Evaluation of Serenade Optimum and Lime-Sulfur for Disease Management in Organic Apple Orchards

Norman Lalancette, Lorna Blaus, and Peninah Feldman
Rutgers Agricultural Research and Extension Center, Bridgeton

Experimental and currently registered fungicides are evaluated every growing season for management of apple and peach diseases. Many of these materials are reduced-risk conventional fungicides that can be readily incorporated into current IPM programs. The major goal of these trials is to determine the efficacy of these fungicides for controlling the various diseases of importance. Once this information is known, the new material can be deployed at the proper rate and timing for effective management of the target disease.

During the 2016 growing season, two fungicides labeled for use in organic apple orchards were examined along with a variety of conventional materials. The first of these OMRI listed materials, Serenade Optimum, contains the bacterium *Bacillus subtilis* (QST 713 strain) as its active ingredient. The preceding products, Serenade and Serenade MAX contain the same active ingredient, but at lower concentrations. The second OMRI material examined was Lime-Sulfur, an older fungicide that has been replaced by conventional materials, but that may still be useful in organic orchards.

Overall ratings. Based on this single year of data, the two organic fungicides provide the following levels of relative efficacy for the indicated apple diseases:

		Serenade Optimum		Lime-Sulfur	
Disease	**Test disease pressure**	**% Control**	**Efficacy rating**	**% Control**	**Efficacy rating**
Foliar scab	High	57-69	++	55-75	++
Fruit scab	High	46	++	29	+
Foliar CA rust	Low	81	---	72	---
Sooty Blotch	High	15	+	78	+++
Flyspeck	High	14	+	66	++
Bitter rot	Low	0	---	0	---
White rot	Low	67	---	67	---
All rots	Low	18	---	18	---
++++ = Excellent; +++ = Good; ++ = Fair; + = Poor; --- = inadequate disease pressure					

Given these results, Lime-Sulfur may be useful for sooty blotch control in organic orchards. Serenade Optimum provided partial foliar and fruit scab control. However, it would need to be integrated with other more effective materials given its "fair" efficacy rating. Finally, fruit rot control, particularly white rot, needs to be further evaluated under higher disease pressure.

In the 2016 study, both of these organic-approved fungicides were applied full season for evaluation of efficacy against all fungal diseases on apple. Comparisons were made to a standard conventional program. A non-treated control was included for determination of disease pressure.

Materials & Methods

Orchard Site. The experiment was conducted during the spring and summer of the 2016 growing season. The test block consisted of 4-year-old 'Cameo' apple trees on M7 semi-dwarf rootstock planted at 15 ft tree x 20 ft row spacing. Ginger Gold and Golden Delicious trees, also on M7 rootstock, were planted as pollinators. The block was 80% Cameo, 10% Ginger Gold, and 10% Golden Delicious.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with two-tree plots. Treatment plots were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for applications. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing were: 30 Mar (1/2" green tip, GT); 8 Apr (tight cluster, TC); 18 Apr (pink, P); 25 Apr (bloom, B); 5 May (petal fall, PF); and 17, 31 May, 14, 27 Jun, 12, 26 Jul, 10, 23 Aug, 6, 20 Sep (first – tenth cover, 1C-10C).

Assessment. Early season scab (*Venturia inaequalis*) and other diseases were evaluated on 25 May by examining all leaves on 10 fruit clusters per plot (5 fruit clusters per tree). Mid-season scab, powdery mildew (*Podosphaera leucotricha*), and cedar apple rust (*Gymnosporangium juniper-virginianae*) were evaluated on 29 Jun by examining all leaves on 10 vegetative shoots per plot (5 shoots per tree). Development of scab, powdery mildew, cedar apple rust, sooty blotch (disease complex), flyspeck (*Zygophiala jamaicensis*), bitter rot (*Colletotrichum gloesporoidies*), white rot (*Botryosphaeria dothidea*), and other rots on fruit were evaluated at harvest on 28 Sep by examining 25 fruit per plot.

Weather Data. Air temperature and rainfall data were recorded by a Campbell Scientific 23X data logger located at the research station. This weather station is part of the Mesonet Network operated by the Office of the NJ State Climatologist. Observations were taken every two minutes and summarized every hour. Hourly temperature and rainfall data were averaged and summed, respectively, for each day of the growing season.

