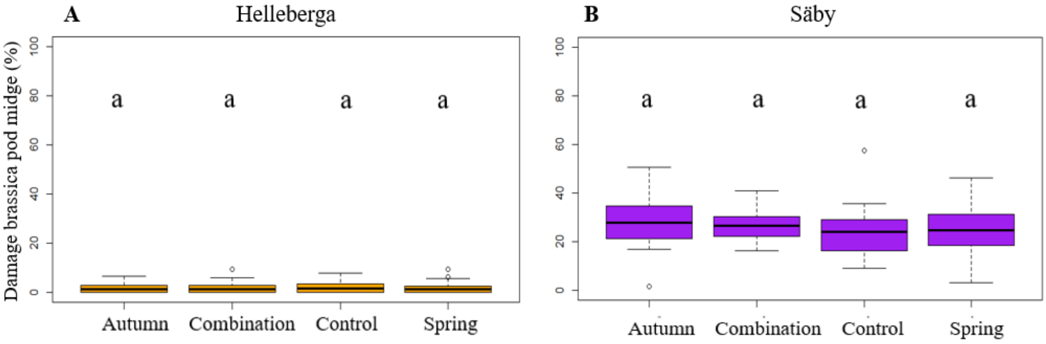


Figure 15. Box plots of damage caused by brassica pod midge depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Outliers are shown as dots. Different letters indicate significant differences between treatments.

3.6 Emergence traps

Emergence traps caught both *C. sulcicollis* and *C. pallidactylus* (Figure 16A; Figure 16B; Figure 17A; Figure 17B). No difference was found between treatments for *C. sulcicollis*. In Helleberga, the number of *C. pallidactylus* showed significant differences between treatments but in post-hoc tests no pairwise test were statistically significant (Table 4; Figure 17A). The average number of *C. pallidactylus* in each treatment was in the order autumn (3.6), combination (4.6), control (6.8) and spring (7.5).

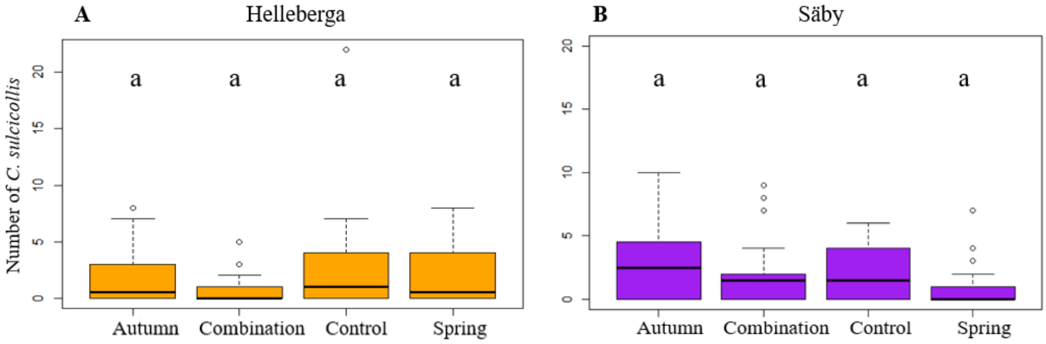


Figure 16. Box plots of number of C. sulcicollis caught in emergence traps depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Outliers are shown as dots. Different letters indicate significant differences between treatments.

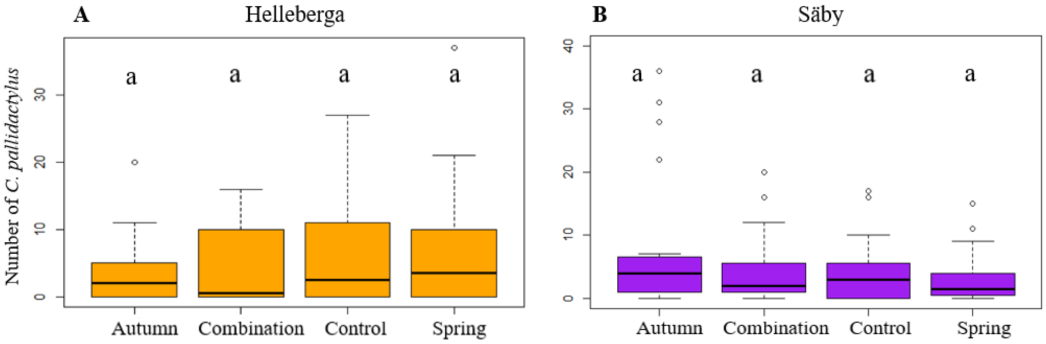


Figure 17. Box plots of number of C. pallidactylus caught in emergence traps depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Outliers are shown as dots. Different letters indicate significant differences between treatments.

3.7 Yield

All three insecticide treatments increased yield compared to control in Helleberga (Figure 18A; Table 4). The yield increase did not significantly differ between the treatments with insecticide use but varied between 170 – 180 kg ha^{-1}. The yield was generally low in Säby and no difference was found between the treatments (Figure 18B; Table 4).

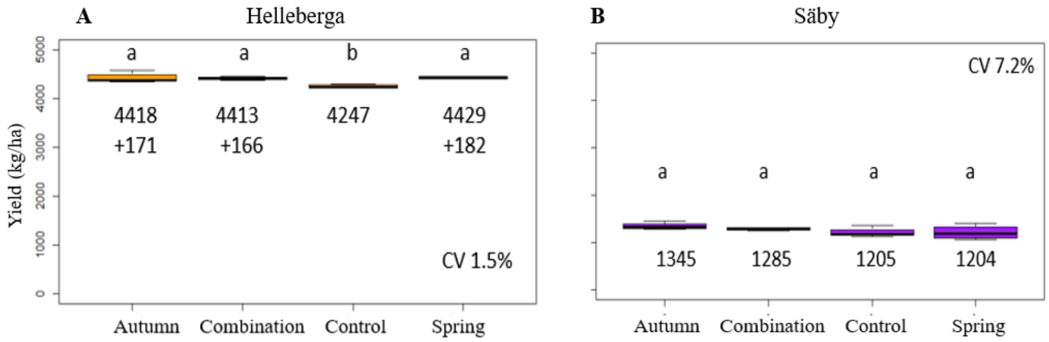


Figure 18. Box plots of yield (kg ha^{-1}) depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Different letters indicate significant differences between treatments.

