SELECTION OF OILSEED RAPE WITH RESISTANCE TO FLEA BEETLES

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INTRODUCTION

The most serious insect pests of spring oilseed rape in western Canada are the flea beetles Phyllotreta cruciferae (Goeze) and P. striolata (F.) (Lamb and Turnock 1982; Lamb 1989). Severe damage can occur when adult beetles attack the seedlings as they emerge. The only effective control measures currently available are systemic insecticides applied at the time of seeding and nearly the whole crop area in Canada receives such treatments.

Species of Cruciferae and cultivars of oilseed rape differ in their susceptibility to attack by flea beetles (Lamb 1980; Lamb 1984; Lamb 1988; Lamb and Palaniswamy 1990; Bodnaryk and Lamb in press). This variation suggests that host resistance may be a viable strategy for controlling flea beetle damage in oilseed rape. The main objective of this study was to determine if there is variability in susceptibility to flea beetles within a locally adapted cultivar of oilseed rape, variability that might be amenable to selection. In this paper, we describe the selection of a population of Brassica campestris L. with an agronomically useful level of resistance to flea beetles and some of the characteristics of the selection that contribute to this resistance.

METHODS

Selecting for Resistance

In 1983, 10 000 seeds of B. campestris cv. Tobin were sown without insecticide at Glenlea, Manitoba and the germinating seedlings were exposed to natural infestations of flea beetles. The intention was to select the most vigorous 1000 survivors, but only 5 plants survived to produce seed. The seed from these plants was subjected to four annual cycles of progeny-row selection by exposing field plots to natural infestations of the beetles without insecticidal protection. The responses of the progeny rows to the flea beetles were assessed 4 weeks after seeding by counting the number of seedlings in each row and cutting and weighing 10 seedlings at random. The seedling survival and growth data from the rows were compared with interspersed rows of Tobin, and used to identify progeny rows warranting further selection. The seed yield from individual plants was also used to identify plants that would be carried forward. Seed quality and agronomic traits were not considered when selecting plants.

Assessing the Level of Resistance

The level of resistance in one of the resulting populations was compared with that of Tobin in field plots at Glenlea, Manitoba in 1989. Three side-by-side experiments were conducted: one with untreated seed, one with lindane-treated seed, and one with carbofuran granules. These two insecticides are the most popular treatments for controlling flea beetles; they were applied at the recommended rates (Manitoba Agriculture 1990). Each experiment consisted of five pairs of 4-row plots, one plot seeded with Tobin and one with the selection. Each plot was 3 m long with 250 seeds per row seeded at a depth of 2.5 cm on 29 May. Four weeks after seeding, the number of surviving seedlings in the 2 centre rows of each plot were counted and 10 randomly-selected seedlings from each of these rows were cut at ground level, dried to constant weight, and weighed. When each plot was ripe, the numbers of surviving plants in the two centre rows were counted and the plants were harvested. The yield of seed was determined for each of the two centre rows in a plot.

Resistance Through Tolerance

In a greenhouse test conducted in November 1990, seedling growth of undamaged and artificially damaged seedlings of Tobin and the selection were compared. Seeds of the two lines were individually weighed and seeds of equal weight were paired and assigned to four treatments: no damage, 25% of cotyledon and first true leaf excised, 50% excised, and 75% excised. The plant tissue was excised by cutting off one side of a cotyledon or leaf with sharp scissors, without damaging the mid-vein. The cotyledons were damaged 7 days after seeding and the true leaves were damaged 14 days after seeding. Twenty days after seeding, 15 plants from each treatment were cut at the soil surface and weighed.

Resistance Through Non-preference

In a laboratory test conducted in May 1990, 7-day old seedlings of Tobin and 4 populations of the selection were exposed to field-collected adults of P. cruciferae. Three arenas were used with 1400 beetles and 100 seedlings in each arena. The seedlings were arranged in a latin square with 2 replicate seedlings of each test population in each row and column giving 20 replicate seedlings per arena. The seedlings were exposed to the beetles for 24 hours and then the level of feeding damage was rated. The rating consisted of a visual estimate of the percentage of cotyledon area damaged on each seedling in 5% increments.

Resistance Through Antibiosis

In May 1990, female flea beetles that had recently emerged from overwintering sites were collected, a sub-sample of beetles was weighed, and the remaining beetles were used in a laboratory feeding test. Two hundred adult P. cruciferae were confined with seedlings of Tobin or the selection in cages and allowed to feed for 2 weeks. The potted seedings were replaced every other day so that only cotyledons were available to the beetles. At the end of the period the female beetles were frozen and weighed individually on a Cahn C-31 microbalance.

RESULTS

Selecting for Resistance

No differences were observed between the selected progeny rows and the rows of Tobin until 1987. In this year, one group of progeny rows from a single parental row showed markedly superior growth to that of Tobin. The difference was evident when the main stem was elongating and the first flowers were opening. The seed from the highest yielding of these progeny rows were pooled and this population was designated with the code number C8711.

