Herbicide Tolerant Volunteer Canola Management In Subsequent Crops

Part 1: A Comparative Analysis Of The 2003 Saskatchewan, 2002 Manitoba, And 2001 Alberta Weed Survey Data
Part 2: Western Canada Grower Survey

Final Report

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As a condition of release of the raw data from these surveys, it was understood that the data could be used only for the express purposes of this analysis, and that AAFC and their provincial partners would review the report prior to general release. It should be noted that AAFC has not verified the analysis reported herein. This analysis and the anticipated publication of the report based on the data provided by AAFC does not preclude AAFC or their partners from conducting an independent analysis of the data related to this topic for publication.

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Glossary Of Terms

Adventitious Presence	Adventitious presence refers to the unintentional and incidental commingling of trace amounts of one type of seed, grain or food product with another. In this study adventitious presence refers to low levels of unintended presence of a herbicide tolerant trait in the seed of another herbicide tolerant system or conventional seed.
CLEARFIELD™ Canola	The CLEARFIELD system (previously called SMART Trait) is tolerant to Pursuit® and Odyssey® herbicides and was developed through a process called mutagenesis. CLEARFIELD is not considered a transgenic canola system, but it is a herbicide tolerant system.
Conventional Canola	Conventional varieties have been developed through traditional breeding methods like cross-pollination and backcrossing. Conventional canola has not been bred to be tolerant to specific herbicides. In this report conventional varieties are those that are not Roundup Ready®, Liberty Link®, InVigor® or CLEARFIELD.
Genetic Engineering (GE)/ Genetically Modified Organism (GMO)	Genetically engineered/genetically modified organism means an organism in which the genetic material has been changed through gene technology in a way that does not occur naturally by multiplication and/or natural recombination. Codex Alimentarius sets international food standards under the Food and Agriculture Organization of the United Nations. Examples of these techniques used in gene technology include: recombinant DNA techniques that use vector systems; techniques involving the direct introduction into the organism or hereditary materials prepared outside the organism; and cell fusion or hybridization techniques that overcome natural barriers.
Herbicide Group	Herbicides are grouped according to mode of action (i.e. whether they block a particular enzyme, inhibit cell division or disrupt growth, inhibit photosynthesis, etc.). It is generally recommended to rotate herbicide groups to prevent weed resistance. There are 13 herbicide groupings in use.
Herbicide Tolerant (HT) Systems	Cropping systems where the crop is bred specifically to tolerate certain herbicides.
Tillage Systems	Conventional tillage refers to tillage used by growers in the fall after harvest or the spring before seeding to prepare the soil for seeding, apply fertilizer or to control weeds. Zero tillage is when growers do not use tillage in the fall or spring and use a one pass seeding operation which places seed and fertilizer into an undisturbed seedbed, packs the furrow and retains adequate surface residues to prevent soil erosion.
Transgenic Canola	In canola there are two commercial “systems” which are considered genetically engineered or transgenic: Roundup Ready (tolerant to the glyphosate herbicide Roundup®) and Liberty Link (tolerant to the herbicide Liberty®) dominated by InVigor® hybrid varieties.

Executive Summary

Introduction

This report assesses the comparative management of volunteer canola in fields following conventional canola as well as three herbicide tolerant (HT) systems: Roundup Ready®, tolerant of the Group 9 herbicide Roundup® (common name glyphosate); Liberty Link®/InVigor®, tolerant of the Group 10 herbicide Liberty® (common name glufosinate ammonium); and CLEARFIELD™, tolerant of Group 2 herbicides Pursuit® (common name imazethapyr) and Odyssey® (common name imazethapyr/imazamox). Management practices, costs of control, impacts, and grower perceptions were considered.

Data sources included the following:

- an analysis of the 2001-3 Prairie Weed Survey conducted by Agriculture and Agri-Food Canada in cooperation with the three prairie provinces (sample size 316 fields previously planted to canola). Data included summer weed counts as well as the results of a self-completed management survey;
- a telephone survey of 335 western Canadian canola growers regarding their 2004 volunteer canola weed management practices; and
- a series of simulations to determine herbicide options and costs for controlling volunteer canola given different crop and target weed scenarios.

Key Findings

A comparative analysis of volunteer canola management by system is complicated by several factors. Some of these are as follows:

- There is a high incidence of growing multiple systems, and of rotating systems from year to year. For example, just one in five of the 2003 conventional growers surveyed in 2004 had grown only conventional varieties over the past five years.
- There are many combinations of subsequent crops (although spring wheat is the most common crop planted following canola), target weeds, available herbicides and tillage options. Field sizes do not always line up from year to year. Weed management appears to have more to do with the subsequent crop and the full spectrum of weeds to be controlled, rather than the previous canola system. As such, it is somewhat difficult for growers to identify particular treatments for volunteer canola in isolation from their total weed management program.
- Volunteers are most often traceable to the crop immediately preceding the current crop, in which case the system can be determined. Volunteers can also be carried over from prior years, they can be spread from field to field by equipment, they can come from seed with adventitious presence, or from a neighbouring field.

The analysis revealed more similarities than differences between systems in terms of volunteer canola management in subsequent crops.

- Volunteer canola was rarely indicated as the primary broadleaf weed to be controlled with a herbicide application, regardless of system. Overall, more serious weed problems were cited, including wild oats, wild buckwheat, Canada thistle, and other broadleaf annuals.
- The incidence of herbicide use and tillage to control volunteers was similar across systems and was not exclusive to HT varieties. Considering the total weed management program, there was an indication that conventional growers made slightly fewer pre-seed passes to apply herbicides, but tilled more, particularly relative to CLEARFIELD.
- Again, considering the total weed management program, the herbicide options and timing of

application (most often in-crop) were similar across canola systems with Group 2 and 4 herbicides used most often for in-crop control. The exception was CLEARFIELD that is designed to be tolerant of particular Group 2 herbicides and therefore Group 4 is most commonly used.

- Management of the canola crop residue in the previous fall was similar across systems.
- The percentage of fields with volunteer canola observed during the summer weed count was very similar across all systems, and rarely exceeded economic thresholds for treatment as defined by the growers at ten plants per square meter.
- Yield and dockage losses have been experienced in crops following canola for all four systems, not just HT canola.
- Volunteer canola control on fields not planted to canola the previous year was practiced very infrequently. If herbicides were applied or tillage operations performed, the source of the volunteers was attributed to HT as well as conventional varieties.
- The presence of volunteer canola on fields not planted to canola the previous year was comparable to the presence of volunteer grains on fields not planted to these same grains the previous year, suggesting that carry over or movement of volunteer canola from field to field was no greater a problem than other volunteer grains, as identified by the summer weed count.
- There were no significant differences between systems in the costs of volunteer canola control, as estimated by the growers themselves; at $10-13 per acre treated with herbicides, and $5 per acre for tillage/harrowing operations.

There was an indication from the Prairie Weed Survey of greater recognition by Roundup Ready and CLEARFIELD growers (relative to conventional growers) that volunteer canola was a more troublesome weed than other broadleaf annuals. This could have been due to greater awareness by these growers of the potential need to control volunteers from these two systems.

Other differences as noted from the 2004 grower survey, follow:

- The majority of canola growers surveyed were not targeting volunteer canola with weed control measures more so than they had in the past, nor had they changed their weed management practices in order to control volunteer canola. Increases in targeting or changes to weed management practices to control volunteer canola were reported by those with a history of growing conventional canola as well as HT systems. If a change was made, it was more often reported by zero till than conventional tillage growers, which corresponded to the adoption of HT varieties. Therefore any change in weed management could be due to the corresponding change in tillage practices and/or by greater awareness of the need to control volunteer canola by HT growers.
- Slightly more Roundup Ready than conventional growers said they targeted volunteer canola from that system with a herbicide application, although the percentage of acres treated (under 20% of the acres following canola) was similar across systems.

Because of the challenges noted above, and the great diversity of products used and weeds targeted, it is somewhat difficult to describe a definitive profile of weed control practices and associated costs in subsequent cereals by system. Typical examples follow:

- A zero-till Roundup Ready grower might add a tank mix of 2,4-D to their pre-seed burn off to control volunteer canola along with other broadleaf annual weeds at a product cost of about $2 per acre. Since the product is tank mixed, there would be no incremental application cost. It is likely that Roundup Ready growers are more able to isolate their volunteer canola treatments from their other broadleaf treatments because they know that Roundup can't control it.
- Conventional, Liberty Link, and CLEARFIELD growers might apply glyphosate as a pre-seed burn off (total cost about $7-13 per acre with

application depending on the rate)[1], but the challenge here would be to allocate a portion of that cost just to controlling volunteer canola, since a variety of broadleaf weeds and others including quack grass are typically targeted with this type of application. Note as well, that growers might decide to make a pre-seed application as a matter of course, and not necessarily in response to an observation of the weed spectrum and infestation levels in the spring. Others growers might apply a dedicated in-crop tank mix of 2,4-D or MCPA, perhaps in the form of products like Buctril M or Frontline, or along with a wild oat herbicide, again at an incremental cost of about $2 per acre.

Canola growers continue to support the adoption of HT varieties:

- The adoption of HT varieties is correlated to the move to zero tillage systems and the resulting benefits.
- Growers surveyed that had experience with both conventional and HT systems reported that volunteer canola management was the same for both types of systems or easier with HT by a factor of three to one (three the same or easier, one more difficult).
- Nearly 60% of the growers who planted a HT variety in 2003 (any of the three systems) reported a carry-over benefit to the 2004 crop in terms of improved weed control. This perception was not supported with the Prairie Weed Survey data where no differences in summer weed counts were found. About half of these growers put a dollar value on this benefit of $11.80 per acre, roughly the cost of product and application of, for example, a typical glyphosate treatment. This cost benefit would offset any incremental cost of volunteer canola control as derived from the grower survey.
- The majority of HT growers continue to support the premise, that overall, the benefits of growing HT varieties, all things considered, including subsequent volunteer control, were greater than the benefits of growing conventional varieties on their farms.

[1] The lower rate of .3 litres per acre is recommended for volunteer canola. If quack grass is targeted, the higher rate (1 litre per acre) is recommended.

In conclusion, differences in, and costs of, volunteer control management between systems are subtle, and practices are not significantly different for HT versus conventional systems. The incidence of herbicide treatments or tillage operations specifically for volunteer canola is very small within the population, and therefore the ability to compare costs with a good degree of confidence is limited. Importantly, the results from the three lines of investigation undertaken in this study were highly consistent. Further tracking of this issue by monitoring future Prairie Weed Survey results is recommended. Definitive research into economic thresholds for volunteer canola in subsequent crops is suggested.

1.0 INTRODUCTION

1.1 BACKGROUND

The Canola Council of Canada released a report in January, 2001 on the "Agronomic and Economic Impact of Transgenic Canola". This study, coordinated by the Canola Council of Canada, was conducted by Serecon Management Consulting Inc.

The results of the project have provided valuable information on growers' attitudes toward, and their experience with, transgenic varieties and the positive benefits of transgenic canola. In brief, the study found a yield and profit advantage for growers using transgenic varieties. Growers indicated that they chose transgenic varieties for better weed control and increased profit. The environmental benefits included less tillage, less fuel consumption, and less herbicide use.

The study has been used in Canada and internationally by regulators, grower groups, and the media to respond to questions on the impact of growing transgenic canola.

One of the areas that the study did not cover was the growers' experiences in dealing with volunteer canola, their practises to manage the volunteers, and the cost of managing volunteers on the field following the planting of a herbicide tolerant (HT) canola variety vis a vis a conventional variety.

Because of the increased adoption of HT varieties, a thorough analysis of the volunteer canola management issue for both conventional and HT systems was initiated.

A two-part study approach was recommended, utilizing the Prairie Weed Survey data set, jointly held by Agriculture and Agri-Food Canada and Alberta Agriculture, Food and Rural Development, Manitoba Agriculture, Food and Rural Initiatives, and Saskatchewan Agriculture, Food and Rural Revitalization, as the primary source of agronomic data from which economic conclusions could be derived. This was supplemented with a perception and opinion survey of prairie canola growers. The telephone survey regarding spring 2004 volunteer canola control practices was conducted in summer 2004. This approach had the advantages of reducing response burden on the growers while maximizing response frame. It provided a reliable data source due to the timeliness of data collection, it offered a cost-effective solution to the client and, most importantly, cross-validation of results from a credible source (The Prairie Weed Survey) and independent research.

The justification for using the Prairie Weed Survey data as the primary agronomic practice source for this project was mainly related to the comprehensiveness of the data set. The data quality was felt to be very good because AAFC and the provinces have a history of directing the survey. The associated management questionnaire was self-completed, so presumably the growers reviewed their records as they completed it. The information was timely in regard to when the practices were implemented, particularly given the need to relate the economic impact back to the original study (based on the 2000 canola crop year). The survey had data for what would be considered more typical years for canola production in both Alberta and Manitoba, given the recent droughts. Actual data from the weed survey (i.e. summer weed counts) was included in the data set, which is a distinct benefit over relying on the producers' recall of what they think the weed problem/incidence was after the fact. The survey was not conducted specifically to look at the volunteer canola problem, therefore topic bias was controlled. There was a dedicated section in the survey on herbicide resistant weeds, which allowed for the capture of perceptions of herbicide resistant volunteers. Finally, the plan by governments to continue these surveys every five to eight years provides a consistent benchmark against which future changes in volunteer management can be tracked.

The primary purpose of the supplemental summer 2004 attitude and opinion survey of prairie farmers was to address the issue of whether the grower would have made the herbicide application or tilled to control weeds if volunteer canola had NOT been present, since a key objective of this study was to determine the incremental cost of HT volunteer control over a conventional system.

1.2 Study Objectives

The Part 1 and Part 2 study objectives were designed to address the following issues by canola system:

- differences in management practices used for controlling conventional volunteers versus HT volunteers;
- comparative costs of controlling conventional volunteers, versus HT canola volunteers and cost differences between conventional and HT fields;
- growers' perceptions of the ease of volunteer canola control before they grew HT versus after adopting HT, and relative to the benefits of growing HT varieties; and,
- comparative analysis between zero till and conventional tillage management of volunteer canola.

1.3 Methodology

1.3.1 Part 1 Methodology: An Analysis Of the Prairie Weed Survey Data

An assessment was conducted of the Prairie Weed Survey data set.

Randomly selected fields were surveyed in July and August prior to harvest of each year and the incidences of weeds that were missed by the normal cycle of weed control practices were recorded. A total of 3830 fields were surveyed in the prairie provinces:

- 1,153 in Alberta in 2001;
- 631 in Manitoba in 2002; and,
- 2,046 in Saskatchewan in 2003.

A comprehensive management questionnaire was then administered to growers. Overall, a 55% response rate to the management questionnaire was received to the three provincial management surveys. The response rate varied by province:

- 64% (Alberta 2001);
- 59% (Manitoba 2002); and,
- 49% (Saskatchewan 2003).

The data available to conduct the bulk of the analysis reported in this document is a subset of the above three provincial surveys. It considered those fields upon which canola was planted the previous year. This field history information (previous year's crop and variety) was reported in the management questionnaire, which provided the canola system used. Reported variety information was somewhat incomplete for some of the surveys, therefore inferences as to the canola system were made by AAFC, based on the herbicides used. Fourteen cases were dropped from the analysis because the system could not be determined. A total of 316 cases were analyzed; 142 from Alberta, 79 from Manitoba, and 95 from Saskatchewan.

Table 1.1: Fields Surveyed Subsequent to Canola by System

	AB	MB	SK	Total
Conventional	31	14	9	**54**
Liberty	7	18	18	**43**
Roundup Ready	73	28	50	**151**
CLEARFIELD	31	19	18	**68**
Total	**142**	**79**	**95**	**316**

Source: 2001 Alberta, 2002 Manitoba, and 2003 Saskatchewan Weed Surveys

The distribution of acres by system in the sample fields fairly closely matched the distribution of acres harvested across western Canada in 2001, according to statistics provided by the Canola Council of Canada. 2001 was chosen as the comparison year because it corresponded to the year previous (when canola was planted) to the mid point of the three weed survey years.

Table 1.2: Distribution of Acres by Canola System

Percentage of Acres

	2001 Total Western Canada Canola (n=9,601,000)	AB/MB/SK Weed Survey Acres (n=41,403)
Conventional	19	17
Liberty	16	14
Roundup Ready	45	47
CLEARFIELD	20	22

Source: 2001 Alberta, 2002 Manitoba, and 2003 Saskatchewan Weed Surveys and Canola Council of Canada

Geographically, the Prairie Weed Survey data included a variable for ecozone (and the subcategories of ecoregions and ecodistricts). This classification approach considers both soil type and climate conditions. The two ecozones corresponding to canola production are the Prairies and Boreal Plains. The 2001 study; "Agronomic and Economic Impact of Transgenic Canola" also considered ecozones in the analysis and the sample distribution was designed to match the canola producer population distribution in western Canada as reported by Statistics Canada in 1996. That study sample broke out as follows: 28% in the Boreal Plains Ecozone and 72% in the Prairies Ecozone (all western Canada). The 2001 Alberta/2002 Manitoba/ 2003 Saskatchewan Weed Survey data sets (n=316) included 34% from the Boreal Plains Ecozone and 66% from the Prairies Ecozone. While the sample appears to be slightly skewed to the Boreal Plains Ecozone, the distribution was within the confidence ranges given the small sample size; therefore the data was not weighted to reflect actual population distribution. Table 1.3 reflects the distribution of fields by system.

Table 1.3: Number of Fields Surveyed by Ecozone

	Conv	Liberty	RR	Clrfld
AB Boreal Pl	15	1	30	15
AB Prairies	16	6	43	16
MB Boreal Pl	2	3	4	3
MB Prairies	12	15	24	16
SK. Boreal Pl	1	8	17	7
SK Prairies	8	10	33	11
Total Boreal Pl	**18**	**12**	**51**	**25**
Total Prairies	**36**	**31**	**100**	**43**

Source: 2001 Alberta, 2002 Manitoba, and 2003 Saskatchewan Weed Surveys

A variety of crops (Table 1.4) were planted following canola. It was the weed management practices on those subsequent fields (including field preparation the previous fall) that were the focus of this analysis. It is always a question of attributing management costs to the benefit of the appropriate crop, recognizing that such factors as the recommended herbicides and the economics of input decisions will vary with that subsequent crop.

The report also references the incidence of volunteer canola as a weed targeted with herbicides, and the incidence of volunteer canola in the summer weed counts on fields planted to something other than canola the previous year; most notably wheat and barley (1,714 sites that had fairly complete information). This analysis could not link volunteer canola to the system because it was not possible to determine the source of the volunteer canola. This analysis was conducted to assess if there were any likely economic implications for controlling volunteer canola that may have originated from a nearby field or from a field planted to canola two or more years previous to the study crop.

Table 1.4: Fields Surveyed Subsequent to Canola by Crop

	AB	MB	SK	Total
Spring Wheat	88	58	54	**200**
Barley	41	7	18	**66**
Canola	5	3	1	**9**
Other[1]	8	11	22	**41**
Total	**142**	**79**	**95**	**316**

[1] Oats, durum, peas, flax or canary seed
Source: 2001 Alberta, 2002 Manitoba, and 2003 Saskatchewan Weed Surveys

Reports of volunteer canola identified as a confirmed or resistant weed were also considered in the analysis.

1.3.1.1 Weed Survey Analysis

The main analysis approach employed was to determine if there were statistical differences between the agronomic practices employed to control volunteer canola between conventional and HT systems, that would in turn justify a detailed comparative costing of these practices.

Steps in the analysis included:

- A request was made to AAFC, and approved by the provincial partners, to release the relevant data for all those records from the 2001 Alberta, 2002 Manitoba, and 2003 Saskatchewan weed surveys (weed count information linked to the management survey data) that indicated canola was grown on the observed field in the respective prior year (i.e. 2000 for Alberta, 2001 for Manitoba, and 2002 for Saskatchewan). The data set was void of specific identifier information to protect the confidentiality of the respondents. An additional request was submitted regarding volunteer canola on fields planted to a crop other than canola the year previous to the surveyed crop.

- Alignment of the Manitoba, Alberta, and Saskatchewan questions because of slight modifications and changes to the ordering of the questions. Note, only the Saskatchewan survey is provided in Appendix A for reference.
- Conversion of the data into Excel and SPSS formats for analysis purposes.
- Confidence tests were run on the first two surveys to assess whether the differences between systems were significant, given the small sample sizes (ANOVA, t-test, Pearson Chi Square, Levene's Test). A review of the results indicated that the data across systems was very tightly clustered; therefore the decision was made to continue with the analysis. A draft report was prepared utilizing the Alberta and Manitoba data. This report was reviewed by the Steering Committee as well as AAFC. The Saskatchewan data was provided in fall 2004, and the report was subsequently updated.
- Table 1.5 outlines the Margin of Error at the 95% confidence level assuming a binomial response of equal probability (50%) and 90% probability.

Table 1.5: Margin of Error at the 95% Confidence Level

	Population[1]	Sample Size	Margin of Error[2] 50:50 Result	Margin of Error[2] 90:10 Result
Total Sample	30,000	316	+/- 5%	+/- 3%
Conventional	5,700	54	+/- 14%	+/- 8%
Liberty	8,700	43	+/- 15%	+/- 9%
Roundup Ready	18,000	151	+/- 8%	+/- 5%
CLEARFIELD	6,900	68	+/- 12%	+/- 7%
If Volunteer Canola was a Weed Targeted with Herbicides	8,450	89	+/- 11%	+/-6%
If Volunteer Canola was Not a Target Weed[3]	21,550	221	+/-7%	+/-4%

[1] Source: 2003 Ipsos Reid Canola Watch Survey (2003 Western Canada grower distribution: 19% conventional, 29% Liberty Link, 60% Roundup Ready, 23% CLEARFIELD) and Statistics Canada 2001 Census of Agriculture (32,670 canola producers in western Canada, discounted to 30,000 to remove growers with less than 80 acres.)

[2] The margin of error declines when the probability of a given response is less than 50%.

[3] Excludes 6 cases that did not indicate weeds targeted with herbicides.

Significant differences in results between systems are highlighted in the text and appear "boxed" in the tables if significant at the 95% confidence level (i.e. the same result would be expected within the margin of error if the survey were repeated 19 times out of 20) or are underlined if significant at the 90% confidence level (i.e. the same result would be expected within the margin of error if the survey were repeated 18 times out of 20).

