Title: Integration of OMRI-Approved Fungicides, Sanitation, and Cultural Controls for Managing Summer Diseases on Apples

Project Leaders:

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Abstract:

Experiments were conducted to determine if organic apple growers could minimize losses to summer diseases on apples by using cultural management strategies and/or regular sprays of liquid lime sulfur (LLS). LLS is an OMRI-approved fungicide. Diseases of concern were black rot, flyspeck, and sooty blotch. The latter two diseases appear as dark-colored blemishes on apple fruit surfaces. Although these blemishes do not directly impact edibility, apple with these surface blemishes are not acceptable to fresh fruit buyers. Black rot is a fruit decay that makes fruit inedible, and fruit with black rot can add off-flavors if they are use for juice. During 2010, field trials were conducted in a Jonamac orchard at the Geneva Experiment Station and in a block containing the cultivars Royal Court and Cameo at the Hudson Valley Lab in Highland. Trees in replicated plots received either cultural controls alone, treatment with LLS alone, or a combination of cultural controls and LLS treatments. Cultural controls included removal of fruitlet mummies that can harbor black rot inoculum and hand-thinning of fruit in June followed by light summer pruning to enhance rapid drying following rains and dews and to allow improved spray coverage. Apples were harvested at commercial maturity and evaluated for disease. Both LLS and cultural controls reduced disease incidence and severity of sooty blotch and flyspeck at both test locations, and both approaches reduced the incidence of black rot at Geneva. Neither LLS, cultural controls, nor the combination of the two approaches were consistently effective against black rot in the Hudson Valley where hot humid summers favor this disease. At Geneva, fruit treated with LLS alone or in combination with cultural controls had no more summer diseases than fruit treated with conventional fungicides. However, conventional fungicide programs generally out-performed LLS against summer diseases in the Hudson Valley. This experiment verifies that LLS sprays can be used to control flyspeck and sooty blotch on organic apple farms, but neither LLS nor the cultural controls that we tested will control black rot on cultivars such as Royal Court that are highly susceptible to this disease.

Background and Justification:

Summer diseases that commonly affect apples in New York State are especially difficult to control on organically produced apples. These diseases include black rot, caused by *Botryo-sphaeria obtusa* (Fig. 1), and flyspeck and sooty blotch which are caused by a complex that includes more than 60 different fungi (Arias et al., 2009) (Fig. 2). The biology of these diseases has been extensively studied, especially in North Carolina where hot, humid summer weather favors disease development (Brown and Sutton, 1995; Ocamb-Basu et al, 1988). Spore release and dissemination from *Z. jamaicensis* have also been studied in Massachusetts (Cooley et al., 2007). Rosenberger and colleagues have also studied control measures for these diseases under New York conditions (Rosenberger and Jentsch, 2006; Rosenberger and Meyer, 2007;

Figure 1. Early stages of black rot on Gala fruit (left) and advanced decay on Honeycrisp fruit (right). Both photos show small mummified fruitlets that can provide inoculum for infection of maturing fruits.

Rosenberger et al., 2009). They found that controlling these diseases during summer is difficult when using OMRI-approved fungicides alone.

The epidemiology of these diseases can be summarized as follows. Flyspeck can be initiated by ascospores that are released from wide range of wild host plant species in orchard perimeters beginning about the time that apples are at the petal fall stage of bud development. Ascospores cause relatively few infections in orchards sprayed with conventional fungicides because the apple scab fungicides control this phase of the disease. Brown and Sutton (1995) showed that after flyspeck ascospores begin growing on apple fruit, approximately 270 hr of cumulative leaf wetting are required before visible signs of the disease will appear on fruit surfaces. Rosenberger's observations suggest that similar durations of wetting are required before conidia are

Figure 2. Flyspeck on a Cameo apple (left) and flyspeck and sooty blotch on a Golden Delicious apple right. Sooty blotch appears as both dense and diffuse cloudy areas on the fruit skin.

released in large numbers from the primary flyspeck infections that occur in wild hosts on orchard perimeters. Secondary spores (conidia) that are released from wild hosts cause most of the economic damage in commercial orchards. If the earliest conidia land on fruit with no fungicide protection, then infections will become evident on the fruit after another 270 hr of cumulative wetting. The final result is that massive outbreaks of flyspeck become evident on unsprayed fruit shortly after 540 hr of accumulated wetting counting from petal fall (hr AWPF). Because secondary infections occur continuously beginning at 270 hr AWPF, visible flyspeck on fruit surfaces gradually increases in severity from 540 hr AWPF until harvest. Sooty blotch development follows much the same pattern except that it is easier to control with fungicides than is flyspeck. As a result, flyspeck usually appears first in sprayed orchards.

