*Reprinted with permission from: Weed Technology. 2000. 14:642-646.*

*Published and copyrighted by: Weed Science Society of America. http://www.wssa.net*

# Biological control of leafy spurge (*Euphorbia esula*) with *Aphthona* spp. along railroad right-of-ways[1]

RODNEY G. LYM and JEFF A. NELSON

*Professor and former Graduate Research Assistant, Plant Sciences Department, North Dakota State University, Fargo, ND 58105. Present address of second author: DowAgro Science, 1804 Warwick Cove, Cedar Park, TX 78613. Corresponding author's E-mail: lym@plains.nodak.edu.*

**Abstract:**

Leafy spurge (*Euphorbia esula*) along long distances of railroad right-of-ways is often treated with the least expensive herbicides available that only control top growth. The objective of this research was to evaluate flea beetles, *Aphthona nigriscutis* and a mixed population of *A. czwalinae* and *A. lacertosa,* for establishment and potential to reduce leafy spurge infestations along railroad right-of-ways. In separate experiments, both *Aphthona* species established the first year following release, and the rate of spread was similar regardless of the initial number released. *Aphthona nigriscutis* reduced leafy spurge approximately 65% up to 16 m from the release point by 3 to 5 years after release. The mixed population of *A. czwalinae* and *A. lacertosa* reduced leafy spurge density over 95% within 4 years of release. Biological control is an alternative to chemical control for leafy spurge along railroad right-of-ways, and establishment at these sites could facilitate biological control agent movement into remote areas.

**Nomenclature:**

Leafy spurge, *Euphorbia esula* L. #[2] EPHES; flea beetles, *Aphthona* spp.

**Additional index words:**

Invasive weed control, biocontrol.

[1] Received for publication November 2, 1999, and in revised form June 28, 2000.

[2] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds,* Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

## Introduction

Leafy spurge habitats include flood plains, river banks, grasslands, ridges, and mountain slopes (Dunn 1979). To date, herbicides have provided the most successful leafy spurge control method, and picloram, and 2,4-D are the most frequently used treatments. Picloram reduces leafy spurge density most effectively, but 2,4-D controls leafy spurge foliage at the lowest cost. Herbicides that effectively control leafy spurge usually are applied at relatively high rates, have a long soil residual, and/or cannot be applied in environmentally sensitive areas (Lym and Messersmith 1990).

Leafy spurge control with herbicides is not always practical on range and untilled land because of the high cost of treating large areas of infestation and the low economic return (Moran 1992). It is estimated that herbicide treatment programs could provide a positive economic return only when the time frame evaluated is at least 20 years and when applied to infestations of 0.2 ha or less (Bangsund *et al*. 1996). However, few treatments, even under favorable environmental and economic conditions, would provide positive returns on infestations 20 ha or more in size. Bangsund *et al*. (1996) estimated that applying herbicides to the perimeter of larger infestations was the only economical treatment for controlling many leafy spurge infestations, but only when treatment programs were subsidized by the government.

Biological control agents may be the best treatment for large leafy spurge infestations because of the economic restraints for herbicide use and the diverse environments where leafy spurge grows (Bangsund *et al*. 1996; Spencer 1994). To date, the *Aphthona* spp. flea beetles have reduced the density of leafy spurge more than other introduced biological control agents. Reasons for the success include reduction of the root system from larvae feeding, the rapid increase in flea beetle population since introduction, and the ease of capturing and transporting flea beetles to additional locations (Hansen *et al*. 1997; Kirby and Carlson 1998; Stromme *et al*. 1996). *Aphthona nigriscutis* originally was the most successful *Aphthona* spp. to establish in the Northern Great Plains region (Carlson and Mundal 1990). However, beginning in 1994, a mixed population of *A. czwalinae* and *A. lacertosa* began to expand rapidly. Over 85 million beetles in mixed populations have been redistributed to various states and Canada since 1995 (North Dakota Department of Agriculture, personal communication).

