Integrated management systems for canola (*Brassica napus* L.)

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Abstract

Canola is the major oilseed crop in Canada. In recent years, management systems for canola production have rapidly evolved and there are now many options for canola cultivation. Here we summarize western Canadian integrated canola management practices that favour canola health as well as economic and environmental sustainability. Canola establishment is optimized when vigourous, certified, hybrid seed is planted relatively early at a rate that is adequate for healthy populations (at least 70 plants m^{-2}). Healthy canola plants in adequate numbers mitigate numerous abiotic (frost, drought, flooding) and biotic (diseases, insects, weeds) threats to optimal canola production. Nitrogen, phosphorous, potassium and a sulphate form of sulphur banded near the seed at the time of seeding often improve crop health. Weeds that emerge with the crop should be controlled by the four leaf stage of the canola. A second in-crop herbicide application is usually not necessary for optimal yields. Disease and insect monitoring are important to determine the necessity of foliar fungicide and insecticide treatments. Using herbicide-resistant (HR) canola cultivars versus non-herbicide-resistant cultivars reduces the need for tillage, improves weed management, protects yield potential, and lowers environmental impact. Compared to other options, economic risks are minimized when glyphosate-resistant canola is planted in late April or early May at 150 seeds m^{-2} and treated with a single application of glyphosate before the canola advances beyond the four-leaf stage. Although HR canola volunteers have increased somewhat, widely-publicized concerns over their persistence and management have largely been over-stated. Hybrid cultivars, given their superior competitive ability over open pollinated cultivars, are less dependent on additional herbicide applications than less competitive open pollinated cultivars. Furthermore, the rapid early growth of hybrid cultivars may also improve fertilizer use efficiency and reduce soil and atmospheric nutrient losses compared to open pollinated cultivars.

Key words: *Brassica napus*, crop health, direct seeding hybrids, integrated crop management, environment

Introduction

Canola is the major oilseed crop in Canada; it is second only to wheat in cropped area and is generally more profitable than wheat. Canola seeded area has increased 55% in the last 10 years (it now occupies 5.5 million ha annually) while wheat area has declined by 20% in the same time period. Continued expansion of canola is likely to continue. The canola crushing industry in Canada will probably require an additional 1.3 million ha of production by 2008. The new Canadian biodiesel market could potentially utilize an additional 2 million ha of canola annually. In addition, Canada is already exporting canola to Europe for their biodiesel market. All of these developments will require canola production in Canada to expand by another 50% in the next decade. It will be a challenge to substantially increase canola production in a sustainable and environmentally sound manner.

Optimal Production Practices

Canola establishment is optimized when vigourous, certified, hybrid seed is planted relatively early at a rate that is adequate for healthy populations of at least 70 plants m^{-2}. Although much lower stand densities of canola can lead to relatively high yields under some conditions, at lower stand densities yields are much more variable and usually require greater herbicide inputs. Healthy canola plants in adequate numbers buffer and mitigate numerous abiotic (frost, drought, flooding) and biotic (diseases, insects, weeds) challenges. Nitrogen and a sulphate form of sulphur are often crucial to optimal canola production and should be banded to within 2 cm of the seed at the time of seeding. In addition, at least some phosphorous should be placed with the seed to enhance early emergence and seedling health. Potassium should be applied according to soil test recommendations.

Weeds that emerge with the crop should be controlled relatively early. Generally, when weeds are controlled by the four-leaf stage of the canola crop, optimal yields can be attained (Clayton et al. 2002; Harker et al. 1999; Martin et al. 2001). Later herbicide applications are usually unnecessary (O'Donovan et al. 2006) and may lead to crop injury (Schilling et al. 2006). Disease and insect monitoring are important to determine the necessity of possible foliar fungicide and insecticide treatments. To avoid damage to beneficial insects, it is important to ensure that pest insects reach economic threshold levels before insecticides are employed (McMenamin 2006).

In recent years, management systems for canola production have rapidly evolved and there are now many options for canola cultivation. In Canada, more that 90% of canola production involves herbicide-resistant (HR) cultivars. The benefits HR canola production in Canada have substantially outweighed perceived risks (Beckie et al. 2006). Using HR canola cultivars versus non-HR cultivars reduces the need for tillage, improves weed management, protects yield potential, and lowers environmental impact (Canola Council of Canada 2001). Compared to other options, economic risks are minimized when glyphosate-resistant canola is planted in late April or early May (Clayton et al. 2004) at 150 seeds m^{-2} and treated with a single application of glyphosate before the canola advances beyond the four-leaf stage (Upadhyay et al. 2005; 2006; Smith et al. 2006).

