Control of Blackleg of Canola

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by

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Acknowledgements

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Abstract

Field and growth chamber experiments were conducted on canola to evaluate large dosages of seed treatment fungicides, carbathiin (Vitavax RS or UBI 2617) and influence of zinc in combination with an early application of prochloraz (Sportak®) foliar spray to control blackleg (*Leptosphaeria maculans*) on *Brassica rapa* cv. Tobin, and on moderately tolerant *B. napus* cvs. Cyclone and Legend; the highly susceptible cultivar Westar (*B. napus)* was also included to serve as a check. Vitavax RS was used at the commercially recommended (normal) rate; for the higher rates, 2.5x or 5x the normal rate, UBI 2617 was used to keep the levels of insecticide lindane at the normal level. Foliar spray of Sportak was applied @ 500 g a.i./ha. In the growth chamber, there was a significant reduction in disease severity and increase in number of healthy plants due to heavy dosages of seed treatments. There was some evidence of phytotoxicity with heavy dosages of UBI 2617. In the field experiments, Westar responded well to the high dosages; the 5x normal dosage resulted in significantly more healthy seedlings than in the normal dosage. However, there was no decrease in the final disease severity or increase in yield. Cotyledon analysis for carbathiin revealed that the amount of the fungicide present in cotyledons two weeks after emergence was very minimal which may not be sufficient to control infection of above ground plant parts caused by airborne spores of *L. maculans*. The phytotoxic effect, however, declined as the season progressed. Effectiveness of the fungicidal spray to control blackleg was not evident most likely because the cultivar Legend possesses some tolerance to the disease. In the zinc experiment, contrary to the published reports from Australia, the disease severity was not significantly reduced with the use of zinc soil treatment.

Introduction

The virulent strain of blackleg (*Leptosphaeria maculans*) has caused serious economic losses to canola crops on the Prairies. The disease spreads with infected seeds and by wind-borne ascospores and pycnidiospores. The registered seed treatment fungicides do not protect seedlings from wind-borne spores (Kharbanda 1992). Extra-large dosages of a registered seed treatment fungicide may protect the seedlings of recently licensed moderately tolerant cultivars from infection during critical early stages of crop growth when the young seedlings are relatively more susceptible to blackleg. Combined with an early spray of prochloraz (Sportak®) before the crop is six weeks old, this could provide an adequate control of the disease in infested areas where farmers, otherwise, can not grow a good crop of canola. Also, a recent report from France indicates that the micronutrient zinc suppresses toxin production by the blackleg fungus (Rouxel et al. 1990). A foliar spray of ZnSO4 was tested in 1991 and was found not very effective. Therefore, soil treatment with chelated zinc to provide constant supply of Zn^{++} to the emerging seedlings was attempted in 1992 and repeated in 1993.

Objectives

The ultimate objective of this project is to develop an economical control of blackleg of canola integrating use of disease tolerance of recently licensed cultivars, crop nutrition, seed treatments, and timing of fungicidal sprays that will also control other canola diseases such as Sclerotinia stem rot and seedling blight. Immediate objectives of theses studies were:

1. To evaluate large dosages of seed treatment fungicides to control blackleg in a susceptible and two moderately tolerant *Brassica napus* cultivars and a *B. campestris (B. rapa)* cultivar of canola.
2. To evaluate large dosage of a seed treatment fungicide and an early application of fungicidal foliar spray to control blackleg in a moderately tolerant *Brassica napus* cultivar.
3. To determine influence of zinc and an early application of fungicidal foliar spray to control blackleg in a susceptible and a moderately tolerant *B. napus* cultivars of canola.

Materials and Methods

Objective 1. To evaluate large dosages of seed treatment fungicides to control blackleg in a susceptible and two moderately tolerant *Brassica napus* cultivars and a *B. rapa* cultivar of canola.

(a) Field experimentation:

The test was conducted in a farmer's field naturally, and heavily, infested with blackleg. *Brassica napus* cultivars included Westar, which is highly susceptible to blackleg, and Legend and Cyclone which are moderately resistant; the *B. rapa* cultivar was Tobin. Seed of the four canola cultivars was coated with carbathiin + thiram (Vitavax RS®) at the commercially recommended rate of 22.4 mL/kg seed. For the higher dosages, 2.5x and 5.0x the recommended rate, a special formulaion UBI 2617 was used in order to keep the amount of insecticide lindane within the recommended rate. A part of the seed was saved for growth chamber experiments. The treated seed and the untreated controls for each cultivar was planted in 6m x 0.9m plots with four rows 20 cm apart. The experimental design was a split plot with four replications; the blocks were split between the two *Brassica* spp. The data on disease severity (DS) and grain yield was recorded for each plot. The DS was evaluated on stems using a scale of 0 to 5, where 0 = no infection, and 5 = lesion girdling the entire stem diameter causing extensive tissue damage and wilting. All plants in each of the two inner most rows of each plot were evaluated individually and mean disease severity (MDS) calculated using the formula:

$$\text{MDS} = \frac{\lesssim (\text{Number of plants in a category x DS numerical value})}{\text{Total number of plants rated}}$$

The data were statistically analyzed using an appropriate ANOVA procedure.