Currently, more than 2,000 km of railroad right-of-way is treated with herbicides for leafy spurge control in North Dakota alone (North Dakota Department of Agriculture, personal communication). Generally, the only weed control of economic importance for a railroad is on the ballast and immediately adjacent to the rails. The remainder of the weed control program along the right-of-way generally is to control weeds designated by law as noxious and to be a good neighbor to adjacent land owners. The expense of treatment is not recovered by the railroad because the herbage is neither grazed nor hayed and the trains do not run smoother or faster. Thus, the least expensive chemical treatments are generally used, which often does little to reduce leafy spurge density. For instance, picloram plus 2,4-D is the treatment of choice for leafy spurge control; however, this treatment costs from \$35 to \$60/ha. Therefore, railroads often use the less expensive 2,4-D, which costs $5 to $10/ha, but it controls only the top growth for a short time and does not reduce the original infestation (Lym and Messersmith 1990).

Biological control of leafy spurge would be the most cost-effective treatment for railroads and would reduce the original infestation. However, a biological control agent faces special and unique challenges when released for weed control along a right-of-way. For instance, in the heavily farmed areas of eastern North Dakota, leafy spurge is confined to the narrow corridor of the railroad right-of-way. The infestations are not large, continuous patches common to rangeland but are often interrupted by bridges, roads, overpasses, and maintenance areas. These small noncontiguous areas of leafy spurge may make it difficult for a biological agent to establish and, if established, to spread to other areas of leafy spurge. However, once established, the railroad corridors could facilitate biological control agent movement into remote areas that would otherwise be difficult to reach. The purpose of this research was to evaluate the potential for *Aphthona* spp. to establish and reduce leafy spurge infestations along railroad right-of-ways.

## Materials and methods

*Aphthona nigriscutis* and the mixed population of *A. czwalinae*/*lacertosa* were evaluated for establishment, dispersal, and leafy spurge stem reduction along railroad right-of-ways in two separate experiments. The plots were arranged in a line parallel with the railroad tracks at both locations. The research plots were as contiguous and uniform as possible, with adjustments made to avoid locations not suitable for *Aphthona* spp. development such as roads, streams, and drainage culverts. No adjustments were made for changes in terrain, slope, cover, litter, or trash. Leafy spurge was generally contiguous along right-of-ways, with occasional patches of very low to no stems, which were 15- to 45-m in diameter.

The first experiment was established along a 4-km stretch of the Burlington Northern-Santa Fe railroad near Buffalo, ND. *Aphthona nigriscutis* flea beetles were collected from an insectary near Cuba, ND, on June 28, 1993. The insects were released in a moderate stand (approximately 40 stems/$m^2$) of leafy spurge in the experimental plots on the same day of collection. There were six treatments consisting 0, 100, 200, 300, 400, and 500 *A. nigriscutis* insects released per treatment. The insects were released immediately adjacent to utility poles running parallel to the railroad tracks (Figure 1). Plots were 32-m-diameter half-circles with the base paralleling the tracks and were 112 m apart with three replications. Insects were released at every other utility pole along the right-of-way. The nonrelease area between each treatment was monitored for changes in leafy spurge stem density over time and also for insect spread between plots.

The terrain at the Buffalo location was generally flat and bordered on both sides by crop land and shelterbelts. The soil pH ranged from 6.8 to 8.1 with an average sand: silt: clay ratio of 44:37:19. The major soils were mapped as Barnes-Sioux complex (fine-loamy, mixed superactive, frigid Calcic Hapludolls), Barnes-Svea loam (fine-loamy, mixed superactive Frigid, Pachic Hapludolls), and Hamerly (fine loamy, mixed superactive, frigid Aeric Calciaquolls).

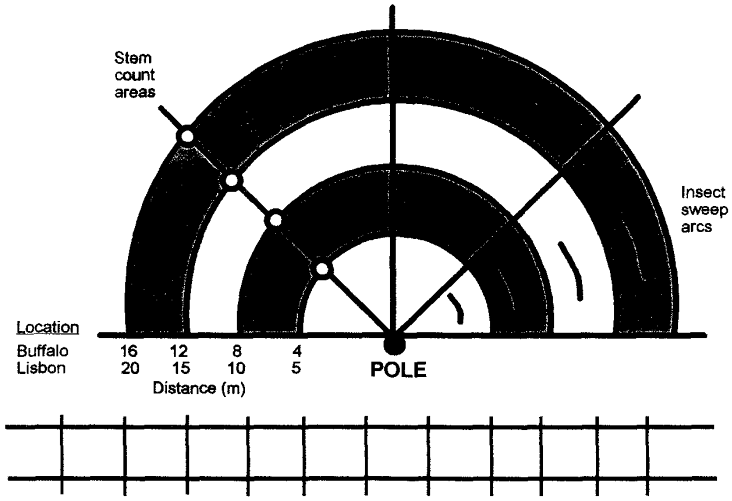


**Figure 1. Design to evaluate leafy spurge control along a railroad right-of-way with *Aphthona nigriscutis* near Buffalo, ND, and *A. czwalinae/lacertosa* near Lisbon, ND.**

