Research Report to the North American Raspberry and Blackberry Association 2008

Title: Evaluation of reduced-risk fungicides for disease control in raspberries.

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Type of Research:
Production research

Objectives:
The overall goal of this proposal we to expand the reduced-risk options for disease control in raspberries and to familiarize growers with these new products. The specific objectives of this proposal were to:
1) Evaluate reduced-risk fungicides for control of foliar and cane diseases of raspberries.
2) Evaluate reduced-risk fungicides for control of pre- and post-harvest fruit rots.

Procedures:
The following products were evaluated for disease control in summer red raspberry (cv. Prelude) in a commercial planting in Onondaga, MI in 2008: ProPhyt (potassium phosphite), Phostrol (mono- and dibasic sodium, ammonium and potassium phosphites), Sporan (rosemary oil, clove oil, thyme oil, wintergreen oil: OMRI listed), Polyversum (*Pythium oligandrum*: biocontrol agent), Kaligreen (potassium bicarbonate: OMRI-listed), Endorse (polyoxin-D zinc salt), Prev-Am (borax and citrus extract), Kocide 3000 (copper hydroxide), Tanos (famoxadone and cymoxanil), and a standard program containing Nova (myclobutanil), Captan (captan), Cabrio (pyraclostrobin), and Switch (cyprodinil and fludioxonil). Plants were maintained in trellised hedgerows approximately 3 ft wide and spaced 9 ft apart. Treatments were applied to 10-ft sections of row and were replicated four times in a randomized complete block design. Sprays were applied with an R&D Research CO_2 cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. Spray volume was 75 gpa. Spray dates and corresponding phenological stages were as follows: 20 May (leafed out), 30 May (bloom), 7 Jun (green fruit), and 21 Jun (first ripe fruit). Total rainfall between sprays was 0.11, 0.51, and 3.02 in., respectively. Total rainfall between the last spray and the first harvest was 0.39 in. Rainfall between harvests was 0.41 and 2.60 in, respectively. On 27 Jun, 2 Jul, and 7 Jul, fifty healthy-looking berries were hand-harvested from the center 3 ft of each plot. Since field rot levels were low, berries were subjected to a post-harvest

rot test. Berries were placed equidistantly on metal screens in aluminum trays and incubated at room temperature and 100% RH for 5 days before being examined for post-harvest rots. On 15 Aug, leaves were evaluated for leaf spot severity and canes were evaluated for spur blight incidence. Plants were also observed for phytotoxicity throughout the season.

Results:
Leaf spot severity was low in 2008. Spur blight, however, was moderately severe with over 80% of the canes having one or more lesions in August. All treatments reduced leaf spot severity, with the standard fungicide program providing 100% control (Table 1). Many other programs were statistically similar to the standard program, including all Tanos programs, Kocide, Endorse, Polyversum, and Prev-Am. All treatments also reduced spur blight incidence compared to the untreated control (Table 2). However, the standard program was numerically the most effective and statistically similar to the 8-oz Tanos program and Kocide. There were no statistical differences between the Kocide program and Kocide alternated with Tanos. ProPhyt was significantly more effective than Phostrol against spur blight, while these fungicides were similar in their efficacy against leaf spot. The reduction in control observed when Tanos was substituted for Cabrio on June 6 suggests that this may be an important timing for spur blight control. Frequent precipitation in June and July resulted in high post-harvest Botrytis fruit infection incidence (Table 3). The most effective treatments were those with Switch as the last spray before harvest. Unfortunately, reliable data were not available for the remaining treatments at the first harvest. However, the effect of Switch on Botrytis rot incidence was still detectable and significant more than two weeks after the last spray.

Conclusions:
Biological and reduced-risk fungicides all controlled raspberry leaf spot. Among these, Polyversum and Endorse were most effective; however, disease pressure was light in 2008. The phosphorous acids showed similar levels of (moderate) control against various diseases as in 2007, indicating that they are more versatile than just controlling Phytophthora root rot. Spur blight was harder to control than leaf spot (probably because most infections occur near the ground) and ProPhyt looked best among the reduced-risk/biological fungicides. Adding Tanos to a program of copper sprays tended to improve disease control, but was generally not significantly different from Kocide applied alone. None of the reduced-risk/biological fungicides was very effective against post-harvest Botrytis gray mold and programs with Switch as the last spray before harvest were most effective. Overall, the "standard" fungicide program with four consecutive sprays of Nova, Captan, Cabrio, and Switch was most effective at keeping raspberries healthy throughout the season. This program also alternates fungicides in different chemical classes for fungicide resistance management.

Matching funding: With NARBA funds, we were able to leverage $3,000 in matching funds from the USDA IR-4 project, and $4,500 in matching funds from DuPont Inc. Fungicides for testing were donated by various companies.

Table 1.

