The Promise of Biological Control for Sustainable Agriculture: a Stakeholder-Based Analysis

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Executive Summary
The agricultural pest control method known as biocontrol has been considered among the most promising technologies for sustainable agriculture: it reduces the reliance on synthetic pesticides, minimizes the negative impact on the environment and improves workers safety while at the same time maintaining the economic viability of crop production. Yet the global rate of biocontrol adoption as compared to conventional pesticide-based methods has remained marginal. This paper seeks to identify the existing barriers to a greater reliance on biocontrol methods in the agricultural system. To this end, it offers a stakeholder-based analysis conducted in British Columbia, Canada. The paper concludes that obstacles to a greater adoption of biocontrol faced by growers working in greenhouses are different from those experienced by growers working in open field horticultural systems. It also provides policy-related recommendations on how to increase the adoption of this environmentally-sensitive technology.

I. Introduction

The agricultural pest control method known as biocontrol, or "bug vs. "bug," has been considered among the most viable alternatives to the excessive use of chemical pesticides in agricultural systems, widely criticized since Rachel Carson's "Silent Spring" (1962) for their damaging impact on human health and the environment. Working via the deliberate introduction of the natural enemies of crop pests such as micro-organisms and insect predators, biocontrol occupies a unique niche as a flexible alternative to conventional pesticide-reliant techniques as well as stringent organic agriculture (UNDP, 1995; Gliessman, Engels and Krieger, 2007; Warner, 2007; Ehlers, 2011). Moreover, some agroecologists have argued that under certain conditions biocontrol is a superior approach to chemical control in terms of long-term productivity and economic competitiveness (Altieri, 1995; Gutt & Wratten, 2000). In addition, a growing consumer preference for pesticide-free agricultural products has created new incentives for some farmers to switch from synthetic pesticides to biocontrol methods (Dent, 2005; Altieri, 1995). Yet despite these considerable advantages, the global rate of reliance on biocontrol agents as the prime pest control method remains relatively insignificant, comprising only one to three percent of the worldwide annual turnover of plant protection products (Guillion, 2004; Ehlers, 2009; Ehlers, 2011).

What are the existing barriers to a wider adoption of the biocontrol methods in agricultural systems? And who are the most relevant stakeholders potentially interested in advancing a greater adoption of this very promising environmentally friendly technology? To address these questions, the paper offers an overview of various stakeholder positions in regards to a greater adoption of biological control in British Columbia, Canada. Several common obstacles to a wider adoption of biocontrol will be identified: 1) the low levels of investment in research and development (R&D) for improving biocontrol agents, 2) the lack of coordination among growers in adopting this method, 3) the weak or conflicting regulatory framework, and 4) the absence of market incentives such as consistent food labelling around biocontrol accompanied by consumer awareness about the advantages of this method.

The paper will also demonstrate that the obstacles faced by growers working with biocontrol agents (BCAs) in greenhouses are different from those experienced by farmers working in open fields.

In greenhouses: For greenhouse use, the potential of a wider application of biocontrol lies in creating a greater consumer awareness of the merits of this method accompanied by an increased consumer willingness to pay an extra premium for products produced without the use of synthetic pesticides (or with a very limited amount of them). Creating a certified label around biocontrol has the potential to deliver this objective, although it implies significant investment in consumer awareness campaigns. Another key factor for increasing the productivity of biocontrol-based methods in greenhouses is the creation of more stable populations of biocontrol agents, which requires additional significant investments in R&D.

In the open field: Although greenhouses are the dominant users of biocontrol agents, examples do exist of the successful implementation of biocontrol methods in open field horticulture. The main obstacle to a wider application of biocontrol in the open field, however, is a lack of coordination between agricultural growers and within the landscape industry (also potential users of biocontrol agents) to collectively reduce their reliance on chemical pesticides and thus prevent the damage from pesticide drifts to beneficial biological agents. Negative externalities such as pesticide drifts from neighbouring fields discourage the independent adoption of biocontrol methods. Similarly, the lack of standardization in the landscape profession also drives landscape practices "to the bottom," avoiding more expensive, knowledge-intensive biocontrol-based pest management techniques in favour of cheaper and simpler pesticide-control methods.

The paper is organized into three sections. It begins with an overview of the global biocontrol industry and the existing international, national and provincial regulatory framework around it. It then turns to a multi-stakeholder analysis conducted in British Columbia where the presence of growers relying on biocontrol agents is considerable. Finally, the paper concludes with a set of recommendations aimed at improving the adoption of biocontrol methods in mainstream agriculture.

