Control of Crucifer Flea Beetle in Canola through Insecticide Strategies and Canola Varieties and Forecasting Spring Infestation Risks - 2004

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Abstract

Phyllotreta cruciferae, Crucifer flea beetle, is an important insect pest of spring-planted canola, especially during the seedling stage. Two different Roundup Ready® varieties of canola, *Brassica napus,* were evaluated: '225' open-pollinated and 'Hyola 357' hybrid. The low and high rates of two commercially available insecticide seed treatments (thiamethoxam, Helix, from Syngenta and clothianidin, Prosper, from Gustafson), and a foliar insecticide (bifenthrin, Capture, from FMC Corporation) were evaluated. Each variety was grown under 11 different treatments to determine their effect on efficacy and agronomic factors: Untreated check, Capture once, Capture twice, Helix lite (200 g ai) seed treatment, Helix lite (200 g ai) seed treatment plus Capture applied once, Prosper low (200 g ai) seed treatment, Prosper low (200 g ai) seed treatment plus Capture applied once, Helix xtra (400 g ai) seed treatment, Helix xtra (400 g ai) seed treatment plus Capture applied once, Prosper high (400 g ai) seed treatment, and Prosper high (400 g ai) seed treatment plus Capture applied once. During the spring of 2004, the cool wet weather caused a prolonged delay in flea beetle emergence, undesirable feeding conditions, and lower infestations in canola. Results show that plant stand counts were affected more by variety differences than insecticide treatments. Percent incidences (or percent of plants with injury) were directly influenced by insecticide treatments, but not variety. Seed treatment and variety were found to be important factors in shoot dry weights, flea beetle damage ratings, and percent coverage. These factors are important indicators of overall "plant vigor," and indicate that seed treatment and variety can affect the amount of crop growth and subsequent crop injury. In general, the high rates of seed treatments and high/low rate of seed treatment plus a foliar spray performed better than low rates of seed treatments, foliar insecticide sprays alone and the untreated check. Differences observed in crop phenology measurements, like flowering dates, maturity dates, and crop height, were primarily attributed to varietal differences. However, some of the insecticide treatments did shorten the period to 10% and 90% flower; however, these differences were not consistent across sites. Yield, kernel weight, and percent oil were also influenced more by varieties than by treatments. However, the reduced flea beetle pressures were partially attributed to the lack of yield differences among treatments. For forecasting risks, summer flea beetle populations decreased in 2004. Overall, low-moderate populations of flea beetles were found throughout the traditional canola growing regions of North Dakota, such as north central and northeast. Although the 2005 spring infestation risk is lower than the previous year, NDSU Extension continues to recommend that North Dakota canola producers use either an insecticide seed treatment or a planned foliar insecticide spray(s) for protection against flea beetles in 2005.

Introduction

Canola, *Brassica napus* L., is an increasingly important crop in the Northern Great Plains. Nutritional research has identified canola oil as one of the healthiest commercially available vegetable oils (e.g. de Lorgeril 1994 & Ascherio 1996) and the crop has further benefited from high profile nutritional studies in the Antarctic (Matheson et al. 1996). Canada is the leading producer of canola oil and has sold their complete annual crop production for the past eight years, still not filling the world demands (Canola Council of Canada 1998). The success of canola oil has actually become a concern for Canadian producers who see the potential of reduced market penetration caused by consumer demand outstripping production. Canadian producers have, therefore, been encouraging U.S. canola production. From 1997 to 1998, the acreage of canola planted in the U.S. increased by 58 percent. Eighty-five percent of this acreage is in North Dakota where production was valued at approximately $116M in 1998, $81M in 1999, $108M in 2000, $158M in 2001, $149M in 2002, $134M in 2003, and $150M in

2004 (USDA NASS 2004; B. Coleman, pers. comm.). Canola provides an important broadleaf crop option for rotation with small grains. The importance of rotating different crops, coupled with the market demand for canola, makes this a potentially important crop for North Dakota agriculture.

A number of insect pests reduce yield in U.S. canola and pest management inputs will probably increase and change with expanding acreage. The crucifer flea beetle, *Phyllotreta cruciferae* Goeze, is the most economically important insect pest of canola in North Dakota (Weiss et al. 1991).

Flea beetles have a single generation in the northern U.S (Canadian Sust. Ag. Facts). Adult flea beetles emerge in early spring from overwintering sites and feed on volunteer canola and mustard before moving to newly planted canola as it emerges (Knodel and Olson 2002). Adult feeding on the cotyledon stages of the crop accounts for the greatest crop loss. Adult flea beetles move readily from plant to plant and infestations often spread from the field edge where they enter from overwintering sites. As temperatures increase above 58°F, the adults fly, further spreading infestations. Personal observations during 2001 also suggest that moisture may be a factor in stimulating flea beetles to leave their overwintering sites. Leaf tissues of the cotyledons die around adult flea beetle feeding sites, which produces a shot-hole appearance. Warm, dry weather promotes flea beetle feeding activity, while simultaneously slowing canola growth. Therefore, sunny, warm conditions result in heavier feeding damage. When flea beetle populations are heavy and weather favorable for feeding, entire fields can be lost as young canola seedlings wilt and die. This may result in having to reseed the field. Less severe infestations may result in stunting and uneven stands and maturation causing harvest problems. Canola has the ability to compensate for defoliation; field stands can re-establish even after 75 percent of the cotyledon area has been damaged (Bodnaryk et al. 1994, Nowatzki & Weiss 1997). Crucifer plant species differ in susceptibility to attack and ability to tolerate defoliation (Bodnaryk and Lamb 1991). Unpublished data from Knodel, Hanson, and Henson also indicated that flea beetle damage is affected by different seed sizes of canola varieties and rate of seed treatments. Commercially applied insecticide seed treatment is the most common way of controlling flea beetle infestations in canola. In addition, foliar treatments applied in response to pest populations can be effective if properly timed (Weiss et al. 1991). However, the best pest management strategies need to be refined based on differences in vigor of canola varieties. Brown et al. (2004) examined a number of lines from *B. napus* L., *B. juncea* L., and *Sinapis alba* L. and found differences in the degree of feeding injury of *P. cruciferae* and yield reduction varied among lines from the same species examined. Best pest management strategies need to be refined based on differences in tolerance of canola varieties.