Leafy spurge stem density was evaluated each year in May, initially before and annually following the *A. nigriscutis* release. The plots were subdivided by five transects at 0, 45, 90, 135, and 180 degrees from the base of the half-circle plot (Figure 1). The leafy spurge stem density was determined at the pole and at distances of 4, 8, 12, and 16 m along each transect by counting stems in a 0.25-$m^2$ quadrat. There were five counts per transect at five transects for a total of 25 counts/plot. Permanent markers were placed at the end of each transect, which allowed evaluations to be made in the same place each year. Leafy spurge stem density was determined in the same manner at the poles between release points. The difference in stem density between treated and untreated paired plots was used to estimate leafy spurge control. Leafy spurge stem density varies from season to season; thus, the use of paired plots would demonstrate changes due to treatments and exclude seasonal variations (Lym and Kirby 1987).

The density of *A. nigriscutis* adults in the field was estimated using an insect sweep net with a 38-cm-diameter hoop. Adults were swept during peak emergence (approximately 1 July) beginning at approximately 11 A.M. until 3 P.M. on sunny and calm days. Four 1-$m^2$ areas were swept between transects at distances of 0 to 4, 4 to 8, 8 to 12, and 12 to 16 m from the pole (arcs on Figure 1). The number of *A. nigriscutis* insects collected was recorded, and the adults were immediately returned to the same area.

The second experiment was established along 5.6 km of the Red River Valley and Western railroad right-of-way near Lisbon, ND, with a density of leafy spurge similar to that in the first experiment. A mixed population of *A. czwalinae/lacertosa* was collected on July 10, 1995, at an insectary near Cuba, ND, and were released the following day. There were five treatments consisting of 0, 500, 1,000, 1,500 and 2,000 *A. czwalinae/lacertosa* insects/treatment. The design and data collection were similar to those described for the Buffalo site, except that there were four replications. Also, the corridor at Lisbon was wider than at Buffalo so the plots were widened to 40-m-diameter half-circles with transects of 5, 10, 15, and 20 m (Figure 1).

The terrain at Lisbon was slightly hilly and bordered by cropland or pasture. The soil pH averaged 7.4 and the sand:silt:clay ratio ranged from 11:67:22 in the first replicate to 50:38:12 in the fourth. The soil was also a Barnes-Sioux, Barnes-Seva, and Hamerly complex similar to the Buffalo location.

The main effects and interactions of stem reduction, insect spread, and year were evaluated using ANOVA. The data were analyzed as a randomized complete block design, and means were separated using Fisher's protected LSD test at the 5% probability level. Experiments at Buffalo and Lisbon were considered separate studies, and data were not combined.

# Results and discussion

*Aphthona nigriscutis* had established at all release points along a railroad right-of-way by 1 year after release regardless of the original number released. Also, the flea beetle population density was similar among treatments in the years following release, so the data were combined over the number released (treatment) (Table 1). The *A. nigriscutis* population averaged 3 beetles/$m^2$ 1 year after release and increased to an average of 6 beetles/$m^2$ 5 years after release. In general, it took longer for the population to increase as the distance from the release point increased, but the increase in population was similar regardless of the initial number released (from 100 to 500 beetles).

*Aphthona nigriscutis* density only slightly increased during the 5 years of this study. Although now present in every county in North Dakota, there are very few locations in the state where *A. nigriscutis* density is greater than 5 to 10 beetles/$m^2$ (Kirby *et al.* 1999). *Aphthona nigriscutis* had begun to spread outside the experimental boundaries 3 years after release. The population density was sampled outside the experiment and was similar to that in the experimental area.

