Award Category: IPM Team/Group Program/Project/Organization
PRISME Consortium

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• Provide a brief summary of the program's accomplishments (500 words or less)

Established since 1982, PRISME is a unique organisation comprising a fruitful partnership between growers and agricultural professionals serving Montérégie region in Quebec, Canada. For 35 years PRISME has engaged in research, development, monitoring, and servicing good agricultural practices, including IPM, improving economic viability and reducing environmental footprint of vegetable sector.

PRISME is funded jointly through Provincial Government and grower memberships; employs 20 professionals and has 45 member growers (recipients of PRISME services); delivers agri-consulting and operational services for 5,000 hectares of vegetables with the largest network of scouting in the province; and services growers with scouting, sampling, testing/diagnostics, forecasting, pest control recommendations, outreach for technology/knowledge transfer.

Sterile insect technique (SIT) for onion maggot and spore trapping for onion blight disease featured here address IPM in onions and are two of several PRISME's successful IPM programs offering sustainable pest management solutions to growers. Both approaches accomplished remarkable reductions in crop loss and amount of pesticides used for these pests.

1. Developed as a 'green solution' alternative to pesticides, SIT technology (https://prisme.ca/services/achat-de-mouches-steriles/) consists in rearing, sterilizing

and coloring in pink flies of onion maggot (*Delia antiqua*), then releasing them weekly in onion fields, when wild pest populations are active, at rates from 15,000-90,000 flies/hectares depending on crop (green/or dry onions) and pest pressure. Coupling wild and sterile flies result in sterile eggs unable to produce larva, thus reducing pest populations without using pesticides. This technology was originally developed and adopted for years in the Netherlands and PRISME transferred it successfully to Quebec. PRISME's experience with SIT expands over 13 years from early research, field validation, technology transfer and economic studies to establishment of a bio-factory for mass-producing sterile flies to meet increasing grower demand.

Key accomplishments:

- 7 years of SIT research and development work leading to 1st commercial release of sterile flies in onion fields in 2011;
- Launched in 2011 a state-of-the-art bio-factory able to rear millions sterile flies annually;
- Onion acreage using SIT increased from 140 to 525 hectares in last 6 years;
- Released 10-20 million sterile flies annually since 2011;
- Decreased by 90% rates of sterile fly releases in last 5 years due to precision treatments.

2. Developed as an original technology in 1990s, spore trapping (https://prisme.ca/services/capteurs-de-spores/) serves as a decision support system helping growers forecast onion blight disease risk and make informed management choices. Since 2007, PRISME implements spore capturing through a network of traps across 1,000 hectares of onion crops. Spores are detected and quantified using a real-time qPCR assay in PRISME's lab and the information is then analyzed and interpreted as part of a disease forecasting approach to predict disease development. PRISME uses this prediction to provide timely alerts and action recommendations to growers, allowing effective disease management with minimum application of fungicides.

Key accomplishments:

- 10 years of spatial and temporal distribution of *Botrytis* spores leading to action threshold implemented commercially since 2007;
- 10 years of consolidated networks of ~12 spore traps across onion crops annually;
- Reduced fungicides use in onions by 35% in last 5 years.

• Describe the goals of the program being nominated; addressing why the program was conducted and what condition does this activity address? (300 words or less):

PRISME's goal is to reduce pesticide use through delivering scientifically proven sustainable pest control tools and IPM approaches as alternatives to pesticides. Thus PRISME actively contributes to current provincial 10-year goal set to reduce pesticide risk by 25% by 2020.

Onion maggot and onion blight are increasing issues threatening onion industry, and concerns with impact of pesticides in the environment and the risk of pesticide resistance building in pest populations due to decrease of product availability led to the need to look into IPM systems as viable alternatives to chemical-based management strategies. Growers needed diverse tools in their toolbox to effectively control these pests and maintain yields with least impact on environment and human health.

Prior to the SIT program onion losses up to 30% were attributed to onion maggot despite regular soil treatments at seeding with granular chlorpyrifos, and 6-8 foliar insecticide sprays (diazinon, pyrethroid). However, organophosphates chlorpyrifos and diazinon were identified as major contaminants of surface water in vegetable production areas of Quebec. Resistance to chlorpyrifos was also reported in onion maggot populations rising concerns of product efficacy. Diazinon is already phased out in 2016, while chlorpyrifos and pyrethroid are under regulatory review in Canada and might be removed from the market. The SIT initiative aimed to provide growers with an alternative solution to maintain onion yield while eliminating preventive (chlorpyrifos [Lorsban]) and unnecessary foliar sprays applications.