(b) Growth chamber experimentation:

The test was conducted using 17 cm fibre pots and pasteurized greenhouse soil mix. A part of the treated seed prepared for field experiment was used. Seeds were planted in soil @ 15 per pot and overlaid with a 1 cm thick layer of perlite infested with a virulent strain of *L. maculans* conidia (1×10^6/mL). There were four replications and the pots were arranged in a split plot design in a growth chamber (21°C, 16h light/8h dark). Data were recorded on disease severity (DS) for each plant, using a scale of 0-5 where 0 = healthy and 5 = plant wilted, at maturity as described under (a) above. Seed yield per pot was determined and the data analyzed statistically.

A seperate test identical to the one described above was set up to determine amount of carbathiin present in the cotyledons of seedlings of treated and untreated seeds. On two dates, 7 days and 14 days after seeding, cotyledons from three seedlings from each replication (pot) of each treatment were clipped, pooled, macerated in acetone, and the extract analyzed for the presence of carbathiin on a gas chromatograph with an Electron Capture Detector.

Results and discussion:

The results of the growth chamber experiments presented in Tables 1 show that there was no phytotoxicity with any of the treatments containing carbathiin. Twelve days after planting (Dec. 22, Table 2), the percent disease-free plants were significantly higher in treatments containing fungicides than in the respective untreated checks. Over the six week period, the number of disease-free seedlings declined considerably in all treatments except the treatments containing the highest dosage of 5x the normal seed treatment rate (Figures 2-5). Similar results were obtained in terms of blackleg disease severity (Tables 4, 5). The results also indicate that blackleg severity was significantly less in Cyclone and Legend than in Westar (Table 3, Figures 2-5); it confirms high susceptibility of Westar and moderate tolerance in Cyclone and Legend to blackleg.

In the field experiments, over all the cultivars tested, the seed treatments with carbathiin @ 5 g a.i./kg seed (UBI 2617, 20 mL/kg seed) controlled the disease significantly better, and resulted in significantly more number of healthy plants, than the normal recommended dosage, 1 g a.i./kg (Vitavax RS, 22.4 mL/kg seed). The 2.5x the normal rate treatment, however, did not give a significant imporovement in disease control. There was no phytotoxicity. Westar responded better than Legend to the heavy dosages of carbathiin in terms of percent healthy seedlings (Tables 6, 7; Figure 5). None of the treatments containing heavy dosages, however, improved yield over the normal recommended rates. On the contrary, in one of the cultivars Cyclone, the highest dosage of 5 g resulted in significantly less yield than the 2.5 g rate; the reason for this reduction is not clear specially because the percent healthy plants was the highest in this treatment. In the cultivar Tobin, heavy dosages did not improve percent healthy plants or yield (Table 8).

The results of cotyledon analysis for carbathiin revealed that amount of the fungicide present in cotyledons was quite low (Table 9), which may not be sufficient to control blackleg infection. The study suggests that most of the fungicide may be present in the hypocotyl region providing protection to the lower part of seedlings resulting in a significant increase in the number of healthy seedlings in both the growth chamber and the field, whereas, the upper part of the plant contained little fungicide resulting in insignificant disease control under natural conditions in the field.

Objective 2. To evaluate large dosage of a seed treatment fungicide and an early application of fungicidal foliar spray to control blackleg in a moderately tolerant *Brassica napus* cultivar.

(a) Field experimentation:

The test was slightly modified and a *Brassica rapa* cultivar Tobin was also included. It was conducted in a farmer's field naturally and heavily infested with blackleg. The seed of canola cultivars Tobin and Legend was coated with carbathiin + thiram (Vitavax RS or UBI 2617) @ either 1x, or 5x the commercial recommended rate, and planted in 6m x 1.6m plots containing 6 rows 20 cm. apart. The experimental design was a split plot with 4 replications. Each week, from June 10 to July 5, a set of 4 plots per treatment, one in each block (replication) was sprayed once with prochloraz @500 g ai/ha. A plot received only one spray during the course of the experiment; unsprayed plots served as check. The data on disease severity (control achieved) (DS) and grain yield were recorded for each plot. The DS was evaluated on stems using a scale of 0 to 5, where 0 = no infection, and 5 = lesion girdling the entire stem diameter causing extensive tissue damage and wilting. All plants in 2 meter sections of each of the two inner-most rows of each plot were evaluated individually and mean disease severity (MDS) calculated as described under Objective 1(a).

The data was statistically analyzed using an appropriate ANOVA procedure.

