1. Project Title
Assessing the impact of swede midge on canola production in the Prairies and Ontario.

2. Principal Researcher: Dr. Rebecca H. Hallett

Department: Environmental Biology
University of Guelph
50 Stone Rd East, Guelph, ON N1G 2W1

Telephone: (519) 824-4120 ext. 54488
Fax: (519) 837-0442
E-mail: rhallett@uoguelph.ca

3. Commencement Date: April 2005
Duration of Project: 3 years

4. RESEARCH SUMMARY

In the third year of the project, areas in the Prairie provinces at risk for establishment of the swede midge were surveyed for the presence of swede midge. In addition, the effects of swede midge feeding and plant phenology on growth and yields of spring canola on a number of Western and Ontario canola varieties were determined in an area of Ontario where swede midge is already prevalent. These planting date and variety trials were conducted in all three years of the project. In the third year of the project, an additional field trial was conducted in Ontario to assess timing of insecticide sprays to protect vulnerable plant stages of spring canola. The potential for swede midge to cause economic damage to winter canola was also investigated.

This project provides a proactive approach to canola pest control. The risk of invasion of swede midge to prairie canola production has been quantified by providing a map of geographic areas which have ecoclimatic features conducive to swede midge population establishment and development. In addition, areas where initial invasion is most likely to occur have been monitored.

Ecoclimatic modeling indicates that most of Canada is suitable for establishment of swede midge, with high population growth possible in parts of British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island (Olfert et al., 2006). The range of swede midge in Ontario has now expanded to all of the areas determined by Olfert et al. (2006) to be “very favourable” for establishment, and its range may still expand significantly.

Most of Saskatchewan is “suitable” for establishment of the swede midge. Now that swede midge has been found in Saskatchewan, it is likely that establishment will occur and that the insect will become a regular pest of canola. However, the high populations that are found in Ontario are not likely to occur in the prairie provinces.

It is recommended that <u>where swede midge is a concern</u>: *Brassica juncea* and/or *Sinapis alba* varieties of canola should be selected over *B. napus* varieties; canola fields should be planted as early as possible and late plantings should be avoided; and, production of winter canola is recommended over production of spring canola, as long as environmental conditions favour winter canola production.

5. RESEARCH OBJECTIVES

The goal of this project was to provide canola producers in the Prairie provinces and Ontario with information about the potential distribution and impact of the swede midge on canola production in order to help producers in affected and at-risk areas to adopt appropriate canola production and management practices. This goal was addressed through the following three objectives:

1. Development of a climate model to determine the potential distribution of swede midge on the prairies;
2. Surveying of areas in the Prairie provinces determined to be at risk for presence of the midge;
3. Determination of the impact of swede midge on canola, for a) varieties of spring canola, b) spring canola sown at different planting dates, and c) winter canola; and,
4. Determine optimal timing of insecticide applications to control swede midge in spring canola.

This research project addressed two of the priority research areas of the CARP Program: optimizing canola production and newer insect threats.

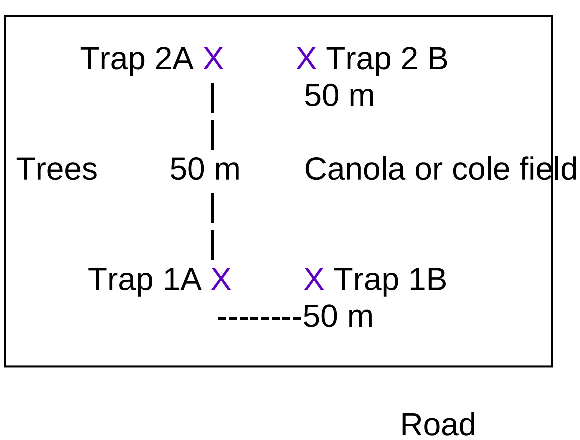
6. RESEARCH ACTIVITIES AND PROGRESS IN 2007

1. Swede midge surveys – This project component was overseen by Dr. J.J. Soroka, AAFC Saskatoon.

Surveys in Alberta, Saskatchewan and Manitoba were conducted at 8 sites in 2007: Lethbridge, AB, Beaverlodge, AB, Smeaton, SK, Saskatoon, SK, Outlook, SK, Lumsden SK (2 sites), and Winnipeg, MB. Traps were set out the week of June 1-6, and monitored until September 6.

Nine locations across the prairies were selected for sampling as listed in Table 1. Swede midge pheromones were placed in white cardboard "Jackson" or modified delta traps, which had a paper 8x12 cm liner coated with Tanglefoot®, a sticky coating in which insects become embedded. The delta traps, with pheromone attached, were secured to 5x5 cm wooden pegs and placed in the fields in the following general configuration:

Two areas of the field edge were selected, preferably adjacent to sheltered areas and at least 100 m apart. A trap was placed at each of the two sites near the field edge, and then a trap was placed into the field perpendicular to each trap and 50 m away from it.



This was the ideal configuration and assumed that traps could be placed in the field without having them being knocked down by agricultural operations. If the latter was a possibility, all four traps were placed at the field edge 50 m apart.

Trap sticky liners were changed weekly or biweekly. Pheromone lures were changed every 4 to 6 weeks. Sticky card liners were placed in plastic bags, frozen, and then shipped to the laboratory of Julie Soroka, where they were again frozen until analysis. Samples from Lumsden were rolled in a cylinder, the roll fastened by a rubber band, and sent to Soroka's laboratory.