The spore trapping research for onion blight initiated in response to raising concerns around development of iprodione-resistant strains of *B. squamosa*; limited efficacy of most disease management schemes; increase in number of fungicide applications to manage disease; and issues of negative effects of fungicides in the environment. Spore trapping aimed to help growers base fungicide spray decisions and timing on field-specific pest pressure and thresholds, thus eliminate unnecessary sprays.

• Describe the level of integration across pests, commodities, systems and/or disciplines that were involved. (250 words or less):

PRISME runs highly collaborative programs cutting across many pests, disciplines, commodities, and partners from the entire value chain. The systems featured here addresses two economic pests of onion: an insect and a fungal disease both with potential to limit viable onion production. To address these pests PRISME collaborated with scientists, experts and industry stakeholders. Control approaches resulting through this work support the onion IPM systems adopted across 1,000 hectares of onions (representing 50% of Quebec's onion acreage). These technologies are also transferrable to others onion growing areas. All acreage is scouted by PRISME, allowing effective coordination of resources, proper set-up, consistent monitoring of impact and follow-up of the system efficacy.

Besides successfully delivering SIT for onion maggot in past 5 years, PRISME continues research into another SIT initiative addressing cabbage maggot, an important pest of crucifer crops. Thus, the bio-factory is currently used to produce sterile cabbage maggot flies for research.

Similarly, the onion blight approach was adapted to other onion diseases (downy mildew and Stemphillium leaf blight). Also, a network of 110 additional spore traps established by PRISME captures spores of 12 other fungal pathogens across 5 other crops (e.g. strawberry, grape and lettuce).

Other crosscutting PRISME projects include:

- A monitoring program documenting the inventory, distribution and accurate identification of four *Delia* spp. damaging crucifer and onion crops in Quebec;
- Biosurveillance program for extensive diagnostics of soil-borne pathogens and pesticide resistance testing for various pathogen populations; (https://prisme.ca/services/laboratoire-de-biosurveillance-phytodetec/);
- Establishment of biobed systems for safe disposal of pesticide rinsate in farms.

• What outcome describes the greatest success of the program? (250 words or less)

IPM adoption brought significant yield loss and pesticide use reductions in onion production:

- Pre-SIT program onion yield losses averaged about 10% and after 2 years under SIT growers report only 0.1-2% loss;
- SIT eliminated use of chlorpyrifos in soil and 5-6 foliar sprays in most onion acreage - with yields comparable to pesticide based control programs;
- Significant decrease of chlorpyrifos contamination in Gibeault-Delisle watershed: detected in 77% and 40% of water samples in 2013 and 2014, respectively, compared to 100% in 2005-2007 samples; also maximum concentrations detected were 0,13 and 0,05 ug/L in 2013 and 2014, compared to 2.2 and 0.92 ug/L in 2006 and 2007, respectively (http://www.mddelcc.gouv.qc.ca/eau/eco_aqua/pesticides/verges-maraicheres/index.htm);
- SIT obtained sustainable development ECOCERT certification in 2016;
- Spore trap usage reduced between 15 to 59% fungicide applications in onion crops;
- Provincial government provides financial incentive for growers adopting IPM practices delivered through PRISME (purchase of sterile flies, spore traps setup, biobed construction, etc.) as part of its IPM support program;

The success of IPM program delivery relies on PRISME's unique partnership with scientists and growers, diverse services offered and its infrastructure. The multi-dimensional consortium allows PRISME and its three other divisions to offer diversified expertise and services to meet different grower needs: '**Phytodata'** group conducts applied research projects developing new IPM tools and practices; **'Phytodetec'** group, through laboratory capabilities specializing in molecular biology protocols, scout teams, and networks of weather and pest monitoring technologies offers biosurveillance services; **'DataSol'** provides services of environmentally-friendly crop production practices.

• Provide evidence of change in knowledge, behavior, or condition because of the program. (300 words or less)

Users of the onion IPM technologies delivered by PRISME include individual growers and grower groups (PRISME members) like **Groupe Vegco**, a co-op of 14 top growers of fresh fruit and vegetables in Quebec: http://groupevegco.com/en/expertise/research-and-development/.

Information about new technologies resulting from PRISME is regularly conveyed to grower and scientific communities through presentations at annual meetings, journal publications, grower tours of experimental plots, online publications of content and videos on PRISME's website and growers/agriculture media (Roses, irradiées et bien élevées : http://www.quebecscience.qc.ca/Roses-irradiees-et-bien-elevees-; L'usine à mouches: http://www.lebulletin.com/actualites/lusine-a-mouches-40393).

PRISME has delivered ~10 scientific publications and ~50 scientific and transfer presentations. Technical information such as factsheets and results from various studies are also easily accessed online on the Pôle d'Excellence en lutte intégrée (Centre of Excellence in IPM) (http://www.lutteintegree.com/) and Agri-reseau (Information and Knowledge Centre for Agri-food sector https://www.agrireseau.net/) websites.