- Recoding of all chemical brand names to reflect herbicide group.
- Recoding of weeds targeted by herbicide applications to reflect type of weed and whether volunteer canola was a target weed for herbicide applications. The reader should be reminded that different practices are recommended for the control of different weed types (annuals, perennials, grassy or broadleaf weeds), including timing of tillage or herbicide application and the specific herbicides recommended (also dependent on crop and chemical rotation plans for that farm).
- Analysis by canola system and if relevant, by surveyed crop, where spring wheat was the main crop compared because it represented the majority of the sample.

1.3.2 Part 2 Methodology: Canola Grower Telephone Survey

A survey of 335 western Canadian canola growers was conducted from July 26th through to August 6th of 2004. This timing was selected because growers typically have a "lull" in fieldwork after the spraying season (and are therefore somewhat more cooperative with research studies), and more importantly, were able to relay information about their spring volunteer management practices while it was still fresh in their minds.

All growers were pre-screened to:

- be actively farming;
- be responsible for weed management decisions;
- have grown at least 80 acres of canola in 2003;
- have grown canola in at least two of the past five years (1999-2003 inclusive); and,
- not be a hybrid seed grower.

The survey sample was managed to approximate the distribution of canola acres by province, according to estimates provided by the respective provincial canola organizations. The distribution of surveyed acres by province was 49.3% Saskatchewan, 28.6% Alberta/BC and 22.1% Manitoba. Minimum quotas of 100 growers were established for each of the three-herbicide tolerant (HT) systems (Roundup Ready, Liberty/Invigor and CLEARFIELD) as well as conventional canola. Because some growers grew more than one system, the total sample size was less than 400.

No quotas were established by ecozone, however, a previous analysis of canola acres grown in Western Canada, based on the 1996 Statistics Canada Census of Agriculture, revealed that 72% of the canola farms fell within the Prairies Ecozone and 28% fell within the Boreal Plains Ecozone. The current grower survey approximated this distribution with 79% falling within the Prairies Ecozone and 21% being within the Boreal Plains.

Monsanto Canada and Bayer CropScience Inc. provided grower lists on a confidential one-time use only basis and all requirements relating to Privacy Act legislation were respected. These lists were merged and "cleaned" of duplicate listings. Table 1.6 details the call results.

The Bayer CropSciences' list was used first, because it was found to be more reflective of the various canola systems, whereas the Monsanto Canada list was heavily biased toward Roundup Ready growers.

The survey was fielded from the Calgary and Lethbridge call centres operated by MarketVisions, a division of Environics West Research Inc., following a thorough pre-test. Up to six attempts were made to each valid number and 10% of the surveys were validated by a shift supervisor. The average survey length was just under nineteen minutes, and .74 completed surveys were obtained per interviewer hour. No incentive was provided to respondents. Some growers reported having been called by Ipsos Reid on another study, within a day or two of this study being fielded, which may have impacted response rates slightly.

Table 1.6: Response Rate and List Quality

	Call Result: 6629 Numbers Attempted
Not Eligible [1]	1,180
Refusal	1,709
Not in Service/Wrong Number/ Fax/Modem, etc.	657
No Answer/Busy/Voice Mail/ Call-Back Attempted	2,414
Quota Fill [2]	334
Completed Surveys	335

[1.] 47% of the not eligible growers had less than 80 acres in 2003, and 41% were no longer farming. The remaining 12% were disqualified because they were not the decision maker, did not provide acres by system, did not grow canola in at least two of the past five years, or were a hybrid seed grower.

[2.] Quota fill refers to cases where a grower was contacted but only grew a system for which at least 100 completed surveys had already been obtained.

Overall, around 1% of the growers, representing about 1.4% of the harvested acres in 2003 in western Canada were surveyed.

The survey considered:

- acres of each system grown, field history and subsequent crops;
- practices such as rotation pattern and tillage system;
- volunteer management in general, including incidence of volunteer canola as a target weed for herbicide applications;
- crop protection product usage, tillage, and sanitation practices to control volunteer canola in fields following canola as well as other fields;
- estimated cost of volunteer canola management;
- impact, if any, of volunteer canola on the subsequent crop;
- benefit, if any, of herbicide tolerant canola systems on subsequent crop; and,
- overall assessment of benefits of growing herbicide tolerant canola vis a vis conventional systems.

Table 1.7: Sample Distribution and Margin of Error by System

System	# Growers Surveyed	# Acres Represented by Surveyed Growers	2003 Estimated # of Growers in Population [1]	2003 # Harvested Acres in Population ('000's) [2]	Margin of Error [3]	
					50:50 Result	90:10 Result
Conventional	121	30,318	5,700	1,160	+/-9%	+/-5%
Liberty Link	126	41,066	8,700	2,436	+/-9%	+/-5%
Roundup Ready	187	65,538	18,000	5,452	+/-7%	+/-4%
CLEARFIELD	106	28,925	6,900	2,552	+/-10%	+/-6%
Total [4]	**335**	**165,847**	**30,000**	**11,600**	**+/-5%**	**+/-3%**

[1] Source: 2003 Ipsos Reid Canola Watch Survey (2003 Western Canada grower distribution: 19% conventional, 29% Liberty Link, 60% Roundup Ready, 23% CLEARFIELD) and Statistics Canada 2001 Census of Agriculture (32,670 canola producers in western Canada, discounted to 30,000 to remove growers with less than 80 acres.)
[2] Source: Canola Council of Canada – includes growers with less than 80 acres
[3] For binomial responses at the 95% confidence level – the margin of error declines when the probability of a given response is less than 50%
[4] Sum of growers by system exceeds total because multiple systems were grown by some

The Canola Council of Canada and the provincial grower associations were identified as the sponsors of the survey.

1.3.2.1 Grower Survey Analysis

The analysis approach used was to compare results by canola system, by ecozone (Boreal Plains or Prairies), tillage system, whether or not volunteer canola had been identified by the respondents as a target weed for herbicide applications, and by province.

Incremental treatments or tillage operations to control volunteer canola were reviewed on a case-by-case basis. This method of analysis allowed for the ability to scrutinize a grower's logic, as well as to link the product decision or the tillage method to the canola system that the volunteers originated from. Herbicide applications were reviewed in detail for each case and a number of anomalies were found. For example, some growers reported having applied a tank mix to control volunteer canola (such as 2,4-D, MCPA, Buctril M or Refine Extra) but also reported a main product, for example something used for wild oat control such as Achieve, Puma or Horizon. The incidence of products reported was adjusted to reflect only those products that would have been able to control volunteer canola (i.e. the broadleaf tank mix portion). Another complicating factor was that field sizes from year to year didn't always line up. Some respondents had difficulty breaking out applications specific to the previous canola acres (and system if applicable). For example, they may have had 320 acres of canola in 2003, representing two systems, planted barley on some or all of these acres, plus had some additional adjacent acres of barley, and then reported their applications for the total barley acres. Again, grower results were reviewed on a case-by-case basis to ensure that acres treated were not over stated and that treatments lined up with the system grown on that field the previous year.

As an additional exercise, a series of simulations were run using the software program: "Prairie Crop Protection Planner" to determine if the herbicides recommended by this program (and their associated costs based on the manufacturers' suggested retail prices) varied with the presence of volunteer canola in the target weed profile.

2.0 Prairie Weed Survey Data Analysis

The data presented in this section was derived from the self-completed management survey portion of the three provincial Weed Surveys.

2.1 Weed Management Practices By System

2.1.1 Herbicide Applications

2.1.1.1 Target Weeds

The management questionnaire portion of the Weed Survey studies asked growers to indicate which weeds they were targeting (up to five mentions were allowed) with their herbicide applications. A total of 41 distinct weeds were mentioned. As can be seen in Table 2.1, the profile of weeds targeted was very similar across systems, with wild oats, wild buckwheat, and Canada thistle being the most frequently targeted weeds, regardless of the previous canola system. Volunteer canola was mentioned as one of five top targeted weeds for control on 29% of the sites. Even though the incidence of volunteer canola as a target weed appears to be less for the conventional system, variations from canola system to canola system were small and within the margin of error, given the very small sub-sample sizes. For example, the margin of error for this result for CLEARFIELD was +/- 11.5% and for conventional, +/- 10.6%. Therefore the actual result for CLEARFIELD could have been between 24% and 48% and for conventional, between 8% and 30%. Results are not considered significant when there is overlap between the respective margins of error. In this case, the overlap was 6 percentage points (between 24% and 30%). None of the differences between systems for targeting volunteer canola in Table 2.1 are significant at either the 90% or 95% confidence levels.

Table 2.1: Top Weeds Targeted with Herbicides by System

Percentage Mentioning Weed as one of 5 targeted with Herbicides- any order

	Total[1] (n=310)	Conventional (n=54)	Liberty (n=40)	Roundup Ready (n=149)	CLEARFIELD (n=67)
Wild Oats	70	69	70	76	57
Wild Buckwheat	45	48	50	42	48
Canada Thistle	45	46	30	46	49
Volunteer Canola	29	19	33	28	36
Stinkweed	22	20	10	21	34
Cleavers	18	15	13	20	18
(Wild) Mustard	16	13	33	14	13
Green Foxtail	16	13	20	19	9
Thistle (Unspecified)	13	15	18	13	10
Hemp Nettle	13	7	13	13	16
(Redroot) Pigweed	12	13	20	12	7
Chickweed	12	13	8	16	4
Kochia	11	9	8	11	15
Sow-thistle[2]	11	6	8	12	13
Dandelion	10	6	10	11	10
Quack Grass	9	13	8	9	7
Pale Smartweed	5	6	10	3	9

[1] Excludes 6 cases that applied herbicides but did not identify specific weeds targeted
[2] Perennial or annual not specified
Differences in results presented in boxes are significant at the 95% confidence level and those underlined are significant at the 90% confidence level .

Please note that if a particular weed was not mentioned, it still could have been present at levels below economic thresholds for treatment with a herbicide, or it may have been targeted with tillage operations. The management survey did not capture weeds specifically targeted with tillage operations.

The important conclusion to draw from this result is that the decision to target volunteer canola as a weed that may affect the subsequent crop, is not exclusive to HT volunteer canola, but rather is typical of all growers of crops following all types of canola.

As would be expected, there were many combinations of weeds targeted with herbicides. The top four weed combinations (none including volunteer canola) were (n=310):

- Canada thistle, wild oats, and wild buckwheat, (9%);
- Canada thistle, wild oats, and annual broadleafs (excluding wild buckwheat and volunteer canola) (9%);
- Wild oats, wild buckwheat, and other annual broadleafs (excluding volunteer canola) (6%); and,
- Canada thistle, wild oats, wild buckwheat, and other annual broadleafs (excluding volunteer canola (6%).

Table 2.2 illustrates that volunteer canola was rarely targeted as the only or primary broadleaf annual weed, and if it was, that decision was not exclusive to HT systems. In fact, in only one field was volunteer canola mentioned as the only weed targeted (this was following Roundup Ready canola).

Similarly, Table 2.3 shows the frequency that volunteer canola was mentioned as the most to least troublesome of the five weeds that the grower targeted with herbicides.

None of the differences in results between systems in Table 2.2 or 2.3 are significant at the 95% confidence level, however the result for volunteer canola being a more troublesome weed than other broadleaf annuals also targeted was significant at the 90% confidence level (Table 2.2) with fewer conventional sites identified relative to Roundup Ready or CLEARFIELD. Although not verified by the management survey, HT growers may be more aware of the potential need to control HT volunteers, hence the difference in response rate.

Table 2.2: Percentage of Sites with Broadleaf Annual Weeds Targeted with Herbicides

	Total[1] (n=310)	Conventional (n=54)	Liberty (n=40)	Roundup Ready (n=149)	CLEARFIELD (n=67)
Volunteer Canola as the Only Broadleaf Annual Targeted	3	4	3	3	3
Volunteer Canola as a More Troublesome Weed Than Other Broadleaf Annuals Also Targeted	14	4	18	15	16
Volunteer Canola as a Less Troublesome Weed Than Other Broadleaf Annuals Also Targeted	12	11	13	9	16
Other Broadleaf Annuals Targeted (no Volunteer Canola)	61	67	58	61	58
No Broadleaf Annuals Targeted[2]	10	15	10	11	6

[1] Excludes 6 cases that applied herbicides but did not identify specific weeds targeted

[2] Includes three cases that targeted no weeds with herbicides (no applications).

Differences in underlined results between systems are significant at the 90% confidence level.

Table 2.3: Percentage of Sites with Volunteer Canola as one of Five Troublesome Weeds Targeted With Herbicides

	Total[1] (n=310)	Conventional (n=54)	Liberty (n=40)	Roundup Ready (n=149)	CLEARFIELD (n=67)
Most Troublesome	7	2	10	9	6
Second	9	7	8	9	10
Third	5	6	2	4	9
Fourth	3	2	2	3	4
Fifth	4	2	10	3	6

[1] Excludes 6 cases that applied herbicides but did not identify specific weeds targeted

2.1.1.2 Herbicide Applications

Not surprisingly, the growers who completed the Weed Survey management questionnaire mentioned many herbicide brands (over 50). The most commonly reported herbicides were Puma Super (19% of the sites that applied and named herbicides, n=309), Roundup (all types), Horizon, MCPA (all types), Buctril M, and Refine Extra, each used on 17% of the sites, Frontline (applied on 10%), Assert 300 SC (9%), 2,4-D (all types) and Target (7% each).

Roundup is a Group 9 herbicide (capable of controlling all but Roundup Ready volunteer canola). Refine Extra and Assert are Group 2 herbicides for use in-crop that controls many weeds, including all but the CLEARFIELD system of volunteer canola. MCPA and 2,4-D (Group 4 herbicides, often used as a tank mix), Target (Group 4), Buctril M (Group 4/6 combination in-crop herbicide), and Frontline (Group 2/4 combination in-crop herbicide), are all used to target a variety of broadleaf annuals, including all systems of volunteer canola. Horizon and Puma are Group 1 grassy weed herbicides that would have no effect on volunteer canola.

All other individual products were mentioned by fewer than 5% of the respondents. With the exception of some very low frequency use herbicides (i.e. ten or fewer mentions for the 309 sites for products such as Attain, Banvel II, Factor, Triumph, Unity and Vantage Plus), all of the products were used in at least one instance on fields following both conventional and HT canola systems. Growers typically select a herbicide based on a number of factors such as weed spectrum and the severity of the infestation or expected infestation, the anticipated impact on yield or grade, current crop and crop rotation plans, cost per acre, formulation and ease of handling, timing of application and weed stage, crop safety, as well as the desire to rotate herbicide groups to avoid weed resistance. The lowest priced herbicide is not necessarily always chosen.

To simplify the comparison of herbicide applications across systems, each herbicide mentioned was coded as to its chemical group or groups and a ratio of acres treated was calculated (i.e. the number of acres treated with that group, divided by the total acres planted for those sites). All applications were included in this summary (pre-harvest in the canola crop, after canola harvest/fall, before seeding or emergence of the subsequent crop in the spring, and after emergence/in-crop of the subsequent crop). For group ratios, if two applications of the same chemical or group were applied, the acres were counted twice. All ratios include 0 passes. For example, on average, about half the total acres had an application of Group 1 herbicide (ratio .52). Note that the bolded values in the tables following represent those chemical groups most often used to control volunteer canola.

Tables 2.4 (all crops) and 2.5 (spring wheat only) show that the ratio of acres treated with the respective herbicide groups was very similar across systems. The only significant difference was the slightly lower Group 2 use following

CLEARFIELD (relative to Roundup Ready), which may be due, at least in part, to the response to the tolerance of CLEARFIELD volunteer canola to Group 2 herbicides. Recall that only about three out of ten fields reported volunteer canola as a target weed.

Table 2.4: Ratio of Acres Treated With Herbicide Group, All Sites Surveyed

	Total (n=309)	Conventional (n=53)	Liberty (n=42)	Roundup Ready (n=147)	CLEARFIELD (n=67)
Total Acres[1]	40,338	6,877	5,433	18,928	9,100
Group 1	0.52	0.50	0.64	0.53	0.46
Group 2	**0.54**	**0.55**	**0.56**	**0.60**	**0.38**
Group 3	0.00	0.00	0.00	0.01	0.00
Group 4	**0.85**	**0.80**	**0.91**	**0.83**	**0.88**
Group 6	0.22	0.21	0.23	0.24	0.19
Group 7	0.00	0.00	0.00	0.01	0.00
Group 8	0.03	0.06	0.00	0.02	0.03
Group 9	0.27	0.17	0.32	0.28	0.29
Group 10[2]	0.01	0.00	0.02	0.01	0.00

[1] Base for calculating ratio was all acres within that system, excluding 7 cases that applied herbicides but did not specify type

[2] Group 10 is Liberty and corresponds with 2 sites that had Liberty Canola planted in the survey year, following one case of Liberty Canola and one case of Roundup Ready Canola planted the previous year.

Differences in results presented in boxes are significant at the 95% confidence level.

Table 2.5: Ratio of Acres Treated With Herbicide Group, Spring Wheat Only

	Total (n=195)	Conventional (n=31)	Liberty (n=30)	Roundup Ready (n=89)	CLEARFIELD (n=45)
Total Acres[1]	26,062	3,942	4,146	11,811	6,163
Group 1	0.60	0.50	0.75	0.61	0.55
Group 2	**0.59**	**0.52**	**0.64**	**0.69**	**0.42**
Group 4	**0.85**	**0.85**	**0.89**	**0.82**	**0.86**
Group 6	0.20	0.14	0.21	0.24	0.16
Group 8	0.03	0.11	0.00	0.01	0.02
Group 9	0.17	0.15	0.24	0.13	0.24

[1] Base for calculating ratio was all acres within that system, excluding 5 cases that applied herbicides but did not specify type.

Differences in results presented in boxes are significant at the 95% confidence level and those underlined are significant at the 90% confidence level.

The use of herbicide groups was correlated to whether volunteer canola was indicated as a target weed. Again, the results were very close for all fields as well as for the spring wheat sample. The average variation for each group was well within the margin of error at the 95% confidence level, however, some difference was noted for group one herbicides (used on fewer acres if volunteer canola was a target) at the 90% confidence level.

Table 2.6: Ratio of Acres Treated With Herbicide Group if Volunteer Canola was a Herbicide Target – All Sites Surveyed

	Fields With Volunteer Canola as a Herbicide Target (n=89)	Fields Without Volunteer Canola as a Target (n=214)
Total Acres[1]	10,943	28,695
Group 1	0.41	0.56
Group 2	**0.52**	**0.54**
Croup 3	0.00	<0.01
Group 4	**0.90**	**0.84**
Group 6	0.21	0.23
Group 7	0.01	0.00
Group 8	0.03	0.03
Group 9	0.24	0.28
Group 10[2]	0.00	0.01

[1] Base for calculating ratio was all acres within that system, excluding 13 cases that applied herbicides but did not specify products and/or target weeds
[2] Group 10 is Liberty and corresponds with 2 sites that had Liberty Canola planted in the survey year, following one case of Liberty Canola and one case of Roundup Ready Canola planted the previous year.
Differences in underlined results between systems are significant at the 90% confidence level.

Table 2.7: Ratio of Acres Treated With Herbicide Group if Volunteer Canola was a Herbicide Target – Spring Wheat Only

	Fields With Volunteer Canola as a Herbicide Target (n=57)	Fields Without Volunteer Canola as a Target (n=134)
Total Acres[1]	7,023	18,539
Group 1	0.47	0.65
Group 2	**0.51**	**0.62**
Group 4	**0.84**	**0.85**
Group 6	0.20	0.20
Group 8	0.02	0.03
Group 9	0.18	0.17

[1] Base for calculating ratio was all acres within that system, excluding 9 cases that applied herbicides but did not specify products and/or target weeds
Differences in underlined results between systems are significant at the 90% confidence level.

2.1.2 Weed Management Operations

A further analysis was conducted of the timing and number of operations to manage weeds, whether for herbicide applications or tillage.

2.1.2.1 Herbicide Passes

Tables 2.8 and 2.9 present the timing of herbicide applications on the surveyed fields. It does not appear that growers were delaying herbicide applications to "catch" emerged volunteer canola. Regardless of system, all growers were following a similar timing pattern in regard to weed control for their subsequent cereal crops, with the exception of the conventional system with fewer pre-seed/pre-emergent applications relative to the Roundup Ready system (significant at the 95% confidence level) and relative to the CLEARFIELD or Liberty systems (both significant at the 90% confidence level).

One issue that was not explored in the management survey was the actual timing of in-crop applications (for example 2-leaf versus 4-leaf stage) and spraying delays, if any, by waiting for volunteer canola or other weeds to emerge. Delayed spraying can have a subsequent impact on crop yield.

Sixty-nine percent of the sample fields (n=314) had only one herbicide application after emergence (in-crop), while another 28% had an in-crop application plus at least one other application at an earlier time period.

If volunteer canola was identified as a target weed for herbicide applications, there were slightly fewer fields receiving a pre or post canola harvest herbicide application, compared to those fields where volunteer canola was not a target (differences significant at the 90% confidence level).

Table 2.8: Timing of Herbicide Applications by System, All Sites Surveyed
Percentage of Fields, Multiple Mentions Allowed

	Total[1] (n=314)	Conventional (n=54)	Liberty (n=42)	Roundup Ready (n=151)	CLEARFIELD (n=67)
Canola Pre-Harvest Application	5	6	7	3	9
After Canola Harvest Application	5	6	10	5	4
Before Crop Seeding/Emergence	22	7	26	26	24
After Emergence (in-Crop)	97	96	100	98	96
None	1	2	0	0	3

[1] Excludes 2 cases that did not specify applications

Differences in results presented in boxes are significant at the 95% confidence level and those underlined are significant at the 90% confidence level.

Table 2.9: Timing of Herbicide Applications if Volunteer Canola was a Target Weed
Percentage of Fields, Multiple Mentions Allowed

	Fields With Volunteer Canola as a Weed Targeted with Herbicides (n=89)	Fields Without Volunteer Canola as a Targeted Weed (n=221)
Canola Pre-Harvest Application	2	7
After Canola Harvest Application	1	7
Before Crop Seeding	26	21
After Emergence (In-Crop)	99	98
None	0	1

[1] Excludes 6 cases that did not specify applications and/or target weeds.

