2009-2010 Metam Sodium Field-scale Shank Injection -Water Run Efficacy Demonstration

PERSONNEL:

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In-kind industry support**:**	Jim Owen, Kurt Volker, and Jerry Krebs Tessenderlo Kerley Inc.
In-kind grower support**:**	Ed Schneider, Schneider Farms, Pasco WA

Introduction:

Soil incorporated shank applications will allow a much greater percent of circles to be fumigated, especially in locations where residential dwellings and difficult to evacuate zones are in close proximity to the field. Upcoming EPA-OPP revised buffer specifications greatly reduce shank application buffers compared to high, medium, and low release water run fumigations. However, some growers have expressed concern that soil incorporated shank applications may not be as effective as surface water run for controlling soil-borne pathogens that can affect vine health and subsequent tuber yield/quality. To provide the grower with efficacy data, side-by-side-by side medium release-solid stream-shank efficacy demonstrations were conducted in 2009-2010 comparing Sectagon 42^{TM} effectiveness. These replicated-randomized block plot trials were also designed to compare each application method's efficacy at traditional (40 GPA), lower (20 GPA), and higher 60 GPA application rates. Pre, post fumigation and pre-harvest assays of soil-borne pathogens, in-season plant evaluations, and harvest yield/quality were collected. This efficacy assessment was conducted within a commercial potato-producing field circle in Franklin County planted in the spring 2010 season with Ranger Russets.

Methods:

A ca. 148 acre eight tower circle with corner catchment was made available in October 2009. This field demonstration was developed to compare water run to shank and to drizzle-boom when using Sectagon 42 at regional application rates of 40 GPA but also investigated product efficacy through harvest at lower (20 GPA) and higher (60 GPA) application rates. The three application rates were randomly assigned (in triplicate) among the nine ca. 12^{o} wedge sections within the test field. A tenth wedge (J) was set aside as an untreated control (see Figure 1). To avoid edge effects, the ninety GPS positions (81 application rate-practice treatment plots (A-I) and 9 untreated control plots (J)) were equidistantly positioned between treatment tower rows and application rate sections. Because of the possibility for overlapping fumigant contamination, untreated control plot locations were not randomized within the A to I treatment sections.

<u>Set-up, field conditioning, and applications</u>: For the water run application, low elevation drop nozzles (ca. 5ft from ground level) were retrofitted to tower rows 1, 3, and 7. The drizzle boom assembly was positioned at tower rows 2, 4, and 5. Towers rows 6, 8, and the corner catcher (row 9) were capped off for subsequent Sectagon 42 ground application by tractor-drawn shank injection with soil compaction. During the center pivot application, line pressure was carefully monitored for sections "A" through "I" to assure even Sectagon 42 application rate coverage at 20, 40, or 60 GPA. Figure 2 shows the retrofitted center pivot water run-drizzle boom system and operations during the fumigation period (retrofitting and application performed by WindFlow Fertilzer). Shortly after completion of the field center pivot chemigation, tractor drawn shank injections (with roller compaction) were performed by Crop Production Services to a blade depth of ca. nine inches within tower rows 6, 8 and 9 (catchment area) according to the "A" to" I" plot section description in Figure 1. The drizzle boom-water run center pivot chemigation was completed one-day before conducting the shank application. Enough water was applied to bring the entire field test sections to ca. 70-80% moisture content before conducting all fumigation treatments.