II. Background and regulatory context

Driving forces and enabling factors

Integrated Pest Management (IPM), with biocontrol being its core component, emerged as early as the 1950s in response to problems caused by the commercial use of synthetic chemical pesticides in irrigated agricultural systems, which had an adverse impact on human and environmental health (Carson, 1962, Kishi, 2005, Relyea, 2005, IAASTD, 2009). It prompted many growers worldwide to turn to biocontrol methods, used for millennia in traditional agricultural systems, while at the same time retaining the need to maintain the economic viability of crop production as their top priority (Warner, 2007). Perhaps the most consequential difference between conventional pesticide-reliant methods and biocontrol-based methods for growers is the high reliance of the latter on more specialized knowledge: introducing biological control requires a careful monitoring the cycle of pests, knowing when to release biocontrol agents, what volume to release, which drives the costs of this method up due to the required specialized professional training and expertise and a labour intensive pest control process. Also, the cost of the production of the biological control agents is higher compared to the cost of chemical pesticides (Ehlers, 2011). These factors create significant economic obstacles for employing this more ecologically-sound method on a larger scale.

In 2009, the total market of the augmentative biocontrol industry was estimated at USD $200 – $260 million with the projection to grow to $350-$400 million by 2015 (FAO, 2009). More than 300 biocontrol agents (BCAs) are commercially available on the global market (Lester, 2009). The biggest markets for biological control agents are in the US (California, Hawaii), Canada (British Columbia), the EU (Spain and the Netherlands), Australia and New Zealand. Some countries have a very high reliance on BCAs: 90 percent of Dutch greenhouse vegetable production is under an IPM system, substantially higher than the five percent global average (Pilkington, 2009). Worldwide, the production of biocontrol agents for commercial use is concentrated in approximately 30 large companies, with two thirds of them located in the EU. However, the overall use of biocontrol is still very marginal representing around one to three percent of the worldwide annual turnover of plant protection products at end user prices of USD $588 million (Myers, 2004, Guillon, 2009; Ehlers, 2009).

International regulatory framework

Use of pesticide regulations

At the international level, the restriction of the use of chemical controls in horticulture is regulated by a number of policy instruments, including the 2001 Stockholm Convention on Persistent Organic Pollutants (POPs). A global treaty to protect human health and the environment from hazardous chemicals, the Stockholm Convention requires signatory parties to take measures to eliminate or reduce the release of POPs into the environment. Initially, twelve hazardous pesticides and industrial chemicals were identified to be banned and removed from use and production. Nine more chemicals were added to the list in 2009 (UNEP, 2009) and five more were under consideration in 2013 (UNEP, 2013). The Stockholm Convention highlights a growing international trend on limiting the use of persistent and damaging chemicals in industry and agriculture. As of April 2014, 179 parties ratified the Convention, including the EU and Canada, obligated to follow its provisions. Notably, the US remains among non-ratifying states.

Another major multilateral environmental treaty, the Convention on Biological Diversity (CBD), added recently a new level of international regulation relevant to the international biocontrol industry, under the Nagoya Protocol on Access and Benefit Sharing (ABS) adopted in 2010 and designed to regulate the movement of genetic resources across national borders. [1] Under the ABS Protocol, producers importing biocontrol agents may have to pay royalties to the indigenous peoples of the host countries if they claim these species (used as biocontrol agents in other countries) to be part of their traditional indigenous knowledge. Currently, many BCAs are freely exchanged between producers located in different parts of the world. Many producers and users of BCAs are concerned that the Nagoya Protocol on Benefit Sharing may negatively impact on this small industry (Cock, 2010). It is recommended that the free multilateral exchange of biocontrol agents for R&D continues and that patent laws do not apply to them.

Risk assessment, plant protection in agriculture and food safety standards

A number of international treaties, under the auspices of FAO, WHO, WTO, and UNEP, regulate the use of biological control at the international level. The International Plant Protection Convention (1997), or IPPC, is the main international document governing biological control agents (BCAs). The IPPC secures action to prevent the spread and introduction of pests and to promote appropriate measures for their control. The IPPC has linkages with the Convention on Biological Diversity (CBD).