Differences in underlined results between systems are significant at the 90% confidence level.

Tables 2.10 and 2.11 present the frequencies and timing of tillage practices by system and whether volunteer canola was targeted with a herbicide. Again, there were almost no significant differences between any of the systems or whether volunteer canola was targeted with herbicides. The one exception was that a single pre-seed tillage operation was more common following the conventional system than following the Roundup System (difference significant at the 90% confidence level).

Table 2.10: Timing of Tillage Operations by System, All Sites Surveyed

Percentage of Fields, Multiple Mentions Allowed

	Total (n=303)[1]	Conventional (n=51)	Liberty (n=42)	Roundup Ready (n=144)	CLEARFIELD (n=66)
1 After Harvest	23	32	19	23	18
2 After Harvest	25	30	30	23	24
3 or 4 After Harvest	10	8	14	9	9
1 Pre-Seed	23	38	24	19	19
2 Pre-Seed	18	15	12	20	22
3-5 Pre-Seed	6	6	2	9	4
Pre or Post Emergent Harrowing	8	12	12	7	8
None	28	25	26	26	35

[1] Excludes up to 13 cases that had incomplete tillage information. The bases (i.e. n=) were slightly higher for individual types of tillage operations but for simplicity, are not listed in this table.

Differences in underlined results between systems are significant at the 90% confidence level.

Table 2.11: Timing of Tillage Operations if Volunteer Canola was a Target Weed

Percentage of Fields, Multiple Mentions Allowed

	Fields With Volunteer Canola as a Weed Targeted with Herbicide s (n=88)	Fields Without Volunteer Canola as a Targeted Weed (n=209)
1 After Harvest	24	23
2 After Harvest	26	26
3 or 4 After Harvest	8	10
1 Pre-Seed	20	25
2 Pre-Seed	22	18
3-5 Pre-Seed	6	7
Pre or Post Emergent Harrowing	8	8
None	28	25

Excludes up to 19 cases that had incomplete tillage information or did not specify target weeds. The bases (i.e. n=) were slightly higher for individual types of tillage operations but for simplicity, are not listed in this table.

2.1.2.2 Summary Herbicide and Tillage Operations

The ratio of the number of acres upon which the operation had been performed was calculated for each system and whether volunteer canola was targeted.

Herbicide passes is the ratio of the sum of the applications; if 2 or more herbicides were applied in one pass (i.e. tank mix), the acres were counted only once.

Zero values were included in all calculations.

Significant differences (based on t-tests) were noted for spring tillage (higher for Roundup Ready, lower for Liberty at the 95% confidence level and higher for conventional and lower for Liberty Link at the 90% confidence level). Fall tillage was lower for CLEARFIELD relative to Liberty and conventional, with differences significant at the 90% confidence level. The only significant difference in total tillage was that more operations were performed following conventional than CLEARFIELD canola (significant at the 90% confidence level).

There were no significant differences in the results for whether or not volunteer canola was a target for weed control with herbicides (Table 2.13).

Once again, there was no basis to suggest that there would be a significant difference in cost of controlling volunteers following HT canola systems over conventional.

Table 2.12: Weed Management Practices by System

Ratio of Acres, All Sites Surveyed

Herbicides Tillage	Total (n=296) (n=303)	Conventional (n=49) (n=51)	Liberty (n=40) (n=42)	Roundup Ready (n=142) (n=144)	CLEARFIELD (n=65) (n=66)
Acres for Herbicides[1]	38,598	6,467	5,083	18,198	8,850
Total Herbicide Passes	**1.33**	**1.33**	**1.37**	**1.33**	**1.30**
Acres for Tillage[2]	39,842	6,592	5,423	18,777	9,050
Fall Tillage	1.14	1.28	1.33	1.09	1.03
Spring Tillage	0.79	0.88	0.49	0.85	0.77
Pre or Post Emergent Harrowing	0.09	0.10	0.10	0.07	0.10
Total Tillage	**2.03**	**2.30**	**1.93**	**2.04**	**1.88**

[1] Base for calculating ratio for herbicides was all acres within that system, excluding 20 cases that applied herbicides but did not specify acres treated for all products.
[2] Base for calculating tillage was all acres within system excluding 13 cases that did not provide complete information for all tillage/harrowing operation.
Differences in results presented in boxes are significant at the 95% confidence level and those underlined are significant at the 90% confidence level.

Table 2.13: Weed Management Practices if Volunteer Canola was a Herbicide Target

Ratio of Acres, All Sites Surveyed

Herbicides Tillage	Fields With Volunteer Canola as a Herbicide Target (n=88) (n=88)	Fields Without Volunteer Canola as a Target (n=205) (n=209)
Acres for Herbicides[1]	10,743	27,635
Herbicide Passes	**1.30**	**1.34**
Acres for Tillage[2]	10,899	28,093
Fall Tillage	0.99	1.18
Spring Tillage	0.75	0.84
Pre or Post Emergent Harrowing	0.08	0.09
Total Tillage	**1.82**	**2.11**

[1] Base for calculating ratio was all acres within target weed group, excluding 23 cases that applied herbicides but did not specify acres treated for all products and/or did not specify target weeds.
[2] Base for calculating ratio was all acres within target weed group, excluding 19 cases that did not provide complete information for all tillage/harrowing and/or did not specify target weeds.

2.1.2.3 Management of Canola Crop Residue in the Fall

In addition to field history, respondents who completed the weed management questionnaire were asked how they handled the residue of their canola crop after harvest. Residue management can have an impact on subsequent volunteer management in the next crop.

Again, results were very consistent, and the only significant difference (at the 90% confidence level) was between Roundup Ready and the CLEARFIELD systems for the practice of spreading canola residue.

Table 2.14: Management of Canola Crop Residue in the Fall by System

Percentage of Fields, Multiple Mentions Allowed

	Total[1] (n=311)	Conventional (n=52)	Liberty (n=42)	Roundup Ready (n=150)	CLEARFIELD (n=67)
Chopped	77	77	76	77	75
Spread	54	50	64	47	69
Chaff Collected	1	2	2	0	0
Baled	8	6	7	9	6
Burned	1	0	2	1	0
None/Not Stated	4	4	5	4	4

1. Excludes 5 cases that did not provide complete residue management information.
Differences in underlined results between systems are significant at the 90% confidence level.

Table 2.15: Management of Canola Crop Residue in the Fall if Volunteer Canola was a Herbicide Target

Percentage of Fields, Multiple Mentions Allowed

	Fields With Volunteer Canola as a Herbicide Target (n=89)	Fields Without Volunteer Canola as a Target (n=216)
Chopped	84	73
Spread	53	55
Chaff Collected	0	1
Baled	6	8
Burned	1	0
None/Not Stated	2	5

Excludes 11 cases that did not provide complete residue management information.

2.2 Weed Resistance Management

The weed management questionnaire included a comprehensive section on weed resistance. Note that because this line of questioning was somewhat more general, comparisons between systems must be made with caution because the source of the resistant weeds could have been from a year prior to the canola crop in question (for which systems were given). Further, growers may rotate canola types from year to year, therefore the definition of a grower as conventional or HT applies to the year prior to the surveyed field year only, and not to their longer term commitment to conventional or HT types.

The majority of respondents (89%, n=309) reported no awareness of suspected or confirmed weed resistance. Seven respondents didn't indicate either way. There was no significant difference in this response for the HT group (i.e. having planted HT canola the year prior) as a whole (89%, n=256) and the conventional group (89%, n=53). When asked what weeds were suspected or confirmed, wild oats was the most common response (19 cases resistant to Group 1 herbicides), followed by a variety of other weeds with just a few mentions each: kochia, cleavers and chickweed resistant to Group 2; wild buckwheat resistant to Group 4; Canada thistle, green foxtail, redroot pigweed, milkweed, and water smartweed resistant to various groups.

Just two respondents (one a Roundup Ready grower, the other a CLEARFIELD grower in the prior year – canola types grown prior to this on that field were not specified) replied that they had resistance to Roundup in volunteer canola. This is not considered to be built-up resistance in the traditional sense because the Roundup Ready canola was developed to be tolerant of this Group 9 herbicide.

There were three cases of volunteer canola herbicide resistance among growers representing those sites not planted to canola the previous year, and who completed the management survey (n=1,714). This included two incidences of canola reported to be resistant to Roundup. Both of these respondents had grown Roundup Ready in the past. The third case was that of reported resistance of volunteer canola to Refine Extra, a Group 2 herbicide, consistent with CLEARFIELD (Group 2 tolerant) canola having been grown on that field previously. So again, none of these cases represent "true" resistance.

To manage resistant weeds, just five of the management survey respondents who reported suspected or confirmed resistant weeds in the survey field, control weeds in suspected patches separate from the remainder of the field before or after harvest. All five of these respondents were growers of HT varieties the previous year. Twenty-one of those respondents reporting resistant weeds in the surveyed field (just one of whom grew conventional canola the previous year, the rest growing HT varieties), alter their cropping practices in the fields if resistant weeds cover a large area. If altered, growers reported rotating crops or herbicides, underseeding, planting silage, or continuous cropping the same canola type.

Respondents to the Management Survey were queried on their use of methods to delay the development of resistant weeds, or to manage resistant weeds. Note that for each practice, a number of respondents did not answer the question, so the sample sizes are somewhat less than 316. Overall:

- 58% of the canola sample (n=261) tank-mix broadleaf weed herbicides from different herbicide groups;
- 84% (n=269) practice herbicide group rotation;
- 70% (n=276) scout their fields during the growing season after herbicide application to check for suspected resistant weed patches; and
- 34% (n=261) reported using other management strategies to prevent or delay the development of resistant weeds. Some examples given included crop rotation (may include silage); early, delayed or staggered seeding times; spraying at optimal/multiple times of the year to control resistant weeds (e.g. pre harvest, post harvest, pre-seed, etc.); always using the full/recommended rate of application for herbicides; practicing summer fallow; and mechanical control/cultivating.

There were no statistical differences between canola systems planted the previous year for any of these practices except for slightly more of the Liberty Link sample (84%, n=38), and fewer of the Roundup Ready sample (63%, n=131) reporting scouting after herbicide application.

Finally, respondents were asked how they would rate the present and future (5 year) impact of weed resistance on their farms.

Current impact (n=307):

- 39% no impact;
- 50% slight impact;
- 9% moderate impact; and
- 1% large impact.

Future impact (n=300):

- 21% no impact;
- 57% slight impact;
- 17% moderate impact; and
- 5% large impact.

Overall 41% of growers (n=300) believed the impact would increase, 2% actually thought it would decrease, and 57% thought there would be no change. There were no statistical differences between systems planted the previous year for these results. Possible reasons for this perceived change in impact were not asked.

2.3 Summer Weed Survey Counts

One of the advantages of using the Prairie Weed Survey data for this analysis was that actual weed counts were recorded for the observed fields. These counts were made in July or August prior to harvest; presumably after any weed control management had been undertaken for that crop. The weed counts therefore reflect weed populations due to lack of targeting the respective weed, ineffective management (for example misapplied herbicides, wrong water volumes or moisture conditions, tillage timing, etc.), late germination/second flush, as well as weeds that were resistant to the herbicide treatment applied.

The analysis revealed (Table 2.16) that the percentage of fields with any volunteer canola plants counted in summer were virtually identical across systems. The table also shows the percentage of growers that had targeted volunteer canola with a herbicide, regardless of whether volunteer canola plants were found in the weed count. In about a third of the cases that targeted volunteer canola with a herbicide application, at least some canola plants were found in the field, regardless of system. It is not surprising to find volunteer canola on a field following a canola crop. There were no significant differences in these results between systems at either the 95% or 90% confidence levels.

Of note was that the incidence of volunteer canola reported as a weed targeted with herbicides appears to have increased from province-to-province and year-to-year:

- fields with volunteer canola as a target weed in 2001 Alberta crop 22% (n=141);
- fields with volunteer canola as a target weed in 2002 Manitoba crop 32% (n=76); and,
- fields with volunteer canola as a target weed in 2003 Saskatchewan crop 37% (n=93).

This result should not necessarily be interpreted as an increase in targeting volunteer canola. Rather the growing conditions the year prior to the surveyed crop must be examined. The year 2002, was a very poor year with only 7,060,000 acres of canola and 3,577,000 tonnes harvested in western Canada, according to a figure released by the Canola Council of Canada. The year 2001 was also low (9,601,000 acres and 5,062,000 tonnes harvested). Drought was typical in these years which may have impacted the efficient harvest (or no harvest) of the canola crop, or allowed some seed to remain dormant in the field until moisture conditions improved.

Interestingly, no such correlation with increasing volunteer canola counts in these fields was noted in the results of the respective summer weed counts by province and year:

- fields with volunteer canola identified in summer weed counts on fields following the 2000 Alberta canola crop 28% (n=142);
- fields with volunteer canola identified in summer weed counts on fields following the 2001 Manitoba canola crop 35% (n=79); and,
- fields with volunteer canola identified in summer weed counts on fields following the 2002 Saskatchewan canola crop 24% (n=95).

Table 2.16: Fields With Volunteer Canola in Summer Weed Counts by System

Percentage of Fields

	Total (n=316)	Conventional (n=54)	Liberty (n=43)	Roundup Ready (n=151)	CLEARFIELD (n=68)
Percentage of Fields With Volunteer Canola[1]	**29**	**24**	**35**	**27**	**32**
Percentage Who Targeted Volunteer Canola With Herbicides	10	9	16	7	13
Percentage Who Did Not Target Volunteer Canola With Herbicides	18	15	19	19	19
Percentage Who Did Not State Weeds Targeted With Herbicides	0	0	0	1	0
Percentage Without Volunteer Canola in Fields	**71**	**76**	**65**	**73**	**68**
Percentage Who Targeted Volunteer Canola With Herbicides	18	20	21	17	18
Percentage Who Did Not Target Volunteer Canola With Herbicides	52	56	42	55	47
Percentage Who Did Not State Weeds Targeted With Herbicides	2	0	2	1	2

[1] Observed weeds during summer field survey.

Table 2.17 provides the range, median and average number of canola plants observed by system. Overall, 29% of the fields that had canola planted the previous year (n=316) had at least some volunteer canola recorded during the summer weed counts:

- 14% of the sites had fewer than 1 plant per square meter;
- 9% had 1 to less than five plants per meter;
- 3% had 5-10 plants per square meter; and,
- 3% had more than 10 plants.
- 71% of the sites had no plants recorded.

Of the ten fields that reported values over 10 plants per square meter, six cases followed Roundup Ready canola (with values of 10.4, 13, 19.2, 23.8, 25.8 and 37.2 per square meter), three cases followed CLEARFIELD canola (with counts of 13.8, 21.2, and 59.6), and one case followed conventional canola (11.4 plants per square meter). The top value following Liberty Link was just 6.8 plants per square meter. There were no statistical differences (at either the 90% or 95% confidence levels) between systems for the average weed counts per square meter, again supporting the conclusion that volunteer canola from HT systems is not a greater issue than it is for conventional systems.

The economic threshold is the point at which the cost of control per acre would be equal to or greater than the lost yield caused by the weeds. This of course lends itself to variations depending on the choice of herbicide and application method. Interestingly, there appears to be no established economic thresholds for canola plants in wheat or barley crops. The 2004 grower survey (see Section 3.2.4), did however indicate that growers consider the economic threshold to be at least 10 plants per acre. The median values counted in the summer weed counts were well below this value for all systems and averaged about 2 plants per square meter.

Of note was that volunteer canola was not a target weed for a herbicide application in the field that had the uppermost value of counts for conventional (11.4 plants per m^2). Similarly, for five Roundup Ready fields for which the uppermost values (between 10 and 25.8 plants per m^2) were recorded, none had been treated with a herbicide to target volunteer canola, however for the top count (37.2), herbicides were reportedly applied to target volunteer canola. For

CLEARFIELD, the field with the uppermost count of volunteer canola plants (59.6) did not have a target application of herbicide applied. Applications were made in the other two cases for this system with more than ten plants per square meter reported, however other broadleaf annuals were also targeted.

Finally, a similar analysis of the other top five weed species (plus wild mustard as this weed is closest physiologically to volunteer canola) by system was conducted (Table 2.18), and again counts were very similar across systems and there were no significant differences between systems at either the 95% or 90% confidence levels for the presence of that weed in the surveyed fields.

The median values for wild oats and green foxtail were similar to those for volunteer canola.

In Tables 2.17 and 2.18 the maximum number of plants, if observed are reported. Note that the minimum number of plants observed in most cases would be .2, corresponding to 1 plant present in the 20 quadrants studied.

Table 2.17: Summer Volunteer Canola Counts by System

	Total (n=316)	Conventional (n=54)	Liberty (n=43)	Roundup Ready (n=151)	CLEARFIELD (n=68)
Maximum Volunteer Canola Plants Per Square Meter (If Observed)	59.6	11.4	6.8	37.2	59.6
Median (If Observed)	2.1	3.0	1.9	1.1	2.8

Table 2.18: Summer Counts of Common Weeds by System

	Total (n=316)	Conventional (n=54)	Liberty (n=43)	Roundup Ready (n=151)	CLEARFIELD (n=68)
Wild Buckwheat					
% of Fields With Weed	55	57	53	60	46
Maximum m^2 (If Observed)	175	175	13	56.2	77.4
Median m^2 (If Observed)	1.4	1.6	1.4	1.2	1.6
Wild Oats					
% of Fields With Weed	51	50	44	55	49
Maximum m^2 (If Observed)	53.2	49.4	31.8	49.4	53.2
Median m^2 (If Observed)	1.8	2.4	1.8	1.8	1.6
Canada Thistle					
% of Fields With Weed	51	46	56	49	54
Maximum m^2 (If Observed)	41.6	11.2	21.4	41.6	14.4
Median m^2 (If Observed)	1	1.2	0.7	1	1
Green Foxtail					
% of Fields With Weed	30	19	37	32	32
Maximum m^2 (If Observed)	241.6	241.6	88	236.8	22.8
Median m^2 (If Observed)	2.6	0.9	6	2.2	3.4
Dandelion					
% of Fields With Weed	23	28	21	23	21
Maximum m^2 (If Observed)	11.8	11.8	5	8	9.4
Median m^2 (If Observed)	0.6	0.8	1	0.4	0.8
Wild Mustard					
% of Fields With Weed	9	15	12	7	6
Maximum m^2 (If Observed)	45.2	4.6	4.6	1.2	45.2
Median m^2 (If Observed)	.4	.3	.6	.2	.9

2.4 Volunteer Canola Impact On Fields That Did Not Have Canola Planted The Previous Year

A special analysis of fields which did not have canola grown on the survey field during the previous year was conducted to determine if any patterns could be observed regarding volunteer canola presence due to carry-over from historical plantings or some other source.

Unfortunately, the weed survey data cannot absolutely identify the system that the volunteers originated from (it only distinguished between argentine or polish volunteers for the Manitoba and Saskatchewan data sets), or the source of the volunteers (e.g. from carry over from canola planted on that field in a year prior to the immediately preceding crop year, from a neighbouring field, spread by equipment, etc.). While the weed survey does contain fairly complete field history (up to five years prior; that is further back than 2000 for Alberta, 2001 for Manitoba, or 2002 for Saskatchewan), it does not provide any field history for neighbouring fields.

Of a total of 1,714 fields that did not have canola grown during the previous year (i.e. 2000 for Alberta, 2001 for Manitoba, or 2002 for Saskatchewan) and indicated if herbicides were applied or not, 165 or 10% reported having targeted volunteer canola with a herbicide application and/or had volunteer canola recorded in the summer weed counts. Overall, 78% of the fields with volunteer canola present in the summer weed counts (n=116) had canola planted on that field in at least one prior year and 15% had no field history of a canola crop. Seven percent of these fields did not provide complete field history information. On nearly all of the fields that had a herbicide application to control volunteer canola, however, canola had been planted on that field sometime previously.

The 165 sites that targeted volunteer canola with a herbicide application and/or had volunteer canola present in the summer weed counts broke out as follows.

Sixty-four sites targeted volunteer canola with a herbicide:

- Four sites with volunteer canola as the only broadleaf annual targeted, all with canola planted two years prior.
- Ten sites with volunteer canola as the main broadleaf annual targeted (others also targeted). Five of these fields had canola planted two years prior to the survey year, two fields each had canola planted three years and four years prior and one case did not fully report previous crops grown.
- Fifty sites with volunteer canola targeted secondarily to other broadleaf annual weeds. In all but four cases (two of these with incomplete field history data reported), canola was grown in at least one of years two to five prior to the survey year.
- Overall, fifteen of these sixty-four sites receiving a herbicide application recorded volunteer canola in the summer weed counts, although counts per square meter were very low (range: .2-3.8, average weighted by acres including zeros .2, median if observed .6).

One difference in the results for volunteer management between fields planted the previous year with canola and those planted with other crops was that volunteer grains were listed very infrequently (just three times in 316 cases or 1%) as a target weed for herbicide applications on the fields following canola. Again, 64 of the 1,714 sites (4%) that did not have canola planted on them the previous year identified volunteer canola as a weed targeted with herbicides. In the majority of these cases volunteer canola was a secondary target. Therefore, it appears that growers may be slightly more aggressive in targeting volunteer canola with herbicides than they were other volunteers such as grains (on fields not planted with the respective crop the previous year), although the incidence was still very low. It should be noted, however, that during the study years, there were no in-crop means of controlling volunteer cereals in wheat or barley crops.

Ninety-eight sites did not target volunteer canola with a herbicide (and three cases did not state which weeds were targeted) but its presence was noted in the summer weed count:

- Thirty-four of these sites had canola planted two years prior on that field, twenty-four sites three years prior, thirteen sites four years prior, and six sites five years prior. In some cases canola was planted in multiple years. Seventeen sites had no reports of canola being planted on that field within the past five years, while an additional seven sites provided incomplete field histories.
- For the most part, the recorded weed counts were low, with all but three sites at under nine plants per square meter (range: .2-24.6, average weighted by acres, if observed 1.7, median if observed .6).

All but three of the recorded levels of volunteer canola are considered well below economic threshold levels.

