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FORUM PAPER

A Canadian national survey on the public perception of biological control

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Abstract A professionally designed telephone survey was conducted, for the first time in any country, to determine the perception of Canadians to the use of biocontrol as a means of pest management. While only 55% of those contacted considered themselves well versed in biological control, over 80% were interested in the environment and nutrition. Women expressed more concern about food safety than men, while people less than 24 and more than 65 years old were the less concerned. The test group clearly believed that foods produced organically or using biocontrol were safer than those using synthetic insecticides. The survey clearly shows that while biological control is preferred over pesticides, there is still a need to "educate" the general public on biological pest management. It would be of interest to have similar surveys carried out in both developed and developing countries, and also to see whether biocontrol is seen in a more positive light in developed countries where genetically modified plants are not as widely used as in Canada.

Keywords Biological control · Pesticides · Survey · Risk perception · Public attitude · Food · Environment

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Introduction

While pesticides are still a significant component of many control programs, their negative environmental and health impacts have stimulated research to develop alternate pest management strategies, such as biological control. Some remarkable early successes for both the control of insect pests and weeds (e.g. the cottony cushion scale *Icerya purchasi* (Maskell) by the vedalia beetle *Rodolia cardinalis* (Mulsant) in California; the prickly pear cactus *Opuntia stricta* (Haw.) by the moth *Catoblastis cactorum* (Berg) in Australia) certainly were an

impetus for further research in this field. Although the levels of success have been variable, biological control is still considered as an important means of pest control, either alone or as component of integrated management programs (see Jervis 2005; Wajnberg et al. 2007, and references therein).

It is clear that for any management approach to be successful, it must not only be economically viable for users but must also, on a much broader scale, be acceptable to the general public (Finucane 2002; Knight and Warland 2004). At this sociological level concerns may range from potential dangers for human health to possible undesirable ecological consequences following the implementation of any given management strategy, as well as the perceived reliability of the sources of information provided (Rosati and Saba 2004).

The introduction of biological control agents has generally not elicited a strong positive or negative public reaction. However, the recent population explosions of Asian lady beetles *Harmonia axyridis* (Pallas) in North America and Europe have drawn public attention to a case of "a good insect gone bad" (Roy and Wajnberg 2008). The formation of large aggregations of overwintering beetles within buildings has been the main reason for so much "press" in the public forum. When confronted with high densities of insects in its homes or places of work, the general public is less impressed with *H. axyridis*' record as an effective biological control agent, and is more concerned about removing the "pestiferous" adults (that reflex bleed, and occasionally bite, when disturbed) each fall and spring. While this is rather an exceptional case, it has resulted in questions about the wisdom of introductions that could have such direct negative impacts on humans.

In this paper we present the general findings of a Canada-wide survey, carried out under the auspices of the Biocontrol Network, a Canadian research and development organisation, to determine how the Canadian public perceived biological control as an alternative to the use of synthetic pesticides for pest control. The questionnaire was developed within a "how consumers perceived risk as it relates to food" framework, given that many biological control agents are used in agro-ecosystems. The approach of perceived risk was deemed appropriate given the diversity of opinions concerning the use of genetically modified (GM) plants to reduce herbicide and insecticide use in certain agricultural crops, and public concerns about GM products being used in foods (Royal Society of Canada 2001).

Materials and methods

Initially, three possible approaches were discussed: face-to-face meetings with small groups, a mail survey or a telephone survey. While interactive face-to-face meetings allow for intense interaction between participants, they are extremely costly. Consequently, in light of a limited budget, we decided against this approach because the number of people we could survey in a country the size of Canada would have been too limited to draw valid conclusions. Mail surveys are inexpensive and would have allowed to cover the entire country, but the return rate on such a passive approach is generally very low. Therefore, for cost effectiveness reasons, a telephone survey was conducted on a random sample of Canadians, so that 1000 respondents who responded to the entire questionnaire could be retained. Such a sample size gives reliable results 19 out of 20 times (or 95% of the time), with a confidence interval of 3.1%. This corresponds to the fraction of 31 out of 1000 respondents supporting reliably the statements of the survey (i.e., 1.96 times 15.8, the standard deviation of the normal distribution of 1000 samples, with 95% of the area under the bell-shaped curve being between ± 1.96 SD).