Results and Discussion:

In the date of spraying trials, there was no significant control of blackleg by spraying prochloraz on any other date except June 24. None of the sprays, however, resulted in increase in yield in

either of the two cultivars tested, Legend and Tobin (Tables 10-13). We reported earlier (Kharbanda 1992a) that in a susceptible cultivar such as Westar a minimum of six sprays may be required to control the disease, which would be very uneconomical. In view of our present results, perhaps two sprays should be evaluated on cultivars relatively more tolerant than Westar.

Objective 3. To determine influence of zinc and an early application of fungicidal foliar spray to control blackleg in a susceptible and a moderately tolerant cultivar of canola.

(a) Growth chamber experimentation:

Two canola cultivars, Westar (susceptible) and Legend (moderately tolerant), were planted separately in a pasteurized soil mix amended with chelated zinc @ 25 kg per hectare in 17-cm fibre pots, seven seedlings per pot. There were four replications and the pots were arranged in a completely randomized block in a growth chamber (21°C, 16h light/8h dark). At the 2-leaf stage, two seedlings from each pot were pulled and their leaves sent to the Soils and Animal Nutrition Lab, Alberta Agriculture, Edmonton, for zinc analysis. The remaining five seedlings were inoculated with a virulent strain of *L. maculans* (10^6 conidia/ml). Five weeks later, the disease severity (DS) was assessed, on a scale of 1-5, individually on all the plants in a pot and the data analyzed statistically as described under Objective 1 (a).

(b) Field experimentation:

The test was conducted in a farmer's field naturally and heavily infested with blackleg. Soil in individual plots was either untreated, or treated with chelated zinc @ 25 kg/ha as required after a soil test. Canola cultivar, Legend was planted in 6m x 1.5m plots, containing six rows 20 cm apart. There were four replications arranged in a split plot design. Each week, from June 15 to July 15, a set of four plots per treatment, one in each block (replication) were sprayed once with prochloraz @ 500 g ai/ha as described under Objective 2 above. To determine the level of zinc in leaves at the time of spraying, a sample of 10 leaves was collected from the outer two rows just prior to spraying the fungicide, and was sent to the Soils and Animal Nutrition Lab, Alberta Agriculture, Edmonton for tissue analysis. The data on disease severity (DS) and yield were recorded for each plot and analyzed using ANOVA as described under Objective 1 (a).

Results and Discussion:

Contrary to the published reports from Australia, no control of blackleg was achieved with application of zinc; the disease severity was not significantly lower in treatments containing zinc in growth chamber or field tests (Table 14-17). Statistical correlation between the mean disease severity and the amount of zinc present in leaves or soil was not high indicating that the zinc application had no effect on the disease development. The effectiveness of fungicidal foliar sprays was also not evident; it could be due to the low disease severity in the field.

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Table 1: Effect of high dosages of seed treatments with carbathiin on emergence of three cultivars of canola, planted in blackleg infested soil in a growth chamber, 1993.

Carbathiin g ai/kg seed	Emergence Count* December 15
Cyclone-Check	15.50 AB
Cyclone- 1	15.25 AB
Cyclone- 2.5	16.67 A
Cyclone- 5	16.50 A
Legend-Check	11.00 C
Legend- 1	14.00 AB
Legend- 2.5	16.00 AB
Legend- 5	13.75 ABC
Westar-Check	13.00 BC
Westar- 1	15.75 AB
Westar- 2.5	16.25 A
Westar- 5	15.75 AB

* Mean of 4 replications; means with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.05).

Table 2: Percent blackleg-free plants on various dates from canola seeds of three cultivars treated with high dosages of carbathiin and planted in blackleg infested soil in a growth chamber, 1993.

Carbathiin g ai/kg seed	Mean Percent Blackleg-free Plants*					
	Dec. 18	Dec. 22	Dec. 29	Jan. 4	Jan. 8	Jan. 14
Cyclone-Check	97 AB	25 CD	5 D	5 E	5 E	5 E
Cyclone- 1	97 AB	96 AB	43 BC	40 BCD	40 BC	40 BC
Cyclone- 2.5	99 A	97 AB	47 BC	47 B	43 B	43 B
Cyclone- 5	99 A	99 A	75 A	75 A	71 A	71 A
Legend-Check	75 C	46 C	3 D	0 E	0 E	0 E
Legend- 1	94 AB	94 AB	55 ABC	55 B	52 B	47 B
Legend- 2.5	97 AB	96 AB	47 BC	46 BCD	46 BC	46 B
Legend- 5	88 ABC	88 B	81 A	81 A	72 A	71 A
Westar-Check	81 BC	22 D	2 D	0 E	0 E	0 E
Westar- 1	96 AB	94 AB	32 C	24 D	18 D	18 D
Westar- 2.5	97 AB	97 AB	35 C	27 CD	24 CD	22 CD
Westar- 5	99 AB	99 AB	61 AB	44 BC	40 BC	34 BCD

* A 3 x 4 factorial with 3 cultivars and 4 levels of fungicides. Means within a column followed by the same letter do not differ significantly (P=0.05) according to Duncan's Multiple Range Test. Analyses performed on arcsin square root transformed data; values in the columns were back-transformed after analyses. Date of planting, December 9, 1992.

