Innovative Methods for Managing Flea Beetles in Canola

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Summary

Flea beetles are among the most chronic and economically damaging insect pests of canola in western Canada. They are a challenge to manage because they are difficult to forecast and can cause significant crop losses very quickly. Several cultural practices, including reduced tillage and the use of large-sized seed with high vigour, can lessen the impact of flea beetle feeding, but insecticide-coated seed dressings remain the primary method of control. The possible decreased toxicity of neonicotinoid insecticides to striped flea beetles makes investigation of other forms of management paramount. Host plant resistance through elevated plant trichomes (hairs) offers an alternate means of flea beetle management, although commercial development of such resistant lines is still several years away.

Appearance and Biology

Flea beetles (Coleoptera: Chrysomelidae) are small oval-shaped beetles (2-3 mm) with enlarged hind femurs. The common name reflects their habit of jumping or hopping when disturbed. There are three main species that attack canola in western Canada[1, 2]. A European introduction, the crucifer flea beetle *Phyllotreta cruciferae* (Goeze) was first found in North America in British Columbia in 1921[3, 4]. The beetles are black with a bluish sheen (Figure 1a) and are the most common species in central and southern regions of canola production. The striped flea beetle, *Phyllotreta striolata* (Fab.), was introduced to North America from Eurasia at a very early date. Specimens of *P. striolata* dating to the last quarter of the seventeenth century have been found in archeological excavations of latrines in Boston, Massachusetts[5]. The beetles are black with two distinctive yellow strips on the elytra (Figure 1b). This species is most common in the northern Parkland and Peace River regions[6]. The hop flea beetle, *Psylliodes punctulata* Melsh., is a native species[7] that occurs in low numbers throughout the prairies[8]. The beetles are bronze black with femurs larger in size than the other two species.

In western Canada, flea beetles have one generation a year and overwinter as adults along shelterbelts and headlands[1,6,9]. Emergence begins with the first extended period of warm weather in April and May. *P. punctulata* adults emerge about 10 days earlier than those of *P. striolata*[10], with *P. striolata* emerging 1-4 weeks earlier than *P. cruciferae*. Peak emergence of *P. cruciferae* occurs when ground temperatures reach 15° C[11]. Emerging beetles initially feed on winter annual weeds or volunteer canola and fly to newly seeded canola crops when day-time temperatures exceed 14° C[1,12]. Females lay eggs, usually singly or in groups of two or four, or up to 25[1], in the soil near host plants from late May until early July[10,1]. The white, grub-like larvae feed on root hairs and surface of the tap root before pupating in earthen cells near their host plant. The next generation of adults emerges from late July to October[9], feeds briefly and moves to overwintering sites.

Figure 1. Crucifer-feeding flea beetle species damaging canola on the prairies: a) *Phyllotreta cruciferae* (Goeze) crucifer flea beetle, b) *P. striolata* (Fab.) striped flea beetle. Photo credit: Ralph Underwood.

Host Range, Damage, and Economic Impact

The hop flea beetle has the widest host range of the three species and feeds on members of the Brassicaceae, Polygonaceae, Chenopodiaceae, Boraginaceae and Asteraceae[1]. The two *Phyllotreta* species are considered Brassicaceae specialists but will also feed on plants in the Capparidaceae and Tropaeolaceae that contain glucosinolates[13]. Crop hosts of the three beetle species include Argentine canola (*Brassica napus* L.), Polish canola (*B. rapa* L.), brown and oriental mustard (*B. juncea* (L.) Czern.), and yellow mustard (*Sinapis alba* L.).