Construction of the questionnaire

There was an initial discussion, involving social scientists and researchers in the field of biological control, about the kind of information the Biocontrol Network would like to obtain from an independent survey. Once this framework was established the project was given to a social science and ethology consultant, with expertise in conducting surveys dealing with environmental and ethical issues. The consultant developed a causal model (Fig. 1), based on attitude perception of risk (Wilkinson 2001) that was used to develop the questionnaire (Appendix 1).

Survey

The telephone survey was conducted by Legendre Lubawin Marketing Inc., Montreal (Quebec) Canada,

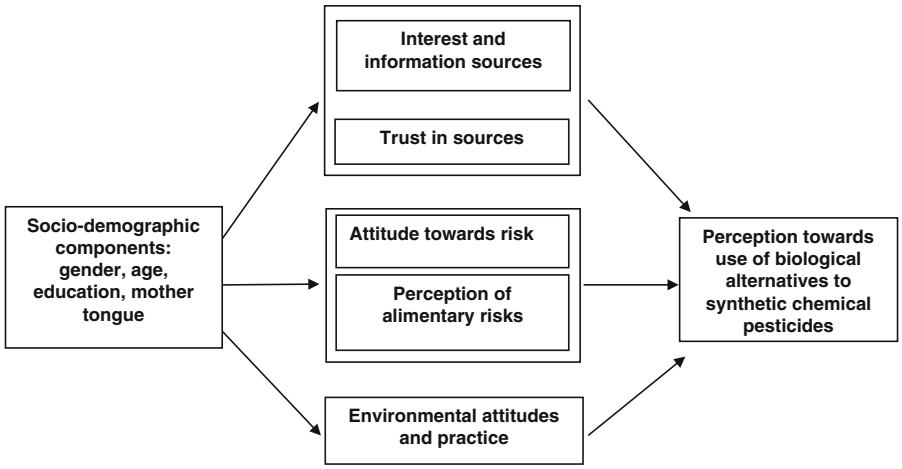

Fig. 1 Causal model used to design the questionnaire to evaluate the perception of Canadians about the use of biological control for pest management in food production

a company that specializes in such polls. The survey was conducted between the 21st of January and 14th of February, 2005, following a trial period, during which the consultant monitored the process on-line. The telephone numbers were generated and dialed by computer. The personnel conducting the survey were perfectly bilingual in French and English, the two official languages of Canada. It took a total of 16,885 calls to provide the sample of 1000 individuals who responded to the entire questionnaire and from which a valid subsample of 967 respondents was retained for statistical analysis. The other calls were either unsuccessful (no answer, busy line, answering service, no service, business line, fax line, etc.) or the responses could not be used for a variety of reasons that included respondents refusing to participate, being busy and requesting to be called back, the interview being interrupted, and linguistic problems.

Data analysis

The raw data was collected and organized by the survey firm, before being adjusted to account for the population distribution in Canada. This was done using demographic data from the 2001 national census (Statistics Canada, Government of Canada, Ottawa, Ontario, K1A 0T6, http://www12.statcan.ca/english/census01/home/index.cfm) on population (total of 31,842,800 individuals in Canada), gender, age, education and mother tongue in each of the principal region of Canada: the Maritimes provinces (a total of 85 respondents were retained in Newfoundland and Labrador, Nova Scotia, Prince Edward Island and New Brunswick for a total population of 2,343,300), Quebec (292 respondents for a total population of 7,542,800), Ontario (326 respondents for a total population of 12,392,700), the Prairies provinces (a total of 159 respondents in Manitoba, Saskatchewan and Alberta for a total population of 5,367,600) and British Columbia (105 respondents for a total population of 4,196,400). The sparsely populated regions of Northern Canada (Nunavut, Yukon and the Northwest Territories) were not surveyed. Thus, to adjust for the disparity in regional population, each respondent in each region was given a weight equal to the ratio of the region's population over Canada's population times the ratio of the total number of valid respondents (i.e., 967) over that of the region. The same approach was used, when relevant, to account for gender, age, education and mother tongue distributions across the country. Analyses (frequency, cross tables and analysis of variance (ANOVA)) were then performed using the SPSS software (ver. 13, SPSS Inc., Chicago, IL, USA). In particular, a factorial analysis was conducted on an attitudinal scale (Question 8 of questionnaire), adapted from Finucane (2002) and Rosati and Saba (2004), attributing to each respondent a factorial score for the perceived risk associated with food. ANOVA was used to detect significant

differences among categories of respondents. Plotted data on Figs. 3, 4 and 5 represent the means ± standard errors of the mean (SEM) and standard errors (SE) are given on Figs. 2, 6, 7, 8, 9 and 10.