Hybrid Canola

Farmer adoption of hybrid canola in Canada has increased from 15 to 70% in the last five years. Hybrid cultivars were adopted because of their higher yield potential (30%) but they have the added benefit of being more competitive with weeds (Harker et al. 2003a; Zand & Beckie 2002). Small weed seedlings are particularly vulnerable to the negative effects of shade (Fenner 1978; Mohler 2001). Astute managers are aware of this vulnerability and strive to promote rapid, uniform crop emergence and ground cover to pre-empt light resources potentially available to weeds. Hybrid cultivars can be effective management tools to ensure that crop canopies develop quickly (Harker et al. 2003b). In addition, weed species that require a "light" signal for germination are actually inhibited when red-light depleted radiation is filtered through crop leaves (Górski 1975; King 1975; Silvertown 1980). Given their superior competitive ability over open pollinated cultivars, hybrids are less dependent on additional herbicide applications than less competitive open pollinated cultivars. O'Donovan et al. (2006) demonstrated that glyphosate-resistant canola can increase revenues and decrease herbicide active ingredient entering the environment. Furthermore, the rapid early growth of hybrid cultivars may also improve fertilizer use efficiency and reduce soil and atmospheric nutrient losses compared to open pollinated cultivars.

Volunteer Canola

Some have suggested that volunteer canola, and more specifically volunteer glyphosate-resistant canola, is over-running western Canadian cropland and will soon be our most important weed species in direct-seeding systems. Post-management weed surveys (Leeson et al. 2005), and crop producer experience do not generally support this supposition (Beckie et al. 2006). Careful volunteer canola management in the year after a canola crop helps preclude additional glyphosate-resistant canola management concerns in subsequent years (Harker et al. 2006). Pekrun et al. (1998) showed that volunteer canola is less prone to develop secondary dormancy and persist in soil seedbanks if tillage is delayed for several weeks after harvest or not employed at all. Indeed, zero tillage and direct-seeding systems tend to reduce the persistence of canola volunteers (Harker et al. 2006).

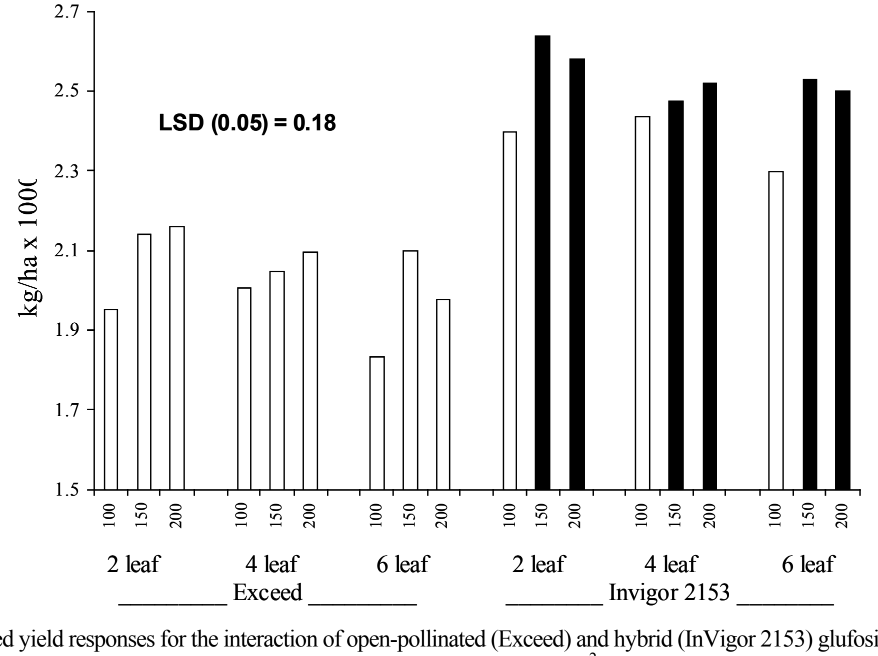

Fig. 1. Mean seed yield responses for the interaction of open-pollinated (Exceed) and hybrid (InVigor 2153) glufosinate-resistant, canola cultivars, time of weed removal (canola growth stages) and seeding rates [seeds m^{-2}] averaged across sites at Lacombe (1998–2000) and Lethbridge (1999 and 2000), Alberta, Canada. The error bar represents the $LSD_{0.05}$ for the three-way interaction among the factors. Black bars indicate canola yields that are statistically similar to the highest canola yield value. [Adapted from Harker et al. 2003a].