3.8 Economic calculations

No significant difference in profitability between the treatments were found in any of the trials (Figure 19A; Figure 19B; Table 4). Similar to a previous case, significant difference between treatments was obtained in Helleberga, but in post-hoc tests no pairwise test was statistically significant (Table 4; Figure 19A). Looking at the mean values for the treatments in Helleberga, control had the lowest partial net (22341 kr ha^{-1}) and autumn treatment has the highest partial net (23009 kr ha^{-1}). In Säby, spring treatment had the lowest partial net (5504 ha^{-1}) and autumn treatment has the highest partial net (6308 kr ha^{-1}).

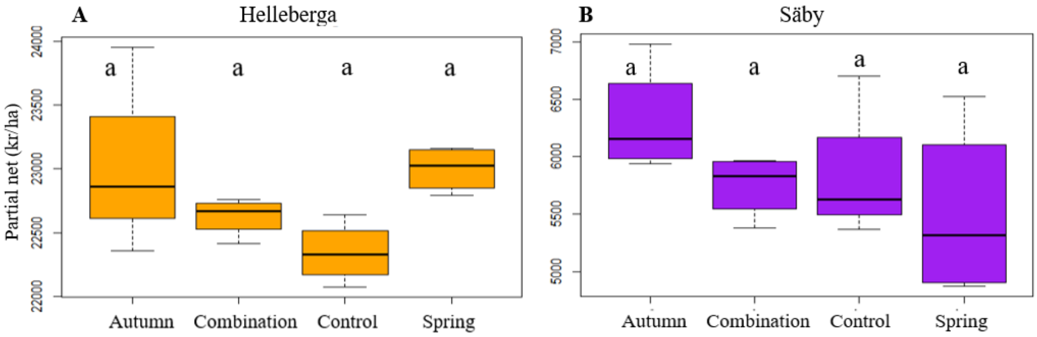


Figure 19. Box plots of partial net (kr ha-1) depending on treatment in (A) Helleberga and (B) Säby. Lower and upper fences are 25th and 75th percentiles, and the median is the bold line in between. Bars represent 10th and 90th percentiles. Different letters indicate significant differences between treatments.

3.9 Association between frequency of stem mining weevils, damage and yield

No significant correlation was found between the frequency of stem mining weevils and the yield (Table 5; Table 6). A positive correlation between the sum of weevils and both *C. pallidactylus* and *C. sulcicollis* was obtained in Helleberga and in Säby (Figure 20A; Figure 20B). In Helleberga, a positive correlation between the number of *C. pallidactylus* and *C. sulcicollis* was found. Furthermore, a positive correlation between damage length in May and damage index in May was observed in Helleberga. This could also be seen in Säby for these two parameters both in May and June. However, a negative correlation can be observed between damage index in May and damage length in June in Säby. Also in Säby, there is a significant positive correlation between the numbers of *C. sulcicollis* caught in emergence traps and the damage in May, both damage length and index (Table 6). There was a positive correlation between damage index in June and yield in Säby.

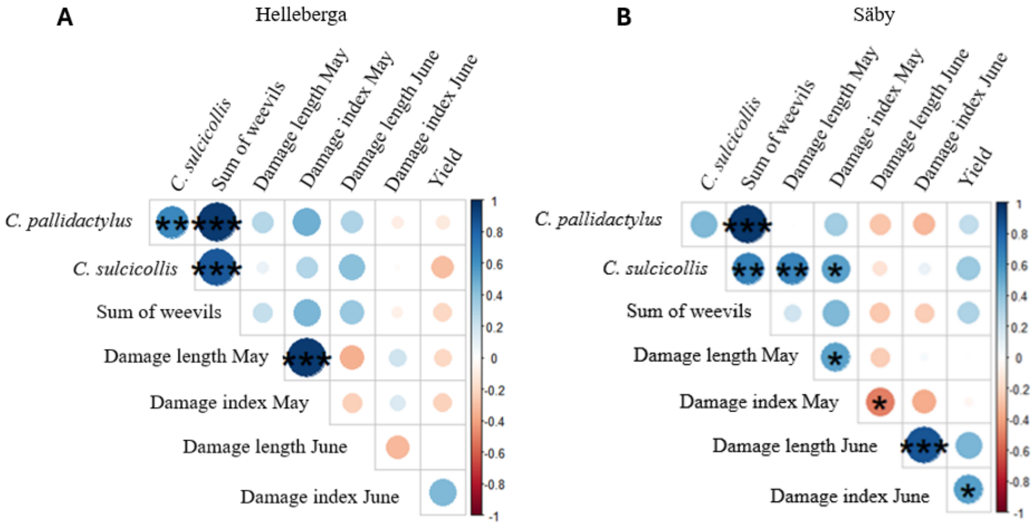


*Figure 20. Correlogram of parameters from the trial in Helleberga (A) and Säby (B). A positive correlation is displayed in blue and a negative correlation is displayed in red. Colour intensity and size of the circle explains the degree of the correlation. Stars shows significance level, *** = p-value <0.001, ** = p-value <0.01, * = p-value <0.05.*

Table 5. Correlation coefficients (CC) and p-values for the parameters in Helleberga. p-value < 0.05 implies statistical difference and is indicated by bold numbers.

	C. pallidactylus		*C. sulcicollis*		Sum of weevils		Damage length May		Damage index May		Damage length June		Damage index June		Yield	
	CC	p-value	CC	p-vale	CC	p-value	CC	p-value	CC	p-value	CC	p-value	CC	p-value	CC	p-value
C. pallidactylus	1															
C. sulcicollis	0.65	**0.0067**	1													
Sum of weevils	0.95	**<0.0001**	0.85	**<0.0001**	1											
Damage length May	0.29	0.2845	0.09	0.7417	0.23	0.3838	1									
Damage index May	0.48	0.0569	0.29	0.2745	0.45	0.0783	0.96	**<0.0001**	1							
Damage length June	0.30	0.2526	0.42	0.1084	0.38	0.1498	-0.36	0.1768	-0.24	0.3764	1					
Damage index June	-0.09	0.7315	-0.02	0.9386	-0.07	0.7881	0.20	0.4521	0.16	0.5616	-0.33	0.2144	1			
Yield	-0.12	0.6580	-0.31	0.2467	-0.21	0.4440	-0.20	0.4495	-0.22	0.4120	-0.01	0.9849	0.45	0.0838	1	

Table 6. Correlation coefficients (CC) and p-values for the parameters in Säby. p-value < 0.05 implies statistical difference and is indicated by bold numbers.