Results

While only 60% of the individuals completing the questionnaire stated they were interested in general issues of science and technology, over 80% expressed an interest for both environmental issues and those relating to nutrition. Fifty-five percent of all respondents considered themselves informed about the concepts or principles of biological control (Fig. 2), but this ranged from 34 to 76% between provinces. While men and women were equally represented in the survey (48.5% vs. 51.5%), the latter group ranked the perceived risk associated with food significantly higher, as demonstrated by the values of the scores (-0.25 ± 0.06 for men versus 0.11 ± 0.04 for women, means ± SEM) derived from principal component factorial analysis of the responses given to Questions 11a to 11h, 12b, 12c, 12e, 12f and 19 of the survey questionnaire (ANOVA with N = 967 (men = 469; women = 498), $F_{1, 965} = 26.55$, $P < 0.001$).

Furthermore, there was a significant age effect, with the youngest and oldest groups being less concerned about food related risks (Fig. 3). This age specific trend was present, though not always

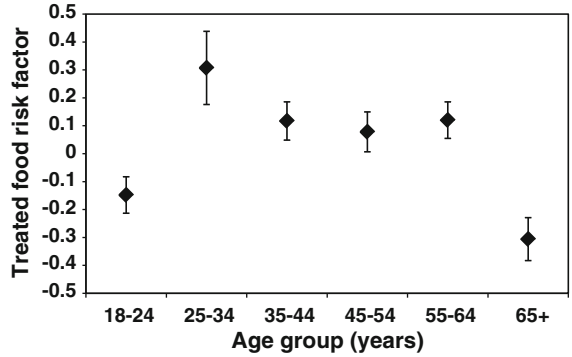

Fig. 3 Effect of age on the perceived risk associated to the consumption of processed foods. The scores derived from principal component factorial analysis of the responses given to Questions 10d to 10f, 10h, 12b, 12e, 12f and 14 of the survey questionnaire were analysed using ANOVA (N = 901 (age 18–24 = 116; age 25–34 = 110; age 35–44 = 148; age 45–54 = 171; age 55–64 = 154; age 65 and over = 203), $F_{5, 895} = 7.81$, $P < 0.001$). The y axis represents the range of factorial scores and the values presented are the means ± SEM

significant, in all aspects of the survey. In addition, there was a direct relationship between individuals' support for the use of biological control as a means of controlling pest problems and (a) their level of perceived risk associated with food sources (Fig. 4) or (b) their level of education (Fig. 5).

It is clear that the test group discriminated in the levels of perceived risk associated with a number of frequently discussed subjects (Fig. 6), as well as those specifically related to food quality (Fig. 7). When

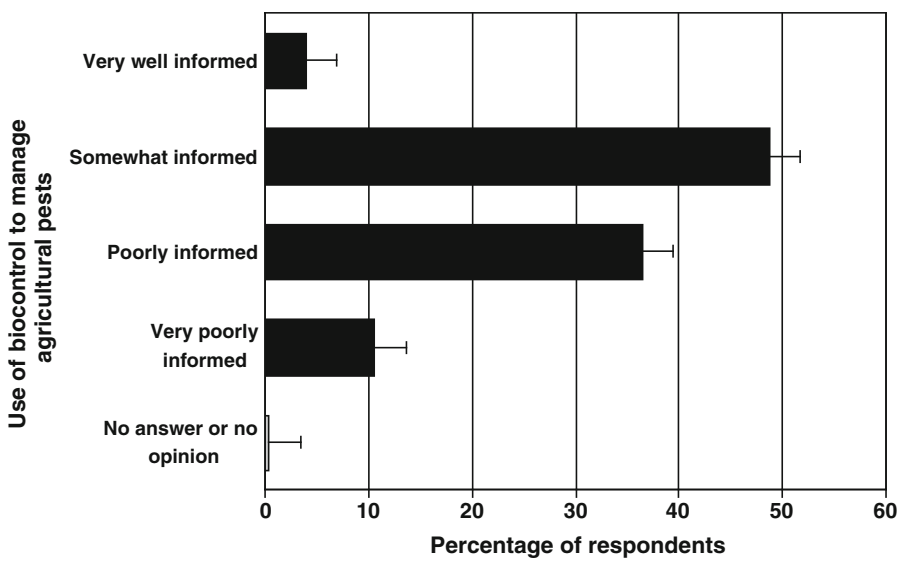

Fig. 2 Level of self-assessed understanding about the concepts of biological control based on the responses to Question 10 of the survey questionnaire. N = 967, error bars are standard errors (SE)

