CAAP

Canadian Agricultural Adaptation Program

Final Report

Evaluation of the efficacy of different spray strategies in Quebec cranberry production

Project 6799

Institut de recherche et de développement en agroenvironnement

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The final report forwarded to the CDAQ in hard copy and in Word copy must include:

- *the deliverables described in Appendix C of the financial contribution agreement;*
- *the supporting documents,numberedand written in the* Financing Plan and Expenditure Reconciliation *document;*
- *the copies of the dissemination documents mentioning the CAAP's contribution according to the program's exposure rules.*

CONSEIL POUR LE DÉVELOPPEMENT DE L'AGRICULTURE DU QUÉBEC

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1. OBJECTIVES

1.1. General Objective

The cranberry production has increased in Quebec since 1999; the exploited area has increased of 10% per year. Quebec is now the third world producer, behind the US states of Wisconsin and Massachusetts (Poirier, 2010). The yield for farms has increased of 61% in 10 years and is considered as the highest in North America (Poirier, 2010). Since 2000, all producers have adopted integrated pest management strategies and have suscribed to services from the Club d'encadrement technique atocas Québec (CETAQ) (Poirier, 2010). Cranberry fields need 1.5 to 5 insecticide treatments per season depending on the farm being conventional or certified organic (CETAQ, personal communication). These insecticides mainly target the black-headed fireworm and the cranberry fruitworm; however, 40% of fruit damage still can be observed at the end of the season in organic farms. Producers and agronomists suspect that the actual spraying techniques could have something to do with this high level of damage and they believe that this situation could be improved. The general objective of this project was to evaluate the efficacy of different spray strategies used in Quebec cranberry production in order to increase the penetration and cover rates as well as the effectiveness of plant protection products used against pests.

Poirier, I. 2010. La canneberge au Québec et dans le Centre-du-Québec. Un modèle de développement durable à la conquête de nouveaux marchés. Ministère de l'agriculture, des pêcheries et de l'alimentation. Victoriaville. 37p.

1.2. Specific Objectives

1- To evaluate the influence of boom height, nozzle type and mixture volume on the penetration and cover rates of a product on artificial targets (year 2013).

2- To evaluate the influence of the best three combinations found in year 2013 on the penetration and cover rates of a product on natural vegetation (year 2014).

3- To evaluate the influence of the best three combinations found in year 2013 on the effectiveness of a plant protection product at ¼ and ¾ of the recommended dose against the blackheaded fireworm (year 2014).

2. RESULTS AND ANALYSIS

The procedures were carried out as specified in the project description. Only the results from the first specific objective will be discussed in this final report. As this project is co-funded with the MAPAQ Prime-Vert program, further results will be delivered in the second year.

Objective 1: To evaluate the influence of boom height, nozzle type and mixture volume on the penetration and cover rates of a product on artificial targets.

2.1. Material and methods

Sprayer and treatment plots

The sprayer used (EXD-203S, Bellspray Inc.) was a compressed air hand-held boom sprayer. Seven nozzles were fixed to the boom; nozzles were 50 cm apart (Fig. 1). Five types of nozzle were used for the different treatments (Table 1) and each set of nozzles was calibrated. To obtain application rates of 250 and 500 L/ha, the vehicle speed, calculated in number of footsteps, was calibrated over 50 m. In accordance with the project description, the treatments were carried out in a seven year old field on a conventional farm located in Saint-Louis-de-Blandford, Quebec. Due to shipping delays of the sprayer, treatments that should have been carried out before the flowering period (first week of June 2013) were carried out after the flowering period (first week of August 2013). The treatment plots were located in one half of a cranberry field, lengthwise. Plots were 3 x 5 m and they were 3 m apart. A 6 m buffer zone was established between the treatment plots and the unused section of the field.

Fig. 1. Spraying with boom set to 1.2 m (August 6, 2013).

Treatments

The treatments are described in Table 1. The following code was used to identify each treatment: nozzle initials of French terms - spray angle - boom height - mixture volume.

Table 1. List of spray treatments carried out in a cranberry field.

