Introduction

The Central Oregon Agricultural Research Center (COARC) faculty and staff are pleased to present this summary of 2015 research activities for your review. The reports included in this publication focus on grass seed, vegetable seed, potatoes and peppermint, forages and cereals and community projects.

As you have heard in the past, the OSU College of Agricultural Sciences (CAS) challenged local agricultural communities around the state to provide 25% of the current base budget for the branch experimental stations. At the time of this challenge, the CAS indicated that future strategic investment across the state would be guided by industry response to this challenge. Not only did you meet this challenge head on, you did so with resounding success.

As a direct result of your ongoing financial support, the College has made several recent investments in COARC. These include contributions toward equipment purchases, infrastructure upgrades and the hiring of two outstanding researchers within the last two years. These investments are helping to move COARC to the forefront of cutting edge research.

In 2014, the COARC Advisory Council recommended continuing the voluntary local contribution plan for the foreseeable future to ensure the ongoing success of the research center and local research faculty. Your ongoing participation is vital to the continued commitment by the College of Agriculture to investing in COARC.

We would like to thank you for your continued support of COARC. Your contributions allow us to continue to provide important research and education opportunities for central Oregon that are vital to the agricultural community and local economy.

Each year, the COARC Advisory Council meets with individual researchers to review their projects from the previous year and to preview projects for the upcoming year. We will also send a pdf version of this report along with a questionnaire to the local agricultural community by email. Please feel free to provide comments in addition to answering the questionnaire. It is through your input that we are able to adjust what we do in order to best serve your needs. Your feedback and comments are appreciated and will be taken under consideration as we plan for the upcoming year.

Thank you,

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Environmental Factors Associated with Ergot Ascospore Production in Seed in Central Oregon and Evaluation of Ergot Resistance/Klendusity in Kentucky Bluegrass Cultivars

Jeremiah Dung, Julia Wilson, and Stephen Alderman

Introduction

Ergot is an important disease of Kentucky bluegrass and can be a persistent problem in seed production systems. The disease is caused by the fungal pathogen *Claviceps purpurea*, which has a very wide host range among grasses and grains in North America. The fungus infects flowers prior to fertilization and colonizes the ovaries, resulting in the production of sclerotia rather than viable seed. Sclerotia are the overwintering structures of the fungus and produce airborne ascospores that serve as primary inoculum the following growing season. Ergot infection and infestation incurs economic losses at various stages of grass seed production, including direct yield loss due to the production of sclerotia instead of seed, costs associated with protective fungicide applications, seed loss during re-cleaning processes that are required to remove ergot sclerotia from infested seed lots, and rejection of certification.

Cool-season grass seed is produced in a wide range of climates in Oregon, ranging from mild and moist conditions in the Willamette Valley, semi-arid high elevation deserts in central Oregon and the Columbia Basin of eastern Oregon, and high mountain valleys in northeastern Oregon. Consequently, the incidence and severity of ergot epidemics in grass grown for seed can vary among and within growing regions and from year to year. In some years the timing of ascospore release by the fungus may not coincide with grass flowering (anthesis), which is the only period of host susceptibility. Cultivars with short, uniform flowering periods, or cultivars that flower outside of periods of peak spore production, may potentially escape ergot infection.

Previous studies have investigated the timing and aerobiology of ergot ascospores production in western and eastern Oregon. In the Willamette Valley, ascospore release in the field was associated with rain events occurring 2 to 3 days prior and was not correlated with temperature or relative humidity. In the high desert of central Oregon, grass seed production fields are frequently irrigated and air or soil temperatures may play more important roles in ascospore release than precipitation events. A further understanding of the environmental conditions that contribute to ergot ascospore production in central Oregon grass seed production systems is needed and could provide information that can be used to predict ascospore release and improve the timing of fungicide applications.

The objectives of this study were to: 1) evaluate Kentucky bluegrass cultivars for the potential to escape or resist ergot infection under central Oregon field conditions; and 2) determine the seasonal timing and concentration of ergot ascospores in central Oregon and identify environmental factors that contribute to ascospore production. It was hypothesized that cultivars which flower before or after peak ergot spore production, or those with shortened periods of anthesis, would escape infection more than those which flower when ergot spores are present at high levels. The ultimate goal is to develop a model that can be used to predict ascospore production events in Kentucky bluegrass seed fields located in central Oregon.

Materials and Methods

Evaluation of Kentucky bluegrass cultivars for disease escape potential
A total of 12 Kentucky bluegrass cultivars ('Blue Ghost', 'Gateway', 'Shamrock', 'Bluechip', 'Gladstone', 'Nuglade', 'PST-K4-7', 'Fielder', 'Midnight II', 'Jumpstart', 'Right', and 'DB-1013') were planted in plots at COARC in August 2014. Plots (26 ft long and 5 ft wide consisting of 6 rows of plants) were planted with each cultivar at a seeding rate of 5 lb seed/acre. Each plot was replicated four times and cultivars were arranged in a randomized complete block design. The border of the experiment area was artificially infested in October 2014 with Kentucky bluegrass sclerotia collected from seed lots produced in central Oregon.