Table 3: Factorial analysis of the data on blackleg-free plants taken on Jan. 14 and presented in Table 2.

Part I

Carbathiin g ai/kg seed	Blackleg-free plants* January 14
Check	0.25 C
1	6.18 B
2.5	6.18 B
5	9.73 A
Cyclone	6.29 A
Legend	6.94 A
Westar	3.13 B

* Mean of 4 replications; means with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.05).

Part II

Source	Degrees of Freedom	Sum of Squares	F ratio
Variety	2	135.94	20.31**
Fungicide	3	549.70	54.76**
Variety X Fungicide	6	50.91	2.54NS
Error	33	110.42	
Total	44	831.20	

**Significant at P=0.01; NS, not significant.

Table 4: Effectiveness of high dosages of seed treatments with carbathiin to control blackleg on three cultivars of canola, in a growth chamber, 1993.

Carbathiin g ai/kg seed	Disease Severity*
	January 19
Cyclone-Check	4.7 AB
Cyclone- 1	2.5 D
Cyclone-2.5	2.8 D
Cyclone- 5	1.5 E
Legend-Check	5.0 A
Legend- 1	2.5 D
Legend- 2.5	2.8 D
Legend- 5	1.8 E
Westar-Check	5.0 A
Westar- 1	4.2 BC
Westar- 2.5	4.4 ABC
Westar- 5	3.8 C

* Mean of 4 replications; means with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.05).

Table 5: Factorial analysis of data presented in Table 4.

Part I

Carbathiin g ai/kg seed	Disease Severity* January 19
Check	4.88 A
1	2.97 C
2.5	3.73 B
5	2.45 D
Cyclone	2.96 B
Legend	2.91 B
Westar	4.35 A

* Mean of 4 replications; means with the same letter are not significantly different as determined by Duncan's Multiple Range Test (p=0.05).

Part II

Source	Degrees of Freedom	Sum of Squares	F ratio
Variety	2	19.05	60.06**
Fungicide	3	36.76	77.24**
Variety X Fungicide	6	5.61	5.89**
Error	32	5.07	
Total	43	65.75	

**Significant at P=0.01; NS, not significant.

Table 6: Emergence, plant stand count, percent healthy plants, blackleg severity and yield in three *Brassica napus* cultivars of canola treated with high dosages of fungicidal seed treatments to control blackleg of canola in an infested field, 1993.

Cultivar Carbathiin g ai/kg seed	Emergence Count*	% Healthy Plants June 28*	Plant Stand Count*	Disease Severity*	Yield*
Cyclone 1	152.50 A	83.50 ABC	46.00 A	0.85 CD	587.23 AB
Cyclone 2.5	119.50 A	87.00 ABC	44.00 A	0.84 CD	713.50 A
Cyclone 5	113.25 A	89.25 ABC	28.50 A	0.58 D	575.33 B
Legend 1	132.75 A	90.75 A	53.25 A	1.24 BC	595.18 AB
Legend 2.5	124.25 A	90.50 A	36.50 A	1.53 B	644.85 AB
Legend 5	145.25 A	89.25 ABC	45.75 A	1.68 B	563.78 B
Westar 1	102.75 A	82.00 C	27.50 A	3.42 A	369.88 C
Westar 2.5	122.75 A	82.75 BC	37.75 A	3.55 A	320.45 C
Westar 5	105.50 A	89.50 AB	28.25 A	3.61 A	300.73 C

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 7: Factorial analysis of the data presented in Table 6.

Carbathiin g ai/kg seed	% Healthy Plants June 28*	Plant Stand Count*	Disease Severity*	Yield*
1	85.42 B	42.25 A	1.83 A	549.30 AB
2.5	86.75 AB	39.42 A	1.97 A	587.42 A
5	89.33 A	34.17 A	1.95 A	515.80 B
Cyclone	86.58 AB	39.50 A	0.75 C	636.79 A
Legend	90.17 A	45.17 A	1.48 B	642.53 A
Westar	84.75 B	31.17 A	3.53 A	357.99 B

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 8: Percent healthy plants, plant stand count, disease severity and yield on cv. Tobin treated with high dosages of fungicidal seed treatments to control blackleg of canola in an infested field, 1993.

