Control of Crucifer Flea Beetle in Canola through Insecticide Strategies and Canola Varieties - 2005

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Abstract

Phyllotreta cruciferae, Crucifer flea beetle, is an important insect pest of spring-planted canola, especially during the seedling stage. Three different varieties of canola, *Brassica napus,* were evaluated: '225' open pollinated and '357' hybrid of Round-up Ready lines, and '4870' Liberty Link InVigor line at the NDSU Research Extension Centers in Minot, Langdon, and Carrington. The low and high rates of two commercially available insecticide seed treatments (thiamethoxam, Helix, from Syngenta and clothianidin, Prosper, from Gustafson/Bayer CropScience), 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/100 kg seed) seed treatment, Helix lite (200 g ai/100 kg seed) seed treatment plus Capture applied once, Prosper low (200 g ai/100 kg seed) seed treatment, Prosper low (200 g ai/100 kg seed) seed treatment plus Capture applied once, Helix xtra (400 g ai/100 kg seed) seed treatment, Helix xtra (400 g ai/100 kg seed) seed treatment plus Capture applied once, Prosper high (400 g ai/100 kg seed) seed treatment, and Prosper high (400 g ai/100 kg seed) seed treatment plus Capture applied once. Overall, low-moderate populations of flea beetles were found at the field research sites and throughout the traditional canola growing regions of North Dakota in 2005, such as north central and northeast. Results show that plant stand counts were affected more by variety differences than insecticide treatments. Percent injured plantss (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 injury 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 sustained by plant. In general, the high rates of seed treatments, high/low rate of seed treatment plus a foliar spray, and foliar insecticide applied twice performed better than low rates of seed treatments, foliar insecticide applied once and the untreated check. Differences observed in crop phenology measurements, like flowering dates, maturity dates and crop height were primarily attributed to varietal differences. Nevertheless, some of the insecticide treatments had a shorter duration 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 treatments. However, the reduced flea beetle pressures were partially attributed to the small differences in yield among treatments. In conclusion, 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.

Introduction

Canola is an oil seed plant belonging to the Cruciferae family (Brassicaceae) (Knodel and Berglund 2005). Canola has become a popular oilseed cash crop in North Dakota. North Dakota leads the United States in canola production with approximately 88 percent of the domestic production. Canola acreage has increased rapidly in North Dakota over the past ten years, with harvested acreage in North Dakota increasing from 15,000 A in 1991 to 1,040,000 A in 2005 (USDA NASS). The highest acreage planted in North Dakota was in 2002 with 1.3 million acres reported (USDA NASS). Statewide yields have averaged from 1250 to 1500 pounds per acre over the past 5 years. Canola provides an important broadleaf crop option for rotation with small grains in North Dakota. The importance of rotating different crops to reduce disease pressures, coupled with the food and biodiesel market demand for canola, makes canola a vital 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 (Knodel and Olson 2005, Weiss et al. 1991).

Flea beetles have a single generation in the northern U.S (Knodel and Olson 2002). 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. Adult feeding on the cotyledon stages of the crop accounts for the greatest crop loss (Knodel and Olson 2002). Adult flea beetles move readily from overwintering sites and infestations often quickly spread from plant to plant throughout the field. 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. Flea beetle feeding injury causes leaf tissues of the cotyledons to die, which produces a shot-hole appearance. Warm, dry weather promotes flea beetle feeding activity, while simultaneously slowing canola growth. Therefore, sunny, warm conditions often result in heavier feeding injury. When flea beetle populations are heavy and weather favorable for feeding, entire fields can be lost as canola seedlings wilt and die. This may result in producers having to reseed the field. Less severe infestations may result in stunting, uneven stands, uneven maturation causing harvest problems, and yield loss (Knodel and Olson 2005).

Canola has the ability to compensate for defoliation; field stands can re-establish even after 75% 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 et al. 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 (Knodel and Olson 2002). In addition, foliar treatments applied in response to pest populations can be effective if properly timed (Weiss et al. 1991). 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 and interactions with different insecticide strategies. Therefore, our objective was to determine the most effective insecticide strategy in different canola varieties for control of the crucifer flea beetle at three different areas (Minot, Langdon, and Carrington) of canola production. This provided valuable information across the state of North Dakota for canola producers.

Materials and Methods

Trials were conducted in research plots located at the NDSU Research Extension Centers in Minot, Langdon, and Carrington. Three different varieties of canola, *Brassica napus,* were evaluated: '225' open pollinated, '357' hybrid of Round-up Ready lines, and '4870' Liberty Link InVigor line. Canola was seeded on May 11, 2005 in Minot, May 16, 2005 in Carrington, and May 17, 2005 in Langdon. The seeding rate was approximately 14-17 pure live seeds per sq. foot. Experimental units were 3.5-4.1 ft. (7 rows) x 20-22 ft, and arranged in a RCB design with four replicates. The low and high rates of two commercially available insecticide seed treatments were evaluated: thiamethoxam (Helix) from Syngenta and clothianidin (Prosper) from Gustafson/Bayer CropScience. 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, and a foliar insecticide applied once and twice. The following insecticide seed treatments were evaluated for each variety for a total of 33 treatments:

