Developing Response Strategies Against Powdery Mildew of Strawberry Based on Risk Estimation and Fungicide Effectiveness

Project QP0018CO

Applicant

Association des producteurs de fraises et framboises du Québec (APFFQ)

Final Report

January 2010

Report written by

Jean Coulombe, M.Sc., Agr., Carl Boivin, M.Sc., Agr.
and Caroline Landry, M.Sc.

With the collaboration of

Odile Carisse, PhD and Julie Bouchard, M.Sc., Agr.-Biol.

January 2010

Table of Contents

List of Tables

List of Figures

1. PROJECT DESCRIPTION

1.1 General Objective

The general objective for this project is to bring to strawberry producers, whose business activity is generating sales of over 21 million dollars annually, a set of reliable and operational protection methods in controlling powdery mildew of strawberry, a fungal disease that is substantially increasing in Quebec strawberry fields. This way, producers will be able to provide consumers with a quality strawberry produced in an environmentally-friendly manner.

1.2 Specific Objectives

- Adapt a forecasting model of powdery mildew risks on strawberry plants to our climatic conditions and production systems;
- Develop one or more pest management strategies against powdery mildew of strawberry by the rational use of certified fungicides, fungicides awaiting certification and new bio-fungicides.

1.3 Objectives Achievement

Although the study hasn't allowed for adapting a model to our climatic conditions, it however allowed to assert that the Gubler-Hoffman model isn't applicable as it is in the Quebec region's conditions. In addition, certain variables have been identified to predict the evolution of a disease through the development of its pathogen. They are: the use of several meteorological variables, the sensitivity of the host plant's cultivars, and the crop's phenological stage.

Generally, the objectives of the 'Pest Management Strategies Against Powdery Mildew' part have been completed and disseminated. Through lack of effective certified pesticides and a model to predict the disease's evolution through the development of its pathogen, validation of the pest management strategies at the commercial scale has not been completed.

2. RESULTS AND ANALYSIS

2.1 Epidemiology and Modeling Part

2.1.1 Highlights

Results achieved with the Gubler-Hoffman model (Appendix A-1) indicate that it isn't appropriate for Quebec conditions. Indeed, with a total number of fungicide applications superior or equal to other treatments, we did not observe a significantly lower severity of powdery mildew in plots where it was used as a decision-making criterion.

Regarding the classification tree analysis, it helped assert that the presence of powdery mildew of strawberry inoculum in the air varies according to several meteorological variables such as mean relative humidity, mean temperature, and daily maximum/minimum air temperature (Appendix A-6).

2.1.2 Methodology and Objectives

Experimental Designs and Treatments

Two sites were located at Île d'Orléans, i.e. one established with a traditional strawberry plant cultivar ('Darselect') and another one day-neutral ('Seascape'). All six treatments under study were set up into randomized complete blocks and are detailed in Appendix A-2.

Regarding the Saint-Charles-de-Bellechasse site, both phytosanitary treatments and all four cultivars were laid out in a split-plot repeated four times. The phytosanitary treatments, i.e. T1 (no treatment) and T2 (with treatment) were in main plots and the 'Jewel', 'Cavendish', 'Kent' and 'Darselect' cultivars were laid out in sub-plots.

Finally, the site established in Deschambault consisted of the 'Seascape' and 'Jewel' cultivars. This site was used to verify the ontogenic resistance of these two cultivars (Appendix A-3).

Data Collection

For sites located at Île d'Orléans, the T°, the air's RH at the vegetation cover level and the pluviometry were continuously measured from May to September. Furthermore, the number de conidia[1] per cubic metre of air was measured three times a week with a spore sampler (Figure 2 of Appendix A-7). In addition, the severity of the disease was observed on leaves on appearance of symptoms and signs four times for the 'Darselect' site (July 3, 10, 17, and 24, 2007) and seven times for the 'Seascape' site (July 30, August 9, 16, 21, and 29, September 7 and 12, 2007).

[1] Spores ensuring fungus reproduction

Finally, the severity of the disease on leaves was quantified with ratings [2] (0 to 5) corresponding to a percentage of covering by powdery mildew in the inner face of newly-mature young leaves.

Regarding the St-Charles-de-Bellechasse site, the incidence of cleistothecia (presence or absence thereof) on the inner and upper surfaces of leaves was noted on September 21, 2006 and the incidence of powdery mildew (presence or absence thereof) on the fruits of the four cultivars, on July 11 and 16, 2007. These observations were made visually.

Data gathered were statistically analyzed with the SAS's GLIMMIX procedure and with the help of the DTREG software (version 6.0).

Objectives

- Validation and refinement of a forecasting model of the powdery mildew epidemic risks in strawberries through the application of appropriate response strategies, based on risk signs (presence of spores in the air and meteorological data);
- Evaluation of the sensitivity level to powdery mildew of different traditional strawberry plant cultivars;
- Determination of the sensitivity of leaves and strawberries to powdery mildew according to their age (ontogenic resistance).

2.1.3 Results

'Darselect' Site

Regarding whether the Gubler-Hoffman forecasting model of powdery mildew of strawberry (Appendix A-1) is effective under the conditions in which it was tested, results observed for T6 of the 'Darselect' site (Table 1) indicate that it isn't. In plots where it was used as a decision-making criterion, powdery mildew severity did not significantly decrease and, in addition, it generated a number of fungicide applications superior or equal to other treatments (Table 3). The frequency of intensity ratings 3, 4, and 5 were higher for other treatments than for the T5 treatment (Table 1).

'Seascape' Site

Fungicides used for the T1 to T3 treatments were Kumulus, Nova, and Pristine. Compared to T2 and T3, the intensity of powdery mildew observed on August 16 and 21 in T6 was lower (p=0.0237 and 0.0011) as well as on August 29, as compared to T1 to T3 (p=0.0027, 0.0005, and 0.0013). Also, the frequency of high intensity ratings (3 to 5) of T6 was nil or very low for the six sampling dates (Table 2). However, the fungicides used were very different that those used for T6 for the 'Darselect' site (Flint and Quintec). Consequently, it is possible that the difference observed is attributable to the effectiveness of the fungicides used, even to the cultivars' sensitivity.

[2] Percentages associated with severity ratings: **0**: < 0% **1**:]0-10%] **2**:]10-25%] **3**:]25-50%] **4**:]50-75%] **5**: > 75%

Table 1. Frequencies observed based on severity rating per treatment for the 'Darselect' site

Dates	Treat.	Ratings						Dates	Treat.	Ratings					
		0	1	2	3	4	5			0	1	2	3	4	5
		< 25%			> 25%					< 25%			> 25%		
July 3	T1	0	1	3	15	16	5	July 17	T1	0	0	9	17	13	1
	T2	0	5	10	11	6	8		T2	0	4	9	14	12	1
	T3	0	2	4	7	11	16		T3	0	0	10	14	11	5
	T4	0	1	1	10	12	16		T4	0	1	16	15	6	2
	T5	1	24	12	3	0	0		T5	0	27	13	0	0	0
	T6	0	1	2	8	12	17		T6	0	0	11	13	15	1
		0	1	2	3	4	5			0	1	2	3	4	5
July 10	T1	0	0	16	16	7	1	July 24	T1	0	2	11	18	7	2
	T2	0	6	16	12	5	1		T2	0	4	9	16	8	3
	T3	0	4	12	8	13	3		T3	0	5	10	14	11	0
	T4	0	2	10	14	8	6		T4	0	5	22	10	3	0
	T5	0	25	13	1	1	0		T5	0	22	16	2	0	0
	T6	0	0	3	10	17	10		T6	0	3	12	17	8	0

Table 2. Frequencies observed per treatment based on severity rating for the 'Seascape' site

Dates	Treat.	Ratings						Dates	Treat.	Ratings						Dates	Treat.	Ratings					
		0	1	2	3	4	5			0	1	2	3	4	5			0	1	2	3	4	5
		< 25%			> 25%					< 25%			> 25%					< 25%			> 25%		
July 30	T1	0	14	16	10	0	0	August 16	T1	0	22	12	6	0	0	August 29	T1	0	8	14	12	5	1
	T2	0	7	15	12	5	1		T2	0	19	14	6	1	0		T2	0	3	15	16	5	1
	T3	0	5	12	19	4	0		T3	0	11	15	10	4	0		T3	0	6	15	12	7	0
	T4	0	9	11	11	7	2		T4	0	26	10	3	1	0		T4	0	16	14	10	0	0
	T5	0	20	14	6	0	0		T5	1	35	4	0	0	0		T5	0	33	6	1	0	0
	T6	0	10	13	13	4	0		T6	1	32	7	0	0	0		T6	0	25	11	1	3	0
		0	1	2	3	4	5			0	1	2	3	4	5			0	1	2	3	4	5
August 9	T1	0	20	16	4	0	0	August 21	T1	0	20	14	6	0	0	September 7	T1	0	17	13	9	1	0
	T2	0	18	14	7	1	0		T2	0	19	15	5	1	0		T2	0	14	16	7	3	0
	T3	0	25	13	2	0	0		T3	0	16	18	6	0	0		T3	0	15	14	7	4	0
	T4	0	19	14	5	2	0		T4	1	21	13	5	0	0		T4	0	24	11	4	1	0
	T5	0	32	8	0	0	0		T5	0	38	2	0	0	0		T5	0	32	7	1	0	0
	T6	0	25	11	4	0	0		T6	0	29	11	0	0	0		T6	1	23	11	2	2	1

It is possible that the Gubler-Hoffman model, based solely on air temperature, does not allow to correctly predict the presence of powdery mildew spores in the air. The classification tree analysis has helped establish the basis of a forecasting system for powdery mildew inoculum in the Quebec region from a set of meteorological data (temperature, relative humidity (RH), precipitations). A target variable (spore concentration in the air) can be predicted by using forecasting (meteorological) variables. The classification tree is built on a binary basis, meaning that a mother branch is divided into two groups (daughter branches), and similarly for each daughter branch. This way, the meteorological variables with a strong impact on the powdery mildew spore concentration are mean relative humidity, mean temperature and daily maximum/minimum temperatures. Appendix A-6 is presenting the complete classification tree. For example, for a given day, if the mean RH was > 70%, the maximum temperature was > 19°C and the minimum temperature was ≤ 12°C, chances of having a large spore concentration in the air (CAT 3) were high.

Cultivar Assessment (Saint-Charles-de-Bellechasse)

When compared among each other, the treated plots (T2) and the control plots (T1), the sum of cleistothecia frequencies observed in the fall of 2006 was not significantly different for all cultivars (Table 3). However, there is a difference between certain cultivars (p=0.0003). Indeed, the lowest incidence was observed with 'Kent' and 'Darselect'.