Integrated Crop Management

Beck (2006) reminds us that "successful crop production, regardless of the methods used, is a careful piecing together of numerous components into a system. Simply replacing one component with another is seldom successful". Focusing on crop health and competitiveness will lead producers to rely on packages of tools which include such things as low-disturbance seeding (maintaining crop residues for moisture conservation and the protection of soil quality), higher seeding rates, optimum fertilizer placement, and diverse crop rotations. High crop competitiveness and higher seeding rates provide a form of biocontrol that reduces herbicide dependence. Poor fertility or damage from improper fertilizer placement can reduce crop health to the degree that all of the tools employed for pest management are negated. Similarly, disease and insect management are also important for weed management because of their impact on crop health and competitiveness.

Harker et al. (2003a) show that HR canola hybrids, when combined with other optimal agronomic practices, enhance opportunities for integrated weed and integrated crop management. Combining the hybrid cultivar with the highest seeding rate, and the earliest time of weed removal led to a 41% yield increase compared with the combination of the weaker cultivar, the lowest seeding rate and the latest time of weed removal. (Fig. 1). The same optimal factor levels also favoured higher levels of weed control and lower weed biomass variability (data not shown here).

It seems almost certain that significantly greater canola production will be required to meet greater market demands in the near- and long-term future. Canola production systems that favour the integration of the above management factors will facilitate crop health as well as economic and environmental sustainability.

References

Beck D. (2006). No-till guidelines for the arid and semi-arid prairies. [Online] http://www.dakotalakes.com/Publications/Guidelines.PDF. [Accessed Nov. 8, 2006.]

Beckie, H. J., K. N. Harker, L. M. Hall, S. I. Warwick, A. Légère, P. H. Sikkema, G. W. Clayton, A. G. Thomas, J. Y. Leeson, G. Séguin-Swartz, and M.-J. Simard. 2006. A decade of herbicide-resistant crops in Canada. Can J. Plant Sci. **86**, 1243-1264.

Booth B. D., S. D. Murphy, and C. J. Swanton. 2003. Plant invasions. B. D. Booth, S. D. Murphy, C. J. Swanton (eds): Weed Ecology in Natural and Agricultural Systems. CABI, Oxford, 235-253

Canola Council of Canada. 2001. An agronomic and economic assessment of transgenic canola. Report prepared by Serecon Mgmt. Consulting Inc. and Koch Paul Assoc. Jan. 2001, Available: http://www.canola-council.org/report_gmo.html [Accessed: November 27, 2006].

Clayton, G. W., K. N. Harker, J. T. O'Donovan, M. N. Baig, and M. J. Kidnie. 2002. Glyphosate timing and tillage system effects on glyphosate-tolerant canola (*Brassica napus*). Weed Technol. **16**, 124-130.

Clayton, G. W., Harker, K. N., O'Donovan, J. T., Blackshaw, R. E., Dosdall, L. M., Stevenson, F. C. and Ferguson, T. 2004. Fall and spring seeding date effects on herbicide-tolerant canola (Brassica napus L.) cultivars. Can. J. Plant Sci. **84**, 419-430.

Dosdall, L. M., G. W. Clayton, K. N. Harker, J.T. O'Donovan and F. C. Stevenson. 2003. Weed control and root maggots: making pest management strategies compatible. Weed Sci. **51**, 576-585.

Fenner, M. 1978. Susceptibility to shade in seedlings of colonizing and closed turf species. New Phytol. **81**, 739-744.

Górski, T. 1975. Germination of seeds in the shadow of plants. Physiol. Plant. **34**, 342-346.