1) Untreated check
2) Capture once
3) Capture twice
4) Helix lite (200 g ai/100 kg seed) seed treatment
5) Helix lite (200 g ai/100 kg seed) seed treatment plus Capture applied once
6) Prosper low (200 g ai/100 kg seed) seed treatment
7) Prosper low (200 g ai/100 kg seed) seed treatment plus Capture applied once
8) Helix xtra (400 g ai/100 kg seed) seed treatment
9) Helix xtra (400 g ai/100 kg seed) seed treatment plus Capture applied once
10) Prosper high (400 g ai/100 kg seed) seed treatment
11) Prosper high (400 g ai/100 kg seed) 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 7 days after the first spray.

To evaluate flea beetle damage, assessments were taken at three times (14-16, 22-24 and 29-33 days after planting (DAP)) using the following techniques:

1) 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 injured plants. Any plant with pitting or other feeding punctures was considered damaged. This also provided a plant stand count (# plants/sq. foot).
2) 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

3) 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 the third assessment (29-33 DAP), one more visual injury 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 to end of 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) or Liberty (28 fl oz/A) + AMS was applied for weed control early in the season. No Ronilan (12 oz/a) application was necessary for disease control during 2005. Best management practices were used regarding fertility and harvest operations. Plots were harvested on August 10, 2005 in Minot, August 12, 2005 in Carrington, and August 30, 2005 in Langdon. Yield (lbs/a), test weight (lb/bu), kernel weight (gm/1000 seeds) and percent oil 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).

Results and Discussion

Plant Stand, Percent Injured plants, Injury Ratings and Dry Weight for 14-16 DAP (Table 1-3):

For plant stand at Minot, only Capture once had significantly lower plants per square foot than the untreated check and the other insecticide treatments. At Carrington and Langdon, none of the treatments were significantly different from the untreated check. Variety 4870 had a significantly higher plant stand counts than variety 357 and 225, and variety 357 had higher plant stand counts than variety 225, regardless of site. [Note: Variety 357 had to be dropped from data analyses at Carrington, because of sulfur deficiency in plot.] This indicates that plant stand count was affected more by variety differences than insecticide treatments.

For percent injured plants (or percent of plant injured by flea beetles), all of the treatments except Capture once and twice had a significantly lower percent injured plants compared to the untreated check at Minot and Carrington. All of the treatments except Capture once, Capture twice and Helix lite had a lower percent injured plants than the untreated check at Langdon. Variety 4870 had a lower percent injured plant than variety 225 at Carrington; in contrast, variety 4870 had a slightly higher percent injured plant than 225 at Langdon. However, there were no differences between varieties at Minot. This indicates that insecticide treatments had a direct influence on the percent of plants injured, but not variety. At Carrington, there was a significant treatment x variety interaction.

Flea beetle pressure was light at all sites with a mean of 1.3 for the first injury rating. All insecticide treatments had a significantly lower injury rating compared to the untreated check at

Minot and Langdon. At Carrington, all insecticide treatments also had a significantly lower injury rating compared to the untreated check, Capture once and Capture twice. Variety 4870 had significantly lower injury rating than variety 225 at Carrington and variety 357 at Langdon. At Minot, differences were not significant between varieties, and there was a significant treatment x variety interaction.

At Minot, none of the insecticide treatments had significantly higher shoot dry weight than the untreated check. The Helix xtra + Capture treatment at Carrington had a highest shoot dry weight and was significantly higher than the untreated check, Capture once and Helix lite + Capture. Similarly at Langdon, Helix xtra and Helix lite had significantly higher shoot dry weight than the untreated check and Capture once. At Minot and Langdon, variety 357 had significantly higher shoot dry weights than variety 4870 and 225, and variety 4870 higher than variety 225. At Carrington, variety 4870 also had higher shoot dry weights than variety 225. These data suggest that seed treatment and variety are important factors in shoot dry weight, which is an important indicator of "plant vigor."

Plant Stand, Percent injured plants, Injury Ratings and Dry Weight for 22-24 DAP (Table 1-3):

For the second assessment date, data was not collected at Langdon since plots were too wet to walk in without damaging plant stands.

At Minot, only Helix lite had significantly higher plant stand counts than the untreated check. There were no differences among treatments from the untreated check at Carrington. However, variety 4870 had a significantly higher plant stands than variety 357 and 225 at Minot and Carrington. These results are similar to what was observed for the first assessment date, and indicate that plant stand count was affected more by variety differences than insecticide seed treatments. At Minot, there was a significant treatment x variety interaction.

At Minot, all insecticide treatments except for Capture once and Capture twice had a significantly lower injury rating than the untreated check. However at Carrington, all insecticide treatment had lower percent injured plants of injured plants than the untreated check. Although not always significant, the insecticide seed treatment plus the foliar Capture applied at 21 DAP had lower percent injured plants than the insecticide seed treatment alone. This suggests that this foliar spray provided additional protection against flea beetles as the residual of the seed treatments was diminishing, and resulted in lower percent injured plants. There were no differences in percent injured plants between varieties at Minot. However, variety 4870 had significantly lower percent injured plants than variety 225 at Carrington.