Grower testimonials in this YouTube video indicate knowledge dissemination is reaching out vast audiences and making an impact.
https://www.youtube.com/watch?v=zWPgaoL6Y9Y&feature=youtu.be)

Local news media has also reported on success of PRISME's IPM programs, another indicator of the large impact of PRISME in the regional agricultural arena:

http://ici.radio-canada.ca/widgets/mediaconsole/medianet/6560594

http://ici.radio-canada.ca/tele/la-semaine-verte/2016-2017/segments/reportage/27652/capteurs-spores-champs-agriculture

Factors for successful delivery and continuity of IPM programs:

- Dedicated team of highly trained professionals with extensive research and extension expertise coaching growers along the adoption process;
- Regular monitoring to identify pest pressures and adjust treatment rates and timing accordingly;
- Continued research and follow up to fine-tune and maintain efficacy of offered technologies;
- Conducts both research and implementation of pest management approaches;
- Network nature of the organisation allows sharing and tracking of data among all growers and PRISME agronomists;
- Participation of growers and crop specialists from the early stage of research and development work;

- Extensive outreach, promotion, study of economics and efforts to increase viability of recommended practices and encourage further uptake.

• Provide evidence of client adoption of IPM practices, improve economic benefits, or pesticide use reduction because of project implementation. (500 words or less)

Acreage under SIT for onion maggot is at 525 hectares of onion crops in 2017 (20 growers), and the treated area almost doubled over the past 5 years. Acreage under spore trapping for onion blight is 1,000 hectares (25 growers), and uptake increased significantly in the last 5 years.

Pesticide use reduction attributed to SIT implementation amounted to elimination of chlorpyrifos soil treatment and 5-6 foliar sprays in about 500 hectares of onion, while reducing crop loss due to onion maggot to negligible levels. SIT also reduced by about 60% chlorpyrifos contamination of waters. Pesticide use reduction attributed to spore trapping implementation has been on average 35% in about 1,000 hectares.

Grower testimonials report high efficacy of the SIT approach and satisfactory long term economic return. Users recommend at least 2 seasons of adoption to observe measurable benefit. Adopting growers encourage their peers to adopt and make use of their shared experiences (https://www.youtube.com/watch?v=zWPgaoL6Y9Y&feature=youtu.be).

PRISME monitors regularly the performance of IPM programs it delivers to maintain efficacy and economic feasibility. Pre-SIT monitoring identifies the pest causing damage (as various *Delia* species cause damage in onion but SIT is only effective for *D. antiqua*) and pest pressures ensuring field specific rates for sterile flies releases are recommended as necessary. Post-release evaluation in the field assesses SIT impact allowing readjustment of release rates along the season to reflect dynamics of natural populations present. As a result, about a 90% reduction in the release rates was observed from 2011-2016 in one area for equivalent yield levels and less pesticide use. This led to significant cost reduction for growers, rendering the approach more attractive to growers and influence more uptake. Proper release protocols reduce pest pressure, gradually reducing the need for future releases.

Adoption of the spore-trapping approach and impact on onion production in term of yield and fungicide usage is monitored every five year and compared to a 3 years reference period (2008-2010). First evaluation conducted in 2015 and 2016 indicated the average reduction of fungicide treatments by 35%. These data also showed that some dedicated growers could reduce their use of fungicide, up to 59%.

Engaging in extensive outreach activities, PRISME has increased its circle of adopters of its IPM technologies outside its service area. While 20 growers in Montérégie region are adopting SIT, 3 other growers from neighbouring Lanaudière region are also using this technology since 2016. PRISME supports and follows-up regularly with these growers and extension specialists. Also, PRISME is conducting a spore-trapping implementation project in Dominican Republic and is selling traps outside Canada (e.g. South Africa).

• Describe the team building process; how did the program being nominated get partners involved? Education and awareness are essential in an IPM program. (250 words or less)

To deliver its initiatives, PRISME looks for sustainable solutions to meet the needs of growers; partners with key experts including academia and federal scientists, provincial pest management specialists, extension experts, growers, agricultural enterprises and other local industry stakeholders; and mobilises various federal, provincial and private funding sources.

To implement SIT, PRISME's director and his scientist partner, college professor Dr. François Fournier (Collège Montmorency) visited the site where this technology was adopted in Netherlands in 2004. Then visited OKSIR, Canada's largest and longest running SIT program for codling moth in British Columbia's apple orchards. Armed with expertise, PRISME launched its own SIT program in 2004. PRISME experts added value to the technology by developing more efficacious colouring techniques for distinguishing sterile flies.