The IPPC is governed by the Commission on Phytosanitary Measures, under the Food Agriculture Organization (FAO) of the United Nations, which adopts International Standards for Phytosanitary Measures. It is also closely linked with the Codex Alimentarius, "the Food Code," established and governed by the FAO and the World Health Organization (WHO). The FAO revises International Standards for Phytosanitary Measures (ISPM) and its guidelines the export, shipment, import, and release of mass-produced biological control agents and other beneficial organisms.[2] The FAO Guidelines for the Export, Shipment, Import and Release of Biological Control Agents and other Beneficial Organisms (2005) extends its range from classical biological control to inundative (i.e., mass-produced) biological control native natural enemies, micro-organisms and other beneficial organisms, and also includes guidelines for the evaluation of environmental impact (Hunt et al, 2008). Within the context of the World Trade Organization, the role of the IPPC is to encourage the international harmonization of food standards and to help ensure that phytosanitary measures are not used as unjustified barriers to trade. The Sanitary and

[1] As of April 2014, the ABS protocol has not entered into force yet, with only 29 parties of the Convention ratifying it. The Protocol will enter into force when ratified by 50 parties.

[2] FAO Guidelines for the Export, Shipment, Import and Release of Biological Control Agents and other beneficial Organisms, ISPM, No. 3, IPCC (IPCC 2005). A revised version of the original FAO Code of Conduct (IPCC, 1996), which extends its range from classical biological control to inundative biological control, native natural enemies, micro-organisms and other beneficial organisms including evaluation of environmental impact (Hunt et al, 2008).

Phytosanitary Agreement of the WTO permits countries to accept measures to protect the health of consumers, animals and plants, which implies that an importing country can reject another country's agricultural products if these products are believed to constitute a threat. National food safety measures are often set up in accordance to the FAO's Codex Alimentarius and SPS. However, some players may employ more precautionary standards, for example countries or regional trading blocks may impose stricter standards than the Codex guidelines, as has happened in the case of the Aflatoxin standards for imports to the European Union (EFSA, 2013).

Among regional organizations, the NAPPO (North American Plant Protection Organization) guidelines on host specificity and biological data serve as general parameters to which all parties, members of the regional trade block, NAFTA, Canada, the US, and Mexico, have to conform. Another point of international coordination pertaining to biocontrol is the existing or perceived threat of the invasion of exotic pests. Governments may impose restrictions on trade with an entire country even if only one region is affected by infestation, as preventing the introduction of an exotic species is the least costly method of protecting national ecosystems (Lichtenberg & Lynch, 2005).

<u>Rules for importations</u>

Shipment rules can also be a source of inefficiencies for the biocontrol industry delivering its products internationally. Thus tightening border control regulations between Canada and the US since 9/11 significantly increased the shipment time of biocontrol agents, a serious challenge for an industry in which freshness is vital. Applied Bionomics reported that it lost 30 percent of its business since 9/11 because of regulatory changes in border trade, which extended delivery time from 24-hours to a 2-day period (Biological Files, 2006). Biological control agent shipments from Canada to the US were treated as if they were shipments with dangerous species, and the producers were required to use packaging stickers labelled "contains plant pest or pathogens" which were seen by border control agents as exotic and potentially dangerous species (Biological Files, 2002). However, biological control industry representatives have sent a request to the North American Plant Protection Organization (NAPPO) to develop recommendations for US regulatory authorities on how to better handle trade in commercial biological control agents which, based on the history of their safe use, do not pose a significant threat of pest infestation, especially as compared to invasive species (Biological Files, 2006).

National regulatory frameworks

The variations in national approaches to regulating biocontrol are quite significant. The biggest regulatory obstacles to the introduction of new BCAs and the regulation of existing biocontrol agents are observed in the EU (Hunt et al, 2008), whereas the Australian and New Zealand regulation systems are reported to be the most clearly defined systems for the introduction of both arthropod and weed biocontrol agents (Messing & Wright, 2005).

<u>Plant protection products regulations</u>

Because plant protection products (PPP), including synthetic pesticides, can be harmful for people and the environment, their usage is regulated by governmental authorities and is based on risk assessment criteria. The process of regulatory approval of new products can be lengthy and expensive, thus the initial time and financial investment in developing new PPP is significant and favours large players with greater resources. Moreover, risk assessment approaches in some jurisdictions (e.g., the EU) treat biocontrol agents on par with synthetic chemicals, even though the former poses a substantially greater risk to the environment and consumers than the latter. Thus roughly 300,000 fatalities per year were reported due to the misuse of chemical controls (WHO, 1990), meanwhile the rate of human fatalities associated with biocontrol is perhaps very low if any, as there is no statistical data existing on the subject (Ehlers, 2009). Yet the EU Directive 91/414/EEC affirms the Precautionary Principle, which is applied to both biological control and chemical control.