Our first objective was to determine the most effective insecticide strategy in contrasting canola varieties for control of the crucifer flea beetle at several sites in North Dakota. This research also continued to validate a forecasting system to predict spring emergence and infestation risk of flea beetles (second objective). Forecasting "Pest Alerts" are an important tool of pest management, and producers need to know risks and when the beetles are moving from their overwintering sites into fields. Research was conducted in three different areas (Minot, Langdon, and Carrington) of canola production and provided valuable information across the state of North Dakota for canola producers.

Materials and Methods

<u>Objective 1: Insecticide Strategy – Variety Study</u> –Trials were conducted in research plots located at the NDSU Research Extension Centers in Minot, Langdon, and Carrington. Two different Roundup Ready® varieties of canola, *Brassica napus,* were evaluated: '225' open-pollinated and 'Hyola 357' hybrid. Canola was seeded on May 17, 2004, in Minot and Carrington, and May 7, 2004, in Langdon. The seeding rate was 14-17 pure live seeds per square foot. A RCB design with four replicates was used. Experimental units were 3.5-4.1 ft. (7 rows) x 20-22 ft. The low and high rates of two commercially

available insecticide seed treatments were evaluated: thiamethoxam (Helix) from Syngenta and clothianidin (Prosper) from Gustafson. A foliar insecticide, bifenthrin (Capture), from FMC Corporation was also evaluated. Within each variety, efficacy of an insecticide seed treatment alone was compared to an insecticide seed treatment plus one application of a foliar insecticide, a foliar insecticide applied once and twice. The following insecticide seed treatments were evaluated for each variety for a total of 22 treatments:

- Untreated check
- Capture once
- Capture twice
- Helix lite (200 g ai) seed treatment
- Helix lite (200 g ai) seed treatment plus Capture applied once
- Prosper low (200 g ai) seed treatment
- Prosper low (200 g ai) seed treatment plus Capture applied once
- Helix xtra (400 g ai) seed treatment
- Helix xtra (400 g ai) seed treatment plus Capture applied once
- Prosper high (400 g ai) seed treatment
- Prosper high (400 g ai) seed treatment plus Capture applied once

Capture was applied at the 1.3 fl oz./acre rate with a CO_2 hand sprayer or tractor-mounted sprayer using 40 psi, and 10 gpa. Capture was applied over the seed treatment on approximately day 21 after planting (or about 14 days after emergence). The "Capture once" treatment was applied within a week after emergence depending on flea beetle pressure. The "Capture twice" treatment had the second application about seven days after the first spray.

Flea beetle populations were monitored weekly using sticky yellow trap cards. To evaluate flea beetle damage, assessments were taken at 18 and 27 days after planting (DAP) using the following techniques:

Counting the total number of plants in a 16 ft. long section of row and then recounting the number of plants with flea beetle damage determined the percent incidence. Any plant with pitting or other feeding punctures was considered damaged. This also provided a plant stand count (# plants/sq. foot).

Plots were visually rated for flea beetle feeding injury using the following rating scheme:

1 = 0-3 pits per seedling
2 = 4-9 pits per seedling
3 = 10-15 pits per seedling
4= 16-25 pits per seedling
5 = >25 pits per seedling
6 = dead

The shoot dry weight of 10 seedlings per plot was recorded to indicate the overall vigor of the plant. All roots were removed from the seedling using a razor.

At 34 DAP, one more visual damage rating (1-6) was taken and the percent of plot area covered by canola plants (percent coverage) was estimated.

During the field season, the following notes on crop development stages were taken:

1st Flower: Days after planting when 10% of plants in plot have at least one open flower.
End Flower: Days after planting when 90% of plants in plot have completed flowering.
Flower Duration: Days from 1st flower – End flower
Days to Mature: Days after planting when pods on lower third of main raceme are dark brown to black, seeds on middle third of main raceme are turning brown or black and seeds on top third of raceme are green but firm and pliable.
Plant Height: Height from soil surface to top of main raceme at the end of flowering.

Roundup (1 pt. /A) + AMS was applied for weed control early in the season. No Ronilan (12 oz/a) application was necessary for disease control during 2004. Best management practices were used regarding fertility and harvest operations. Plots were harvested on September 7, 2004, in Carrington, and September 17, 2004, in Langdon. Unfortunately, plots were destroyed in the swath by a hail storm on August 19-20, 2004, in Minot. Yield (lb/a), test weight (lb/bu), and kernel weight (gm/1000 seeds) were obtained at the end of the season to facilitate agronomic comparisons.

Data Analysis: Treatments were compared using Analysis Variance (ANOVA) (Zar 1984) and Fisher's Protected LSD (SAS institute 1991).

<u>Objective 2: Spring Flea Beetle Forecasting Model</u> – Three field sites were monitored for spring emergence of overwintering flea beetles, and for subsequent summer populations of flea beetles in the major canola-producing areas of North Dakota: Ward County – Minot; Cavalier County – Langdon; and Foster County - Carrington. In the spring, flea beetles were monitored using 4x6 inches yellow sticky traps that are commercially available from PheroTech®. Five traps were placed in an untreated canola block before flea beetles emerge from their overwintering sites in the early spring (usually late April-early May). Traps were randomly placed using a "Z" pattern and spaced at 40 meter intervals within the block. The number of flea beetles captured per trap was counted and recorded two times a week. Spring monitoring continued until the end of emergence, usually the end of June. Crop phenology was also recorded during spring trap monitoring. For the summer population of flea beetles, a standard 15-inch sweep net was used for monitoring populations of flea beetles on freshly swathed canola fields (within one week of swathing). A total of 20 sweeps (180º) per field or four sweeps at five different locations within a field was used. [Note: This was also part of the Canola Disease and Flea Beetle Survey 2004.]