In total, 264 traps were examined for presence of swede midge males. No swede midges were found at any location, although several other midge species were, albeit none having all the characters attributed to swede midge.

There were fewer Cecidomyiidae of any species found in the 2007 season than in the 2006 season. Other pest insects, however, were often very common in 2007. Smeaton traps had high numbers of root maggot (*Delia* spp.) flies and orange blossom wheat midge (*Sitodiplosis mosellana*) in June and July. Outlook, where traps were frequently disturbed during field operations, had 21 diamond back moths (*Plutella xylostella*) on one trap on one occasion, and 337 flea beetles (*Phyllotreta* spp.) on another. Leafhoppers were present in significant numbers at most locations on many dates. The Lethbridge location had few insects on the traps, likely because the field was aerially sprayed for cabbage seedpod weevil on June 29. A considerable number of parasitic Hymenoptera of several species was found in Beaverlodge traps. There was a good representation of mymarids throughout the season, and 207 encyrtids were found on one sticky card on August 7. If swede midge ever does establish in the area, some of these Hymenoptera may be potential biological control agents of the pest.

In order to develop a molecular technique for determining the species identity of midge samples that are not identifiable by morphological means, swede midge adults were obtained from locations in Ontario and Switzerland. The brassica pod midge, *Dasyneura brassicae*, was also collected from Switzerland. Molecular analysis of the samples awaits time and resources.

As in 2006, the Canadian Food Inspection Agency conducted an extensive swede midge survey across the three prairie provinces in 2007. This year, positive results were found from traps in three locations in Saskatchewan: one male swede midge was found on one trap on one date in August in canola fields near Melfort and Yorkton, and one midge on one date in August, and eight midges a week later in a trap in a field near Nipawin, SK. (Incidentally, swede midge was also found for the first time in Nova Scotia this year).

Because of these findings, in October we collected soil cores from the three canola fields that tested positive for swede midge presence and three nearby fields. Five cores from a metal soil coring tube (inside diameter of 2.54 cm, inserted to a depth of 15 cm, the resulting core has a surface area of 5.06 cm^2) were taken from each of three locations in a field, bulked in a plastic bag and stored at 2°C until processed. The soil cores were washed through progressively smaller screens until insect cocoons and larvae were retrieved. Although several larvae and cocoons were found, based on the prominent thoracic spatula of Cecidomyiidae and anal papillae of *Contarinia* and other size and colour descriptions, none of them were swede midge.

Table 1. Locations and types of crops where swede midge pheromone traps were placed, 2007.

Location	Crop	Weekly sampling period	Total no. traps
1. Beaverlodge, AB	canola	June 28-Oct 3	56
2. Lethbridge, AB	canola	June 12-Aug 28	18
3. Smeaton, SK	canola	June 1-Sept 6	44
4. Saskatoon, SK	cabbage, cauliflower	June 1-Sept 6	44
5. Outlook, SK	cole crops	June 1- Sept 14	44
6. Lumsden, SK	cole crops	July 10-Aug 28	21
7. Lumsden, SK	cole crops	July 10-Aug 28	21
8. La Salle, MB	cole crops	June 28-July 19	8
9. Glenlea, MB	canola	June 28-July 19	8

2. Swede midge injury to canola – This project component was overseen by Dr. R.H. Hallett, University of Guelph.

Pheromone traps were established at both field locations (Elora & Arkell) in Ontario in mid-May and maintained until the end of September in order to monitor swede midge populations. Swede midge populations were quite high at the Elora site, but low at Arkell, throughout the season.

A) Varietal susceptibility of spring canola. In order to quantify the impact of swede midge damage on canola development, yield and seed quality, an experiment was conducted at two locations in Ontario (Elora and Arkell) in 2007, utilizing a split-plot design, with the main plot as insecticide treatment and varieties as subplots. Twenty canola varieties (listed in Table 2) were included and the field trial was replicated four times at each location. Planting occurred on May 19 (Arkell) and May 20 (Elora). Each variety was planted in 7 row subplots, 5 m long, and assessments made on plants in the middle three rows. Alternating applications of ASSAIL™ (acetamiprid) and MATADOR™ (lambda-cyhalothrin) were made at weekly intervals from June 1st until August 17th. Swede midge damage ratings were conducted during the vegetative stage (June 13), at flowering (June 18-22, June 27-29) and during pod fill (June 27-29, July 4, July 11).

Table 2: Varieties included in spring canola trial for swede midge damage at Arkell and Elora Research Stations, University of Guelph, ON, in 2007.

SPECIES	VARIETY	ATTRIBUTES*	COMMENTS
B. napus	AC Excel	OP	Western check
	OAC Cyclone	OP	Ontario variety
	OAC Senator	OP	Ontario variety
	Hyola 401	H	Ontario variety
	Hyola 357RR	H, HT	Ontario variety, Roundup Ready
	Invigor 5020	H, HT	Ontario variety, Liberty Link
	Invigor 5030	H, HT	Ontario variety, Liberty Link
	45H21		
	46H02		
	AP7978RR		Roundup Ready
	7145RR		Roundup Ready
B. rapa	AC Boreal	OP	Western check
	AC Sunbeam	OP	--
	ACS-C7	S	--
	ACS-C18	S	--
B. juncea	AC Vulcan	OP	Western variety; non-canola quality
	Arid	OP	Western variety
	Dahinda	OP	Canola quality
Sinapis alba	AC Pennant	OP	Generally resistant to insects
	Ochre	OP	

* H = hybrid, HT= herbicide tolerant, OP= open pollinated, S= synthetic.