For the spore-trapping approach, PRISME mainly collaborated with scientist Dr. Odile Carisse and her team at Agriculture and Agri-food Canada. Her implication was essential for the development of the methods, protocol, tools and analysis. She also trained several graduate students (like H. Van der Heyden) who later became involved in the implementation and further development of the approach. PRISME also collaborated with several other researchers in the US and in Europe on this approach.

Besides the capacity to deliver scientifically proven technologies, quality consulting and monitoring, PRISME has a highly qualified team specializing in outreach engaging in extensive promotional activities for technology and knowledge transfer e.g. 'how to' youtube videos, factsheets, and one-on-one assistance. These help promote grower confidence in accepting and adopting IPM approaches.

• Did this project utilize any innovative methods that could be shared with others? (Please explain in 200 words or less)

PRIZME transferred successfully the SIT from Netherlands to Quebec through a long and dedicated research, development, and implementation work. PRISME experts added value to the technology by developing more efficacious pink colouring techniques for distinguishing sterile flies. The technique is largely adopted by growers of serviced under PRISME, but is also being adopted by growers in other regions (e.g. Lanaudière). The approach can be transferred to other onion growing areas affected by onion maggot.

PRISME continuously builds its expertise with the onion maggot SIT program delivery and is committed to transfer the successful experience to advance IPM programs using similar techniques addressing other priority pests (e.g. cabbage maggot).

The spore-trapping technology is original, initiated as a joint research program between PRISME and Agriculture and Agri-Food Canada scientists. This approach can also be transferred to other onion growing areas affected by onion blight. PRISME has already adapted this approach for other onion diseases (Downey mildew and Stemphillium leaf blight) and other pathosystems (i.e. grape, strawberry, and lettuce diseases). Moreover, exchanges of experience and technology transfer is already happening nationally (with Ontario growers) and internationally (Dominican Republic and South Africa).

• Please share one article that represents the work of the team (No Vita's or Resumes) Our committee would prefer if you include a link to this article in the box; however, if that is not possible please, send this document via email to Janet Hurley at jahurley@ag.tamu.edu with the subject line "IPM Team/Group Award Category and nominee's name

Management of Botrytis Leaf Blight of Onion: The Québec Experience of 20 Years of Continual Improvement http://apsjournals.apsnet.org/doi/pdf/10.1094/PDIS-11-10-0797

A decision support system for knowledge-based management of Botrytis leaf blight of onion
https://www.uoguelph.ca/muckcrop/pdfs/Botrytis_squamosa_Walker_onion_eng.pdf?id=1359302820152&lang=eng

COLLÈGE
MONTMORENCY

Laval, June 28th 2017

Object: Support of PRISME nomination for an IPM Achievement Award

Dear members of the selection committee,

I am writing you to strongly support the nomination of PRISME for the IPM Achievement Award. As an applied researcher in IPM and biological control at Collège Montmorency, I have collaborated with PRISME for more than 12 years. During this long period, I have been witness of their professionnalism and enthousiasm at developing and implementing alternative methods for pest management in vegetable production in Québec.

I was first contacted by them in 2004 to conduct a feasability study on the use of sterile insect releases for the contol of the onion maggot. Following that study, I realized most of the laboratory experiments to establish optimal irradiation and diapause induction conditions but, when field trials had to be planned, I knew I could rely on their competent staff to apply research protocol in various conditions. This allowed us to confirm the efficacy of sterile male releases in small scale and large scale field trials. Our collaboration extended at developing their production facility, and we keep working together to improve the production methods and now testing SIT against the cabbage maggot. All that research would not have been possible without their strong and constant financial and organisational support.

In Québec, PRISME is the reference in IPM organization since they managed to develop a research culture among their growers-members. This culture result in a strong support for short and long term research, and rapid adoption of new IPM practices. I believe they are a model organization that deserves the recognition of your organization.

François Fournier
Professeur chercheur en biologie

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Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

SUSTAINABLE CROP PROTECTION

Results from the Pesticide Risk Reduction Program

A DECISION SUPPORT SYSTEM FOR KNOWLEDGE-BASED MANAGEMENT OF BOTRYTIS LEAF BLIGHT OF ONION

I. Introduction

Botrytis leaf blight (BLB) of onion, caused by the fungal pathogen *Botrytis squamosa* Walker, is an important disease that threatens onion production in Canada and other onion production areas of the world. The disease is endemic and is especially severe on yellow globe onions.

Onion growers are concerned about adequate management of this disease in their crops as no commercially available onion cultivars are fully resistant to *B. squamosa*. Moreover, some of the fungicides used for this disease are either under regulatory re-evaluation (iprodione) or already phased out (vinclozoline), and there is a risk of pathogen populations developing resistance to current fungicides. Resistance of *B. squamosa* isolates to some of the older fungicides (e.g. dicarboximides) is already reported.