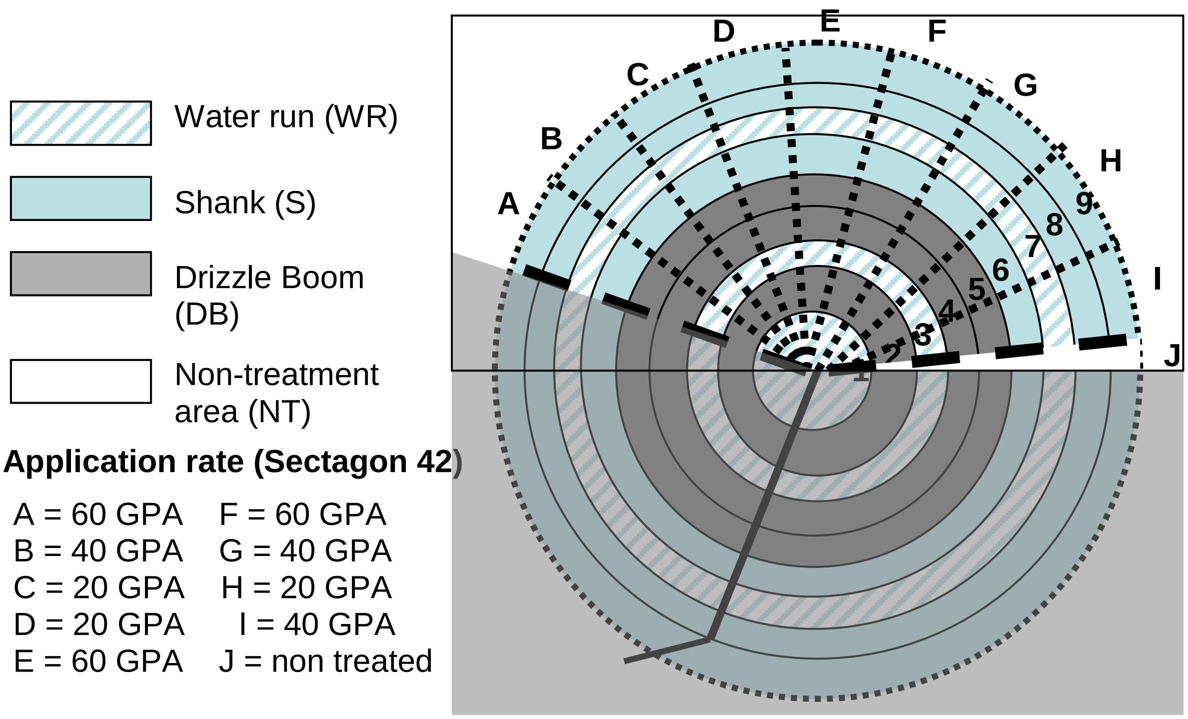

Figure 1: 2009-2010 Field Efficacy Layout (148 acre 8 tower circle with corner catchment)

Figure 2: Sectagon 42 Center Pivot Water Run-Drizzle Boom Application

Soil borne pathogen soil assays: Before the fall 2009 field fumigation and in the spring of 2010 before seeding, soil cores were taken and segregated into two soil depths (0-12 and 12-24 inches) then composited from each of the treatment plots. The 360 composited soil core samples (90 soil treatment plots x 2 depths x 2 sampling dates) were assayed by OSU HAREC for *Verticillium dahliae, Pythium* spp., and *Fusarium*.

Visual plant evaluations: Field foliage sampling was conducted by WSU-Plant Pathology on September 3rd, 2010; one week before commercial field harvesting. Stems were sampled fresh and not previously vine killed. Stems were immediately to the WSU Plant Pathology lab the day of sampling. Samples were air dried in 48°F storage, held at 90% relative humidity, and examined in November 2010 for sclerotia incidence and severity of *Verticillium dahliae*. Approximately 60 cm of combined above and below ground stem were rated for percent sclerotia on stems. Six stems (subsamples) were averaged for disease from each of three replications by rate and application method.

Yield and grade assessments: Tubers were sampled September 7th 2010 from ninety 30 foot row vine-cleared plot sections. Potatoes were removed using a single row digger (CPS) or by hand digging (OSU and WSU). The potatoes were bagged and labeled from each plot, palletized, then transported on the day of field sampling to OSU HAREC for subsequent yield and grade assessment.

Results: OSU-HAREC Soil borne pathogen soil assays: *Verticillium* CFU pre-fumigation counts were low and more variable relative to *Pythium* and *Fusarium* for all three application methods. Tables 1 and 2 show lower post fumigation *Pythium, Fusarium,* and *Verticillium* CFUs after fumigation for all application methods-treatment rates and at both composited soil core depths. Although variable, the below tables show consistent trends in higher shank post-fumigation CFU numbers for *Fusarium* and *Pythium* when compared to the two water run and solid stream surface application method treatments at all three application rates. The observed differences in higher pre-fumigant untreated control to treatment *Pythium* and *Fusarium* CFU counts is not readily explainable but could be partially attributed to less randomization from the "J" untreated control section.

Table 1: Composited 0-12" pre and post fumigation CFUs for three application methods and at three Sectagon 42 application rates