Treatment	Nozzle type	Boom height	Mixture volume	Droplet size
JP-110-1.2-250	110° flat fan	1.2 m	250 L/ha	Medium-Fine
JP-110-0.5-250	110° flat fan	0.5 m	250 L/ha	Medium-Fine
JBD-80-0.5-250	80° twin fan	0.5 m	250 L/ha	Fine
JP-80-1.2-250	80° flat fan	1.2 m	250 L/ha	Medium
JP-80-0.75-250	80° flat fan	0.75 m	250 L/ha	Medium
AD-80-1.2-250	80° antidrift air induction flat fan	1.2 m	250 L/ha	Coarse-Very coarse
AD-80-1.2-500	80° antidrift air induction flat fan	1.2 m	500 L/ha	Coarse-Very coarse

During field tests, the time required for each pass was noted so that the actual application rate could be calculated. This rate depends on the vehicle speed, the sprayed surface and the total flow rate of the nozzles. Each plot was 17.5 m^2 (3.5 m wide by 5 m long). To obtain the required application rate, the vehicle speed had to be 3 km/h; therefore, the 5 m length of the plot had to be covered in 0.1 min. The actual application rate was calculated using the recorded times for each pass and was accounted for in the analysis (Table 2).

Table 2. Ideal and actual application rates for each treatment.

Treatment	Ideal rate (L/ha)	Average actual rate (L/ha)
JP-110-1.2-250	254	227 ± 18
JP-110-0.5-250	254	214 ± 1
JBD-80-0.5-250	252	212 ± 1
JP-80-1.2-250	253	220 ± 17
JP-80-0.75-250	253	213 ± 1
AD-80-1.2-250	248	237 ± 19
AD-80-1.2-500	432	389 ± 40

Three solutions of water and food dyes (tartrazine, red 40 and brilliant blue) were used to evaluate the penetration and cover rates of each treatment. Following standard procedures for this type of test, three treatments, each with its own dye, were applied one after the other on a single plot (overlaid treatments). Treatments were compared by groups of three as described in Table 3 (JP-110-1.2-250 being the common spray strategy used by producers). Three replicates each for the five groups were randomly distributed in the three blocks of the field. The observations for each position in the vegetation were done using artificial targets and they were repeated in space.

Table 3. Treatment combinations and associated dye for each treatment.

Combination	Treatment		
	Red 40	Brilliant blue	Tartrazine
1	JP-110-1.2-250	JP-110-0.5-250	JBD-80-0.5-250
2	JP-110-1.2-250	JP-80-0.75-250	JP-80-1.2-250
3	JP-110-1.2-250	AD-80-1.2-250	AD-80-1.2-500
4	JP-110-1.2-250	JP-80-0.75-250	JBD-80-0.5-250
5	JP-110-1.2-250	AD-80-1.2-250	JP-80-1.2-250

There were two types of artificial targets:

-Sticky vinyl discs, in place of leaves, at two different heights: 1) in the top part of the canopy (2.5 cm below the top) and 2) within the canopy (10 cm below the top) (Fig. 2 and 3). For both heights, two discs were placed on the top and the underside of flat horizontal wooden sticks (four sampling units).

-Cylindrical copper sticks, in place of shoots, placed horizontally at the same two heights as the vinyl discs (Fig. 2 and 4). There was another stick, placed vertically, with two sampling units (high and low).

All targets were repeated five times in each plot (8 sampling units × 5 replicates × 15 plots = 600 samples) (Fig. 5).