In previous work, Rosenberger and coworkers have shown that low rates of liquid-lime sulfur (LLS) applied during summer will suppress flyspeck and sooty blotch, but not black rot (Rosenberger and Meyer, 2007; Rosenberger et al., 2009). However, during the wet 2009 growing season, regular sprays of LLS failed to control SBFS in both Geneva and Highland on heavily cropped trees with semi-dense canopies (Rosenberger et al., 2011a, 2011b).

Black rot infections can occur anytime between petal fall and harvest. Inoculum often comes from fruitlet mummies left in the tree when crop load adjustment sprays applied the previous year killed the fruitlets but did not allow an abscission layer to form (Russo et al., 2008). Other researchers have shown that incidence and severity of SBFS can be reduced via pruning that allows both better spray coverage and better airflow through tree canopies in late summer (Cooley et al., 1997; Ocamb-Basu et al., 1988). However, no one has determined if removing fruitlet mummies during winter will reduce the incidence of black rot the following summer, and no one has tested an integrated approach using all of these methods for controlling summer diseases on apples in orchards under organic management.

Objective: Evaluate an integrated combination of an OMRI-approved fungicide program, sanitation, and cultural controls in replicated research plots to determine its effectiveness for managing flyspeck, sooty blotch, and summer fruit rots on apples.

Procedures:

In Highland, treatments were evaluated in an orchard planted in 2001 wherein each plot contained one Cameo tree on Bud.9 rootstock and one Royal Court tree on EMLA.111 rootstock with an M.9 inter-stem. During winter pruning, all fruitlet mummies were removed from half of the trees used for this experiment, and then each fungicide treatment was replicated four times on trees from which mummies had been removed and four times on trees that still contained overwintering fruitlet mummies. Trees from which mummies had been removed were also hand-thinned on 12 Jul to ensure that fruiting clusters contained no more than two fruit and that fruit from adjacent clusters were not touching one another. The crop load had been adjusted at normal fruit thinning time using carbaryl and naphthalene acetic acid, but some clusters still carried three fruit, especially on Royal Court trees. At the same time, light pruning was used to remove limbs in Royal Court trees that had come down with crop load and that were therefore impeding airflow and fungicide coverage within the tree canopy.

Prior to the start of this experiment in Highland, the following fungicides were applied to the entire block using an airblast sprayer: COCS (copper) 2 lb/A plus Damoil 2 qt/A on 3 Apr (half-in. green); Nova 40W 4.5 oz/A + Dithane 75W 2.7 lb/A on 6 Apr (tight cluster) and 14 Apr (pink); Nova 4 oz/A + Penncozeb 75W 3 lb/A on 24 Apr (full bloom); Sovran 50W 4.6 oz/A plus Penncozeb 3 lb/A on 2 May (petal fall); and Nova 5 oz/A plus Penncozeb 3 lb/A on 13 May (first cover). The summer fungicides evaluated in this trial were applied on 11 Jun, 2 and 27 July, and 16 and 28 Aug. These treatments were applied using a handgun and a tractor-driven high-pressure sprayer (270 psi) to spray trees to drip.

The months of April and May and the period from mid-June through mid-August were exceptionally dry. The accumulated wetting hours (awhr) as measured on a DeWit string recorder and the accumulated rainfall for the spray interval preceding each spray were 155 hr/2.66 in., 97 hr/1.42 in., 110 hr/1.18 in., 71 hr/1.14 in., and 79 hr/4.67 in. for sprays applied on 11 Jun, 2 Jul, 27 July, 16 Aug, and 28 Aug, respectively. During the interval from the last spray on 28 Aug until Royal Court harvest on 9 Sep, trees were exposed to 48 awhr from dews with no rainfall during that period. From 28 Aug until Cameo harvest on 8 Oct, totals were 403 awhr and 4.55 in. rainfall. However, 194 hr of wetting and 3.4 in. of rain occurred during the last 10 days before harvest.

Data was collected by harvesting 75 arbitrarily selected fruit from each Royal Court tree on 9 September and from each Cameo tree on 8 October. Fruit were evaluated immediately after harvest and fruit with decays were discarded. The remaining fruit were then incubated at 70°F and 100 percent relative humidity for either 19 (Royal Court) or 14 (Cameo) days before they were evaluated a second time. The incubation period allowed recent infections that were not yet visible at harvest to develop visible signs or symptoms on fruit. Data was analyzed using SuperANOVA software from Abacus Concepts. The experimental design allowed a two-way analysis (2 cultural trts X 4 fungicide trts) in a randomized block design with four replications.