Results from ratings conducted at the 4.2 developmental stage (i.e. many flowers opened, lower pods elongating) are presented in Tables 3-5. Swede midge populations were higher throughout the season at Elora than at Arkell. At both sites and for both primary and secondary racemes, damage was significantly higher on untreated control plants than on those that received weekly foliar insecticide applications (Table 3).

Greater differentiation between varieties was observed at Arkell (Table 5), where swede midge populations were lower, than at Elora (Table 4). Damage to both the primary and secondary racemes was higher among *B. napus* varieties than among *B. juncea* and *S. alba* varieties at both Elora and Arkell.

At Elora, Invigor 5030 and OAC Senator had the highest, and AC Pennant the lowest, damage ratings to the primary raceme. Among *B. napus* varieties at Elora, OAC Senator and Hyola 401 had significantly lower primary raceme damage ratings than Invigor 5030.

At Arkell, AP7978RR and Invigor 5020 had the highest, and AC Sunbeam, AC Pennant, Arid and Ochre had the lowest, damage ratings to the primary raceme. Among *B. napus* varieties at Arkell, Hyola 357RR and 45H21 had significantly lower primary raceme damage ratings than AP7978RR and Invigor 5020.

Damage to the tertiary racemes was negligible for all varieties at both sites.

Table 3: Effect of foliar insecticides on swede midge damage to spring canola varieties at the 4.2 stage of development, Arkell and Elora Research Stations, ON, in 2007.

	Average swede midge damage rating		
	Primary Raceme (0 to 4 scale)	**Secondary Raceme (0 to 12 scale)**	**Tertiary Raceme (0 to 12 scale)**
Elora 2007			
Untreated	0.102 a	0.118 a	0.013
Weekly	0.054 b	0.056 b	0
Arkell 2007			
Untreated	0.153 a	0.177 a	0.003
Weekly	0.033 b	0.087 b	0.014

Table 4: Swede midge damage to spring canola varieties at the 4.2 stage of development at Elora Research Station, ON, 2007.

Elora 2007		Average swede midge damage rating				
Species	Variety	Primary Raceme (0 to 4 scale)		Secondary Raceme (0 to 12 scale)		Tertiary Raceme (0 to 12 scale)
B. napus	AC Excel	0.081	abc	0.127	abc	0
	OAC Cyclone	0.144	ab	0.132	abc	0
	OAC Senator	0.044	bc	0.144	abc	0
	Hyola 401	0.038	bc	0.100	bc	0
	Hyola 357RR	0.088	abc	0.094	abc	0.143
	Invigor 5020	0.075	abc	0.100	abc	0
	Invigor 5030	0.194	a	0.058	bc	0
	45H21	0.138	abc	0.304	a	0
	46H02	0.094	abc	0.104	abc	0
	AP7978RR	0.094	abc	0.156	abc	0
	7145RR	0.138	abc	0.208	ab	0
B. rapa	AC Boreal	0.082	abc	0.019	bc	0
	AC Sunbeam	0.044	bc	0.044	bc	0
	ACS-C7	0.106	abc	0.032	bc	0
	ACS-C18	0.125	abc	0.063	bc	0
B. juncea	AC Vulcan	0.025	bc	0.006	bc	0
	Arid	0.031	bc	0.019	bc	0
	Dahinda	0.013	bc	0	c	0
Sinapis alba	AC Pennant	0	c	0.013	bc	0
	Ochre	0.006	bc	0.013	bc	0

Table 5: Swede midge damage to spring canola varieties at the 4.2 stage of development at Arkell Research Station, ON, 2007.

Arkell 2007		Average swede midge damage rating				
Species	Variety	Primary Raceme (0 to 4 scale)		Secondary Raceme (0 to 12 scale)		Tertiary Raceme (0 to 12 scale)
B. napus	AC Excel	0.119	bcde	0.184	abcd	0
	OAC Cyclone	0.169	bcd	0.129	bcd	0
	OAC Senator	0.119	bcde	0.325	ab	0
	Hyola 401	0.125	bcde	0.153	bcd	0
	Hyola 357RR	0.025	cde	0.044	cd	0
	Invigor 5020	0.231	ab	0.449	a	0
	Invigor 5030	0.119	bcde	0.056	bcd	0
	45H21	0.069	cde	0.139	bcd	0
	46H02	0.175	bc	0.176	abcd	0
	AP7978RR	0.338	a	0.319	abc	0
	7145RR	0.156	bcde	0.172	abcd	0
B. rapa	AC Boreal	0.013	de	0.063	bcd	0
	AC Sunbeam	0.006	e	0.075	bcd	0
	ACS-C7	0.113	bcde	0.120	bcd	0.029
	ACS-C18	0.031	cde	0.050	bcd	0
B. juncea	AC Vulcan	0.025	cde	0.063	bcd	0
	Arid	0	e	0.013	d	0.020
	Dahinda	0.019	cde	0.088	bcd	0.054
Sinapis alba	AC Pennant	0	e	0.025	d	0
	Ochre	0	e	0	d	0

B) Effect of planting date on susceptibility of spring canola: In order to investigate the effect of plant phenology on susceptibility to swede midge damage, an experiment was conducted at two locations in Ontario (Elora and Arkell), utilizing a split-plot design, with the main plot as planting date, foliar insecticide applications as subplots and seed treatments (Helix Xtra or fungicide alone) as sub-subplots. There were three planting dates (early spring, two weeks after first planting, and two weeks after second planting), which were replicated four times. The first planting was made on May 19 & 20 (Arkell and Elora, respectively). These trials were conducted using Invigor 5030 (Liberty Link; i.e. glufosinate tolerant). Plot parameters were the same as for the variety trial above. Alternating applications of ASSAIL™ (acetamiprid) and MATADOR™ (lambda-cyhalothrin) were made at weekly intervals from June 1st until August 24th.