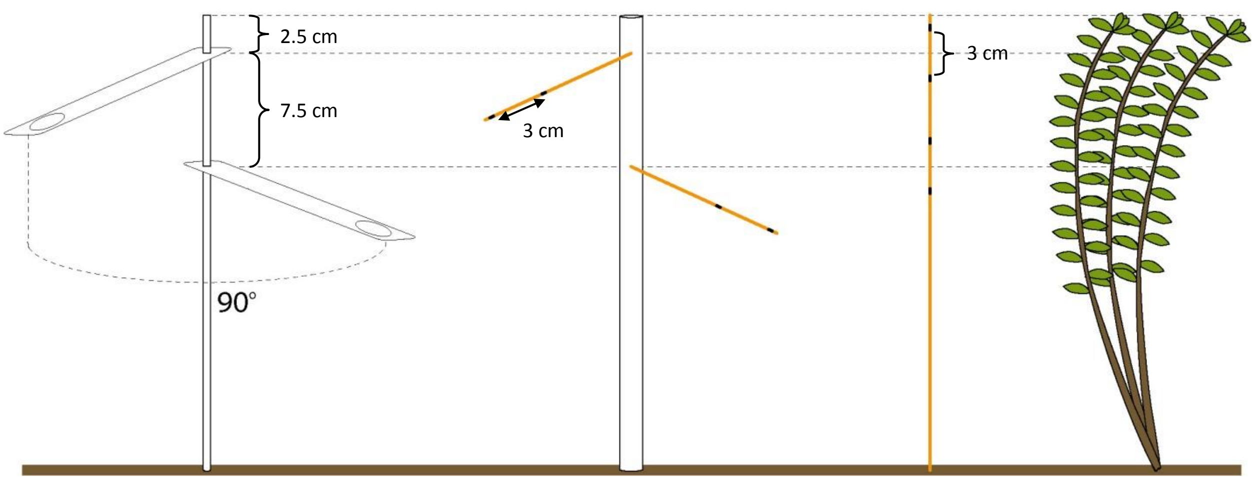

Figure 2. The three different artificial targets in position (Illustration: F. Vanoosthuyse)

Fig. 3. Vinyl discs placed on two flat wooden sticks (left) and top view of targets set up in the field (right).

Fig. 4. Horizontal copper sticks fixed to a PVC tube (left) and top view of targets set up in the field (right).

The amount of each dye was measured from the vinyl discs and copper sticks which were combined by position for each plot (Table 2). There were five replicates for each of the eight sampling units in each plot. A spectrophotometer (Tecan Infinite® 200 Pro) and the Magellan V 7.1 software were used to measure the amount of dye on each target.

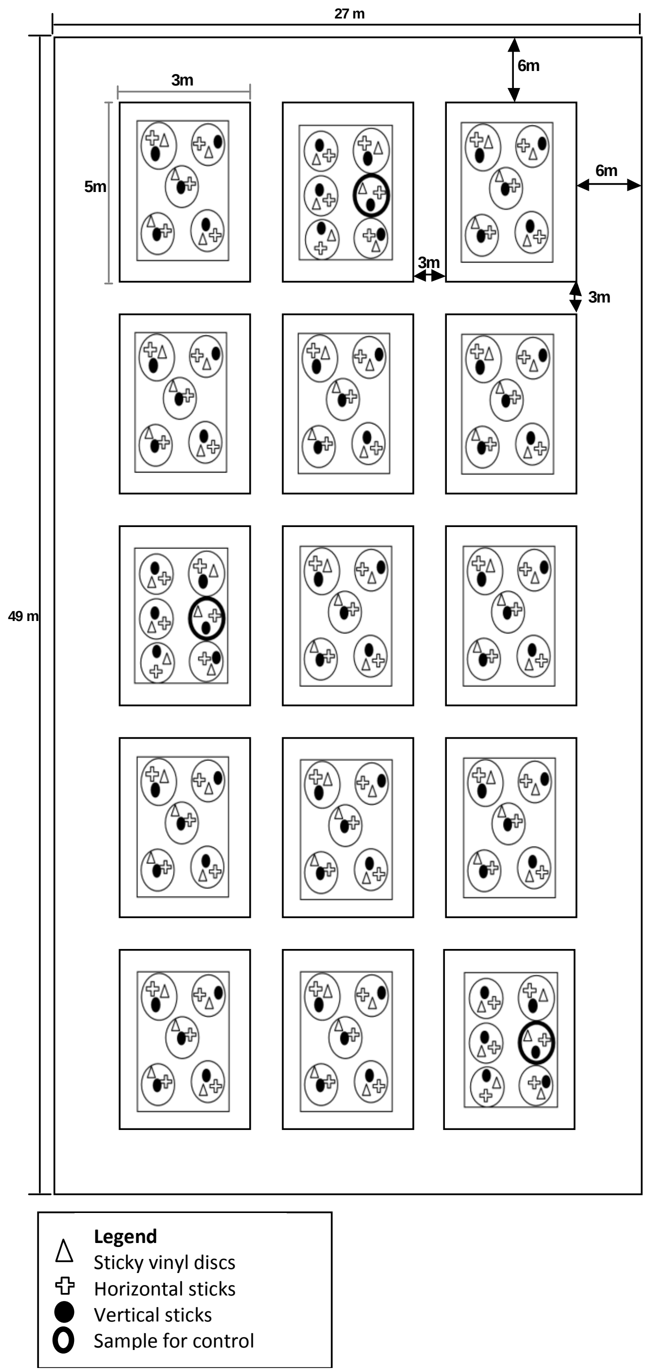

Fig. 4. Schematic representation of the treatment plots.