To put these results into perspective, 10% of the fields with canola planted (of an identifiable system) during the previous year (n=316) had recorded weed counts for other volunteer crops including barley, wheat, oats, flax, canary grass and peas (range: .2-15.4, average weighted by acres including zeros .08, median if observed .4). This compares to the 116 sites with volunteer canola (7% of 1,714 fields) that had crops other than canola grown the year immediately preceding the survey year. In other words, the incidence of fields with volunteers of any type appears to be consistent across crops – the presence of volunteer canola on fields NOT planted to canola the previous year was about the same as the presence of other volunteers (e.g. grains) on fields NOT planted to these crops the previous year.

An interesting finding was that of 90 fields that had at least some volunteer canola identified in the summer weed counts and had canola planted in at least one of the four years prior to the immediately proceeding year for which field history had been given:

- 38% of the fields had a conventional canola variety planted in that prior year;
- 20% had Roundup Ready canola planted previously on that field;
- 19% had CLEARFIELD;
- 4% had Liberty Link; and
- 19% had canola of some type but the variety was not identified.

Note that in the few cases where canola had been planted in more than one prior crop year, only the most recent variety was noted in the percentages above. Volunteer canola may or may not have been a target weed for herbicide applications in the survey year for these 90 fields.

While it cannot be definitely said that the source of the volunteer canola counted in the survey years was from a prior year's canola planting, the results of the 2004 Grower Survey (see Section 3.3.2) suggest that the majority of growers attribute volunteer canola, if present, to a prior years' planting. The significance of these results is that any carry over does not appear to be exclusive to HT varieties; volunteer canola that may be linked to a prior year's planting of conventional canola was also present in the summer weed counts.

3.0 2004 Grower Survey Results

This section presents the results of the summer 2004 canola grower telephone survey.

3.1 Respondent Profile

Table 3.1 compares the four types of growers according to several parameters. It is important to note that when interpreting these results, a particular system is not exclusive to the growers associated with that system. For example, some conventional growers (i.e. 121 were surveyed as identified in the row header in Table 3.1) also grew HT varieties, as reflected in the reported average acres by system. Boxed values in Table 3.1 indicate significant differences between systems, which were few.

As noted, there was a fairly high incidence of multiple systems grown, with only about one-third of growers of each system growing only that system. For example, just 46 cases of the 121 growers who grew conventional systems in 2003 (38%) grew only conventional varieties, thus limiting the ability to conduct a comparative analysis of "pure" conventional versus "pure" HT farms. Further, just 19% of the conventional growers had not grown herbicide tolerant canola any time within the past five years, so only 23 cases of the total sample were considered long time conventional growers with no HT. Overall, 54% of the sample (n=335) grew only one system, 24% grew more than one HT system but no conventional, and 22% grew both conventional and at least one HT system.

While the distribution of acres planted on fields following canola appears to be fairly consistent from system grower to system grower, some of the true differences in terms of subsequent crops grown may be masked by the effect of multiple canola systems being grown the previous year. For example, the distribution in Column 1 of Table 3.1, is not specific to acres of conventional canola, but rather the distribution of acres of subsequent crops planted by conventional growers on their 2003 canola acres, regardless of system (if multiple systems were grown). These results do show, however, how consistent rotation patterns are between the four grower system types.

Those who grew **conventional canola** had the smallest average number of reported canola acres in 2003, and had not increased their canola acres at the same rate as the HT growers. As would be expected, fewer conventional growers grew an HT variety, however over one-third reported having grown an HT variety every year for the past five. The incidence of zero tillage was lowest for conventional growers and the increase in zero till acres was also less for conventional growers than for the HT growers as a group.

Liberty Link growers reported the highest average number of acres in canola in 2003. More reported having increased their acres of canola within the past five years, relative to the other systems, they were also amongst the highest adopters of zero tillage, and correspondingly, more had increased their acres in zero/min till over this period.

Roundup Ready growers were most representative of the average canola grower surveyed because Roundup Ready is the most prevalent system grown.

Fewer **CLEARFIELD** growers were represented in Manitoba (and more in Saskatchewan) relative to the other systems. CLEARFIELD growers had increased their canola acres over the past five years at about the same rate as did the conventional growers, which lagged behind Roundup Ready and Liberty Link Growers. CLEARFIELD growers more often planted an HT variety every year for the past five. They were also amongst the highest adopters of zero tillage.

Table 3.1: Profile of Respondents by System Grown in 2003

Percentage of Respondents Unless Otherwise Indicated

	Conventional (n=121)	Liberty Link (n=126)	Roundup Ready (n=187)	CLEARFIELD (n=106)
Distribution of Respondents by Province				
Alberta/BC	21	25	32	21
Saskatchewan	50	47	47	63
Manitoba	28	28	21	16
Distribution of Respondents by Ecozone				
Prairies	84	77	81	74
Boreal Plains	16	23	19	26
Average Acres of Canola				
Average acres of Canola Grown in 2003	506	637	571	583
Conventional Acres	251	75	58	44
Liberty Link Acres	84	326	99	87
Roundup Ready Acres	130	163	350	180
CLEARFIELD Acres	41	74	64	273
Change in Canola Acres over 5 Years				
More Acres	32	58	46	34
Same Acres	53	35	43	50
Fewer Acres	15	7	11	16
History				
Percent Growing Only That System in 2003	38	28	34	34
Percent Growing Canola Every Year of the Past 5	92	94	93	93
Percent Planting HT Canola Every Year of the Past 5	37	55	55	58
Percent Rotating HT Systems (if grown)	58	63	55	63
Canola Rotation (Same Field)				
Every 1-2 Years	6	9	8	8
Every 3 Years	31	29	37	26
Every 4 Years	51	50	43	52
Every 5 or More Years	5	8	5	8
No Pattern	7	4	6	8
Distribution of Acres Planted on Fields Following Canola				
Spring Wheat	55	61	55	58
Barley	21	17	23	24
Canola	6	6	3	3
Oats	3	4	3	3
Durum	2	3	3	0
Pulses	3	1	1	4
Other	9	8	10	8
Fallow	2	0	1	0
Percentage of Respondents Practicing Tillage System				
Zero Till	25	44	37	44
Min/reduced Till	51	43	50	50
Conventional Tillage	19	10	9	4
Combination	4	2	4	2

Table 3.1: Profile of Respondents by System Grown in 2003
Percentage of Respondents Unless Otherwise Indicated

	Conventional (n=121)	Liberty Link (n=126)	Roundup Ready (n=187)	CLEARFIELD (n=106)
Change in Zero/Min Till Over 5 Years				
More Acres	33	52	49	47
Same Acres	50	37	41	43
Less Acres	5	4	5	8
NA/Have None	12	7	5	2
Change in Use of Pre-Seed Burn-off Over 5 Years				
Percentage Increasing	52	53	51	56

Columns may not add to 100% due to rounding

Differences in results presented in boxes are significant at the 95% confidence level and those underlined are significant at the 90% confidence level.

3.2 Volunteer Canola Targeting And Perceptions

3.2.1 Volunteer Canola as a Target for Weed Control Measures

Overall, 82% of the respondents (n=335) targeted volunteer canola with weed control measures.

- 16% mentioned volunteer canola as one of the TOP five weeds that they most often target with weed control measures in an average year (unprompted).
- 64% affirmed when prompted that they do target volunteer canola with weed control measures (if not already mentioned).
- 2% do not typically target volunteer canola but did make a herbicide application or perform a tillage operation to control this weed in spring of 2004.
- 18% do not typically target volunteer canola, nor did they do so in 2004.

The incidence of targeting volunteer canola was somewhat higher for CLEARFIELD growers, and less for conventional growers.

Unprompted mentions of volunteer canola as a target weed included both conventional and herbicide tolerant system types. Of those respondents indicating that they targeted volunteer canola on an unprompted basis (n=54), 59% of the mentions were for volunteer canola in general, 46% for a herbicide tolerant variety specifically, and 20% were for a conventional variety specifically (multiple mentions were allowed).

Table 3.2: Incidence of Targeting Volunteer Canola by System Grown in 2003
Percentage of Respondents

	Conventional (n=121)	Liberty Link (n=126)	Roundup Ready (n=187)	CLEARFIELD (n=106)
One of Top Five Weeds Typically Targeted (Unprompted)	14	17	20	17
Targeted (Prompted)	60	61	64	70
Targeted in 2004 But Not Typically Targeted	2	2	1	3
Sub Total Targeted	76	80	85	90
Not Targeted	24	20	15	10

Differences in results presented in boxes are significant at the 95% confidence level

Those respondents that targeted volunteer canola (n=268) were asked if they were targeting this weed with control measures more so, less so or about the same as they did five years ago. The majority (two-thirds) had made no change, 30% were targeting it more, and 3% less. This result for those targeting it more was about half that for those who only grew conventional varieties in 2003 (15%, n=33) versus those that grew only HT or both conventional and HT (31%, n=235) in that year. This difference is significant at the 90% confidence level. The result does show that the reported increase in targeting volunteer canola was not exclusive to herbicide tolerant varieties planted in 2003; those with a history of planting conventional canola also reported a change in targeting volunteers. Again, please note that the conventional growers may have grown HT systems within the five year period, or vice versa. The reported incidence of targeting volunteer canola more-so within the past five years was higher for zero till growers (42%, n=102), than for conventional tillage growers (11%, n=28). These differences are significant at the 95% confidence level.

The most common reason for targeting volunteer canola more so over the past five years was attributed to growing herbicide tolerant varieties instead of conventional (51%, n=87). Other, less frequently mentioned reasons were:

- growing canola every year or including it more often in the rotation (8%);
- the overall increase in canola acres (6%);
- less tillage, less summer fallow, or more direct seeding/continuous cropping (6%);
- the drought or poor growing conditions, which caused some plants to be missed when combining, thus allowing them to reseed (5%);
- not an HT grower, but more HT varieties grown in the area (5%); and,
- overall better management (2%).

One grower reported that any change was dependent on the rotation the following year (and therefore the need to control volunteer canola).

Reasons for targeting volunteer canola less so (although applicable to only 8 respondents) were growing fewer acres of canola, or in one case, switching back to conventional varieties from Roundup Ready. A few respondents also mentioned that they were practicing better management overall, thus keeping their fields cleaner.

Thirteen percent of respondents could not provide an explanation for the increase or decrease in targeting volunteer canola.

3.2.2 Changes in Volunteer Canola Management

All those who had been growing canola for at least five years (but not necessarily every year within this period) were posed the following question: *"Thinking back over the past five years, have you changed your weed management practices in order to control volunteer canola in any way?"*

Twenty-three percent answered affirmatively (23%, n=332) and changes were reported by those who grew only conventional varieties in 2003, as well as those who grew HT varieties, so again, reported change was not exclusive to HT systems. Differences in reported change by system grown in 2003 were not significant above the 90% confidence level. The incidence of reported change was much higher though for those that were operating under zero-till systems (32%, n=124), versus those that practiced conventional tillage (2%, n=41). Differences are significant at the 95% confidence level.

Those respondents who reported a change in their management practices (n=76) were asked to describe that change. Responses included:

- making a specific herbicide application (38%);
- increasing use of pre-seed burn off treatments (24%);
- adding a tank mix (13%);
- changing the crop rotation (11%);
- changing the herbicides used (9%);
- doing spot treatments (7%);
- more chemical use in general (5%);
- more 2,4-D use for broadleaf weeds (4%);
- more fallow (3%);
- stopped seeding Roundup Ready canola (3%);
- switched to CLEARFIELD or Liberty (i.e. to allow use of Roundup) (3%);
- more volunteer control practiced in general (1%);
- better record keeping (1%);

- stopped seeding CLEARFIELD canola (1%); and,
- switched back to conventional (1%).

The sub sample sizes for each system are too small to report, however, the most commonly mentioned changes were not exclusive to any one system having been grown in 2003.

3.2.3 Perceptions of Volunteer Canola Management by System

Growers that have had experience with both conventional and HT varieties were asked to compare volunteer canola management. Of those that could provide a response (n=286), 60% said that volunteer canola management on land seeded to herbicide tolerant systems the year before was about the same as with conventional varieties, 14% felt that it was easier, and 25% thought that it was more difficult. The difference between those stating more difficult (25%) and easier (14%) was significant at the 95% confidence level. Results were very similar by HT system grown in 2003.

3.2.4 Economic Threshold

About two-thirds of the respondents (n=335), could provide a response to the question: *"What is the economic threshold, that is the number of volunteer canola plants per square foot that would have to be present before you would consider any application or cultivation specifically to control volunteer canola?"*

There were no statistically significant differences in the ability to cite any number of plants per square foot, according to canola system type. Note that respondents could answer for any unit area that they chose to, and all values were converted to plants per square foot (the most common unit of measure reported) for reporting purposes.

- 14% said no plants needed to be present;
- 21% said one plant and slightly more Roundup Ready growers (25%, n=187) gave this response than did the growers of the other systems;
- 10% said two plants;
- 8% said three plants;
- 7% said four to seven plants; and,
- 2% said over ten plants.

The range was from 0-33 plants per square foot, the median value was one plant per square foot (10.6 plants per square meter), and the mean value was two plants per square foot (21.5 plants per square meter).

3.3 Volunteer Canola Management For The 2004 Crop Year

Respondents were queried as to their management practices to control volunteer canola for the 2004 crop year. They were asked to describe herbicide application practices on up to three fields as well as tillage practices on up to three fields that had been planted to canola in 2003, regardless of what was planted on those fields in 2004. They were also asked about any herbicide applications or tillage operations to control volunteer canola on fields that had not been planted to canola in 2003. In all cases where an application had been made or a practice performed, growers were asked to identify the source (system) of the volunteer canola.

Before commencing with this series of questions, respondents were asked if there was anything unusual about the conditions in 2003 or spring 2004 that may have affected the incidence of volunteer canola or their management of volunteer canola in the current crop year. Thirty-six percent (36%, n=335) answered affirmatively. There were no significant differences by system grown in 2003.

Drought was the most common condition reported in Saskatchewan and Alberta/BC, while wet weather/ fields were more often reported in Manitoba. A cool spring was also reported, especially in Alberta/BC more so than to the east, and had more of an impact on CLEARFIELD growers. Less than 5% overall reported hail damage (all from Saskatchewan) and just 2% noted insect (flee beetle) damage.

3.3.1 Incremental Herbicide Applications on Subsequent Fields

The approach taken to compare herbicide applications between systems on subsequent fields was to analyze each case to ensure reasonableness. In

all cases, respondents were asked to specify only herbicide applications that specifically targeted volunteer canola on any field that had been planted to canola the previous year. The interviewers went on to say *"These are applications that you would not have made if volunteer canola had not been present, and may have included tank mixes or spot treatments. You may have been targeting other weeds with this application as well."*

Overall, about one-quarter of respondents had made such an application. Somewhat more Roundup Ready growers (who may also have grown other systems) made an application (31%, n=187), than did those growing the other systems (24-26% each – significant at the 95% confidence level). Zero till growers (32%, n=125) were also somewhat more likely to have made applications (significant at the 90% confidence level), while those in Manitoba less often did so (14%, n=66; significant at the 95% confidence level).

Respondents were instructed to combine fields and report on total acres, only if the fields were identical, in terms of canola system planted the previous year, subsequent crop planted and products used. Reporting on up to three different fields (or combined fields) was accommodated in the survey. This allowed for respondents to provide information on acres treated and products used for multiple canola systems, if more than one was grown. Only two cases of the 86 that applied a product to control volunteer canola, made such an application on more than three fields or combination of fields, therefore the survey was able to capture virtually all of the applications made on the fields represented by these respondents.

For each field or combination of fields that received a treatment for volunteer canola, growers were asked to indicate the canola system planted on that field in 2003, the subsequent crop planted in 2004, the number of passes, tank mixes and spot treatments made, the products used, the rate and unit for each product, the acres treated, the timing of application, whether other weeds were also targeted with the application, and an estimated per acre cost for the treatments (products, labour and equipment combined).

Sources of information used to verify products mentioned were manufacturer's web sites as well as the Alberta government's Crop Protection guide (Blue Book).

Products: The responses were analyzed to confirm that the products that were indicated were in fact products that could control volunteer canola (and the specific system of volunteer canola, if applicable). Many respondents listed products such as wild oat herbicides (including a tank mix), or in the case of Roundup Ready canola, glyphosate products (with a tank mix), and included the cost of these other products in their total estimated per acre costs. The incidence of these other products were not included in the analysis in these cases. Glyphosate products were included in the incidence of products used for the non-Roundup Ready systems. Where a combination product was used (e.g. Achieve Extra Gold, or Horizon BTM), only the broadleaf tank mix product was included in the analysis. This approach was also used if PrePass was indicated as a treatment for volunteer canola following the planting of a Roundup Ready variety (only the florasulam portion was included), if PrePass was used following CLEARFIELD (only the glyphosate portion was included), or if Frontline was used following CLEARFIELD (only the MCPA ester portion was included). In a few cases, the respondent specified that they used a combination product but indicated it was only the tank mix portion that was used to control volunteer canola; so only that portion was included.

Rate: Generally, the grower reported rates were deemed to be unreliable. Some growers stated that they applied at the "recommended rate", some could not provide the rate, they provided the water volume rate instead of the product rate, they provided the rate for one product (e.g. a wild oat herbicide) but not the tank mix product that was added to control volunteer canola and perhaps other broadleaf annuals, or provided a rate well outside of the recommended range. Responses were carefully scrutinized for conversion units (e.g. ml/acre or l/acre). As a general observation, the rate frequently given by respondents for glyphosate products was 1 litre per acre, however, the published rate for controlling volunteer canola (up to 8 cm in height) is only .3 litres/acre.

Acres Treated and Weeds Targeted: In some cases, respondents were inconsistent in their reporting of acres treated that corresponded to fields planted with a particular type of canola the previous year. For example, a grower may have been giving product use details about a 300-acre barley field, only 150 acres of which had been planted to canola in 2003, and 150

acres to something else. In this example, the grower treated all 300 acres of the barley field the same, so the treatment was attributed in the analysis to the 150 acres of whichever canola system only. The fact that additional acres that had not been planted to canola the previous year were treated the same as those that had been, brings into question the issue of whether the grower would have made the application if volunteer canola were not present. This observation underscores the difficulty in a grower's ability to isolate a treatment for one weed, when the decision is likely made on a combination of targeted weeds. Nevertheless, if the respondent said they made the application because volunteer canola were present, their response was taken at face value, regardless of other weeds mentioned. Total acres treated (allowing for multiple treatments on the same field; for example a pre-seed treatment and an in-crop treatment) was checked against total acres of canola planted for that system and acres planted of the subsequent crop to correct any issues with double counting.

Herbicide Application Results by Canola System

Overall, about one in four respondents made a herbicide application to control volunteer canola related to at least one system (if multiple systems were grown) in their subsequent crop. As well:

- 13% of conventional growers made an application to control conventional volunteers on 10% of the acres surveyed in that system;
- 15% of Liberty Link growers made an application to control volunteers related to this system on 15% of the surveyed acres;
- 25% of the Roundup Ready growers made an application on 19% of the acres related to this system; and,
- 20% of the CLEARFIELD growers made an application on 19% of the acres related to this system.

None of the differences between the four systems for percentage of acres treated are considered significant, given the sub-sample sizes, however the difference in the percentage of respondents treating is significant between Roundup Ready and the conventional sample at the 90% confidence level.

Table 3.3: Weeds in Addition to Volunteer Canola Targeted With Herbicides by Canola System That Volunteers Were Attributed To

Percentage of Respondents who Applied Herbicides for Volunteer Canola

Target Weed	Conventional (n=16)	Liberty Link (n=19)	Roundup Ready (n=47)	CLEARFIELD (n=21)
Canada Thistle	44	26	32	38
Quack Grass	0	11	13	10
Wild Buckwheat	50	21	23	10
Wild Mustard	19	11	17	19
Wild Oats	25	37	38	43
Other Broadleaf Annual	56	68	66	57
Other Grassy Annual	13	16	21	14
Other Perennial	13	0	11	19
No Other	0	5	0	5
Not Stated	6	5	2	5
Combined Cases of Other Broadleaf Annual, Wild Mustard, Wild Buckwheat	75	84	79	71

Differences in results presented in boxes are significant at the 95% confidence level

The vast majority of respondents, who said they made a herbicide application to control volunteer canola, also targeted other weeds (Table 3.3) with that application, drawing into question whether they would have made the application if volunteer canola had not been present. Just two respondents said they targeted no other weed with the application, one each related to the Liberty Link and CLEARFIELD systems. Overall, about three-quarters targeted at least one other broadleaf annual weed with the treatment, most notably wild buckwheat or wild mustard, in addition to volunteer canola. The only significant difference between systems (at the 95% confidence level) was that more conventional canola growers targeted wild buckwheat, relative to those growing CLEARFIELD.

Table 3.4 summarizes the ratio of types and timing of treatments to control volunteer canola, among those that made an application for this purpose. Both tank mixes and dedicated passes were used to control volunteer canola. Two conventional growers also reported spot treatments. In terms of timing of application, some acres received multiple treatments, i.e. both a pre-seed and an in-crop treatment. Two Roundup Ready and one CLEARFIELD respondent also reported fall 2003 treatments.

The most significant difference in the results was that Roundup Ready growers more often treated volunteer canola in the subsequent crop with a tank mix (typically with their pre-seed Roundup application), while those in the other systems made almost an equal number of passes as tank mixes. Differences are significant at the 95% confidence level between Roundup Ready and each of the other three systems for the ratio of passes to tank mixes.

Table 3.5 reflects the incidence of products used to control volunteer canola (acres treated in fall 2003/ spring 2004) as a percentage of canola acres planted with that system in 2003; only those products that are capable of controlling volunteer canola in that system were included in the table. Note that because relatively few of the surveyed acres received a herbicide application for this purpose, the absolute differences in percentages should be interpreted with extreme caution. Nevertheless, a few interesting observations can be made.

- The percentage of acres treated for volunteer canola was similar across systems (at fewer than 20% of the surveyed acres within each system). Acres that had been previously planted to conventional canola were statistically as likely (at both the 90% and 95% confidence levels) to have received a herbicide treatment to control volunteer canola as were those acres previously planted to herbicide tolerant canola.
- The most common tank mix products (2,4-D, and MCPA, perhaps in the form of Buctril M , Frontline, or other combination products) were used by all systems. MCPA (form not specified) use on its own is statistically significant at the 95% level for CLEARFIELD over Liberty Link, however, when all forms of MCPA are considered (i.e. the amine or ester form as well as in combination products), there were no significant differences between systems.