Adult flea beetles make small circular pits in leaf tissue as they feed. The tissue surrounding the feeding site desiccates, creating a shot-hole appearance (Figure 2). Canola plants are most vulnerable to injury at the cotyledon and early true leaf stages[14], with damage past the fourth leaf stage having little impact on subsequent crop performance[15,16]. Feeding at the early seedling stage can cause seedling mortality, reduced plant growth, delayed and uneven maturity and lower seed yield or grade[17,14]. Damage is often most severe at field edges as flea beetles emigrate from overwintering sites. Canola seedlings can compensate for defoliation levels around 20%[18]. The nominal economic threshold for control is when 25% of the leaf surface is eaten[19]. Flea beetle numbers can be very high in ripening canola in the fall. If crops are very late in maturity, extensive feeding on pods can lower yields and increase green seed content[20]. However, seed yields are usually not affected when crop maturity is more advanced than growth stage 5.2, when the seeds in lower pods are turning green[21].

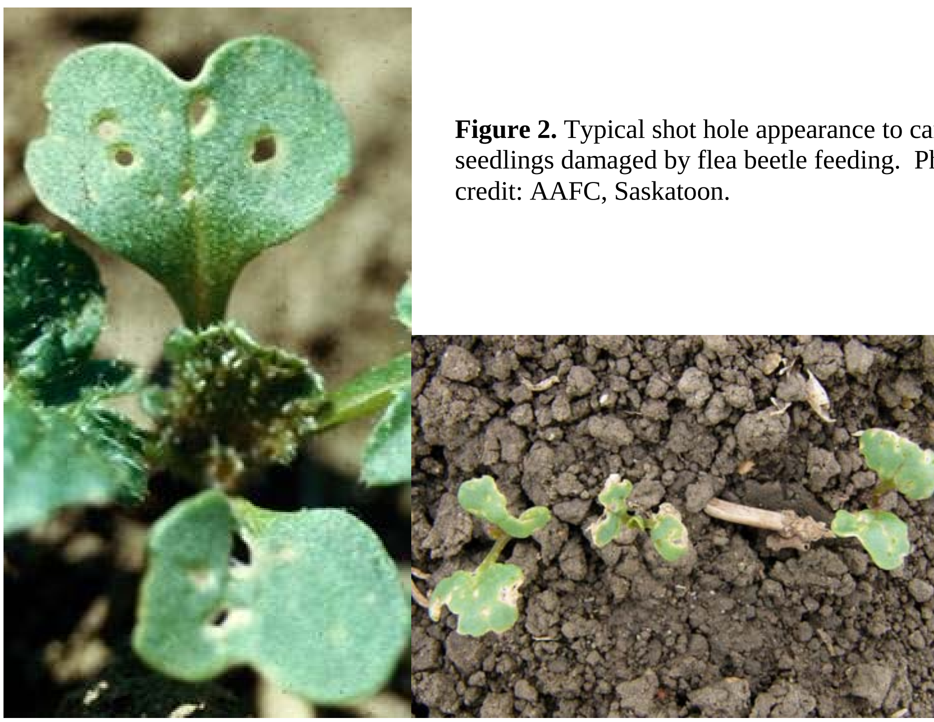

Figure 2. Typical shot hole appearance to canola seedlings damaged by flea beetle feeding. Photo credit: AAFC, Saskatoon.

Flea beetle damage to oilseed *Brassica* crops is estimated to reduce production by 10%[22,23]. Losses are estimated to exceed $300 million annually in North America[24].

Forecasting and Monitoring

The presence of high flea beetle numbers in fall may signal the potential for high numbers the following spring. Various methods have been used to monitor flea beetle populations in the spring. These include sweep nets, emergence traps, yellow sticky cards and traps baited with the attractant allyl isothiocyanate. Aggregation pheromones of male *P.*

cruciferae and *P. striolata* have been field tested[25,26] but are not available commercially. To date, none of these methods has provided accurate forecasting of potential flea beetle damage. Feeding injury is greatest when it is warm, dry and calm. Under these conditions, seedling canola fields should be inspected daily for evidence of flea beetle activity and damage.