	C. pallidactylus		*C. sulcicollis*		Sum of weevils		Damage length May		Damage index May		Damage length June		Damage index June		Yield	
	CC	p-value	CC	p-vale	CC	p-value	CC	p-value	CC	p-value	CC	p-value	CC	p-value	CC	p-value
C. pallidactylus	1															
C. sulcicollis	0.45	0.0811	1													
Sum of weevils	0.96	**<0.0001**	0.67	**0.0043**	1											
Damage length May	0	0.9863	0.65	**0.0062**	0.20	0.4588	1									
Damage index May	0.35	0.1885	0.53	**0.0347**	0.45	0.0831	0.54	**0.0313**	1							
Damage length June	-0.27	0.3067	-0.15	0.5887	-0.27	0.3120	-0.24	0.3654	-0.51	**0.0452**	1					
Damage index June	-0.32	0.2223	0.08	0.7557	-0.24	0.3659	0.03	0.9041	-0.36	0.1675	0.85	**<0.0001**	1			
Yield	0.24	0.3645	0.36	0.1700	0.31	0.2433	0.01	0.9777	-0.05	0.8583	0.45	0.0800	0.54	**0.0297**	1	

4. Discussion

The aim of the field experiment was to vary crop injury by stem mining weevils to understand their impact on the crop yield. To achieve the variation in crop injury temporally varying insecticide treatments and control without any insecticide treatment were performed. Damage variation was successfully achieved in Hellberga, which confirms that the trial idea was functional. In Säby, no response to insecticide treatment was observed, meaning that we did not obtain any variation in damage and few conclusions could be made. A suggestion for the outcome in Säby is the low number of plants in the trial in spring, due to low winter survival of the crop. The damage by *C. sulcicollis* and *C. pallidactylus* was overall higher in Säby compared to Helleberga. It may be due to higher number of weevils, especially of *C. pallidactylus,* in Säby but it could also be due to weevils´ tendency to be more common in sparse stands (Ferguson et al. 2003).

4.1 Damage length and index

The results from Helleberga in May demonstrate shorter damage length in the stems when insecticide was applied in autumn compared to spring treatment and control. Mean damage length in control respectively autumn treatment was 7.8 cm respective 1.7 cm, a reduction of almost 80 %. The damage in May is assumed to be caused by *C. sulcicollis* but no studies investigating damage length by this species has been found to compare the results with. Spring treatment did not show any effect relative to control. Spring application was performed only one day before grading, and hence no effect was expected to be seen in May.

Damage observed in June can be caused by both *C. sulcicollis* and *C. pallidactylus*. The damage length had increased in all four treatments in Helleberga since May. However, the earlier observed difference between treatments had now disappeared. Similar development occurred regarding the damage index, where autumn and combination treatments increased the most. In recent Danish field trials (SEGES Innovation P/S 2023) the damage length was halved when one insecticide treatment was applied and was shortened to a quarter when two insecticide treatments were performed, compared to control without insecticide. The grading was made at the end of May and the damage was caused by *C. pallidactylus*. There is no given answer to why the damage in Helleberga caused by *C. sulcicollis* was reduced by insecticides, but not the damage that was observed in June. A possible explanation to the largest damage increase in the plants treated in the autumn between May and June is less competition between weevils. The damage impact of *C. pallidactylus* became larger in the plants where damage by *C. sulcicollis* previously was the lowest. Another suggestion is that there is a maximum damage length or grade of damage and that the less damaged plants caught up in the level of damage in June. In Säby, the damage increased between May and June as well but, no difference between treatments could be seen.

The damage caused by common pollen beetle and brassica pod midge did not vary between treatments. It has been reported that damage caused by stem weevil larvae could be positively correlated with damage of pollen beetle but not that of pod midge (Zaller et al. 2008), however no similar discoveries was made in this experiment since no damage variation was observed in June. A combined pest control of *C. pallidactylus* and pollen beetle has been investigated to reduce the insecticide input, and can be possible if the threshold values are exceeded at the same time (Juran et al. 2020; Seidenglanz et al. 2020).

4.2 Yield and profitability

Both weevil species should continue to be monitored in regions with high frequency since yield was increased by 170 to 180 kg ha^{-1} in all treatments with insecticide application compared to control in Helleberga. This is a yield increase of approximately 4 %, which is in line with earlier trials in Sweden when treatment was performed in spring and autumn, as well as spring treatment in Czech Republic (Gustafsson 1991; Spitzer et al. 2014). Other studies shows a higher yield increase when spring treatment is performed, to be specific 300 – 400 kg ha^{-1} and 500 – 700 kg ha^{-1} (19 %) (Grantiņa et al. 2011; SEGES Innovation P/S 2023).

Since *C. sulcicollis* hibernates in the field, it is practical to apply insecticide treatment in autumn after the peak of flight activity. The spring treatment against *C. pallidactylus* in the field trial in Helleberga resulted in yield increase but not less observed damage compared to control. Low efficiency of insecticides has been reported when application is performed when the main flight activity is detected in yellow water traps (Spitzer et al. 2014). Insecticide was instead the most effective at later application (16 days after first flight activity), at the time when females were also present in the traps. Female weevils can emerge later than male weevils, why monitoring of females in yellow water traps can lead to a more precise date for optimum insecticide treatment (Spitzer et al. 2014). The timing of insecticidal sprays can also be complicated when the period of flight activity is prolonged, which is expected to occur more frequently for *C. pallidactylus* because of climate change (Junk et al. 2012). The spring application of insecticide in Helleberga was perhaps sufficiently timed to increase yield but not to decrease the observed stem damage.

In Helleberga, the profitability was numerically highest when insecticide was applied in autumn, but no significant difference could be detected between the treatments. The cost for one insecticide application is 230 – 265 kr ha^{-1} which corresponds to a yield increase of 40 – 50 kg ha^{-1}. Since the significant yield increase in Helleberga when insecticides are applied is much larger, a significant increase in profitability was expected. Despite this, when statistical analysis of profitability was performed the differences between treatments becomes too small to be significant. The field trial in Säby yielded low, only 42 % of the mean yield in Östergötland 2023 (Jordbruksverket n.d.), and the results from the economic calculations did not explain any significant variations. When comparing medians of the treatments, autumn treatment had the highest profitability, like in Helleberga.

The yellow water traps from multiple sites shows that the number of weevils caught during a few weeks per trap can vary from zero to several thousand between fields and years. In Estonia, *C. sulcicollis* is not considered to be of economic importance today, although, new investigations speculate that sufficient monitoring might reveal a widespread occurrence (Sulg et al. 2022). In my compilation there are tendencies of higher prevalence of *C. sulcicollis* in Östergötland and in Västra Götaland compared to Mälardalen. The species has earlier been reported to be more common in the eastern part of central Sweden, and less common in the south (Gustafsson 1991). The levels of *C. pallidactylus* seems to vary less between regions, and if anything, has a somewhat lower abundance in Västra Götaland compared to the other monitored regions. The field trials on the other hand, varied more between each other regarding catches of *C. pallidactylus* compared to *C. sulcicollis*. This further confirms that local variations can occur.