Carbathiin g ai/kg seed	% Healthy Plants* June 28	Plant Stand Count*	Disease Severity*	Yield*
1	89.50 A	38.50 A	2.57 B	419.13 A
2.5	89.50 A	39.50 A	3.10 A	425.40 A
5	83.50 A	43.25 A	2.65 AB	420.68 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 9: Trace analysis for carbathiin and lindane in two *Brassica napus* cultivars of canola treated with high dosages of fungicidal seed treatments to control blackleg of canola.

	Wet Weight of Tissue (g)		Carbathiin µg/g	
Cultivar Carbathiin g ai/kg seed	Week 1	Week 2	Week 1	Week 2
Legend Check	0.055	0.261	< 5.55	< 1.15
Legend 1	0.052	0.244	< 6.00	< 1.20
Legend 2.5	0.044	0.268	< 6.05	< 1.10
Legend 5	0.032	0.279	< 9.70	< 1.05
Westar Check	0.098	0.281	< 3.20	< 1.05
Westar 1	0.131	0.263	< 2.35	< 1.15
Westar 2.5	0.139	0.271	< 2.25	< 1.10
Westar 5	0.126	0.256	< 2.90	< 1.15

Table 10: Effect of seed treatment with different dosages of carbathiin, and of a foliar spray with prochloraz on blackleg incidence, severity, and grain yield of canola cv. Legend in an infested field, 1993.

Carbathiin g ai/kg seed	Date of Spray	Plant Stand Count*	Disease Severity*	Yield*
1	June 10	38.50 A	0.76 A	529.77 A
1	June 17	41.50 A	0.86 A	615.60 A
1	June 24	35.50 A	0.77 A	449.48 A
1	July 5	45.75 A	1.10 A	566.83 A
1	Check	35.75 A	1.04 A	436.18 A
5	June 10	39.25 A	1.24 A	468.65 A
5	June 17	40.75 A	0.80 A	459.67 A
5	June 24	30.00 A	0.78 A	466.33 A
5	July 5	41.75 A	0.99 A	491.27 A
5	Check	35.75 A	1.19 A	532.33 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 11: Factorial analysis of the data presented in Table 10.

	Plant Count*	Disease Severity*	Yield*
Carbathiin g ai/kg seed			
1	39.40 A	0.90 A	470.45 A
5	37.50 A	1.00 A	444.98 A
Date of Spray			
June 10	38.88 A	1.00 AB	473.99 A
June 17	41.13 A	0.83 AB	449.31 A
June 24	32.75 A	0.78 B	443.66 A
July 5	43.75 A	1.04 AB	467.13 A
Check	35.75 A	1.11 A	454.48 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 12: Effect of seed treatment with different dosages of carbathiin, and of a foliar spray with prochloraz on blackleg incidence, severity, and grain yield of canola cv. Tobin in an infested field, 1993.

Carbathiin g ai/kg seed	Date of Spray	Plant Stand Count*	Disease Severity*	Yield*
1	June 10	27.25 A	2.34 AB	291.28 A
1	June 17	25.25 A	2.06 AB	306.77 A
1	June 24	26.25 A	1.71 B	300.43 A
1	July 5	27.25 A	2.31 AB	302.50 A
1	Check	25.50 A	2.71 A	169.55 A
5	June 10	26.75 A	2.14 AB	274.68 A
5	June 17	22.25 A	2.23 AB	284.28 A
5	June 24	29.00 A	1.89 AB	275.95 A
5	July 5	28.50 A	2.47 AB	290.23 A
5	Check	27.50 A	2.59 AB	220.60 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 13: Factorial analysis of the data presented in table 12.

	Plant Count*	Disease Severity*	Yield*
Carbathiin g ai/kg seed			
1	26.30 A	2.23 A	284.48 A
5	26.80 A	2.26 A	270.67 A
Date of Spray			
June 10	27.00 A	2.24 AB	282.98 A
June 17	23.75 A	2.14 AB	293.91 A
June 24	27.63 A	1.80 B	288.19 A
July 5	27.88 A	2.39 AB	297.24 A
Check	26.50 A	2.65 A	200.18 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 14: Effect of soil amendment with zinc and of a foliar spray with prochloraz on blackleg severity and grain yield of canola cv. Legend in an infested field, 1993.

Date of Spray	Disease Severity*	Yield (g/plot)*
CHECK		
June 10	0.90 AB	497.4 A
June 17	0.81 AB	555.5 A
June 24	0.83 AB	520.5 A
July 1	0.59 AB	471.8 A
July 8	1.07 AB	586.9 A
No spray	1.09 AB	493.1 A
ZINC		
June 10	1.03 AB	546.8 A
June 17	1.05 AB	592.5 A
June 24	1.05 AB	530.8 A
July 1	1.27 A	555.5 A
July 8	0.82 AB	577.4 A
No spray	1.34 A	541.4 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05). Disease severity rated on a scale of 0 (Healthy) - 5 (Dead).

Table 15: Factorial analysis of the data presented in Table 14.

