Implementation of a Virus Management Nursery Program in Nova Scotia

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1. Introduction

In just a few weeks I will be traveling up to Nova Scotia with Dr. Guido Schnabel, Plant Pathologist, Clemson, to visit Balamore Farms, Ltd., an 82 acre strawberry nursery in the Great Village region. To say the least, this nursery has been the source of a lot of attention since the start of the 2012-2013 strawberry season, a season characterized by some new and very different plant health issues. We eventually figured out that aphids feeding on strawberry plants in the Great Village area of Nova Scotia were vectoring a virus complex that causes strawberry plants to lose vigor, become stunted, have reduced fruit set and may even cause complete plant death in warmer growing areas like Florida.

In North Carolina, where I had just come out of retirement in August 2012 to work part-time as the state strawberry extension specialist, I started getting calls in September from concerned growers, agents and specialists not just in my state, but growers in Virginia, South Carolina, and several other states were reporting problems with fresh dug plants from a nursery in Nova Scotia (Balamore). The plants were growing off so poorly in some cases that growers elected to pull the plug on these plants, and re-set with plugs in late October and early November. A common denominator with these fresh dug plants was their connection to a nursery production region in Great Village, Nova Scotia.

With the plug plant crop in North Carolina, it was much more difficult to figure out what was going on in the fall season. Most of the plug plants grown from runner tips sourced from Balamore in Nova Scotia looked normal at setting time, but then we began to see different kinds of issue with these plants show up in the post-plant period. Often, we would see fields of Balamore-sourced plants that had "streaks" of very low vigor plugs. Many of the weakest looking plugs in these plantings were dead by the time of the *Southeast Strawberry Expo* in early November. In my communications with Dr. Chuck Johnson, Plant Pathologist, VA-Tech, I learned of similar postplant problems they were seeing in the Virginia Beach area. Dr. Johnson had found certain root and crown fungal diseases in fresh dugs from Balamore. But, none of us were able to really pinpoint what was going on with plug plants sourced from Nova Scotia?

Around Thanksgiving I started hearing "horror" stories out of Florida where growers were reporting nearly complete crop failures with bare-roots from two nurseries in Great Village, Nova Scotia. But, it was difficult for the virus disease experts, including USDA virologist, Dr. Bob Martin, to accept that a virus infection could be causing this much damage so soon after planting? Dr. Martin has had a lot of experience with strawberry viruses in the Pacific Northwest over the years, but the decline in plant vigor is more gradual, and reductions in yield associated with Strawberry Mottle Virus (SMoV), for example, is about 30% (Maas, 1998). It simply

did not make sense that a virus could be causing reductions in plant stands of more than 80%?

To fast forward to January of this year, it was determined by the first week of January that we did have a virus complex in plant leaf samples sent to Dr. Martin's lab in Corvallis, OR, just before Christmas. Then, in late March, Dr. Martin, who was the feature speaker at our Plant Health Mini-Symposium in Raleigh on March 27th, announced that a strawberry virus complex was indeed at the root of the devastating losses experienced by Florida growers this past winter season.

In North Carolina, after a very cold March, we could finally see in April the fuller expression of virus-symptoms in plug plantings of Chandler, Camarosa, and Sweet Charlie from Nova Scotia. Ultimately, yield reductions in North Carolina plugs sourced from Great Village region were in the range of 25 to maybe 50%, but it is hard to say for sure because we had such serious problems with rains throughout most of the harvest season in May. The season came to an abrupt end form many growers when tropical cyclone Andrea hit on June 7-8.

2. Fact-finding trips to Nova Scotia in late-fall 2012

Both Dr. Martin and I made fact-finding visits to Nova Scotia late last year. These trips were prompted by the fact that growers from Maryland to Florida were having plant establishment problems with plugs and fresh dugs from Balamore Farms, Ltd., Great Village, NS. Dr. Martin's trip to Nova Scotia from Portland was made at the very end of October – just when Super Storm Sandy hit the east coast! Thankfully, I did not encounter any serious storms when I flew up to Nova Scotia in early December, though I do recall that our plane in Raleigh had to be de-iced early in the morning on December 3rd. Soon after my arrival in the Great Village area (Dec. 4, 2013), I was able to meet a matted row producer, Terry Wenham, who allowed us to look under the straw mulch cover (used for winter protection), to see some very sub-par looking 'Mira' strawberry plants. It turned out that Dr. Martin had tested samples of Terry's plants in the summer of 2012, and he determined that problems were caused by a combination of two viruses, Strawberry Mild Yellow Edge Virus (SMYEV) and Strawberry Mottle Virus (SMoV). Mr. Wenham shared his lab report with me from Dr. Martin (Table 1). The grower used a method of sampling where he called normal looking plants "healthy" and smaller, stunted Mira plants were called "diseased." He sent duplicate samples of each group, as well as another matted row variety called Annapolis. It was very interesting to see that the so-called "healthy" plants were negative for SMoV, but were positive for SMYEV. The diseased looking plants were positive for both SMoV and SMYEV.