Swede midge damage assessments were conducted at weekly intervals from the 2.5 stage (rosette stage with fifth true leaf expanded) for each of the three planting dates.

At the vegetative stage, swede midge damage to plants was higher in stands planted at later dates than early dates under higher swede midge pressure (i.e. at Elora; Table 6), however damage at the vegetative stage was relatively low. Under lower swede midge pressure at Arkell, damage was higher in the late planting than in the mid-planting treatment, but this was not evident until the third week of sampling (Table 7). At both sites, damage levels were lower on insecticide-treated than untreated plots.

Damage at the flowering stage, to both primary and secondary racemes, increased with later planting date (Table 8 & 9). These results indicate that crop stage is an important factor in determining the susceptibility of canola to swede midge damage. In areas of swede midge infestation, canola must be planted early to avoid damage.

All plants in all treatments produced primary racemes, however fewer plants produced secondary racemes in the late planting treatment than in earlier planting date treatments (Table 10). This effect was particularly pronounced at Arkell, where only 39% of plants in the late planting treatment produced secondary racemes, and all of those plants were in the insecticide-treated plots. Very few plants in any treatments produced tertiary racemes, however there was no consistent effect of planting date on tertiary raceme production. No harvests were conducted of late planted plots that were untreated with insecticides, because few pods were set and plants did not mature properly. Swede midge damage can thus completely reduce the harvestable yield in late canola plantings.

Table 6: Effect of planting date and use of foliar insecticides on swede midge damage during vegetative stages of spring canola growth, Elora Research Station, 2007. Weekly sampling intervals commenced once canola reached the 2.5 stage (i.e. rosette stage with fifth true leaf expanded).

Elora 2007		Average swede midge damage rating Vegetative Stage (0 to 3 scale)		
Planting Date	**Foliar insecticide treatment**	**Week 1**	**Week 2**	**Week 3**
Planting Date and Insecticide Treatment				
Early	Untreated	0.013 a	0.100 a	0.050 bc
Early	Weekly	0 a	0.088 a	0.013 c
Mid	Untreated	0 a	0.063 a	0.263 a
Mid	Weekly	0 a	0 a	0.050 bc
Late	Untreated	0.063 a	0.013 a	0.400 a
Late	Weekly	0.063 a	0 a	0.225 ab
Planting Date				
Early		0.006 b	0.094 a	0.031 c
Mid		0 b	0.031 b	0.156 b
Late		0.063 a	0.006 b	0.313 a
Insecticide Treatment				
	Untreated	0.025 a	0.058 a	0.238 a
	Weekly	0.021 a	0.029 a	0.096 b

* Average damage ratings within a column and category that are followed by different letters are significantly different from each other, ANOVA and Tukey's HSD, with P< 0.05.

Table 7: Effect of planting date and use of foliar insecticides on swede midge damage during vegetative stages of spring canola growth, Arkell Research Station, 2007. Weekly sampling intervals commenced once canola reached the 2.5 stage (i.e. rosette stage with fifth true leaf expanded).

Arkell 2007		**Average swede midge damage rating**		
		Vegetative Stage (0 to 3 scale)		
Planting Date	**Foliar insecticide treatment**	**Week 1**	**Week 2**	**Week 3**
Planting Date and Insecticide Treatment				
Early	Untreated	0.063 a	0.075 a	0.050 ab
Early	Weekly	0 a	0.038 a	0.025 b
Mid	Untreated	0 a	0.063 a	0.175 a
Mid	Weekly	0 a	0 a	0.038 b
Late	Untreated	0.038 a	0.125 a	0.050 ab
Late	Weekly	0 a	0 a	0 b
Planting Date				
Early		0.031 a	0.056 a	0.038 ab
Mid		0 a	0.031 a	0.106 a
Late		0.019 a	0.063 a	0.025 b
Insecticide Treatment				
	Untreated	0.033 a	0.088 a	0.092 a
	Weekly	0 b	0.013 b	0.021 b

* Average damage ratings within a column and category that are followed by different letters are significantly different from each other, ANOVA and Tukey's HSD, with $P < 0.05$.

Table 8: Effect of planting date and use of foliar insecticides on swede midge damage during reproductive stages of spring canola growth, Elora Research Station, 2007.