The approval process is expensive and may exceed eight years, with the cost of registration between 500,000 and 2.5 million Euros (Ehlers, 2009). Because the biocontrol industry lacks the resources to support such high costs of approval, only a few products are currently available (Ehlers 2009). At the same time, however, the EU has an advantage over Canada and the US in having more native biocontrol species that do not need to go through the extensive registration process (Ehlers, 2009). Overall, the Canadian (and US) regulatory approach to granting approval to new BCAs for commercial use is more permissive as compared to that of the EU. It takes about six months for processing an import and release application in Canada: longer than Australia's 90 working days but shorter than the eighteen months in the US (Hunt et al, 2008), and much shorter than the EU approval process measured in years (Ehlers, 2009).

Among the policies acting as enabling for a greater adoption of biocontrol agents, environmental protection and regional development initiatives stand out as perhaps the most consequential. In the EU, these measures are accepted under the Common Agricultural Framework. In Canada, where the agricultural policy framework is a partnership of the two levels of government, the federal government has supported biological control via a number of programs and policies i.e., via direct federal investment in the research and development of new BCAs and in federal-provincial partnerships in various agricultural and environmental programs.[3]

In the US, the import and release of new BCAs fall under the Plant Protection Act (2000), which is administered under the Plant Protection and Quarantine Program of the United States Department of Agriculture (USDA), the Animal and Plant Health Inspection Service (APHIS-PPQ), and the Secretary of Agriculture (Hunt et al, 2008). Although less stringent than the EU Precautionary Principle approach, the US regulatory regime is defined by a lack of coordination between federal and state-level regulations. Even though the Environmental Protection Agency (EPA) is in charge of biocontrol, each US state has its own regulatory regime, with various degrees of stringency (Messing & Wright, 2006). Many BCAs are currently regulated by pre-existing chemical regulatory frameworks, where registration costs are reported to be high and the registration process lengthy. Moreover, post 9/11 increased security measures and enhanced concerns about a possible agroterrorism threat is another obstacle to a more streamlined nation-wide policy harmonization.

In Canada, biological control agents are approved under the Pest Control Products Act and their imports are regulated under the Plant Protection Act (Elliott, 2005). Approvals for new biocontrol agents are issued by the Plant Health Division of the Canadian Food Inspection Agency. The application for the release approval of foreign or new biocontrol agents in Canada must be consistent with the North American Plant Protection Organization (NAPPO) standards including the Standards on Phytosanitary Measures consistent with that of the WTO/FAO. Altogether, four regulatory agencies are involved in the process: CFIA's Plant Health Division, AAFC's Biological Control Review Committee, Health Canada's Pest Management Regulatory Agency, and Environment Canada.

In addition, in Canada, all three levels of government - the national, the provincial and the municipal - issue regulations over pest control products. Thus Canada's Pest Management Regulatory Agency registers pest control products, whereas the provinces regulate their sale, use, storage, transportation and disposal. Yet a provincial government may prohibit or restrict the use of a federally registered pesticide. Finally, municipalities have authority over local pesticide use including in landscape design and lawn care.

Although permits for the use of pesticides and biologicals are issued at the federal level and fall under the portfolio of CFIA and Health Canada, Canadian provinces have begun to regulate the use of pesticides in landscape and horticulture. Two general approaches seem to have emerged in the Canadian provinces since the early 2000s: 1) a very stringent approach based on complete prohibitions of the sales and use of cosmetic pesticides (Quebec in 2003 and Ontario in 2009) and 2) a less stringent approach based on IPM. Two Canadian provinces, British Columbia and New Brunswick, introduced Integrated Pest Management Acts in 2003 and 2009 respectively.

III. Stakeholders and their interests

The list of stakeholders in the area of pest control regulation is far reaching and goes well beyond policy-makers and biocontrol producers. It also includes agricultural growers and their associations, marketing agencies, scientist-entomologists, IPM specialists and agro-ecologists, environmental NGOs, and the retail sector and consumer groups.