	Disease Severity*	Yield (g/plot)*
Soil Amendment		
Zinc	1.09 A	557.7 A
Check	0.88 B	520.9 A
Date of Spray		
June 10	0.96 A	522.1 A
June 17	0.93 A	574.0 A
June 24	0.94 A	525.6 A
July 1	0.93 A	513.7 A
July 8	0.94 A	582.1 A
No spray	1.22 A	517.3 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 16: Effectiveness of soil amendment with zinc on blackleg severity on different plant parts of canola cvs. Westar and Legend in a growth chamber, 1993.

Zinc Rate	Cotyledon Disease Rate* May 6	Leaf Disease Rate* May 25	Stem Disease Rate* July 26	Leaf ZN^{++} ppm*
Westar				
25 kg/ha	3.00 AB	2.65 A	2.70 A	6.7
50 kg/ha	2.80 AB	2.55 A	2.35 A	6.3
Check	3.10 A	2.75 A	2.55 A	6.3
Legend				
25 kg/ha	2.25 BC	1.90 B	1.03 B	6.3
50 kg/ha	1.40 D	1.70 B	1.15 B	6.4
Check	1.70 CD	1.80 B	0.75 B	5.9

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

Table 17: Factorial analysis of the data presented in Table 16.

	Disease Severity*
Cultivar	
Legend	0.98 B
Westar	2.53 A
Zinc Rate	
25 kg/ha	1.86 A
50 kg/ha	1.75 A
Check	1.65 A

* Mean of 4 replications; mean in columns followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (P=0.05).

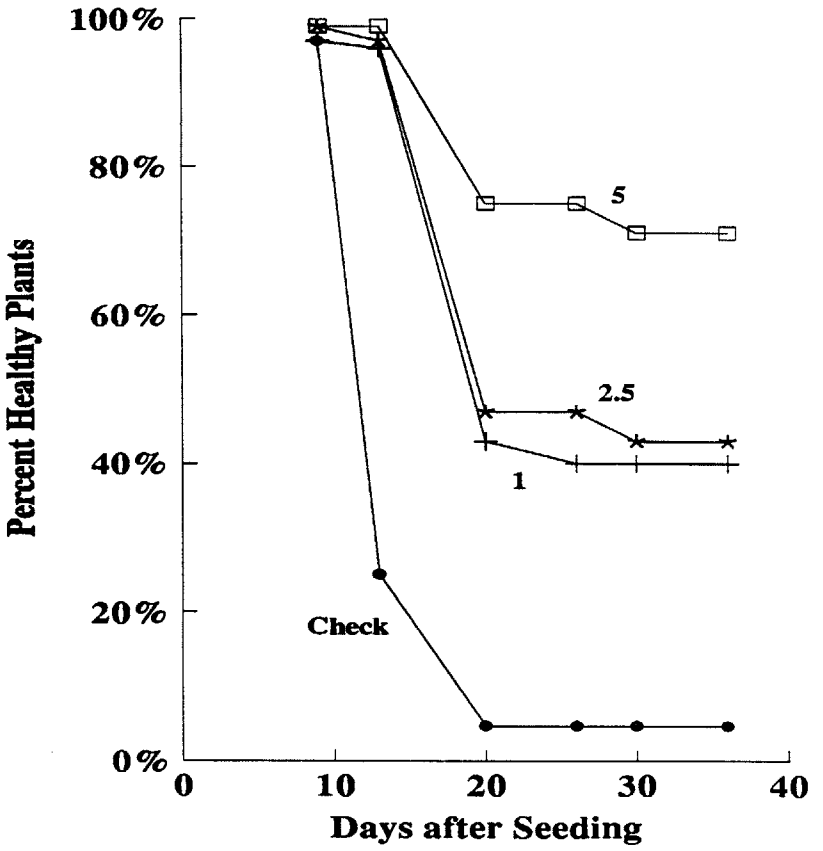

Figure 1: Percent healthy plants resulting from different dosages of seed treatments with carbathiin (g ai/kg seed) on canola cultivar Cyclone, 5 weeks after seeding in a growth chamber.