Crop phenology was assessed weekly between May 14 and June 10, 2015 to determine the timing and duration of anthesis for each Kentucky bluegrass cultivar. Crop phenology was measured using the Feekes scale, whereby the appearance of stigmas and/or anthers was considered the beginning of flowering (stage 10.51). The percentage of tillers at each Feekes stage were estimated in each plot. Flowering was considered to be completed with at least 90% of the plot reached Feekes stage 11.1. Disease incidence (number of infected seed heads) and severity (number of sclerotia) were determined from a random sample of 100 seed heads collected from each plot at harvest. Data were analyzed using ANOVA and multiple comparisons were made using Tukey's test.

Spore sampling, environmental data collection, and model development
A Burkard 7-day recording volumetric spore sampler was used to collect airborne ascospores of *C. purpurea* in the Kentucky bluegrass plots described above. The spore sampler was placed in the middle of the plots from April 11, 2015 and June 23, 2015 with the air intake orifice located approximately 2 ft above the soil. Spore trap tapes were replaced weekly and each tape was cut into daily segments, stained, and the number of *C. purpurea* ascospores were determined for each hour and then totaled to establish daily counts.

Air and soil temperatures, relative humidity, dew point, and soil moisture were monitored at hourly intervals in each field using a Watchdog 1000 Series Micro Station (Spectrum Technologies, Aurora, IL). Air temperature, relative humidity, and dew point were recorded at a height of 3 ft and soil temperature and moisture were recorded at 2 inches below the soil surface. Similar data, as well as daily precipitation and evapotranspiration, were obtained from the AgriMet MRSO weather station located at COARC. Cumulative air and soil degree days were calculated using air and soil temperature data collected from the MRSO station beginning on January 1. Daily and cumulative degree days were calculated for both air and soil temperatures using a base temperature of 50° F and an upper threshold temperature of 77° F. Base and upper threshold temperatures were based on previous incubation studies which found that ergot sclerotia germination was inhibited by temperatures outside of this range.

Correlation analysis was performed to identify significant correlations between environmental variables and spore counts and logistic regression was used to model daily counts of ascospores with environmental variables. Local regression, which does not assume a linear relationship, and box-and-whisker plots were used to identify trends in daily ascospore counts against significant environmental variables and visually identify upper and lower threshold values of environmental factors that were significantly associated with ascospore occurrence.

Results and Discussion

Evaluation of KBG cultivars for disease escape potential

Significant differences in anthesis initiation date, anthesis termination date, and anthesis duration were observed among the 12 KBG cultivars ($P \leq 0.003$) (Table 1). Among the cultivars tested, Midnight II exhibited the highest ergot incidence and severity, while Jumpstart and Fielder exhibited the lowest ergot incidence and severity (Table 1). A significant positive correlation was observed between anthesis initiation date and ergot incidence ($P = 0.002$; $r = 0.44$) and severity ($P = 0.01$; $r = 0.37$) was observed, suggesting that cultivars which initiated flowering earlier in the season exhibited reduced ergot in central Oregon. Significant differences in ergot levels were observed among Kentucky bluegrass cultivars. Further research is needed to determine if the differences in ergot levels were due to genetic/physiological resistance to ergot, anthesis periods that did not coincide with peak ergot spore production, or other factors.

Spore sampling, environmental data collection, and model development

Similar to 2014, the first ergot spores were detected on May 20. Although the first occurrence of spores occurred on the same day in 2015 as in 2014, the accumulated air and soil degree days on May 20 were lower in 2015 (air = 185; soil = 143) compared to 2014 (air = 294; soil = 175) suggesting that accumulated air or soil degree days are not a reliable predictor for the first occurrence of ergot spores. A total of 1,087 spores were captured during the 74 day period, and the number of spores captured varied drastically from day-to-day (Fig. 1). Over 42% of the total spores were captured on a single day (June 10), which appeared to be associated with an increase in soil moisture and favorable soil temperatures (between 60 and 70° F) (Fig. 1). Spores were not detected after June 13.