The biocontrol industry

The structure of the biocontrol industry is defined by diversity and the absence of big international

[3] The Minor Use Program was designed under the Agricultural Policy Framework, 2003-2008. The Risk Reduction component focused on priorities for pest management including biological controls and safer minor use pesticides.

corporations (Ehlers, 2011). However, recently some big agro-biotech companies such as Syngenta have became more interested in producing biocontrol agents, perhaps for reputational reasons.[4] Yet the majority of BCA manufacturing firms are small or medium size enterprises with annual sales of USD $1-2 million (Guillon, 2009). In order to stay in business, it is vital for biocontrol companies to produce BCA cheaply and efficiently, and to ship them to the end user in a short time in order to ensure freshness of the product. The production of biocontrol agents is more costly as compared to chemical pesticides. The margin of profit can be low due to significant market fluctuations: even small changes in demand for biocontrol products are very damaging for smaller production companies (Myers, 2004). Due to the still marginal demand for BCAs, the inefficiency of the small scale of production, and the large investments required for building the initial rearing facility (Cowan & Gunby, 1996), the biocontrol industry has not grown much.

The majority of producers, 85 percent of the total, are located in the US, Canada and the EU (Dunham & Trimmer, 2012). Canada has four facilities for the commercial production of biocontrols: Applied Bionomics (British Columbia), The Bug Factory (British Columbia), Bugs by Nature Banker Plants (British Columbia) and Biobest Canada (Ontario) (Elliott, 2005). The majority of biocontrol agents used by Canadian growers have been produced abroad, mostly by the three largest biocontrol companies: Koppert, Biobest and Syngenta Bio-Line (Elliott, 2005).

In British Columbia, the first start-up of a large-scale commercial production facility, Applied Bio-Nomics Ltd, was enabled by Agriculture Canada's pilot program for control of whitefly and spider mites in Canada's Saanichton Research Station in the 1970s (Elliott, 2005). From 1985 until now, the development of the BC biocontrol industry has been facilitated by several factors: 1) government investments in R&D; 2) the active cooperation of the greenhouse industry; 3) work with research entomologists and 4) work with provincial and federal funding agencies (Elliott, 2005). In general, the development of efficient biological controls is a long-term process, taking 5-10 years from the initial research and development to production and commercialization (Elliott, 2005). Thus the professional ties between the biocontrol industry, the users of biocontrol, and researchers-entomologists tend to be long-term.

Users of biocontrol agents

The Commission on Genetic Resources for Food and Agriculture (CGRFA, 2009) identifies the main users of biological control as follows:

- Greenhouses, especially in the EU and North America (here biocontrol is used as part of Integrated Pest Management).
- Open field agriculture and forestry, especially in Latin America and China.
- Domestic residents, the landscape industry, public places and research facilities.

A grower's prime motivation for using BCAs is usually economic, targeting increased efficiency and reduced cost of production. Concerns for environmental sustainability are secondary to economic sustainability, although these considerations are increasingly important. Yet, pressed by harsh competition resulting from regional and global free trade regimes, growers find themselves under more economic stress since even marginal losses in yields loom large in terms of economic competitiveness. Consequently, a strong aversion to risk prompts growers to look for agricultural technologies that promise not only higher yields but also higher certainty. The initial introduction of synthetic, broad-spectrum pesticides several decades ago fulfilled both of these objectives since pesticides were perceived to provide an almost certain stream of high crop yields as long as growers strictly followed the spray schedule (Cowan and Gunby, 1996). Against this backdrop, Integrated Pest Management and biological control have been perceived by many growers as too knowledge and labour intensive, requiring constant monitoring of the field and thus potentially increasing the cost of production (Warner, 2007). Moreover, Integrated Pest Management demands growers to be more

[4] In 2009, Syngenta acquired Circle One Global company, which produced anti-toxin biological crop protection technology, Alfa Guard, released to reduce aflatoxin in crops such as corn and peanuts. The Syngenta's press-release stated that "food security and quality are high on the agenda of the food chain and consumers... The acquisition of this technology adds an important biological crop protection technology to the Syngenta portfolio." (Syngenta, June 11, 2009, http://www.syngenta.com/global/corporate/en/news-center/news-releases/Pages/en-090611.aspx; accessed on April 16, 2014).

comfortable with crop variability as well as with the presence of some pests, especially initially, when switching from chemical to biological control may result in a temporarily increase of pest populations (Warner, 2007). In addition, the IPM approach does not keep the environment free of pests entirely, but instead relies on determining a certain economic (not physical) threshold of pests beyond which the economic costs of controlling the pest is higher than the economic benefits of not controlling them (Warner, 2007). The fact that pest populations are not entirely eradicated, but kept instead at a minimum level, is viewed by some growers as disadvantageous (Bale et al., 2008).