Statistical Analysis. Analyses of variance (ANOVA) and treatment mean comparisons were performed using the General Linear Models (GLM) procedure of SAS v9.4. The Bayesian Waller-Duncan means test was used to compare treatment means. Arcsin and log transformations were performed as needed for propor-

Table 1. Scab incidence on cluster leaves (May 25).[1]

	Treatment	Rate / A	Timing	% Infected Leaves [2]
1	Non-treated control	--------	--------	34.9 a
2	**Vangard 75WG** **Indar 2F + Manzate Pro-stik 75DG** **Inspire Super 2.82EW** Captan 80WDG	**5 oz** **8 fl oz + 6 lbs** **12 fl oz** 3.5 lb	**½ GT** **TC, P, B, PF** **1C** 2C-10C	9.1 c
3	**Lime-Sulfur** **Lime-Sulfur**	**2 gal** **1 gal**	**½ GT, TC, P** **B, PF, 1C,** 2C-10C	15.7 b
4	**Serenade Optimum 26.2WP** Serenade Optimum 26.2WP	**18 oz** 18 oz	**½ GT-1C** 2C-10C	14.9 bc

[1] Primary apple scab treatments, rates, and application timings in **boldface**.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

tions and lesion count data, respectively, to correct for departures from the ANOVA assumptions.

Results & Discussion

Environment. Weather conditions were highly favorable for apple scab development, particularly during the primary scab infection season. From ½" Green Tip (½"GT) through the end of first cover (1C), 22 days with rainfall ≥ 0.10 inches were recorded. Although extended periods of dry weather occurred during the summer, particularly in August and September, occasional rains occurred with a high enough frequency to allow continued secondary scab infection on both vegetative shoots and fruit.

Rainfall frequencies were generally adequate for bitter rot, white rot, sooty blotch, and flyspeck infection during 1C through 4C, although temperatures were initially cool, particularly for the rots. Dryer periods in August and September may have diminished

Table 2. Scab and cedar apple rust (CAR) on shoots (June 29).[1]

	Treatment	Rate / A	Timing	% Infected Leaves [2] Scab	CAR
1	Non-treated control	--------	--------	82.4 a	2.20 a
2	**Vangard 75WG** **Indar 2F + Manzate Pro-stik** **Inspire Super 2.82EW** **Captan 80WDG**	**5 oz** **8 fl oz + 6 lbs** **12 fl oz** **3.5 lb**	**½ GT** **TC, P, B, PF** **1C** **2C, 3C**, 4C-10C	5.1 d	0.35 b
3	**Lime-Sulfur** **Lime-Sulfur**	**2 gal** **1 gal**	**½ GT, TC, P** **B, PF, 1C- 3C**,4C-10C	20.8 c	0.62 b
4	**Serenade Optimum 26.2WP** Serenade Optimum 26.2WP	**18 oz** 18 oz	**½ GT, - 3C** 4C-10C	25.8 b	0.41 b

[1] Scab and cedar apple rust rates and application timings in **boldface**.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 3. Scab, sooty blotch, and flyspeck on fruit at harvest (September 28).

	Treatment	Rate / A	Timing	% Infected Fruit[1] Scab	Sooty Blotch	Flyspeck
1	Non-treated control	--------	--------	80 a	92 a	93 a
2	Vangard 75WG Indar 2F + Manzate Pro-stik Inspire Super 2.82EW Captan 80WDG	5 oz 8 fl oz + 6 lbs 12 fl oz 3.5 lb	½ GT TC, P, B, PF 1C 2C, 3C, 4C-10C	2 d	0 d	2 d
3	Lime-Sulfur Lime-Sulfur	2 gal 1 gal	½ GT, TC, P B, PF, 1C-10C	57 b	20 c	32 c
4	Serenade Optimum 26.2WP	18 oz	½ GT-10C	43 c	78 b	80 b

[1] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 4. Fruit rots at harvest (September 28).