Data for several environmental variables collected from the Watchdog data logger placed in the field and the MRSO weather station at COARC were significantly ($P \leq 0.05$) and positively correlated with ergot spore production (Table 2). Logistic regression using data from the field data logger identified a model that included minimum air temperature, minimum and maximum soil temperatures, dew point, and soil moisture that predicted the presence of ergot spores with over 92% accuracy. Using data from the MRSO weather station, logistic regression identified a model that included minimum and mean air temperature and minimum, maximum and mean soil temperatures that predicted the presence of ergot spores with over 91% accuracy. Local regression and box-and-whisker plots were used to identify upper and lower threshold values for environmental factors significantly correlated with spore production. A minimum air temperature greater than 41° F, minimum soil temperature greater than 50° F, maximum soil temperature less than 71° F, dew point between 40 and 50° F, and a volumetric water content between 18 and 25% in the field were associated with ergot spore production. These results are consistent with controlled studies conducted in incubation chambers which concluded that the highest percentage of ergot sclerotia germination was observed at temperatures between 50 and 77° F and germination was reduced at temperatures below 41°F and above 77° F. Based on the results obtained in this study and in other trials, minimum air temperature, minimum and maximum soil temperatures, dew point, and soil moisture appear to be the important factors contributing to ergot spore production. Several years of data will be required to develop and test a final model for ergot spore prediction in Central Oregon Kentucky bluegrass seed production.

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Evaluation of Predator Mites for Control of Two-Spotted Spider Mites in Carrots Grown for Hybrid Seed in Central Oregon, 2015

Marvin Butler, Rich Affeldt, Aubrey Holliday, Bruce Martens and Ralph Berry

Abstract

Two-spotted spider mites (TSSM) are an important pest on hybrid carrot seed production in central Oregon. Predator mites have been used to successfully control TSSM in peppermint production in central Oregon and a preliminary project on carrots grown for seed conducted in 2014 indicated that there is potential for use of predator mites in carrots. Results from 2015 indicate that predator mites were successfully established at all locations in non-Zeal and Zeal-treated plots, the combination of Zeal and predator mites held TSSM populations below the treatment threshold, while the late application of predators alone was unable to keep TSSM populations in check in the non-Zeal plots.

Introduction

Two-spotted spider mites (TSSM) are a significant pest in hybrid carrot seed in central Oregon. Spider mite populations can increase dramatically during the time bees are present to pollinate the crop from late June until mid-August. During this time, no insecticide applications are made. Once bees are removed from the fields, a cleanup application to control insect pests often includes a combination of Orthene (acephate) and Comite (propargite). However, Comite is problematic due to the two weeks it takes for mites to die and the two week re-entry interval (REI) that prevents rouging crews from accessing the fields. If predator mites can be used effectively to control TSSM during crop pollination, elimination of the cleanup spray may be possible. A reduction in miticide applications would benefit the environment, worker safety, seed quality and grower profitability.

The objectives of this project were: 1) document whether predators can be successfully established in hybrid carrot grown for seed, 2) evaluate predator mite application timing to prevent crop injury from TSSM and 3) evaluate the integration of predator mites with the miticide Zeal (etoxazole).

Methods and Materials

Research was conducted in five commercial hybrid carrot seed fields, three near Madras and two near Culver, Oregon. Large, non-replicated plots the length of the field consisted of one to two sets of females not treated with Zeal and two sets of females treated with Zeal, as was the remainder of the field. Field configuration of male and female plants consists of four female rows separated by two male rows centered between blank rows separating the male and female rows.

Predator mites used in the study consisted of a blend of two species *Galendromus occidentalis* and *Neoseiulus fallacis* released at the rate of 1,250 mites/acre. These are the species and application rate commonly used on peppermint in the area. The timing for the release of predators followed application of Warrior for lygus control by at least three weeks to minimize any detrimental effect of residual product on predator survival.

Pre-counts of TSSM were taken at each of the three locations in the morning of the day predator mites were released in the evening. Releasing predators in the evening was done to provide time for them to adapt to their new surrounding before exposure to the summer heat the following day. Mites are dispensed from a salt shaker-type container held over the outside female rows while walking and tapping the container lightly every 15 feet. For logistical reasons, predators were released a day apart at the five locations starting on June 30 and completed on July 6. Post-release counts of TSSM and predator mites were taken weekly for up to six weeks until the plants became "crispy" as they dried down prior to harvest.

Mite counts were taken by sampling a leaf from the middle of the plant and using a hand lens to count TSSM. Thirty plants were sampled per plot, with fifteen plants 30 feet apart accessed from each side of the four-row female plots. The maximum number of mites recorded per sample was 20. Observing predators by examining leaves with a hand lens was not successful in the preliminary study from 2014. As a result, predator mite counts were taken by shaking a leaf over an 8 ½ x 11 piece of black tag board and counting the number observed. To increase the chances of finding predators the area shaken was increased to the entire stem the leaf was attached to starting on July 27.

Results and Discussion

Results across the five locations indicate that predators were able to survive in a Zeal-treated environment and were able to keep TSSM under reasonable control in combination with Zeal (Table 1). With application of predators delayed until after the field Warrior application, TSSM populations in the non-Zeal plots were initially too high for predator mites alone to bring down to acceptable levels. Predator mites were found at all five locations in Zeal-treated plots as well as the non-Zeal plots, with the exception of the non-Zeal plots at H & T (Table 2). In non-Zeal plots predator mites were able to bring the TSSM populations down over time but not below the treatment threshold level (Table 3).