The second visual damage ratings were taken on 22-24 DAP and flea beetle pressures continued to be light with a mean injury rating of 1.1 across field sites. At Minot and Carrington, all treatments had significantly lower injury ratings than the untreated check. All seed treatments also had significantly lower injury ratings than the Capture once and Capture twice. The two Capture treatments were not significantly difference from each other. At Carrington, variety 4870 had a significantly lower injury rating than variety 225. There were no significant differences among varieties at Minot. At Carrington, there was a significant interaction between treatment x variety. These results indicated that insecticide strategy as well as variety influence injury ratings.

For shoot dry weight at 22-24 DAP, only the Helix xtra treatment had a significantly higher weight than the untreated check at Minot. At Carrington, the following treatments also had a significantly higher weight than the untreated check (ranked highest to lowest): Helix xtra + Capture, Helix xtra, Helix lite, Capture twice, and Prosper 400. Among varieties, variety 4870 and 357 had a significantly higher weight than variety 225 at Minot and Carrington (minus variety 357). These results are similar to shoot dry weights taken earlier in plant development at the first assessment, and indicate that seed treatment and variety are important factors affecting overall plant vigor

Injury Rating and Percent Coverage for 29-33 DAP (Table 1-3):

Since dry weight was not taken during the second assessment at Langdon due to wet plots, plants were collected on the third assessment. All insecticide treatments had a significantly higher dry weight than the untreated check, except for Capture once, Helix lite and Helix lite + Capture. Variety 357 had significantly higher dry weight than varieties 4870 and 225. Variety 4870 also had a higher dry weight than variety 225. These results were similar to those at Minot and Carrington collected during the second assessment.

For the third assessment of flea beetle injury rating, all insecticide 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 injury rating; then, the low rate of seed treatment plus foliar sprays, Capture twice, low rate of seed treatment and Capture once. Again, it is interesting to note the insecticide seed treatment plus the foliar Capture spray at 21 DAP usually had lower injury rating than the insecticide seed treatment alone. For varieties, variety 4870 and 225 had a significantly lower injury rating than variety 357 regardless of the site. Variety 4870 also had a significantly lower injury rating than variety 357 at Langdon. Again, these results indicated that treatment and variety affect plant injury caused by flea beetles. This explains the significant interaction between treatment x variety at all sites.

For percent coverage, all insecticide treatments had a significantly higher percent of land area covered than the untreated check at all sites, except for Helix lite + Capture at Carrington. There were small differences between insecticide treatments due to the light flea beetle pressures with injury rating ranging from 1.2 to 2. In general, the high rates of seed treatments, high/low rate of seed treatment plus a foliar spray, and Capture twice had higher percent coverage than low rates of seed treatments, Capture once, and untreated check. For varieties, variety 4870 and 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 level of crop injury sustained by plant.

Crop Phenology (Table 4-6):

For flowering data, there were small differences among treatments for 10% flower, 90% flower, flower duration, maturity, and crop height. No consistent trends were evident among treatment and sites. However in some cases, the insecticide treatments were earlier to flower. Flower duration and maturity were often similar between insecticide treatments and the untreated check. Variety 4870 and 357 usually had a significantly shorter period to 10% flower, 90% flower and flower duration, and a taller plant than variety 225, regardless of site. However, variety 4870 had a significantly longer maturity period than variety 357 and 225 at Carrington and Langdon. It was not significantly different at Minot. The differences observed in crop phenology measurements were primarily attributed to varietal differences. The insecticide treatments did appear to decrease the period to 10% and 90% flower; however, these differences were not consistent across site.

Agronomic Data (Table 4-6):

At Minot, all insecticide treatments had a significantly higher yield than the untreated check, except for Helix lite, Prosper 200, Prosper 400 and Prosper 400 + Capture. Results were similar at Carrington with all insecticide treatments having a significantly higher yield than the untreated check, except for Capture once, Helix lite, Prosper 200 and Prosper 400. For Langdon, only Prosper 200 + Capture had a significantly higher yield than the untreated check. There were small differences among treatments for test weight, kernel weight and percent oil data, and no consistent trends were evident among treatment and sites. Variety 4870 had significantly higher yield, test weight and kernel weight than variety 357 and 225. Percent oil

was also higher for variety 4870 than varieties 357 and 225 at Carrington and Langdon. These data indicate that yield, kernel weight, and percent oil are more strongly influenced by variety than insecticide treatments. Since spring flea beetle populations were low in 2005, it made it difficult to detect agronomic data differences between treatments. There was a significant treatment x variety interaction for test weight at Minot and percent oil at Carrington.

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Table 1. Analysis of variance P-values in the response of two canola cultivars to flea beetle control treatments trial, NDSU Minot, 2005.