Results and Discussion

<u>Objective 1 - Insecticide Strategy – Variety Study</u>

Plant Stand, Incidence, Dry Weight, Damage Ratings for 18 DAP (Tables 1-3):

For plant stand at Langdon, only Helix xtra + Capture had significantly higher plants per square foot than the untreated check. At Carrington, none of the treatments were significantly different from the untreated check, but Helix xtra had higher plants per square foot than Capture once and Capture twice. Variety 357 had a significantly higher plant stand count than variety 225 at Langdon and Carrington. However, there were no differences in plant stand counts between treatments or varieties at Minot. This indicates that plant stand count was affected more by variety differences than insecticide treatments.

For incidence (or percent of plant attacked), all of the treatments except Capture twice had a significantly lower incidence than the untreated check at Minot. All of the treatments except Helix lite had a lower incidence than the untreated check at Langdon and Carrington. Variety 225 had a higher incidence at Langdon, whereas variety 357 had a higher incidence at Carrington. However, there were no differences between varieties at Minot. Thus, the relative susceptibility of varieties differed among environments.

At Minot, Helix lite + Capture, Helix xtra, and Helix xtra + Capture had significantly higher shoot dry weight than the untreated check, Capture twice, Prosper 200 and Prosper 400. Similarly, Helix extra + Capture at Langdon had a higher shoot dry weight than the untreated check, Capture once, Capture twice, Helix lite, Prosper 200, Prosper 200 + Capture, Prosper 400, and Prosper 400 + Capture. At Minot and Langdon, variety 357 had significantly higher shoot dry weights than variety 225. However, there were no differences in shoot dry weights among treatments or varieties at Carrington, perhaps due to lighter flea beetle pressures at Carrington compared to Minot and Langdon. These data suggest that seed treatment and variety are important factors in shoot dry weight, which is an important indicator of "plant vigor." At Langdon, there was a significant treatment x variety interaction.

There were no significant differences among treatments for the first visual damage rating at 18 DAP, regardless of the site. Flea beetles had not moved into plots to feed yet due to the cool, wet spring weather.

Plant Stand, Incidence, Dry Weight, Damage Ratings for 27 DAP (Table 1-3):
At 27 DAP, plant stand counts were not significantly different among treatments regardless of site. However, variety 357 had a significantly higher plant per square foot count than variety 225 at all sites. These results are similar to what was observed in 18 DAP, and indicate that plant stand count is affected more by variety differences than insecticide seed treatments.

At Minot and Langdon on 27 DAP, all plants were injured by flea beetle feeding regardless of the treatment (100% incidence). Capture twice had a significantly lower incidence of injured plants than other treatments at Carrington. This suggests that this foliar spray was well-timed to the spring movements of flea beetles into plots, and resulted in a lower percent incidence. There were no differences in percent incidence between varieties regardless of site. There was no impact on percent incidence from varieties. At Langdon, there was a significant treatment x variety interaction for percent incidence.

For shoot dry weight at 27 DAP, the following treatments had a significantly higher weight than the untreated check at Minot (ranked highest to lowest): Helix xtra + Capture, Helix xtra, Prosper 200 + Capture, Helix lite, Prosper 200, Helix lite + Capture, and Prosper 400. At Langdon, Prosper 400 + Capture, Helix xtra + Capture, and Helix xtra had significantly higher plant weight than the untreated check. At Carrington, the following treatments also had a significantly higher weight than the untreated check (ranked highest to lowest): Helix xtra, Helix xtra + Capture, Helix lite, Capture twice, and Helix lite + Capture. Among varieties, variety 357 had a significantly higher weight than variety 225 at Minot and Langdon. In contrast, variety 225 had a significantly higher weight than variety 357 at Carrington. These results are similar to shoot dry weights taken earlier in plant development at 18 DAP, and indicate that seed treatment and variety can be important factors in shoot dry weight.

The second visual damage ratings were taken on 27 DAP. At Minot and Carrington, all treatments had significantly lower damage ratings than the untreated check. The treatments ranked from lowest to highest at Minot are: Helix xtra + Capture, Helix xtra, Helix lite + Capture, Prosper 400, Prosper 400 + Capture, Prosper 200 + Capture, Capture twice, Helix lite, Capture once, and Prosper 200. At Carrington, it is interesting to note that Capture once and Capture twice had the lowest damage ratings, then the high rate of seed treatments + Capture, high rate of seed treatments, and low rate of seed treatments or low rate of seed treatments + Capture. At Langdon, flea beetle pressures were heavier and resulted in higher damage ratings. Treatments that were significantly different from the untreated check and ranked from lowest to highest ratings include: Helix xtra + Capture, Helix lite + Capture, Helix xtra, Prosper 400 + Capture, Capture twice, Prosper 200 + Capture, and Prosper 400. At Langdon and Carrington, variety 225 had a significantly higher damage rating than variety 357. There were no significant differences within variety at Minot. At Langdon, there was a significant interaction between treatment x variety. These results indicated that treatment and variety can influence damage ratings.