Table 3. Sum of cleistothecia frequencies observed in 2006 and average percentage of fruits showing presence of powdery mildew in 2007 for 4 cultivars

Treatments	Cultivars	Cleistothecia 2006 (frequency observed)	Fruits with powdery mildew 2007 (average %)
T1 (no treatment)	Jewel	21	5.5
	Darselect	10	22.7
	Cavendish	13	21.0
	Kent	8	20.3
T2 (complete protection against powdery mildew)	Jewel	10	11.0
	Darselect	3	41.5
	Cavendish	6	24,0
	Kent	3	22.3

The probability of observing powdery mildew in the summer of 2007 on fruits of the 'Jewel' cultivar was very low as opposed to other cultivars for T1 (Table 3). In addition, the risk of observing powdery mildew on 'Jewel' fruits is about reduced by half when compared to 'Cavendish' and 'Kent' and four times lower than 'Darselect' for T2 (Table 3). From results achieved, it is hard to determine the impact of the incidence of cleistothecia observed in the fall of 2006 on powdery mildew development on fruits in 2007. Indeed, there could be a powdery mildew sensitivity difference between the different parts of the plant. This way, a ripe strawberry could be considerably less sensitive than a young leaf. However, this explication is still an assumption. Finally, as reported by Viret, Ancay and Terrettaz (1998), the role of cleistothecia as an infection source has never been proven.

Deschambault Site (Ontogenic Resistance)

The objective pursued for this site was to determine the sensitivity of the traditional and day-neutral strawberry plant leaves based on their age. The information gathered on the ontogenic resistance of strawberry plants would have been used to define windows of opportunity for intervention against powdery mildew. Artificial field inoculation (Appendix A-3) was harder than expected. Also, in addition to inoculations that didn't help achieved satisfying results, several strawberry plants became infected with verticillium wilt (*Verticillium* spp.).

2.1.4 Conclusions

The study on powdery mildew epidemiology enables us to assert that a forecasting system that only uses temperature as variable to understand the disease's evolution is not complete (Gubler-Hoffman model). Indeed, since the maximum risk index (100) was reached in early June, temperature can't be the only discriminant variable with regard to the quantity of powdery mildew spores in the air. Thus, the Gubler-Hoffman model is not applicable as is in the Quebec region's conditions. In each of the existing forecasting systems, here are a few of the constants observed to predict the evolution of a disease through the development of its pathogen: the use of several meteorological variables, the sensitivity of the host plant's cultivars and its phenological stage. Although powdery mildew can be controlled with fungicides applied regularly, they are not required if environmental conditions aren't favourable to the development of the disease and if there is little or no quantity of spores in the air (inoculum). Although the classification tree analysis remains a tracking study since it was never used to this end, it could help improve the tools available to producers and advisors for good powdery mildew management. Other studies will be necessary to improve this forecasting system by adding more variables, such as wind speed or light length and intensity.

2.2 Pest Management Strategies

2.2.1 Development of Response Strategies in Production Year of Traditional and Day-Neutral Strawberry Plants

Tests in traditional strawberry plants were completed in strawberry fields established the previous year at Île d'Orléans producers (Table 4). Tests in day-neutral strawberry plants have been established during the production year at Île d'Orléans and St-Nicolas producers (Table 5). Tests for both types of strawberry plants have been carried out according to a complete randomized block device including four repetitions. Detailed treatments, treatment application dates, and strawberry plant stage are described in the progress reports for the 2006 and 2007 seasons and in Appendix B for the 2008 season. The doses used are described in Appendix C.

Table 4. Summary description of tests completed in traditional strawberry plants at Île d'Orléans

Season	Cultivar	Management	Number of treatments
2006	Jewel	Matted rows	6
2007	Darselect	Plastic mulch	6
2008	Darselect	Matted rows	8
2008	Darselect	Plastic mulch	8

Table 5. Summary description of tests completed in day-neutral strawberry plants (Seascape cv)

Season	Site	Management	Number of treatments
2006	Île d'Orléans	Plastic mulch	6
2007	Île d'Orléans	Plastic mulch	6
2008	Île d'Orléans	Plastic mulch	8
2008	St-Nicolas	Plastic mulch	8

2.2.2 Traditional Strawberry Plants

The incidence of powdery mildew (*Sphaerotheca macularis* f. sp. *fragariae)* was low in the matted row tests, with the Jewel cultivar in 2006 and the Darselect cultivar in 2008. No difference between treatments (including 'No treatment') in 2008 has been observed. On plastic mulch, a strong incidence of the disease has been observed with the Darselect cultivar for both testing seasons (2007 and 2008). Results presented in this report are only for tests conducted on plastic mulch.

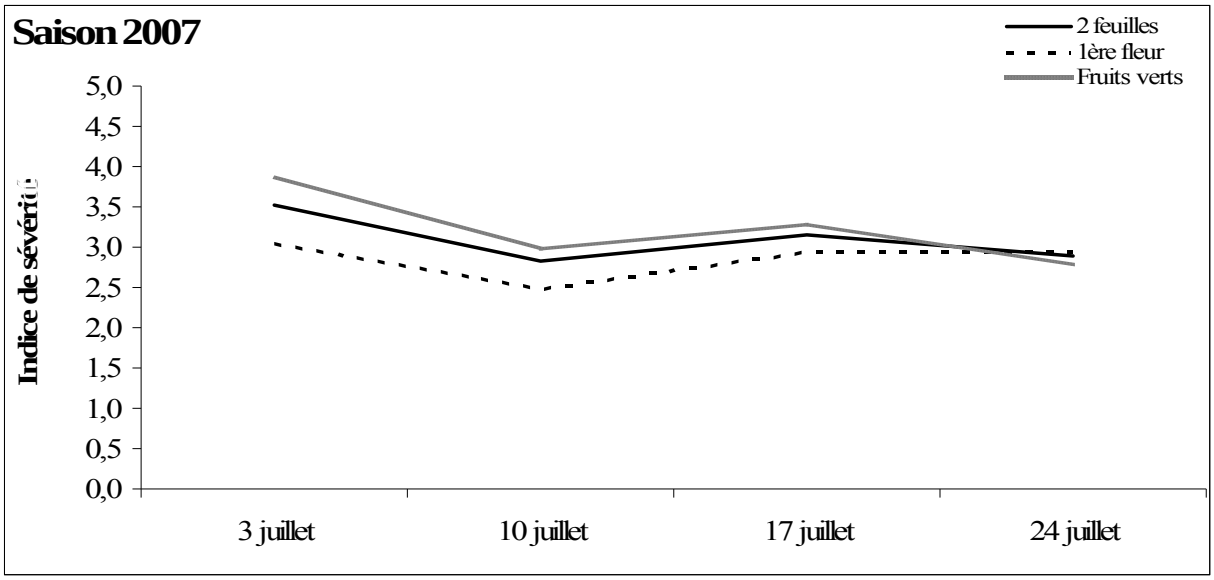
Developmental stage of strawberry plants for the first intervention to manage powdery mildew at the start of the season

Dates of the first treatments and products used are presented in Table 6. Results are not indicating any reduction in the incidence of powdery mildew for treatments with sulfur at the 2 leaves and 1st flower stage for both testing seasons with the Darselect cultivar on plastic mulch (Figure 1). In 2008, it was also observed that an early treatment with Flint, another fungicide known for being effective in controlling powdery mildew, did not influence powdery mildew development during the season compared to sulfur (Figure 2). It seems that the first treatment with sulfur or another fungicide against powdery mildew of strawberry could be delayed at the green fruit stage. At Île d'Orléans, despite conditions that are favourable to powdery mildew development (Figure 3), the number of powdery mildew spores in the air remained low up until the green fruit stage for both testing seasons (Figure 4). However, these results must be validated at the commercial level and for the other production areas.

Table 6 Treatment based on the traditional strawberry plant (Darselect cv on plastic mulch) stage at the first treatment to control powdery mildew

Stade du fraisier au 1er traitement	**Date 1er traitement**		**Produit appliqué***		
	2007	**2008**	**2 feuilles**	**1ère fleur**	**Fruits verts**
2 feuilles	26 mai	24 mai	Soufre	Soufre	Pristine 2007 Flint 2008
1ère fleur	7 juin	4 juin	-	Soufre	Pristine 2007 Flint 2008
Fruits verts	18 juin	12 juin	-	-	Pristine 2007 Flint 2008

** The applied products were the same for all treatments from the green fruit stage.*



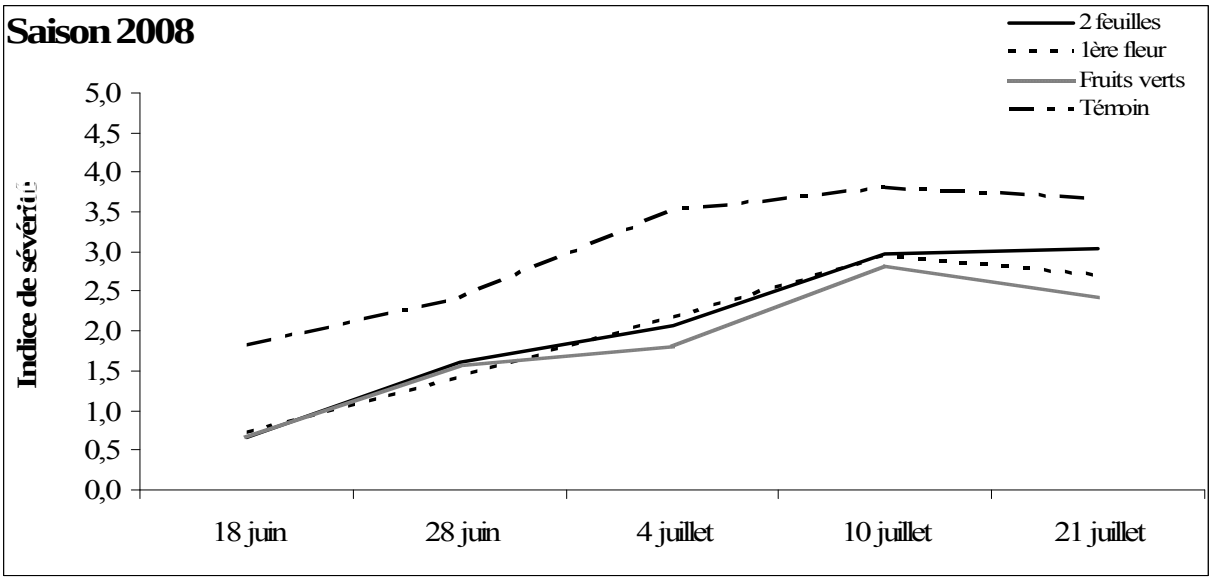


Figure 1. Effect of the developmental stage of traditional strawberry plants (Darselect cv) on the development of powdery mildew on the flag leaf, Île d'Orléans.