An earlier release of predator would be possible if an alternative to Warrior for lygus control more compatible to predator survival was found. This would open the door for additional research to determine if predators alone could provide adequate control of TSSM when released earlier in the spring while TSSM populations are low.

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The primary author would like to thank the Agricultural Research Foundation for funding this project, Rich Affeldt and Aubrey Holliday for their active involvement and Bruce Martens, Ralph Berry and Mark Morris for their helpful advice.

Table 1. Average number across locations of predator mites and TSSM per leaf sampled from seed carrots in plots without Zeal applied and treated with Zeal near Madras and Culver, Oregon.

	Mites/Leaf			
	Non-Zeal		Zeal Treated	
Sample Date	Predators	TSSM	Predators	TSSM
Pre-Count	0.00	10.6	0.00	2.5
Week 1	0.06	10.4	0.01	1.3
Week2	0.00	14.7	0.01	2.4
Week 3	0.03	16.4	0.02	4.7
Week 4	0.02	12.6	0.01	3.5
Week 5	0.03	13.4	0.02	3.4
Week 6	0.04	12.2	0.03	3.5

Table 2. Average number of predator mites per leaf or leaf and stem sampled from seed carrots at each location in plots without Zeal applied and treated with Zeal near Madras and Culver, Oregon.

	Average Predator Mites per Location									
	Madras		Roff		Harris		Boyle		H & T	
Sample Date	Non-Zeal	Zeal	Non-Zeal	Zeal	Non-Zeal	Zeal	Non-Zeal	Zeal	Non-Zeal	Zeal
Pre-Count	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Week 1	0.13	0.07	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Week 2	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Week 3	0.03	0.03	0.03	0.00	0.03	0.00	0.03	0.03	0.00	0.03
Week 4	0.00	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.00	0.07
Week 5	0.03	0.03	0.03	0.00	0.03	0.03	0.03	0.03	---	---
Week 6	0.03	0.03	0.07	0.03	0.03	0.03	0.03	0.03	---	---

Table 3. Average number of TSSM per leaf sampled from seed carrots at each location in plots without Zeal applied and treated with Zeal near Madras and Culver, Oregon.

	Average TSSM per Location									
	Madras		Roff		Harris		Boyle		H & T	
Sample Date	Non-Zeal	Zeal	Non-Zeal	Zeal	Non-Zeal	Zeal	Non-Zeal	Zeal	Non-Zeal	Zeal
Pre-Count	3.2	0.1	10.9	0.1	15.5	3.9	11.1	0.5	12.4	8.1
Week 1	8.9	0.1	16.2	2.2	17.5	3.3	1.0	0.8	8.2	0.2
Week 2	6.7	0.2	19.4	4.3	19.6	3.4	19.1	4.0	8.8	0.2
Week 3	12.5	0.6	16.1	4.5	15.4	5.4	18.4	5.2	19.6	7.8
Week 4	10.4	2.3	15.3	0.0	12.7	6.9	12.9	2.4	11.9	1.4
Week 5	17.4	3.7	11.3	1.2	11.6	5.7	13.3	3.0	---	---
Week 6	15.7	4.5	11.8	1.4	8.0	5.0	13.3	3.0	---	---

Layby Herbicide Treatments to Control Weeds
During Row Closure in Sugar Beets Grown for Seed, 2015

Marvin Butler, Gordon Fellows and Joe Bristol

Abstract

Sugar beets grown for seed in central Oregon is a small, established industry. Weed control in sugar beets is dependent on precise application timings early in weed development for adequate control while minimizing crop damage. This project was designed to evaluate layby herbicide applications to extend weed control during row closure and minimize the need for hand weeding. Outlook at 18 oz/acre plus Nortron at 16 oz/acre provided the best control at 75 percent. There was a broad spectrum of weed species in the plot area, with common lambsquarter, hairy nightshade, redroot pigweed and knotweed included on the herbicide labels that were tested.

Introduction

A small acreage of sugar beet seed production has been grown in Jefferson County since the late 1990's. While the acreage is modest in size, sugar beet seed has been a consistent part of agricultural production in the area. Effective weed control in sugar beets is an inherently difficult process, as sugar beets are in the plant family Amaranthaceae that includes difficult to control types of pigweed. Herbicides are first applied to the crop at the two-leaf stage in an effort to control young weeds without damaging the crop.

The objective of this project was to evaluate layby herbicide applications to provide additional weed control during the growing season while row closure is taking place. Once row closure occurs the crop is able to more effectively compete with the weed pressure.