In Geneva, the orchard used for this trial was a mature planting of 14-yr-old 'Jonagold' trees on M.9/M.111 inter-stem rootstocks. Fungicide treatments were applied dilute (150 gal/A) to drip using a handgun (200 PSI) at typical cover spray timings (14-21 days) for summer diseases as follows: 21 Jun–3rd cover, 8 Jul–4th cover, 27 Jul-5th cover, 10 Aug–6th cover, 25 Aug–7th cover. For some treatments, cultural adjustments applied at 2nd cover consisted of removing mummified fruitlets, pruning to open the canopy, and hand thinning to one fruit per cluster. The incidence of flyspeck and sooty blotch symptoms on 'Jonagold' was assessed for mature fruit at fresh market harvest maturity (24 Sep). The incidence of disease was expressed as the number of mature fruit with flyspeck or sooty blotch, out of five sampled fruit with 10 such samples assessed for 4-8 replicate trees per treatment. During sooty blotch and flyspeck (SBFS) assessment, the incidence of fruit with "out of grade" fruit finish (russetting and severe discoloration) and summer rots (black, white, and bitter rot) was also recorded. Disease incidence and fruit finish data were subjected to analysis of variance (ANOVA) for a randomized block design using accepted statistical procedures and software (General Linear Model procedure of SAS, version 9.2; SAS Institute Inc., Cary, NC). All percentage data was subject to arcsine square root transformation prior to analysis.

Results:

In Highland, fruitlet mummies were removed from trees used for cultural adjustment plots after winter pruning had been completed, but before bud break. The mummies that were removed were counted and categorized. Royal Court trees contained a mean of 195.4 mummies per tree whereas Cameo trees had only 2.6 mummies per tree. For Royal Court trees, the total count included 9.5 large mummified fruit per tree that remained from the 2009 season, 52.5 additional mummies per tree that were larger than 10 mm in diameter, and 133.4 mummies per tree that were less than 10 mm in diameter.

The threshold of 540 awhr from petal fall that we use to predict when SBFS should appear in unsprayed trees occurred on 22 Aug. Development of flyspeck in Royal Court control plots was monitored by observing 25 fruit per tree in each of three replicates. Incidence of flyspeck on control fruit was 0, 16, 76, and 97% on 26 Jul, 9, 19 Aug, and 3 Sep, respectively. Thus, SBFS appearance on control fruit increased very rapidly between 9 and 19 Aug, slightly earlier than expected because cumulative wetting from petal fall for 9 and 19 Aug was only 466 and 526 hr, respectively, whereas in previous years, when observing SBFS development on Golden Delicious, we have found the flyspeck appearance usually spiked shortly after 540 awhr-PF.

Effects of treatments on 16 different parameters are shown in Table 1 where results from the two-way analyses are summarized. Treatment means for each of these parameters are shown in Tables 2 through 9. There were significant differences due to fungicide treatment for all of the 16 parameters evaluated (Table 1). Cultural adjustments affected outcomes for only 9 of the 16 parameters and had more impact on incidence of sooty blotch and flyspeck than on incidence of black rot. Interaction effects were significant for only one of the 16 parameters evaluated.

The liquid lime sulfur (LLS) treatments consistently reduced SBFS incidence and severity (percent fruit down-graded) as compared to control treatments, but it was as good as the Captan + ProPhyt standard treatments in only five of the 11 parameters related to SBFS diseases (Table 1). LLS was less effective against black rot and was no different from the control treatments for three of the four parameters evaluated.

LLS and the Captan/ProPhyt treatments provided comparable control of SBFS on Royal Court (Table 2). Most of the infections on treated fruit were so small that the fruit would not have been downgraded on the packing line, but fruit were not graded for USDA standards during the harvest rating. Trees with cultural adjustments showed slight but significant reductions in flyspeck compared to trees that received no cultural adjustments (Table 2). The same trend was apparent for sooty blotch, but differences were not significant.