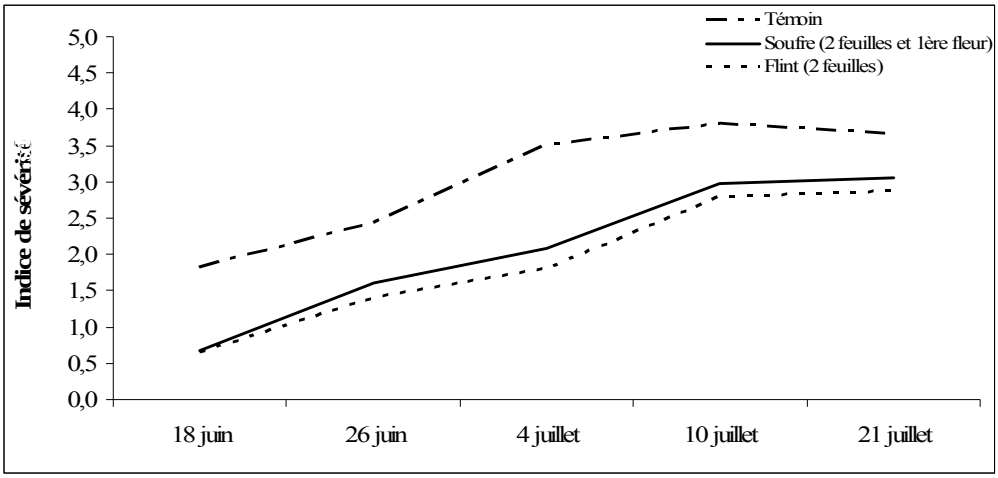


Figure 2. Effect of the product for treatments early into the season to manage powdery mildew on the mature flag leaf of strawberry plants, on plastic mulch, Darselect cv, 2008 season.

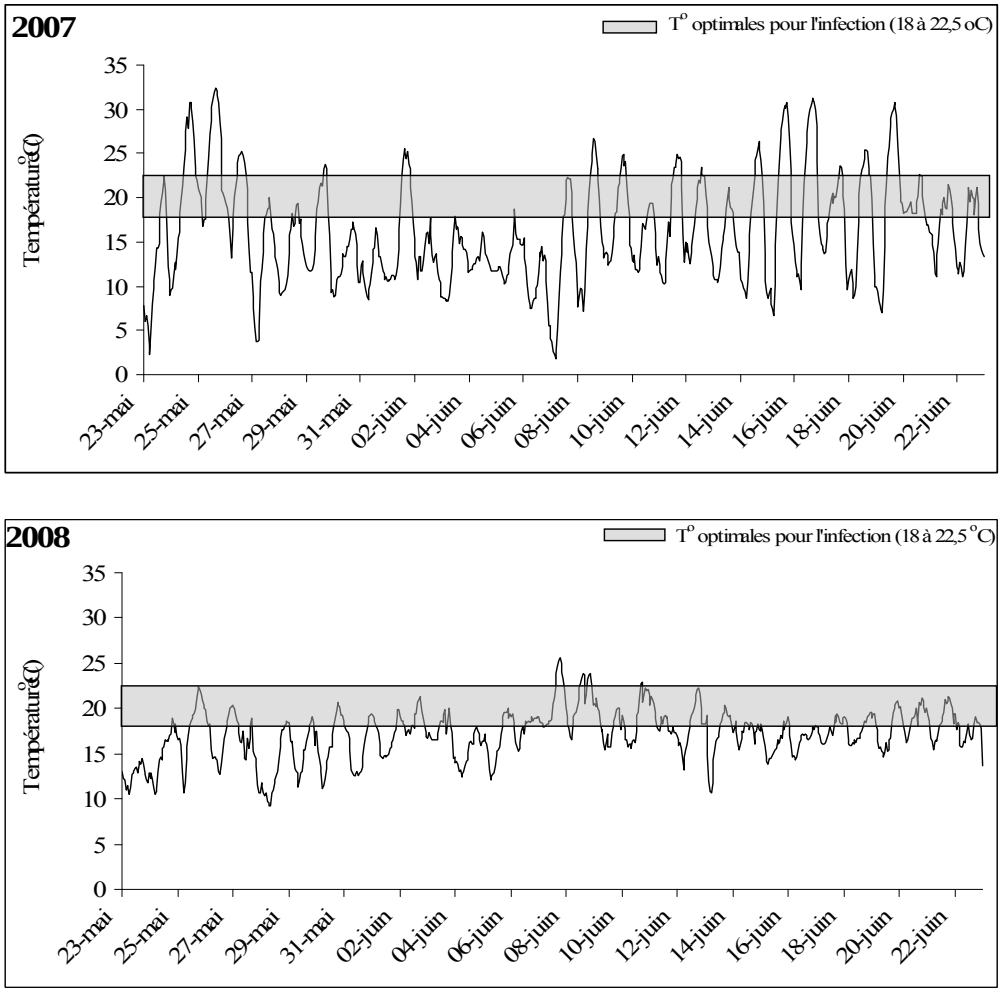


Figure 3. Hourly temperatures near the vegetation cover in traditional strawberry plants (Darselect cv) on plastic at Île d'Orléans.

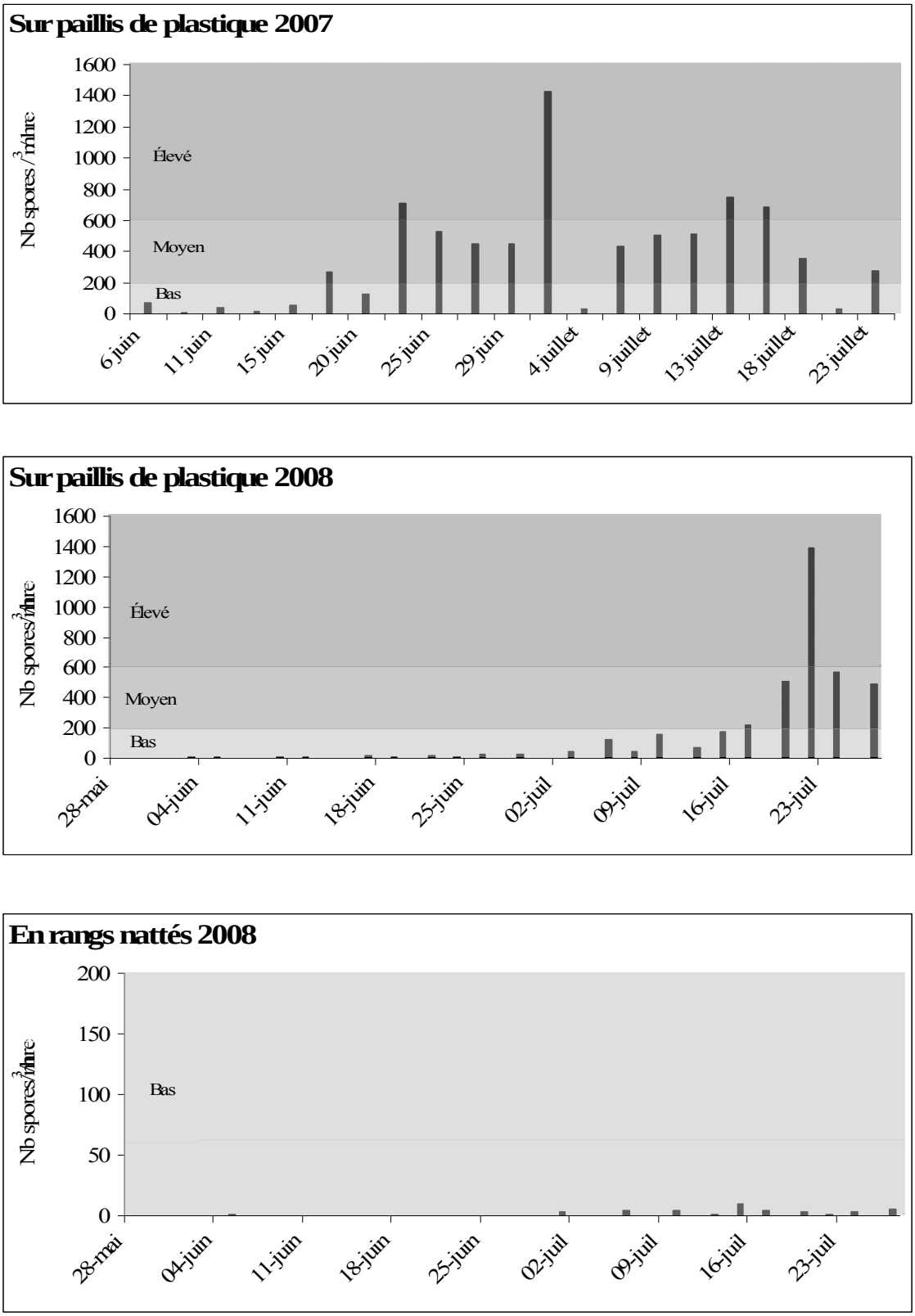


Figure 4. Evolution of the number of powdery mildew spores (*Sphaerotheca macularis* f. sp. *fragariae*) in the air, test with traditional strawberry plants (Darselect cv).

Strategies for Fungicide Application on the Development of Powdery Mildew of Strawberry

Tests have also been conducted to determine the effectiveness of the different sequences of different products in controlling powdery mildew of strawberry. In 2007, results indicated that the best treatments were the application of Flint and Quintec alternatively, followed by the producer's program (Table 7). In 2008, the CRAAQ program (sulfur, Pristine followed with Nova+Switch) has led to a control that was as effective as the use of Flint instead of Pristine (Table 8). Moreover, the effectiveness of Pristine has been demonstrated in fungicide tests conducted on the Darselect cultivar after renovation in 2006 and 2008 (Table 9). In 2008, alternating Actinovate and Nova alone or combined with Switch did not significantly reduce the incidence of powdery mildew of strawberry (Table 8). Nova's decrease in effectiveness was demonstrated in fungicide tests after Darselect cv strawberry plant renovation (Section 2.2.4, Table 15). In addition, Actinovate did not significantly reduce the incidence of powdery mildew in bio-fungicides tests conducted in the Darselect cv strawberry plants after renovation (Section 2.2.4, Table 16). However, Switch used alone or combined with Nova has reduced the incidence of powdery mildew (Section 2.2.4, Table 15). These results indicate that the products' effectiveness must be considered for developing pest management strategies to control powdery mildew of strawberry. The low number of spores in the air for the matted row test with the Darselect cultivar in 2008 (Figure 4) likely explains the low incidence of the disease. These results indicate that control of powdery mildew in traditional strawberry plants during the production year would be more important for a crop on plastic rather than on matted rows. However, these results must be validated at the commercial level and for the other production areas.