Elora 2007		Average swede midge damage rating - Reproductive Stage								
		Primary Raceme (0 to 4 scale)			Secondary Raceme (0 to 12 scale)			Tertiary Raceme (0 to 12 scale)		
Planting Date	**Foliar insecticide treatment**	**Week 5**	**Week 6**	**Week 7**	**Week 5**	**Week 6**	**Week 7**	**Week 5**	**Week 6**	**Week 7**
Planting Date & Insecticide										
Early	Untreated	0.100 c	0.175 ab	0.038 a	0.025 c	0.175 b	0.013 a	0 a	0.033 a	--
Early	Weekly	0.150 c	0.038 b	0 a	0.113 c	0.050 b	0.013 a	0 a	0 a	0
Mid	Untreated	0.100 c	0.291 a	--	0.038 c	0.835 a	--	0 a	10.564 a	--
Mid	Weekly	0 c	0.013 b	--	0.075 c	0.150 b	--	0 a	0 a	--
Late	Untreated	1.038 a	--	--	1.258 a	--	--	0 a	--	--
Late	Weekly	0.575 b	--	--	0.671 b	--	--	0 a	--	--
Planting Date										
Early		0.125 b	0.106 a	0.019	0.069 b	0.113 b	0.013	0 a	0.019 a	--
Mid		0.050 b	0.151 a	--	0.056 b	0.491 a	--	0 a	4.337 a	--
Late		0.806 a	--	--	0.950 a	--	--	0 a	--	--
Insecticide Treatment										
	Untreated	0.413 a	0.233 a	0.038 a	0.389 a	0.503 a	0.013 a	0 a	5.986 a	--
	Weekly	0.242 b	0.025 b	0 a	0.275 a	0.100 b	0.013 a	0 a	0 a	0

* Average damage ratings within a column and category that are followed by different letters are significantly different from each other, ANOVA and Tukey's HSD, with P< 0.05.

Table 9: Effect of planting date and use of foliar insecticides on swede midge damage during reproductive stages of spring canola growth, Arkell Research Station, 2007.

Arkell 2007		Average swede midge damage rating - Reproductive Stage								
		Primary Raceme (0 to 4 scale)			Secondary Raceme (0 to 12 scale)			Tertiary Raceme (0 to 12 scale)		
Planting Date	Foliar insecticide treatment	Week 5	Week 6	Week 7	Week 5	Week 6	Week 7	Week 5	Week 6	Week 7
Planting Date & Insecticide										
Early	Untreated	0.150 ab	0.075 a	0.038 a	0.141 a	0.151 a	0 a	0 a	--	--
Early	Weekly	0.075 ab	0.113 a	0 a	0 a	0.038 a	0 a	0 a	0 a	--
Mid	Untreated	0.013 b	0.013 a	--	0.128 a	0 a	--	0 a	--	--
Mid	Weekly	0.025 ab	0.013 a	--	0.050 a	0 a	--	0 a	0 a	--
Late	Untreated	0,025 ab	--	--	--	--	--	--	--	--
Late	Weekly	0.200 a	--	--	0.064 a	--	--	0 a	--	--
Planting Date										
Early		0.113 ab	0.094 a	0.019	0.070 a	0.092 a	0	0 a	0 a	--
Mid		0.019 b	0.013 b	--	0.089 a	0 b	--	0 a	0 a	--
Late		0.142 a	--	--	0.064 a	--	--	0 a	--	--
Insecticide Treatment										
	Untreated	0.100 a	0.044 a	0.038 a	0.135 a	0.074 a	0 a	0 a	--	--
	Weekly	0.070 a	0.063 a	0 a	0.034 a	0.019 a	0 a	0 a	0	--

* Average damage ratings within a column and category that are followed by different letters are significantly different from each other, ANOVA and Tukey's HSD, with P< 0.05.

Table 10: Percent production of secondary and tertiary racemes by spring canola plants according to planting date at Elora and Arkell Research Stations, 2007.

	Elora		Arkell	
	Secondary	Tertiary	Secondary	Tertiary
Early	100 %	3 %	98 %	16 %
Mid	100 %	21 %	99 %	6 %
Late	87 %	23 %	39%	4 %

C) <u>Susceptibility of winter canola to swede midge damage</u>. *2006-07 season*. In order to quantify the impact of swede midge damage on development, yield and seed quality of winter canola, an experiment was established in early September 2006 at Elora, utilizing a randomized complete block design, with treatment levels including weekly foliar insecticide applications (none or weekly), and seed treatment (Helix Xtra or fungicide alone). The variety Kronos was used in this experiment, which was replicated four times. The field plot was planted on Sep 11, 2006 near an infested spring canola field to ensure presence of swede midge adults in the fall.

Each plot consisted of three seven-row subplots, 5m long; with all sampling done on the middle subplot. Two applications of ASSAIL™ (acetamiprid) and/or MATADOR™ (lambda-cyhalothrin) were made to the insecticide-treated plots every week beginning at the first true leaf stage in the fall (Sep 27, 2006) and on Oct 5; inclement weather prevented any further insecticide applications. Swede midge damage ratings were made three times in the fall (Sep 26, Oct 5, 12 and 19). Winter weather and considerable frost heaving led to high levels of overwintering plant mortality throughout the trial, so the trial was not continued in spring 2007.

Swede midge did cause damage in the fall (12 Oct 2006) to plants that were not protected by insecticides (Table 11). However, this level of damage was quite low and did not appear to affect overwintering survival of the plants.

Table 11: Effect of foliar and seed treatment insecticides on swede midge damage during vegetative stages of winter canola growth, Elora Research Station, Fall 2006.