Treatment rate/A	Application timing[z]	Leaf spot severity (% leaf area infected)	% Control[y]
Untreated	1, 2, 3, 4	3.75 a[x]	
Sporan 3 pt	1, 2, 3, 4	1.25 b	[67]
ProPhyt 4 pt	1, 2, 3, 4	1.25 b	[67]
Phostrol 4 pt	1, 2, 3, 4	1.13 b	[70]
Kaligreen 3 lb	1, 2, 3, 4	1.00 b	[73]
Prev-Am 25 fl oz	1, 2, 3, 4	0.88 bcd	[77]
Polyversum 1.43 oz	1, 2, 3, 4	0.50 bcd	[87]
Endorse 16 oz	1, 2, 3, 4	0.38 bcd	[90]
Kocide 3000 1 lb	1, 2, 3, 4	0.38 bcd	[90]
Tanos 10 oz + Kocide 3000 1 lb fb Kocide 3000 1 lb	1, 3, 2, 4	0.13 cd	[97]
Tanos 8 oz + Kocide 3000 1 lb fb Kocide 3000 1 lb	1, 3, 2, 4	0.13 cd	[97]
Nova 40W 2 oz fb Captan 80WDG 3 lb fb Tanos 10 oz fb Switch 62.5WG 14 oz	1, 2, 3, 4	0.13 cd	[97]
Nova 40W 2 oz fb Captan 80WDG 3 lb fb Cabrio EG 14 oz fb Switch 62.5WG 14 oz	1, 2, 3, 4	0.0 d	[100]

[z]Spray dates: 1 = 20 May (leafed out), 2 =30 May (bloom), 3 = 7 Jun (green fruit), and 4 = 21 Jun (first

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[x]The percent control is expressed relative to the untreated check.

Table 2.

Treatment rate/A	Application timing[z]	Spur blight incidence (% canes infected)	% Control[y]
Untreated	1, 2, 3, 4	81.3 a[x]	
Kaligreen 3 lb	1, 2, 3, 4	63.8 b	[22]
Phostrol 4 pt	1, 2, 3, 4	56.3 bc	[30]
Polyversum 1.43 oz	1, 2, 3, 4	53.8 bcd	[34]
Prev-Am 25 fl oz	1, 2, 3, 4	50.0 cd	[38]
Sporan 3 pt	1, 2, 3, 4	43.8 cde	[46]
Endorse 16 oz	1, 2, 3, 4	43.8 cde	[46]
Nova 40W 2 oz Captan 80WDG 3 lb Tanos 10 oz Switch 62.5WG 14 oz	1, 2, 3, 4	42.5 de	[48]
ProPhyt 4 pt	1, 2, 3, 4	36.3 ef	[55]
Tanos 10 oz + Kocide 3000 1 lb Kocide 3000 1 lb	1, 3, 2, 4	33.8 ef	[58]
Kocide 3000 1 lb	1, 2, 3, 4	25.0 fg	[69]
Tanos 8 oz + Kocide 3000 1 lb Kocide 3000 1 lb	1, 3, 2, 4	23.8 fg	[71]
Nova 40W 2 oz Captan 80WDG 3 lb Cabrio EG 14 oz Switch 62.5WG 14 oz	1, 2, 3, 4	15.0 g	[82]

[z]Spray dates: 1 = 20 May (leafed out), 2 =30 May (bloom), 3 = 7 Jun (green fruit), and 4 = 21 Jun (first ripe fruit).

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[x]The percent control is expressed relative to the untreated check.

Table 3.

Treatment rate/A	Application timing[z]	Post-harvest Botrytis gray mold (% fruit infected)[y] Harvest 1		Harvest 2		Harvest 3	
Untreated	1, 2, 3, 4	55.0	a[w]	83.5	ab	77.9	ab
Tanos 10 oz + Kocide 3000 1 lb	1, 3,	-	[v]				
Kocide 3000 1 lb	2, 4			88.0	a	81.1	a
Phostrol 4 pt	1, 2, 3, 4	-		83.8	ab	52.1	bc
Kocide 3000 1 lb	1, 2, 3, 4	-		83.7	ab	60.5	abc
Tanos 8 oz + Kocide 3000 1 lb	1, 3,	-					
Kocide 3000 1 lb	2, 4			81.2	ab	59.4	abc
Sporan 3 pt	1, 2, 3, 4	-		81.1	ab	51.0	c
Polyversum 1.43 oz	1, 2, 3, 4	-		79.0	ab	78.4	a
Kaligreen 3 lb	1, 2, 3, 4	-		78.5	abc	77.2	ab
ProPhyt 4 pt	1, 2, 3, 4	-		76.5	bcd	65.4	abc
Prev-Am 25 fl oz	1, 2, 3, 4	-		76.5	bcd	64.9	abc
Endorse 16 oz	1, 2, 3, 4	-		66.4	d	61.9	abc
Nova 40W 2 oz Captan 80WDG 3 lb Tanos 10 oz Switch 62.5WG 14 oz	1, 2, 3, 4	5.0	b	67.8	cd	43.9	c
Nova 40W 2 oz Captan 80WDG 3 lb Cabrio EG 14 oz Switch 62.5WG 14 oz	1, 2, 3, 4	4.5	b	54.0	e	42.8	c

[z]Spray dates: 1 = 20 May (leafed out), 2 =30 May (bloom), 3 = 7 Jun (green fruit), and 4 = 21 Jun (first ripe fruit).

[y]Percent berries with >10% of their surface area covered with Botrytis were considered infected.

[x]Data did not pass Bartlett's test for homogeneity of variance; assumptions of the ANOVA may have been violated.

[w]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[v]Due to illness of laboratory assistant, these treatments were rated late and were therefore not comparable.