Table 1 Cultivar name and field ID	Strawberry Mottle Virus (SMV)	Strawberry Mild Yellow Edge Virus (SMYeV)	phytoplasma
Terry Mira healthty sample1	-	+	-
Terry Mira healthty 1	-	+	-

Mira Terry diseased 1	+	+	-
Mira Terry Diseased 2	+	+	-
Annapolis	+	+	-

(2a)

(2b)

(2c)

Figures 2a-c. (2a) Terry Wenham is primarily a Mira strawberry matted row grower in the Great Village region of Nova Scotia (yellow coat). On Dec. 4, 2012, I was able to visit his matted row planting that had been covered in straw mulch in November for winter cold protection. (2b) Photo shows Mr. Wenham and Mr. Joe Cooper, Balamore Farms, Ltd., uncovering Mira plants (planted in spring 2012); and (2c) shows a close up of virus-infected Mira plant.

Figure 3. According to John Lewis, of Perennia, this photo is typical of virus-infected Mira during the spring season. Note that older leaves tend to be a normal green while the newest leaves emerging over the last few weeks are the ones showing the symptoms. These have a generalized chlorosis (yellowing) that is focused more on the leaf margins. Source: http://www.novascotiastrawberryblog.com/

On February 13, 2013, Dr. Chuck Johnson, Plant Pathologist, VA-Tech, produced a report called, *2012-2013 Strawberry Virus "Issue,"* and with this report he included photos (Figures 4a-4b) of strawberry plants in the Virginia Beach and Chesepeake areas, that he, Roy Flanagan and Watson Lawrence saw on December 19th that were doing poorly, but at that time they were still unsure about the cause(s) of these problems.

(4a)

(4b)

As Dr. Johnson noted in his report, "Upon returning to NC, Barclay collected and submitted 7 plant samples to Dr. Martin's lab (on Dec. 17), and found one with SMoV and five with SMYEV. All infected plants were plug plants produced from tips grown by the same nursery (Balamore) in the Great Valley area. Although four of Barclay's samples were Chandlers, one such plant that looked "good" tested negative for both viruses, while another "good" plant tested positive for SMYEV only."

In Virginia, Johnson and his Extension team submitted 35 samples to Dr. Martin's lab before Christmas, at about the same time I shipped off my North Carolina samples. Of the 35 samples sent, 86% were infected by SMYEV, 69% with SMoV, and 66% with both viruses. Only 17% were non-infected. All of the infected plants were originally sourced from the Balamore nursery in the Great Valley area of Nova Scotia, but infected plug plants from Balamore tips were grown-out by 4 different producers (Table 2).

Table 2. Summary of Virus Assay Results for VA and NC, January 2013

Virus Assay Results from Bob Martin's USDA Lab in Oregon
Sorted by Detection of SMoV, then by SMYEV