		Average swede midge damage rating Vegetative Stage (0 to 3 scale)			
Foliar insecticide treatment	**Seed insecticide treatment**	**26 Sep 06**	**5 Oct 06**	**12 Oct 06**	**19 Oct 06**
Foliar and Seed Treatment					
Untreated	Untreated	0	0	0.063 a	0.088 a
Untreated	Helix	0	0	0 b	0.050 a
Foliar	Untreated	0	0	0.013 ab	0.038 a
Foliar	Helix	0	0	0.013 ab	0.100 a
Foliar Treatment					
Untreated		0	0	0.031 a	0.069 a
Foliar		0	0	0.013 a	0.069 a
Seed Treatment					
	Untreated	0	0	0.038 a	0.063 a
	Helix	0	0	0.006 a	0.075 a

* Average damage ratings within a column and category that are followed by different letters are significantly different from each other, ANOVA and Tukey's HSD, with P< 0.05.

D) <u>Timing of insecticide applications for swede midge control in spring canola</u>. Results from the first two years of the project indicated that late planted canola is particularly vulnerable to damage by swede midge. The most vulnerable stages of plant development appear to be during the vegetative stage, early inflorescence formation, and the formation of secondary and tertiary inflorescences in leaf nodes, depending upon planting date and occurrence of swede midge population peaks. In 2007 an experiment was conducted at two locations in Ontario (Elora and Arkell) to examine the efficacy of different insecticide regimes in controlling swede midge on canola planted at suboptimal timing (i.e. mid to late spring). Swede midge insecticide timing treatments (all Matador) were:

1. Untreated control;
2. Spray at first bud stage;
3. Spray at branching (i.e. when secondary and tertiary buds forming in leaf axils of primary raceme);
4. Spray at first bud and at branching.

In order to determine the effect of other insect damage from pod formation until harvest, a split-plot design was utilized where half of the plots did not receive any additional insecticide treatments after flowering was complete, and half received weekly alternating applications of ASSAIL™ (acetamiprid) and MATADOR™ (lambda-cyhalothrin) from the end of flowering until browning down of plants in late August.

Planting occurred on May 20, 2007. These trials were conducted using Invigor 5030 (Liberty Link; i.e. glufosinate tolerant) and all seed was treated with Helix Xtra. Plot parameters were the same as for the variety trial above. Bud insecticide applications were made on June 21 and branching insecticide applications were made on July 13; weekly post-flowering treatments commenced on July 26 and the last was applied on August 17th. Swede midge damage assessments were conducted at weekly intervals from the 2.5 stage (rosette stage with fifth true leaf expanded). Damage ratings were made on plants in the middle of each plot, as in above experiments.

Plants treated with insecticide at the bud stage at Elora had significantly less damage than other treatments at the July 4th and 11th post-spray dates (Tables 12 & 13). However, significant differences were found among treatments after this time. No significant differences were found among treatments at Arkell on any dates (Tables 14 & 15). Damage levels in both trials were very low. Insecticide timing needs further investigation under higher swede midge pressure.

Table 12: Effect of the timing of foliar insecticide applications on swede midge damage during vegetative stages of spring canola growth, Elora Research Station, 2007. First insecticide application (bud stage) made on June 21st.

Elora 2007	Average swede midge damage rating Vegetative Stage (0 to 3 scale)			
	Pre-spray		Post 1st spray	
Timing of Swede Midge insecticide Treatment	13 June (Stage 2.5)	20 June (Stage 2.7)	27 June (Stage 3.2)	4 July (Stage 3.8)
At bud	0.013 a	0.094 a	0.069 a	0.050 b
At branching	0.025 a	0.056 ab	0.031 a	0.188 a
At bud + branching	0.013 a	0.025 b	0.075 a	0.119 ab
Untreated	0.006 a	0.038 ab	0.031 a	0.106 ab

Table 13: Effect of the timing of foliar insecticide applications on swede midge damage during reproductive stages of spring canola growth, Elora Research Station, 2007. Bud insecticide applications were made on June 21 and branching insecticide applications were made on July 13.

Elora 2007	Average swede midge damage rating - Reproductive Stage								
	Primary Raceme (0 to 4 scale)			Secondary Raceme (0 to 12 scale)			Tertiary Raceme (0 to 12 scale)		
Timing of Swede Midge Treatment	11 July (Stage 4.4)	18 July (Stage 4.7)	25 July (Stage 5.0)	11 July (Stage 4.4)	18 July (Stage 4.7)	25 July (Stage 5.0)	11 July (Stage 4.4)	18 July (Stage 4.7)	25 July (Stage 5.0)
At bud	0.088 b	0.144 a	0 a	0.150 a	0.154 a	0.031 a	0 a	0	--
At branching	0.188 ab	0.206 a	0.006 a	0.200 a	0.108 a	0.006 a	0 a	0	0
At bud + branching	0.213 ab	0.119 a	0.013 a	0.266 a	0.095 a	0 a	0.067 a	0	--
Untreated	0.269 a	0.231 a	0.006 a	0.350 a	0.157 a	0.025 a	0.278 a	0	0

Table 14: Effect of the timing of foliar insecticide applications on swede midge damage during vegetative stages of spring canola growth, Arkell Research Station, 2007. First insecticide application (bud stage) made on June 21st.