Methods and Materials

Plots were established at layby following the last cultivation in the spring. Plots 20 feet wide by 24 ft long included 4 female rows with blank rows and a male row on each side. Plots were replicated 4 times in a randomized design centered down the single set of 4 females. Five treatments included Outlook alone and in combination with Dual Magnum and Nortron at two rates, along with an untreated check. Treatments were applied May 21 using a CO_2 pressurized, hand-help boom sprayer at 40 psi and 20 gal/acre water. Plots were evaluated June 11 for percent weed control. A follow-up evaluation was conducted on June 16 to count the number of plants for each weed species per plot.

Results and Discussion

The best layby weed control was provided by Outlook at 18 oz/acre plus Nortron at 16 oz/acre with 75 percent control (Table 1). This was followed by Outlook alone at 21 oz/acre and in combination with Nortron at 8 oz/acre with 68 percent control. Outlook at 21 oz/acre plus Dual Magnum at 16 oz/acre provided 42 percent control.

There was a broad spectrum of weed species in the plot area. Weeds species listed on the herbicide label for Outlook includes common lambsquarter, hairy nightshade and redroot pigweed, the label for Nortron includes common lambsquarter, redroot pigweed and protrate knotweed, while the label for Dual II Magnum includes hairy nightshade and redroot pigweed.

When evaluating herbicide treatment performance against each of the weed species, Nortron at both rates plus Outlook provided 100 percent control of buttonweed, Nortron at 16 oz/acre in combination with Outlook provided the best control of kochia and lambsquarter, and Dual II Magnum with Outlook provided the best control of hairy nightshade. All treatments controlled watergrass and appeared to have some control against redroot pigweed and common groundsel. The data is less conclusive for knotweed, field bindweed, buttonweed and was inconclusive for China lettuce and yellow mustard.

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Table 1. Anthesis initiation, termination, and duration, total number of ergot spores captured during anthesis, and ergot incidence and severity at harvest for 12 Kentucky bluegrass cultivars grown in artificially infested plots at COARC[1]

Treatment	Anthesis initiation	Anthesis termination	Anthesis duration	Total spores during anthesis	Incidence (%)	Severity
Blue Ghost	136.0 b	153.0 bc	17.0 b	229 c	11 ab	27.5 ab
Gateway	141.0 a	159.0 abc	18.0 b	511 abc	8 ab	11.0 b
Shamrock	134.8 b	153.0 bc	18.3 b	229 c	3 b	11.0 b
Bluechip	134.5 b	161.0 ab	26.5 a	605 b	10 ab	23.0 ab
Gladstone	134.8 b	159.0 abc	24.3 ab	511 abc	11 ab	35.3 ab
Nuglade	143.5 a	164.5 ab	21.0 ab	811 a	10 ab	26.3 ab
PST-K4-7	141.0 a	161.0 ab	20.0 ab	605 ab	5 b	5.0 b
Fielder	135.3 b	155.0 bc	19.8 ab	323 bc	3 b	3.3 b
Midnight II	143.8 a	162.8 ab	19.0 ab	686 ab	17 a	51.8 a
Jumpstart	136.0 b	155.0 bc	19.0 ab	323 bc	2 b	3.8 b
Right	135.3 b	153.0 bc	17.8 b	229 c	4 b	6.0 b
DB-1013	135.8 b	153.0 bc	17.3 b	229 c	7 ab	14.0 b
	$P < 0.0001$	$P < 0.0001$	$P = 0.003$	$P < 0.0001$	$P = 0.0002$	$P = 0.0006$

[1] Means followed by the same letters are not statistically different using Tukey's comparison. Anthesis initiation and termination dates are presented as perpetual Julian days (134 = May 14; 164 = June 12

Table 2. Correlations (*r*-values) between the number of ergot spores captured and environmental data collected from Watchdog data loggers placed in the field or environmental data collected from the AgriMet MRSO weather station located at COARC[1]

Environmental variable	Field	MRSO
Maximum air temperature	0.38*	0.40*
Minimum air temperature	0.50*	0.52*
Mean air temperature	0.46*	0.47*
Air daily degree days	0.25*	0.46*
Air cumulative degree days	0.33*	0.32*
Maximum soil temperature	-0.02	0.52*
Minimum soil temperature	0.48*	0.47*
Mean soil temperature	0.36*	0.49*
Soil daily degree days	0.30*	0.51*
Soil cumulative degree days	0.35*	0.32*
Relative humidity	0.17	0.04
Dewpoint	0.52*	0.51*
Soil moisture	0.48*	NR[2]
Daily precipitation	NR	-0.11
Evapotranspiration	NR	0.37*

[1] An *r*-value = 1 indicates a perfect correlation, while an *r*-value = 0 indicates no correlation. A * indicates the correlation was significant at $P < 0.05$.
[2] Not recorded