Damage Rating and Percent Coverage for 34 DAP (Table 1-3):
For damage rating at 34 DAP, all treatments were significantly different from the untreated check at all sites. For rankings from lowest to highest damage ratings, the high rate of seed treatment with foliar spray and high rate of seed treatment usually had the lowest damage rating; then, the low rate of seed treatment plus foliar sprays, low rate of seed treatment, Capture twice, and Capture once. However, the Capture twice had the lowest damage ratings among all treatments at Carrington. This was attributed to a well-timed insecticide application and moderate flea beetle pressures in spring. For varieties, variety 225 had a significantly higher damage rating than variety 357 regardless of

the site. Again, these results indicated that treatment and variety affect damage caused by flea beetles.

For percent coverage, all insecticide treatments had a significantly higher percent of land area covered than the untreated check at all sites. The treatments ranked from the highest to lowest percent coverage at Minot include: Helix xtra + Capture, Helix lite + Capture, Prosper 400 + Capture, Prosper 200 + Capture, Capture twice, Helix xtra, Helix lite, Prosper 400, Prosper 200, and Capture once. The treatments ranked from the highest to lowest percent coverage at Langdon include: Helix xtra + Capture, Prosper 400 + Capture, Helix xtra, Helix lite + Capture, Capture twice, Prosper 200 + Capture, Prosper 400, Capture once, Prosper 200, and Helix lite. The treatments ranked from the highest to lowest percent coverage at Carrington include: Helix xtra + Capture, Capture twice, Prosper 400 + Capture, Helix lite + Capture, Helix xtra, Prosper 200 + Capture, Capture once, Prosper 400, Helix lite, and Prosper 200. Again, it is interesting to note that Capture twice had a higher percent coverage than most of the seed treatment due to its spray timing coinciding with spring movements of flea beetles into plots. In general, the high rates of seed treatments and high/low rate of seed treatment plus a foliar spray had higher percent coverage than low rates of seed treatments, foliar insecticide treatments alone, and the untreated check. For varieties, variety 357 had a higher percent coverage than variety 225 regardless of site, which indicates that a variety's vigor can influence crop growth. These data suggest that seed treatment and variety can affect the amount of crop growth and subsequent crop injury sustained by the plant.

Table 1. Analysis of variance P-values in the response of two canola cultivars to flea beetle control treatments trial, NDSU Minot, 2004.

		18 DAP				27 DAP				34 DAP	
		Plant Stand		Visual	Dry Wt	Plant Stand		Visual	Dry Wt	Visual	%
Source of Variation	df	Pl/ft^2	% Inc	Rat 1	g/10 pl	Pl/ft^2	% Inc	Rat 2	g/10 pl	Rat 3	Coverage
Rep	3	0.8159	0.3219	--	0.0224	0.8959	--	0.8034	0.0001	0.3847	0.0751
Treatment	10	0.2769	0.0021	--	0.0266	0.3963	--	<.0001	0.0078	<.0001	<.0001
Variety	1	0.1244	0.269	--	<.0001	0.0498	--	0.5828	<.0001	0.0018	<.0001
Treatment x Variety	10	0.9203	0.1317	--	0.1737	0.6753	--	0.3464	0.4191	0.2502	0.1809

Table 1. Response of two canola cultivars to flea beetle control treatments, NDSU Minot, 2004. (analyzed as an 11 x 2 factorial)

		18 DAP				27 DAP				34 DAP	
		Plant Stand		Visual	Dry Wt	Plant Stand		Visual	Dry Wt	Visual	%
Treatment	Variety	Pl/ft^2	% Inc	Rat 1	g/10 pl	Pl/ft^2	% Inc	Rat 2	g/10 pl	Rat 3	Coverage
Seed Treatment											
Untreated Gust Fung	---	17.4	8 a	1.0	0.154 cd	11.1	100.0	2.9 a	2.104 c	3.8 a	40.6 f
Capture Once	---	17.1	4 b	1.0	0.157 bcd	10.6	100.0	1.6 bc	2.622 bc	2.3 b	50.0 e
Capture Twice	---	18.6	7 a	1.0	0.146 d	11.8	100.0	1.3 cd	2.641 bc	1.8 cd	59.4 bcd
Helix lite	---	18.1	3 b	1.0	0.169 abc	12.4	100.0	1.4 bcd	2.778 ab	1.9 bc	56.3 d
Helix lite + Capture	---	17.7	3 b	1.0	0.180 a	12.4	100.0	1.0 d	2.668 b	1.4 de	63.1 ab
Prosper 200	---	17.1	3 b	1.0	0.155 cd	11.5	100.0	1.7 b	2.695 b	2.2 bc	50.6 e
Prosper 200 + Capture	---	18.5	2 b	1.0	0.162 abcd	11.9	100.0	1.1 d	3.019 ab	1.3 ef	61.3 abc
Helix xtra	---	20.0	3 b	1.0	0.177 ab	13.1	100.0	1.0 d	3.020 ab	1.3 ef	58.1 cd
Helix xtra + Capture	---	18.0	3 b	1.0	0.178 ab	12.6	100.0	1.0 d	3.312 a	1.0 f	65.0 a
Prosper 400	---	16.7	3 b	1.0	0.153 cd	10.4	100.0	1.0 d	2.663 b	1.3 ef	56.3 d
Prosper 400 + Capture	---	17.0	3 b	1.0	0.165 abcd	11.5	100.0	1.0 d	2.491 bc	1.1 ef	62.5 abc
LSD (0.05)	***---***	***NS***	***0.03***	***---***	***0.022***	***NS***	***---***	***0.4***	***0.560***	***0.4***	***4.8***
Variety											
---	225	17.4	0.03	1.0	0.130	11.3	1.0	1.4	2.400	1.9	53.9
---	357	18.2	0.0	1.0	0.200	12.2	1.0	1.3	3.100	1.6	59.4
t-test	**---**	**NS**	**NS**	**---**	**	*	**---**	**NS**	**	**	**
Mean	---	17.8	0.0	1.0	0.16	11.8	1.0	1.4	2.728	1.8	56.6
CV (%)	---	13.4	82.7	0.0	13.4	19.6	0.0	28.1	20.5	23.2	8.4

Table 2. Analysis of variance P-values in the response of two canola cultivars to flea beetle control treatments trial, NDSU Langdon, 2004.