Agriculture and Agri-Food Canada's Pest Management Centre has funded work to develop new decision support tools and information which can be used in an integrated system for management of BLB. This factsheet summarizes key tools and approaches recommended as a result of this work. These tools can help growers achieve improved control of BLB and judicious use of fungicides, while reducing crop protection costs and optimizing fungicide resistance management.

Botrytis leaf blight of onion develops in two phases. It starts with a leaf spotting phase followed by a leaf blighting phase. Initially, spot lesions appear on leaves 24-48 hours after an inoculation and are whitish in color, 1 to 5 mm in length and generally surrounded by greenish-white halos which appear water-soaked at first (Fig. 1).

Figure 1. Discrete spot lesion caused by *Botrytis squamosa* on an onion leaf.

Figure 2. Upper leaf blighting symptom caused by *Botrytis squamosa*.

As lesions age, the centres become sunken, straw-coloured and sometimes develop a slit that is oriented lengthwise in the lesion. Older onion leaves are more susceptible than younger leaves. Partial or complete leaf blighting generally occurs within 5 to 12 days after the initial lesion development (Fig. 2). Under severe epidemics, the entire crop may express advanced blight symptoms (Fig. 3).

Figure 3. Onion crop severely infected by *Botrytis squamosa*.

Canada

II. Epidemiology

Botrytis squamosa overwinters as sclerotia (compact mass of fungal mycelium) formed on infected onion leaves and necks of onion bulbs that remain in the soil after harvest or on crop debris in cull piles. In the spring, ascospores produced within apothecia arising from sclerotia (Fig. 4) are released in the air infecting leaves of new onion plants. However, ascospores are not considered to be a significant source of primary inoculum.

Figure 4. Apothecia arising from a *Botrytis squamosa* sclerotium.

Figure 5. Conidia produced on a *Botrytis squamosa* sclerotium.

Epidemics are mainly initiated by conidia, a spore type produced on sclerotia overwintering in soil, on onion debris or on onion cull piles (Fig. 5). Sclerotia of *B. squamosa* can produce conidia over a prolonged period of time, usually extending from spring to early summer.

The optimum condition for conidia to infect onion leaves is a combination of air temperatures between 18-20˚C and leaf wetness for at least 6 hours (Fig. 6). Following the leaf spotting phase of the disease, *B. squamosa* continues to colonize the infected leaves causing blighting and die back. New sporulation and subsequent conidia production occurs on dead leaves, mainly around the dead leaf tip (Fig. 7). This occurs mainly at night, when the leaves are wet for at least 12 hours and the mean temperature is between 8 and 22˚C.

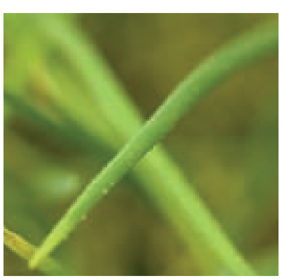

Figure 6. Morning dew on a young onion leaf.

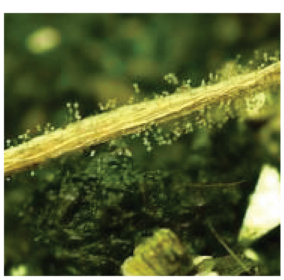

Figure 7. Conidia produced on dead onion leaves.

In the spring, temperature is generally not a limiting factor for the production of conidia because these are produced at temperatures ranging from 3 to 27˚C (optimum of 9˚C). The initial cohorts of conidia developing from sclerotia are responsible for the leaf spotting phase of the disease. At this stage, the disease generally progresses slowly. However, as leaf blighting and leaf tip dieback progress, new crops of conidia are produced on dead tissues which are capable of initiating subsequent disease cycles. At this stage, disease spreads much faster and wider across onion crops.

III. Disease management

The conventional fungicide spray program for onion leaf blight management comprises application of fungicides at a fixed 7 to 10 day intervals from the 3-4 leaf growth stage to shortly after the onions lodge. In eastern Canada, growers typically start their fungicide programs with a preventive fungicide, such as a dithiocarbamate applied at 7 to 10 day intervals, followed by fungicides such as chlorothalonil or iprodione often mixed with a dithiocarbamate, depending on disease pressure. Mixtures of fungicides are also used to provide control for both botrytis leaf blight and downy mildew (*Perenospora destructor*). The fungicides Pristine (pyralostrobin and boscalid, BASF) and Switch (cyprodonil and fludioxonil, Syngenta) are incorporated when disease pressure is perceived to be high.

a. Limitations of fixed interval fungicide spray programs

A common fixed interval fungicide program for Botrytis leaf blight may involve 6 to 14 fungicide sprays per season, among which are 3 or 4 sprays with iprodione applied alone or in a fungicide mixture. This intensive spray program can negatively impact the sustainability of BLB management.