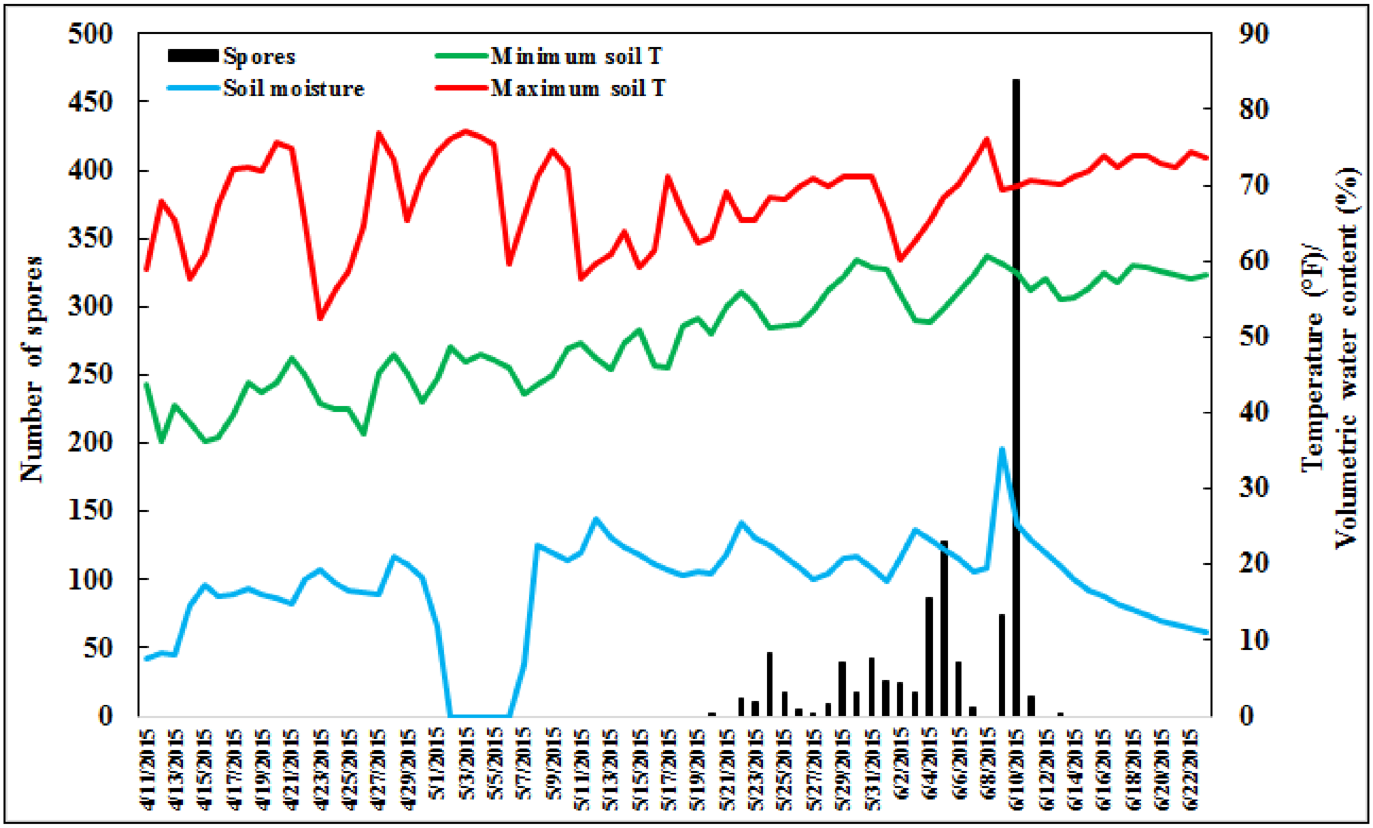

Figure 1. Daily number of ergot spores captured in artificially infested Kentucky bluegrass plots located at COARC (black bars) plotted with minimum daily soil temperature (green line), maximum daily soil temperature (red line), and mean daily soil moisture measured as volumetric water content (blue line).

Incidence, Resistance, and Evaluation of Chemical Controls for Bacterial Soft Rot in Carrot Stecklings

Jeremiah Dung, Jeness Scott, Bruce Martens, and Mike Weber

Introduction

Bacterial soft rot, caused by *Pectobacterium* spp. (formerly *Erwinia carotovora*), can be an important disease of certain carrot steckling lines used for hybrid carrot seed production. In surveys conducted in two hybrid Kuroda steckling-to-seed carrot seed fields in Jefferson County, OR during the summer of 2014, between 22 and 43% of female plants exhibited soft rot symptoms. A follow-up survey in 2015 observed between 19 and 27% of female plants with soft rot symptoms. It has also been observed that symptoms in the field are more severe on the female line compared the male line. The objectives of this study were to: 1) quantify the incidence of soft rot infection in stecklings used for hybrid seed production; 2) determine if the male line is more resistant to soft rot than the female line; and 3) test the efficacy of chemical treatments to reduce losses caused by soft rot.