Survey Number	Source	Sample	Variety	Source			SMoV	SMYEV
				Tip	Bre-Rt	Plant		
1	NCSU	NCSU #1	Camerosa	PEI			-	-
5	NCSU	NCSU #5 (good)	Chandler	Balamore			-	-
16	VA Beach	4B	Chandler	PEI			-	-
25	VA Beach	9A	Chandler	PEI			-	-
19	VA Beach	6A	Chesapeake				-	-
9	VA Beach	1B	Ovation				-	-
15	VA Beach	4A	Sweet Charlie	PEI			-	-
40	VA Beach	13D	Albion	Balamore		G+W	-	+
21	VA Beach	8A	Albion/Mitchell Wren	Balamore			-	+
35	VA Beach	12A	Camarosa	Balamore		Aaron's Creek	-	+
42	VA Beach	13F	Camarosa	Balamore		Org.	-	+
41	VA Beach	13E	Chandler	Balamore		Org.	-	+
20	VA Beach	7A	Pungo				-	+
2	NCSU	NCSU #2 (bad)	Benicia	Balamore			-	+
3	NCSU	Rudd #3 (good)	Benicia	Balamore			-	+
4	NCSU	NCSU #4 (bad)	Chandler	Balamore			-	+
7	NCSU	NCSU #7, (Good)	Chandler	Balamore			-	+
31	VA Beach	11A	Albion				+	+
12	VA Beach	2B	Albion	Balamore		Mitchell Wren	+	+
30	VA Beach	10E	Albion	Balamore			+	+
10	VA Beach	1C	Camarosa	Balamore		Aaron's Creek	+	+
37	VA Beach	13A	Camarosa	Balamore		Fresh Pik	+	+
33	VA Beach	11C	Camarosa				+	+
8	VA Beach	A1	Chandler	Balamore		Aaron's Creek	+	+
11	VA Beach	2A	Chandler	Balamore		Aaron's Creek	+	+
14	VA Beach	3B	Chandler	Balamore		Aaron's Creek	+	+
17	VA Beach	5A	Chandler	Balamore		Aaron's Creek	+	+
23	VA Beach	8C	Chandler	Balamore		Aaron's Creek	+	+
36	VA Beach	12B	Chandler	Balamore		Aaron's Creek	+	+
39	VA Beach	13C	Chandler	Balamore		Aaron's Creek	+	+
38	VA Beach	13B	Chandler	Balamore		Fresh Pik	+	+
18	VA Beach	5B	Chandler	Balamore			+	+
28	VA Beach	10C	Chandler	Balamore			+	+
34	VA Beach	11D	Chandler bare root		Bare-rt		+	+
32	VA Beach	11B	Chandler plugs				+	+
13	VA Beach	3A	Festival	Balamore		Aaron's Creek	+	+
29	VA Beach	10D	San Andreas	Balamore			+	+
24	VA Beach	8D	Sweet Charlie	Balamore		Aaron's Creek	+	+
26	VA Beach	10A	Sweet Charlie	Balamore			+	+
27	VA Beach	10B	Camino Real	Balamore			+?	+?
6	NCSU	NCSU #6 (Bad)	Chandler	Balamore			+	+
22	VA Beach	8B	Festival	Balamore		Aaron's Creek	+?	+?

3. Plant Health Mini-Symposium, March 27th

The main thrust of our discussions in Raleigh on March 27th was to identify nursery management practices that could reduce, if not eliminate, the damaging effects of viruses and diseases in our strawberry plant supply. From our keynote speaker, Dr. Martin, we learned a number of important factors that nurseries must take into consideration with the management of Strawberry Mottle Virus (SMoV) and Strawberry mild edge yellow edge virus (SMYEV).

Strawberry mottle virus. SMoV is probably the most common virus of strawberries and is present wherever they are grown (Tzanetakis and Marin, 2013). SMoV is also aphid-transmitted (*C. fraegaefolii*, several other *Chaetosiphon* species, and the melon aphid, *Aphis gossypii*). However, SMoV is "semi-persistently" transmitted. Severe strains of this virus can cause a decline in vigor and reduce yield by up to 30% Compendium of Strawberry Diseases Second Edition, p. 66). According to Tzanetakis and Marin (2013), the time between acquisition and efficient transmission is about 1 hr, thus chemical control can be an effective way to minimize spread of the virus in the field.

Strawberry mild edge yellow edge virus. SMYEV is one of the most widespread virus diseases of strawberry in North America. It is spread only by strawberry aphids, which are members of the genus *Chaetosiphon.* These insects must feed on plants containing the virus to transmit the virus by moving to nearby healthy plants to feed. The acquisition and transmission of some viruses may take place in a few seconds, but SMYEV is a "persistent, circulatively transmitted" virus. "Persistent" means that these aphids need to feed for hours or days in order to "get" and spread the virus (as Dr. Johnson pointed out in his excellent article, *Virus Infections in the 2012-2013 Strawberry Crop,* which appeared in the April newsletter of *Small Fruit New,* Vol. 13, No. 2). "Circulative" mean that a virus spreads through the body of an insect once the virus has been acquired. This virus complex can be moved considerable distances by aphid vectors transported by wind currents. The "good news" about SMYEV is that (like SMoV), "systemic insecticides have also proven useful in its control (Compendium of Strawberry Diseases Second Edition, p. 66)."

4. Vector control in Nova Scotia this Spring

John Lewis, who spoke at our Mini-Symposium and specializes in small fruits with the Nova Scotia Crown corporation *Perennia,* has recently posted an update (May 31st), where he reports, "Controls that have been used so far that seem to be working well are the **Admire soil drench as well as the foliar application**, and Thiodan." In his blog he mentions that cooperating growers, "have done a tremendous job managing strawberry aphid populations during this time."