Pathogen insensitivity to fungicides can be a serious problem. Frequent and repetitive use of fungicides of similar groups and modes of action in particular can lead to resistance development in the pathogen population. Laboratory tests comparing the sensitivity of field isolates of *B. squamosa* to currently used fungicides revealed that all isolates were resistant to mancozeb (Dithane DG) and chlorothalonil (Bravo 500), but a few isolates were insensitive to both dicarboximide fungicides iprodione (Rovral) and vinclozolin (Ronilan) (Fig. 8).

Another limitation is the production cost, which often increases with the overuse of fungicides, especially when disease pressure does not reach economic thresholds and spray applications are deemed unwarranted.

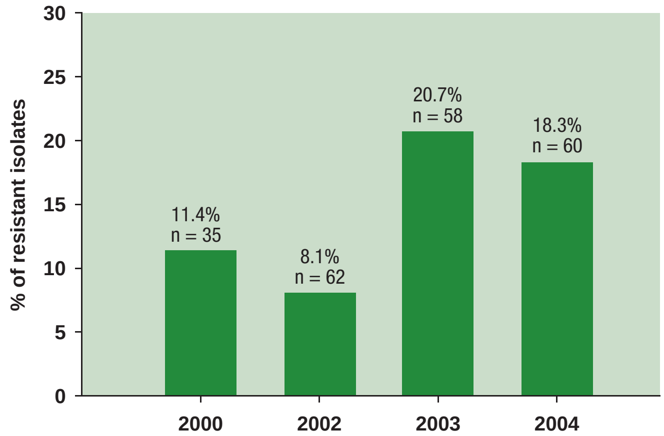

Figure 8. Incidence of *Botrytis squamosa* isolates resistant to fungicide iprodione monitored from 2000 to 2004 in the main onion production region in the province of Quebec varied from 8 to 21%.

In recent years, new fungicides belonging to different chemical groups were registered for management of BLB, including boscalid (Lance or Endura, BASF), boscalid and pyraclostrobin (Pristine, BASF), and cyprodinil and fludioxonil (Switch, Syngenta). The availability of these fungicides allows for a better rotation of products with different modes of action (fungicide groups), which in turn leads to better resistance management.

b. Estimating disease risk

The potential yield losses due to BLB vary widely (e.g. 7 to 30%) depending on weather conditions and disease pressure during the season. Therefore, the frequency and timing of fungicide sprays may be crucial in some years and less important in other years. In years with low rainfall, BLB may be so low that there is no need to apply fungicides for disease control. However, in most years, humidity is high and leaves need to be protected from disease to avoid yield loss and to ensure that plants have sufficient green leaves to absorb the sprout inhibitor applied to onions intended for long term storage.

Determining the risk of BLB, the need for, and the optimum timing of fungicide applications in onion crops can improve disease control while avoiding unnecessary sprays, thus saving on treatment costs. There are a number of disease prediction models proposed to date to estimate the risk of BLB development in onion crops. Some predictors rely on monitoring-based risk indicators derived from field observations, some others on weather-based risk indicators related to conditions conducive to disease development. A recent study showed that monitoring-based predictors are more reliable; however some weather-based predictors have provided good estimation of disease risk. Table 1 summarizes the findings from this study, indicating the performance levels of various BLB predictors.

Good disease forecasting and management decision support tools can improve control efficacy with less fungicide use, which in turn can slow down or prevent the development of fungicide insensitivity and can lower crop protection costs.

Table 1. Levels of prediction accuracy and reliability of various BLB disease risk indicators.

Disease risk indicators	Percent of good decisions (%)	
	First spray	Subsequent sprays
Monitoring - Based		
Airborne inoculum	89	82
Number of lesions on oldest leaves	85	82
Number of lesions on youngest leaves	82	75
Weather - Based		
Sporulation Index	64	73
Inoculum Production Index	72	63
Infection Probability	36	57
Disease Severity Values	67	71

c. Knowledge-based management: A stepwise decision making process

Optimum management of BLB should be based on regular field observations, including monitoring of airborne inoculum present and number of lesions per leaf (thresholds established for BLB are 3 lesions on the oldest leaves and 1 lesion on the youngest leaves), as well as past, present and forecasted weather conditions (Fig. 9). Generally, field observations are more costly to obtain than regional weather conditions.