Even if profitability of insecticide treatment is achieved in a field trial, this does not mean that insecticide application is generally profitable in agriculture. The sites of the field trials in this experiment were chosen with the expectation that pest levels would be high. Especially the pest level of *C. sulcicollis* was very high and a reasonable question is: what would the outcome be if the pest level was moderate? Further research to evaluate insecticide treatment at different pest levels are needed in order to be able to set profitability threshold values. Another factor to be aware of is the good cultivation conditions in the field trials that resulted in high yield. Helleberga yielded 147 % compared to mean yield in Östergötland the same year (Jordbruksverket n.d.). In commercial agriculture there may be several yieldlimiting factors that could limit a similar yield increase as achieved in Helleberga. Why there was no response to insecticide treatments in Säby is not fully understood, but the very low yield may be part of the explanation. Lastly, profitability calculations do not consider resistance development or eventual detrimental effects on natural enemies.

4.3 Emergence traps

The number of weevil individuals in the emergence traps showed no clear relationship to the different treatments. There were no considerable differences between Helleberga and Säby although the plants in Säby had more damage. Emergence traps can be a useful tool for species determination of adult weevils. When weevils were observed as larvae inside the plant, the damage could not be derived to a specific species. Nevertheless, one can consider if this method is suitable to distinguish effects of insecticide treatments or not, since no difference between treatments was obtained from the field trials. Emergence traps have been used in the UK to relate the new generation of *C. pallidactylus* to stem injury, however no relationship was found (Ferguson et al. 2003). The traps caught *C. pallidactylus* from end of June to end of July and mean number of individuals per trap was 119.5 when trap size was 798 mm in diameter. The size of the traps in the field trials were 350 mm and the highest sum of *C. pallidactylus* for a single trap was obtained in Säby, 75 weevils, but overall the numbers were much lower in the field trials in comparison to the numbers of Ferguson et al. (2003).

4.4 Association between frequency of stem mining weevils, damage and yield

The yield was not associated with the number of weevils in the emergence traps in either of the field trials. Since no significant difference in the number of weevils was obtained between treatments, perhaps this is not so surprising after all. On the other hand, the number of *C. sulcicollis* was positively correlated to the damage in May in Säby, even though no significant difference in damage between treatments was seen in Säby. The yield was only correlated with the damage index in June in Säby, and was unexpectedly positive correlated. A hypothetical explanation could be the preference for plants with larger stem diameters that have been reported for ovipositing *C. pallidactylus* (Dechert & Ulber 2004). Perhaps there is a tendency for high yielding plants with larger stem diameters to be more damaged by stem mining weevils.

In three of four cases, the damage length and the damage index were related to each other. Based on this, perhaps only one parameter is necessary. The damage index was used by Gustafsson (1991), but damage length is a more commonly used parameter and more easily relatable.

The correlogram for Helleberga showed a few unexpected correlations. The most interesting was the positive correlation between the two weevil species. The interaction can be assumed probable because of similar interaction between *C. pallidactylus* and *C. napi*. It has been reported that *C. pallidactylus* tends to lay eggs in plants already infested by eggs and larvae of *C. napi* rather than on uninfested plants (Dechert & Ulber 2004).

5. Conclusion

Larvae of stem mining weevils (*C. sulcicollis* and *C. pallidactylus*) cause damage in winter oilseed rape when feeding inside the stems but their impact on yield is not fully investigated. By applying insecticides, this study established that a significant yield increase can be achieved by pest control. In one of two trials, the results show a mean yield increase varying between 170 to 180 kg ha^{-1} when insecticides are applied in autumn, spring and a combination of the two compared to control. The autumn treatment decreased the damage inside the stem caused by *C. sulcicollis*, however no response to insecticide treatment was observed later in the season when *C. pallidactylus* is expected to cause damage as well. The field trials did not show any significant difference between the four treatments in profitability, even though the yield increase covers the financial costs that spraying entails. Further research is needed to 1) understand the reasons behind the yield increase without stem damage decrease when spring treatment is performed and 2) to evaluate insecticide treatment at different pest levels in order to be able to set profitability threshold values.

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Popular science summary

The larvae of blue stem weevil and cabbage stem weevil cause damage inside oilseed rape plants as they bore and feed on the stem. However, their impact on yield is yet fully understood and pest control recommendations for stem mining weevils are lacking in Sweden. Monitoring has revealed high numbers of stem mining weevils in certain oilseed rape fields and certain years. The purpose of this thesis was to understand the impact of the pests on yield by using insecticides. The result of the thesis was intended to be a foundation for future pest control recommendations.