Table 3.4: Treatments to Control Volunteer Canola and Other Broad Leaf Annuals (if mentioned) with Herbicides by Canola System That Volunteers Were Attributed To

Ratio of Treatments if Herbicides Applied to Control Volunteer Canola

	Conventional (n=16)	Liberty Link (n=19)	Roundup Ready (n=47)	CLEARFIELD (n=21)
Type of Treatment				
Ratio of Passes to Tank Mixes	1.44	1.00	.21	.71
Timing				
Ratio of Pre-Seed to In-Crop Treatments	.38	.56	1.07	.60

Differences in results presented in boxes are significant at the 95% confidence level

Table 3.5: Products Used to Control Volunteer Canola and Other Broad Leaf Annuals (if mentioned) by Canola System That Volunteers Were Attributed To

Percentage of Surveyed Acres in System Treated with Product

Product	Conventional (n=121)	Liberty Link (n=126)	Roundup Ready (n=187)	CLEARFIELD (n=106)
2,4-D	1.3	3.3	10.4	5.3
Ally	-	0.4	0.3	-
Attain	-	0.3	-	0.3
Buctril M (Achieve Extra Gold)	2.3	2.7	1.4	0.5
Curtail	0.8	-	0.5	-
Estaprop	-	-	0.5	-
Express Pack/Toss N Go	-	-	0.5	-
Frontline	-	2.9	0.7	1.2
Harmony Total	-	-	0.2	-
Horizon BTM	-	0.6	-	0.3
Liberty	-	-	0.2	-
MCPA (not specified)	-	-	1.6	7.9
MCPA Amine/Ester	2.1	-	1.0	0.3
PrePass	1.1	1.3	1.9	1.0
Prestige	-	0.6	-	-
Refine Extra	2.0	0.2	1.3	-
Roundup/Transorb/Glyphosate	2.1	3.1	-	6.3
Pursuit	0.7	-	-	-
Sencor	-	-	0.3	0.6
Spectrum	-	0.1	-	-
Sword	-	-	0.2	-
Target	0.9	-	0.8	0.3
Thumper	-	1.0	0.7	-
No Treatment	90.1	84.5	81.3	81.0
Surveyed Acres Treated	2,995	6,360	12,034	5,477
Surveyed Acres in System	30,318	40,966	64,348	28,895

Differences in results presented in boxes are significant at the 95% confidence level and those underlined are significant at the 90% confidence level.

- Glyphosates were used to control all but Roundup Ready canola. CLEARFIELD growers used glyphosate more often than both Roundup Ready and Liberty Link growers (significant at the 95% confidence level). Use of glyphosate by Liberty Link growers (on 3.1% of the surveyed acres) was also significant at the 95% confidence level relative to zero use by Roundup Ready growers, for the purpose of controlling canola volunteers.
- Refine Extra was used in all systems except CLEARFIELD because of Group 2 tolerance.
- Roundup Ready users more often tank mixed 2,4-D with their Roundup application to control volunteers in the subsequent crop. 2,4-D use was significantly higher at the 95% confidence level for Roundup Ready growers, relative to conventional, and at the 90% confidence level relative to Liberty Link growers.

Decisions to use other products appear to be linked to the total weed spectrum to be controlled.

The median grower reported costs reported in Table 3.6 revealed no statistical differences at the 90% or 95% confidence levels between systems. Median values are reported for comparison because of the extremely small sample sizes among those reporting a treatment. The higher values in the ranges reported typically included products that would not be effective for controlling volunteer canola (e.g. the total cost of Achieve Extra Gold, not just the tank mix portion).

The median grower reported value for conventional canola was at the high end of the four systems, supporting the finding that growers do not perceive that the cost of controlling volunteers from a conventional system is significantly less than that for controlling volunteers from an HT system.

Table 3.6: Comparative Grower Reported Cost of Herbicide Applications to Control Volunteer Canola and Other Broad Leaf Annuals (if mentioned) by Canola System That Volunteers Were Attributed To

	Conventional (n=16)	Liberty Link (n=19)	Roundup Ready (n=47)	CLEARFIELD (n=21)
Range of Per Acre Grower Reported Costs, Treated Acres	$3-20	$1-72	$1-40	$1-56
Median Per Acre Grower Reported Cost, Treated Acres	$13.00	$13.00	$11.00	$10.00
Costs include labour and application				

Herbicide Application Results by Tillage System

Herbicide applications to control volunteer canola were also analyzed by tillage system (Table 3.7), but because of the small number of conventional tillage growers that participated in the survey, and the extremely small number that applied herbicides to control volunteers, these results should be interpreted with extreme caution. Also note that the respondents were asked about the tillage system practiced on the majority of their acres, not necessarily on the acres that had been planted to canola the previous year.

As would be expected, the incidence of herbicide use was higher for those practicing less tillage.

- 32% of the zero till growers (n=125) made an application to control volunteers on 19% of the surveyed acres related to this tillage system;
- 22% of the minimum till growers (n=159) made an application on 13% of the acres related to this tillage system;
- 12% of conventional tillage growers (n=41) made an application to control volunteers on 7% of the acres surveyed in that tillage system; and,
- 50% of the combination/not stated tillage growers (n=10) made an application on 37% of their acres.

Respondents who practiced minimum or zero tillage controlled volunteers from all four canola systems with herbicides. Those few conventional tillage respondents (just four that used herbicides) did so to control volunteers from conventional, Roundup Ready and Liberty Link canola systems, but not CLEARFIELD. CLEARFIELD was grown very infrequently by conventional tillage respondents.

Differences in grower reported (median) costs between zero and minimum till are insignificant and values for conventional tillage and combination tillage cannot be compared with statistical reliability because of the extremely small sample sizes.

Table 3.7: Grower Reported Herbicide Cost of Controlling Volunteer Canola and Other Broad Leaf Annuals (if mentioned) by Tillage System

	Zero Till (n=37)	Min Til (n=34)	Conventional Tillage (n=4)	Combination (n=5)
Range of Per Acre Grower Reported Costs, Treated Acres	$1-40	$7-72	$4-20	$10-30
Median Per Acre Grower Reported Cost, Treated Acres	$10.50	$13.00	$12.00	$22.50

3.3.2 Incremental Herbicide Applications on Other Fields

Respondents were asked to indicate if they made any herbicide applications to control volunteer canola on fields that had not been planted to canola in 2003. They were asked to include all applications, tank mixes and spot treatments, but only if they made the application specifically because of volunteer canola. They were asked to indicate where they thought the volunteer canola came from, what system it could be attributed to, how many acres they treated, and what they estimated to cost per acre for this control to be. Specific applications, products and rates were not queried.

Overall, 6% of the respondents to the survey (n=335) made such an application. The incidence of treatment was higher in Saskatchewan (10% of the Saskatchewan respondents made such an application, while just 3% in Alberta, and 2% in Manitoba did so). Rates of application were very similar for both the Prairies and Boreal Plains Ecozones, as well as the tillage system.

The ability to attribute volunteer canola to any particular system is complicated because some growers had multiple systems. Further, the relationship between having grown a particular system in 2003 and the system which the grower attributed the source of volunteer canola on these other fields did not always correspond because of the practice of switching from system to system year over year.

Of the twenty-one respondents who said they made a herbicide application:

- ten cases were attributed only to Roundup Ready canola, plus three more attributed it to Roundup Ready plus at least one other system;
- six cases were attributed only to CLEARFIELD Canola, plus three more to CLEARFIELD and at least one other system;
- one case was attributed only to conventional canola, plus two more to conventional and at least one other system;
- one case was attributed to Liberty Link, however, this grower also said that it could have been attributed to any of the three other systems; and,
- three were uncertain.

Most respondents (15 of the 21 respondents) who made such an application attributed the source to carry over from canola planted on that field in 2002 or earlier. Three respondents attributed it to seed spread by equipment or trucks, while two respondents each said it came from a neighbouring field or seed with adventitious presence. Three respondents couldn't say where it came from. Of the eighteen that did say where it came from, three listed multiple sources and fifteen just a single source (multiple mentions were allowed).

Carry over from 2002 or earlier was associated with all four systems. All three of the incidences associated with equipment/trucks were attributed to Roundup Ready canola. The two cases from seed with adventitious presence and the two neighbouring field cases were attributed to either Roundup Ready or CLEARFIELD.

Note that it should not be interpreted that there is more volunteer canola controlled with herbicides on these other fields than is attributed to Roundup Ready canola. Recall that 56% of the sample grew Roundup Ready canola in 2003, therefore it is not unreasonable that a similar proportion of cases would have attributed the source of the volunteer canola to this system. Because the majority of explanations for where the volunteers came from related to the system planted in 2002, or earlier, without examining a longer term field history, it is not possible to draw conclusions about the cost of volunteer control on these other fields that could translate to a cost against, say the 2003 canola crop, by system. Further investigations, for example, as to whether the incidence of volunteer canola control in fields not planted to canola the previous year is higher for CLEARFIELD and lower for Liberty Link systems, as may be suggested by these results, is recommended.

What can be concluded from these results is that volunteer canola control with herbicides is practiced on these other fields for canola from all four systems; it is not exclusive to herbicide tolerant canola. Further, one of the explanations for this problem could be tied to growing conditions, as reported previously. Recall that more growers in Saskatchewan reported unusual growing conditions, particularly drought, and that the incidence of volunteer canola control with herbicides on these other fields was also higher in Saskatchewan.

The median value reported for controlling volunteer canola with herbicides on these other fields was $8 per acre (product, labour and equipment combined). The reported range was from $2-25 per acre.

The grower reported median values did not differ significantly between systems (keeping in mind the extremely small sample sizes for each system):

- Conventional: Range - $4 to 8 per acre, Median - $6
- Roundup Ready: Range - $2 to 20 per acre, Median - $8
- CLEARFIELD: Range $2-25 per acre, Median - $8
- Liberty: $8

Relating acres treated for these other fields to acres planted with canola in 2003, reveals a ratio of about 1 in 20 for the total sample. Therefore, about 40 cents per acre for subsequent volunteer canola control could be allocated back to the original canola crop (i.e. distributed across all canola acres in the survey, assuming total acres of canola is constant year over year) in an economic analysis (instead of this cost being accrued to the crop planted in 2004, which is the normal practice), however, the limitations of this survey cannot conclude differences by system. In fact, the results suggest that these costs could apply to any system. Further, this cost may have been an anomaly associated with drought conditions and may not apply every year.

3.3.3 Incremental Tillage Operations on Subsequent Fields

Just 13 respondents (less than 4% of the sample) made an incremental cultivation or pre/post emergent harrowing operation specifically to control volunteer canola on a field that had been planted to canola in 2003:

- five of these cases were associated with conventional canola;
- three of these cases were associated with Liberty Link;
- six of these cases were associated with Roundup Ready; and,
- four with CLEARFIELD.

Note that three of the cases associated their tillage or harrowing operations with multiple canola systems.

None of these operations were performed by Alberta respondents, while nine Saskatchewan and four Manitoba respondents reported at least one cultivation or harrowing operation.

Only one of these 13 respondents said they practiced conventional tillage on the majority of their acres, while the remainder generally followed zero or no till programs, even though they may have cultivated or harrowed to control volunteer canola. The sub sample sizes were too small to compare costs by tillage system.

Table 3.8 details the costs of tillage by canola system, but again, due to the extremely small sub sample sizes for those cultivating and/or harrowing, caution should be exercised when comparing average costs between systems.

For all systems, the median cost of the operations reported by growers was $5.00 per acre. The standard rates for cultivation are assumed at $6.50 and for harrowing $3.75 per acre (average $5.00), which confirms the grower reported average median value of $5.00. The low of $3.00 reported by the growers in the table above was for one harrowing operation and the high of $15.00 was for one cultivation. The extreme value for conventional ($50.00) reported in Table 3.8 was for one operator who said he cultivated up to four times and harrowed twice, however, it appears that this respondent reported all of his operations, not just those specific to controlling volunteer canola. Overall, an almost equal number of fields received a harrowing operation (12) as cultivation (10). Both types of operations were preformed to control volunteer canola from all four systems, however harrowing was somewhat more common with HT varieties.

Table 3.8: Comparative Cost of Incremental Tillage Operations to Control Volunteer Canola and Other Broad Leaf Annuals (if mentioned) by Canola System That Volunteers Were Attributed To

Percentage of Respondents Unless Otherwise Stated

System Operation Attributed To:	Conventional (n=121)	Liberty Link (n=126)	Roundup Ready (n=187)	CLEARFIELD (n=106)
Percentage of Growers in That System Reporting at Least One Harrowing and/or Cultivation Operation	3	2	3	3
Percentage of Acres in That System With at Least One Harrowing and/or Cultivation Operation	5	2	2	3
Range of Grower Reported Per Acre Costs (If Operation Performed)*	$5-50	$3-15	$3-15	$5-10
Median Grower Reported Cost Per Acre (If Operation Performed)*	$5	$5	$5	$5

*** Conventional (n=5), Liberty Link (n=3), Roundup Ready (n=6), CLEARFIELD (n=4)**

3.3.4 Incremental Tillage Operations on Other Fields

Just eight respondents (2% of the sample) said they performed a cultivation or harrowing operation specifically to control volunteer canola on fields not planted to canola in 2003. Five of these cases were to control Roundup Ready volunteer canola and three were to control conventional volunteer canola. Six of these cases were located in Saskatchewan and two in the Alberta/BC region, six cases were in the Prairies Ecozone and two were in the Boreal Plain Ecozone. All but one of those controlling Roundup Ready canola on these other fields were Roundup Ready growers in 2003, the fifth grew only conventional canola in 2003. Of the three controlling conventional volunteer canola on these other fields, two were conventional canola growers in 2003 and one grew CLEARFIELD canola.

Of the five cases attributed to Roundup Ready canola, two were associated with carry over from a Roundup Ready crop planted on that field in 2002 or earlier, and two were attributed to come from seed with adventitious presence. One respondent did not state where the source was from. Of the three conventional cases, two were blamed on carry over from a conventional canola crop planted on that field

in 2002 or earlier, and one was attributed to having been spread by equipment or trucks.

As was the situation with incremental herbicide applications on these other fields, it is not possible to allocate costs by system without having access to a long term field history and a sampling that included growers who were confirmed to have planted canola in 2002 and previously. An estimate of cost can be determined, by relating acres treated for these other fields to acres planted with canola in 2003 (i.e. a ratio of about 1 to 50 acres for the total sample). Assuming an average cost of $5.00 per acre for these operations, just under $0.10 per acre (i.e. distributed across all canola acres in the survey) for subsequent volunteer canola control could be allocated back to the original canola crop in an economic analysis instead of this cost being accrued to the crop planted in 2004, which is the normal practice. However, as with the attempt to attribute the costs of volunteer canola control with herbicides on these other fields, the limitations of this survey cannot conclude differences by system. In fact, the results suggest that these costs could apply to either a herbicide tolerant or conventional canola system.

3.3.5 Sanitation

A "hidden" cost of volunteer control relates the thoroughness with which a grower may clean equipment when moving from field to field (i.e. a labour cost). Growers who had grown herbicide tolerant canola for at least one of the past five years were asked to indicate if their cleaning procedures were the same, greater, or less when moving from a field on which herbicide tolerant canola was planted versus moving from a field where conventional canola was planted. The assumption was that all of the herbicide tolerant growers would have had some experience with conventional varieties with which to compare. Those who had only grown conventional canola over the past five years were excluded from this line of questioning because they would have had no basis for comparison.

As the Table 3.9 indicates, the majority (about 80% for all types of equipment) of HT growers surveyed are not more aggressive with their equipment cleaning practices when moving from HT fields, than they had been in the past moving from conventional fields. A few growers are being more careful, particularly in regard to equipment used in harvesting (13%), however a comparative cost (presumably a labour cost) was not determined from this survey, nor were any possible resulting benefits (cost savings) in other weed control measures.

There were no significant differences in these results if volunteer canola was a targeted weed or not.

Table 3.9: Change in Equipment Cleaning Procedures for HT over Conventional Canola
Percentage of Respondents (n=305)

	Seeders	Tillage Equipment (Cultivators, Harrowers, Discs)	Harvesters, Swathers, Grain Handling Trucks
Same	82	80	81
Greater	8	3	13
Less	0	<1	0
Not Applicable	10	17	6

3.4 Impact Of Volunteer Canola On Subsequent Crop

A series of questions were asked to determine if growers had experienced either a positive or negative impact on their subsequent crop as a result of the presence of, or required control measures for, volunteer canola.

3.4.1 Rotation

When considering overall economic impact, it is important to understand where canola fits within the crop rotation plan and whether changes have been made because of increasing adoption of canola (and specifically HT adoption), which may impact overall farm profitability. This study was not designed to determine those costs or benefits but rather to assess whether there might be a basis to suggest that rotation changes were due to volunteer canola management.

About one in ten growers surveyed replied that they had changed their crop rotation on fields following canola because of the specific canola system planted the year before. Only 5 of these thirty-five respondents, however, indicated a change related to volunteer canola management. Other crop rotation changes reported had to do with potential herbicide carry over following CLEARFIELD, the opportunity for better economic return with some crops over others, moisture conditions, cropping decisions based on wild oat or quack grass control, changes to rotation intervals between canola plantings, unrelated herbicide rotation patterns, or disease problems encountered with Nexera brand varieties.

Of the five growers who changed rotation because of volunteer canola management:

- Three respondents would not follow CLEARFIELD canola with a pulse crop because they believed that there was no way to control the volunteer canola.
- One respondent switched to Liberty Link from Roundup Ready canola because of a herbicide rotation decision.
- One did not relate the change to a specific system, but rather planted crops that could be sprayed with 2,4-D to control the volunteers.

3.4.2 Yield, Grade or Dockage Loss

Overall, 16% of the total sample said they had experienced a yield, grade or dockage loss to a crop following canola because of the presence of volunteer canola. This was not specific to the 2004 crop.

Crops affected were (n=54, multiple responses were allowed):

- 46% spring wheat;
- 32% pulses;
- 19% barley;
- 7% durum;
- 4% canola; and,
- 13% other crops (flax, winter wheat, sunflowers, canary seed).

The systems that this loss was attributed to were (n=54, multiple responses were allowed):

- 43% Roundup Ready;
- 41% CLEARFIELD;
- 28% conventional, and,
- 4% Liberty Link.

Recall that the distribution of surveyed growers (2003 canola system) was 56% Roundup Ready, 36% conventional, 32% CLEARFIELD and 38% Liberty Link, and the sampling was not intended to be representative of the distribution of these systems in the population.

This result confirms that reported impact on subsequent crops is not exclusive to HT varieties.

Thirty-seven percent (37%) of those that had experienced a loss (37%, n=54) had taken no measures to control the volunteer canola. Forty-four percent (44%) had practiced weed control in all cases where they had experienced such a loss, and 19% had practiced weed control in some situations but not all. There were no significant differences in reported "failure" of the weed control measure (i.e. cases where a loss was experienced in spite of having practiced volunteer canola control) by the canola system that the loss was attributed to.

Respondents (n=54) who reported a loss were also asked if they felt the loss experienced was trending upwards, downwards or remaining unchanged over the past five years. Forty-one percent (41%) said the rate of loss was unchanged, 22% noted an increase, and 33% replied that it had actually decreased. Presumably these growers have become more adept at managing volunteer canola. Four percent were uncertain. Again, there were no significant differences between systems, given the extremely small sub sample sizes.

3.4.3 Weed Control Carry Over Benefit

If any HT variety had been planted in 2003 (n=289), respondents were asked if they observed any carry-over benefit in terms of fewer weeds of any type, or easier weed control in their 2004 crop planted on that field.

Fifty-eight percent (58%) responded affirmatively, 41% saw no carry over benefit and 2% did not know. Where a benefit was realized, about half of these respondents (n=167) were able to put a dollar value on this benefit, one-quarter said there was no monetary benefit, and another quarter could not quantify the benefit.

If a dollar benefit was reported (n=83), the average estimated per acre dollar benefit (considering both weed control savings and/or improved revenue from the subsequent crop) was $11.80. The range in benefit realized was typically up to $30.00. It is interesting to note that the average benefit approximates the value of product and application cost of, for example, about one glyphosate treatment at one litre/acre.

There were no significant differences by herbicide tolerant system in terms of any carry-over benefit realized or the average estimated benefit.

3.4.4 Herbicide Injury due to Odyssey or Pursuit Carry Over

Another economic cost of adopting one HT system in particular, CLEARFIELD, relates to possible crop damage due to injury caused by the carry over of Odyssey or Pursuit herbicides on fields planted to a subsequent crop. Of those respondents that had grown CLEARFIELD at least once within the past five years (n=174), the majority had never experienced a problem, while 31% reported having had experienced some economic loss to the subsequent crop. The loss may have been minor; note that the magnitude of the loss was not quantified. Perceptions of the effect of the drought on herbicide carryover was also not captured.

3.5 Overall Perceptions Of The Benefits Of HT Canola

Not surprisingly, the majority of HT canola growers responded that they thought the benefits of growing herbicide tolerant canola, all things considered including subsequent volunteer control, were greater than the benefits of growing conventional varieties on their farm (Table 3.10).

There were no significant differences within the three HT systems (Table 3.10).

Zero till growers were particularly favourable toward the benefits of HT with 85% (n=125) saying the benefits were greater than for the conventional canola system. Another 11% said the benefits were the same or it depended on the growing conditions that year.

Those that felt the benefits of HT were less than those of growing conventional varieties, mainly did so because the cost of growing HT canola was perceived to be too high (including the fees, burn-off costs or overall economics due to lower yields experienced).

Other reasons cited by just one or two respondents each included:

- market acceptance issues;
- more problems in general using HT canola;
- restrictions in using Roundup Ready canola specifically;
- difficulties in controlling herbicide tolerant volunteers;
- system doesn't work as well; and,
- dirtier fields/more weeds.

Table 3.10: Perceived Benefits of Growing HT Canola Relative to Conventional

Percentage of Respondents

	If Grew Conventional Only in 2003 (n=45)	If grew HT Only in 2003 (n=214)	If Grew Both in 2003 (n=75)
Greater Than Conventional	39	82	71
Less Than Conventional	26	3	7
Same as Conventional	20	11	19
Depends on Growing Conditions That Year	9	3	3
Don't Know	7	1	1

Differences in results presented in boxes are significant at the 95% confidence level

Finally, growers were asked to indicate their per acre profits for the particular canola system they grew in 2003 after all input expenses, including labour and operating expense for equipment. Half of the respondents in each system refused this question or could not provide a response. A number also recorded zero as their answer, which may have meant their inputs actually exceeded their revenues. Therefore, the data was not considered reliable enough to report. Note that the January 2001 study "An Agronomic and Economic Assessment of Transgenic Canola", conducted by Serecon Management Consultants Inc., identified about a $5.80 grower reported per acre net return advantage for transgenic canola (Roundup Ready and Liberty Link only), over conventional in the 2000 crop year.