		18 DAP				27 DAP				34 DAP	
		Plant Stand		Visual	Dry Wt	Plant Stand		Visual	Dry Wt	Visual	%
Source of Variation	df	Pl/ft^2	% Inc	Rat 1	g/10 pl	Pl/ft^2	% Inc	Rat 2	g/10 pl	Rat 3	Coverage
Rep	3	0.7792	0.3788	--	0.0057	0.9631	0.5413	0.1380	0.4299	0.9250	0.7428
Treatment	10	0.0454	0.0103	--	0.0136	0.8103	0.531	<.0001	0.0096	<.0001	<.0001
Variety	1	<.0001	<.0001	--	<.0001	<.0001	0.6583	<.0001	<.0001	<.0001	<.0001
Treatment x Variety	10	0.2789	0.7212	--	0.0401	0.6277	0.4011	0.0013	0.1504	0.3698	0.2639

Table 2. Response of two canola cultivars to flea beetle control treatments, NDSU Langdon, 2004. (analyzed as an 11 x 2 factorial)

		18 DAP				27 DAP				34 DAP	
		Plant Stand		Visual	Dry Wt	Plant Stand		Visual	Dry Wt	Visual	%
Treatment	Variety	Pl/ft^2	% Inc	Rat 1	g/10 pl	Pl/ft^2	% Inc	Rat 2	g/10 pl	Rat 3	Coverage
Seed Treatment											
Untreated Gust Fung	---	11.2 bc	9 a	1.0	0.061 b	8.0	100.0	5.3 a	0.412 d	4.9 a	18.1 e
Capture Once	---	10.4 c	4 c	1.0	0.0613 b	8.7	100.0	5.1 ab	0.533 cd	4.0 b	37.5 cd
Capture Twice	---	10.3 c	6 bc	1.0	0.0618 b	8.5	100.0	4.3 de	0.692 bcd	2.6 cd	48.1 b
Helix lite	---	11.6 abc	8 ab	1.0	0.069 b	9.7	100.0	4.9 abc	0.614 bcd	3.8 b	35.6 d
Helix lite + Capture	---	10.2 c	6 bc	1.0	0.070 ab	9.2	99.7	4.2 e	0.631bcd	2.7 c	48.8 ab
Prosper 200	---	10.9 bc	5 bc	1.0	0.0623 b	8.8	100.0	4.9 abc	0.457 d	4.0 b	36.3 cd
Prosper 200 + Capture	---	10.8 bc	5 bc	1.0	0.065 b	8.7	100.0	4.6 cde	0.630 bcd	2.8 c	44.4 bc
Helix xtra	---	12.3 ab	2 bc	1.0	0.070 ab	9.7	100.0	4.3 de	0.796 abc	2.7 c	48.8 ab
Helix xtra + Capture	---	13.1 a	3 c	1.0	0.0778 a	8.9	99.9	3.7 f	0.843 ab	2.0 d	56.9 a
Prosper 400	---	11.0 bc	4 c	1.0	0.064 b	8.5	100.0	4.7 bcd	0.648 bcd	3.5 b	38.8 cd
Prosper 400 + Capture	---	11.3 bc	3 c	1.0	0.067 b	9.6	100.0	4.3 de	1.031 a	2.6 cd	50.6 ab
LSD (0.05)	***---***	***1.7***	***0***	***---***	***0.009***	***NS***	***NS***	***0.4***	***0.308***	***0.6***	***8.6***
Variety											
---	225	10.1	0.04	1.0	0.047	7.9	1.0	5.3	0.412	3.7	33.5
---	357	12.3	0.1	1.0	0.085	10.0	1.0	3.8	0.913	2.7	50.8
t-test	***---***	**	**	***--***	**	**	***NS***	**	**	**	**
Mean	---	11.2	0	1.0	0.1	8.9	100	4.6	0.662	3.2	42.2
CV (%)	---	15.4	66.1	0.0	13.7	23.2	0.2	9.7	46.6	18.5	20.4

Table 3. Analysis of variance P-values in the response of two canola cultivars to flea beetle control treatments trial, NDSU Carrington, 2004.

		------------------------18 DAP			-------------------------	----------------------------27 DAP			-----------------------	---------34 DAP-------	
Source of Variation	df	Plant Stand Pl/ft^2	% Inc	Visual Rat 1	Dry Wt g/10 pl	Plant Stand Pl/ft^2	% Inc	Visual Rat 2	Dry Wt g/10 pl	Visual Rat 3	% Coverage
Rep	3	0.9313	0.3686	--	0.6726	0.9821	0.5126	<.0001	0.0004	<.0001	0.7420
Treatment	10	0.5368	0.0445	--	0.7844	0.1910	0.0062	<.0001	0.0164	<.0001	<.0001
Variety	1	0.0002	0.0458	--	0.4614	0.0036	0.3378	0.1212	<.0001	0.0012	<.0001
Treatment x Variety	10	0.3615	0.8425	--	0.4757	0.1515	0.1212	0.8787	0.2214	0.5260	0.4351

Table 3. Response of two canola cultivars to flea beetle control treatments, NDSU Carrington, 2004. (analyzed as an 11 x 2 factorial)