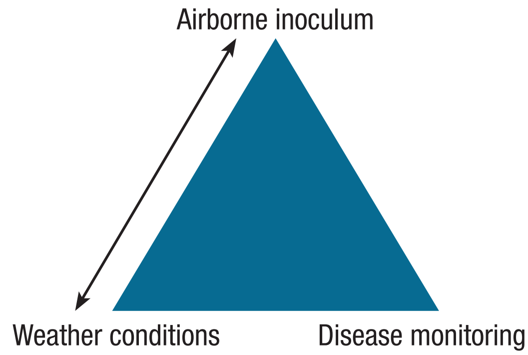

Figure 9. Key factors to determine risk for BLB disease.

Optimum management of BLB could be achieved following a stepwise approach:

Step 1. Using weather-based risk indicators. For eastern Canada, the best weather-based risk indicators are the Sporulation Index developed by Lacy and Pontius in 1983 and the Disease Severity Values proposed by Sutton et al., in 1986 (Fig. 10). The Sporulation Index represents the degree of favourability of weather factors, mainly temperature and vapor pressure deficit, on the production of spores by *B. squamosa* on a scale of 0 to 100, where 0 represents no potential for sporulation and 100 conditions that are highly favorable for sporulation. Warning and action threshold of 50 and 80, respectively were set based on field experimentations. The cumulative disease severity value represents the progress of BLB. The best way to use these risk indicators is to combine the two indices calculated from weather forecasts.

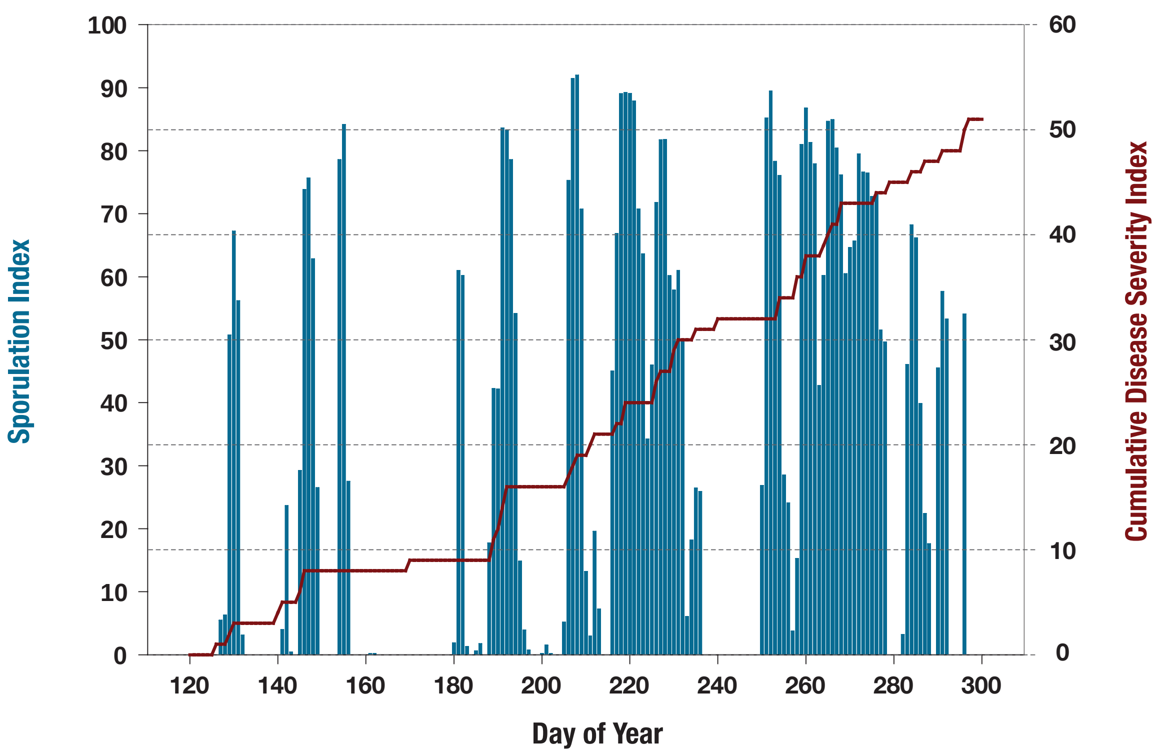

Figure 10. Performance of weather-based risk indicators for predicting BLB.

Step 2. Monitoring airborne inoculum. The concentration of airborne inoculum (spores) of *B. squamosa* was identified as a good risk indicator for disease development. Concentration of spores can be measured by using a rotating-arm spore sampler such as the one shown in Fig. 11. This information can be used to determine the timing for the initial spray and the need for subsequent applications (Table 1).

Figure 11. A typical rotating-arm spore sampler used to monitor *B. squamosa* spores in the field.