Statistical analysis

Data were analysed with the software JMP® 11 by SAS, using an ANOVA (one-way ANOVA or factorial ANOVA) followed by Tukey-Kramer HSD or LSD comparison tests.

2.2. Results

In general, the dyed water mixture taken from the targets was the same for all treatments (ANOVA, $p>0.05$). Variability was important within the data; even with the JP-110-1,2-205 treatment (strategy commonly used by producers), the percentage of mixture collected from the targets varied greatly (from 15.8% to 20.3%).

Table 4. Percentage of mixture collected from all targets for each treatment.

JP-110-1.2-250	JP-110-0.5-250	JBD-80-0.5-250	JP-80-1.2-250	JP-80-0.75-250	AD-80-1.2-250	AD-80-1.2-500
18.3 a	19.7 a	17.4 a				
18.6 a			16.7 a	18.1 a		
20.3 a					16.3 a	11.7 a
15.8 a		18.3 a		19.7 a		
18.2 a				15.2 a	19.1 a	

Different letters on a single row indicate a significant difference at α=0.05 (Tukey-Kramer).

However, differences were observed for the penetration and cover rates depending on the type of target and the treatment (Table 5). The amount of mixture collected from the underside discs of the JBD-80-0.5-250 treatment was significantly larger than for the other treatments, but the amount collected from the horizontal sticks was significantly lower for this treatment than for the JP-110-xx-250 treatments at the two heights. Significantly less mixture was collected from the top discs and the vertical and horizontal sticks with the AD-80-1.2-500 treatment than with the JP-110-1.2-250 treatment. Also, there was significantly less mixture collected from the vertical sticks with the JP-80-1.2-250 treatment than with the JP-110-1.2-250 and AD-80-1.2-250 treatments.

Table 5. Mixture collected from the targets regardless of their height and location.

Target	JP-110-1.2-250	JP-110-0.5-250	JBD-80-0.5-250	JP-80-1.2-250	JP-80-0.75-250	AD-80-1.2-250	AD-80-1.2-500
Top disc	42.0 a	46.7 a	49.8 a				
Underside disc	0.10 b	0.10 b	0.20 a				
Vertical stick	14.1 a	14.7 a	7.6 a				
Horizontal stick	17.0 a	17.4 a	12.1 b				
Top disc	49.5 a			51.9 a	49.4 a		
Underside disc	0.02 a			0.13 a	0.02 a		
Vertical stick	11.7 a			5.8 a	9.3 a		
Horizontal stick	13.3 a			8.9 a	13.6 a		
Top disc	43.2 a					35.7 ab	26.9 b
Underside disc	0.06 a					0.07 a	0.09 a
Vertical stick	17.6 a					11.4 ab	9.0 b

Horizontal stick	20.2 a					18.0 a	10.7 b
Top disc	39.0 a		53.7 a		55.3 a		
Underside disc	0.01 b		0.08 a		0.003 b		
Vertical stick	12.1 a		9.0 a		9.6 a		
Horizontal stick	12.3 a		10.6 a		14.0 a		
Top disc	49.2 a			45.4 a		49.3 a	
Underside disc	0.05 b			0.19 a		0.04 b	
Vertical stick	11.5 ab			6.7 b		12.7 a	
Horizontal stick	12.2 a			8.4 a		14.6 a	

Different letters on a single row indicate a significant difference at α=0.05 (Tukey-Kramer).

There was an effect of height on the amount of mixture collected for all top discs. These data are presented in Table 6. For the majority of combinations, there was more mixture on the top discs than on the underside discs (up to four times more) (Tukey-Kramer, $p<0.05$). At a specific height, the cover rate on the vinyl discs was the same for all treatments except for AD-80-1.2-500 which had less mixture than JP-110-1.2-250.

Table 6. Percentage of mixture collected from the top discs.

Height	JP-110-1.2-250	JP-110-0.5-250	JBD-80-0.5-250	JP-80-1.2-250	JP-80-0.75-250	AD-80-1.2-250	AD-80-1.2-500
High	71.3 a	75.3 a	79.0 a				
Low	12.6 b	18.0 b	20.6 b				
High	77.2 a			78.8 a	73.4 a		
Low	21.8 b			25.1 b	25.4 b		
High	70.8 a					55.3 ab	38.7 b
Low	15.7 c					16.1 c	15.0 c
High	56.0 ab		76.1 a		76.0 a		
Low	22.1 b		31.3 b		34.7 ab		
High	72.0 a			69.4 a		74.4 a	
Low	26.4 a			21.5 a		24.3 a	

Different letters for the high and low top discs from a single combination indicate a significant difference at α=0.05 (Tukey-Kramer).