		------------------------18 DAP			-------------------------	----------------------------27 DAP			-----------------------	---------34 DAP-------	
Treatment	Variety	Plant Stand Pl/ft^2	% Inc	Visual Rat 1	Dry Wt g/10 pl	Plant Stand Pl/ft^2	% Inc	Visual Rat 2	Dry Wt g/10 pl	Visual Rat 3	% Coverage
Seed Treatment											
Untreated Gust Fung	---	15.5	36 a	1.0	0.095	12.5	100 a	4.1 a	0.243 d	4.8 a	33.1 f
Capture Once	---	14.3	6 b	1.0	0.100	12.2	97 a	1.6 f	0.268 cd	1.8 e	56.3 cd
Capture Twice	---	14.9	4 b	1.0	0.110	13.2	82 b	2.1 e	0.311 abc	1.1 f	65.0 ab
Helix lite	---	15.3	16 ab	1.0	0.115	12.9	100 a	3.0 bc	0.329 abc	3.3 bc	49.4 e
Helix lite + Capture	---	15.7	5 b	1.0	0.173	11.3	100 a	3.3 b	0.310 abc	2.3 d	58.1 c
Prosper 200	---	15.8	4 b	1.0	0.099	12.5	99 a	3.3 b	0.294 bcd	3.5 b	48.1 e
Prosper 200 + Capture	---	16.4	5 b	1.0	0.178	13.3	100 a	3.2 b	0.269 cd	2.5 d	57.5cd
Helix xtra	---	17.5	4 b	1.0	0.116	12.6	99 a	2.4 de	0.357 a	2.3 d	57.5 cd
Helix xtra + Capture	---	15.7	3 b	1.0	0.113	14.6	99 a	2.4 de	0.333 ab	1.8 e	66.9 a
Prosper 400	---	15.5	2 b	1.0	0.111	11.9	99 a	2.7 cd	0.267 cd	2.9 c	52.5 de
Prosper 400 + Capture	---	15.1	14 b	1.0	0.086	13.5	99 a	2.5 d	0.303 abcd	1.8 e	60.0 bc
LSD (0.05)	***---***	***NS***	***0.2***	***---***	***NS***	***NS***	***0.1***	***0.4***	***0.100***	***0.3***	***5.1***
Variety											
---	225	14.6	0.0	1.0	0.109	12.1	99	2.8	0.218	2.7	49.2
---	357	16.6	0.1	1.0	0.126	13.4	97	2.7	0.378	2.4	60.7
t-test	***---***	**	*	***--***	***NS***	**	***NS***	***NS***	**	**	**
Mean	---	15.6	9	1.0	0.118	12.8	98	2.8	0.298	2.5	54.9
CV (%)	---	15.5	218.3	0.0	90.4	16.2	9.0	14.7	20.9	13.7	9.3

Crop Phenology (Table 4-6):
At Minot, there were no significant differences among treatments in any of the crop phenology measurements: 10% flower, 90% flower, flower duration, maturity, or crop height. Variety 225 had a significantly longer period to 10% flower, 90% flower, and flower duration than variety 357 and a significantly taller plant than variety 357. However, there were no differences in maturity periods.

At Langdon, there were no significant differences among treatments in flower duration or height. For 10% and 90% flower, all of the treatments except Capture once had a significantly shorter period to flower than the untreated check. There were little differences among treatments. Again, variety 225 had a significantly longer period to 10% flower, 90% flower, flower duration, and maturity than variety 357; and a significantly taller plant than variety 357.

At Carrington, there were no significant differences among treatments in flower duration, maturity, or height. For 10% flower, all of the treatments had a significantly shorter period to flower than the untreated check. There were few consistent differences among treatments. For 90% flower, Capture once, Capture twice, Prosper 200 + Capture, and Helix lite + Capture had a significantly shorter period than the untreated check. Again, variety 225 had a significantly longer period to 10% flower, 90% flower, flower duration, and maturity than variety 357 and a significantly taller plant than variety 357.

The differences observed in crop phenology measurements were primarily attributed to varietal differences. However, some of the insecticide treatments did appear to decrease the period to 10% and 90% flower; however, these differences were not consistent across sites.

Agronomic Data (Table 4-6):
At Minot, the agronomic data (yield, kernel weight, oil) were lost due to a severe hail storm. At Langdon and Carrington, there were no significant differences among treatments in yield, kernel weight, or percent oil. At Langdon, there were no varietal differences in yield. Variety 225 had significantly higher kernel weight and percent oil than variety 357. At Carrington, variety 357 had significantly higher yield and kernel weight than variety 225. But, variety 225 had significantly higher percent oil than variety 357. These data indicate that yield, kernel weight, and percent oil are more strongly influenced by variety than treatments. Since spring flea beetle populations were reduced in 2004, it made it difficult to detect agronomic data differences between treatments. At Langdon, there was a significant treatment x variety interaction for yield and percent oil.

Table 4. Crop Phenology, NDSU Minot, 2004.

Source of Variation	df	10% Flower (Days)	90% Flower (Days)	Flower Duration (Days)	Maturity (Days)	Height in.	Yield lb/bu	Kernel Weight g/1000	Percent Oil
Rep	3	0.0067	0.0002	0.0898	0.3812	<.0001			
Treatment	10	0.1113	0.598	0.1481	0.4367	0.8682	No Data	No Data	No Data
Variety	1	<.0001	<.0001	0.0002	0.3762	0.0101			
Treatment x Variety	10	0.2407	0.0745	0.2316	0.4287	0.7938			

Table 4. Crop Phenology, NDSU Minot, 2004.

