APPLE (*Malus domestica* 'Rome')
Powdery Mildew; *Podosphaera leucotricha*
Scab; *Venturia inaequalis*

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Evaluation of soil injected fungicide for management of apple diseases, 2022-2024.

This trial was conducted at the Botany and Plant Pathology Field Laboratory in an apple orchard planted on a Camas gravelly sandy loam soil type. Fungicide treatments were arranged in a randomized complete block design in a block of 'Rome' apples on M-7 rootstock planted in 1979 on 20 x 20 ft spacing. Each treatment consisted of 5 single tree replicates. The diameter of trees 8 inches above ground was determined 25 Oct 2022. The fungicide RTSA 505 was injected into the soil around trees using an HTI 2000 Soil Injector connected to a Maruyama MS75 backpack power sprayer. The nozzle end of the injector was inserted 4 inches into the soil prior to horizontal injection of the fungicide solution. The amount of fungicide solution injected was based on the diameter of each tree where 250 ml of solution was injected per inch diameter. For example, 11 separate injection sites were evenly distributed within the drip zone of a tree 11 inches in diameter.

Soil Injections 2022 to 2023

Fall injections occurred on 8 Nov 2022 (leaves still on tree) and spring injections occurred 27 Apr 2023 (green tip) and 11 May 2023 (full bloom). The fungicide solution emerged from about half the injection sites (through cracks and earthworm middens) during application and puddled on the ground before subsequently absorbing. Due to dry conditions, a supplemental irrigation of between 0.25 and 0.5 inches water was applied on 16 May 2023 with low angle sprinkler heads that do not wet the canopy. The fungicide Banner Maxx II was foliar applied using a hydraulic handgun sprayer at 100 psi, such that 4.5 to 6 gal of a spray suspension was applied per 5 trees (122 to 163 gal water/A), depending on the amount of foliage present.. Foliar sprays were applied on 27 Apr 23 (green tip), 11 May 23 (full bloom), 25 May 23 (fruit set), 8 Jun 23 (2nd cover) and 23 Jun 23 (3rd cover). Trees were pruned late Feb 2023. No fertilizer was spread within tree rows. A delayed dormant oil spray of Omni supreme-oil (2.0 gal/A) was applied on 12 Apr 23 for aphid management. Insecticide sprays were applied to the entire block using a Rear's air blast sprayer. GlyStar Plus (5.23 oz/gal) and Galligan 2e (2 pts/A) were applied on 1 Mar 23 for weed control using a Rear's 100g boom sprayer. Apple scab infection periods were monitored using a Meter ATMOS 41 All-In-One weather station equipped with standard sensors and a ZL6 data logger. Using a modified primary infection model for apple scab (wet periods start with rain and end with 8 hr drying time), a total of 4 infection periods were detected from Apr through Jun 2023: 2 high risk infection periods (5 and 20 Apr), 1 moderate risk infection period (9 Apr) and 1 low risk infection period (31 Mar). The incidence of scab and powdery mildew on leaves was determined on 10 Jul 23, by examining all leaves from 20 arbitrarily selected vegetative shoots (190 to 240 leaves for an average of 223) from each tree. Incidence of fruit russet and scab was determined on 28 Aug 23 by examining 100 fruit arbitrarily selected from each tree. To evaluate possible plant growth regulation effects, the height and width of fruit was determined on 29 Aug 23 by examining 50 fruit arbitrarily selected from each tree. Defoliation was accessed on 29 Nov 2023.

Rainfall during the dormant season (Oct 2022 to March 2023) was 3.18 inches below normal. Spring weather conditions were normal to dry in April and first week of May but then became very dry with little rainfall for the remainder of the season. Soil moisture was measured at 30% water content (29-32%) during both the fall and spring injections. Conditions throughout the spring were considered low risk for apple scab development but high risk for powdery mildew. Apple scab was first found on crabapple pollenizers in a nearby block on 17 Apr 2023 but not until June in this block. Shoots covered with powdery mildew due to infection the previous year were first observed on 15 May.