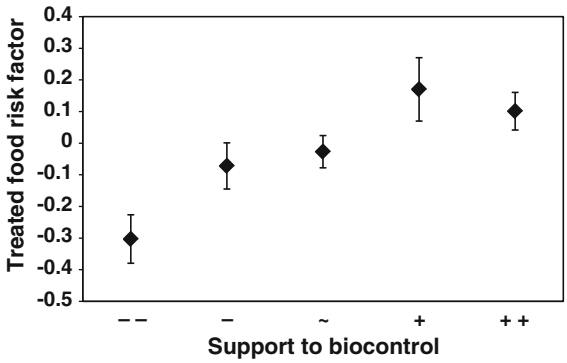

Fig. 4 Relationship between the perceived risk of consuming treated food and support to biocontrol (− − being the least and ++ being the most favourable) with respect to the use of biological control as a means of controlling pests in agriculture. The scores derived from principal component factorial analysis of the responses given to Questions 8a to 8f, 10, 11a to 11f, 12a and 12c to 12f of the survey questionnaire were analysed using ANOVA (N = 646 (− −, 117 respondents; −, 121 respondents; ~, 128 respondents; +, 150 respondents; ++, 130 respondents), $F_{4, 641} = 5.65$, $P < 0.001$). The x axis is an additive scale based on the five subgroups of respondents defined by their level of support to biocontrol, while the y axis represents the range of factorial scores and the values presented are the means ± SEM

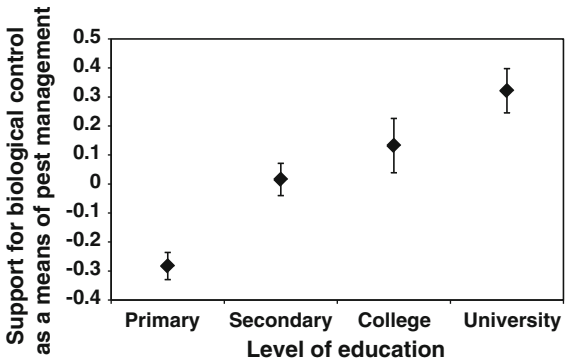

Fig. 5 Effect of the level of education on the support for biological control as a means of pest management. The scores derived from principal component factorial analysis of the responses given to Questions 11a to 11h and 15 of the survey questionnaire were analysed using ANOVA (N = 944 (Primary = 287; Secondary = 333; College = 145; University = 179), $F_{3, 940} = 15.47$, $P < 0.001$). The y axis represents the range of factorial scores and the values presented are the means ± SEM

Canadians were asked about various means for controlling pests from the perspective of food safety, there were markedly different levels of perceived risk, with organic farming and biological control being seen as significantly safer than synthetic chemical pesticides (Fig. 8). While nearly 25% of individuals questioned considered that biological control would be more harmful to the environment than insecticides (Fig. 9), the vast majority felt that there would be less risk associated with consuming food when biological control agents, rather than synthetic chemical means, were used to control pests (Fig. 10).

Discussion

The results of this national survey clearly show that, within the broad frameworks of environmental concerns and perceived health risks, Canadians generally consider biological control agents as a safer, acceptable alternative to traditional pesticides for the production of food crops.

More than 70% of the people questioned indicated they would prefer to buy food produced when farmers had used biological control agents rather than insecticides to control pests. However, 45% expressed concern about eating such food, if the question included "beneficial microbes" as an example of a biological control agent. One possible reason may be an association between the term "microbe" with contamination of food products or human health problems, or both. However, in all cases, the public perceived a significantly lower risk associated with the consumption of foods treated with any form of biological control than those treated with synthetic chemical pesticides. Less than half of the people questioned said they would be willing to pay more for such products, and over 80% of the respondents thought that food products should be labelled if biological control was used in the pest management programme.