Treatment	Pre-Fumigation Pythium (CFU/g dry soil)	Post Fumigation Pythium (CFU/g dry soil)	Pre vs. Post Pythium	Pre-Fumigation Fusarium (CFU/g dry soil)	Post Fumigation Fusarium (CFU/g dry soil)	Pre vs. Post Fusarium	Pre-Fumigation Verticillium (CFU/g dry soil)	Post Fumigation Verticillium (CFU/g dry soil)	Pre vs. Post Verticlillium
Water Run @ 60 gpa	48 b	8 c	0.0039*	4725 b	1475 bc	0.0006*	6.0 bc	0.0 a	0.0004*
Drizzle Boom @ 60 gpa	33 b	7 c	0.0402*	4937 b	1834 bc	0.002*	9.6 ab	0.4 a	0.0017*
Shank @ 60 gpa	36 b	15 bc	0.0854	4790 b	2275 bc	0.0027*	6.9 abc	0.9 a	0.0048*
Water Run @ 40 gpa	62 b	8 c	0.0013*	4978 b	1085 c	<.0001*	8.4 abc	0.9 a	0.0006*
Drizzle Boom @ 40 gpa	50 b	2 c	<.0001*	4932 b	1038 c	<.0001*	6.7 abc	0.9 a	0.0024*
Shank @ 40 gpa	53 b	22 abc	0.0495*	5213 b	1620 bc	<.0001*	5.3 bc	2.0 a	0.1555
Water Run @ 20 gpa	58 b	6 c	<.0001*	4567 b	1611 bc	<.0001*	11.1 ab	0.4 a	0.0067*
Drizzle Boom @ 20 gpa	41 b	4 c	0.0092*	5198 b	1465 bc	<.0001*	13.8 a	1.1 a	0.0007*
Shank @ 20 gpa	48 b	36 ab	0.5434	4454 b	2538 b	0.0127*	12.4 ab	0.0 a	0.0025*
Untreated Control	121 a	40 a	0.0396*	9499 a	5760 a	0.1314	1.5 c	1.3 a	0.8597
	P=0.0086	P=0.0014		P=0.0052	P<.0001		P=0.0124	P=0.4522	

Values in the same column followed by the same number are not significantly different
*Pre and post fumigation CFU values are significantly different

Table 2: Composited 12-24" pre and post fumigation CFUs for three application methods and at three Sectagon 42 application rates

Treatment	Pre-Fumigation Pythium (CFU/g dry soil)	Post Fumigation Pythium (CFU/g dry soil)	Pre vs. Post Pythium	Pre-Fumigation Fusarium (CFU/g dry soil)	Post Fumigation Fusarium (CFU/g dry soil)	Pre vs. Post Fusarium	Pre-Fumigation Verticillium (CFU/g dry soil)	Post Fumigation Verticillium (CFU/g dry soil)	Pre vs. Post Verticlillium
Water Run @ 60 gpa	30 b	1 c	0.001*	3458 b	380 c	0.009*	12.0 a	1.1 ab	0.0123*
Drizzle Boom @ 60 gpa	23 b	2 bc	0.0171*	4459 b	485 bc	0.0356*	3.8 bcd	1.1 ab	0.0037*
Shank @ 60 gpa	24 b	7 bc	0.0639	2427 b	1028 a	0.0003*	6.7 abcd	0.2 b	0.002*
Water Run @ 40 gpa	51 b	1 c	0.0003*	3542 b	334 c	0.0001*	10.2 abc	1.1 ab	0.0198*
Drizzle Boom @ 40 gpa	50 b	0 c	0.0063*	4088 b	501 bc	0.0001*	3.6 cd	1.1 ab	0.0667
Shank @ 40 gpa	62 ab	2 bc	0.0021*	3161 b	853 ab	0.0071*	6.2 abcd	1.1 ab	0.0148*
Water Run @ 20 gpa	21 b	2 bc	0.0001*	3441 b	455 bc	<.0001*	10.0 abcd	1.3 ab	0.0092*
Drizzle Boom @ 20 gpa	38 b	2 bc	0.0083*	2930 b	554 bc	0.002*	11.1 ab	0.0 b	0.0006*
Shank @ 20 gpa	32 b	15 a	0.2271	2907 b	1194 a	0.0036*	9.8 abcd	0.7 b	0.0003*
Untreated Control	94 a	9 ab	0.0071*	7499 a	989 a	0.001*	2.7 d	2.9 a	0.8914
	P=0.0079	P=0.0001		P=0.0226	P=0.0001		P=0.0286	P=0.2094	

Values in the same column followed by the same number are not significantly different
*Pre and post fumigation CFU values are significantly different

WSU-Plant Pathology *Verticillium* sclerotia assessments: There were low disease severities among all application method and application rate plots (p < 0.5%). The non treated (J) plots were, however, observed to have ca. 2 % disease severity. In agreement, only 3.4% of the sub sampled stems from fumigated plots were observed with *Verticillium* sclerotia compared to 26 % of the stems from the non-fumigated (J) control plots. As was observed during the earlier 2009 plant samples, the general lack of *Verticillium* sclerotia could be influenced by the collection of stems before senescence.

Two statistical approaches were conducted: one for all the trial plots and another not using the data from the 1st two towers (center of pivot) and the last most distal tower (#9) which were typically stressed. This also aided to reduce the bias of the water run and shank treatments which were more separated (Figure 1). From the two analyses, even though there was a lack of disease and much sample variation, there was a trend among plants sampled at the higher Sectagon treatment rate plots to have fewer *Verticillium* sclerotia. The trends in the data also showed that the water run treatment method had the least *Verticillium* sclerotia compared to the shank method while the water run and the solid stream surface treatments did not appear to differ.