When compared across both cultural treatments, Royal Court fruit from trees receiving LLS developed more black rot than fruit from either the control or from the Captan/ProPhyt treatments (Table 3). The LLS treatments apparently caused surface injuries on fruit that allowed black rot to become established. Royal Court fruit treated with LLS also had significantly more fruit with severe phytotoxicity (Table 3). Much of the phytotoxicity occurred following the application on 2 Jul. Maximum daily temperatures for 3 to 9 Jul were 88, 95, 96, 100, 99, and 89°F. Injury was evident by 12 Jul (Fig. 3). A light frost on 28 Apr caused some

Figure 3. Injury on Royal Court fruit caused by application of liquid lime sulfur followed by a week of high temperatures. Photo was taken on 12 Jul.

fruit russetting and accounts for most of the burn/russet recorded for the other treatments. This injury occurred only on Royal Court and not on Cameo. No evidence of injury on Cameo was visible either during summer or during harvest evaluations.

Incidence of SBFS for fruit evaluated after incubation was consistently greater than for fruit evaluated at harvest (compare Tables 2 and 4). Effects of cultural adjustments were significant for both flyspeck and sooty blotch on incubated fruit. Although most treatments had more than 10% of fruit with SBFS (Table 4), many of these infections remained small or were limited to the stem end or the calyx cup where they would not have resulted in downgrading on the packing line. Downgrading due to SBFS affected less than 5% of fruit for most treatments (Table 5).

Data for Cameo are shown in Tables 6 through 9. Disease incidence was generally lower for Cameo than for Royal Court, except that SBFS incidence in the LLS treatments tended to be higher in Cameo, especially after incubation. This fact suggests that the residual activity of LLS was exceeded by the long interval between the last application and Cameo harvest whereas residual activity of LLS was adequate for the shorter preharvest interval on Royal Court.

In Geneva, the incidence of flyspeck and sooty blotch ranged from 0-57% and 0-82%, respectively (Table 10). With the exception of the treatment involving copper (Badge X2), all programs provided more than 75% control of both flyspeck and sooty blotch. Programs involving Millers Liquid Lime Sulfur and Badge X2 did not adversely affect fruit finish. The Inspire Super plots had few fruit with "out of grade" finishes and Inspire Super provided complete control of all three diseases we evaluated. The incidence of "out of grade" fruit finish on mature fruit was always less than 20%, and it was highest on the Captan + ProPhyt and the Pristine programs.

<u>Discussion</u>:

Our 2010 field trials verified that LLS can provide effective control of SBFS, at least in years with low to moderate rainfall during summer. In a 2005 field trial, LLS was as effective or more effective than Topsin M, Flint, Sovran, or Pristine for controlling flyspeck (Rosenberger & Meyer, 2006). In 2006, four applications of LLS at either 2 qt or 4 qt controlled flyspeck just as well as four sprays of Topsin M plus Captan (the commercial standard) whereas four applications of LLS at 1 qt/100 gal were less effective (Rosenberger and Jentsch, 2006b). LLS applied at 1 qt/100 gal in 2009 failed to control SBFS (Rosenberger et al., 2011a), and that was the reason that we opted to evaluate the higher rate of 2 qt/gal in the Hudson Valley in 2010. However, the 2 qt/100 gal rate of LLS exacerbated black rot on Royal Court (Table 3) and LLS failed to control black rot on Cameo as determined by evaluations conducted at harvest. LLS also failed to control summer fruit decays in our 2010 study (Rosenberger, et al., 2011b).

We had anticipated that removing fruitlet mummies might reduce the amount of black rot inoculum available within trees because these mummies have long been recognized as a potential source of inoculum (Holmes and Rich, 1970). Thus, we were surprised to find that removal of mummies had no effect on black rot incidence except for black rot that showed up on Royal Court during postharvest incubation (Table 5). Black rot inoculum can come from various sources, and simply removing over-wintering inoculum apparently did not have enough impact on the total inoculum load to trigger differences in fruit decays at harvest.

An unexpected outcome of this trial was that the cultural adjustments had a significant impact on the incidence and severity of sooty blotch and flyspeck. The cultural adjustments that we used involved mummy removal, hand thinning, and light summer pruning, and there is therefore no way to know which of these cultural practices had the greatest impact. Summer pruning was shown to reduce SBFS incidence in previous trials (Cooley et al., 1997), but the relatively small amount of summer pruning used in this trial was unlikely to account for all of the impacts we found from our combined cultural adjustments.

Results from this trial are consistent with previous work showing that cultivars differ in their susceptibility to black rot (Biggs, and Miller, 2004; Holmes and Rich, 1970; Rosenberger & Jentsch, 2006). We have also noted in previous trials that cultivars differ in their susceptibility to damage by LLS. Because we do not have any OMRI-approved fungicides that will control summer fruit decays, organic apple growers can avoid black rot only by selecting cultivars that will tolerate LLS and/or copper sprays during summer, by avoiding cultivars that are especially susceptible to black rot, and by using LLS at conservative rates that will not exacerbate black rot by causing fruit injuries that provides entry points for decays.