4.0 Herbicide Simulations

In an attempt to determine if different combinations of herbicides were consistently recommended if volunteer canola was present or not, a series of simulations for applications in wheat and barley were conducted using the "Prairie Crop Protection Planner" software program which reflects MSRP pricing. This program allows for the entry of up to four target weeds as well as for the distinction between CLEARFIELD volunteer canola and simply volunteer canola (specification of the other HT systems is not allowed). The model does not allow for any weighting depending on the severity of the weed problem, nor does it have a provision for entering field history. Some of the more common weed combinations as indicated by the results to the Weed Survey question on the five weed types targeted with herbicide applications were tested in the simulations. Specifically, the presence of volunteer canola was tested with and without combinations of other broadleaf annual weeds. The majority of simulations focused on in-crop applications.

Note that CLEARFIELD Canola is tolerant of Pursuit and Odyssey (neither are appropriate for weed control in wheat or barley) and both are Group 2 herbicides. Roundup Ready is tolerant of Group 9, and Liberty is tolerant of Group 10, neither of which came up in any of the in-crop simulations tested. Therefore it can be assumed that the profile of product options would be identical for conventional and these transgenic varieties.

Groups that are in italics are those most commonly used to control volunteer canola. Note that in all tables following, reference to "recommended" means recommended by the software program, and may not include all products that are registered for use. The software program also does not distinguish between efficacies of the various products.

4.1 In-Crop Applications

Table 4.1: Simulation # 1 In-Crop Applications to Target Canada Thistle, Wild Oats and Wild Mustard in Wheat

Weed Combination	Number of Herbicide Brands or Combinations Recommended	Number of Times Herbicide Group Recommended					Per Acre Price Range	Per Acre Median Price (Low End if Range Given)
		Grp 1	*Grp 2*	*Grp 4*	Grp 6	Grp 8		
Canada Thistle Wild Oats Wild Mustard	103	74	***40***	***93***	14	9	$2.61- $48.50	$22.42
Canada Thistle Wild Oats Wild Mustard Volunteer Canola	86 (all herbicides and combinations included in above scenario)	60	***38***	***76***	14	8	$5.47- $38.80	$22.31
Canada Thistle Wild Oats Wild Mustard CLEARFIELD Volunteer Canola	71 (all herbicides and combinations included in above scenario)	48	***24***	***71***	14	7	$5.47- $34.15	$22.34

Observations: This simulation considered the two most common weeds targeted with herbicides plus one other broadleaf annual weed. Note that spring in-crop timing is not optimal for control of established Canada thistle. If volunteer canola was not present, the grower had somewhat more options for controlling the combination of Canada thistle, wild oats and wild mustard in wheat. There were no additional herbicides recommended if volunteer canola was present, and therefore no basis to assume an additional cost would be incurred under this scenario. In either scenario (with and without volunteer canola other than CLEARFIELD), a Group 2 or 4 herbicide was always recommended and only Group 2 was ever recommended on its own. If CLEARFIELD volunteer canola was present, a Group 4 herbicide was always recommended. The price ranges of available herbicides and combinations and the median price for the recommended products were virtually identical for all three scenarios.

Interestingly, this simulation was rerun without the other annual broadleaf weed (wild mustard). The profile of recommended products was identical with and without wild mustard, if volunteer canola was also a target. Again, a Group 2 or 4 product was always recommended (whether or not volunteer canola was targeted – except for CLEARFIELD where only Group 4 was always recommended). If volunteer canola was not a target, four additional products/combinations were recommended to control the wild oat/Canada thistle combination (total 107), but all of these were in the highest cost range of the array. Therefore, it can be concluded that volunteer canola, whether the only target annual broadleaf, or in addition to wild mustard which is in the same plant family, would likely not create an incremental cost to wild oat and Canada thistle control.

Table 4.2: Simulation # 2 In-Crop Applications to Target Canada Thistle, Wild Oats and Wild Mustard in Barley

Weed Combination	Number of Herbicide Brands or Combinations Recommended	Number of Times Herbicide Group Recommended					Per Acre Price Range	Per Acre Median Price (Low End if Range Given)
		Grp 1	*Grp 2*	*Grp 4*	Grp 6	Grp 8		
Canada Thistle Wild Oats Wild Mustard	59	44	***20***	***51***	8	9	$2.61- $48.18	$22.44
Canada Thistle Wild Oats Wild Mustard Volunteer Canola	47 (all herbicides and combinations included in above scenario)	34	***18***	***40***	8	8	$5.47- $30.40	$22.42
Canada Thistle Wild Oats Wild Mustard CLEARFIELD Volunteer Canola	38 (36 herbicides and combinations included in above scenario)	27	***9***	***38***	8	7	$5.47- $30.40	$22.47

Observations: The barley results were very similar to the wheat simulation for this weed combination.

Table 4.3: Simulation # 3 In-Crop Applications to Target Perennial Sow-thistle, Stinkweed and Green Foxtail in Barley

Weed Combination	Number of Herbicide Brands or Combinations Recommended	Number of Times Herbicide Group Recommended				Per Acre Price Range	Per Acre Median Price (Low End if Range Given)
		Grp 1	*Grp 2*	*Grp 4*	Grp 6		
Perennial Sow-thistle Stinkweed Green Foxtail	49	44	***11***	***42***	8	$2.61-$48.18	$19.64
Perennial Sow-thistle Stinkweed Green Foxtail Volunteer Canola	35 (all herbicides and combinations included in above scenario)	34	***10***	***30***	8	$5.47-$30.40	$21.62

Observations: This scenario considered a variety of less commonly reported weeds plus one other broadleaf annual, stinkweed. As with Simulations 1 and 2 the number of options available if volunteer canola was in the mix was somewhat more limited. For example, a Group 4 herbicide was sometimes recommended on its own if volunteer canola was not also in the mix, but Group 4 in combination with another group was always recommended if volunteer canola was targeted. The cost range per acre was tighter if volunteer canola was in the mix (with a lower maximum price in the range), however the median cost was about 10% higher with volunteer canola.

Table 4.4: Simulation # 4 In-Crop Applications to Target Perennial Sow-thistle, Quack grass and Dandelion in Wheat

Weed Combination	Number of Herbicide Brands or Combinations Recommended	Number of Times Herbicide Group Recommended			Per Acre Price Range	Per Acre Median Price (Low End if Range Given)
		Grp 2	*Grp 4*	Grp 6		
Perennial Sow-thistle Quack grass Dandelion	5	***5***	***3***	2	$15.84-$24.37	$18.82
Perennial Sow Quack grass Dandelion Volunteer Canola	5 (all herbicides and combinations included in above scenario)	***5***	***3***	2	$15.84-$24.37	$18.82

Observations: This scenario considered volunteer canola as the only annual broadleaf in the mix. No differences in in-crop recommendations were noted if volunteer canola was targeted with perennial sow-thistle, quackgrass and dandelion.

Table 4.5: Simulation # 5 In-Crop Applications to Target Canada Thistle, Wild Oats and Wild Buckwheat in Wheat

Weed Combination	Number of Herbicide Brands or Combinations Recommended	Number of Times Herbicide Group Recommended					Per Acre Price Range	Per Acre Median Price (Low End if Range Given)
		Grp 1	*Grp 2*	*Grp 4*	Grp 6	Grp 8		
Canada Thistle Wild Oats Wild Buckwheat	97	68	***41***	***87***	14	9	$5.47-$69.27	$22.57
Canada Thistle Wild Oats Wild Buckwheat Volunteer Canola	82	56	***38***	***72***	14	8	$5.47-$38.80	$22.43
Canada Thistle Wild Oats Wild Buckwheat Volunteer CLEARFIELD Canola	67	44	***24***	***67***	14	7	$5.47-$34.15	$22.50

Observations: This scenario tested volunteer canola with and without the most commonly reported target annual broadleaf, wild buckwheat, as indicated by the Weed Survey management questionnaire survey results. Wild buckwheat alone would not typically be targeted with a specific herbicide application. Therefore this simulation was run with two other common weeds, Canada thistle and wild oats. Group 2 or 4 herbicides were always recommended, regardless of whether volunteer canola was included in the mix. This also was the case for CLEARFIELD canola.

Results were similar to Simulation 1 and again confirmed that the costs and options available were comparable regardless of the presence of volunteer canola and that no incremental application or tank mix is recommended by the program.

Simulation #6: In-Crop Applications to Target Volunteer Canola on its own.

Many herbicides and combinations were recommended by the model if volunteer canola was the only target weed identified. In wheat, 163 options were recommended (somewhat less at 134 if CLEARFIELD volunteer canola was specified). All recommendations included a Group 2, 4 or 5 herbicide, either alone, in combination with each other, or in combination with a Group 1, 6, 7 or 8 herbicide. Cost per acre varied from a low of $1.23 per acre for 2,4-D Ester 500, a Group 4 herbicide, to a high of over $35.00 for Horizon, Refine Extra and Lontrel combination (Groups 1, 2 and 4). The median cost was associated with Sundance, a Group 2 herbicide at $15.84 per acre (not recommended for CLEARFIELD unless a tank mix is added). Dyvel (Group 4, at $4.53-5.99/acre) and Buctril M (Group 4 and 6 at $6.78/acre) were other examples, while Refine Extra (at $5.92/acre), a Group 2 herbicide was also recommended for control of volunteer canola (but not for CLEARFIELD) in both spring wheat and barley. Therefore, the "worst case scenario" for a dedicated application of a herbicide to control volunteer canola in a subsequent wheat or barley crop, regardless of whether it is HT or conventional, could be about a $6.00 per acre for product cost plus application. It could be under $2.00 per acre for the herbicide if the less expensive 2,4-D product is used. The more expensive options would not likely be used if volunteer canola was the only weed targeted.

The 2001 Agronomic and Economic Assessment of Transgenic Canola study assumed a $4.00 per acre application cost for spray herbicides. The worst case scenario would therefore likely be a $6.00 to $10.00 per acre charge if volunteer canola were the only weed targeted. Note that the probability of a dedicated application for only volunteer canola appears to be quite remote. Only one of the 221 cases studied (Weed Survey) listed volunteer canola as the only target weed in the subsequent crop, and just one case targeted volunteer canola in addition to grassy and broadleaf perennial weeds (no other annuals). Another four cases listed volunteer canola as the only broad-leaf annual weed targeted with herbicides although other grassy annuals were also targeted. Of these six cases that targeted volunteer canola as the only broadleaf annual, one case was associated with a conventional canola variety planted previously on that field. The sample sizes were too small to make inferences as to the probability of a dedicated application for volunteer canola only by canola system. The results do suggest, however, that volunteer canola may, albeit infrequently, be the only broadleaf weed, and in some cases, the only weed targeted with a herbicide application, regardless of whether it is an HT or conventional variety. Only in this case does it appear that a significant incremental cost would be incurred for control.

4.2 Pre-Seeding Applications

Simulation #7: Pre Seeding Application to Target Wild Oats.

This simulation considered pre-seed applications in fields subsequently planted to both spring wheat and barley. There were no differences depending on the crop. If volunteer canola was not included as a target for a pre-emergent application, the program recommended that wild oats could be controlled with a fall or spring application of four herbicides (all containing Group 8 herbicides), two of which also included a Group 3 herbicide in combination. These herbicides are incorporated into the soil, killing the wild oat seed as it germinates, typically before it emerges. Brand names include Avadex, Fortress, and Rival in combination with Avadex. Product costs per acre range from $9.49 to $21.39. If volunteer canola was also targeted with a pre-seed application, then these pre-emergent options are not recommended. Rather, a pre-seed burn down application of a Group 9 herbicide (glyphosate) was recommended. However, the success of this application would be dependent on application only after the wild oats and volunteer canola have emerged (which may present a timing issue in regard to crop seeding and emergence). Further, if the volunteer canola is from a Roundup Ready system the pre-seed application will only be effective if the Group 9 product also includes a non-Group 9 herbicide such as a Group 2 or 4 product. The program listed fourteen products/ combinations. The three most costly examples included Pre-Pass ($8.95/acre), Banvel II with Roundup Original ($8.02) and Rustler ($5.99-$7.55 depending on rate). If the volunteer canola is not from a Roundup Ready system, then it and the emerged wild oats can be treated with a straight glyphosate. The model indicated a wide range of costs (from $2.16-$27.42 per acre). The variation in costs related more to rates of application than actual differences in product costs. In conclusion, while a pre-seed application to control volunteer canola in combination with wild oats is not optimal in terms of timing, additional costs (both product and application) would be incurred to control volunteer canola if the only other application was for a pre-emergent to control wild oats. In this case, an in-crop application to control volunteer canola would be more logical. There are also many products available to control wild oats in-crop, so the better decision would likely be to delay the total weed control program to in-crop.

If the volunteer canola was from a Roundup Ready system, then the glyphosate/combination product choices for the pre-seed burndown application were more limited, but wild oats and volunteer canola could still be controlled with one pass. The difference in cost between Roundup Ready volunteer control and any other volunteer canola control would simply be the difference, if any, in product cost between, for example, Roundup with a phenoxy tank mix and straight Roundup, which is about $2.00 per acre.

Note that while the program did not identify 2,4-D as a pre seed application (whether for wild oats or other broadleaf annual weeds), this product can be used to cost effectively control a wide spectrum of weeds, including volunteer canola, regardless of system.

As reported previously, pre-emergent/pre-seeding applications were quite infrequent (about 11% of the 221 cases had such an application, 96% did an in-crop application and 1% made no application). Of those that did a pre-emergent/pre-seed application, 88% followed up with an in-crop treatment. The Weed Survey data did not link target weeds to specific application timing, although of the 25 cases that did a pre-emergent treatment, six cases (24%) were targeting volunteer canola, a rate similar to the overall sample of 221 cases.

5.0 Summary and Conclusions

The results from the three lines of investigation undertaken in this study were highly consistent, and are summarized below. The incidence of herbicide treatments or tillage operations specifically for volunteer canola is very small within the population, and therefore the ability to compare costs with a good degree of confidence is limited.

5.1 Prairie Weed Survey

The analysis of the Prairie Weed Survey data (i.e. agronomic weed management practices by canola system) indicated that there was insufficient justification to perform a full economic analysis, which would entail converting all of the inputs to a dollar value (cost). Offsetting, full revenue analysis cannot be performed using this data, because only yield of the subsequent crop was captured in the management survey, not grade or dockage.

The very large number of combinations of crop, target weeds, available herbicides, and tillage options complicates any analysis of this type. While a "case study" type approach was considered as a method for deriving economic differences for volunteer control, based on a review of the 316 fields previously planted to canola included in the Prairie Weed Survey, there does not appear to be a definitive "typical" scenario upon which such a case comparison could be made.

Rather, the approach taken with this analysis was to compare specific practices and herbicide groups used by system and whether volunteer canola was present as a target weed. Note that analysis by tillage system was not performed on this data, because the sample size was too small to draw meaningful comparisons.

The conclusion from this analysis was that in spite of the small sample sizes for individual systems, the data generally fell within a very tight range. Weed control management appears to have more to do with the subsequent crop, than the previous canola system.

Key arguments to support this conclusion of "no difference" are that:

- The herbicide options available and those in fact used by the Prairie Weed Survey growers to treat volunteer canola in the subsequent cereal crop (mainly Group 2 and 4 herbicides) were almost identical for each system. The exception was more limited choice for CLEARFIELD because of the Group 2 tolerance. Note, however, that resistance of other weeds to Group 2 herbicides has been reported elsewhere (e.g. annual sow-thistle, chickweed, cleavers, hempnettle, kochia, wild mustard and wild oats)[2], which would necessitate using another group anyway.
- As would be expected, this data shows that no Group 9 (i.e. Roundup) or Group 10 (Liberty) herbicides were used for in-crop weed control in cereals because cereal varieties tolerant of these herbicides were not available in the survey years. These products would not have controlled Roundup Ready or Liberty Link canola volunteers respectively, so other products would have to be used for in-crop weed control. The presence of volunteer canola as a target weed does not therefore limit herbicide choice.
- Considering their total weed management program, the majority of growers applied herbicides in-crop, which is optimal because a broad spectrum of weeds can be controlled with the appropriate herbicide combinations, after they germinate, for more effective control. Fall or pre-seed application timings are more effective at targeting established perennial weeds such as Canada thistle or quack grass. There did not appear to be any evidence to suggest that growers of HT canola were making multiple applications or were delaying their applications to only in-crop, at a rate different than the albeit small conventional sample,

[2] 2002 Crop Protection (page 42, Herbicide Resistant Weeds in Alberta), Alberta Agriculture Food and Rural Development.

although somewhat fewer conventional growers made pre-seed/pre-emergent applications. This was offset by more tillage by conventional growers relative to that reported by CLEARFIELD growers.

- Volunteer canola was fairly infrequently mentioned as a target weed for herbicide applications in fields following a canola crop, regardless of system, and it was very rarely indicated as the primary weed targeted with a herbicide application. Many combinations of other broadleaf annual weeds were cited with and without volunteer canola (87% of the fields surveyed were targeted with herbicides for broadleaf weeds in addition to or instead of volunteer canola). Overall, more serious weed problems were cited, which likely drive the weed management decisions because of their potential competition with the crop. While there was an indication of greater recognition by Roundup Ready and CLEARFIELD growers (relative to conventional growers) that volunteer canola was a more troublesome weed than other broadleaf annuals, this could have been due to greater awareness by these growers of the potential need to control volunteers from these two systems.
- Management of the canola crop residue in the previous fall was similar across systems.
- The percentage of fields with volunteer canola observed during the summer weed count was very similar across all systems. In most cases, the range of plants observed was well below the economic threshold (estimated at 10 plants per square meter) for treatment, and therefore wouldn't in turn impact negatively on cereal crop yields. Therefore, whatever control measures were employed for each system, appear to be working effectively in controlling the volunteers and minimizing impact on the crops.
- The summer weed counts also indicated that there was no difference in the presence of other weeds between systems. Therefore, no conclusion can be drawn to suggest that more effective weed control in the canola crop due to an HT canola system (a reason sited by growers for adopting HT canola[3]) would carry forward to the subsequent crop, thus creating an additional economic benefit.
- The incidence of fields with volunteers of any type appears to be consistent across crops (about 10%). The presence of volunteer canola on fields not planted to canola the previous year was comparable to the presence of volunteer grains on fields not planted to these grains the previous year, suggesting that carry over or movement of volunteer canola between fields was no greater a problem than other volunteer grains, as identified by the summer weed counts.
- The incidence of reported (other) weed resistance also did not vary between HT and conventional systems, although it appears that the HT growers were somewhat more aggressive in tank mixing herbicides of different groups. Importantly, there were no incidences of volunteer canola being reported as a resistant weed among any of the growers completing the management survey (regardless of whether canola was grown on the previous field or not), except in a few cases where it was a corresponding herbicide tolerant variety.

5.2 2004 Grower Survey

The results of the 2004 grower survey also revealed that there were few differences in volunteer control for herbicide tolerant over conventional systems.

Analysis of differences by system was complicated by many factors:

- Many canola growers grow multiple systems in any given year and rotate systems from year to year. Relatively few growers surveyed grew only conventional varieties over the past five years. Therefore it is difficult to isolate true conventional system growers from HT system growers.

[3] 50% of those growers adopting transgenic canola (n=523) stated easier and better weed control overall as a reason for adopting. "An Agronomic and Economic Assessment of Transgenic Canola, January 2001, Serecon Management Consulting Inc.

- The impact of volunteers as a weed and the cost of control are typically attributed to the subsequent crop, not the crop that the volunteers originated from. Volunteers originate most commonly from the crop planted on the field the previous year, but they can also come from prior years, being spread by equipment, a neighbouring field, or from seed with adventitious presence, which makes it a challenge to link the source system (and year planted) to the appearance of the volunteers.
- The growers surveyed had some difficulty in isolating volunteer canola control practices on fields that were previously planted to canola. In practice, fields do not always "line-up" in terms of subsequent crops planted, field size, and weed control practices used. Weed control practices are dictated by the growing conditions and subsequent crop planted in the rotation, in addition to the number and spectrum of weeds present.
- The growers surveyed do not typically make herbicide treatments for just one weed. About three-quarters of the respondents targeted at least one other broadleaf weed with their herbicide applications, and only two respondents out of the 335 surveyed said they targeted no other weed in addition to volunteer canola with their application. As such, some had difficulty isolating herbicide costs relating only to volunteer canola control, because they used broad spectrum or combination products.

The majority of canola growers surveyed were not targeting volunteer canola with weed control measures more so than they had in the past, nor had they changed their weed management practices in order to control volunteer canola. Increases in targeting or changes to weed management practices to control volunteer canola were reported by those with a history of growing conventional canola as well as HT systems. If a change was made, it was more often reported by zero till than conventional tillage growers, which corresponded to the adoption of HT varieties. Therefore any change in weed management could be due to the corresponding change in tillage practices and/or by greater awareness of the need to control volunteer canola by HT growers.

The majority (about four out of five growers) who had experience with both HT and conventional systems had not changed their sanitation (equipment cleaning practices) when moving from field to field as a result of adopting HT canola.

Three quarters of growers that had experience with both conventional and HT systems reported that volunteer canola management was the same or easier with HT systems, as compared to conventional.

An analysis of volunteer canola practices by system revealed that there is no basis to suggest that the cost of controlling HT varieties is greater than that for conventional varieties. In fact, there were no significant differences between systems in the costs of volunteer canola control, as estimated by the growers themselves; at $10-13 per acre treated with herbicides, and $5 per acre for tillage/harrowing operations.

- The percentage of acres treated with herbicides to control volunteer canola was similar across systems (at fewer than 20% of the surveyed acres within each system). Acres that had been previously planted to conventional canola were statistically as likely (given the sample sizes) to have received a herbicide treatment to control volunteer canola as were those acres previously planted to herbicide tolerant canola.
- The most common tank mix products (2,4-D, and products containing MCPA) were used by all systems.
- Refine Extra was used to control all but CLEARFIELD volunteers because of the group 2 tolerance.
- Glyphosates were used to control all but Roundup Ready volunteer canola.
- Decisions to use other products appear to be linked to the total weed spectrum to be controlled.