Materials and Methods

Sampling for natural infection

Petioles from 100 each of male and female carrot stecklings were sampled from steckling cold storages in March and tested for the presence of soft rot bacteria. Non-surface sterilized sections of petioles 1 cm in length were sampled 1 cm away from the crown of each steckling. Depending on the number of petioles on each steckling, between one and eight pieces were placed in phosphate buffer. Petioles were incubated in phosphate buffer for 15 min at room temperature, vortexed, and a 10 µl aliquot was plated onto crystal violet pectate (CVP) agar.

Crowns and root tissue from a total of 100 each of male and female stecklings were sampled for the presence of soft rot bacteria. One half of the male and female stecklings were surface-sterilized in 10% bleach, rinsed with water, and air-dried. The other half of the stecklings were not surface-sterilized. A 1 cm slice of crown tissue was aseptically cut from each steckling and placed in a moist chamber. A second 1 cm slice of root, approximately 5 cm away from the top of the crown, was cut and also placed in a moist chamber. A slice of carrot was inoculated with 10 µl of a virulent *Pectobacterium* strain and placed in each chamber as a positive control. The carrot slices were incubated for 4 days at 82° F and the moist chambers were misted twice daily with sterile water.

Resistance assay

Slices (2 cm thick) were taken from the middle of 20 male and 20 female stecklings. The carrot slices were surface-sterilized in 10% bleach, air-dried, and weighed. A 10 µl drop of a virulent *Pectobacterium* strain was placed on each slice and placed in moist chambers in a completely randomized design. Mock inoculations with phosphate buffer were included as negative controls (one male and one female per moist chamber). Carrot slices were incubated at 82° F and the moist chambers were misted twice daily with sterile water. After 6 days, the rotted tissue was washed from the slices. The slices were air dried and weighed to determine the amount of tissue lost due to soft rot. The experiment was repeated once.

Treatments for soft rot control in stecklings
A field trial was set up at the Central Oregon Agricultural Research Center to test the efficacy of treatments to reduce soft rot in stecklings. The trial consisted of 4 rows and two border rows. Plots 25 ft long were set up with 30 inch row spacing and five foot buffers in between plots. Borders 25 ft in length were planted at the end of each row. A total of 9 treatments (Table 1) and a non-treated control were arranged in a randomized complete block design. Drench treatments were applied and the stecklings were allowed to air-dry before planting. Stecklings were hand-planted approximately 6 inches apart in each row. In-furrow treatments were applied in a 1 ft band after planting using a CO_2 backpack sprayer. Stecklings were watered in using overhead irrigation and then drip-irrigated for the remainder of the season. Off-types were rogued throughout the season. Standard management practices for steckling-to-seed hybrid carrot seed crops were followed. Plots were evaluated every 3 to 4 weeks and the number of plants exhibiting soft rot symptoms was recorded. Plants with aboveground symptoms of soft rot (chlorosis, wilting, black discoloration on stems) were pulled from the ground and to verify that soft rot was present on belowground tissue (soft, wet, rotting stecklings).

Results and Discussion

Sampling for natural infection
Visual examination of the petioles suggested that most petioles on female stecklings were rotting, with only five petioles exhibiting a healthy appearance. Petioles of the majority of male stecklings appeared to be healthy. However, soft rot bacteria were recovered from 87% of petiole samples from male stecklings and 94% of petiole samples from female stecklings as indicated by pitting on CVP agar.

Approximately 8 and 87% of male and female crowns, respectively, exhibited natural infection with soft rot bacteria and approximately 5% of male and 78% female root slices also exhibited natural infection with soft rot bacteria (Table 2). Based on visual examination of stecklings, it appears that the infection begins at the crown, likely the petiole, and moves down the steckling over time (Fig. 1). This is consistent with samples brought to the plant pathology lab in the summer of 2014.

Resistance assay
Carrot root slices from female carrot lines exhibited significantly greater tissue loss compared to carrot root slices from male carrot lines in both trials (Fig. 2). Less than 3% of carrot slices from male lines exhibited soft rot symptoms following artificial inoculations, while 95% of carrot slices from female carrot lines exhibited symptoms. Asymptomatic slices increased in mass, likely due to imbibing water during six days of incubation at >95% relative humidity.

Treatments for soft rot control in stecklings
Although some plants survived until the final assessments performed on July 29, the majority of plants (84 to 93%) exhibited soft rot symptoms on belowground tissues (Table 1). A significant difference was not observed among treatments ($P = 0.5$). Further research is needed to identify chemical control options for soft rot in steckling-planted carrot seed crops.

Acknowledgements

The researchers thank Central Oregon Seeds Inc. for providing funding and in-kind support. We would also like to thank PACE 49 Inc., OCION Water Sciences Inc., and DuPont for providing in-kind support. The authors acknowledge Julia Wilson, Hoyt Downing and Mitchell Alley for providing technical assistance.