Table 7. Effect of different fungicide application strategies on powdery mildew development on the mature flag leaf of traditional strawberry plants (Darselect cv) on plastic mulch, Île d'Orléans, 2007 season

Traitement	Indice de sévérité (0-5)*			
	3 juillet	10 juillet	17 juillet	24 juillet
Soufre 7 juin - Nova 18 juin - Pristine 25 juin - Nova 1er juillet - Pristine 10 juillet (programme du producteur)	3,1 b**	2,5 c	2,9 a	2,9 a
Pristine 7 juin - Nova 18 juin - Pristine 25 juin - Nova 1er juillet - Flint 10 juillet	4,0 a	3,2 b	2,8 a	2,3 b
Flint 7 juin - Quintec 18 juin - Flint 25 juin - Quintec 3 juillet - Flint 10 juillet	1,4 c	1,5 d	1,3 b	1,5 c
Soufre 31 mai - Soufre 7 juin - Nova 18 juin - Nova 25 juin - Soufre 1er juillet - Pristine 10 juillet	4,1 a	3,9 a	3,2 a	2,8 a

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 8. Effect of different fungicide application strategies on powdery mildew development on the mature flag leaf of traditional strawberry plants (Darselect cv) on plastic mulch, Île d'Orléans, 2008 season

Traitement	Indice (0-5)*				
	18 juin	26 juin	4 juillet	10 juillet	21 juillet
Témoin (aucun traitement)	1,83 a**	2,43 a	3,52 a	3,82 a	3,68 a
CRAAQ: Soufre 3 juin - Pristine 12 juin - Nova+Switch 1er juillet	0,58 b	1,50 b	2,10 b	3,03 a	2,87 b
Soufre 24 mai - Flint 12 juin - Nova+Switch 1er juillet	0,73 b	1,43 b	2,18 b	2,95 a	2,72 b
Soufre 24 mai - Actinovate 3 juin - Nova + Switch 12 juin - Actinovate 1er juillet - Nova 8 juillet	1,07 ab	1,63 b	2,87 ab	3,42 a	3,23 ab
Soufre 3 juin - Flint 12 juin - Nova 1er juillet	1,10 ab	1,67 b	2,07 ab	3,23 a	3,30 ab

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

2.2.3 Day-Neutral Strawberry Plants

Developmental stage of day-neutral strawberry plants for the first intervention to control powdery mildew at the start of the season

Dates of the first treatments and products used are presented in Table 9. Results are not indicating any reduction in the incidence of powdery mildew on the mature flag leaf for treatments with sulfur and/or Nova before the 6-8 leaves stage for all three testing seasons with the Seascape cultivar on plastic mulch (Figures 5 and 6). In addition, these treatments early into the season have not influenced the development of powdery mildew on old leaves during the 2008 season (Figure 7). At Île d'Orléans and St-Nicolas, despite conditions that are favourable to powdery mildew development (Figure 8), the number of powdery mildew spores in the air remained low up until the 6-8 leaves stage for all three testing seasons (Figure 9). However, these results must be validated at the commercial level and for the other production areas.

Table 9. Treatment based on the stage of day-neutral strawberry plants (Seascape cv) at the first treatment to control powdery mildew

Stade du fraisier au 1er traitement	Date 1er traitement			Produit appliqué*		
	2006	2007	2008	2-4 feuilles	4-6 feuilles	6-8 feuilles
2-4 feuilles	27 mai	31 mai	4 juin	Soufre	Nova 2006 Soufre 2007 Soufre 2008	Nova 2006 Nova 2007 Flint 2008
4-6 feuilles	2 juin	14 juin	12 juin	-	Nova 2006 Soufre 2007 Soufre 2008	Nova 2006 Nova 2007 Flint 2008
6-8 feuilles	12 juin	23 juin	20 juin	-	-	Nova 2006 Nova 2007 Flint 2008

** The applied products were the same for all treatments from the 6-8 leaves stage.*

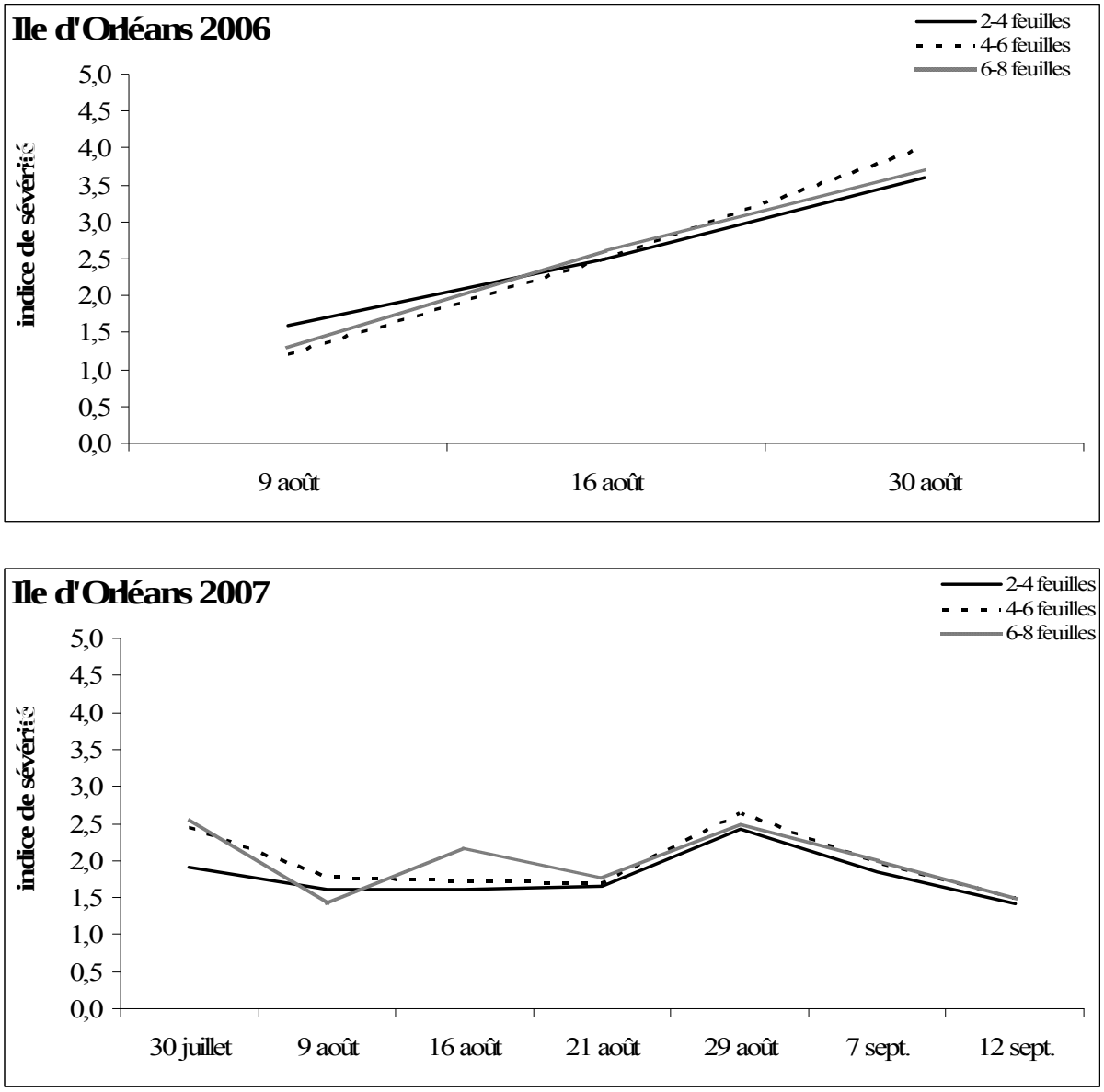
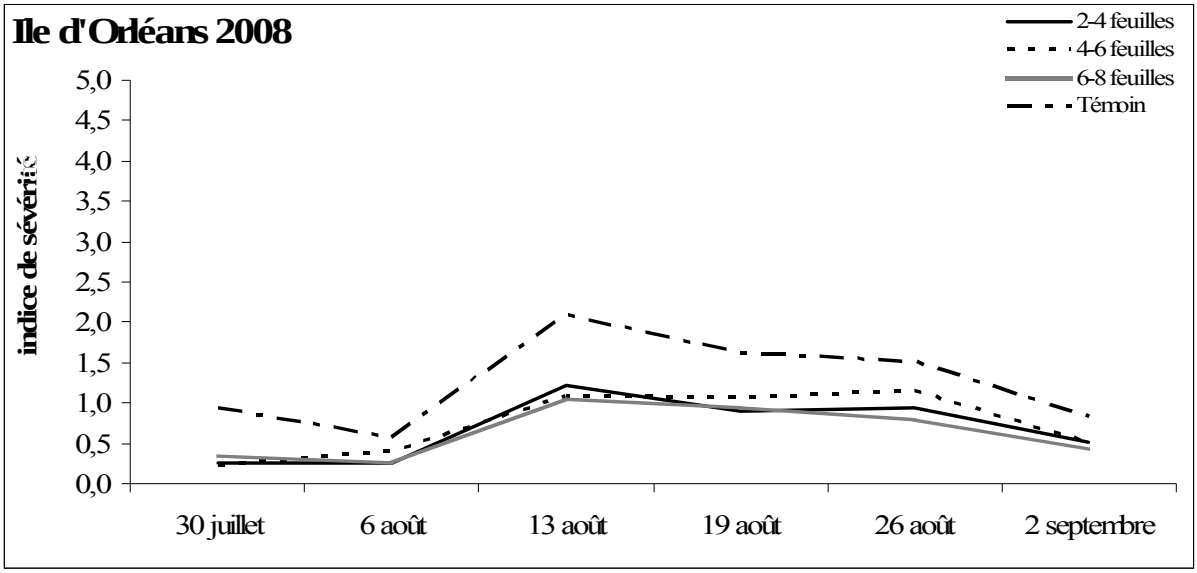


Figure 5. Effect of the developmental stage of day-neutral strawberry plants (Seascape cv) on the development of powdery mildew on the flag leaf, Île d'Orléans, 2006 and 2007 seasons.