	Treatment	Rate / A	Timing	% Infected Fruit [1]		
				Bitter Rot	White Rot	All Rots
1	Non-treated control	--------	--------	7 a	9 a	17 a
2	Vangard 75WG Indar 2F + Manzate Pro-stik Inspire Super 2.82EW Captan 80WDG	5 oz 8 fl oz + 6 lbs 12 fl oz 3.5 lb	½ GT TC, P, B, PF 1C 2C, 3C, 4C-10C	0 d	0 b	0 b
3	Lime-Sulfur Lime-Sulfur	2 gal 1 gal	½ GT, TC, P B, PF, 1C-10C	9 a	3 b	14 a
4	Serenade Optimum 26.2WP	18 oz	½ GT-10C	10 a	3 b	14 a

[1] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

infection. Also, since the orchard is young, overwintering inoculum from cankers and other colonized dead tissue was probably minimal. However, nearby wooded areas should have provided some inoculum, particularly for sooty blotch and flyspeck.

Although 'Cameo' is considered moderately susceptible to powdery mildew, the same frequent early season rains that promoted scab probably lessened powdery mildew infection. Only occasional mildew lesions were observed. Overwintering primary mildew shoots were not observed, even on the highly susceptible 'Ginger Gold'.

Early Season Scab. Primary scab disease pressure on fruit cluster leaves was moderate. About 35% of non-treated cluster leaves had scab lesions (Table 1). No other diseases, such as powdery mildew or cedar apple rust, were observed in sufficient quantities on the cluster leaves to allow statistical analysis.

All early season treatment programs, whether conventional or organic, significantly reduced primary scab incidence on cluster leaves (Table 1). The major difference among treatments was in the degree of disease control. The Vangard / Indar + Manzate / Inspire Super standard (treatment 2) provided 74% control of primary scab. In comparison, the organic Lime Sulfur and Serenade Optimum programs provided only 55% and 57% control, respectively.

Scab and Cedar Apple Rust on Shoots. Foliar scab disease pressure was very high on vegetative shoots. Non-treated shoots had 82% leaves with scab (Table 2). All early season treatments, including cover sprays prior to the assessment in late June, significantly reduced scab incidence. The standard program (treatment 2) yielded 94% control. The Serenade Optimum and Lime-Sulfur treatments yielded 69% and 75% control, respectively.

In contrast to scab, cedar apple rust infection was very low with only 2.2% leaf infection on control trees (Table 2). Nevertheless, all treatments significantly reduced rust incidence. However, no treatment differences were observed under this low disease pressure. Disease control ranged from 84% for the standard to 72% for Lime-Sulfur.

Scab, Sooty Blotch, and Flyspeck on Fruit. Disease pressure was very high for development of scab, sooty blotch, and flyspeck on fruit. Disease incidence for these three diseases on control trees were 80%, 92%, and 93% fruit infected, respectively (Table 3). Lesion density, a measure of disease severity, was not assessed but most fruit had multiple numbers of lesions, blotches, or speck colonies.

The standard conventional fungicide treatment (#2) significantly reduced scab, sooty blotch, and flyspeck disease incidence, providing 98 to 100% control (Table 3). The two organic treatments (3 & 4) also significantly reduced disease development relative to the control. Serenade Optimum provided better control of scab while Lime-Sulfur was more effective at controlling sooty blotch and flyspeck. However, the level of disease control was much lower than observed with the conventional standard treatment. Serenade Optimum provided 46%, 15%, and 14% control of scab, sooty blotch, and

flyspeck, while Lime-Sulfur provided 29%, 78%, and 66% control of scab, sooty blotch, and flyspeck (both respectively).

Fruit Rots. Bitter rot levels were low with only 7% infection of non-treated control fruit (Table 4). Under these low disease pressure conditions, the standard treatment, which used captan for all of its cover sprays, provided 100% control. In stark contrast, both Serenade Optimum and Lime-Sulfur failed to provide any bitter rot control.

White rot disease pressure, at 9% incidence, was slightly higher than bitter rot (Table 4). All three treatments significantly reduced white rot. The captan standard provided 100% control while Lime-Sulfur and Serenade Optimum yielded 67% control.

The category "All Rots" provided a general measure of treatment efficacy against all fruit rots, regardless of whether or not they can be easily identified (Table 4). This category encompasses bitter rot and white rot plus other rots such as black rot and bull's-eye rot. The conventional standard treatment program (captan) once again provided 100% control. The two organic treatments were not effective.