		14 DAP[1]				22 DAP[1]				30 DAP[1]	
Source of Variation	df	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Injury Rating[2]	% Coverage
Rep	3	0.4333	0.0026	0.3359	0.098	0.6789	0.1151	0.0400	0.0001	<.0001	<.0001
Treatment	10	0.0767	0.0006	<.0001	0.4375	0.1448	<.0001	<.0001	0.0078	<.0001	<.0001
Variety	2	<.0001	0.3356	0.0197	<.0001	<.0001	0.2329	0.2446	<.0001	<.0001	<.0001
Treatment x Variety	20	0.0249	0.6183	0.001	0.2951	0.0468	0.0015	0.1112	0.7258	<.0001	0.3439

Table 1. Response of two canola cultivars to flea beetle control treatments, NDSU Minot, 2005.

		14 DAP[1]				22 DAP[1]				30 DAP[1]	
Treatment	Variety	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Injury Rating[2]	% Coverage
Untreated Gust Fung	---	15.1 ab	5.8 a	1.5 a	0.070 ab	11.5 bc	40.3 a	1.6 a	0.232 bcd	3.6 a	36.3 f
Capture Once	---	13.0 c	5.3 a	1.0 c	0.072 ab	11.8 abc	43.7 a	1.3 b	0.218 bcd	1.8 e	50.0 bc
Capture Twice	---	13.5 bc	7.8 a	1.2 b	0.068 b	11.6 bc	32.8 a	1.3 b	0.201 d	1.5 ef	53.3 b
Helix lite	---	15.4 ab	1.4 b	1.0 c	0.074 ab	14.2 a	8.8 b	1.0 c	0.234 bc	2.9 b	42.9 e
Helix lite + Capture	---	15.7 a	1.5 b	1.0 c	0.072 ab	11.2 c	7.1 b	1.0 c	0.206 cd	1.3 fg	53.8 b
Prosper 200	---	15.6 a	1.0 b	1.0 c	0.072 ab	13.3 abc	5.8 b	1.0 c	0.217 bcd	2.9 b	43.3 de
Prosper 200 + Capture	---	15.6 ab	1.2 b	1.0 c	0.074 ab	13.1 abc	9.3 b	1.1 c	0.223 bcd	1.3 fg	53.8 b
Helix xtra	---	14.1 abc	1.2 b	1.0 c	0.077 a	11.3 c	6.9 b	1.0 c	0.270 a	2.2 d	48.3 c
Helix xtra + Capture	---	16.0 a	0.8 b	1.0 c	0.074 ab	11.3 c	13.3 b	1.0 c	0.240 ab	1.1 g	59.2 a
Prosper 400	---	14.3 abc	1.0 b	1.0 c	0.074 ab	14.0 ab	7.8 b	1.0 c	0.220 bcd	2.5 c	47.9 cd
Prosper 400 + Capture	---	15.3 ab	0.8 b	1.0 c	0.071 ab	12.0 abc	8.7 b	1.0 c	0.231 bcd	1.2 g	59.6 a
LSD (0.05)	***---***	***2.09***	***3.71***	***0.14***	***0.007***	***2.56***	***12.9***	***0.2***	***0.032***	***0.4***	***4.7***
Variety											
---	225	10.9 a	3.1	1.1 ab	0.050 a	9.6 a	15.1	1.1	0.150 a	2.6 b	38.8 a
---	357	13.8 b	2.7	1.1 ab	0.090 c	11.2 b	20.2	1.2	0.261 b	1.8 a	51.8 b
---	4870	19.9 c	1.7	1.0 a	0.08 b	16.2 c	15.1	1.1	0.268 b	1.7 a	59 c
LSD (0.05)	***---***	***1.09***	***NS***	***0.07***	***0.004***	***1.34***	***NS***	***NS***	***0.02***	***0.17***	***2.5***
Mean	***---***	***14.9***	***2.5***	***1.1***	***0.07***	***12.3***	***16.8***	***1.1***	***0.226***	***2.0***	***49.9***
CV (%)	***---***	***17.3***	***182.4***	***15.8***	***11.8***	***25.7***	***95.1***	***19.7***	***17.5***	***19.6***	***11.7***

Means within a column followed by the same letter are not significantly different (P < 0.05); NS = not significant.

[1] DAP = Days After Planting

[2] Injury Rating: 1 = 0-3, 2 = 4-9, 3 = 10-15, 4 = 16-25, 5 = >25 pits per seedling, and 6 = dead seedling.

Table 2. Analysis of variance P-values in the response of two canola cultivars to flea beetle control treatments trial, NDSU Carrington, 2005.

		15 DAP[1]				24 DAP[1]				33 DAP[1]	
Source of Variation	df	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Injury Rating[2]	% Coverage
Rep	3	0.7554	0.7530	0.5505	0.4870	0.2477	0.1850	0.2966	0.1156	0.8027	0.0019
Treatment	10	0.4906	<.0001	<.0001	0.2727	0.0885	0.0002	<.0001	0.0567	<.0001	0.0241
Variety	2	<.0001	<.0001	0.0003	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Treatment x Variety	20	0.6257	0.0042	0.1143	0.7557	0.3935	0.6589	<.0001	0.0059	0.0002	0.4675

Table 2. Response of two canola cultivars to flea beetle control treatments, NDSU Carrington, 2005.