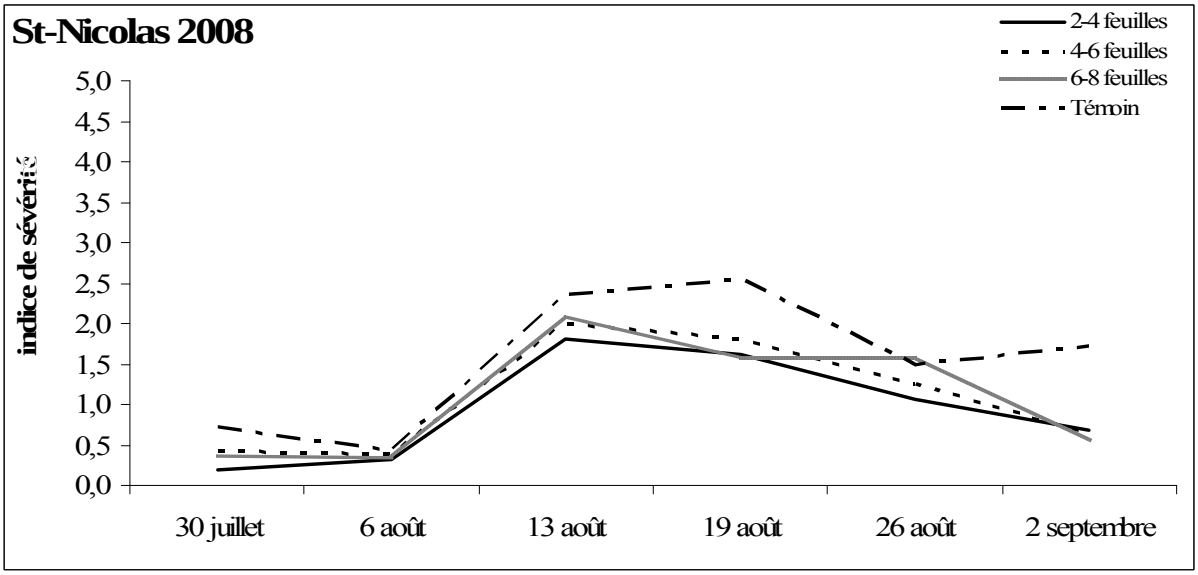


Figure 6. Effect of the developmental stage of day-neutral strawberry plants (Seascape cv) on the development of powdery mildew on the flag leaf, 2008 season.

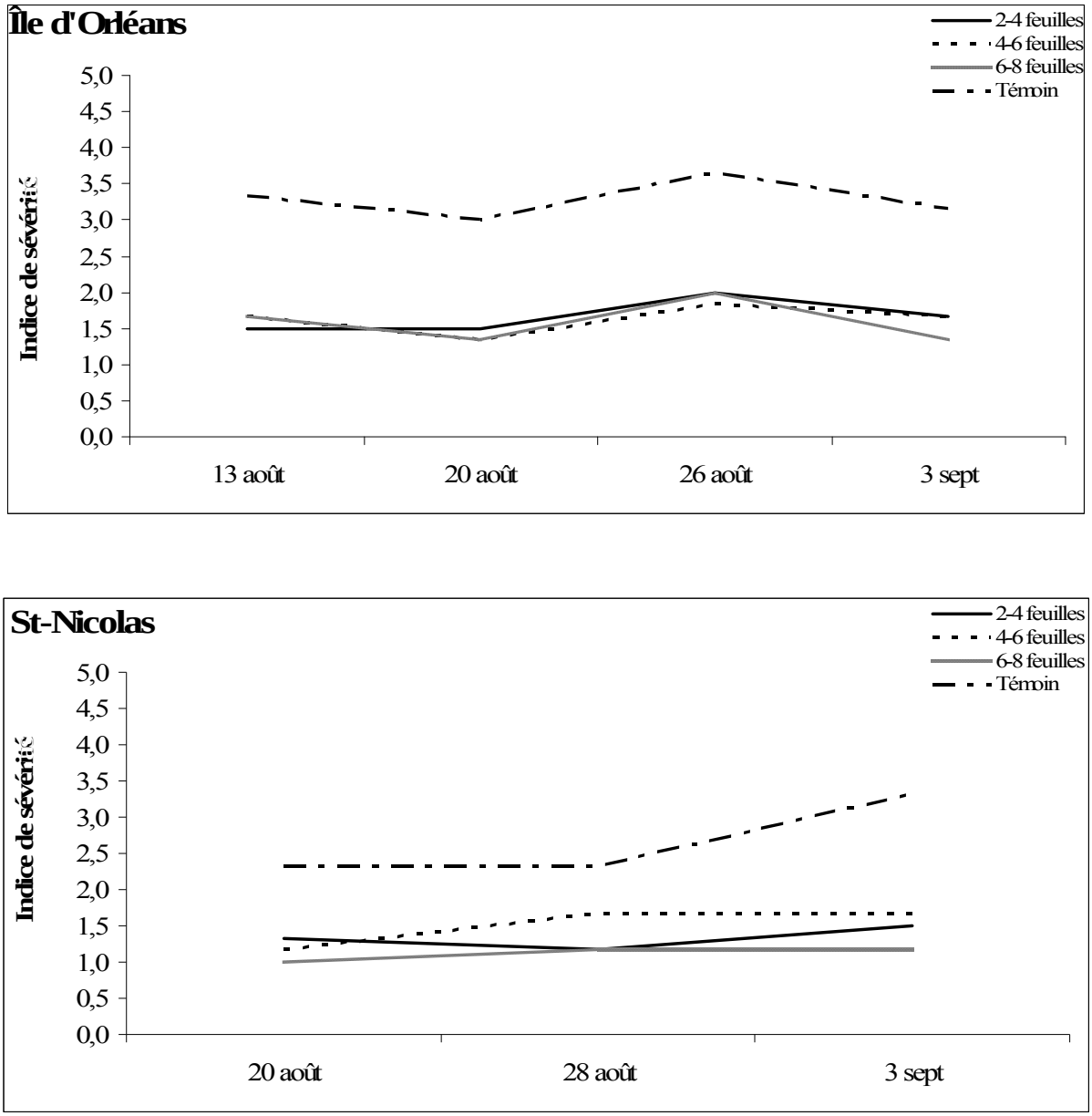


Figure 7. Effect of the developmental stage of day-neutral strawberry plants (Seascape cv) on the development of powdery mildew on old leaves, Île d'Orléans and St-Nicolas, 2008 season.

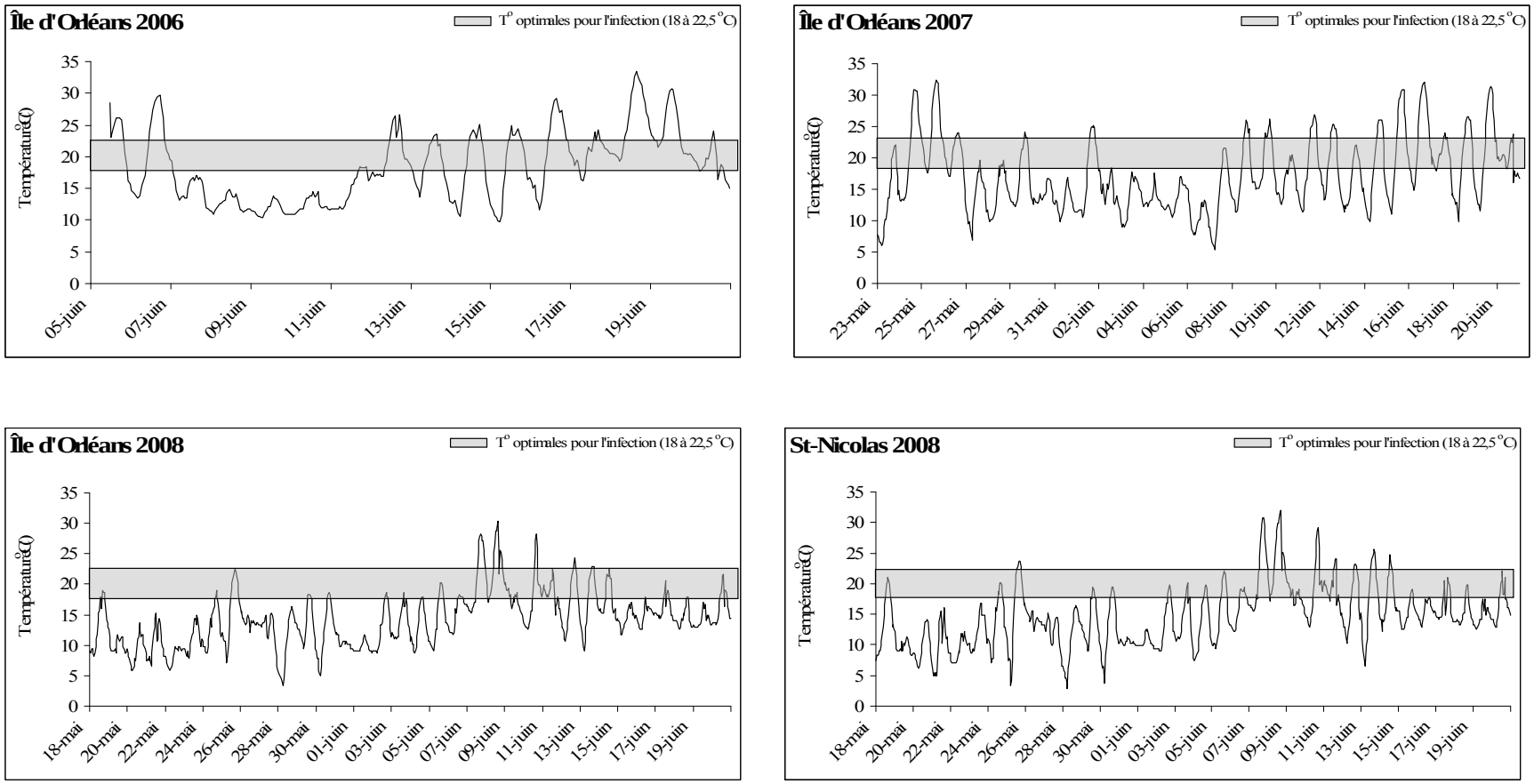


Figure 8. Hourly temperatures near the vegetation cover in day-neutral strawberry plants (Seascape cv) on plastic.