Because of the challenges noted above, and the great diversity of products used and weeds targeted, it is somewhat difficult to describe a definitive profile of weed control practices and associated costs in subsequent cereals by system. Typical examples follow:

- A zero-till Roundup Ready grower might add a tank mix of 2,4-D to their pre-seed burn off to control volunteer canola along with other broadleaf annual weeds at a product cost of about $2 per acre. Since the product is tank mixed, there would be no incremental application cost. It is likely that Roundup Ready growers are more able to isolate their volunteer canola treatments from their other broadleaf treatments because they know that Roundup can't control it.
- Conventional, Liberty Link, and CLEARFIELD growers might apply glyphosate as a pre-seed burn off (total cost about $7-$13 per acre with application, depending on the rate)[4], but the challenge here would be to allocate a portion of that cost just to controlling volunteer canola, since a variety of broadleaf weeds and others including quack grass are typically targeted with this type of application. Note as well, that growers might decide to make a pre-seed application as a matter of course, and not necessarily in response to an observation of the weed spectrum and infestation levels in the spring. Others growers might apply a dedicated in-crop tank mix of 2,4-D or MCPA, perhaps in the form of products like Buctril M or Frontline, or along with a wild oat herbicide, again at an incremental cost of about $2 per acre.

There were no statistical differences in the incidence of tillage or harrowing operations to control volunteer canola on fields previously planted to canola by system. The incidence of cultivation practices to control volunteer canola was very low amongst the survey population.

Herbicide applications and tillage operations performed to control volunteer canola on fields that had not been planted to canola the previous year were infrequent. If such operations were performed, the source of the volunteer canola was attributed to conventional varieties as well as HT varieties. The cost of such operations that could be attributed back to the total number of acres of the originating canola crop was estimated at about 50 cents per acre.

[4] The lower rate of .3 litres per acre is recommended for volunteer canola. If quack grass is targeted, the higher rate (1 litre per acre) is recommended.

As with volunteer control management, the impacts of volunteer canola on subsequent crops were not exclusive to HT varieties.

- Yield and dockage losses have been experienced in crops following canola of all four systems, not just HT canola.
- Nearly 60% of the growers who planted a HT variety in 2003 (any of the three systems) reported a carry-over benefit to the 2004 crop in terms of improved weed control. This perception was not supported with the Prairie Weed Survey data where no differences in summer weed counts were found. About half of these growers put a dollar value on this benefit of $11.80 per acre, roughly the cost of product and application of, for example, a typical glyphosate treatment. This cost benefit would offset any incremental cost of volunteer canola control derived from this survey.

The majority of HT growers continue to support the premise, that overall, the benefits of growing HT varieties, all things considered, *including subsequent volunteer control*, were greater than the benefits of growing conventional varieties on their farms.

5.3 Herbicide Use Simulations

The herbicide use simulation exercise suggested that the "worst case" economic scenario would be if volunteer canola was the only weed targeted with a distinct herbicide application. In that case, the incremental cost of the recommended product and application was estimated at between six and ten dollars per acre. This application could be made regardless of system, however. The sample sizes from the Weed Survey and the Grower Survey were too small to determine the probability of this application being required in any system, but both sources indicated that it would be very small (under 1%).

5.4 General Recommendations

The Prairie Weed Survey certainly provides a valuable resource for tracking the volunteer canola

issue in the future. Assuming this survey is repeated, then such benchmarks as the percentage of acres that were targeted with herbicide applications for volunteer canola, the herbicide groups used, and the summer weed counts should be tracked.

Finally, if not already underway, consideration should be given by the canola industry to work with the weed scientists to research and establish economic thresholds for volunteer canola.

Appendix A: 2003 Saskatchewan Weed Survey Questionnaire

The 2003 Saskatchewan Weed Survey is provided as an example. Slightly different versions of the 2002 Manitoba and 2001 Alberta surveys were also used in this study.

2003 Saskatchewan Weed Survey Questionnaire

1. **PLEASE READ ALL QUESTIONS CAREFULLY AND ANSWER AS MANY QUESTIONS AS POSSIBLE. EVEN A PARTIALLY COMPLETED QUESTION IS USEFUL.**
2. Answer the questions only as they apply to the surveyed field **location** and the main **crop** *(not the underseeded crop)* shown below on the label unless stated otherwise.

Surveyed Field

If the crop, underseeded crop or acreage is missing or incorrect on the label, please specify the **crop** _____ **underseeded crop**_____ and **acreage** _____.

Seeding Practices

1.1 What variety of the crop was planted in the surveyed field in 2003?_____

1.2 Was the seed used in the surveyed field in 2003 treated with an insecticide or fungicide?
9 No 9 Yes *If yes, please specify product*_____

1.3 When was the 2003 crop seeded in the surveyed field?
Month _____ Day

1.4 What seeding rate was used for the crop in the surveyed field?
Bu/acre _____ or lb/acre

1.5 What depth was the crop seeded in the surveyed field?
9 Broadcast 9 1 to 2 inches
9 Less than 1 inch 9 Greater than 2 inches

1.6 What row spacing was used to seed the crop in the surveyed field? _____inches

1.7 Which system was used to seed the crop in the surveyed field?
9 Air tank 9 Broadcast and harrowed 9 Precision seeder
9 Gravity feed drill box 9 Broadcast and cultivated 9 Other (specify)_____

1.8 Which type of opener was used to seed the crop in the surveyed field?
9 Knife (1 inch or narrower) 9 Double disc 9 Hoe
9 Spoon (2 to 5 inches wide) 9 Offset single disc (Barton) 9 Discer
9 Sweeps (6 inches or wider) 9 Other (specify)_____

1.9 Was any other equipment used in seeding the crop? *Check all that apply.*
9 None 9 Fluted coulters 9 Smooth coulters
9 On-row packing 9 Harrowpacker
9 Tine harrow 9 Rotary harrow
9 Other (specify)_____

1.10 What was the yield of the crop in the surveyed field in 2003?
Bu/acre _____ or lb/acre _____

Weed Management

2.1 Were herbicide(s) applied to the surveyed field? *Check all that apply.*

9 Pre harvest application in 2002
9 After harvest application in 2002
9 Before seeding or emergence of the crop in 2003
9 After crop emergence in 2003 (in-crop)
9 None of the above application times *If no herbicide applied, skip to question 2.21 on page 4.*

2.2 Which specific herbicide(s) were applied at each time specified in question 2.1? If *2,4-D or MCPA* were applied, please specify formulations (Example: 2,4-D amine 600, MCPA ester 500).

Name of herbicide	Date of application *(month and day)*	Rate *(specify units)*	Acreage treated	Water volume *(specify units)*	Applicator *(yourself, neighbour, aerial, custom ground)*

2.3 Which troublesome weeds were you trying to manage with herbicide applications in the surveyed field?

Most Troublesome 1.
2.
3.
4.
Less Troublesome 5.

If you did not spray herbicides on the surveyed field yourself, skip to question 2.21 on page 4.

If you sprayed the surveyed field yourself, answer the following questions as they pertain to the main sprayer used on the surveyed field.

2.4 What type of ground sprayer did you use on the surveyed field?

9 Truck-mounted 9 Large self-propelled 9 Pull-type
9 Tractor-mounted 9 Small self-propelled (*For example:* Melroe Spra-Coupe)
9 Other (specify)_____

2.5 Does the sprayer used on the surveyed field have shrouds or cones?
9 Shrouds 9 Cones 9 None

2.6 How large is the tank of the sprayer used on the surveyed field (imperial gallons)?
9 Less than 200 9 401 to 600 9 801 to 1000
9 200 to 400 9 601 to 800 9 More than 1000

2.7 How wide is the boom of the sprayer used on the surveyed field (feet)?
9 Less than 40 9 61 to 80 9 101 to 120
9 40 to 60 9 81 to 100 9 More than 120

2.8 What was your travel speed for in-crop herbicide application on the surveyed field (mph)?
9 3 to 5 9 6 to 10 9 11 to 15 9 16 to 20 9 More than 20

2.9 What was your typical boom height above crop canopy for in-crop herbicide application on the surveyed field (inches)?
9 12 to 20 9 21 to 40 9 More than 40

2.10 What type of pump does the sprayer used on the surveyed field have?
9 Centrifugal 9 Roller 9 Diaphragm 9 Piston
9 Other (specify)_____

2.11 At what pressure did you operate the sprayer used on the surveyed field (psi)?
9 Less than 20 9 41 to 60 9 81 to 100
9 20 to 40 9 61 to 80 9 More than 100

2.12 Did you use an automatic rate controller when spraying the surveyed field?
9 No 9 Yes

2.13 If you use less than the recommended water volume, what is your reason? *Check all that apply.*
9 Sprayer is designed to be used with lower volumes
9 Reduces water hauling
9 Pesticides work better
9 Other (specify)_____

2.14 How concerned are you about spray drift during your spraying operation?
9 Not at all 9 Somewhat 9 Very much 9 Depends on what's downwind

2.15 Which nozzles did you use for your herbicide applications on the surveyed field? *Check all that apply.*

a) Flat fan: 9 TeeJet XR 9 ComboJet ER
9 Lurmark (Hypro) TR, VP 9 Delavan
9 Other (specify)_____

b) Conventional low-drift: 9 Turbo TeeJet 9 TeeJet DG
9 ComboJet DR 9 Delavan RF 9 Lurmark (Hypro) LD
9 Other (specify)_____

c) Venturi nozzles: 9 Air Bubble Jet 9 SprayMaster Raindrop Ultra
9 Lechler ID 9 Greenleaf TurboDrop or TD-XL
9 TeeJet AI 9 Lurmark (Hypro) Ultra Lo-drift
9 Other (specify)_____

d) Specialty nozzles: 9 Hollow Cone 9 Air Assist
9 Lurmark Twin Cap 9 Electrostatic
9 Other (specify)_____

2.16 What is your sprayer calibration method? *Check all that apply.*
9 Capture output from each nozzle along boom
9 Capture output from a few select nozzles along boom
9 Use automatic flow regulator to ensure correct application volume
9 Calculate the acres done per tank
9 Other (specify)_____

2.17 How often do you calibrate your sprayer?
9 Several times a year 9 Annually 9 Every 2 to 3 years 9 Never
9 Other (specify)_____

2.18 How often do you replace your nozzles?
9 1 to 3 years 9 3 to 6 years 9 More than 6 years

2.19 Why do you replace your nozzles? *Check all that apply.*
9 Regular part of sprayer maintenance 9 New technology available
9 Old ones are worn (large difference on calibration) 9 Bought a new sprayer
9 Poor pattern 9 Other (specify)_____

2.20 How many different nozzle types did you use on **your farm** this year?
9 1 9 2 9 3 9 4 9 More than 4

2.21 Please rank the following practices as to their usefulness for weed management on **your farm**. Rank the practice you find most useful with a "1", the next most useful practice with a "2", etc. Do **not** rank practices that you do not consider useful.

___ Rotate crops	___ Narrow row spacing	___ Collect chaff
___ Grow competitive crops	___ Increase seeding rate	___ Graze in spring or fall
___ Grow competitive varieties	___ Vary seeding date	___ Hand weed
___ Grow green manure crops	___ Clean equipment	___ Mow weed patches
___ Use fall or spring tillage	___ Tarp trucks	___ Cultivate field edges
___ Use post-seeding tillage	___ Other (specify)_____	

Field History

3.1 Please specify the crop and variety grown (or summer fallow) and the herbicides used on the surveyed field for the past five crop years**. If no herbicide was applied in a year, write "NO" in first Herbicide column**. Please specify formulations of 2,4-D and MCPA. (*Example: 2,4-D amine 600, MCPA ester 500*)

Year	Crop & Variety *or* Fallow	Herbicides applied Before Seeding or Crop Emergence	Herbicides applied After Crop Emergence	Herbicides applied Pre harvest	Herbicides applied After Harvest
2002				*Include in Question 2.2*	*Include in Question 2.2*
2001					
2000					
1999					
1998					
1997	*Do not write in this box*	*Do not write in this box*	*Do not write in this box*		

3.2 Which herbicide (s) or herbicide group (s) did you frequently use in the surveyed field prior to 1997?

_____

_____

_____

3.3 IF THE SURVEYED FIELD WAS SUMMER FALLOWED IN 2002**, WAS THE SUMMER FALLOW MAINTAINED BY:**

9 Tillage and chemical weed control 9 Tillage only 9 Chemical weed control only

3.4 On the surveyed field, how did you handle the residue from the **2002** crop?

9 Chopped 9 Spread 9 Chaff collected 9 Baled 9 Burned 9 None

Weed Resistance

4.1 Are you aware of or do you suspect that you have a herbicide resistant weed in the surveyed field?

9 No *If no, skip to question 4.3*
9 Suspected *If suspected, specify the weed(s) and the herbicide or group in table below*
9 Confirmed *If confirmed, specify the weed(s) and the herbicide or group in table below*

Weed	Herbicide or herbicide group to which weed is resistant

4.2 To manage resistant weeds, do you:

a) Control weeds in suspected patches separate from the remainder of the field before or at harvest? 9 No 9 Yes

b) Alter your cropping practices in the field if resistant weeds cover a large area? 9 No 9 Yes
If yes, please indicate how you alter your practices? _____
_____
_____

4.3 To delay the development of resistant weeds or to manage resistant weeds, do you:

a) Tank-mix broadleaf weed herbicides from different herbicide groups (For example: Groups 2 & 4)? 9 No 9 Yes

b) Practice herbicide group rotation? 9 No 9 Yes
If yes, how long have you practiced herbicide group rotation? _____ years
And, do you follow a set rotation? Check one box only.
9 No
9 Yes, herbicide group used in a field once every _____ years
9 Rotation interval varies with herbicide group

c) Scout your fields during the growing season **after** herbicide application to check for suspected resistant weed patches? 9 No 9 Yes

4.4 Do you use other management strategies to prevent or delay the development of resistant weeds?

9 No 9 Yes *If yes, please specify strategy used?* _____
_____
_____

4.5 How would you rate the ***present*** impact of weed resistance on your farm:

9 No impact 9 Slight impact 9 Moderate impact 9 Large impact

4.6 How would you rate the ***future*** (next 5 years) impact of weed resistance on your farm:

9 No impact 9 Slight impact 9 Moderate impact 9 Large impact

Insect Management

5.1 Was an insecticide applied after crop emergence to the surveyed field in **2003**?

9 No *If no, skip to question 6.1*

9 Yes *If yes, which specific insecticide did you use?*

Name of insecticide	Target Insect	Date of application *(month & day)*	Rate *(specify units)*	Water volume *(specify units)*	Applicator *(yourself, neighbour, aerial, custom ground)*

Disease Management

6.1 Was a fungicide applied after crop emergence to the surveyed field in **2003**?

9 No *If no, skip to question 7.1*

9 Yes *If yes, which specific fungicide did you use?*

Name of fungicide	Target Disease	Date of application *(month & day)*	Rate *(specify units)*	Water volume *(specify units)*	Applicator *(yourself, neighbour, aerial, custom ground)*

Tillage Practices

7.1 Was the surveyed field tilled **after harvest** in the fall of **2002**?

9 No *If no, skip to question 7.2*

9 Yes *If yes, specify the number of times that you used each implement*

Implement	Number of Times	Implement	Number of Times
Anhydrous knives		Discer	
Cultivator (heavy duty-spikes)		Heavy harrow	
Cultivator (heavy duty-sweeps)		Harrow	
Cultivator (field)		Harrowpacker	
Tandem disc (3" deep or less)		Rodweeder	
Tandem disc (more than 3" deep)		Packer	
Moldboard plough		Other (specify)_____	

7.2 Was the surveyed field tilled **before seeding** in the spring of **2003**?

9 No *If no, skip to question 7.3*

9 Yes *If yes, specify the number of times that you used each implement*

Implement	Number of Times	Implement	Number of Times
Anhydrous knives		Discer	
Cultivator (heavy duty-spikes)		Heavy harrow	
Cultivator (heavy duty-sweeps)		Harrow	
Cultivator (field)		Harrowpacker	
Tandem disc (3" deep or less)		Rodweeder	
Tandem disc (more than 3" deep)		Packer	
Moldboard plough		Other (specify)_____	

7.3 Was any tillage used for weed control **after seeding** in **2003**?

9 None 9 Pre-emergent harrowing 9 Post-emergent harrowing

9 Pre-emergent rodweeding 9 Other (specify)_____

Fertilizer Practices

8.1 Was manure applied to the surveyed field in the **fall of 2002** or **spring 2003**?

9 No 9 Yes *If yes, please specify number of acres treated* _____

8.2 Was fertilizer applied to the surveyed field? *Check all that apply.*

9 After harvest **2002**

9 Before seeding **2003**

9 At seeding **2003**

9 In-crop **2003**

9 None of the above application times *If no fertilizer applied, skip to question 9.1*

8.3 How did you determine the rate of fertilizer application for the surveyed field? *Check all that apply.*

9 Soil test recommendations 9 General fertilizer use guidelines 9 Dealer recommendations

9 Estimate based on past yield 9 Estimate based on experience 9 Price/cost limitations

8.4 Details of fertilizer use at each application time specified in question 8.2
Please answer
Part A** if you know the **ACTUAL** amount of each nutrient applied **OR
Part B** if you know the **FORMULATION** and **RATE OF PRODUCT

Part A (Actual)

Date of application *(month and day)*	Nitrogen *(lb/acre)*	Phosphate *(lb/acre)*	Potassium *(lb/acre)*	Sulphur *(lb/acre)*	Placement *(broadcast, injected, Deep banded, surface banded, side banded, mid-row banded, seed placed, foliar)*

Part B (Formulation)

Date of application *(month and day)*	Formulation *(For example: 12-51-0-0)*	Rate of the product applied *(For example: 30 lb/acre)*	Placement *(broadcast, injected, Deep banded, surface banded, side banded, mid-row banded, seed placed, foliar)*

General

9.1 How many acres do you farm?

9 Less than 500 9 500 to 1000 9 1000 to 1500 9 1500 to 3000
9 3000 to 7000 9 7000 to 12000 9 12000 to 20000 9 More than 20000

9.2 What are the main commodities produced on your farm? *Check all that apply.*

9 Cereals
9 Oilseeds
9 Pulses
9 Forages
9 Other crop types (specify)_____
9 Cattle
9 Hogs
9 Other livestock (specify)_____

Additional Comments

10.1 Do you have any additional comments to make on the weeds in the field, the management of the field, or this survey?

Thank you for completing the Saskatchewan Weed Survey Questionnaire. We will use this information to focus weed research and to make weed control and management recommendations.

Appendix B: 2004 Volunteer Canola Survey

2004 Volunteer Canola Survey

Province Index: 1 SK 2 MB 3 AB/BC

Hello, my name is _____ and I'm calling on behalf of the Canola Council. I am with MarketVisions, a professional market research firm. We're conducting a very important study for the Canola Council of Canada and the provincial canola associations regarding canola and weed control.

For the purposes of this study, I need to speak to the person in your household who is most involved in making decisions about weed control. Could I please speak to that person?

1 Speaking **[CONTINUE]**
2 Yes, I'll get him/her **[CONTINUE AND REPEAT INTRO]**
3 Not available **[QUALIFY BY ASKING Q1 AND ARRANGE CALLBACK]**
4 No longer farming **[THANK AND TERMINATE]**

We would like you to participate in this study, which should take from 12 to 15 minutes of your time, depending on your answers. Your responses will be used to help the Council and the associations in furthering knowledge about management practices in canola on the prairies. You may need to refer to your records, as I will be asking you which crop protection products and methods you used. I want to assure you that your responses will remain confidential and no one from the sponsoring organizations will see your answers or know who participated.

[IF ASKED ABOUT NAME SOURCE] Your name was provided by a company that maintains a database of farmers. Your participation will not result in your name being added to any other list for research or sales purposes. **[IF ASKED,** say "the CCC works with all the companies that provide products and services to the canola industry" – provide names if a condition of participation – eg Monsanto or Bayer CropScience**].**

Do you have time to complete the interview now?