		15 DAP[1]				24 DAP[1]				33 DAP[1]	
Treatment	Variety	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Injury Rating[2]	% Coverage
Untreated Gust Fung	---	23.7 ab	24.8 b	2.1 a	0.237 b	31.4 abc	51.9 a	1.8 a	1.832 c	2.2 a	82.5 b
Capture Once	---	23.0 ab	41.8 a	2.1 a	0.237 b	33.4 ab	31.8 b	1.3 b	2.290 abc	1.1 b	89.4 a
Capture Twice	---	23.2 ab	24.6 b	1.9 a	0.280 ab	34.0 a	22.0 bc	1.3 b	2.496 ab	1.1 b	91.9 a
Helix lite	---	22.5 b	9.1 c	1.1 b	0.262 ab	27.6 c	26.4 bc	1.0 c	2.501 ab	1.1 b	93.8 a
Helix lite + Capture	---	22.4 b	8.4 c	1.1 b	0.245 b	30.2 abc	19.1 bc	1.0 c	2.100 bc	1.1 b	88.8 ab
Prosper 200	---	22.7 b	6.1 c	1.3 b	0.256 ab	31.2 abc	25.5 bc	1.0 c	2.227 bc	1.1 b	92.5 a
Prosper 200 + Capture	---	24.3 ab	10.0 c	1.1 b	0.270 ab	28.7 c	25.0 bc	1.0 c	2.124 bc	1.0 b	90.0 a
Helix xtra	---	22.0 b	7.3 c	1.0 b	0.278 ab	31.0 abc	19.5 bc	1.0 c	2.589 ab	1.0 b	95.0 a
Helix xtra + Capture	---	22.5 b	10.8 c	1.1 b	0.305 a	27.7 c	14.3 c	1.0 c	2.833 a	1.0 b	93.8 a
Prosper 400	---	27.0 ab	8.6 c	1.1 b	0.255 ab	29.5 abc	26.4 bc	1.0 c	2.471 ab	1.0 b	93.8 a
Prosper 400 + Capture	---	22.2 b	7.4 c	1.1 b	0.254 ab	29.0 bc	16.0 c	1.0 c	2.352 abc	1.0 b	92.5 a
LSD (0.05)	***---***	***4.1***	***9.9***	***0.3***	***0.1***	***4.5***	***14.2***	***0.4***	***0.556***	***0.2***	***6.6***
Variety											
---	225	18.5 a	19.9 b	1.5 b	0.210 a	26.1 a	32.3 b	1.2 b	1.929 a	1.2 b	85.7 a
---	357	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
---	4870	27.9 b	8.9 a	1.2 a	0.313 b	34.5 b	18.2 a	1.1 a	2.77 b	1.1 a	96.8 b
LSD (0.05)	***---***	***1.8***	***4.2***	***0.1***	***0.02***	***1.9***	***6.0***	***0.1***	***0.2***	***0.1***	***2.8***
Mean	***---***	***23.2***	***14***	***1.4***	***0.262***	***30.3***	***25.2***	***1.1***	***2.347***	***1.2***	***91.3***
CV (%)	***---***	***17.6***	***68.3***	***23.3***	***19.8***	***14.8***	***56.1***	***14.5***	***23.7***	***15.4***	***7.2***

Means within a column followed by the same letter are not significantly different (P < 0.05); NS = not significant.

[1] DAP = Days After Planting

[2] Injury Rating: 1 = 0-3, 2 = 4-9, 3 = 10-15, 4 = 16-25, 5 = >25 pits per seedling, and 6 = dead seedling.

Table 3. Analysis of variance P-values in the response of two canola cultivars to flea beetle control treatments trial, NDSU Langdon, 2005.

		16 DAP[1]				22 DAP[1]			29 DAP[1]	29 DAP[1]	
Source of Variation	df	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Injury Rating[2]	% Coverage
Rep	3	0.0342	0.256	0.0408	0.3853				<.0001	0.0031	<.0001
Treatment	10	0.6538	7E-04	<.0001	0.1437	No Data	No Data	No Data	0.3076	<.0001	0.0013
Variety	2	<.0001	2E-04	0.0262	<.0001				<.0001	<.0001	<.0001
Treatment x Variety	20	0.0855	0.987	0.9623	0.9560				0.8825	0.0021	0.9648

Table 3. Response of two canola cultivars to flea beetle control treatments, NDSU Langdon, 2005.