Treatment	Variety	10% Flower (Days)	90% Flower (Days)	Flower Duration (Days)	Maturity (Days)	Height in.	Yield lb/bu	Kernel Weight g/1000	Percent Oil
Seed Treatment									
Untreated Gust Fung	---	50.3	63.5	13.3	81.8	95.6			
Capture Once	---	49.9	63.4	13.5	81.0	96.1			
Capture Twice	---	50.3	63.5	13.3	81.0	93.9			
Helix lite	---	49.6	63.8	14.1	81.0	94.5			
Helix lite + Capture	---	49.5	63.1	13.6	81.0	96.3			
Prosper 200	---	50.0	63.6	13.6	81.0	93.3	No Data	No Data	No Data
Prosper 200 + Capture	---	49.9	63.4	13.5	71.9	95.3			
Helix xtra	---	49.9	63.6	13.8	81.0	98.3			
Helix xtra + Capture	---	49.8	63.5	13.8	81.0	97.4			
Prosper 400	---	49.9	63.8	13.9	81.0	96.8			
Prosper 400 + Capture	---	50.0	63.8	14.0	80.8	95.8			
LSD (0.05)	***---***	***NS***	***NS***	***NS***	***NS***	***NS***			
Variety									
---	225	50.3	64.3	13.9	79.5	97.4			
---	357	49.5	62.8	13.4	81.0	94.1			
t-test	**---**	**	**	**	**NS**	**			
Mean	---	49.9	63.6	13.7	80.2	95.7			
CV (%)	---	1.0	1.3	5.3	9.7	6.0			

Table 4. Crop Phenology, NDSU Langdon, 2004.

Source of Variation	df	Days: 10% Flower	Days: 90% Flower	Days: Flower Duration	Days: Maturity	Height in.	Yield lb/bu	Kernel Weight g/1000	Percent Oil
Rep	3	0.9272	0.1366	0.1383	0.0892	0.3534	0.4448	0.2608	0.2324
Treatment	10	0.0006	0.0006	0.0802	0.0616	0.0646	0.2288	0.7434	0.1791
Variety	1	<.0001	<.0001	<.0001	<.0001	<.0001	0.1176	0.0121	<.0001
Treatment x Variety	10	0.9218	0.8997	0.3850	0.2103	0.0992	0.0179	0.0557	0.0131

Table 4. Crop Phenology, NDSU Langdon, 2004.

Treatment	Variety	Days: 10% Flower	Days: 90% Flower	Days: Flower Duration	Days: Maturity	Height in.	Yield lb/bu	Kernel Weight g/1000	Percent Oil
Seed Treatment									
Untreated Gust Fung	---	59.8 a	81.5 a	21.8	105.8	96.1	1790	2.89	46.5
Capture Once	---	58.3 ab	80.6 ab	22.4	105.0	95.3	1805	2.84	46.9
Capture Twice	---	56.0 d	79.8 bcd	23.8	105.3	97.8	2123	2.88	46.8
Helix lite	---	57.4 bcd	79.4 cd	22.0	104.6	96.6	1859	2.89	47.5
Helix lite + Capture	---	56.9 bcd	79.8 bcd	22.9	105.3	97.1	1841	2.87	47.4
Prosper 200	---	57.8 bc	80.6 ab	22.9	105.3	96.1	1983	2.88	46.6
Prosper 200 + Capture	---	57.9 bc	80.3 bc	22.4	105.6	93.4	2022	2.83	46.9
Helix xtra	---	56.6 cd	79.3 cd	22.7	104.6	99.3	1955	2.82	46.8
Helix xtra + Capture	---	55.9 d	79.0 d	23.1	104.3	98.4	2089	2.86	47.3
Prosper 400	---	57.9 bc	79.6 bcd	21.8	105.0	93.0	1964	2.91	47.0
Prosper 400 + Capture	---	56.9 bcd	79.8 bcd	22.9	105.0	97.5	1967	2.88	47.2
LSD (0.05)	***---***	***1.6***	***1.1***	***NS***	***NS***	***NS***	***NS***	***NS***	***NS***
Variety									
---	225	60.2	82.0	21.8	105.9	99.4	1900	2.9	47.9
---	357	54.6	78.0	23.4	104.2	93.4	1991	2.8	46.1
t-test	***---***	**	**	**	**	**	***NS***	*	**
Mean	---	57.4	80.0	22.6	105.1	96.4	1945	2.9	47.0
CV (%)	---	2.8	1.3	5.7	0.9	4.2	13.9	3.6	1.5

Table 4. Crop Phenology, NDSU Carrington, 2004.

Source of Variation	df	----Days---- 10% Flower	90% Flower	Flower Duration	Maturity	Height in.	Yield lb/bu	Kernel Weight g/1000	Percent Oil
Rep	3	<.0001	<.0001	0.0232	0.3128	0.0026	<.0001	0.7590	0.4379
Treatment	10	<.0001	0.0068	0.0605	0.0157	0.6681	0.2304	0.3562	0.1274
Variety	1	<.0001	<.0001	<.0001	<.0001	0.0001	<.0001	<.0001	<.0001
Treatment x Variety	10	0.8604	0.2223	0.1272	0.4529	0.7551	0.5674	0.4670	0.7080

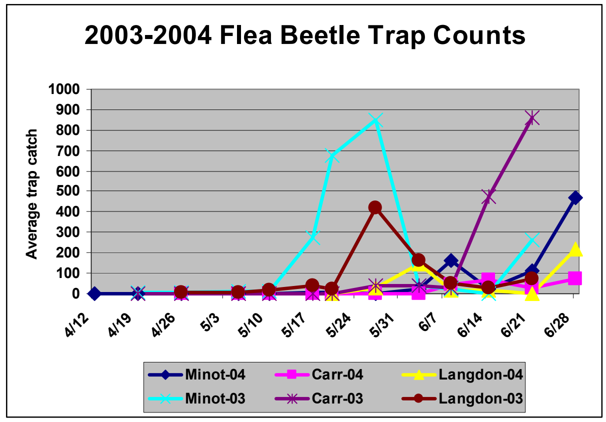
Table 4. Crop Phenology, NDSU Carrington, 2004.