**Table 1. *Aphthona nigriscutis* (flea beetle) population change and radial spread 1 to 5 years after release along a railroad right-of-way averaged over insect densities of 100 to 500 beetles per release.**

| | Years after release | | | | |
|---|---|---|---|---|---|
| Distance from release point | 1 | 2 | 3 | 4 | 5 |
| m | beetles/$m^2$ | | | | |
| 0 to 4 | 1 | 5 | 7 | 4 | 7 |
| 4 to 8 | 4 | 7 | 7 | 7 | 4 |
| 8 to 12 | 3 | 5 | 4 | 6 | 5 |
| 12 to 16 | 1 | 2 | 1 | 4 | 7 |
| Mean | 3 | 5 | 5 | 5 | 6 |
| LSD (0.05) distance by year = 3; year = 1 | | | | | |

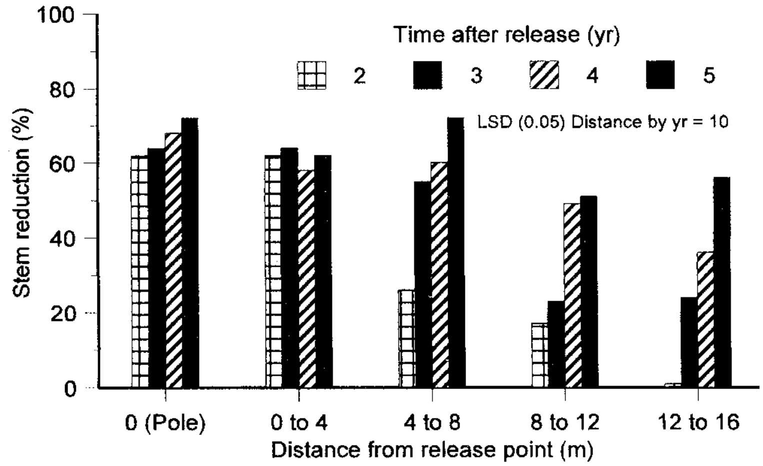


**Figure 2. Leafy spurge stem reduction with *Aphthona nigriscutis* at several distances from the release point along a railroad right-of-way near Buffalo, ND. Data were combined over initial releases of 100, 200, 300, 400, or 500 adults by the pole.**

*Aphthona nigriscutis* reduced approximately 60% of leafy spurge top growth 1 year after release up to 4 m from the release point (Figure 2). Reduction was similar regardless of the initial number of adults released, so the data were combined over the five populations of *Aphthona* released (treatment). Leafy spurge stem reduction at the release point and at the 0 to 4 m distance remained the same or only slightly increased 3 to 5 years after release and averaged 65% by the end of the experiment. Stem density gradually decreased at distances of 4, 8, 12, and 16 m as time after release increased. In general, the gradual decrease in stem reduction corresponded to the slight increase in *A. nigriscutis* population at the corresponding distances (Figure 2; Table 1). For instance, leafy spurge stem reduction at the 12- to 16-m distance increased from less than 5% the year after release to 60% 5 years after release as the insect population increased from 1 to 7 beetles/$m^2$.

*Aphthona nigriscutis* population seemed to reach an equilibrium of 5 to 7 beetles/$m^2$ (Table 1) and maintained leafy spurge stem reduction (Figure 2) at 60 to 70% 5 years after the initial release. It is unlikely that leafy spurge stem density will significantly decrease in the future. Environmental constraints such as moisture, soil type, temperature, and available food determine *A. nigriscutis* density and the subsequent level of leafy spurge control. Subtle changes in *A. nigriscutis* density likely will occur in the future; however, other biological agents, control methods, or both will need to be implemented to further decrease leafy spurge density at this location.

*Aphthona nigriscutis* was the first leafy spurge flea beetle to increase in population enough in North Dakota to allow for redistribution to new sites and to establish new research experiments (North Dakota Department of Agriculture, personal communication). The 4,500 *A. nigriscutis* adults used to establish this study was the largest movement of a leafy spurge biocontrol agent in the state at that time. However, as other biocontrol agents began to establish in the state, it became obvious that *A. nigriscutis* likely would not be the most effective agent in North Dakota. A mixed population of *A. czwalinae/lacertosa* had established in an insectary near Valley City, ND, and when redistributed, established faster and in higher populations than *A. nigriscutis.* Thus, a second experiment was established with *A. czwalinae*/*lacertosa* along a different railroad.