		16 DAP[1]				22 DAP[1]			29 DAP[1]	29 DAP[1]	
Treatment	Variety	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Plant Stand Pl/ft[2]	% Injured Plants	Injury Rating[2]	Dry Wt g/10 pl	Injury Rating[2]	% Coverage
Untreated Gust Fung	---	13.1 ab	55.3 a	2.1 a	0.366 b				4.700 b	2.1 a	82.1 b
Capture Once	---	12.6 ab	54.4 a	1.8 b	0.366 b				5.651 ab	1.4 bcd	89.6 a
Capture Twice	---	12.8 ab	45.4 ab	1.4 cd	0.376 ab				6.110 a	1.2 def	89.4 a
Helix lite	---	12.9 ab	44.7 abc	1.5 c	0.412 a				5.900 ab	1.5 bc	88.8 a
Helix lite + Capture	---	12.5 ab	40.1 bcd	1.3 cde	0.397 ab				5.871 ab	1.1 ef	91.7 a
Prosper 200	---	13.9 a	36.5 bcd	1.4 cd	0.394 ab	No Data	No Data	No Data	6.478 a	1.6 b	89.6 a
Prosper 200 + Capture	---	12.3 b	29.7 d	1.4 cd	0.382 ab				6.210 a	1.1 ef	90.0 a
Helix xtra	---	12.4 ab	30.5 d	1.0 e	0.414 a				6.169 a	1.1 f	89.6 a
Helix xtra + Capture	---	13.3 ab	37.3 bcd	1.2 de	0.401 ab				6.276 a	1.2 def	91.3 a
Prosper 400	---	13.6 ab	31.7 cd	1.2 de	0.398 ab				6.250 a	1.3 ced	90.0 a
Prosper 400 + Capture	---	13.2 ab	34.0 bcd	1.3 cde	0.378 ab				6.238 a	1.1 ef	90.3 a
LSD (0.05)	***---***	***1.7***	***13.6***	***0.27***	***0.038***				***1.246***	***0.2***	***3.9***
Variety											
---	225	10.9 a	32.4 a	1.5 b	0.273 a				4.568 a	1.6 c	79.8 a
---	357	12.6 b	47.7 c	1.4 ab	0.488 c				7.275 c	1.3 b	94.2 b
---	4870	15.4 c	39.7 b	1.3 a	0.408 b				6.116 b	1.1 a	93.9 b
LSD (0.05)	***---***	***0.87***	***7.1***	***0.14***	***0.02***				***0.651***	***0.119***	***2.06***
Mean	***---***	***13.0***	***40***	***1.4***	***0.4***				***5.986***	***1.3***	***89.3***
CV (%)	***---***	***15.7***	***42.1***	***24.3***	***12.0***				***25.7***	***20.8***	***5.4***

Means within a column followed by the same letter are not significantly different (P < 0.05); NS = not significant.

[1] DAP = Days After Planting

[2] Injury Rating: 1 = 0-3, 2 = 4-9, 3 = 10-15, 4 = 16-25, 5 = >25 pits per seedling, and 6 = dead seedling.

Table 4. Crop Phenology, NDSU Minot, 2005.

Source of Variation	df	10% Flower DAP[1]	90% Flower DAP[1]	Flower Duration Days	Maturity Days	Height in.	Yield lb/acre	Test Weight lb/bu	Kernel Weight g/1000	Percent Oil
Rep	3	0.0352	0.0008	0.0146	..	0.0682	0.0061	0.0001	0.0177	0.1562
Treatment	10	<.0001	0.1128	0.7461	..	0.1979	0.0037	0.3852	0.1325	0.0085
Variety	1	<.0001	<.0001	<.0001	..	<.0001	<.0001	<.0001	<.0001	<.0001
Treatment x Variety	10	<.0001	0.2282	0.6732	..	0.0544	0.5659	0.0154	0.6115	0.1196

Table 4. Crop Phenology, NDSU Minot, 2005.