Treatment	Variety	----Days---- 10% Flower	90% Flower	Flower Duration	Maturity	Height in.	Yield lb/bu	Kernel Weight g/1000	Percent Oil
Seed Treatment									
Untreated Gust Fung	---	46.4 a	68.8 ab	22.4	93.8 ab	92.4	2228	3.1	46.8
Capture Once	---	45.1 cde	67.3 d	22.1	91.6 d	93.4	2554	3.2	47.2
Capture Twice	---	44.9 de	67.5 cd	22.6	92.4 bcd	94.5	2510	3.1	47.1
Helix lite	---	45.3 cd	68.8 ab	23.5	93.3 abc	91.9	2414	3.1	47.3
Helix lite + Capture	---	45.1 cde	67.8 bcd	22.6	92.9 abcd	89.4	2357	3.0	47.6
Prosper 200	---	45.8 b	68.9 a	23.1	93.9 ab	93.9	2185	3.1	47.0
Prosper 200 + Capture	---	45.3 cd	67.5 cd	22.3	91.8 cd	90.8	2380	3.1	47.1
Helix xtra	---	44.9 de	68.5 abc	23.6	92.9 abcd	89.9	2471	3.1	46.7
Helix xtra + Capture	---	44.8 e	67.9 abcd	23.1	92.0 cd	95.5	2397	3.1	47.1
Prosper 400	---	45.5 bc	68.9 a	23.4	94.3 a	91.6	2291	3.2	47.1
Prosper 400 + Capture	---	45.1 cde	68.3 abcd	23.1	93.0 abcd	92.5	2382	3.1	46.6
LSD (0.05)	***---***	***0.5***	***1.0***	***NS***	***1.6***	***NS***	***NS***	***NS***	***NS***
Variety									
---	225	46.1	69.9	23.8	93.9	95.0	2142	3.00	47.6
---	357	44.4	66.4	22.0	91.9	89.6	2616	3.2	46.5
t-test	***---***	**	**	**	**	**	**	**	**
Mean	---	45.3	68.2	22.9	92.9	92.3	2379	3.1	47.1
CV (%)	---	1.0	1.5	4.7	1.7	6.7	11.6	3.9	1.4

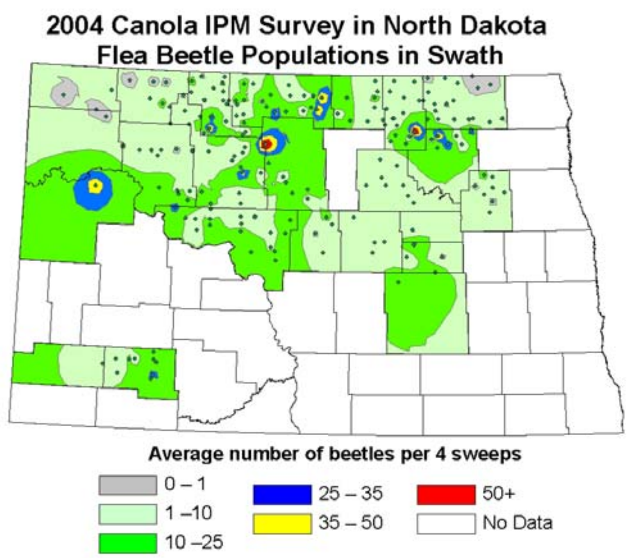
Objective 2 - Spring Flea Beetle Forecasting Model

Spring Flea Beetle Populations:
During 2003 and 2004, the spring emergence of flea beetle was delayed due to the cool, wet early May (Fig. 1 to right). In 2004, flea beetles were ready to emerge as the canola seedlings were emerging in late May and first week of June. This was the major peak of activity, and spring emergence continued until late June. However, flea beetle populations were much lower in 2004 than 2003. There was no strong peak of spring trap catches in 2004 compared to 2003. The average trap catch for 2004 and 2003, respectively, was 13 and 181 beetles per trap day in Minot, 4 and 181 beetles per trap day in Carrington, and 7 and 85 beetles per trap day in Langdon. Overall, flea beetle populations decreased at trap sites. The cool and wet weather caused a prolonged delay in flea beetle emergence and undesirable feeding conditions during spring 2004. This may have also demised the energy reserves of overwintering flea beetles. As a result, overwintering mortality was probably higher than normal in 2004 as well.

Summer Flea Beetle Populations:



A total of 195 fields in 22 counties of North Dakota and nine fields in three counties of Minnesota were surveyed for flea beetles in 2004. Flea beetle populations decreased in 2004 with an average of nine beetles per four sweeps and a high of 39 beetles per four sweeps in North Dakota. In contrast, the 2003 survey averaged 52 beetles per four sweeps and had a high of 185 beetles per four sweeps in North Dakota. The cool summer weather is partially the cause for reduced pressures from flea beetles in canola this past year. Overall, low-moderate populations of flea beetles were found throughout the traditional canola growing regions of North Dakota, such as north central and northeast (see green, blue, and yellow colors on map).



Although the spring infestation risk is lower than the previous year, NDSU Extension continues to recommend that North Dakota canola producers use either an insecticide seed treatment or a planned foliar insecticide spray(s) for protection against flea beetles in 2005. The summer flea beetle survey is intended to provide information about potential "hot spots" of flea beetle activity in the spring of 2005. Forecasting "Pest Alerts" are an important tool of Integrated Pest Management, and producers need to be aware of risk factors, such as, when and how many beetles will be emerging from their overwintering sites and moving into fields. In addition to how many flea beetles will be overwintering, the weather has a big impact on their behavior and their infestation risk in spring-planted canola. For example, cool temperatures and rain in spring will delay flea beetle emergence and suppress movements into fields and subsequent feeding activity (as seen in 2004). Additional flea beetle population and weather data are in the process of being analyzed for the Minot, Langdon, and Carrington field sites.

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