Yet despite these actual and perceived shortcomings of IPM as compared to pesticide-reliant methods, the long-term prospects of the former are stronger especially in light of the challenge of pests developing resistance to pesticides faced today by many growers around the world (BBC News, 2012). Another grower concern is the increased cost of pesticides and the volatile and potentially increasing fossil fuel prices, which can make reliance on chemical controls more expensive than the more labour-intensive biocontrol methods. Finally, the third motivation that prompts some growers to consider the use of biocontrol is a rapidly growing concern for occupational health safety. Environmental concerns such as the preservation of biodiversity as well as the reduction of greenhouse gases are not as strong among crop growers as compared to other motivations, yet they are also on the increase (Gaye, 2007).

Greenhouse growers

Around 80 percent of the global commercial revenue generated by biological control agents is attributed to their use in greenhouses (Pilkington, 2009). In British Columbia, 99 percent of greenhouse vegetable growers employ biocontrol agents such as ladybugs and mites to reduce or eliminate the use of pesticides in the production of tomatoes, peppers and cucumbers (Elliott, 2005). Because it is difficult to establish a stable biocontrol population in greenhouses, growers rely on augmentative biological agents released consistently from time to time. Therefore, greenhouse growers are eager to have more stable biocontrol populations with longer lifespans, which will help reduce their cost.

The main enabling factor for greenhouses' reliance on biocontrol is the degree of control over BCAs that the greenhouses allow. Having biocontrol agents living inside a greenhouse as opposed to an open field shields them from being exposed to pesticide drifts from neighbouring fields while at the same time keeping these beneficial insects within the boundaries of a hothouse. In addition, to a greater degree as compared to open field farmers, greenhouse growers are generally used to applying innovation and research and therefore are more willing to embrace knowledge and labour -intensive technologies such as IPM. For example, the BC Greenhouse Growers Association, bringing together 42 vegetable operations producing 96 percent of all greenhouse vegetables in the province, lists the R&D in developing new and improving existing biocontrol methods as its top priority.[5]

Yet the main motive for greenhouse growers to use biocontrol agents are driven by two other factors: the growing resistance that some pests have developed to synthetic pesticides as well as the growing concerns for occupational health and safety since exposure to synthetic pesticides within the confines of a greenhouse can be more detrimental to workers as compared to the open field environment.

Open field growers: various crops

Open field growers are less predisposed to relying on biocontrol methods due to the labour- and knowledge-intensive costs these methods require, the drift of pesticides from neighbouring fields, and the higher economic uncertainty associated with shifting from pesticide-reliant techniques to biological control. Because of pest incursion from neighbouring properties, a grower's ability to maintain effective control and the consequent pay-offs from a unilateral switch from chemical to biological control are rather low. Therefore, Integrated Pest Management in open fields can promise increasing returns only when a significant number of growers working in the same district or region embrace this approach in a coordinated manner. In other words, the pay-offs of cooperation are higher than those of non-cooperation, yet no one wants to take the first initiative, to face the initial higher risk/lower payoff, which poses a significant collective action dilemma. It is hence recommended that some form of coordination among neighboring field growers be established in order coordinate a

[5] See the BC Greenhouse Growers' Association's mission statement, http://www.bcgreenhouse.ca/what_we_do.htm; accessed April 16, 2014.

simultaneous switch from conventional methods to IPM-based methods.

Open field growers: fruit producers

Among open field growers, the pome fruit industry (apples and pears) stands out for its high level of organization defined by many coordinated interactions among apple growers and their strong affiliations with government agencies. Thus the only area-wide open field IPM program in Canada was implemented by the BC Fruit Growers Association, under the Okanagan-Kootaney Sterile Insect Release Program (SIR).

The SIR program has relied on an IPM-based alternative to the use of organophosphates, releasing around ten to twelve million sterile moths a week between May and September (Ross Husdon, 2004). The initial investment for building the SIR insect rearing facility (CAD $7.4 million) was provided by the federal and the BC governments in 1991. The annual operating cost ranges from CAD $3 to $4 million and is funded by five regional district governments through regional taxes on both growers and property owners, with some supplemental grants provided by the province and federal government Growers pay a tax based on orchard acreage. The program claims to have reduced the use of pesticides in the region by roughly 80 percent since the beginning of its implementation in 1993. It is estimated that without the SIR program, growers would be using up to six times more pesticides (Ross Husdon Management, 2004). Significant benefits are accrued in terms of employee health and safety since the program was implemented.[6]

Organic growers

A rather small faction of all farmers, organic growers have not been very supportive of Integrated Pest Management mostly because the IPM does allow for some usage of chemical pesticides, which is incompatible with the purist concept of "organic" agriculture. The common definition of organic, based on contrasting "organic" ("natural") with "synthetic" (or "chemical", "unnatural"), is dichotomous and therefore cognitively simpler to formalize as compared to the more complex IPM concept, which goes beyond the organic-synthetic dichotomy while admitting that neither of them on their own are necessarily environmentally sustainable.