There were two, somewhat unexpected but interesting, findings of this study. The first was that younger (less than 25 years old) Canadians appeared to be less concerned about food related risks and thus were less interested in biological control. We are unable to state that these reflect "I am young and invincible" and "too late to worry" attitudes, as this may be the result of a small sample size, for while there were a 1000 people surveyed, specific subgroups (such as age, geographic region) may not be sufficiently represented to draw valid conclusions. However, if true, then presentations on the subject

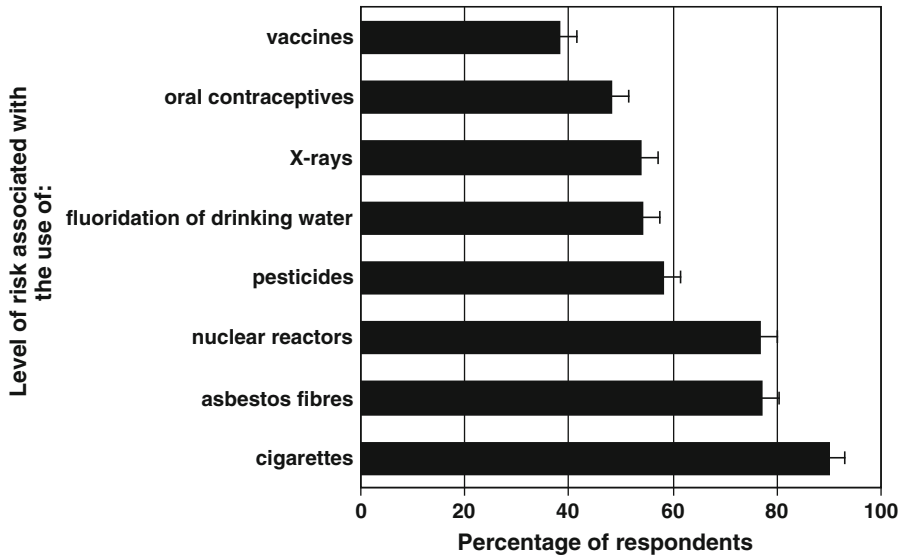

Fig. 6 Level of perceived risk associated with different factors that might be commonly encountered by members of the general public (Questions 4a to 4h of survey questionnaire). N = 967 (vaccines = 911; oral contraceptives = 819; X-rays = 905; fluoridation = 886; pesticides = 941; nuclear reactors = 917; asbestos fibres = 876; cigarettes = 963), error bars are SE

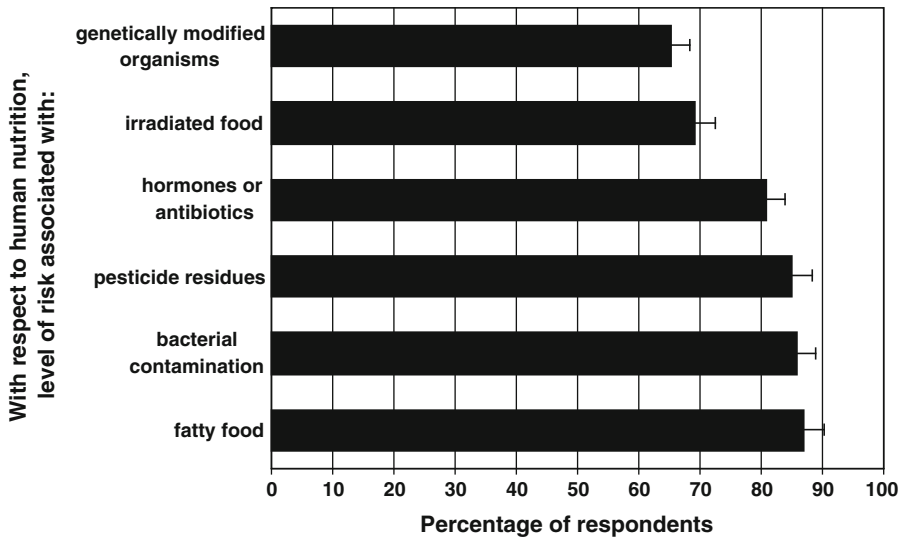

Fig. 7 Level of perceived risk associated with different factors that might affect food quality (Questions 8a to 8f of survey questionnaire). N = 967. Number of respondents considering the risks to be important or very important: genetically modified organisms = 631; irradiated food = 670; hormones or antibiotics = 782; pesticide residues = 822; bacterial contamination = 829; fatty food = 842, error bars are SE

targeting school-age children would be an effective approach to reach this sector of the population. The second finding was that the individuals polled felt there were lower risks associated with consuming food produced using GM plants that those treated with pesticides.