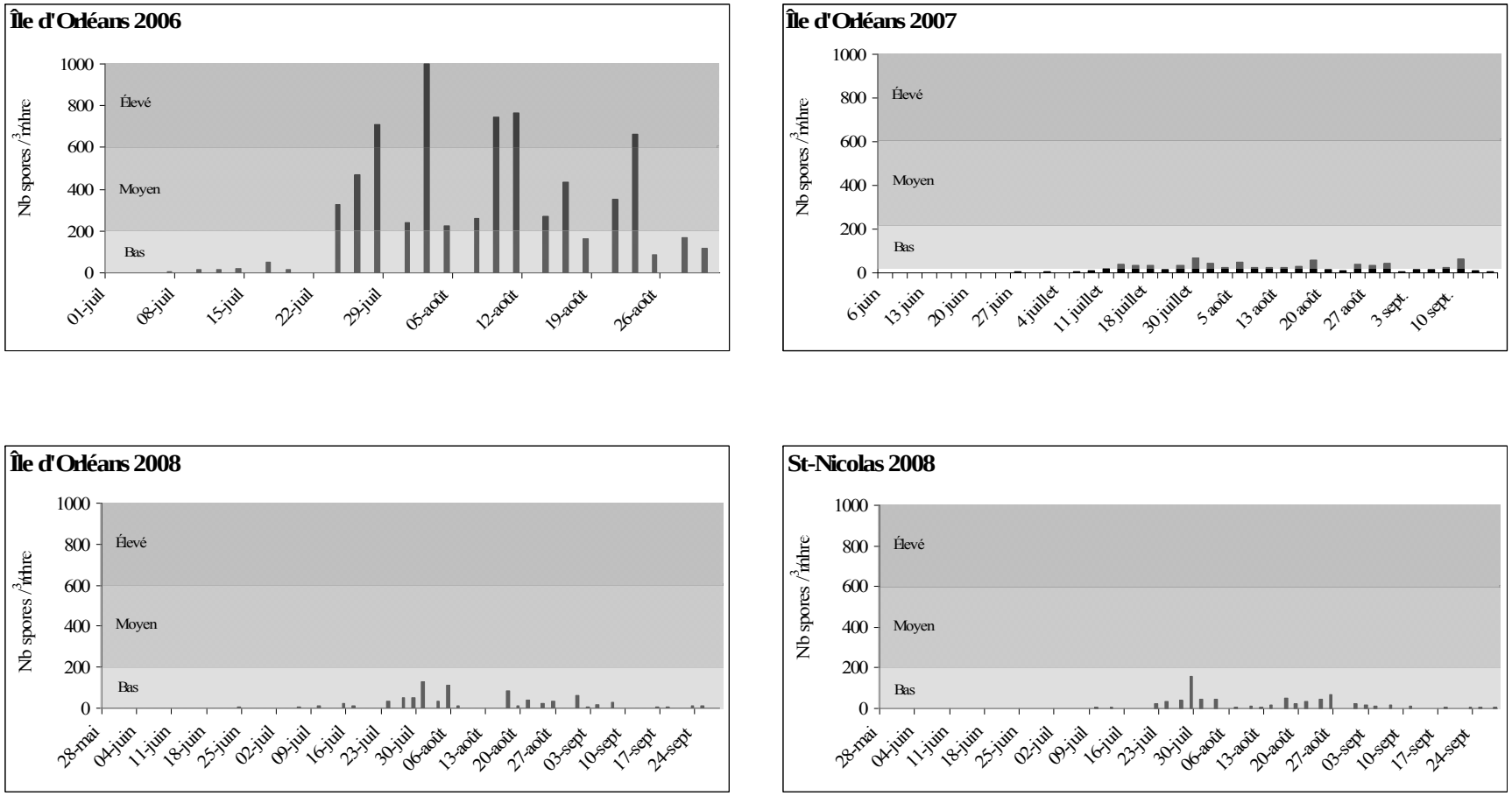


Figure 9. Evolution of the number of powdery mildew spores in the air, test with day-neutral strawberry plants (Seascape cv) on plastic.

Strategies for Fungicide Application on the Development of Powdery Mildew of Strawberry

The tests have also been conducted to determine the effectiveness of the different sequences of different products in controlling powdery mildew of day-neutral strawberry plants. In 2006, results indicated that Silamol applied before the first treatment with Nova and five times alternatively with the producer's program did not improve powdery mildew control (Table 10). Moreover, Silamol had not significantly reduced the incidence of powdery mildew in bio-fungicides tests after traditional Darselect cv strawberry plant renovation (Section 2.2.4, Table 16). Although we are observing a significant difference in the incidence of powdery mildew severity for readings on August 16, 2006 between the producer's program and programs A and B based on the Gubler model, these differences would probably be due to variations on the experimental site. Indeed, treatments of July 28 and August 3 and 12 were the same (Pristine, Nova + Switch and Pristine respectively). However, the total number of treatments was less in program B compared to program A and the producer's program (Table 10).

In 2007, Flint applied from July 12 has given the best powdery mildew control (Table 11). However, Quintec and Flint applied alternatively from August 1st and following the treatments recommended by the CRAAQ, was the second best treatment and significantly superior than CRAAQ treatments with certified products. These results matched those in traditional strawberry plants from 2007, which best treatment was Flint and Quintec alternatively. However, this treatment was not significantly superior than Quintec applied from July 12 in day-neutral strawberry plants.

In 2008, the incidence of powdery mildew on the mature flag leaf was low in both day-neutral strawberry plant tests (Tables 12 and 13). The evaluations on the mature flag leaf of strawberry plants were difficult and despite certain differences observed, it was hard to draw conclusions. However, the evaluation of the incidence of powdery mildew on old leaves indicates that the best treatment included Flint alternatively with Nova+Switch (Table 14). Although the treatment that included Actinovate alternatively with Nova+Switch has significantly reduced the incidence of powdery mildew and the effectiveness was comparable to the Nova and Pristine treatment alternatively, it seems that control would come not only from Actinovate, but also Switch. Moreover, Actinovate alone only somewhat reduced powdery mildew on the mature flag leaf of strawberry plants (Section 2.2.4, Table 16) and had no effect on old leaves (Table 17 of the same section).

These results indicate that pest management strategies against powdery mildew of strawberry should be based on product effectiveness and not the number of treatments. However, these results must be validated at the commercial level and for the other production areas.

Table 10. Effect of different fungicide application strategies on powdery mildew development on the mature flag leaf of strawberry plants (Darselect cv), Île d'Orléans, 2006 season

Traitement	Nombre d'applications				Indice de sévérité (0-5)*		
	Soufre	Nova	Pristine	MilStop	9 août	16 août	30 août
Programme du producteur - Nova/Soufre/Pristine en alternance	2	6	4	0	1,2 a-c**	2,5 a	4,0 a
Six applications de Silamol en plus du programme du producteur - application hâtive au Silamol le 27 mai et avant la première application de Nova du producteur	2	6	4	0	1,6 a	2,5 a	3,3 a
Programme A: Soufre tôt (27 mai) et selon le modèle de Gubler en utilisant en alternance Nova - Soufre - Pristine - MilStop	5	2	2	2	0,7 c	1,4 b	3,6 a
Programme B: Soufre tôt (27 mai) et selon le modèle de Gubler en utilisant en alternance Nova - Soufre - Pristine	2	3	3	0	1,0 bc	1,7 b	4,0 a

** Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

***For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test,with a significance level of 5%.*

Table 11. Effect of different fungicide application strategies on powdery mildew development on the mature flag leaf of strawberry plants (Darselect cv), Île d'Orléans, 2007 season

Traitement	Indice de sévérité (0-5)*					
	30 juillet	9 août	16 août	21 août	29 août	7 sept
CRAAQ: Soufre tôt en saison (31 mai et 14 juin) + Nova et Pristine en alternance du 23 juin au 26 août (3 applications de chaque): Total = 8 traitements	1,9 ab	1,6 a	1,6 a	1,7 a	2,4 a	1,9 a
Quintec du 12 juillet au 26 août: Total = 5 traitements	2,6 a	1,8 a	1,5 a	1,6 ab	1,9 b	1,6 ab
Flint du 12 juillet au 26 août: Total = 5 traitements	1,7 b	1,2 b	1,1 a	1,1 c	1,2 c	1,2 b
Soufre tôt en saison (31 mai) et **modèle de Gubler** Nova-Souffre-Nova entre 23 juin et 21 juillet puis **Quintec/Flint en alternance à partir du 1er août**: Total = 8 traitements	2,3 ab	1,5 ab	1,2 a	1,3 bc	1,6 bc	1,6 ab

** Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

*** For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 12. Effect of different fungicide application strategies on powdery mildew development on the mature flag leaf of strawberry plants (Darselect cv), Île d'Orléans, 2008 season

Traitement	Indice de sévérité (0-5)*					
	30 juil	6 août	13 août	19 août	26 août	2 sept
Témoin (aucun traitement)	0,9 a**	0,6 a	2,1 a	1,6 a	1,5 a	0,8 a
Soufre tôt en saison (4 et 12 juin) + Nova et Pristine en alternance à partir du 20 juin	0,5 ab	0,4 a	1,6 ab	1,4 a	1,1 ab	0,8 a
Soufre tôt en saison (4 et 12 juin) + Flint et Nova+Switch en alternance à partir du 20 juin	0,3 b	0,3 a	1,2 b	0,9 a	0,9 b	0,5 b
Soufre tôt en saison (4 et 12 juin) + Actinovate et Nova+Switch en alternance à partir du 20 juin	0,7 ab	0,5 a	2,2 a	1,3 a	0,9 b	0,9 a

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 13. Effect of different fungicide application strategies on powdery mildew development on the mature flag leaf of strawberry plants (Darselect cv), St-Nicolas, 2008 season

Traitement	Indice de sévérité (0-5)*					
	30 juil	6 août	13 août	19 août	26 août	2 sept
Témoin (aucun traitement)	0,7 a**	0,4 a	2,4 a	2,6 a	1,5 a	1,7 a
Soufre tôt en saison (4 et 12 juin) + Nova et Pristine en alternance à partir du 20 juin	0,4 a	0,3 a	2,0 a	1,7 a	1,2 a	1,1 ab
Soufre tôt en saison (4 et 12 juin) + Flint et Nova+Switch en alternance à partir du 20 juin	0,4 a	0,3 a	2,1 a	1,6 a	1,6 a	0,6 b
Soufre tôt en saison (4 et 12 juin) + Actinovate et Nova+Switch en alternance à partir du 20 juin	0,7 a	0,4 a	1,8 a	1,9 a	1,7 a	1,0 b

**Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

*** For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 14. Effect of different fungicide application strategies on powdery mildew control on old leaves in Seascape cv strawberry plants, 2008 season

Traitement	Indice de sévérité (0-5)*						
	Ile d'Orléans				St-Nicolas		
	13 août	20 août	26 août	3 sept	20 août	28 août	3 sept
Témoin (aucun traitement)	3,3 a**	3,0 a	3,7 a	3,2 a	2,3 a	2,3 a	3,3 a
Soufre tôt en saison (4 et 12 juin) + Nova et Pristine en alternance à partir du 20 juin	2,2 bc	2,2 ab	2,7 b	2,3 b	1,7 bc	1,7 bc	2,0 b
Soufre tôt en saison (4 et 12 juin) + Flint et Nova+Switch en alternance à partir du 20 juin	1,7 c	1,3 b	2,0 c	1,3 c	1,0 c	1,2 c	1,2 c
Soufre tôt en saison (4 et 12 juin) + Actinovate et Nova+Switch en alternance à partir du 20 juin	2,3 ab	3,0 a	2,8 b	2,8 ab	2,0 ab	2,0 ab	2,7 ab

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

2.2.4 Fungicide and Bio-Fungicide Evaluation

The effectiveness of fungicides and bio-fungicides has been evaluated in tests conducted with the Darselect cultivar and following renovation in 2006 and 2008. Fungicides were applied biweekly, while sulfur (Kumulus) and bio-fungicides were applied weekly. The detailed treatments and treatment application dates are described in the 2006 progress report and in Appendix B for the 2008 season. The doses used are described in Appendix C.

The results of fungicide tests are presented in Table 15. The sulfur (Kumulus) treatments and all fungicide treatments have significantly reduced the powdery mildew severity index. However, the most effective fungicides were Pristine, Quintec, and Flint. However, results indicate that Nova is less effective for controlling powdery mildew that the Pristine, Quintec, and Flint fungicides. Switch recommended for controlling mould is also effective for controlling powdery mildew. However, the Nova and Switch mix does not increase powdery mildew control compared to Switch alone. The application of Pristine and/or Flint from groups different than Topas and/or Nova during the first treatment has improved powdery mildew management. Kumulus applied one week after the Nova application and one week before the Pristine application has also reduced the incidence of powdery mildew in the 2006 season test.

Weekly treatments with MilStop and Silamol did not significantly reduce the incidence of powdery mildew (Table 16). Under strong pressure of the pathogen, the effectiveness of the Actinovate and Influence bio-fungicides is less than that of sulfur (Table 16). However, these

products show a certain effectiveness on the mature flag leaves, as well as the old leaves when powdery mildew pressure is low (Tables 17 and 18). However, these results do not enable one to put forward that treatments with Actinovate and Influence would be effective to control powdery mildew of strawberry in commercial fields.

Table 15. Effectiveness of fungicides to manage powdery mildew of strawberry (Darselect cv) following renovation, Île d'Orléans

Traitement	Saison 2006			Saison 2008		
	17 août	30 août	13 sept.	26 août	3 sept.	26 sept.
Témoin	2,6 a**	3,2 a	3,3 a	4,3 a	4,5 a	4,3 a
Kumulus	1,9 b	2,4 cd	2,7 b	3,3 b	2,8 c	3,0 cd
Topaz	1,8 b	2,5 bc	2,8 b	2,7 c	3,3 c	3,7 b
Nova	1,9 b	2,7 b	2,8 b	3,3 b	4,0 b	3,7 b
Nova + Switch	-	-	-	3,0 bc	2,8 c	2,8 de
Switch	-	-	-	2,8 c	3,2 c	2,8 de
Pristine	1,8 b	2,1 de	2,4 c	2,2 d	2,5 cd	2,5 ef
Cabrio	-	-	-	3,3 b	3,3 c	3,3 bc
Flint	1,4 c	1,9 e	2,4 c	2,7 c	2,7 cd	2,5 ef
Quintec	-	-	-	2,5 dc	2,3 d	2,2 f
Nova/Pristine	1,6 bc	2,3 cd	2,7 b	-	-	-
Topaz/Pristine	1,2 c	2,1 de	2,8 b	-	-	-
Nova/Flint	1,5 bc	2,1 de	2,8 b	-	-	-
Nova/Kumulus/ Pristine	1,2 c	1,8 e	2,4 c	-	-	-

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 16. Effectiveness of bio-fungicides to manage powdery mildew of traditional strawberry plants (Darselect cv) following renovation, Île d'Orléans

Traitement	Indice de sévérité (0-5)*					
	Saison 2006			Saison 2008		
	17 août	30 août	13 sept.	26 août	3 sept	26 sept
Témoin	2,6 a*	3,2 a	3,3 a	4,3 a	4,5 a	4,3 a
Kumulus	1,9 b	2,4 b	2,7 b	3,3 b	2,8 c	3,0 b
Actinovate	-	-	-	3,8 ab	3,8 b	4,3 a
Influence	-	-	-	3,8 ab	4,0 b	4,0 ab
MilStop	2,4 a	3,1 a	3,2 a	-	-	-
Silamol	2,2 ab	3,0 a	3,2 a	-	-	-

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 17. Effectiveness of bio-fungicides to manage powdery mildew on the mature flag leaf of Seascape cv strawberry plants, Île d'Orléans, 2008 season

Traitement	Indice de sévérité (0-5)*					
	30 juil	6 août	13 août	19 août	26 août	2 sept
Témoin (aucun traitement)	0,9 a**	0,6 a	2,1 a	1,6 a	1,5 a	0,8 a
Soufre tôt en saison (4 et 12 juin) + Nova et Pristine en alternance à partir du 20 juin (témoin commercial)	0,5 b	0,4 a	1,6 ab	1,4 a	1,1 ab	0,8 a
Actinovate à partir du stade 2-4 feuilles	0,5 b	0,4 a	2,0 a	1,4 a	1,3 ab	0,8 a
Influence à partir du stade 2-4 feuilles	0,7 ab	0,5 a	2,2 a	1,3 a	0,9 b	0,9 a

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

Table 18. Effectiveness of bio-fungicides to manage powdery mildew on old leaves in the Seascape cv strawberry plants, 2008 season

Traitement	Indice de sévérité (0-5)*			
	13 août	20 août	26 août	3 sept.
Témoin (aucun traitement)	3,3 a**	3,0 a	3,7 a	3,2 a
Soufre tôt en saison (4 et 12 juin) + Nova et Pristine en alternance à partir du 20 juin	2,2 b	2,2 a	2,7 b	2,3 b
Actinovate à partir du stade 2-4 feuilles	3,0 a	3,2 a	3,2 ab	3,0 a
Influence à partir du stade 2-4 feuilles	2,3 b	3,0 a	3,7 a	3,0 a

* *Severity Index: 0 = 0%; 1 less than 10%; 2 = 11-25%; 3 = 26-50%; 4 = 51-75% and 76% more cover of the inner face of leaflets by powdery mildew.*

** *For a same column, the values followed by a same letter are not significantly different among themselves based on the LSD test, with a significance level of 5%.*

2.2.5 Evaluation of Fungicides and Sulfur Against Powdery Mildew of Darselect cv Strawberry Plants After Renovation – Impact on Crop the Following Season

In the three tests conducted during the project, the application of fungicides during the establishment year and/or after the strawberry field renovation has reduced the infection by powdery mildew on strawberry plant leaves in the fall. However, there is no notable effect on powdery mildew development the following year, nor on crop development and on fruit performance of the Darselect cultivar.

2.2.6 Conclusions

Results of pest management strategy tests enable us to draw the following conclusions:

- For the three testing seasons, the preventative treatments to control powdery mildew at the start of the season have not reduced the incidence of the disease on foliage for both strawberry plant types. For the Quebec region, the first treatment could be delayed at the green fruit stage of strawberry plants and in the day-neutral strawberry plants at the 6 to 8 leaves stage. However, these results must be validated at the commercial level before they can be applied.

- Results indicate that the products' effectiveness must be considered for developing pest management strategies to control powdery mildew of strawberry. Moreover, the effectiveness of sulfur, Pristine, Flint, and Quintec has been demonstrated in tests. However, there is a decrease in Nova effectiveness to control powdery mildew in fields where tests were conducted.

- The effectiveness of fungicides applied at the doses and frequency recommended by the manufacturer, and of alternating product groups have been demonstrated during tests.

- Control of powdery mildew in traditional strawberry plants during the production year would be more important for a crop on plastic rather than on matted rows. However, these results must be validated at the commercial level and for the other production areas.

- When the incidence of powdery mildew does not reduce the development of the crop, treatments for controlling powdery mildew during the establishment year and/or after the strawberry field renovation have no effects on the development of the disease the following year and on fruit performance. However, treatments reduce the infection of the disease on strawberry plant leaves in the fall.

2.3 Impact

Impact on the Sector

The study on powdery mildew epidemiology has enabled us to assert that a forecasting system that only uses temperature as variable to understand the disease's evolution is not complete for Quebec (Gubler-Hoffman model). Although the classification tree analysis remains a tracking study since it was never used to this end, it could help improve the tools available to producers and advisors for good powdery mildew management.

Results of these pest management strategy tests have established that the first intervention to control powdery mildew could be delayed in both strawberry plant types. The effectiveness of fungicides, certified bio-fungicides and bio-fungicides awaiting certification has been established and will enable a wiser choice of products. The work has shown the need for new fungicides to manage powdery mildew and has helped support a certification request. The study has also helped establish the differences in the needs to intervene based on cultivar sensitivity to powdery mildew and also based on its crop method in traditional strawberry plants. Finally, data are available to help advisors and producers make a decision to intervene during the establishment year and/or after the strawberry field renovation.

Project Sustainability

Results achieved could be used as basis for other studies in order to improve this forecasting system by adding more variables, such as wind speed or light length and intensity.

A better understanding of the use of effective fungicides in pest management strategies and also the possibility of delaying the first intervention at the start of the season will allow producers to reduce the number of treatments per season. In addition, using results to demonstrate the lack of effective pesticides and of different groups has helped support the Quintec certification request (group different from Nova, Pristine, and Flint). Knowledge acquired on the fact that no

intervention is required to control powdery mildew on the establishment year and/or after renovation when crop growth is not affected will have an impact on reducing the number of applications and also on reducing risks of pathogen resistance to certain fungicides. The varietal and management effects (matted rows vs. plastic mulch) observed in traditional strawberry plants will help advisors and producers make a decision on the need to intervene to control powdery mildew.