Treatment	Variety	10% Flower DAP[1]	90% Flower DAP[1]	Flower Duration Days	Maturity Days	Height in.	Yield lb/acre	Test Weight lb/bu	Kernel Weight g/1000	Percent Oil
Untreated Gust Fung	---	49.6 a	69.9 a	20.3 a	85.0	71.8 abc	1370.8 cd	51.5 ab	3.0 abc	44.9 e
Capture Once	---	48.3 cd	69.0 abc	20.8 a	85.0	73.6 ab	1636.2 ab	51.7 a	3.0 c	45.4 abcd
Capture Twice	---	48.0 d	68.7 bc	20.7 a	85.0	71.4 abc	1594.6 ab	51.4 b	3.0 abc	45.5 a
Helix lite	---	48.8 bc	69.6 ab	20.8 a	85.0	70.6 bc	1369.2 d	51.5 ab	3.1 abc	45.1 bcde
Helix lite + Capture	---	48.0 d	68.7 bc	20.7 a	85.0	67.5 c	1582.4 ab	51.5 ab	3.0 abc	45.2 abcde
Prosper 200	---	49.0 b	69.7 ab	20.7 a	85.0	70.2 bc	1354.2 d	51.5 ab	3.1 a	45.2 abcde
Prosper 200 + Capture	---	48.0 d	68.7 bc	20.7 a	85.0	71.8 abc	1694.9 a	51.4 b	3.0 bc	45.5 a
Helix xtra	---	48.0 d	69.0 abc	21.0 a	85.0	75.5 a	1635.8 ab	51.6 ab	3.1 abc	45.0 cde
Helix xtra + Capture	---	48.0 d	69.3 abc	21.3 a	85.0	71.8 abc	1640.1 ab	51.5 ab	3.0 bc	45.0 de
Prosper 400	---	48.3 cd	69.3 abc	21.1 a	85.0	70.6 bc	1477.5 bcd	51.5 ab	3.0 abc	45.5 ab
Prosper 400 + Capture	---	48.0 d	68.3 c	20.3 a	85.0	70.6 bc	1575.2 abc	51.6 ab	3.1 ab	45.4 abc
LSD (0.05)	***---***	***0.57***	***1.1***	***NS***	***NS***	***4.77***	***205.89***	***0.22***	***0.12***	***0.41***
Variety										
---	225	48.8 b	70.6 b	21.8 b	85.0	61.9 a	996.2 a	51.3 a	3.0 b	45.9 b
---	357	48.0 a	68.2 a	20.2 a	85.0	64.4 b	1419.7 b	51.2 a	3.2 c	43.9 a
---	4870	48.2 a	68.6 a	20.3 a	85.0	87.9 c	2201.6 c	52.1 b	2.9 a	45.9 b
LSD (0.05)	***---***	***0.3***	***0.58***	***0.54***	***NS***	***2.5***	***107.52***	***0.11***	***0.06***	***0.21***
Mean	***---***	***48.4***	***69.1***	***20.8***	***85.0***	***71.4***	***1539.2***	***51.5***	***3.0***	***45.2***
CV (%)	***---***	***1.5***	***2.0***	***6.1***	***0.0***	***8.2***	***16.5***	***0.5***	***4.9***	***1.1***

Means within a column followed by the same letter are not significantly different (P < 0.05); NS = not significant.

[1] DAP = Days After Planting

Table 5. Crop Phenology, NDSU Carrington, 2005.

Source of Variation	df	10% Flower DAP[1]	90% Flower DAP[1]	Flower Duration Days	Maturity Days	Height in.	Yield lb/bu	Test Weight lb/bu	Kernel Weight g/1000	Percent Oil
Rep	3	0.2370	0.3941	0.1872	<.0001		<.0001	0.0047	0.8787	0.0077
Treatment	10	0.2852	0.7209	0.4989	<.0001	No Data	<.0001	0.5647	<.0001	0.0007
Variety	2	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
Treatment x Variety	20	0.8948	0.8525	0.7448	0.0273		0.1867	0.2526	0.5420	0.0139

Table 5. Crop Phenology, NDSU Carrington, 2005.

Treatment	Variety	10% Flower DAP[1]	90% Flower DAP[1]	Flower Duration Days	Maturity Days	Height in.	Yield lb/bu	Test Weight lb/bu	Kernel Weight g/1000	Percent Oil
Untreated Gust Fung	---	40.5 a	61.6 a	21.1 ab	78.4 a		2026.9 e	51.8 ab	2.7 a	45.3 a
Capture Once	---	39.9 ab	59.9 a	20.0 b	77.4 bc		2132.9 de	51.7 b	2.4 d	43.9 cd
Capture Twice	---	39.6 b	60.3 a	20.6 ab	78.8 a		2499.4 a	52.1 ab	2.5 cd	44.7 abc
Helix lite	---	39.8 b	60.3 a	20.5 ab	77.0 c		2175.8 cde	52.1 ab	2.5 cd	43.7 d
Helix lite + Capture	---	39.9 ab	61.0 a	21.1 ab	78.0 ab		2289.3 bcd	51.9 ab	2.5 cd	45.1 ab
Prosper 200	---	39.8 b	61.4 a	21.6 a	77.1 c	No Data	2132.0 de	51.9 ab	2.5 bc	44.8 ab
Prosper 200 + Capture	---	39.8 b	61.1 a	21.4 ab	78.0 ab		2275.5 cd	52.2 a	2.5 cd	44.8 ab
Helix xtra	---	39.5 b	60.6 a	21.1 ab	76.9 c		2305.9 abcc	52.3 a	2.5 bcd	43.7 d
Helix xtra + Capture	---	39.6 b	61.3 a	21.6 a	78.1 ab		2483.9 ab	52.1 ab	2.5 bc	44.7 abc
Prosper 400	---	39.5 b	60.3 a	20.8 ab	77.0 c		2111.5 de	52.1 ab	2.6 ab	44.4 bcd
Prosper 400 + Capture	---	39.8 b	60.4 a	20.6 ab	78.4 a		2335.4 abc	52.0 ab	2.5 cd	45.1 ab
LSD (0.05)	***---***	***0.7***	***NS***	***1.5***	***0.9***		***202.2***	***0.6***	***0.1***	***0.8***
Variety										
---	225	38.1 a	59.8 a	21.7 b	76.6 a		1851 a	51.7 a	2.4 a	43.8 a
---	357	No Data	No Data	No Data	No Data		No Data	No Data	No Data	No Data
---	4870	41.5 b	61.7 b	20.2 a	78.8 b		2652.8 b	52.4 b	2.6 b	45.4 b
LSD (0.05)	***---***	***0.3***	***0.8***	***0.6***	***0.4***		***86.2***	**0.2**	***0.04***	***0.4***
Mean	***---***	***39.8***	***60.7***	***21.0***	***77.7***		***2252***	***52.0***	***2.5***	***44.6***
CV (%)	***---***	***1.7***	***3.2***	***7.0***	***1.1***		***9.0***	***1.1***	***3.9***	***1.9***