In our trials, all treatments were applied with a handgun, thereby ensuring complete fruit coverage. However, spraying fruit to drip may also have increased the potential for injury from LLS. Thus, growers who apply LLS with an airblast sprayer may be less likely to sustain the damage that we encountered with LLS treatments applied to Royal Court, but they may also find that LLS works less well against SBFS than our results would suggest, especially if dense tree canopies and heavy crop loads impede spray coverage during late summer.

Results from this work should be applicable to organic farmers throughout New York and New England. Growers in the northern reaches of this region will have less difficulty with apple summer diseases than will grower in the Hudson Valley and southern New England where summers tend to be warmer and more humid.

Literature Cited:

Arias, M.M.D., Batzer, J.C., Wong, A.W., Bost, S.C., Cooley, D.R., Ellis, M.A., Hartman, J.R., Rosenberger, D.A., Sundin, G.W., Sutton, T.B., Travis, J.W., Wheeler, M.J., Yoder, K.S., Gleason, M.L. 2009. Diversity and biogeography of sooty blotch and flyspeck fungi on apple in the eastern and Midwestern United States. Phytopathology 99 (accepted 26 Aug 2009)).

Biggs, A. R., and Miller, S. S. 2004. Relative susceptibility of selected apple cultivars to Botryosphaeria obtusa. HortScience 39:303-306.

Brown, E.M. and T.B. Sutton. 1995. An empirical model for predicting the first symptoms of sooty blotch and flyspeck of apples. Plant Dis. 79:1165-1168.

Cooley, D.R., J.W. Gamble, and W.R. Autio. 1997. Summer pruning as a method for reducing flyspeck disease on apple fruit. Plant Dis. 81:1123-1126.

Cooley, D.R., S. M Lerner, and A.F. Tuttle. 2007. Maturation of thyriothecia of Schizothyrium pomi on the reservoir host Rubus allegheniensis. Plant Dis. 91:136-141.

Holmes, J. and Rich, A. E. 1970. The influence of the retention of immature apple mummies by certain cultivars on the overwintering of *Physalospora obtusa*. Phytopathology 60:452-453.

Ocamb-Basu, C.M., T.B. Sutton, and L.A. Nelson. 1988. The effects of pruning on severity and incidence of *Zygophiala jamaicensis* and *Gloeodes pomigena* infections of apple fruit." Phytopathology 78:1004-1008.

Rosenberger, D. and Jentsch, P. 2006a. Evaluation of organic pest controls and fruit thinning on multiple apple cultivars. N.Y. State IPM Program 2006 IPM Project Report. On-line at http://nysipm.cornell.edu/grantspgm/projects/proj06/fruit/rosenberger2.asp

Rosenberger, D. and Jentsch, P. 2006b. Effectiveness of lime-sulfur and phosphorous acid for controlling summer diseases on apples. N.Y. State IPM Program 2006 IPM Project Report. On-line at http://nysipm.cornell.edu/grantspgm/projects/proj06/fruit/rosenberger.pdf.

Rosenberger, D.A. and Meyer, F.W. 2006. Post-infection control of flyspeck with new fungicides, 2005. Fungicide and Nematicide Tests (online.) Report 61:PF024. DOI:10.1094/FN61. The American Phytopathological Society, St. Paul, MN.

Rosenberger, D.A., and Meyer, F.W. 2007. Control of flyspeck with phosphorous acid, liquid lime-sulfur, and other fungicides, 2006. Plant Disease Management Reports (online). Report 1:PF019. DOI:10.1094/PDMR01. The American Phytopathological Society, St. Paul, MN.

Rosenberger, D.A., Meyer, F.W, Rugh, A.L. and Sudol, L.R. 2011a. Controlling sooty blotch and flyspeck with fungicides approved for organic production, 2009. Plant Disease Management Reports (online). Report 5: [In press.] DOI:10.1094/PDMR05. The American Phytopathological Society, St. Paul, MN.

Rosenberger, D.A., Meyer, F.W, Rugh, A.L. and Sudol, L.R. 2011b. Controlling fruit decays caused by Botryosphaeria species in organic apple production, 2009. Plant Disease Management Reports (online). Report 5: [In press.] DOI:10.1094/PDMR05. The American Phytopathological Society, St. Paul, MN.