Highest amount of apple scab on leaves in 2023 was found on non-treated trees and was significantly higher than all fungicide treated trees (Table 1). Lowest amount of apple scab on leaves was found on trees treated with Banner Maxx II and was significantly lower than all other fungicide treated trees. Highest amount of apple scab on fruit was found on non-treated trees, however, it was not significantly different

from scab found on trees treated with 10 ml RTSA 505 in the fall. Lowest amount of apple scab on fruit was found on trees treated with Banner Maxx II, however, it was not significantly different from fruit scab found on trees treated with 5 ml RTSA 505 at bud break. Highest amount of powdery mildew in 2023 was found on non-treated trees and was significantly higher than all fungicide treated trees (Table 2). Lowest amount of powdery mildew was found on trees treated with Banner Maxx II and was significantly lower than all other fungicide treated trees. Highest amount of fruit russet in 2023 was found on non-treated trees, however, it was not significantly different from that found on trees treated with 10 ml RTSA 505 in the fall (Table 3). Lowest amount of fruit russet was found on trees treated with Banner Maxx II and was significantly lower than all other fungicide treated trees. Highest fruit diameter to height ratio was found on trees treated with Banner Maxx II, which was not significantly different from non-treated trees. Lowest fruit diameter to height ratio was found on trees treated with 5 ml RTSA 505 in the fall and at bud break, however, it was not significantly different from that found on trees treated with just 5 ml RTSA 505 at bud break or at bud break and 2 weeks later. There was no difference in defoliation among any of the treatments (Table 2). Phytotoxicity was not observed on any treated trees.

Soil Injections 2023 to 2024

A similar trial was conducted on the same set of trees from 2023 to 2024. Fall injections occurred on 14 Dec 2023 (leaf fall) and spring injections occurred 11 Apr 2024 (calyx) and 24 Apr 2024 (30% bloom). The fungicide Banner Maxx II was foliar applied using a hydraulic handgun sprayer at 100 psi, such that 4.5 to 6 gal of a spray suspension was applied per 5 trees (122 to 163 gal water/A), depending on the amount of foliage present.. Foliar sprays were applied on 11 Apr 24 (calyx), 24 Apr 24 (30% bloom), 9 May 24 (petal fall), 23 May 24 (fruit set), 6 Jun 24 (2^{nd} cover) and 20 Jun 24 (3^{rd} cover). Trees were pruned 8 Feb 2024. No fertilizer was spread within tree rows. Omni Supreme Spray Oil (2.6 qt/A) was applied on 9 Apr for aphid management. Insecticide sprays were applied to the entire block using a Rear's air blast speed sprayer. GlyStar Plus (5.7 pt/A) was applied on 18 Mar for management of weeds. A total of 9 infection periods were detected from Apr through Jun 2024: 3 high infection periods (25 Apr, 3 May, and 2 Jun), 4 moderate infection periods (22 Mar, 2 Apr, 1 May and 16 Jun) and 2 low infection periods (28 Mar and 6 Apr). The number of powdery mildew flag shoots per tree was determined on 10 Jun 24. The incidence of scab and powdery mildew on leaves was determined on 11 Jul 24, by examining all leaves from 20 arbitrarily selected vegetative shoots (178 to 239 leaves for an average of 199) from each tree. Incidence of fruit russet and scab was determined on 22 Aug 24 by examining 100 fruit arbitrarily selected from each tree. To evaluate possible plant growth regulation effects, the height and width of fruit was determined on 22 Aug 24 by examining 50 fruit arbitrarily selected from each tree.

Rainfall during the dormant season 2023-24 was 4.1 inches above normal, spring weather conditions were close to long-term norms while summer was accented by a few high heat events. Scab was first observed on crabapple pollenizers on 25 Mar 24 and then on non-treated trees on 8 Apr 24 in a nearby block. Flag shoots with powdery mildew was first observed on 22 Apr 24 and leaves with powdery mildew were first observed on 13 May 24.