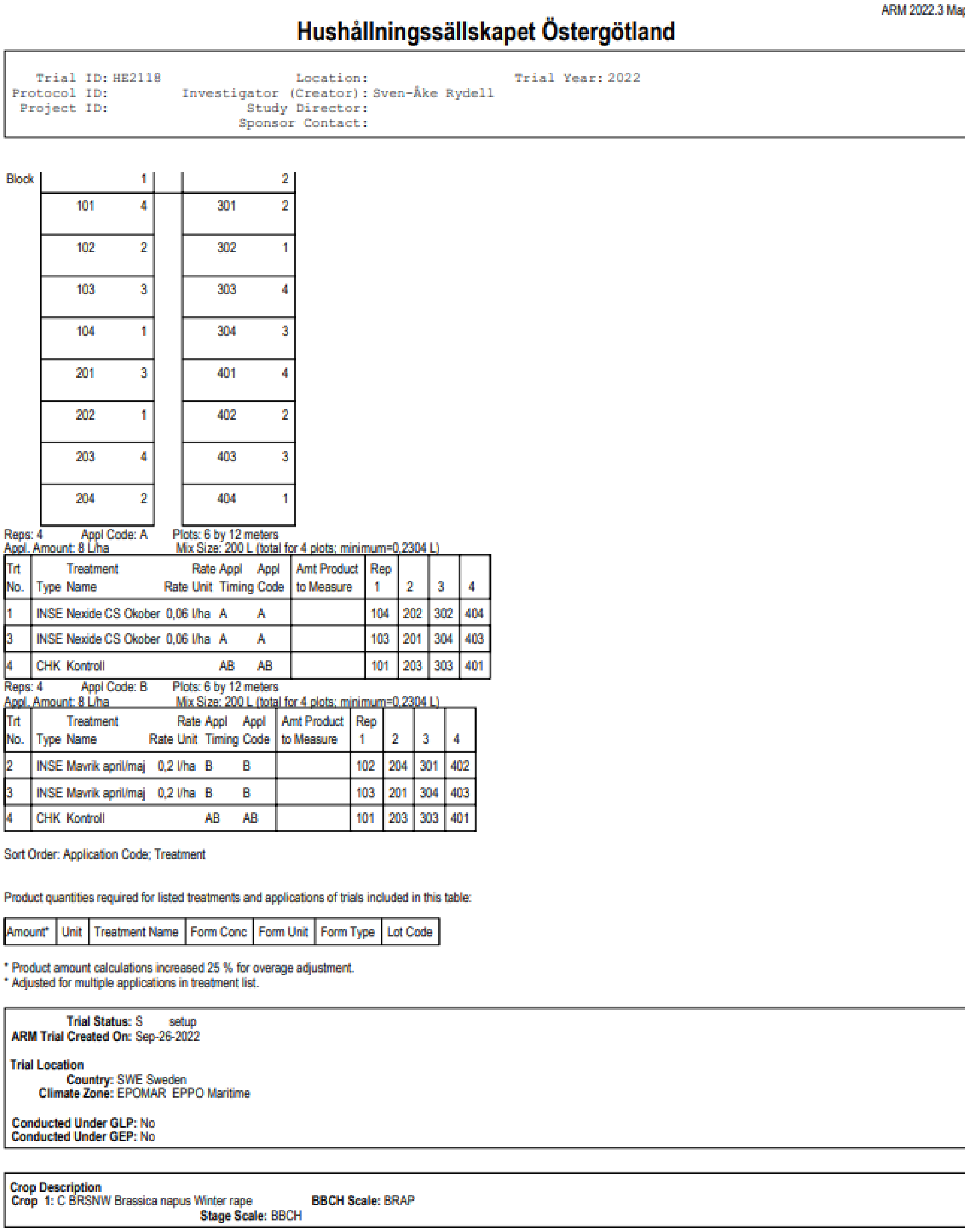
The pest control experiments were conducted in two separate fields in Östergötland. Spraying of insecticide was either performed in autumn, spring or both in autumn and spring. No insecticide was applied in the control treatment. The autumn treatment was intended to control blue stem weevil and the spring treatment to control cabbage stem weevil. Spraying in autumn against blue stem weevil decreased damage length inside the stem, however no response to insecticides was seen later in the season when both weevils is expected to cause damage. The results showed that insecticide application increased yield on average between 170 to 180 kg ha^{-1} compared to control, corresponding a yield increase of approximately 4 % in one of the two experiments. Economic calculations showed a tendency of higher profitability when spraying was performed in autumn compared to the other application times and the control, but the difference was not statistically significant. Monitoring of weevils using yellow water traps in the trials and in Östergötland, Mälardalen and Västra Götaland demonstrated high numbers of weevils in the experiment. When making conclusions regarding the observed yield increase, we must keep in mind the high pest pressure in the location. Further research is needed to evaluate spraying at different pest levels to be able to set pest control recommendations.

Acknowledgements

I would like to express my deepest appreciation to my supervisor Ola Lundin who has assisted with advice throughout the process. Thanks should also go to the Plant Protection Centres (Växtskyddscentralen) in Linköping for all help in the data collection and literature search. Lastly, I´d like to acknowledge Hushållningssällskapet in Östergötland for answering my questions regarding the trials.

Appendix 1

Location Helleberga.



ARM 2022.3 Ma

Hushållningssällskapet Östergötland

```
   Trial ID: HE2118              Location:                  Trial Year: 2022
Protocol ID:          Investigator (Creator): Sven-Åke Rydell
 Project ID:                  Study Director:
                             Sponsor Contact:
```

Block	1		2
101	4	301	2
102	2	302	1
103	3	303	4
104	1	304	3
201	3	401	4
202	1	402	2
203	4	403	3
204	2	404	1

Reps: 4 Appl Code: A Plots: 6 by 12 meters
Appl. Amount: 8 L/ha Mix Size: 200 L (total for 4 plots; minimum=0,2304 L)

Trt No.	Treatment Type	Name	Rate	Rate Unit	Appl Timing	Appl Code	Amt Product to Measure	Rep 1	2	3	4
1	INSE	Nexide CS Okober	0,06	l/ha	A	A		104	202	302	404
3	INSE	Nexide CS Okober	0,06	l/ha	A	A		103	201	304	403
4	CHK	Kontroll			AB	AB		101	203	303	401

Reps: 4 Appl Code: B Plots: 6 by 12 meters
Appl. Amount: 8 L/ha Mix Size: 200 L (total for 4 plots; minimum=0,2304 L)

Trt No.	Treatment Type	Name	Rate	Rate Unit	Appl Timing	Appl Code	Amt Product to Measure	Rep 1	2	3	4
2	INSE	Mavrik april/maj	0,2	l/ha	B	B		102	204	301	402
3	INSE	Mavrik april/maj	0,2	l/ha	B	B		103	201	304	403
4	CHK	Kontroll			AB	AB		101	203	303	401

Sort Order: Application Code; Treatment

Product quantities required for listed treatments and applications of trials included in this table:

Amount*	Unit	Treatment Name	Form Conc	Form Unit	Form Type	Lot Code

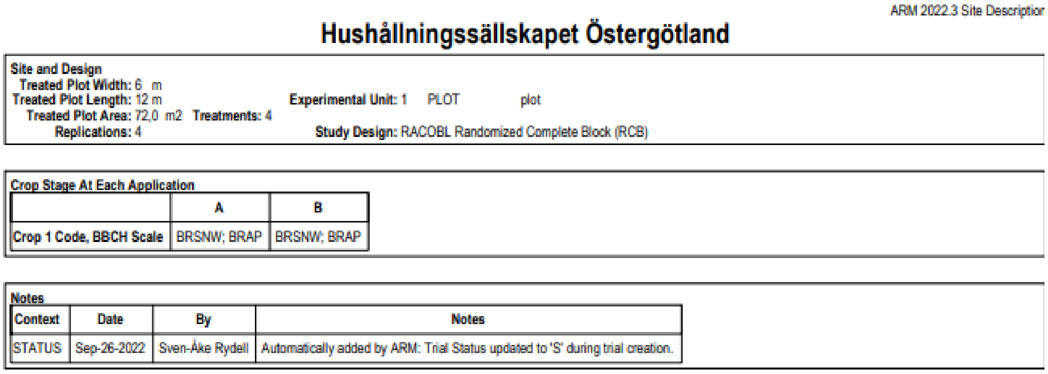
* Product amount calculations increased 25 % for overage adjustment.
* Adjusted for multiple applications in treatment list.