Rosenberger, D.A., Meyer, F.W., and Rugh, A.L. 2009. Controlling flyspeck, sooty blotch, and fruit decays with fungicides applied during summer, 2008. Plant Disease Management Reports (online). Report 3:PF011. DOI:10.1094/PDMR03. The American Phytopathological Society, St. Paul, MN.

Russo, N.L., Rosenberger, D.A., and Cox, K. D. 2008. Effect of apple scab fungicide programs on colonization and survival of Botryosphaeria spp. in mummified apple fruitlets in NY. Abstr. 2008 Ann. Mtg. Am. Phytopathol. Soc. On-line at http://www.apsnet.org/meetings/2008/abstracts/a08ma720.htm .

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Table 1. Summary of treatment effects from analyses for 16 different parameters as determined by comparing means from two-way analyses involving four fungicide treatments that were each applied to plots with or without cultural adjustments designed to reduce disease pressure in Highland, NY.

	P-values: grand means[z]			Fungicide grand means[y]		
Variable evaluated	effects of fungi-cides	effects of cultural adjust-ments	inter-action effects	lime sulfur better than control	Captan/ Prophyt b.t.[w] lime sulfur	lime sulfur equal to or b.t.[w] Captan/ Prophyt
Flyspeck (% fruit affected):						
Royal Court at harvest (T. 2)[x]	**0.001**	**0.049**	0.810	**[y]	-	**
Royal Court incubated (T. 4)	**<0.001**	**0.017**	0.741	**	-	**
Cameo at harvest (T. 6)	**<0.001**	**0.029**	0.060	**	**	-
Cameo incubated (T. 8)	**<0.001**	**0.001**	0.110	**	**	-
Sooty blotch (% fruit affected):						
Royal Court at harvest (T. 2)	**<0.001**	0.096	0.348	**	-	**
Royal Court incubated (T. 4)	**<0.001**	**0.006**	0.306	**	-	**
Cameo at harvest (T. 6)	**<0.001**	**0.008**	0.393	**	**	-
Cameo incubated (T. 8)	**<0.001**	**<0.001**	**0.015**	**	**	-
% fruit downgraded for SBFS:						
Royal Court incubated (T. 5)	**<0.001**	0.053	0.458	**	**	**
Cameo at harvest (T. 7)	**<0.001**	**0.001**	0.065	**	**	-
Cameo incubated (T. 9)	**<0.001**	0.067	0.531	**	**	-
% down-graded for fruit finish:						
Royal Court at harvest (T. 3)	**<0.001**	0.674	0.849	-	**	-
Black rot (% fruit affected):						
Royal Court at harvest (T. 3)	**<0.001**	0.395	0.389	-	**	-
Royal Court incubated (T. 5)	**0.001**	**0.001**	0.974	-	**	-
Cameo at harvest (T. 7)	**0.007**	0.423	0.845	-	**	-
Cameo incubated (T. 9)	**0.006**	0.560	0.528	**	-	**

[z] *P*-values for grand means from the two-way analyses. *P*-values are shown in bold type where analyses indicate that significant differences exist among the means ($P \leq 0.05$).

[y] A double asterisk indicates situations were grand means for the fungicide comparison noted in the header were significantly different ($P \leq 0.05$) as determined by applying the LSD test to the grand means. Comparisons that lacked significant differences are denoted with a dash. In comparisons involving Captan + ProPhyt, differences were noted as significant if the comparisons noted in the header would be true for either one of the two Captan + ProPhyt treatments.

[x] Treatment means are shown in the tables referenced after each variable.

[w] b.t. = better than.

Table 2: Effects of fungicides and cultural adjustments on incidence of flyspeck and sooty blotch on **Royal Court** fruit at the time of **harvest** on 9 Sep as determined by evaluating 75 fruit per tree in Highland, NY.

	% fruit with flyspeck			% fruit with sooty blotch		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal [z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	98.3 b[y]	96.4 b	97.4 b[x]	84.3 b	66.8 b	75.6 b[x]
Liquid Lime Sulfur 2 qt	11.0 a	7.0 a	9.0 a	6.7 a	4.0 a	5.3 a
Captan 16 oz/Prophyt	11.0 a	9.0 a	10.0 a	5.7 a	3.0 a	4.4 a
Captan 10 oz/Prophyt	12.6 a	3.7 a	8.1 a	2.7 a	0.7 a	1.7 a
Grand means: cultural	33.2 B	29.0 A[x]		24.2 A	19.3 A[x]	

[z] Treatments were applied 11 Jun, 2 and 27 Jul, 16 and 28 Aug. Lime-sulfur was Millers Liquid Lime Sulfur. Captan formulation was 80W, and ProPhyt in both treatments was applied at 21.3 fl oz/100 gallons of dilute spray.