In less than two weeks, both Dr. Guido Schnabel, Plant Pathologist, Clemson , and I will be visiting Balamore Farms, where a great deal of money and effort has already been spent this spring to implement a virus vector control program. We will no doubt touch base with John Lewis to learn more about the success of the chemical control program itself, but I also know from communications that I have received from Joe Cooper since the Plant Health Mini-Symposium (Figure 5), that a lot else has been happening since the end of March!

Figure 5. At the Mini-Symposium, Joe Cooper, Balamore Farms discussed the "aggressive steps" (including a strawberry crop destruct in Great Village region), that he and other strawberry nursery and fruit growers have taken since the Symposium to hopefully prevent any future virus infections from occurring in their nurseries in summer 2013.

5. Updates from Joe Cooper since the Mini-Symposium

To assist our understanding of the steps that Balamore Farms have been taking, Joe Cooper sent me a series photos with some very informative captions. In addition, Joe has also sent to me on June 28th a very extensive report that has just come back from the Phyto Diagnostics lab in British Columbia. This is the lab that Balamore has been utilizing since last year to test for both SMoV and SMYEV. In the June 25th report from Phyto Diagnostics you can see that 234 leaf samples submitted (its and 8-page report), and every leaf sample from all tests were negative for SMYEV for every variety in all of their commercial fields (using Elisa method). The only positive was a wild berry sample, which they anticipated would be positive. As Joe VanVulpen, Manager, Balamore Farms wrote to me on June 30th, "Very good results."

In Mid-May, Joe Cooper sent this email to me, "Our 82 acres of plasticulture strawberry fields have been sprayed with insecticides and herbicides 3 times on April 15, April 27and May 8. The plastic was lifted and sent to the landfill." He further wrote, "We are now underway with planting our new strawberry plants for 2013 this week (Mid-May). Essentially, there has been no green strawberry vegetation in our entire region (Great Village, Nova Scotia) in April and early May 2013 due to a voluntary "crop destruct" that was undertaken by Balamore Farms and all of the strawberry growers in the Great Village area. This should give an adequate break period for viral elimination."

Fig. 6. Carryover plasticulture bed that was destroyed before planting in mid-May.

Fig 7. Planting of new dormant plant stock that began on May 13th

In the foreground of the next picture (Figure 8), you can see an aphid trap. These have been installed in all of the propagation fields at Balamore this season. Each field is being monitored three times/week during the growing season. Three of Balamore Farms employees have been trained by the Nova Scotia Department of Agriculture to identify aphids and their eggs, and to monitor traps. In addition, employees of *Perennia* are also supporting the aphid scouting operation, and on June 25th, Bridget Wilson, a summer scout with *Perennia,* sent this update (Table 2).

Table 2. Summer Scouting Report

Sample	# STB Aphids	# Other Aphids	# Leaves/Traps
Plastic mulch	0	12 winged (black)	10
Matted row traps	0	19 winged (black)	10
Matted row leaves	0 nymphs, 1 winged STB aphid	0	60

Fig. 8. An aphid trap is shown in he foreground in one of the new plant beds. The scouts cover 82 acres of nursery production. Each field is inspected 3X/week, and reports such as the one shown in Table 3 are produced on a regular basis.

6. Summary - So far, so good!

Well, I feel like we have all been on a tremendous learning curve with this new virus challenge facing the North American strawberry nursery and fruit industry. I have personally let go of all my former notions that viruses are not a big concern in eastern strawberry plasticulture. There is way too much at stake for us not to be front and center on this issue! We have learned from the experts like Dr. Martin what we're up against, and with the support of Dr. Martin and other researchers like Dr. Ioannis E. Tzanetakis, Dept. of Plant Pathology, Division of Agriculture, University of Arkansas, I am very hopeful that it is possible to develop an effective vector control program for nurseries in Canada, and it appears to me that Balamore Farms is well on its way to turning the corner on this issue. I know that Dr. Schnabel and I are eagerly looking forward to our July 14-16 visit, and we'll surely have more information to share with everyone after that trip on the web http://strawberries.ces.ncsu.edu, but, at this time in early July, I think its fair to say, *so far, so good.*

7. Literature cited:

Johnson, Charles. 2013. 2012-2013 Strawberry Virus Issue. http://www.ces.ncsu.edu/wp-content/uploads/2013/02/021413-CSJ-Strwbry-Virus-email-public.pdf

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