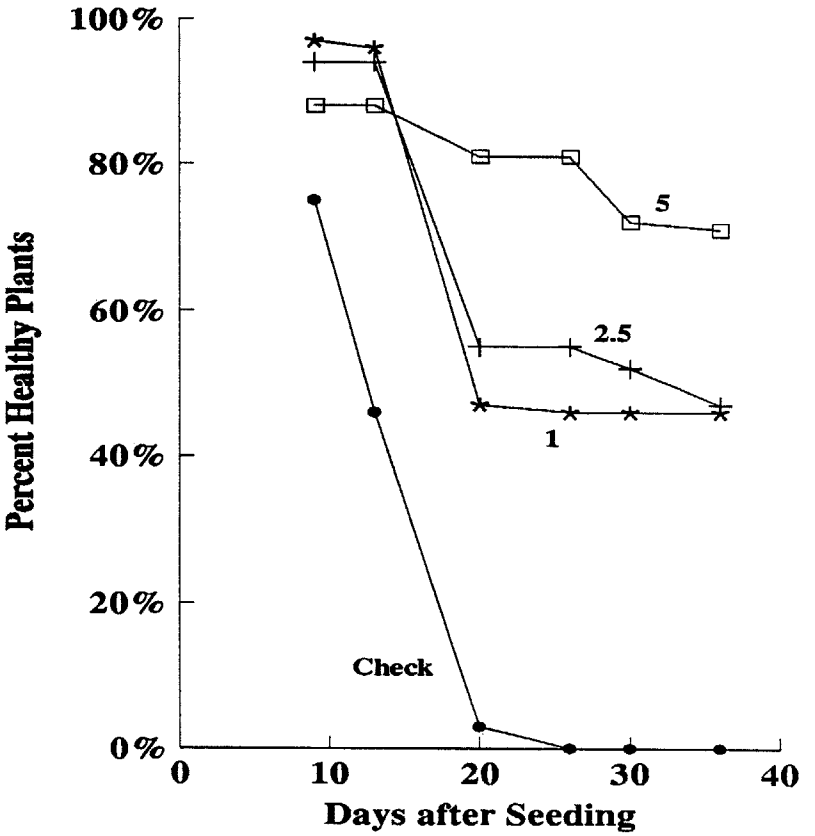

Figure 2: Percent healthy plants resulting from different dosages of seed treatments with carbathiin (g ai/kg seed) on canola cultivar Legend, 5 weeks after seeding in a growth chamber.

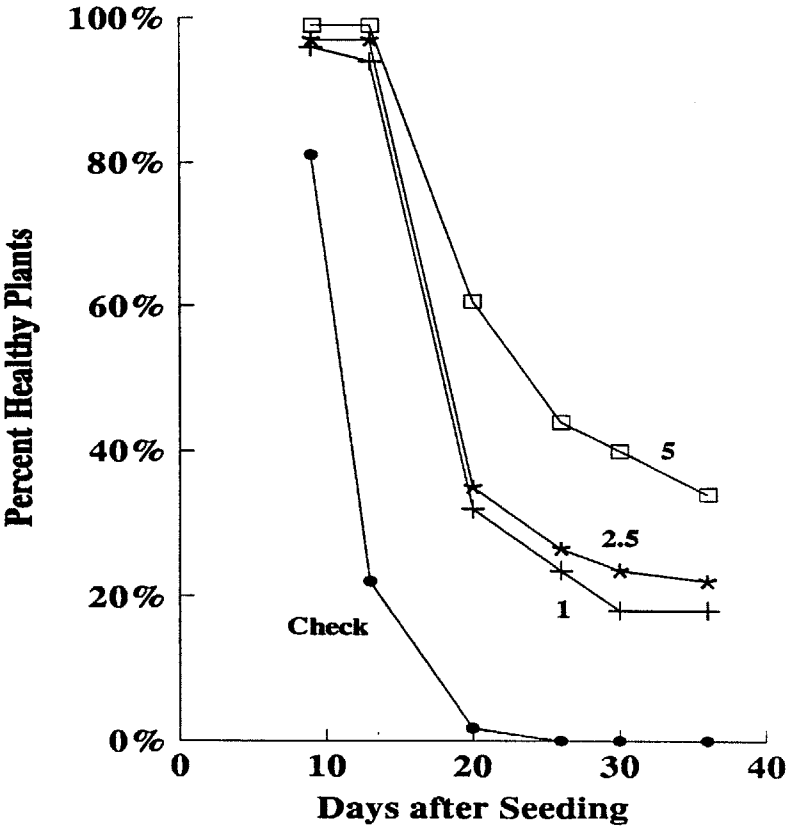

Figure 3: Percent healthy plants resulting from different dosages of seed treatments with carbathiin (g ai/kg seed) on canola cultivar Westar, 5 weeks after seeding in a growth chamber.