Thus British Columbia's Organic Growers Association relies on certification standards that prohibit the use of synthetic materials. Moreover, the transition period from the "conventional" to the "organic" is 36 months and is based on estimating the time of the last application of a "prohibited substance."[7] Such a stringent formula leaves no room for the Integrated Pest Management approach, which does not entirely rule out the use of pesticides.

IPM labelling and consumer awareness

Rising consumer awareness of health and environmental issues pertaining to agriculture is a potentially powerful force to motivate change in agricultural practices. Organic retailers usually rely on a core and very committed group among their customers whose preference is not primarily driven by price – this core group is reported to give the first priority to health consideration, secondly to food quality, and thirdly to the environmental sustainability of the production process. The latter priority is growing and often transcends the concept of the "organic" as "naturally produced".[8] Pesticides are the breaking point for the concept of organic products, which limits the marketing potential among customers of IPM produce. The most committed customers of organic produce are perhaps not the targeted group for an IPM/biocontrol label, since their strong commitment to organic signifies a well-established system of beliefs about the health and the moral superiority of the organic label.

The current level of consumer awareness of IPM and biocontrol remains low. Biocontrol-based labelling may be too specific and too narrow, as compared to the well-established "organic" labelling. Consequentially, a more all-encompassing approach may have a wider market appeal in order to represent other important agro-ecological and social practices, given the growing consumer awareness of

[6] See "Sterile Insect Release Programs Benefits," SIR Program web-site, http://www.oksir.org/benefits.asp; accessed April 16, 2014.

[7] For certification standards of BC Certified Organic, see COABC Accreditation Board, "British Columbia certified Organic Producton Operation Policies and Management Standards," (created 1994, revised 2013); available at http://www.certifiedorganic.bc.ca/standards/docs/Book_1_V10.pdf; accessed April 16, 2014.

[8] Personal interviews with several BC retailers of organic food conducted in November 2009.

issues of sustainable and ethical food production. The fact that consumers are becoming more interested in learning about labour-related and environmental impact of food production practices creates favourable conditions for introducing more encompassing labels rather than simply the purist "organic."

Highlighting this trend, some retailers report that their consumers demand more information besides health and safety, to also include information on the process of production, place of production, and the environmental impact. At the same time, mainstream retailers have removed most educational and explanatory materials that accompanied many food products in the past.[9] These two trends seem contradictory, as one points to the growing consumer demands for more information, whereas the other points to movements by conventional retailers to reduce this information to a minimum.

As a general trend, however, consumer awareness of ecological agriculture and its products is expanding and is no longer limited to the questions of health and food safety, but also includes concerns for the environment, carbon footprint, social equity, labour standards, and other considerations. The organic identity in food labelling is shifting as well, which may be conducive to introducing more comprehensive labels speaking to growing consumer awareness of the social and environmental aspects of food production.

Among the most recognizable labels in British Columbia, introduced in late 1980s, the BC HotHouse label represents farming practices based on IPM that "rely primarily on biological controls (such as ladybugs and wasps to control plant damaging insects.)[10] In the neighbouring US, a label created around the use of biocontrol and Integrated Pest Management is called "Responsible choice." Besides covering pest management practices, this certification standard also includes sustainable composting, energy and water conservation, a small carbon footprint, packaging, recycling, and social responsibility.[11]

Municipal government

Municipalities are motivated to introduce restrictions on the use of pesticides for several reasons: the increased societal pressure coming from environmental groups to ban the use of pesticides on municipal lands, growing negative public opinion on pesticide health impacts, a snow-ball effect of using "the best practices" employed in other municipalities, provincial-level initiatives on restricting the use of pesticides, and other factors. Many elected politician working at the municipal level have a stronger interest in choosing complete pesticide bans in cosmetic use over middle-ground IPM approaches, as the former resonates much better with the public and promises higher political payoffs than the latter. On the other hand, a perception among city managers, who are not elected, that the complete ban or reduction in the use of pesticides may lead to an outbreak of pests in parks and municipal areas is also strong (Biocontrol Files, 2005, p. 8).