Step 3. Disease monitoring. Knowing what is happening in the field is essential to optimize BLB management. Field monitoring of lesion development as well as disease incidence and severity could be used to reinforce the need for fungicide sprays as determined by disease predictors, airborne inoculum or both. In addition, BLB monitoring could be used to evaluate the effectiveness of the last fungicide sprays (Fig. 12).

Several tools and new information are now available for optimal and sustainable use of fungicides to manage BLB of onion. Also, some of these tools and information are being offered to growers through various services available in some eastern provinces (e.g. Quebec and Ontario). Using these tools will enable growers to maintain disease pressure below the economic threshold and achieve optimal onion yield with minimum use of fungicides.

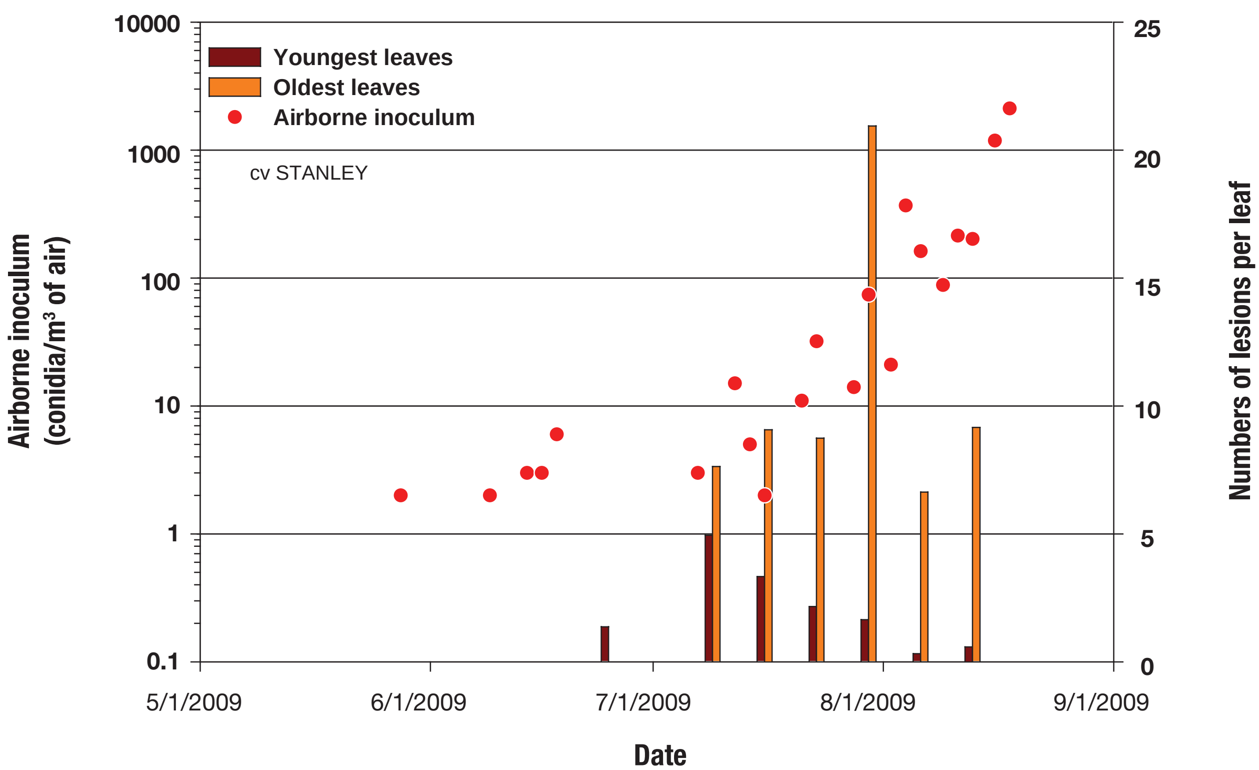

Figure 12. Relationship between airborne inoculum and BLB progress in a managed onion field.

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Other useful resources

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About the Pesticide Risk Reduction Program at Agriculture and Agri-Food Canada

The Pesticide Risk Reduction Program delivers viable solutions for Canadian growers to reduce pesticide risks in the agricultural and agri-food industry. In partnership with the Pest Management Regulatory Agency of Health Canada, the Program achieves this goal by coordinating and funding integrated pest management strategies developed through consultation with stakeholders and pest management experts.

The Pesticide Risk Reduction Program is actively pursuing the development and implementation of strategies which are key to reducing pesticide risks in the agricultural environment. To view the Program’s current priorities and the issues being addressed, visit: www.agr.gc.ca/pmc. To consult other factsheets in this series, visit: www.agr.gc.ca/sustainable-crop-protection.

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