The potential negative impact of introduced biological control agents has been recognised for some time (Howarth 1991) and since this survey a number of specific entomological cases have been documented. For example, the Asian lady beetle has impacted negatively on indigenous species of lady beetles (Lucas et al. 2007; Roy and Wajnberg 2008) and the parasitoid *Compsilura concinnata* (Meigen), introduced repeatedly in the last 50 years as a biological control agent for more than ten different North American forest pest species, has affected native giant silk moth populations (Boettner et al. 2000; Kellogg et al. 2003). The results of our study also show that the public has a number of misconceptions about biological control and we believe that these findings underline the need for practitioners to

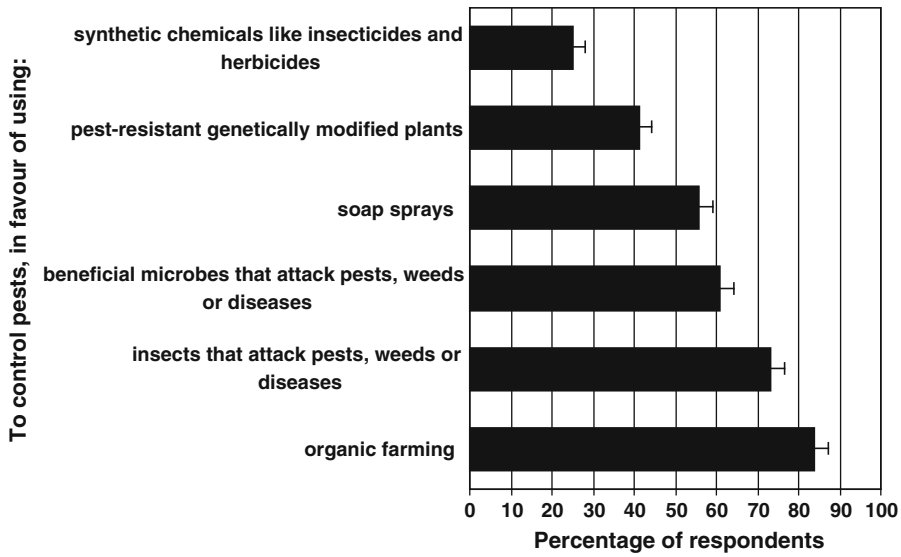

Fig. 8 Proportion of those interviewed expressing support for different means of managing pest species on consumable crops (Questions 9a to 9f of survey questionnaire). N = 967. Number of respondents being somewhat or totally in favour of: synthetic pesticides = 242; genetically modified plants = 397; soap sprays = 541; beneficial microbes = 589; beneficial insects = 709; organic farming = 813, error bars are SE