Trial Status: S setup
ARM Trial Created On: Sep-26-2022

Trial Location
Country: SWE Sweden
Climate Zone: EPOMAR EPPO Maritime

Conducted Under GLP: No
Conducted Under GEP: No

Crop Description
Crop 1: C BRSNW Brassica napus Winter rape **BBCH Scale:** BRAP
Stage Scale: BBCH



ARM 2022.3 Site Descriptior

Hushållningssällskapet Östergötland

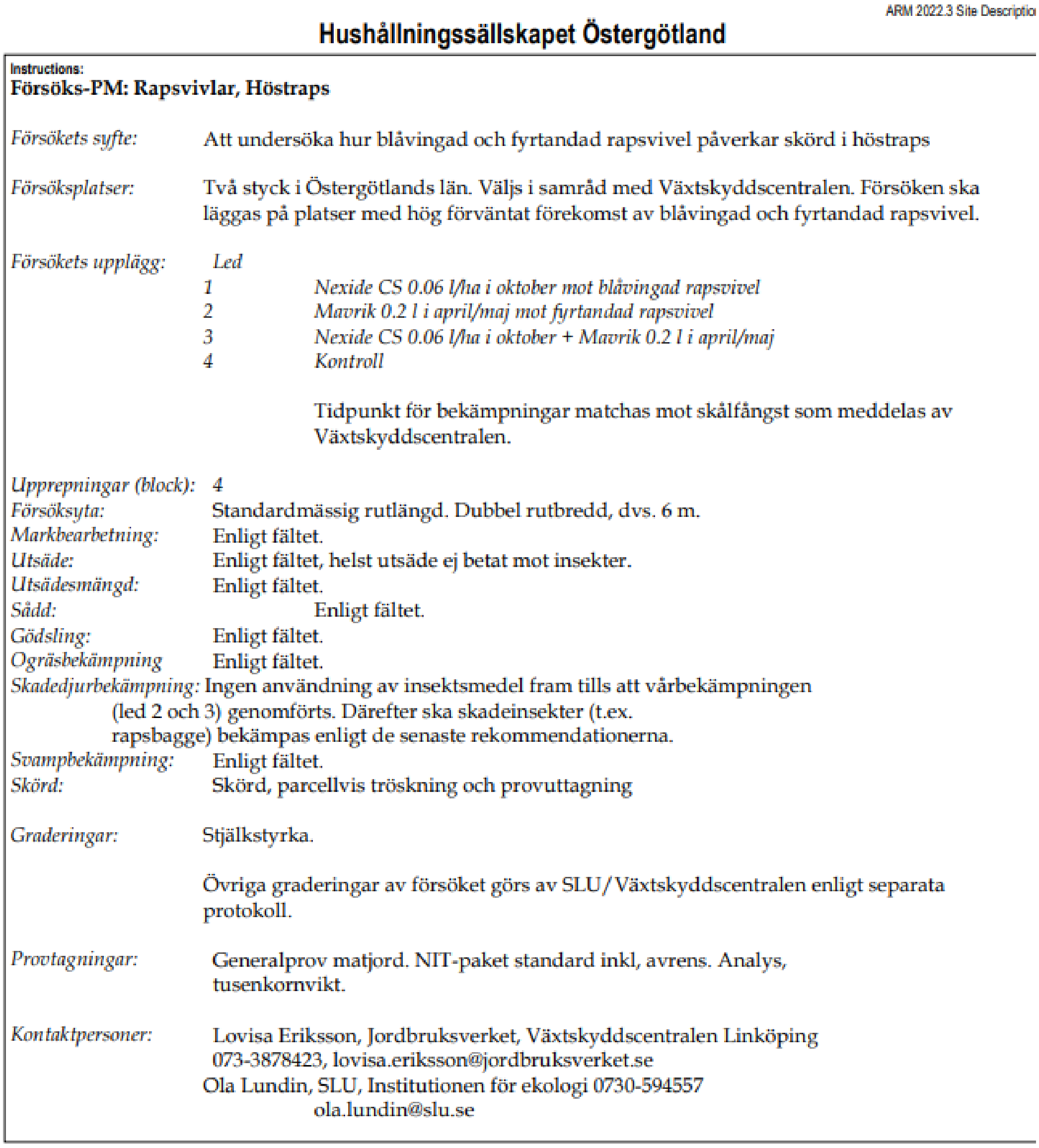
Site and Design
Treated Plot Width: 6 m
Treated Plot Length: 12 m **Experimental Unit:** 1 PLOT plot
Treated Plot Area: 72,0 m2 **Treatments:** 4
Replications: 4 **Study Design:** RACOBL Randomized Complete Block (RCB)

Crop Stage At Each Application

	A	B
Crop 1 Code, BBCH Scale	BRSNW; BRAP	BRSNW; BRAP

Notes

Context	Date	By	Notes
STATUS	Sep-26-2022	Sven-Åke Rydell	Automatically added by ARM: Trial Status updated to 'S' during trial creation.



ARM 2022.3 Site Descriptio

Hushållningssällskapet Östergötland

Instructions:

Försöks-PM: Rapsvivlar, Höstraps

Försökets syfte: Att undersöka hur blåvingad och fyrtandad rapsvivel påverkar skörd i höstraps

Försöksplatser: Två styck i Östergötlands län. Väljs i samråd med Växtskyddscentralen. Försöken ska läggas på platser med hög förväntat förekomst av blåvingad och fyrtandad rapsvivel.

Försökets upplägg: *Led*

Led	
1	*Nexide CS 0.06 l/ha i oktober mot blåvingad rapsvivel*
2	*Mavrik 0.2 l i april/maj mot fyrtandad rapsvivel*
3	*Nexide CS 0.06 l/ha i oktober + Mavrik 0.2 l i april/maj*
4	*Kontroll*

Tidpunkt för bekämpningar matchas mot skålfångst som meddelas av Växtskyddscentralen.

Upprepningar (block): 4
Försöksyta: Standardmässig rutlängd. Dubbel rutbredd, dvs. 6 m.
Markbearbetning: Enligt fältet.
Utsäde: Enligt fältet, helst utsäde ej betat mot insekter.
Utsädesmängd: Enligt fältet.
Sådd: Enligt fältet.
Gödsling: Enligt fältet.
Ogräsbekämpning Enligt fältet.
Skadedjurbekämpning: Ingen användning av insektsmedel fram tills att vårbekämpningen (led 2 och 3) genomförts. Därefter ska skadeinsekter (t.ex. rapsbagge) bekämpas enligt de senaste rekommendationerna.
Svampbekämpning: Enligt fältet.
Skörd: Skörd, parcellvis tröskning och provuttagning

Graderingar: Stjälkstyrka.