[y] Arithmetic means are shown in the table, but means separations were determined by applying Fisher's Protected LSD to results from two-way analyses of arcsine-transformed data. Simple means within columns followed by the same lower-case letter or grand means followed by the same upper case letter do not differ significantly ($P \leq 0.05$). Simple means followed by asterisks differ significantly ($P \leq 0.05$) from the corresponding simple mean in the next column.

[x] *P*-values from the analyses are shown in Table 1.

Table 3: Effects of fungicides and cultural adjustments on incidence of black rot and phyto-toxicity on **Royal Court** fruit at the time of **harvest** on 9 Sep as determined by evaluating 75 fruit per tree in Highland, NY.

	% fruit with black rot			% out-of-grade for burn/russet		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal [z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	2.7 a[y]	4.3 ab	3.5 a	2.3 a[y]	1.6 a	2.0 a
Liquid Lime Sulfur 2 qt	21.0 b	12.7 b	16.9 b	22.0 b	28.1 b	25.0 b
Captan 16 oz/Prophyt	1.7 a	1.3 a	1.5 a	5.0 a	2.0 a	3.5 a
Captan 10 oz/Prophyt	3.0 a	3.0 ab	3.0 a	2.3 a	2.3 a	2.3 a
Grand means: cultural	7.1 A	5.3 A		7.9 A	8.5 A	

[z, y] See footnotes for Table 2.

Table 4: Effects of fungicides and cultural adjustments on incidence of flyspeck and sooty blotch on **Royal Court** fruit **following incubation** at 70°F and 100% relative humidity for 19 days after harvest on 9 Sep in Highland, NY.

	% fruit with flyspeck			% fruit with sooty blotch		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal [z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	100.0 b [y]	99.0 b	99.4 b	94.2 c [y]	91.1 b	92.6 b
Liquid Lime Sulfur 2 qt	20.5 a	10.1 a	15.3 a	24.4 b	10.1 a	17.3 a
Captan 16 oz/Prophyt	23.6 a	11.5 a	17.6 a	20.9 ab	8.9 a	14.9 a
Captan 10 oz/Prophyt	20.9 a	15.9 a	18.4 a	11.3 a	11.4 a	11.4 a
Grand means: cultural	41.2 B	34.1 A		37.8 B	30.4 A	

[z, y] See footnotes for Table 2.

Table 5: Effects of fungicides and cultural adjustments on disease incidence and severity on **Royal Court** fruit **following incubation** at 70°F and 100% relative humidity for 19 days after harvest on 9 Sep in Highland, NY.

	% out-of-grade due to SBFS			% fruit with black rot decay		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal [z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	94.5 b [y]	87.9 b	91.2 c	24.9 b [y]	12.6 bc	18.7 b
Liquid Lime Sulfur 2 qt	5.3 a	3.3 a	4.3 b	30.7 b	15.5 c	23.0 b
Captan 16 oz/Prophyt	2.4 a	0.7 a	1.5 ab	10.2 a	3.0 a	6.6 a
Captan 10 oz/Prophyt	1.4 a	1.1 a	1.2 a	11.1 a	3.5 ab	7.3 a
Grand means: cultural	25.9 A	23.2 A		19.2 B	8.6 A	

[z, y] See footnotes for Table 2.

Table 6: Effects of fungicides and cultural adjustments on incidence of flyspeck and sooty blotch on **Cameo** fruit at the time of harvest on 8 Oct as determined by evaluating 70 fruit per tree in Highland, NY.

	Fruit (%) with flyspeck			Fruit (%) with sooty blotch		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal [z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	100.0 c [y]	100.0 c	100.0 c	99.3 c [y]	99.1 c	99.2 c
Liquid Lime Sulfur 2 qt	22.6 b	7.1 b	14.9 b	22.0 b*	8.6 b	15.3 b
Captan 16 oz/Prophyt	2.8 a	2.5 ab	2.7 a	3.2 ab	1.8 a	2.5 a
Captan 10 oz/Prophyt	3.6 a	1.8 a	2.7 a	2.1 a	0.0 a	1.1 a
Grand means: cultural	32.3 B	27.9 A		31.7 B	27.4 A	

[z, y] See footnotes for Table 2.

Table 7: Effects of fungicides and cultural adjustments losses disease incidence and severity on **Cameo** fruit at the time of harvest on 8 Oct as determined by evaluating 70 fruit per tree in Highland, NY.