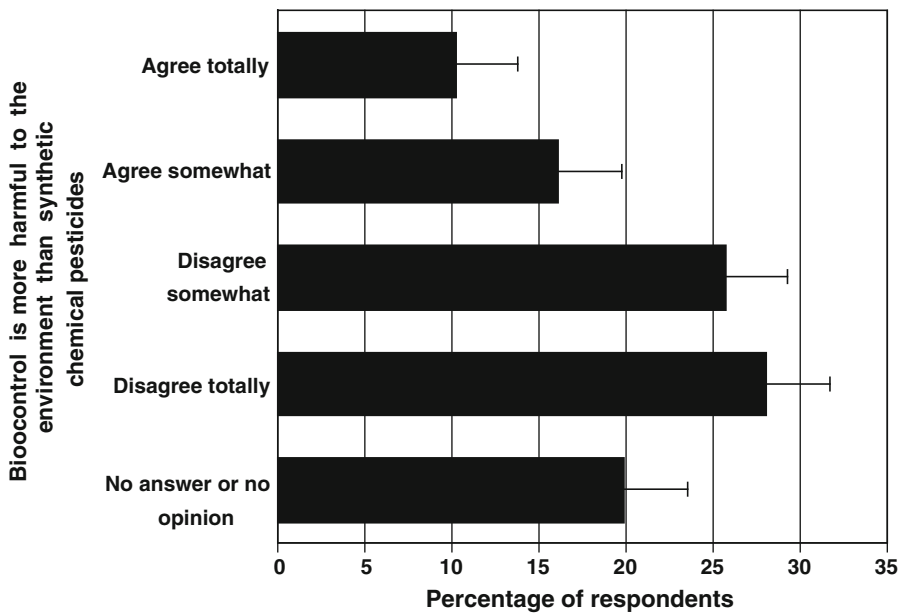

Fig. 9 Proportion of Canadians interviewed who believed that biological control would be more damaging to the environment than synthetic chemical pesticides (Question 11b of survey questionnaire). N = 967 (agree totally = 98; agree somewhat = 156; disagree somewhat = 249; disagree totally = 272; no answer or no opinion = 192), error bars are SE

undertake the appropriate outreach activities to ensure that the general public understands the strengths, as well as the limitations, of such an approach for pest management. We do not think that openly discussing the costs and benefits would hurt the implementation of biological control, as this management approach generally fares well when compared with the cost/benefit scenarios of conventional pesticide use.

We believe that it would be very interesting to carry out similar surveys in other developed, as well as in some developing countries. It would be particularly instructive to include at least one European country where the use of GM plants in crop production is more hotly contested than in Canada, as one would predict a higher approval for the use of biological control agents than observed in the current survey.

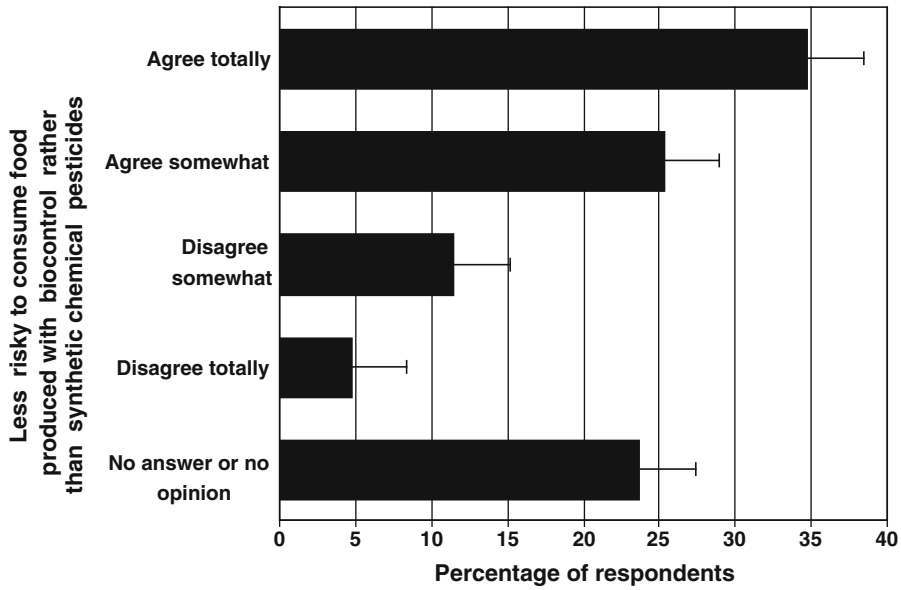

Fig. 10 Proportion of people interviewed who believed that it would be less harmful to eat produce if biological control had been used for pest management instead of synthetic chemical pesticides (Question 11c of survey questionnaire). N = 967 (agree totally = 336; agree somewhat = 245; disagree somewhat = 112; disagree totally = 46; no answer or no opinion = 229), error bars are SE