Övriga graderingar av försöket görs av SLU/Växtskyddscentralen enligt separata protokoll.

Provtagningar: Generalprov matjord. NIT-paket standard inkl, avrens. Analys, tusenkornvikt.

Kontaktpersoner: Lovisa Eriksson, Jordbruksverket, Växtskyddscentralen Linköping
073-3878423, lovisa.eriksson@jordbruksverket.se
Ola Lundin, SLU, Institutionen för ekologi 0730-594557
ola.lundin@slu.se

Product for experimental use only
Prt: **Appl:** A
Name: Nexide CS Okober
Form: **Rate:** 0,06 l/ha
Amt: **Trt:** 1

Product for experimental use only
Prt: **Appl:** B
Name: Mavrik april/maj
Form: **Rate:** 0,2 l/ha
Amt: **Trt:** 2

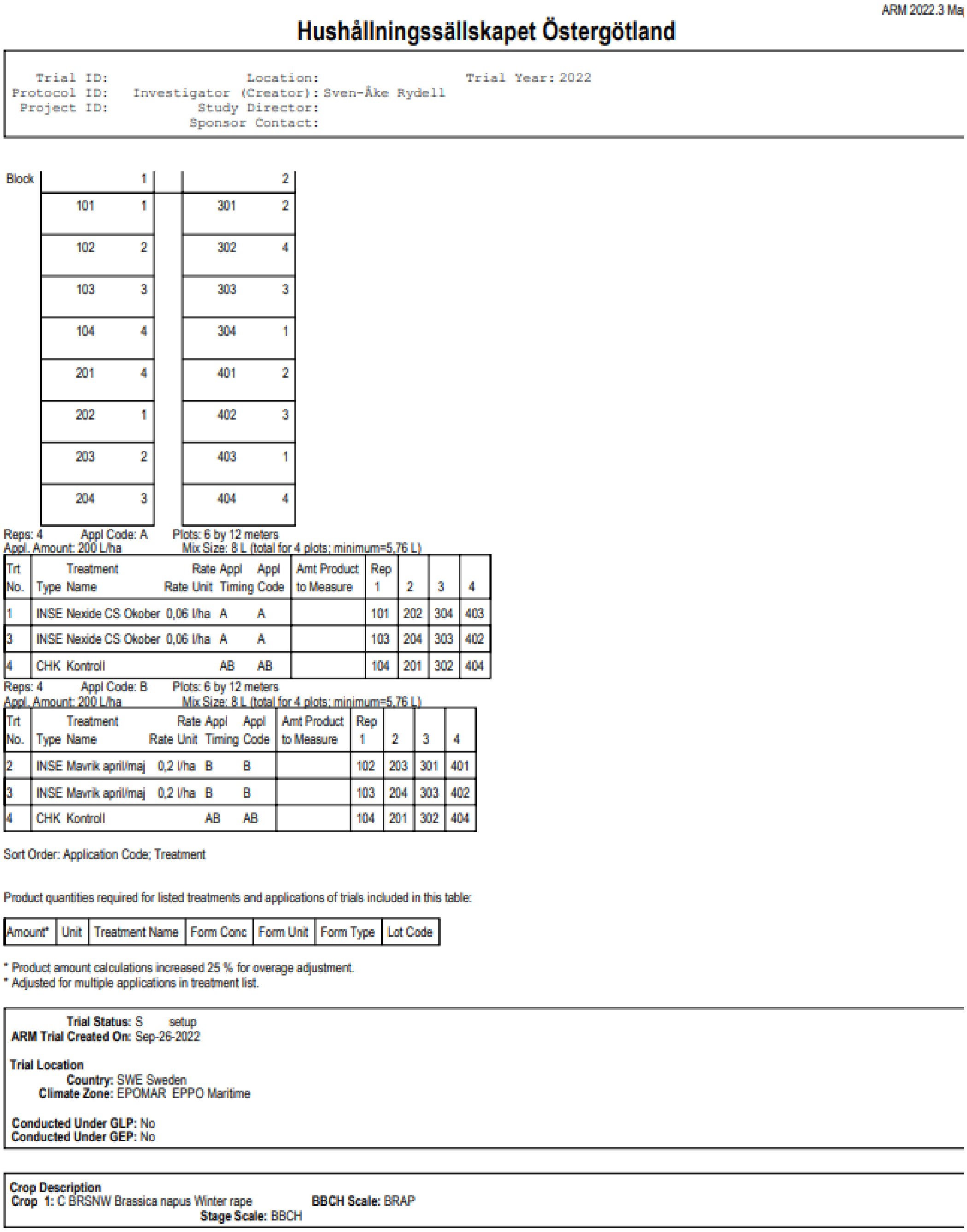
Product for experimental use only
Prt: **Appl:** A
Name: Nexide CS Okober
Form: **Rate:** 0,06 l/ha
Amt: **Trt:** 3

Product for experimental use only
Prt: **Appl:** B
Name: Mavrik april/maj
Form: **Rate:** 0,2 l/ha
Amt: **Trt:** 3

Product for experimental use only
Prt: **Appl:** AB
Name: Kontroll
Form: **Rate:**
Amt: **Trt:** 4

Appendix 2

Location Säby.



ARM 2022.3 Ma

Hushållningssällskapet Östergötland

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Protocol ID: Investigator (Creator): Sven-Åke Rydell
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Reps: 4 Appl Code: A Plots: 6 by 12 meters
Appl. Amount: 200 L/ha Mix Size: 8 L (total for 4 plots; minimum=5,76 L)

Trt No.	Treatment Type	Treatment Name	Rate	Rate Unit	Appl Timing	Appl Code	Amt Product to Measure	Rep 1	2	3	4
1	INSE	Nexide CS Okober	0,06	l/ha	A	A		101	202	304	403
3	INSE	Nexide CS Okober	0,06	l/ha	A	A		103	204	303	402
4	CHK	Kontroll			AB	AB		104	201	302	404

Reps: 4 Appl Code: B Plots: 6 by 12 meters
Appl. Amount: 200 L/ha Mix Size: 8 L (total for 4 plots; minimum=5,76 L)

Trt No.	Treatment Type	Treatment Name	Rate	Rate Unit	Appl Timing	Appl Code	Amt Product to Measure	Rep 1	2	3	4
2	INSE	Mavrik april/maj	0,2	l/ha	B	B		102	203	301	401
3	INSE	Mavrik april/maj	0,2	l/ha	B	B		103	204	303	402
4	CHK	Kontroll			AB	AB		104	201	302	404