Highest amount of apple scab on leaves in 2024 was found on non-treated trees and was significantly higher than all fungicide treated trees (Table 1). Lowest amount of apple scab on leaves was found on trees treated with Banner Maxx II but was not significantly different from that found on trees injected in both the fall and spring. Highest amount of apple scab on fruit was found on non-treated trees, however, it was not significantly different from scab found on trees treated with 10 ml RTSA 505 in the fall of 2022 or at bud break in 2023. Lowest amount of apple scab on fruit was found on trees treated with Banner Maxx II and was significantly lower than all fungicide treated trees. Flag shoots covered with powdery mildew due to infection in 2023 were highest on non-treated trees and lowest on trees treated with Banner Maxx II (Table 2). Highest amount of powdery mildew on leaves in 2024 was found on non-treated trees and was significantly higher than all fungicide treated trees. Lowest amount of powdery mildew was found on trees treated with Banner Maxx II and was significantly lower than all other fungicide treated trees. Highest amount of fruit russet in 2024 was found on non-treated trees (Table 3). Lowest amount of fruit russet was found on trees treated with Banner Maxx II but was not significantly different from that found on trees injected in the fall of 2022 only, bud break only in 2023 and 2024, and bud break and 2 weeks later in both years. Fruit diameter to height ratio in 2024 was not significantly different among the various treatments. Phytotoxicity was not observed on any treated trees.

Table 1. Leaves and fruit with apple scab.

Treatment & Rate/injection or /100 gal as indicated below	Time of Application[X]	Ave. Tree Diameter (inches) [Y]	Apple Scab Leaves (%)[Y]		Apple Scab Fruit (%)[Y]	
			2023	2024	2023	2024
Non-treated……..	None……	11.0	18.3 a	22.7 a	5.6 a	55.4 a
RTSA 505 at 10 ml/injection……	Fall 22 only……	10.7	8.6 bc	11.0 b	4.6 a	41.8 abc
RTSA 505 at 5 ml/injection……..	Fall 22 and 23and Bud Break 22 and 23	10.2	7.5 c	6.6 cd	2.0 b	38.2 c
RTSA 505 at 5 ml/injection……..	Bud Break 22 and 23	11.2	10.6 b	7.7 c	1.2 bc	37.2 c
RTSA 505 at 10 ml/injection……	Bud Break 23 only…	10.8	8.1 bc	11.8 b	2.6 b	54.0 ab
RTSA 505 at 5 ml/injection……..	Bud Break 22 & 23 plus 2 weeks later 22 and 23	11.8	9.1 bc	9.1 bc	2.4 b	40.4 bc
Banner Maxx II at 4 fl oz/100 gal.	Foliar apps 23 and 24	10.9	2.6 d	4.0 d	0.4 c	20.4 d

[X] Injections occurred on 8 Nov 2022, 27 Apr 2023 (green tip) and 11 May 2023 (full bloom) and then again on 14 Dec 2023 (leaf fall), 11 Apr 2024 (calyx) and 24 Apr 2024 (30% bloom). The fungicide Banner Maxx II was foliar applied on 27 Apr 23 (green tip), 11 May 23 (full bloom), 25 May 23 (fruit set), 8 Jun 23 (2nd cover) and 23 Jun 23 (3rd cover) and again on 11 Apr 24 (calyx), 24 Apr 24 (30% bloom), 9 May 24 (petal fall), 23 May 24 (fruit set), 6 Jun 24 (2nd cover) and 20 Jun 24 (3rd cover).

[Y] Means followed by the same letter do not differ significantly based on Fisher's protected LSD ($P \leq 0.05$). Means without letters were not significantly different.

Table 2. Leaves with powdery mildew in 2023 and 2024 and defoliation at the end of 2023 season.