	Fruit (%) with black rot			% downgraded due to SBFS		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal [z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	9.6 ab	14.2 b	11.9 b	99.3 c*[y]	96.3 b	97.8 c
Liquid Lime Sulfur 2 qt	12.0 b	11.8 ab	11.9 b	6.0 b*	1.4 a	3.7 b
Captan 16 oz/Prophyt	6.1 ab	5.0 ab	5.5 a	0.7 a	0.0 a	0.4 a
Captan 10 oz/Prophyt	3.5 a	3.2 a	3.4 a	0.0 a	0.0 a	0.0 a
Grand means: cultural	7.8 A	8.6 A		26.5 B	24.4 A	

[z, y] See footnotes for Table 2.

Table 8: Effects of fungicides and cultural adjustments on incidence of flyspeck and sooty blotch on **Cameo** fruit **following** incubation at 70°F and 100% relative humidity for 17 days after harvest on 8 Oct in Highland, NY.

	Fruit (%) with flyspeck			Fruit (%) with sooty blotch		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal[z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	100.0 c[y]	100.0 c	100.0 c	100.0 c[y]	99.6 c	99.8 c
Liquid Lime Sulfur 2 qt	32.3 b*	15.5 b	23.9 b	56.9 b*	23.0 b	40.0 b
Captan 16 oz/Prophyt	9.8 a*	3.8 a	6.8 a	14.3 a	5.7 a	10.0 a
Captan 10 oz/Prophyt	5.6 a	2.6 a	4.1 a	9.6 a	5.2 a	7.4 a
Grand means: cultural	36.9 B	30.5 A		45.2 B	33.4 A	

[z, y] See footnotes for Table 2.

Table 9: Effects of fungicides and cultural adjustments on disease incidence and severity on **Cameo** fruit **following** incubation at 70°F and 100% relative humidity for 17 days after harvest on 8 Oct in Highland, NY.

	% out-of-grade due to SBFS			% fruit with black rot decay		
	cultural adjustm'ts		grand	cultural adjustm'ts		grand
Products/rates per 100 gal[z]	none	mummies removed	means for fungicide	none	mummies removed	Means for fungicides
Control	100.0 c[y]	99.2 b	99.6 c	9.0 a[y]	14.0 b	11.5 b
Liquid Lime Sulfur 2 qt	6.1 b	2.4 a	4.3 b	4.1 a	7.1 ab	5.6 a
Captan 16 oz/Prophyt	0.7 a	0.4 a	0.6 a	4.8 a	2.3 a	3.5 a
Captan 10 oz/Prophyt	0.7 a	0.4 a	0.6 a	3.0 a	1.9 a	2.4 a
Grand means: cultural	26.9 A	25.6 A		5.2 A	6.3 A	

[z, y] See footnotes for Table 2.

Table 10. Effects of fungicides and cultural adjustments in disease incidence and fruit finish on Jonagold fruit harvested 24 Sep in Geneva, NY.

	Percent fruit affected			
Summer treatment programs (amt./A)	fruit russet	flyspeck	sooty blotch	fruit rot
Untreated	16.7 b	56.9 c	81.5 c	17.1 c
Untreated + cultural adjustments	3.3 a	48.3 c	45.0 b	2.5 a
Millers Liquid Lime Sulfur 3 qt	5.0 a	11.4 ab	5.0 a	2.1 a
Millers L-L Sulfur 3 qt + cultural adjustments	2.5 a	8.8 ab	2.5 a	0.8 a
MBadge X2 16 oz + Lime-Calcium 0.75 qt	2.5 a	20.8 b	10.0 a	3.8 ab
Serenade Max 2 lbs + ProPhyt 2 qt	15.8 b	5.0 a	7.8 a	6.4 abc
Captan 80WDG 2.5 lbs + ProPhyt 2 qt	7.1 ab	1.9 a	0.6 a	9.2 bc
Pristine 14.5 oz	10.4 b	7.8 ab	1.3 a	3.3 ab
Inspire Super 12 fl oz	2.5 a	0.0 a	0.0 a	0.0 a

[z]All values represent the means of five fruit from at least 10 fruit collections across 4-8 replicate trees. Values within columns followed by the same letter are not significantly different ($P \leq 0.05$) according to Fisher's protected LSD test.

[y]Treatments were applied on 21 Jun–3rd cover, 8 Jul–4th cover, 27 Jul–5th cover, 10 Aug–6th cover, and 25 Aug–7th cover.