Management

Biological. Insect predators such as the flower beetle, *Collops vittatus* (Say), big-eyed bug, *Geocorus bullatus* (Say), damsel bugs (*Nabis* spp.), field crickets (*Gryllus pennsylvanicus* Berm.) and lacewings (*Chrysopa* spp.) play a minor role in controlling flea beetles[27,28,29,30]. Although the native braconid wasp *Microctonus vittatus* Muesebeck is a widespread parasitoid of adult flea beetles across the prairies (Soroka upubl.), parasitism by the wasp usually averages less than 5%[31,32]. This and other native wasps and parasitic nematodes provide only limited control of flea beetles[33,34]. *Townesilitis bicolor* (Wesmael), a braconid wasp that occurs in central Europe, was found to parasitize up to 50% of the crucifer-feeding flea beetles there[35]. This wasp was imported and released in Manitoba in multiple introductions from 1978 to 1983 but did not become established for reasons unknown.

Recently, Xu et al. (2010)[36] found isolates of entomopathogenic nematodes that are promising candidates for the biological control of *P. striolata* under field conditions in China.

Cultural. Agronomic practices that promote good stand establishment and rapid seedling growth will reduce the impact of flea beetles on canola seed yield. Emergence and growth can be improved by planting seed lots with higher seed weights and germination above 95% in the standard germination test or pre-chill test[37,38]. Investigations on sized seeds indicate that seedlings grown from large seed (1.8-2.0 mm for *B. rapa* and 2.0-2.2 mm for *B. napus* seed) are more vigorous and tolerant of flea beetle damage than seedlings grown from small seed (1.4-1.6 mm for *B. rapa* and 1.6-1.8 mm for *B. napus* seed)[39,40]. Tolerance in *B. napus* is due to a higher initial seedling weight and faster growth rate. Plants grown from large seed have less flea beetle damage, better stand establishment, higher shoot weights and higher seed yield than plants grown from small seed.

Tillage practices can affect flea beetle damage to canola[41,42]. Flea beetle numbers and damage levels are lower when plants are grown in zero- or no-till plots than in tilled plots. Reduced tillage or direct seeding appears to provide a microclimate that is cooler, moister, and less favourable to flea beetles. Compared to conventional tillage, zero till canola production in Alberta can reduce flea beetle damage to levels equivalent to those found with the use of insecticidal seed treatments[42].

Flea beetle damage is greater in spring-seeded canola than in fall-seeded, dormant canola[43]. In the following spring, fall-seeded plants develop 20-30 days before plants seeded in April and May. Fall seeding enables plants to progress beyond the vulnerable cotyledon stage before flea beetle injury starts.

The effect of seeding date on flea beetle damage varies from region to region. In North Dakota, feeding injury may be greater when canola is planted in late April or early May rather than in late May[41,44]. In southern Alberta, canola planted in April has fewer flea beetles and suffers less damage than canola planted in May, while the opposite is true in central and northern Alberta[45]. Producers are urged to seed canola as early as practical to maximize seed yield.

Seeding rates can affect flea beetle damage levels. Dosdall et al. (1999)[42] found that damage to individual plants was lower with a 10 kg/ha seeding rate than with a 5.0 or 7.5 kg/ha rate. Higher seeding rates and plant densities are believed to dilute and reduce damage to individual plants. However, the benefits of higher seeding rates for flea beetle control need to be tempered by the costs, which include increased production costs and pesticide load to the environment, and the possibility of increased lodging and susceptibility to diseases.

For reasons that are poorly understood, Dosdall et al. (1999)[42] found that flea beetle damage to *B. napus* and *B. rapa* canola was lower with 30 cm row-spacing than with 10 or 20 cm row-spacing. Higher plant densities associated with wide row spacing may reduce flea beetle numbers and/or damage to individual plants.

Although flea beetle distribution is generally continuous across the canola-growing areas of the prairie provinces, Burgess (1977a)[1] found localized areas 10, 20, or occasionally 60 km across with very heavy flea beetle populations, while adjacent areas had only modest numbers. Burgess (1977a)[1] also found that in any area the intensity of attack sometimes varied greatly between nearby *Brassica* fields. Because the reasons behind such variable local distributions are unknown, because the current large production area devoted to canola across the prairies makes isolating canola fields in space and time difficult, and because flea beetles have a considerable ability for inter-field flight under sunny, warm conditions[12], crop rotation has limited value as an effective method of reducing flea beetle damage. While intercropping with non-host plants has reduced flea beetle damage in brassicaceous vegetables, the benefits of field-scale intercropping of canola and wheat[46] or canola and field peas[47] currently are not sufficient to warrant their use as flea beetle management options.