As in the first experiment with *Aphthona nigriscutis,* the distance and rate of spread of *A. czwalinae*/*lacertosa* was similar regardless of the initial adult release number, so data were combined over the four populations released (treatment) (Table 2). *Aphthona czwalinae*/*lacertosa* adults established at all release points and were found up to 10 m from the release point 1 year following release. The flea beetle density 1 year after release averaged 8 adults/m$^2$ at the release point and 4 adults/m$^2$ at the 0- to 5-m distance (Table 2), but no reduction in leafy spurge stem density was observed.

**Table 2. *Aphthona czwalinae*/*lacertosa* (flea beetle) population change and radial spread 1 to 4 years after release along a railroad right-of-way averaged over insect densities of 500 to 2,000 beetles/release.**

| | Years after release | | | |
|---|---|---|---|---|
| Distance from release point | 1 | 2 | 3 | 4 |
| m | beetles/m$^2$ | | | |
| 0 (release point) | 8 | 96 | 14 | 102 |
| 0 to 5 | 4 | 103 | 36 | 109 |
| 5 to 10 | 1 | 14 | 29 | 50 |
| 10 to 15 | 0 | 3 | 23 | 56 |
| 15 to 20 | 0 | 2 | 20 | 56 |
| Mean | 2 | 50 | 27 | 79 |
| LSD (0.05) distance by year = NS; year = 34 | | | | |

There was a large increase in the number of adults collected between the first and second year after release (Table 2). *Aphthona czwalinae*/*lacertosa* averaged 96 and 103 beetles/m$^2$ at the release pole and the 0- to 5-m distance, respectively. Leafy spurge stem density began to decline by the second year after release with 50% reduction at the release pole and 10% reduction at the 0- to 5-m distance (Figure 3). Also, *A. czwalinae/lacertosa* insects 2 years after release were found at distances of 10 to 15 and 15 to 20 m from the release pole, but there was no reduction in leafy spurge stem density (Table 2; Figure 3).

*Aphthona czwalinae/lacertosa* densities across the experiment were similar regardless of distance from the release point by 3 years after release and average 27 adults/m$^2$ (Table 2). There were fewer beetles at the release point and the 0- to 5-m distance at 3 years compared to 2 years after release, which probably was due to the dramatic reduction in leafy spurge. Stem reduction 3 years after release averaged greater than 90% up to 5 m from the release pole (Figure 3). Thus, there was little leafy spurge foliage for the adults to feed on and they began to disperse from the experiment area. Leafy spurge stem reduction averaged approximately 60, 50, and 40% at distances of 5 to 10, 10 to 15, and 15 to 20 m, respectively, 3 years after release.

Leafy spurge stem reduction averaged 95% or better regardless of the distance from the initial release point 4 years after release of *Aphthona czwalinae/lacertosa* (Figure 3). Even though the population averaged 79 beetles/$m^2$, many adults were found on grass and other vegetation as well as the few remaining leafy spurge stems. Flea beetles were found more than 100 m outside the experiment area by 4 years after release and seemed well on the way to controlling leafy spurge along this section of the railroad.

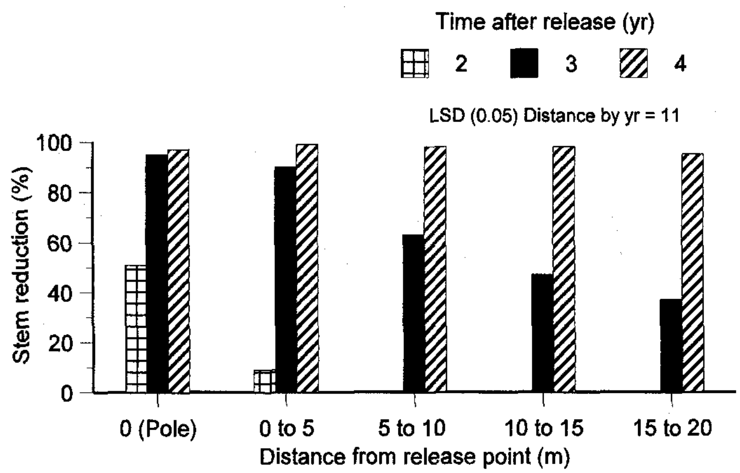


**Figure 3. Leafy spurge stem reduction with *Aphthona czwalinae/lacertosa* at several distances from the release point along a railroad right-of-way near Lisbon, ND. Data were combined over initial releases of 500, 1,000, 1,500, or 2,000 adults by the pole.**