Arkell 2007	Average swede midge damage rating Vegetative Stage (0 to 3 scale)			
	Pre-spray		Post 1st spray	
Timing of Swede Midge insecticide Treatment	13 June (Stage 2.5)	20 June (Stage 2.7)	27 June (Stage 3.2)	4 July (Stage 3.8)
At bud	0.050 a	0.125 a	0.181 a	0.269 a
At branching	0.025 a	0.031 c	0.213 a	0.231 a
At bud + branching	0.031 a	0.119 ab	0.163 a	0.200 a
Untreated	0.025 a	0.038 bc	0.206 a	0.225 a

Table 15: Effect of the timing of foliar insecticide applications on swede midge damage during reproductive stages of spring canola growth, Arkell Research Station, 2007. Bud insecticide applications were made on June 21 and branching insecticide applications were made on July 13.

Arkell 2007	Average swede midge damage rating - Reproductive Stage								
	Primary Raceme (0 to 4 scale)			Secondary Raceme (0 to 12 scale)			Tertiary Raceme (0 to 12 scale)		
Timing of Swede Midge Treatment	11 July (Stage 4.4)	18 July (Stage 5.0)	25 July (Stage 5.1)	11 July (Stage 4.4)	18 July (Stage 5.0)	25 July (Stage 5.1)	11 July (Stage 4.4)	18 July (Stage 5.0)	25 July (Stage 5.1)
At bud	0.306 a	0.331 a	0.079 a	0.271 a	0.316 a	0.071 a	0.037 a	0	--
At branching	0.231 a	0.356 a	0.136 a	0.333 a	0.600 a	0.043 a	0 a	0	--
At bud + branching	0.244 a	0.356 a	0.206 a	0.268 a	0.609 a	0.019 a	0 a	0	--
Untreated	0.288 a	0.275 a	0.250 a	0.284 a	0.504 a	0.014 a	0 a	0	--

7. CONCLUSIONS and RECOMMENDATIONS ARISING FROM THIS PROJECT:

Ecoclimatic modeling indicates that most of Canada is suitable for establishment of swede midge, with high population growth possible in parts of British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island (Olfert et al., 2006). The range of swede midge in Ontario has now expanded to all of the areas determined by Olfert et al. (2006) to be “very favourable” for establishment, and its range may still expand significantly.

Most of Saskatchewan is “suitable” for establishment of the swede midge. Now that swede midge has been found in Saskatchewan, it is likely that establishment will occur and that the insect will become a regular pest of canola. However, the high populations that are found in Ontario are not likely to occur in the prairie provinces.

<u>Where swede midge is a concern:</u>
- *Brassica juncea* and/or *Sinapis alba* varieties of canola should be selected over *B. napus* varieties.
- Canola fields should be planted as early as possible and late plantings should be avoided. In areas where swede midge populations are high, it may be best not to plant at all than to plant in mid to late June, as damage will be very high, the crop will likely be unharvestable and resulting overwintering midge populations will present a risk to the following year’s crop.
- Production of winter canola is recommended over production of spring canola, as long as environmental conditions favour winter canola production.

8. PUBLICATIONS and PRESENTATIONS:

Publication arising from this project:
- Olfert, O.O., Hallett, R.H., Weiss, R., Soroka, J.J. and S. Goodfellow. 2006. Potential distribution and relative abundance of swede midge, *Contarinia nasturtii* (Diptera: Cecidomyiidae), an invasive pest in Canada. *Entomologia Experimentalis et Applicata*, 120: 221-228.

Forthcoming Publications arising from this project:
- Hallett, R.H., Sears, M.K., Earl, H.J., and J.J. Soroka. Susceptibility of spring canola varieties to damage by the swede midge.
- Hallett, R.H., Sears, M.K., Earl, H.J., and J.J. Soroka. The effect of planting date and plant phenology on the occurrence of swede midge damage on spring and winter canola.

Associated Publications:
- Goodfellow, S.A., Hallett, R.H., Weiss, R.M. and O. Olfert. MidgEmerge, a new predictive model for determining emergence of the swede midge, *Contarinia nasturtii* (Kieffer) (Diptera: Cecidomyiidae). Submitted to *Entomologia Experimentalis et Applicata*, Sep 21, 2007, 30pp. MS# EEA-2007-0256, in review.
- Mika, A.M., Weiss, R.M., Olfert, O., Hallett, R.H., and J.A. Newman. Will climate change be beneficial or detrimental to swede midge in North America? Contrasting predictions using climate projections from different general circulation models. *Global Change Biology*, Accepted December 2007, in press.

- Hallett, R.H., S.A. Goodfellow and J.D. Heal. 2007. Monitoring and detection of the swede midge (Diptera: Cecidomyiidae). *The Canadian Entomologist*, 139: 700-712.
- Hallett, R.H. 2007. Host plant susceptibility to the swede midge (Diptera: Cecidomyiidae). *Journal of Economic Entomology*, 100: 1335-1343.
- Hallett, R.H., Fraser, H., and J. Allen. 2008. The Swede Midge – A Pest of Crucifer Crops. OMAFRA Factsheet Order No. TBD.
- International Swede Midge Task Force. 2005. 2005 Interim Best Management Practices to Control the Swede Midge (Contarinia nasturtii Kieffer). Online publication at http://www.omafra.gov.on.ca/english/crops/facts/bmp_swedemidge.htm, 18 March 2005.