Harker, K. N., G. W. Clayton, R. E. Blackshaw, J. T. O'Donovan, E. N. Johnson, Y. Gan, F. A. Holm, K. L. Sapsford, R. B. Irvine, and R. C. Van Acker. 2006. Persistence of glyphosate-resistant canola in western Canadian cropping systems. Agron. J. **98**, 107-119.

Harker, K. N., G. W. Clayton, R. E. Blackshaw, J. T. O'Donovan and F. C. Stevenson. 2003a. Seeding rate, herbicide timing and competitive hybrids contribute to integrated weed management in canola (Brassica napus). Can. J. Plant Sci. **83**, 433-440.

Harker, K. N., G. W. Clayton, and A. M. Johnston. 1999. Time of weed removal for canola. Proc. 10th International Rapeseed Congress. Sep. 26-29, Canberra, Australia, 4 p. (CD ROM).

Harker, K. N., G. W. Clayton, J. T. O'Donovan, R. E. Blackshaw, A.K.W. Tong and T. Lui. 2003b. Digital canola canopy analysis: effect of cultivar and seeding date. Proc. 11th International Rapeseed Congress. July 6-10, The Royal Veterinary and Agricultural University, Copenhagen, Denmark. Vol. **3**, 800-802.

King, T. J. 1975. Inhibition of seed germination under leaf canopies in Arenaria serpyllifolia, Veronica arvensis and Cerastum (sic) holosteoides. New Phytol. **75**, 87-90.

Leeson, J. Y., A. G. Thomas, L. M. Hall, C. A. Brenzel, T. Andrews, K. R. Brown, and R. C. Van Acker. 2005. Prairie weed surveys of cereal, oilseed and pulse crops from the 1970s to the 2000s. Agriculture and Agri-Food Canada Weed Survey Series. Pub. 05-1.

Liebman, C. L. Mohler, and C. P. Staver eds. Ecological Management of Agricultural Weeds. Cambridge University Press, UK.

Martin, S. G., L. F. Friesen, and R. C. Van Acker 2001. Critical period of weed control in spring canola. Weed Sci. **49**, 326–333.

McMenamin, H. 2006. Natural enemies – farmer's unpaid helpers. Top Crop Manager, November 2006, 50-54.

Mohler, C. L. 2001. Weed life history: identifying vulnerabilities. M. Liebman, C. L. Mohler, and C. P. Staver eds. Ecological Mgmt. of Agricultural Weeds. Cambridge University Press, UK, 40-98.

O'Donovan, J. T., K. N. Harker, G. W. Clayton, and R. E. Blackshaw. 2006. Comparison of a glyphosate-resistant canola (*Brassica napus* L.) system with traditional herbicide regimes. Weed Technol. **20**, 494-501.

Pekrun, C., J.D.J. Hewitt, and P.J.W. Lutman. 1998. Cultural control of volunteer oilseed rape (Brassica napus). J. Agric. Sci. **130**, 155-156.

Schilling, B. S., K. N. Harker and J. R. King. 2006. Glyphosate can reduce glyphosate-resistant canola growth after individual or sequential applications. Weed Technol. **20**, 825-830.

Silvertown, J. 1980. Leaf-canopy-induced seed dormancy in a grassland flora. New Phytol. **85**, 109-118.

Smith, E. G., B. M. Upadhyay, R. E. Blackshaw, H. J. Beckie, K. N. Harker, and G. W. Clayton. 2006. Economic benefits of integrated weed management systems in field crops in the Dark Brown and Black soil zones of western Canada. Can. J. Plant Sci. **86**, 1273–1279.

Upadhyay, B. M., E. G. Smith, G. W. Clayton, K. N. Harker, and R. E. Blackshaw 2006. Economics of integrated weed management in herbicide-resistant canola (*Brassica napus* L.). Weed Sci. **54**, 138-147.

Upadhyay, B. M., E. G. Smith, G. W. Clayton, K. N. Harker, J. T. O'Donovan, and R. E. Blackshaw. 2005. Economic evaluation of seeding decisions in hybrid and open-pollinated herbicide-resistant canola (*Brassica napus* L.). Can J. Plant Sci. **85**, 761-769.

Zand, E. and H. J. Beckie. 2002. Competitive ability of hybrid and open-pollinated canola (Brassica napus) with wild oat (Avena fatua). Can. J. Plant Sci. **82**, 473-480.