OSU-HAREC Yield and grade assessments: Table 3 provides yield and specific gravity for potatoes collected from the 90 test plot locations. Total yield, size, and specific gravity were not significantly different (p< 0.05) among treatments and non-treated controls. However, total yield numbers were consistently higher from plots treated by surface applied water run/solid stream fumigation methods compared to shank application and at most all Sectagon product rates. Among the two surface applied methods, there was no appreciably difference in yield numbers. Yield numbers among replicates were too variable to separate out differences among the incremental 20, 40, and 60 GPA application rate increases. The below data does not consistently indicate product rates above 40 GPA appreciably increase total yield.

Table 3: Yield and grade assessment

Treatment	Yield						Specific Gravity
	Under 4 oz	Culls/2's	4 to 8 oz	8 to 12 oz	Over 12 oz	Total Yield	
Water Run @ 60 gpa	15.6 c	3.4 a	66.0 a	43.0 abc	17.5 a	145.6 a	1.0896 a
Drizzle Boom @ 60 gpa	16.3 bc	3.8 a	57.9 a	44.6 ab	19.2 a	141.8 a	1.0882 ab
Shank @ 60 gpa	20.6 ab	3.5 a	56.1 a	35.0 bc	15.9 a	131.1 a	1.0842 c
Water Run @ 40 gpa	18.2 bc	4.2 a	62.3 a	49.3 a	19.1 a	153.1 a	1.0861 bc
Drizzle Boom @ 40 gpa	17.0 bc	5.3 a	62.0 a	43.3 abc	20.7 a	148.3 a	1.0856 bc
Shank @ 40 gpa	19.1 abc	3.0 a	58.5 a	42.6 abc	16.0 a	139.2 a	1.0860 bc
Water Run @ 20 gpa	17.5 bc	4.3 a	60.1 a	38.1 bc	19.3 a	139.3 a	1.0859 bc
Drizzle Boom @ 20 gpa	16.1 bc	4.8 a	61.9 a	44.4 ab	17.7 a	145.0 a	1.0861 bc
Shank @ 20 gpa	17.3 bc	1.3 a	57.2 a	40.3 abc	16.0 a	132.1 a	1.0869 abc
Untreated Control	22.6 a	2.1 a	56.1 a	33.6 c	14.7 a	129.0 a	1.0842 c
	P=0.0146	P=0.15	P=0.646	P=0.028	P=0.8703	P=0.2721	P=0.0149

Values in the same column followed by the same letter are not siginificantly different

Discussion:

This efficacy field demonstration show consistent trends towards fewer stem counts, fewer post-fumigation soil *Fusarium* and *Pythium* CFUs, and higher total yield tuber numbers at harvest when Sectagon 42 is applied at the soil surface (medium release height water run and solid stream) compared to soil incorporated shank treatments. The percent difference in total yield in shank to surface applications was ca. 7% at the 40 GPA Sectagon product rate. It is important to emphasize that the shank injection was conducted at a 9" soil depth for both soil borne pathogen control and nematode suppression.

Although there was a trend towards reduction in yield, the data sets also indicate that incremental adjustment in blade depth should enhance product efficacy while retaining reduced-emission shank buffer zone benefits to the grower. EPA-OPP made clear that buffer zones for shank applications will be substantially less restrictive when compared to all soil surface water run-solid stream application practices. As a given example during a recent February 2011 joint EPA-OPP/WSDA fumigation training session, a shank buffer (without water seal) will be ca. *60 feet* compared to a *600 foot* low release solid stream application buffer when on a 120 acre field at ca. 40 GPA Sectagon product rate. This shank buffer distance can be further reduced to *25 feet* if a water lap of 0.25 inches can be put down immediately after the shank application.

Shank and low drift solid stream application technology decisions will take on immediate importance in PNW potato-producing regions starting in 2012. Grower decisions will be especially important where field edges exist near dwellings, near or at residential/commerce interfaces, or in close proximity to "difficult to evacuate" locations and will involve considering buffer label specifications together with efficacy/economics and available shank/chemigation resources. This field-scale regional demonstration on comparative field efficacy should provide greater assurance to the grower in making prudent metam sodium fumigation decisions.

This side-by-side-by side efficacy demonstration would not have been possible funding by the Washington State Potato Commission, Oregon Potato Commissions and also without the close working associations and resources provided by crop consultants (Jim Ossman, CPS and Monte Spence, WindFlow, growers (Ed Schneider, Schneider Farms), registrants (TKI), and university WSU-OSU faculty-staff (Dennis Johnson, Tom Cummins, Phil Hamm, Don Horneck, Jordan Eggers, Jane LePage and James Cavenah).