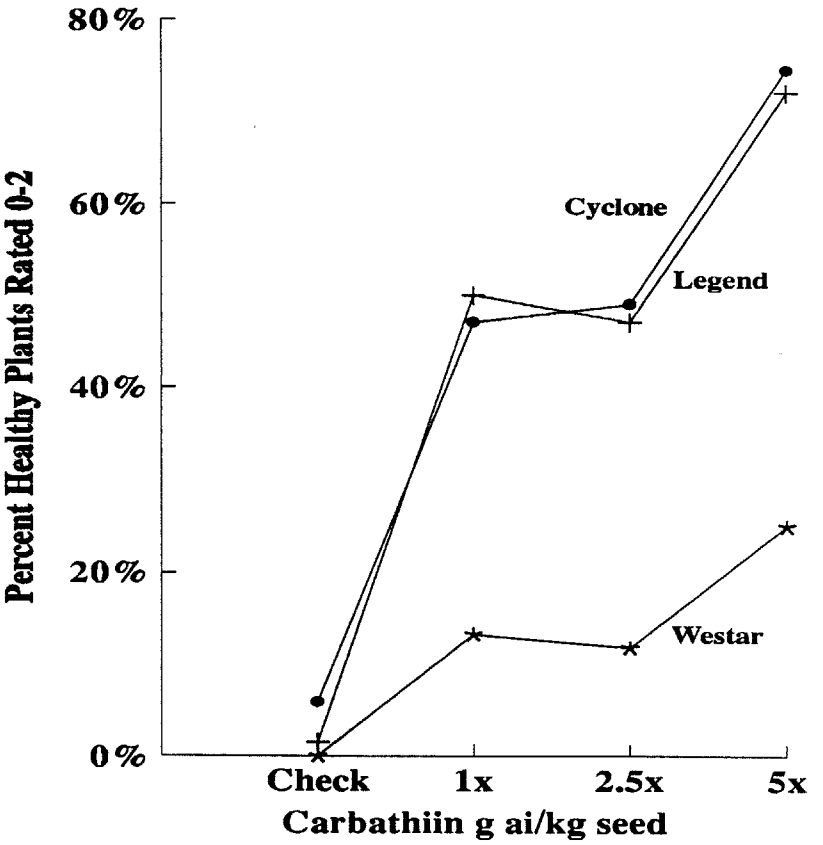

Figure 4: Percent healthy canola plants (disease severity less than 2, on a scale of 0-5) resulting from canola seed of three cultivars treated with high dosages of carbathiin, 5 weeks after seeding in a growth chamber.

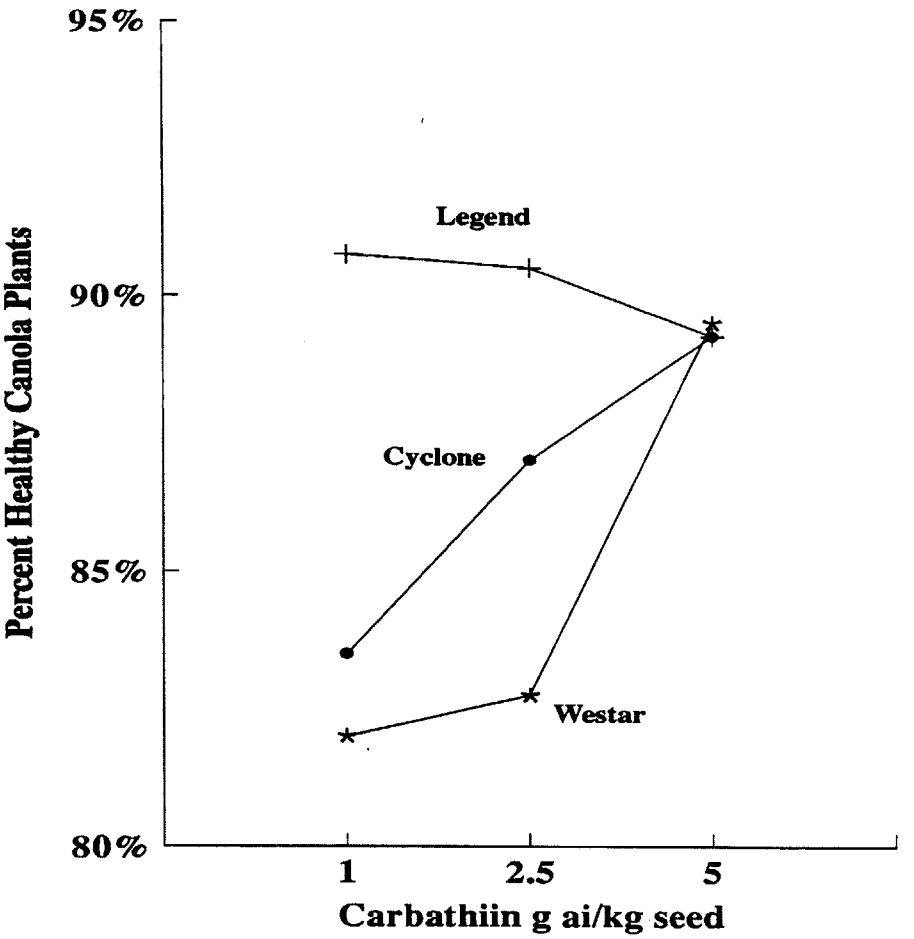

Figure 5: Percent healthy seedlings resulting from canola seed of three cultivars treated with different dosages of carbathiin in a blackleg infested field near Sedgewick, 1993.