1 Yes **[CONTINUE]**
2 No

[IF NO] We would like to set an appointment with you at a convenient time to complete the interview. I just need to ask you a few short questions to make sure I'm talking to the right person. **[QUALIFY BY ASKING Q1 – Q3 AND ARRANGE CALLBACK]**

Section 1: Introduction - Field History

1. How many acres of canola did you plant in **2003** – that's the last growing season?
   1 Specify **[IF LESS THAN 80 ACRES, THANK AND TERMINATE]**
   88 Don't know **[THANK AND TERMINATE]**
   99 Refused **[THANK AND TERMINATE]**

2. Thinking of the years 1999-2003, in how many of these past five years have you planted any type of canola on your farm?
   1 1 – 2003 only [THANK AND TERMINATE]
   2 2
   3 3
   4 4
   5 5-all
   88 Don't know **[THANK AND TERMINATE]**
   99 Refused **[THANK AND TERMINATE]**

2B. Are you a hybrid canola seed grower?
1 – yes **[THANK AND TERMINATE]**
2 – no - continue

3. I am going to read a list of types of canola. Please tell me how many acres of each, if any, you planted in 2003. **[READ a-d]**

a. Conventional or any variety that is NOT herbicide tolerant
b. Liberty Link or InVigor System that is tolerant to the Liberty herbicide
c. Roundup Ready System that is tolerant to Roundup herbicide
d. Clearfield or SMART Trait System that is tolerant to Odyssey or Pursuit herbicides

1 Specify # acres **[CHECK – TOTAL SHOULD = Q1]**
2 None
88 Don't know **[THANK AND TERMINATE]**
99 Refused **[THANK AND TERMINATE]**

[MINIMUM QUOTAS: 200 CONVENTIONAL, 100 LIBERTY, 100 ROUNDUP, 100 CLEARFIELD – MAY QUALIFY FOR MORE THAN ONE]

4. This year, that is in 2004, what did you plant on the fields that were planted to canola in 2003… how many acres of each? **[CHECK – TOTAL SHOULD = Q1– DO NOT READ]**
a. Barley
b. Spring Wheat
c. Durum Wheat
d. Canola
e. Peas/beans/lentils/chickpeas (pulses)
f. Oats
g. Forage/grass
h. Other (specify)
i. None/summerfallow

1 Specify # acres
2 None
88 Don't Know
99 Refused

5. Now thinking about your rotation, how often do you typically plant canola on the SAME field?
1 Every year
2 Once in 2 years (every other)
3 Once in three years
4 once in 4 years
5 once in 5 or more years
6 Varies – no set pattern
88 Don't know
99 Refused

6. In how many of the past five years, that is 1999-2003, if any, have you planted herbicide tolerant canola, that is a Roundup, Liberty or Clearfield System?
    1 None
    2 1
    3 2
    4 3
    5 4
    6 5-all
    88 Don't know
    99 Refused

7. **[IF >1 year in Q6 CODE 3-6 – HT CANOLA]** Do you make it a practice to rotate herbicide tolerant canola systems on your farm?
    1 Yes
    2 No
    88 Don't know
    99 Refused

8. Do you have more, less or the same number of acres in canola than you did five years ago? **[PROBE FOR TREND]**
    1 More
    2 Less
    3 Same
    88 Don't know
    99 Refused

9. What would best describe the tillage system you use on your farm? Would it be…**[READ 1-3]**
    1 Zero tillage
    2 Minimum or reduced tillage
    3 Or conventional tillage
    4 Combination/depends **[VOLUNTEERED]**
    88 Don't know
    99 Refused

10. Do you have more, less or the same number of acres under zero till or reduced tillage than you did five years ago? **[PROBE FOR TREND]**
    1 More
    2 Less
    3 Same
    4 Had none – all conventional tillage
    88 Don't know
    99 Refused

11. Have you increased your use of pre-seed burn off treatments compared to five years ago?
    1 Yes
    2 No
    88 Don't know
    99 Refused

Section 2: Volunteer Management

12. Thinking about an average year and your total cropping operation what are the top five weeds that you most often target with control measures? **[PROBE FOR HERBICIDE TOLERANT (CODE 2) OR CONVENTIONAL (CODE 3) IF SAY VOLUNTEER CANOLA IN TOP 5 WEEDS BUT DON'T SPECIFY TYPE – ACCEPT CODE 1 IF MULTIPLE TYPES OR DON'T KNOW THE TYPE]**
    1 Volunteer canola (not specified) **[GO TO Q 14]**
    2 Any Herbicide Tolerant Volunteer Canola (Roundup Ready/Liberty Link/Clearfield/ SMART Trait) **[GO TO Q 14]**
    3 Conventional volunteer canola **[GO TO Q 14]**
    4 Others (any top 5 that does not include volunteer canola)
    5 None
    88 Don't know
    99 Refused

13. Do you target volunteer canola with weed control measures on your farm?
    1 Yes
    2 No **[GO TO Q 16]**
    88 Don't know **[GO TO Q 16]**
    99 Refused **[GO TO Q 16]**

14. Are you targeting volunteer canola with weed control measures moreso, less or the same as you did five years ago? **[PROBE FOR TREND]**
    1 More
    2 Less
    3 Same
    88 Don't know
    99 Refused

15. **[IF MORE/LESS]** To what do you attribute this increase in/change in targeting volunteer canola with weed control measures? **[DO NOT READ]**

    MORE
    1 More acres of canola
    2 Canola included every year or more often in rotation
    3 Grow herbicide tolerant instead of conventional
    4 Do less tillage now
    5 Less summer fallow now/more continuous cropping
    6 Other (specify)

    LESS
    7 Fewer acres of canola
    8 Other (specify)

    88 Don't know
    99 Refused

16. Thinking back over the past five years, have you changed your weed management practices in order to control volunteer canola in any way? **[IF YES]** How? **[MULTIPLE RESPONSE- DO NOT READ]**
    1 No change
    2 Make specific herbicide applications
    3 Tank mix
    4 Spot treat
    5 Do an extra cultivation, harrowing operation
    6 Less fallow
    7 More fallow
    8 Changed crop rotation
    9 More pre seed burnoff
    10 Other specify
    11 Not applicable
    88 Don't know
    99 Refused

17. **[IF HT CANOLA IN Q6, CODES 2-6]** Has volunteer canola management on land seeded to herbicide tolerant canola the year before been… **[READ 1-3]**
    1 About the same as with a conventional variety
    2 Easier than with conventional varieties or
    3 More difficult?
    4 Not applicable
    88 Don't know
    99 Refused

18. Was there anything unusual about the conditions in 2003 or spring 2004 that may have affected the incidence of volunteer canola or your management of volunteer canola in the current crop year?
    1 Yes
    2 No/not applicable **[GO TO Q20]**
    88 Don't know **[GO TO Q20]**
    99 Refused **[GO TO Q20]**

19. Please describe the conditions.
    1 Drought
    2 Wet weather/fields
    3 Grasshoppers
    4 Hail damage
    5 Other - Specify
    88 Don't know
    99 Refused

20. What is the economic threshold, that is the number of volunteer canola plants per square foot, yard or meter that would have to be present before you would consider any herbicide application or cultivation specifically to control volunteer canola? **[IF VARIES IN FIELD ASK FOR PROBLEM AREAS]**
    1 Specify plants and unit of measure
    88 Don't know
    99 Refused

Section 3: Incremental Herbicide Applications On Subsequent Fields

Now I would like to ask you a little more about your specific volunteer canola management practices.

21. In 2004, did you make any herbicide applications that specifically targeted volunteer canola on any of the fields that had been planted to canola the previous year? These are applications that you would NOT have made if volunteer canola had not been present, and may have included tank mixes or spot treatments. You may have been targeting other weeds with this application as well.
    - 1 Yes
    - 2 No **[SKIP TO Q 33]**
    - 88 Don't know **[SKIP TO Q 33]**
    - 99 Refused **[SKIP TO Q 33]**

22. On how many fields did you make such an application? **[CLARIFY IF MORE THAN ONE –** DID YOU TREAT THESE FIELDS DIFFERENTLY…HAD THEY BEEN PLANTED WITH THE SAME CANOLA SYSTEM IN 2003 AND THE SAME CROP IN 2004 **- IF ALL THE SAME TAKE AS 1 FIELD AND SAY –** "FOR THE NEXT FEW QUESTIONS - PLEASE THINK OF THE COMBINED ACRES FOR THESE IDENTICAL FIELDS WHERE VOLUNTEER CANOLA CONTROL APPLICATIONS WERE THE SAME"]
    - 1 Specify # fields
    - 88 Don't know
    - 99 Refused

IF MORE THAN THREE DIFFERENT FIELDS AND MORE THAN 1 CANOLA SYSTEM SAY "I AM NOW GOING TO ASK YOU ABOUT THREE OF THESE FIELDS - PLEASE TELL ME ABOUT AT LEAST ONE FIELD FROM EACH OF THE DIFFERENT SYSTEMS THAT YOU GROW"
[REPEAT SERIES Q23-32 FOR EACH FIELD/COMBINATION OF FIELDS – MAXIMUM 3]

23. **[IF MORE THAN ONE TYPE OF CANOLA GROWN IN Q3]** Thinking about this **first, second, or third field** what type of canola did you grow on this (these) field(s) in 2003? **[DO NOT READ IF DON'T KNOW PROBE FOR HERBICIDE TOLERANT OR CONVENTIONAL]**
    - 1 Conventional
    - 2 Liberty Link or InVigor System (Tolerant to Liberty herbicide)
    - 3 Roundup Ready System (Herbicide tolerant)
    - 4 Clearfield or SMART Trait System (Tolerant to Odyssey and Pursuit herbicides)
    - 5 Any herbicide tolerant (not specified)
    - 88 Don't know
    - 99 Refused

24. And again thinking about this **first, second, third or these field(s),** what crop did you plant on this field this year? **[DO NOT READ]**
    - 1 Barley
    - 2 Spring Wheat
    - 3 Durum Wheat
    - 4 Canola
    - 5 Peas/lentils/beans/chickpeas
    - 6 Oats
    - 7 Forage/grass
    - 8 Other (specify)
    - 9 None/summerfallow
    - 88 Don't know
    - 99 Refused

25. How many of each of these three types of applications did you make on this field specifically to control volunteer canola? **[READ a-c]**
    a. Specific passes
    b. Tank mixes
    c. Spot treatments

    1 Specify #
    88 Don't know
    99 Refused

26. What products did you use? **[MULTIPLE MENTIONS – DO NOT READ – IF SAY PHENOXY ASK FOR 2,4-D or MCPA]**
    1 2,4-D Amine or Ester
    2 Achieve Extra Gold
    3 Assert 300 SC
    4 Attain
    5 Buctril M
    6 Credit
    7 Curtail M
    8 Frontline
    9 Glyfos
    10 Harmony Total
    11 Horizon
    12 Horizon BTM
    13 MCPA
    14 MCPA Amine or Ester
    15 Pre-pass
    16 Prestige
    17 Puma
    18 Puma Super
    19 Refine Extra
    20 Roundup
    21 Round-Up Transorb
    22 Sundance
    23 Target
    24 Touchdown
    25 Triumph Plus
    26 Unity
    27 Other (specify)
    88 Don't know
    99 Refused

[ASK Q 27- 30 FOR EACH PRODUCT-SKIP TO Q30 IF SPOT TREAT ONLY IN Q25]

27. At what rate did you apply?
    1 Specify number
    88 Don't know
    99 Refused

28. What unit? **[DO NOT READ]**
    1 Liters/acre
    2 Gallons/acre
    3 Ml/acre
    4 Acres/case
    5 grams per acre
    6 Recommended rate
    7 Spot treat
    8 Other
    88 Don't know
    99 Refused

29. How many acres did you treat ?
    1 Specify # acres
    88 Don't know
    99 Refused

30. When did you make the application? Was it …**[READ 1-3]**
    1 Fall 2003
    2 Preseeding or premergent in spring 2004
    3 In-crop in 2004
    88 Don't know
    99 Refused

31. Which other weeds, if any, were you able to control with this (these) applications or tank mix? **[MULTIPLE MENTIONS – DO NOT READ – REFER TO LIST]**
    1 No other
    4 Canada Thistle
    5 Quack grass
    6 Wild buckwheat
    7 Wild Mustard
    8 Wild oats
    9 Any other broadleaf annual
    10 Any other grassy annual
    11 Any other perennial
    88 Don't know
    99 Refused

32. What do you estimate to be the per acre cost of this (these) treatment(s) for product, labor and equipment costs?
    1 Specify $
    88 Don't know
    99 Refused

Section 4: Incremental Herbicide Applications on Other Fields

33. In 2004 did you make any herbicide applications to control volunteer canola on fields that had NOT been planted to canola in 2003? Again include specific applications, tank mixes and spot treatments, but only if you made the application specifically because of the volunteer canola.
    1 Yes
    2 No **[SKIP TO Q 38]**
    88 Don't know **[SKIP TO Q 38]**
    99 Refused **[SKIP TO Q 38]**

34. What do you believe to be the source of this volunteer canola? In other words, where did it come from? **[MULTIPLE RESPONSES – DO NOT READ]**
    1 Neighboring field
    2 Carry over from canola planted on field 2002 or earlier
    3 Contaminated seed
    4 Spread by equipment/trucks etc.
    88 Can't tell/Don't know
    99 Refused

35. What type or system do you believe this volunteer canola was from? **[MULTIPLE RESPONSES – DO NOT READ – IF DON'T KNOW PROBE FOR HERBICIDE TOLERANT OR CONVENTIONAL]**
    1 Conventional
    2 Liberty Link or InVigor System (Tolerant to Liberty herbicide)
    3 Roundup Ready System (Herbicide tolerant)
    4 Clearfield or SMART Trait System (Tolerant to Odyssey and Pursuit herbicides)
    5 Any herbicide tolerant (not specified)
    88 Don't know
    99 Refused

36. How many acres were treated in total – include all fields that you applied a herbicide to control volunteer canola in 2004 that had NOT been planted to canola in 2003?
    1 Specify # acres
    2 Spot treated
    88 Don't know
    99 Refused

37. What do you estimate to be the per acre cost of this treatment for product, labor and equipment costs?
    1 Specify $/acre
    88 Don't know
    99 Refused

Section 5: Incremental Tillage Operations

38. Did you do an additional cultivation or pre or post emergent harrowing operation specifically to control volunteer canola on any fields that had been planted with canola in 2003? That is an operation that you wouldn't have made if volunteer canola had not been present?
    1 Yes
    2 No **[SKIP TO Q 45]**
    88 Don't know **[SKIP TO Q 45]**
    99 Refused **[SKIP TO Q 45]**

39. On how many fields did you perform such an operation **[CLARIFY IF MORE THAN ONE –** DID YOU PERFORM DIFFERENT OPERATIONS ON THESE FIELDS ….HAD THEY BEEN PLANTED WITH THE SAME CANOLA SYSTEM IN 2003 AND THE SAME CROP IN 2004? **- IF ALL THE SAME TAKE AS 1 FIELD AND SAY –** FOR THE NEXT FEW QUESTIONS - PLEASE THINK OF THE COMBINED ACRES FOR THESE IDENTICAL FIELDS] ?
    1 Specify # fields
    88 Don't know
    100 Refused

IF MORE THAN THREE DIFFERENT FIELDS AND MORE THAN 1 CANOLA SYSTEM SAY "I AM NOW GOING TO ASK YOU ABOUT THREE OF THESE FIELDS - PLEASE TELL ME ABOUT AT LEAST ONE FIELD FROM EACH OF THE DIFFERENT SYSTEMS THAT YOU GROW"

[REPEAT SERIES Q40-44 FOR EACH FIELD – MAXIMUM 3]

40. **[IF MORE THAN ONE TYPE OF CANOLA GROWN IN Q3]** Thinking about this **first, second, third or these field(s),** what type of canola did you grow on this (these) field(s) in 2003? **[DO NOT READ -IF DON'T KNOW PROBE FOR HERBICIDE TOLERANT OR CONVENTIONAL]**
    1 Conventional
    2 Liberty Link or InVigor System (Tolerant to Liberty herbicide)
    3 Roundup Ready System (Herbicide tolerant)
    4 Clearfield or SMART Trait System (Tolerant to Odyssey and Pursuit herbicides)
    5 Any herbicide tolerant (not specified)
    88 Don't know
    99 Refused

41. Again, thinking about this **first, second, third or these field(s),** what crop did you plant on this field this year? **[DO NOT READ]**
    1 Barley
    2 Spring Wheat
    3 Durum Wheat
    4 Canola
    5 Peas/lentils/beans/chickpeas
    6 Oats
    7 Forage/grass
    8 Other (specify)
    9 None/summerfallow
    88 Don't know
    99 Refused

42. How many operations of each of these two types were preformed on this (these) field(s) specifically to control volunteer canola? **[READ a-b]**
    a. Cultivation
    b. Harrowing

    1 Specify #
    88 Don't know
    99 Refused

43. How many acres was(were) this (these) field(s)?
    1 Specify # of acres
    88 Don't know
    99 Refused

44. What do you estimate the per acre cost of this (these) operations to be for this (these) field(s), including labor, equipment and fuel costs?
    1 Specify $/acre
    88 Don't know
    99 Refused

Section 6: Incremental Tillage Operations on Other Fields

45. In 2004 did you perform any cultivations or harrowing operations specifically to control volunteer canola on fields NOT planted to canola in 2003?
    1 Yes
    2 No **[SKIP TO Q 51]**
    88 Don't know **[SKIP TO Q 51]**
    99 Refused **[SKIP TO Q 51]**

46. How many fields?
    1 Specify # fields
    88 Don't know
    99 Refused

IF MORE THAN 3 FIELDS – SAY "I'M JUST GOING TO ASK YOU ABOUT 3 OF THESE FIELDS – PLEASE THINK ABOUT 3 THAT YOU BELIEVE ARE MOST REPRESENTATIVE"

[REPEAT SERIES Q47-50 FOR EACH FIELD – MAXIMUM 3]

47. How many operations… (on field one, two, three)?
    1 Specify # operations
    88 Don't know
    99 Refused

48. How many acres?
    1 Specify # acres
    88 Don't know
    99 Refused

49. What do you believe to be the source of this volunteer canola? In other words, where did it come from? **[MULTIPLE RESPONSES – DO NOT READ]**
    1 Neighboring field
    2 Carry over from canola planted on field 2002 or earlier
    3 Contaminated seed
    4 Spread by equipment/trucks etc.
    88 Can't tell/Don't know
    99 Refused

50. What type or system do you believe this volunteer canola was from? **[MULTIPLE RESPONSES – DO NOT READ - IF DON'T KNOW PROBE FOR HERBICIDE TOLERANT OR CONVENTIONAL]**
    1 Conventional
    2 Liberty Link or InVigor System (Tolerant to Liberty herbicide)
    3 Roundup Ready System (Herbicide tolerant)
    4 Clearfield or SMART Trait System (Tolerant to Odyssey and Pursuit herbicides)
    5 Any herbicide tolerant (not specified)
    88 Don't know
    99 Refused

Section 7: Sanitation

51. **[IF HT CANOLA IN Q6, CODES 2-6]** For each of the following types of equipment, are your cleaning procedures the same, greater or less when moving from a field on which herbicide tolerant canola was planted versus moving from a field where conventional canola was planted? **[READ a - c]**

    a. Seeders
    b. Tillage equipment including cultivators, harrowers, discs etc
    c. Harvesters, swathers or grain handling trucks

    1 Greater
    2 Less
    3 Same
    4 Not applicable
    88 Don't know
    99 Refused

Section 8: Impact on Subsequent Crop

52. Thinking back over the past five years, have you changed your crop rotation on fields following canola because of the specific canola system planted the year before? **[IF YES]** Please describe the canola system, the crop that would have been planted and the crop that was planted and why you made this change.
    1 Specify
    2 No
    88 Don't know
    99 Refused

53. Has the presence of volunteer canola ever caused you a yield, grade or dockage loss to the crop following canola?
    1 Yes
    2 No **[SKIP TO Q 58]**
    88 Don't know **[SKIP TO Q 58]**
    99 Refused **[SKIP TO Q 58]**

54. Which crops were affected? **[MULTIPLE RESPONSES – DO NOT READ]**
    1 Barley
    2 Spring Wheat
    3 Durum Wheat
    4 Canola
    5 Peas/lentils/beans/chickpeas
    6 Oats
    7 Forage/grass
    8 Other (specify)
    88 Don't know
    99 Refused

55. What type or system do you believe this volunteer canola was from? **[MULTIPLE RESPONSES – DO NOT READ]**
    1 Conventional
    2 Liberty Link or InVigor System (Tolerant to Liberty herbicide)
    3 Roundup Ready System (Herbicide tolerant)
    4 Clearfield or SMART Trait System (Tolerant to Odyssey and Pursuit herbicides)
    5 Any herbicide tolerant (not specified)
    88 Don't know
    99 Refused

56. In this/these case(s), did you practice any control measures to minimize the loss?
    1 Yes – all
    2 Some yes/some no
    3 All no
    88 Don't know
    99 Refused

57. In relative terms, has the annual loss increased, decreased or remained unchanged over the past five years? **[PROBE FOR TREND]**
    1 Increased
    2 Decreased
    3 Unchanged
    88 Don't know
    99 Refused

58. **[IF ANY ACRES IN Q3, b, c or d]** Do you feel you realized a carry-over benefit in terms of fewer weeds of any type or easier weed control in your 2004 crop that followed the herbicide tolerant canola planted in 2003?
    1 Yes
    2 No **[SKIP TO Q 60]**
    88 Don't know **[SKIP TO Q 60]**
    99 Refused **[SKIP TO Q 60]**

59. Can you put an average per acre dollar value on this benefit – considering both weed control savings and/or improved revenue from your crop?
    1 Specify $/acre
    2 No dollar benefit realized
    88 Don't know
    99 Refused

60. **[IF NO TO CLEARFIELD IN Q3 AND CODES 2-6 in Q6]** Have you grown Clearfield canola within the past 5 years?
    1 Yes
    2 No **[SKIP TO Q 62]**
    88 Don't know **[SKIP TO Q 62]**
    99 Refused **[SKIP TO Q 62]**

61. **[IF YES TO CLEARFIELD IN Q3 or Q60]** Have you ever experienced herbicide injury in a crop planted on a field following Clearfield that resulted in an economic loss? This would have been due to carry over of Odyssey or Pursuit herbicides.
    1 Yes
    2 No
    88 Don't know
    99 Refused

Section 9: Conclusion

62. **[IF CONVENTIONAL GROWN IN Q 3]** What was the average per acre profit, after all input expenses including labor and operating expense on equipment that you realized from your conventional canola crop in 2003?
    1 Specify $/acre
    88 Don't know
    99 Refused

63. **[IF ROUNDUP READY GROWN IN Q 3]** What was the average per acre profit, after all input expenses including labor and operating expense on equipment that you realized from your Roundup Ready canola crop in 2003?
    1 Specify $/acre
    88 Don't know
    99 Refused

64. **[IF LIBERTY GROWN IN Q 3]** What was the average per acre profit, after all input expenses including labor and operating expense on equipment that you realized from your Liberty canola crop in 2003?
    1 Specify $/acre
    88 Don't know
    99 Refused

65. **[IF CLEARFIELD GROWN IN Q 3]** What was the average per acre profit, after all input expenses including labor and operating expense on equipment that you realized from your Clearfield canola crop in 2003?
    1 Specify $/acre
    88 Don't know
    99 Refused

66. All things considered, including subsequent volunteer control, do you think the benefits of growing herbicide tolerant canola are greater than, less than or the same as the benefits of growing conventional varieties on your farm?
    1 Greater **[SKIP TO Q 68]**
    2 Less
    3 Same **[SKIP TO Q 68]**
    4 Depends on growing conditions that year **[SKIP TO Q 68]**
    88 Don't know **[SKIP TO Q 68]**
    99 Refused **[SKIP TO Q 68]**

67. **[IF LESS]** Why do you think the overall benefits growing herbicide tolerant canola are less than the benefits of conventional?
    1 Specify
    88 Don't know
    99 Refused

68. Just for classification purposes, what town is closest to your farming operation?
    1 Specify
    88 Don't know
    99 Refused

Thank you very much for your time and co-operation! Results of this study will assist the Canola Council of Canada in their efforts to provide information to stakeholders that reflects grower's attitudes and farming practices.