Both *Aphthona nigriscutis* and the mixed population *A. czwalinae/lacertosa* established and reduced leafy spurge density along railroad right-of-ways. *Aphthona nigriscutis* reduced leafy spurge stem density approximately 60%, although the population 5 years after release did not exceed densities of 10 beetles/$m^2$. *Aphthona czwalinae/lacertosa* established, rapidly increased in population, and reduced the leafy spurge density by 95% or greater within 4 years of release. Leafy spurge control with flea beetles is dependent on various environmental factors, such as soil type and stem density (Kirby *et al*. 1999), and can vary from the stem reductions observed in this study to near zero. Further research is needed to, help determine which *Aphthona* flea beetle is best adapted for use in the many types of environments where leafy spurge is found.

Although not directly comparable in this study, *A. czwalinae/lacertosa* increased to larger numbers and reduced leafy spurge stem densities faster and to a greater extent over time than *A. nigriscutis*. Similar results have been reported in other studies (Kirby *et al*. 1999). Even though flea beetles are gregarious, *Aphthona* spp. insects are capable of flight (Maw 1981) and could move from patch to patch of leafy spurge along the right-of-way if necessary. Thus, the use of *Aphthona* spp. is a viable alternative to currently available herbicides for leafy spurge management along railroad right-of-ways and likely other industrial sites that have traditionally only used herbicides. Once established, flea beetles could maintain leafy spurge densities at much lower densities than currently found. However, *Aphthona* spp. alone would never eliminate leafy spurge.

## Literature cited

Bangsund, D. A., J. A. Leitch, and F. L. Leistritz. 1996. Economics of herbicide control of leafy spurge (*Euphorbia e*sula L.). J. Agric. Res. Econ. 21:381-395.

Carlson, R. B. and D. Mundal. 1990. Introduction of insects for the biological control of leafy spurge in North Dakota. ND Farm Res. 47(6):7-8.

Dunn, P. H. 1979. The distribution of leafy spurge (*Euphorbia esula*) and other weedy *Euphorbia s*pp. in the United States. Weed Sci. 27:509-516.

Hansen, R. W., R. D. Richard, P. E. Parker, and L. E. Wendel. 1997. Distribution of biological control agents of leafy spurge (*Euphorbia esula* L.) in the United States: 1988-1996. Biol. Control 10:129-142.

Kirby, D. R. and R. B. Carlson. 1998. Leafy spurge control with flea beetles (*Aphthona s*pp.). Proc. West. Soc. Weed Sci. 51:130.

Kirby, D. R., M. Hayek, D. Cline, K. Krabbenhoft, and C. O'Brien. 1999. Site characteristics of established flea beetle colonies in western North Dakota. *In* Proc. Leafy Spurge Symposium, Medora, ND. Fargo: North Dakota State University. p. 24.

Lym, R. G. and D. R. Kirby. 1987. Cattle foraging behavior in leafy spurge (*Euphorbia esula*)-infested rangeland. Weed Technol. 1:314-318.

Lym, R. G. and C. G. Messersmith. 1990. Cost-effective long-term leafy spurge control with herbicides. Weed Technol. 4:635-641.

Maw, E. 1981. Biology of some *Aphthona s*pp. (Col.:Chrysomelidae) feeding on *Euphorbia* sp. near *esula*. M.S. thesis. University of Alberta, Edmonton. 258 p.

Moran, G. 1992. Leafy spurge a candidate for biological control. ND Farm Res. 49(5):3-6.

Spencer, N. R. 1994. Insects for leafy spurge control. *In* Proc. Great Plains Agriculture Council GPC-14, Leafy Spurge Control in the Great Plains. Bozeman, MT: Montana State University. pp. 36-38.

Stromme, K., D. E. Cole, A. S. McClay, C. J. Richardson, and J. deValois. 1996. Biocontrol of leafy spurge with *Aphthona nigriscutis* in Alberta "The Beverly Bridge Site." *In* Proc. Great Plains Agriculture Council GPC-14, Leafy Spurge Control in the Great Plains. Brandon, Manitoba: Manitoba Agriculture. pp. 26-27.