Chemical. The principal means of flea beetle control in western Canada has been and continues to be chemical. Because flea beetles emerge early in the spring and can migrate into seedling canola fields rapidly, insecticide-coated seed treatments are the most effective means of flea beetle control[22, 14, 48]. Since 2001, all seed treatments registered for control of flea beetles in Canada contain a neonicotinoid insecticide. This insecticide class has systemic activity in plants and inhibits nervous conduction in insects by blocking the nicotinoid acetylcholine receptor[49]. Currently over 90% of the canola grown in western Canada is treated with an insecticide[50]. Application of foliar insecticide may be required when feeding damage encompasses 25% of the leaf surface[51, 44]. If damage around field edges is high but flea beetles have not dispersed throughout the field, limiting insecticide application to the field perimeter may be sufficient. A study by Soroka et al. (2008)[50] found that in years with moderate levels of flea beetle damage, producers can decrease the proportion of insecticide-coated seed by one-third with no subsequent seed yield reduction. While the practice currently is not recommended because of the highly variable and unpredictable nature of flea beetle damage, it may have application in conjunction with other integrated management strategies or with improved forecasting.

In a recent greenhouse trial, when crucifer flea beetles were exposed to seedlings of canola grown from neonicotinoid-treated seed, they fed less and had higher mortality than striped flea beetles in the same trial[52]. The differential toxicity of seed treatments to the two species may result in a shift in their geographic distribution and economic importance.

Host Plant Resistance.

Host plant resistance is an alternative method of flea beetle management. Several studies have shown that flea beetles prefer certain crucifer hosts[53, 54, 55]. Host selection is based on a combination of chemical, physical, and environmental characteristics of plants. Antixenosis (non-preference) and antibiosis may be due to the presence of deterrent phytochemicals or the absence of stimulatory compounds in a potential host[56, 57]. The lower levels of flea beetle feeding seen on yellow mustard seedlings compared to canola seedlings is likely due to an aversion to the levels of glucosinalbin in mustard seedlings and to seedling tolerance to feeding injury[58, 59]. Trichomes (leaf hairs) impart resistance to flea beetles in certain crucifers[20, 60]. Canola germplasm with increased numbers of hairs on young true leaves (Figure 3)[61] displayed resistance to flea beetles in field trials at Saskatoon and Lethbridge[62], in some cases surpassing the protection level provided by neonicotinoid seed treatments. Although the cotyledons of the tested canola lines with elevated trichomes were hairless, they also experienced less feeding than did the parental less hirsute lines, possibly because of the presence of hairs on the stem below the cotyledon and on the cotyledon petiole, sites where trichomes do not occur in the parental lines[62]. These hairs may have discouraged flea beetles from walking up hairy stems. Advanced canola lines with further elevated numbers, lengths, and complexities of plant trichomes are currently in trials and may achieve levels of resistance to flea beetles at present seen only with insecticide use.

Figure 3. "Hairy canola" with increased numbers of trichomes (hairs) on the first true leaves. Hairless cotyledon on bottom. Photo credit: AAFC, Saskatoon.

Integrating management practices

Currently, most farmers manage flea beetles in canola crops on the Canadian prairies by using insecticide-coated canola seed. As this review notes, there are several other practices that could reduce our dependency on chemical control of this insect. Observation of the levels of flea beetle populations in canola during fall harvesting operations can forewarn producers of potential populations in the next spring. Activities that encourage rapid, even germination of the crop will mitigate flea beetle effects. Seeding large-sized seed with high vigour and germination rates into minimally or zero tilled fields can effectively reduce flea beetle feeding injury, and can reduce the impact of the injury that does occur. By integrating management practices we can lessen our need for chemical control of flea beetles while maintaining canola productivity.

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