Treatment & Rate/injection or /100 gal as indicated below	Time of Application[X]	Powdery Mildew [Y]			Defoliation 2023 (%)[Y]
		Leaves (%) 2023	Flag Shoots 2024	Leaves (%) 2024	
Non-treated……..	None……	85.7 a	171 a	90.2 a	62
RTSA 505 at 10 ml/injection……	Fall 22 only……	70.0 c	73 c	68.6 c	62
RTSA 505 at 5 ml/injection……..	Fall 22 and 23and Bud Break 22 and 23	78.1 b	86 c	67.7 c	64
RTSA 505 at 5 ml/injection……..	Bud Break 22 and 23	75.3 bc	129 b	76.8 b	68
RTSA 505 at 10 ml/injection……	Bud Break 23 only…	70.5 c	88 c	66.9 c	70
RTSA 505 at 5 ml/injection……..	Bud Break 22 & 23 plus 2 weeks later 22 and 23	71.6 c	87 c	76.9 b	60
Banner Maxx II at 4 fl oz/100 gal.	Foliar apps 23 and 24	32.4 d	24 d	16.6 d	56

[X] Injections occurred on 8 Nov 2022, 27 Apr 2023 (green tip) and 11 May 2023 (full bloom) and then again on 14 Dec 2023 (leaf fall), 11 Apr 2024 (calyx) and 24 Apr 2024 (30% bloom). The fungicide Banner Maxx II was foliar applied on 27 Apr 23 (green tip), 11 May 23 (full bloom), 25 May 23 (fruit set), 8 Jun 23 (2nd cover) and 23 Jun 23 (3rd cover) and again on 11 Apr 24 (calyx), 24 Apr 24 (30% bloom), 9 May 24 (petal fall), 23 May 24 (fruit set), 6 Jun 24 (2nd cover) and 20 Jun 24 (3rd cover).

[Y] Means followed by the same letter do not differ significantly based on Fisher's protected LSD ($P \leq 0.05$). Means without letters were not significantly different.

Table 3. Fruit diameter to height ratio and fruit russeting.

Treatment & Rate/injection or /100 gal as indicated below	Time of Application [X]	Fruit Diameter to Height Ratio [Y]		Fruit Russet (%)[Y]	
		2023	2024	2023	2024
Non-treated……..	None……	1.11 ab	1.2	47.8 a	74.0 a
RTSA 505 at 10 ml/injection……	Fall 22 only……	---[Z]	1.2	45.0 a	25.4 cd
RTSA 505 at 5 ml/injection……..	Fall 22 and 23and Bud Break 22 and 23	1.05 c	1.2	26.4 b	33.6 bc
RTSA 505 at 5 ml/injection……..	Bud Break 22 and 23	1.09 bc	1.2	21.6 c	28.4 cd
RTSA 505 at 10 ml/injection……	Bud Break 23 only…	1.11 ab	1.2	28.6 b	41.8 b
RTSA 505 at 5 ml/injection……..	Bud Break 22 & 23 plus 2 weeks later 22 and 23	1.11 abc	1.2	26.4 b	21.4 d
Banner Maxx II at 4 fl oz/100 gal.	Foliar apps 23 and 24	1.16 a	1.2	15.0 d	18.2 d

[X] Injections occurred on 8 Nov 2022, 27 Apr 2023 (green tip) and 11 May 2023 (full bloom) and then again on 14 Dec 2023 (leaf fall), 11 Apr 2024 (calyx) and 24 Apr 2024 (30% bloom). The fungicide Banner Maxx II was foliar applied on 27 Apr 23 (green tip), 11 May 23 (full bloom), 25 May 23 (fruit set), 8 Jun 23 (2nd cover) and 23 Jun 23 (3rd cover) and again on 11 Apr 24 (calyx), 24 Apr 24 (30% bloom), 9 May 24 (petal fall), 23 May 24 (fruit set), 6 Jun 24 (2nd cover) and 20 Jun 24 (3rd cover).

[Y] Means followed by the same letter do not differ significantly based on Fisher's protected LSD ($P \leq 0.05$). Means without letters were not significantly different.

[Z] Data for fall injection with 10 ml RTSA 505 not included in analysis due to significantly smaller fruit.