Means within a column followed by the same letter are not significantly different (P < 0.05); NS = not significant.

[1] DAP = Days After Planting

Table 6. Crop Phenology, NDSU Langdon, 2005.

Source of Variation	df	10% Flower DAP[1]	90% Flower DAP[1]	Flower Duration Days	Maturity Days	Height in.	Yield lb/bu	Test Weight lb/bu	Kernel Weight g/1000	Percent Oil
Rep	3	0.5607	0.0007	0.0013	<.0001	0.987	0.3046	0.2253	0.0023	0.0005
Treatment	10	0.0953	0.1125	0.1729	0.2265	0.6480	0.1016	0.3463	0.1626	0.3367
Variety	2	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Treatment x Variety	20	0.3118	0.5408	0.6921	0.9916	0.6731	0.0785	0.4107	0.0695	0.3473

Table 6. Crop Phenology, NDSU Langdon, 2005.

Treatment	Variety	10% Flower DAP[1]	90% Flower DAP[1]	Flower Duration Days	Maturity Days	Height in.	Yield lb/bu	Test Weight lb/bu	Kernel Weight g/1000	Percent Oil
Untreated Gust Fung	---	43.0 a	61.1 a	18.1 b	89.5 abc	108.5 ab	2906.4 bcd	50.9 a	3.4 abc	42.6 abc
Capture Once	---	42.7 abc	61.3 a	18.6 ab	89.5 abc	108.3 ab	2873 d	50.7 ab	3.4 abc	42.4 abc
Capture Twice	---	42.3 bc	61.1 a	18.8 a	89.1 c	109.4 ab	2960.2 abcd	50.8 a	3.4 abc	42.7 ab
Helix lite	---	42.2 c	60.5 b	18.3 ab	89.3 bc	106.5 b	2953 abcd	51.0 a	3.4 bc	42.4 abc
Helix lite + Capture	---	42.4 abc	61.0 a	18.6 ab	89.3 abc	109.8 a	2999 abcd	51.0 a	3.4 abc	41.7 bc
Prosper 200	---	42.8 ab	61.3 a	18.5 ab	89.8 ab	107.8 ab	3030.1 abc	50.7 ab	3.5 a	42.8 a
Prosper 200 + Capture	---	42.8 abc	61.3 a	18.5 ab	89.9 a	109.1 ab	3079.2 a	50.9 a	3.5 ab	41.6 c
Helix xtra	---	42.7 abc	61.1 a	18.4 ab	89.5 abc	109.0 ab	2988.7 abcd	50.8 ab	3.5 ab	42.2 abc
Helix xtra + Capture	---	42.4 abc	61.0 ab	18.5 ab	89.4 abc	108.8 ab	3046 ab	50.1 b	3.4 ab	42.1 abc
Prosper 400	---	42.8 ab	61.0 a	18.2 b	89.1 c	108.8 ab	2882.9 cd	51.0 a	3.4 abc	42.0 abc
Prosper 400 + Capture	---	42.3 bc	61.1 a	18.8 a	89.3 abc	109.6 a	3048.3 ab	51.0 a	3.3 c	42.2 abc
LSD (0.05)	***---***	***0.6***	***0.5***	***0.5***	***0.6***	***2.9***	***152.7***	***0.7***	***0.1***	***1.0***
Variety										
---	225	41.1 b	60.3 b	19.2 c	88.5 a	97.8 a	2730.3 a	51.0 b	3.3 a	43.5 c
---	357	40.4 a	59.0 a	18.6 b	88.5 a	96.6 a	2992.3 b	48.8 a	3.5 c	41.2 a
---	4870	46.2 c	63.8 c	17.6 a	91.2 b	131.6 b	3213.8 c	52.6 c	3.4 b	42 b
LSD (0.05)	***---***	***0.31***	***0.26***	***0.27***	***0.32***	***1.53***	***79.8***		***0.05***	***0.53***
Mean	***---***	***42.6***	***61.1***	***18.5***	***89.4***	***108.7***	***2978.8***	***50.8***	***3.4***	***42.2***
CV (%)	***---***	***1.7***	***1.0***	***3.5***	***0.9***	***3.3***	***6.3***	***1.6***	***3.3***	***3.0***

Means within a column followed by the same letter are not significantly different (P < 0.05); NS = not significant.

[1] DAP = Days After Planting