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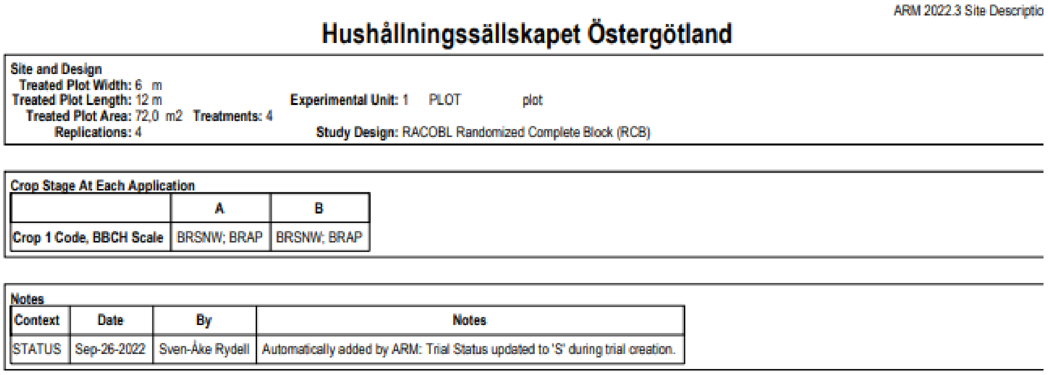
Stage Scale: BBCH



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Notes

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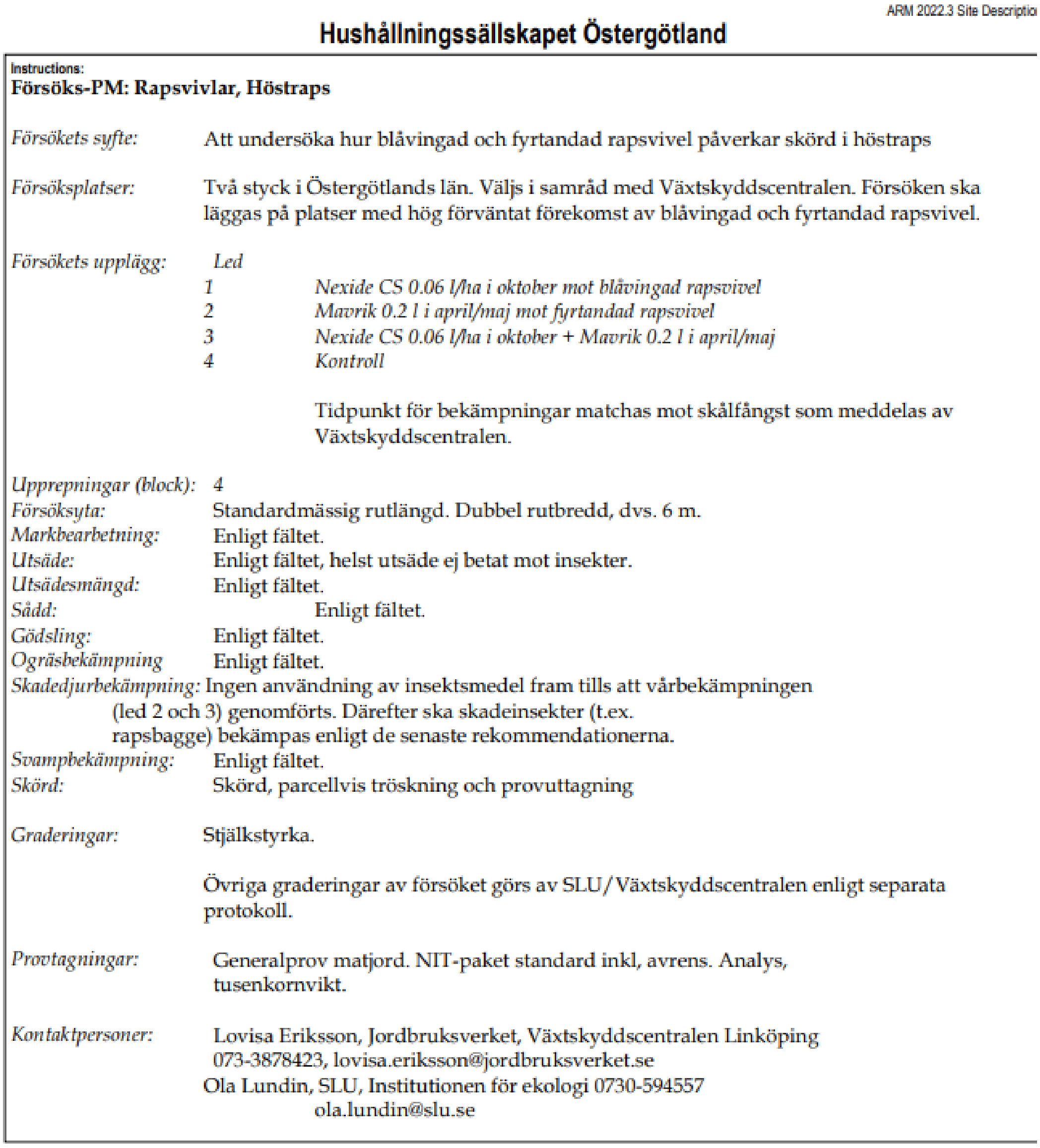

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4	*Kontroll*

Tidpunkt för bekämpningar matchas mot skålfångst som meddelas av Växtskyddscentralen.

Upprepningar (block): 4
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Markbearbetning: Enligt fältet.
Utsäde: Enligt fältet, helst utsäde ej betat mot insekter.
Utsädesmängd: Enligt fältet.
Sådd: Enligt fältet.
Gödsling: Enligt fältet.
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Skörd: Skörd, parcellvis tröskning och provuttagning

Graderingar: Stjälkstyrka.

Övriga graderingar av försöket görs av SLU/Växtskyddscentralen enligt separata protokoll.

Provtagningar: Generalprov matjord. NIT-paket standard inkl, avrens. Analys, tusenkornvikt.

Kontaktpersoner:

Lovisa Eriksson, Jordbruksverket, Växtskyddscentralen Linköping
073-3878423, lovisa.eriksson@jordbruksverket.se
Ola Lundin, SLU, Institutionen för ekologi 0730-594557
ola.lundin@slu.se

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Amt: **Trt:** 2

Product for experimental use only
Prt: **Appl:** A
Name: Nexide CS Okober
Form: **Rate:** 0,06 l/ha
Amt: **Trt:** 3

Product for experimental use only
Prt: **Appl:** B
Name: Mavrik april/maj
Form: **Rate:** 0,2 l/ha
Amt: **Trt:** 3

Product for experimental use only
Prt: **Appl:** AB
Name: Kontroll
Form: **Rate:**
Amt: **Trt:** 4

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