As for the underside discs (Table 7), the amount of mixture collected at both heights under the JBD-80-0.5-250 treatment was significantly larger than under the JP-110-1.2-250 and JP-80-0.75-250 treatments. Also, significantly more mixture was collected from the high disc under the JP-80-1.2-250 treatment than under the JP-110-1.2-250 and AD-80-1.2-250 treatments.

Table 7. Percentage of mixture collected from the underside discs.

Height	JP-110-1.2-250	JP-110-0.5-250	JBD-80-0.5-250	JP-80-1.2-250	JP-80-0.75-250	AD-80-1.2-250	AD-80-1.2-500
High	0.14 a	0.11 a	0.21 a				
Low	0.07 a	0.09 a	0.18 a				
High	0.02 a			0.16 a	0.02 a		
Low	0.02 a			0.10 a	0.01 a		
High	0.10 a					0.06 a	0.14 a
Low	0.03 a					0.08 a	0.04 a
High	0.01 b		0.08 a		0.002 b		
Low	0.005 b		0.08 a		0.005 b		
High	0.05 b			0.24 a		0.04 b	
Low	0.05 b			0.15 ab		0.03 b	

Different letters for the high and low top discs from a single combination indicate a significant difference at α=0.05 (Tukey-Kramer).

Conclusion

There were only a few instances where a significant effect was observed on the cover rate of the mixture for a treatment. As a result, no definitive conclusion can be drawn from the data from the first year of this study regarding the best combination of spray strategies for cranberry production. However, relevant information was gained from the first part of the project. Therefore, the 2014 field trials should be more specific.

-Combination 1: the results significantly show that the finer droplets produced by the 80° twin fan nozzle at a 0.5 m height allow for a better penetration rate, but that the larger droplets produced by the 110° flat fan nozzle have a better rate regarding the cover of horizontal sticks.

-Combination 3: the results significantly show that the 110° flat fan and 80° antidrift nozzles at a 1.2 m height allow for an equivalent cover of discs and sticks at the same application rate.

-Combination 4: the results significantly show that the finer droplets produced by the 80° twin fan nozzle at a 0.5 m height allow for a better penetration rate.

-Combination 5: the results significantly show that 1) the 80° antidrift nozzle producing medium to large droplets allows for a better cover of the sticks than the 80° flat fan and 2) the 80° flat fan at a 1.2 m height allows for a better cover of the higher underside discs than the other two nozzles.

Summary

- *The lowering of the boom does not provide any significant gain. However, spraying at a height of 1.2 m reduces by 30% the amount of mixture collected compared to heights of 0.5 and 0.75 m (combination 4).*
- *The 110° flat fan nozzle produces larger droplets that cover the sticks better.*

- *The 80° twin fan nozzle produces fine droplets. These droplets have a better penetration rate of the canopy.*
- *Spraying with an 80° antidrift nozzle at 500 L/ha reduces the cover and penetration rates.*

3. CONCLUSION

The tests carried out as part of this project allowed to evaluate a variety of spraying strategies in cranberry production. To achieve this, an experimental sprayer was used as well as artificial targets and three food dyes. Five nozzle types, three boom heights and two mixture volumes were compared in field conditions. Results did not show any significant difference of the cover rate between the treatments. However, spraying at a 1.2 m height reduces the cover rate by 30%. The 80° twin fan nozzle produces finer droplets than the 110° flat fan nozzle, at a 1.2 m height, used by most producers; these finer droplets have a better penetration rate than the medium ones produced by the 110° flat fan nozzle. Antidrift nozzles do not increase the cover or penetration rates. As for the 500 L/ha application rate, it reduces the cover rate of the mixture. Results from 2013 will be used as a basis for the 2014 tests and collaboration with spray consultants should lead to protocols and conclusions as good as possible for the second year of the project during which the objectives 2 and 3 should be carried out. Finally, the collaboration with the CETAQ allows a direct transfer of the knowledge gained throughout the project to the producers.