Table 1. The mean responses of C8711 and Tobin to attack by flea beetles when the plants in five paired, replicate plots were treated with no insecticide, a lindane seed dressing, or a carbofuran granule at seeding

	Treatment						
	Untreated		Lindane		Carbofuran		Pooled standard error
Plant measure[1]	C8711	Tobin	C8711	Tobin	C8711	Tobin	
	4-wk after seeding						
No. plants	11.7	5.3	6.6	8.7	16.2	10.0	1.7
Plant wt., g	2.8	0.9	5.0	2.2	16.3	11.6	0.4
	At harvest						
No. plants	10.6	2.2	7.0	6.5	14.8	11.3	0.6
Yield, g	4.1	0.2	5.2	1.5	22.7	16.8	2.6

(1) Per m of row in the centre two rows of five 3-m, 4-row plots.

Assessing the Level of Resistance

When the survival and growth of C8711 and Tobin were compared in paired field plots without insecticide, twice as many seedlings of C8711 survived, as compared with Tobin (Table 1). C8711 seedlings also weighed substantially more than those of Tobin. More than 4 times as many C8711 plants survived to harvest and the surviving C8711 plants yielded substantially more than did Tobin. All these differences were significant in paired t-tests ($P < 0.05$). Seedling weights and yield were also higher for C8711 than for Tobin when both were treated with lindane, although the number of surviving plants did not differ (Table 1). The yield of C8711 plants without insecticide was more than twice that of Tobin with a lindane seed dressing. In the experiment treated with carbofuran granules, C8711 survived better, grew more rapidly and yielded about 35% more than Tobin (Table 1), but Tobin with carbofuran yielded substantially more than C8711 with no insecticide. C8711 matured 5-7 days later than Tobin when both were protected by insecticide, and its seed had a glucosinolate level higher than that permitted in modern canola cultivars.

Resistance Through Tolerance
Undamaged 20-day old seedlings of C8711 were 15% heavier than those of Tobin (Table 2). For both lines progressively higher levels of damage reduced the weight of the seedlings. At the highest damage level (75%), the Tobin seedlings were 28% of the weight of the undamaged controls, whereas the C8711 seedlings were 41% of the weight of the undamaged controls. At all damage levels, C8711 seedlings weighed significantly more than seedlings of Tobin (Table 2).

Resistance Through Non-preference
When flea beetles were allowed to feed on 7-day old seedlings of Tobin and 4 populations of C8711, the percentage of cotyledon surface damaged was 10-18% higher on Tobin than on C8711 (Table 3). Analysis of variance with Duncan's multiple range test showed that the difference between Tobin and C8711 was significant ($P < 0.05$).

Table 2. Weight, mg (S.E.), of foliage for C8711 and Tobin 20 days after seeding when subjected to various levels of artificial damage

	Percent damage			
Line	0	25	50	75
C8711	1165 (82)	894 (86)	743 (66)	473 (65)
Tobin	1017 (70)	833 (100)	523 (61)	289 (31)

Table 3. Percentage of cotyledon area damaged and pooled standard error (S.E.) for C8711 and Tobin exposed to flea beetles in a laboratory test

	Populations of C8711				
Tobin	1	2	3	4	Pooled S.E.
59	49	46	43	41	1.7

Resistance Through Antibiosis
The post-hibernation weight of field collected flea beetles was 0.819 ± 0.021 mg. After feeding for two weeks on Tobin cotyledons the beetles weighed 1.141 ± 0.041 mg, whereas beetles fed on C8711 weighed 1.022 ± 0.057, a 12% difference in weight gain for the two lines.

DISCUSSION

The selection process used in this study established that variation in resistance to flea beetle damage exists in the cultivar Tobin. The selected population C8711 represents the first source of resistance to flea beetles identified in oilseed rape.

The resistance shown by C8711 is not complete, but it is sufficient to be agronomically useful. C8711 without insecticide grew more rapidly as a seedling and yielded more seed than Tobin grown with a lindane seed dressing, one of the popular insecticides. C8711, however, did not show a level of resistance equivalent to that provided by carbofuran granules. With the superior protection provided by carbofuran, C8711 continued to outyield Tobin. The selection appears to be higher yielding than Tobin whether or not it is protected by insecticides. Flea beetle densities are particularly high at the Glenlea site, and the beetle damage that occurs in small experimental plots is usually higher than the damage that occurs in commercial fields (Lamb and Turnock 1982). Thus, it is likely that the resistance exhibited by C8711 could contribute substantially to protecting the crop against flea beetles in most areas of western Canada where Tobin is grown.

The resistance of plants to insects is usually categorized into three types: tolerance, non-preference, and antibiosis (Painter 1951). All three types of mechanism appear to be involved in the resistance of C8711. The seedlings of the selection grow more quickly, and are able to continue growing more quickly when damaged, than is the case for Tobin seedlings. Furthermore, flea beetles prefer to feed on Tobin than on C8711. Finally, beetles feeding on Tobin gain weight more rapidly than they do on C8711. None of these differences, by itself, appears large enough to account for the difference in performance between C8711 and Tobin in the field. The combination of mechanisms all contribute to the resistance. There may also be unidentified factors that contribute to the resistance. The diversity of factors involved in the resistance suggests that the inheritance of the resistance is not simple.

Although C8711 has a useful level of resistance to flea beetles, it may not provide a ready source of resistance for breeders of B. campestris. The resistance in the selection relies on at least three factors that may not be readily transferred during crosses with breeding lines. Furthermore, C8711 does not exhibit all the quality and agronomic characteristics necessary in a canola cultivar. Nevertheless, the successful selection of a plant population with flea beetle resistance demonstrates that breeding for resistance is a viable control strategy for this serious pest of canola.

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