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Appendix 1: Questionnaire

1. Would you tell me if the following subjects interest you a lot, somewhat, a little, or not at all:
   a. Nutrition
   b. Economic issues
   c. Health issues
   d. Science and technology
   e. Environmental issues (the quality of our environment)
2. To keep yourself informed do you use the following media a lot, somewhat, a little or not at all:
   a. The written media (papers and/or periodicals)
   b. Electronic media (television and/or radio)
   c. The internet
3. Do you have a lot, some, little, or no confidence in the following sources to provide reliable information on societal issues:
   a. Different levels of government
   b. Environmental organisations
   c. Journalists
   d. Consumer associations
   e. Scientific and technological experts
4. Do you consider the risk associated with the use of the following products to be very high, reasonably high, not so high or really not high:
   a. Asbestos fibers
   b. Nuclear reactors
   c. Fluoridation of drinking water
   d. X rays
   e. Pesticides
   f. Oral contraceptives
   g. Vaccines
   h. Tobacco
5. Where do you buy most of the fruits and vegetables that you eat:
   a. At a supermarket
   b. At a smaller grocery store
   c. At a greengrocer (a fruit and vegetable store)
   d. At a health food store
   e. At a local public market
   f. None of the above/Other/Does not buy fruits and vegetables
6. And in the summer do they generally come from:

a. A community garden
b. Your own garden
c. None of the above/Other/Does not buy fruits and vegetables

7. Do you agree totally, agree somewhat, disagree somewhat, or disagree totally with the following opinions:

a. The environment is one of the most important issues facing society today
b. We should pay a significant amount of money to preserve our environment
c. Strict global measures must be taken immediately to halt environmental decline
d. Personally, I cannot help to slow down environmental deterioration
e. The benefits of overcoming environmental deterioration are not sufficient to warrant the expense involved
f. The importance of the environment is frequently exaggerated

8. Do you consider the risks associated with the following products to be very important, somewhat important, of minor importance or of no importance with respect to human nutrition:

a. Genetically modified organisms
b. Irradiated food
c. Pesticide residues
d. Bacterial contamination
e. Hormones or antibiotics
f. Fatty foods

9. Are you totally in favour, somewhat in favour, somewhat against or totally against using the following means of controlling pests (insects, diseases or weeds) that attack food crops:

a. Organic farming
b. Insects that attack various pest populations, weeds or disease
c. Beneficial microbes that attack various pest populations, weeds or disease
d. Soap sprays
e. Synthetic chemicals like insecticides and herbicides
f. Plants that have been genetically modified for resistance to insects, diseases or weeds
g. Mechanical means that reduce the probability that pest populations will increase

10. Do you consider yourself to be very well informed, somewhat informed, poorly informed, or very poorly informed on the use of insects and microbes, known as biological agents, to control agricultural pests (insects, diseases or weeds)?

11. Do you agree totally, agree somewhat, disagree somewhat, or disagree totally with the following opinions:

a. The use of biological agents for pest control is better than the use of synthetic chemical pesticides
b. The use of biological agents for pest control would be more harmful to the environment than the use of synthetic chemical pesticides
c. The risk of food being contaminated is less when biological agents for pest control are used rather than synthetic chemical pesticides
d. The higher costs associated with the use of biological agents for pest control does not justify their use instead of synthetic chemical pesticides
e. I would be wary of eating food where microbes had been used to control pests
f. I would rather buy food where the pests had been controlled using biological agents rather than synthetic chemical pesticides
g. I would not be willing to pay more for products where the pests had been controlled using biological agents rather than synthetic chemical pesticides
h. Special labelling should be used to inform consumers that biological agents were used to control pests of produce they are buying

12. Would you fully trust, trust somewhat, distrust somewhat, or totally distrust the following groups to supervise pest control with biological agents:

a. Government agencies
b. Pharmaceutical companies
c. Agricultural producers
d. Scientific experts from University and public laboratories
e. Environmental groups
f. Consumer associations

13. Are you a member of, or do you participate in the activities of

a. A social club (e.g., the Optimists)
b. A sports/recreation organisation
c. A consumer association or environmental group
d. A cultural or artistic organisation (e.g., choir)
e. A religious group
f. A political party or movement

14. In what year were you born?
15. What is the highest level of education you completed:

a. Primary
b. Secondary
c. College
d. University

16. What is your mother tongue (e.g., the first one you learned and still speak):

a. English
b. French
c. Other

17. During the last year have you mainly worked:

a. Full time
b. Part time

or have you been:

c. Looking for a job
d. In school
e. Running a household
f. Retired
g. Not working by choice/Other/Refused to answer

18. Postal code
19. Sex of respondent

a. male
b. female

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R. Laprade is a biophysicists working on pore-forming bacterial toxins. Together with J.-L. Schwartz he founded and led the Biocontrol Network regrouping 60 Canadian scientists, which aims at reducing the use of chemical pesticides by designing strategies based on natural enemies of insect pests and diseases.

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