As more municipalities introduce tougher restrictions on pesticides, the lawn-care industry will have more reasons to look for biological control solutions. This presents great potential for the biocontrol industry to establish new linkages with nursery and lawn care companies as partners, with a growing need to develop lawn-care strategies alternative to pesticide control.

The landscape industry

As a significant a potential user of biocontrol agents, the BC landscaping industry has relied on three broad-spectrum pesticides: weed-and-feed, roundup, and merit. The industry represents a promising area for future development of the Integrated Pest Management for several reasons: 1) the landscape industry has less economic pressure to rely on pesticides as compared to growers, since landscapers do not have the same risk of losing yields and income due to increased pest population; and 2) civil society pressures on municipal and provincial governments to limit the application of pesticides in land use are growing.

[9] Interview with an expert from the Sustainable Agri-Food Systems, Institute of Sustainable Horticulture, Kwantlen Polytechnic University, December 16, 2009, Vancouver.

[10] HotHouse, http://www.bchothouse.com/products-home.html; accessed April 16, 2014.

[11] See Stemilt growers, http://www.stemilt.com/ourdifference/Pages/ResponsibleChoice.aspx; accessed April 16, 2014.

The landscape industry has recently come under strong public pressure to reduce or completely eliminate the use of pesticides. Some Canadian municipalities have introduced stringent by-laws on the use of pesticides, to enhance protection from unwanted exposure from lawn pesticides. This in turn has created a big challenge for the unregulated landscape industry prompting it to move away from the use of pesticides towards milder methods such as biocontrol. Yet the majority of landscape workers do not have necessary skills to use more knowledge-intensive Integrated Pest Management techniques.[12] One of the solutions is developing IMP certification programs for the municipal landscape companies with a necessary training component for landscape workers. In 2008, the BC Landscape and Nursery Association, together with the Institute of Sustainable Horticulture Program of the Kwantlen Polytechnic University, launched a third-party pest management accreditation program, Plant Health BC, to reduce reliance on pesticides, promote sustainable landscaping, and increase professional standards among landscapers.[13]

IV. Conclusion

Does the biocontrol method have prospects for greater worldwide adoption as a viable alternative to synthetic pesticides? The stakeholder positions discussed in this paper suggest that this question, under certain enabling conditions, can have a positive response. For greenhouse growers, the most important enabling factor is the creation of more stable populations of biocontrol agents whereas for open-field farmers the critical factor is an area-wide coordination among neighbouring growers. For both greenhouse and open field growers, consumer awareness about the benefits of biocontrol methods for human health, occupational safety and the environment is clearly important.

The currently relatively small market share of the biocontrol industry can be somewhat misleading. In fact, the literature reviewed in this paper (Altieri, 1995; Nicholls, 2002; Kishi, 2005; Bale et al, 2007; Daane, 2008; IAASTD, 2009; UNCTAD, 2013; and many others) suggest the significant and not fully realized potential of biocontrol methods, based on at least four unfolding processes:

1) An increasing number of pesticides are being banned from use, under strong public pressure, at all levels of governments: international, national and local.
2) Among growers, dissatisfaction with pesticide-reliant methods is also mounting, mostly due to the chemical industry not being able to keep pace with pests developing resistance to new pesticides.
3) Consumer preferences are changing to embrace a more nuanced concept of sustainable food and concerns with practices associated with food production.
4) Overall, health and safety requirements, including occupational safety for growers, are becoming more stringent.

Yet the rate of adoption of the Integrated Pest Management and biocontrol has remained marginal as compared to conventional pesticide-based methods. Even though the major international agencies such as the UN Food and Agriculture Organization, the World Bank and others have continuously promoted "farmer-driven ecologically-based pest control" (IAASTD, 2009, p. 103), the actual national implementations of these global policy recommendations are weak (Karel, 2004). Yet the world's agricultural systems need these methods more than ever. As the global population has been on the increase, the need for affordable food has also grown and so has the need to decrease the negative environmental impact of agricultural practices associated with input-intensive agriculture. The biocontrol-based method offers a compromise between these two seemingly conflicting demands: keeping crop productivity high while significantly reducing the use of harmful pesticides.

[12] Interview with an expert from the Sustainable Agri-Food Systems, Institute of Sustainable Horticulture, Kwantlen Polytechnic University, December 16, 2009, Vancouver.
[13] Ibid.

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