2.5 Dissemination of Results

Scheduled activities	***Completed activities***	***Description*** *(theme, title, location, etc.)*	***Completion date***	***Number of people reached***	***Exposure given to CDAQ and AAFC***
Academic case study	Report written by Denis Langlois (a student who worked on the project)	Testing of various phytosanitary treatments against powdery mildew of strawberry, in the context of developing an integrated response strategy. Laval University	October 2006		Mention
Academic case study	Presentation of a poster by Denis Langlois (a student who worked on the project)	Poster presented at Laval University within professional internship in agronomy	December 2006	150 and more	Mention
Conferences to agriculture professionals and producers	PowerPoint presentation during horticultural days in St-Rémi and INPACQ days in Drummondville	Le blanc du fraisier, on s'en occupe ! St-Rémi	December 6, 2006 and February 7, 2007	125 and 50 participants	Mention
Conference at the APFFQ's BOD	Presentation of the 2006 projects and results to the APFFQ's BOD	Trois-Rivières	December 11, 2006	20 participants	Mention
Demonstration day	Demonstration of tests on powdery mildew during the MAPAQ-Region tour of the Capitale-Nationale	Ste-Pétronille, Île d'Orléans	September 6, 2007	30 participants	Mention
Demonstration day	Demonstration of tests on powdery mildew to Bayer CropScience representatives during the national horticultural meeting	Ste-Pétronille, Île d'Orléans	September 12, 2007	22 participants	Mention

Scheduled activities	***Completed activities***	***Description*** *(theme, title, location, etc.)*	***Completion date***	***Number of people reached***	***Exposure given to CDAQ and AAFC***
Conferences to agriculture professionals and producers	Two PowerPoint presentations during horticultural days in St-Rémi (Odile Carisse and Jean Coulombe)	'Le blanc du fraisier sous toutes ses facettes' and 'Stratégies de lutte contre le blanc du fraisier : Bilan de deux saisons de recherche'.	December 6, 2007	150 participants	Mention
Progress report summary	Presentation in the APFFQ's 2007 and 2008 annual reports	Developing response strategies against powdery mildew of strawberry based on risk estimation and fungicide effectiveness	January 2008 and 2009	APFFQ members	Mention
Demonstration day	Presentation of results	Journée champêtre petits fruits - Innovation et technologie au champ, St-Nicolas	August 17, 2008	200 participants - Quebec – Ontario and Maritimes	Mention
Conferences and discussions with small fruit professionals	Two PowerPoint presentations and round table at the RAP's training days (Carl Boivin and Jean Coulombe), Stoneham	Le blanc du fraisier – Résultats de recherche et Stratégies de lutte contre le blanc du fraisier : Bilan de trois saisons de recherche	March 31, 2009	40 participants	Mention
Popular article	Popular article in the Producteur Plus magazine	Stratégies de lutte contre le blanc du fraisier – en bref, Producteur Plus, May-June 2009	May 2009	Producteur Plus subscribers	Mention
Popular article	Participated in the drafting of a RAP newsletter	Participation in the drafting of the 'petits fruits No. 07 – Stratégies d'intervention contre le blanc du fraisier' newsletter	May 20, 2009	RAP – petits fruits subscribers	Mention

Scheduled activities	***Completed activities***	***Description*** *(theme, title, location, etc.)*	***Completion date***	***Number of people reached***	***Exposure given to CDAQ and AAFC***
Submission of reports on the Agri-Réseau Website in the 'petits fruits' section	Submission of reports to Mr. Luc Urbain of the MAPAQ to be put on the Agri-Réseau Website in the 'petits fruits' section	Progress report No. 1 and 2 Final Report	January 19, 2010 To come	APFFQ members	Logo and mention
Popular article	Presentation in the APFFQ's 2009 annual report	Stratégies de lutte contre le blanc du fraisier – Résumé de trois saisons de recherche	January 2010	APFFQ members	Mention

3. A SUCCESS STORY

Powdery mildew of strawberry is an increasingly important problem in Quebec. This recrudescence may be due to the development of new production systems, the introduction of more sensitive cultivars, as much in traditional strawberry plants as in day-neutral strawberries, or the occurrence of fungus biotypes that are more aggressive or resistant. The primary objective of this project is to provide Quebec strawberry producers with a set of reliable and operational methods of protection in the fight against powdery mildew of strawberry.

Tests were conducted during the 2006 to 2008 seasons to help develop knowledge, forecasting models and response strategies to achieve a rational use of available and effective pest control products, possibly combined with other pest control methods.

Results achieved with the Gubler-Hoffman model indicate that it isn't appropriate to Quebec conditions. It was determined that the presence of powdery mildew of strawberry inoculum in the air varies based on several meteorological variables, such as mean relative humidity, mean temperature, and daily maximum/minimum air temperatures.

It was established that the first intervention to control powdery mildew could be delayed in both strawberry plant types. The effectiveness of fungicides, certified bio-fungicides and bio-fungicides awaiting certification has been established and will enable a wiser choice of products. The work has shown the need for new fungicides to manage powdery mildew and support a certification request. The study has also helped establish the difference in the needs to intervene based on cultivar sensitivity to powdery mildew and also based on its crop method in traditional strawberry plants. Finally, data are available to help advisors and producers to make a decision to intervene during the establishment year and/or after the strawberry field renovation.

The number of participants and the questions asked during demonstration days have helped establish that producers will be using, to the extent possible, the results from these tests. These results were largely distributed to advisors and agricultural producers.

The work has shown the need for new fungicides to manage powdery mildew and has helped support a certification request for a fungicide certified in the United States.

Through lack of reliable data and certified products, validation tests at the commercial scale could not be completed.

4. ACKNOWLEDGEMENTS

The authors wish to thank Ms. Hélène Rousseau and Messrs. Luc Urbain, Bruno Gosselin, Patrice Thibault, Denis Langlois, Louis Gosselin, Philippe Vaillancourt, Daniel Pouliot, Mathieu Plante, Vincent Méthot, Claude-Olivier Blais, and Denis Giroux for their precious help in preparing projects and/or providing their help in the field. They also wish to thank Ms. Tanya Tocheva and Messrs. Luc Bourgeois, Jacques Madison, Christian Beaudry, and Michel Tremblay for their support in finalizing research protocols and obtaining phytosanitary products.

Many thanks to the owners of Polyculture Plante inc., Ferme Onésime Pouliot, and Ferme MP Vaillancourt at Île d'Orléans, as well as the Ferme François and Lise Méthot from St-Nicolas that provided, free of charge, the land, inputs, irrigation, as well as their time for the completion, harvest and evaluation of different tests on their respective farms. Many thanks also to the Bayer CropScience, Dow Agro-Science, Engage Agro, and Syngenta companies that provided, free of charge, the phytosanitary products used in these tests.

Finally, these tests could not have been completed without the financial support of the Conseil pour le développement de l'agriculture du Québec (CDAQ), Ontario's Agricultural Adaptation Council, Agri-Futures Nova Scotia, Investment Agriculture Foundation of British Colombia, Agriculture and Agri-Food Canada (AAFC), and the ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ).

5. REFERENCES

Blanco, C., de los Santos, B., Barreau, C., Arroyo, F.T., Porras, M., and Rommero, F. 2004. Relationship among concentrations of *Sphaerotheca macularis* conidia in the air, environmental conditions, and the incidence of powdery mildew in strawberry. Plant Dis. 88 : 878-881.

Carisse, O. and R. Bacon. 2004. Le blanc de la vigne. Bulletin d'information No. 10 (May 7, 2004), RAP, MAPAQ. http://www.agrireseau.qc.ca/Rap/documents/b10pf04.pdf Accessed September 2, 2006.

CRAAQ, 2007. Fraisier – Guide de protection 2007. 33 pages

Gubler, W.D. et al. 1999. Control of Pondery Mildew Using the UC Davis Powdery Mildew Risk Index. APSnet Feature, January 6-31, 1999.

Hoffmann, L.E. et al. 2002. Validation of the UC Davis strawberry powdery mildew risk index. Phytopathology 92, No.6 (Supplement) 2002:S36.

Lacroix, Michel. 2004. Le blanc du fraisier. Laboratoire de diagnostic en phytoprotection. MAPAQ. htpp://www.agrireseau.qc.ca/lab/documents/Blanc%20fraisier%20E.pdf.

Meszka, B. and BH Abanowska, 2006. Effectiveness of Switch 62.5 WG and Signum 33 WG for the control of strawberry grey mould (*Botrytis cinerea* Pers.) and reduction of two-spotted spider mite (*Tetratnychus urtucae* Koch) populations. OILB/SROP newsletter 29: 9, 15-20

Miller, T. C., Gubler, W. D., Geng, S., and Rizzo, D. M. 2003. Effects of temperature and water vapor pressure on conidial germination and lesion expansion of *Sphaerotheca macularis* f. sp. *fragariae*. Plant Disease 87:484-492.

Peries, O. S. 1962a. Studies on strawberry mildew, caused by *Sphaerotheca macularis* (Wallr. Ex. Fries) Jaczewski*. I. Biology of the fungus. Ann. appl. Biology 50:211-224.

Authors' Contact Info

Jean Coulombe, Agr., M.Sc., Agronomist-Consultant, 1551 chemin Royal, Saint-Laurent-de-l'Île-d'Orléans, Quebec G0A 3Z0, phone: 418-828-2119; fax: 418-828-0721, email: jeancoul@videotron.ca

Carl Boivin, Agr., M.Sc., Researcher, Research and Development Institute for the Agri-Environment (IRDA), Complexe scientifique, 2700 Einstein, Sainte-Foy, Quebec G1P 3W8, phone: 418-646-2931; fax: 418-644-6855, email: carl.boivin@irda.qc.ca

Caroline Landry, M.Sc., Research Professional, 2679 Boulevard Talbot, Stoneham, Quebec G3C 1J6, phone: 418-907-2164, email: landryc@ccapcable.com

Contribution par conseil/Remboursement par conseil
Contribution by Council/Refund by Council

Province	Contribution originale par conseil/ Original Contribution by Council $	Remboursement par conseil/ Refund by Council $	Contribution finale par conseil/ Final Contribution by Council $
Québec	50 000 $	1 805 $	48 195 $
Ontario	35 000 $	1 263 $	33 737 $
Nouvelle-Écosse	10 000 $	361 $	9 639 $
Colombie-Britannique	5 000 $	180 $	4 820 $
Total	**100 000 $**	**3 609 $**	**96 391 $**