Extension Presentations:

- Soroka, J., Olfert, O., and Hallett, R. 2008. Swede midge – A new canola pest. Presentation to Tri-Provincial Insect Monitoring Network Planning Meeting, Saskatoon, SK, January 29-30, 2008.
- Hallett, R.H. 2007. Development of IPM practices for control of the swede midge. Pioneer Hi-Bred Production, Caledon, ON, 6 Feb 2007.
- Hallett, R.H., and D. Lance. 2006. Pheromone trapping of the swede midge. Ontario Fruit & Vegetable Convention, 15-16 February 2006, St. Catherine's, ON. (Invited Poster).
- Hallett, R.H., and M.K. Sears. 2006. Action thresholds for the swede midge. Ontario Fruit & Vegetable Convention, 15-16 February 2006, St. Catherine's, ON. (Invited Poster).
- Hallett, R.H., and M.K. Sears. 2006. Update on 2006 Swede Midge Research Program in Canola. Ontario Canola Growers Association Canola Crop Tour, Shelburne, ON, July 7, 2006.
- Fraser, H., Allen, J., Hallett, R.H., and M.K. Sears. 2005. OMAF Swede midge training for consultants and government, Guelph, ON, July, 2005.

Scientific Presentations:

- Hallett, R.H. 2007. Management of the swede midge, Contarinia nasturtii, an exotic pest of cole crops and canola. Ontario Pest Management Conference, Guelph, ON, 8 Nov 2007. (Invited speaker).
- Hallett, R.H., M.K. Sears, P. Lafontaine, D. Roy, and S. Martinez. 2006. Development of action thresholds for control of the swede midge, *Contarinia nasturtii* (Diptera: Cecidomyiidae). Entomological Society of America Annual Meeting, 10-13 December 2006, Indianapolis, Indiana. (Paper # 25981).
- Cheng, M., Wu, Q., Hallett, R.H., Sears, M.K., Zhao, J., and A.M. Shelton. 2006. The efficacy of insecticides and application methods against swede midge (Diptera: Cecidomyiidae) under laboratory and field conditions. 5th International Workshop on Management of the Diamondback Moth and Other Crucifer Insect Pests, 24-27 October 2006, Beijing, China. (Paper).

Other Contributions:

- Survey data provided to the Canadian Food Inspection Agency (CFIA) in 2006 and 2007.
- Research activities reported annually to the Ontario Field Crop Protection Subcommittee.
- Expert advice to Abdul Ameen, CFIA Ottawa, in preparing Pest Risk Assessment for swede midge in canola, Dec 2007 and Feb 2008.

RESEARCH ACTIVITY SCHEDULE			
Milestone/ Deliverables:			
Description of Activities	**Expected starting date**	**Expected completion date**	**Status**
1. Development of CLIMEX™ model - literature review, museum contact - ecoclimatic model developed - model validated, forecast map generated - scientific paper prepared, submitted and published in scientific journal	 April 1, 2005 August 1, 2005 January 1, 2006 November 2005	 July 31, 2005 Dec 31, 2005 March 31, 2006 August 2006	 Completed Completed ahead of schedule Completed
2. Prairies surveyed - samples obtained - samples analyzed - summary report written	 June 15, 2006 & 2007 Oct 1, 2006 & 2007 March 1, 2007 & 2008	 Sept 15, 2006 & 2007 Feb 29, 2007 & 2008 March 15, 2007 & Feb 28, 2008	 Completed.
3. Swede Midge damage A. Canola varieties - plots established - cultivars sprayed, canola growth parameters measured - plots harvested, data analyzed - summary report written	 April 2005, 2006 & 2007 June 2005, 2006 & 2007 Sept 2005, 2006 & 2007 Feb 1, 2006, 2007 & 2008	 Sept 2005, 2006 & 2007 Jan 31, 2006, 2007 & 2008 Feb 28, 2006, 2007 & 2008	 Completed.
B. Planting date - plots established - cultivars sprayed, canola growth parameters measured - plots harvested, data analyzed - summary report written	 April 2005, 2006 & 2007 June 2005, 2006 & 2007 Sept 2005, 2006 & 2007 Feb 1, 2006, 2007 & 2008	 June 2005, 2006, 2007 Sep 2005, 2006 & 2007 Jan 31, 2006, 2007 & 2008 Feb 28, 2006, 2007 & 2008	 Completed.
C. Winter canola - plots established - cultivars sprayed, canola growth parameters measured - plots harvested, data analyzed - summary report written	*Milestone dates revised to reflect commencement of trial one year ahead of schedule* Sept 2005 & 2006 Sept 2005 & 2006 July 2006 & 2007 Feb 1, 2006 & 2007	 July 2006 & 2007 Jan 31, 2007 & 2008 Feb 28, 2007 & 2008	 Completed.
D. Insecticide timing - plots established - plots sprayed, canola growth parameters measured - plots harvested, data analyzed - summary report written	 April 2007 June 2007 Sept 2007 Feb 1, 2008	 Sept 2007 Jan 31, 2008 Feb 28, 2008	 Completed.
4. Project Summary - Interim Report 1 written - Annual Report 1 written - Interim Report 2 written - Annual Report 2 written - Interim Report 3 written - Final Report written	 August 30, 2005 April 30, 2006 August 30, 2006 December 15, 2006 November 1, 2007 February 1, 2008	 Sept 15, 2005 May 30, 2006 Sept 15, 2006 January 15, 2007 November 15, 2007 February 28, 2008	 Completed Completed Completed Completed Completed Completed

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