Table 1. Percentage of healthy and diseased plants in experimental plots after treatments with bactericides and disinfectants

Treatment (application method)	Active ingredient (concentration)	Rate	Healthy plants[1]	Diseased plants[1]
Non-treated	**NA**	NA	4%	93%
ManKocide (in furrow spray)	**Mancozeb (15%), Cu(OH)2 (46.1%)**	2.5 lb/acre	6%	92%
Ocion PT81 (in furrow spray)	**CuSO4•5H2O (20.3%)**	40 oz/acre	15%	84%
Ocion FT33 (in furrow spray)	**Cu (4.16%), Zn (1.64%), S (4.97%)**	40 oz/acre	9%	89%
KleenGrow (in furrow spray)	**Didecyldimethyl ammonium chloride (7.5%)**	25 oz/acre	10%	86%
Oxidate (in furrow spray)	**Hydrogen dioxide, peroxyacetic acid**	1 gal/acre	8%	88%
Ocion PT81 (pre-plant drench)	**CuSO4•5H2O (20.3%)**	0.4 oz/gal	9%	90%
KleenGrow (pre-plant drench)	**Didecyl dimethyl ammonium chloride (7.5%)**	1.5 oz/gal	10%	89%
Oxidate (pre-plant drench)	**Hydrogen dioxide, peroxyacetic acid**	1.28 oz/gal	12%	84%
Bleach (pre-plant drench)	**NaOCl (8.25%)**	10,000 ppm	7%	91%

1 Off-type stecklings were rogued and not included in the healthy or diseased plant counts.

Table 2. Incidence of natural soft rot infection in the crowns and roots of male and female carrot stecklings

		Non-surface-sterilized	Surface-sterilized	Mean infected
Male	**Crown**	13%	4%	8%
	Root	9%	2%	5%
Female	**Crown**	86%	88%	87%
	Root	80%	76%	78%

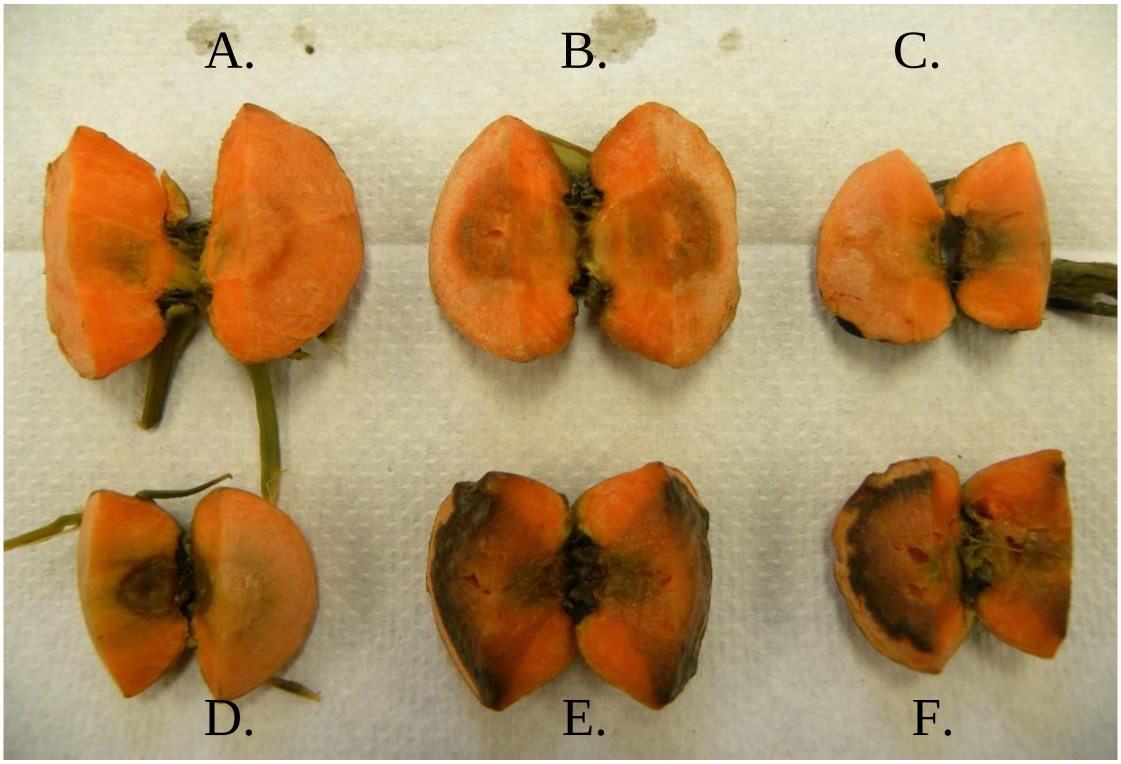

Figure 1. Soft rot progression from petioles into the crown. A) Healthy crown; B-F) Increasing severity of soft rot in the crown, likely originating from the petioles.

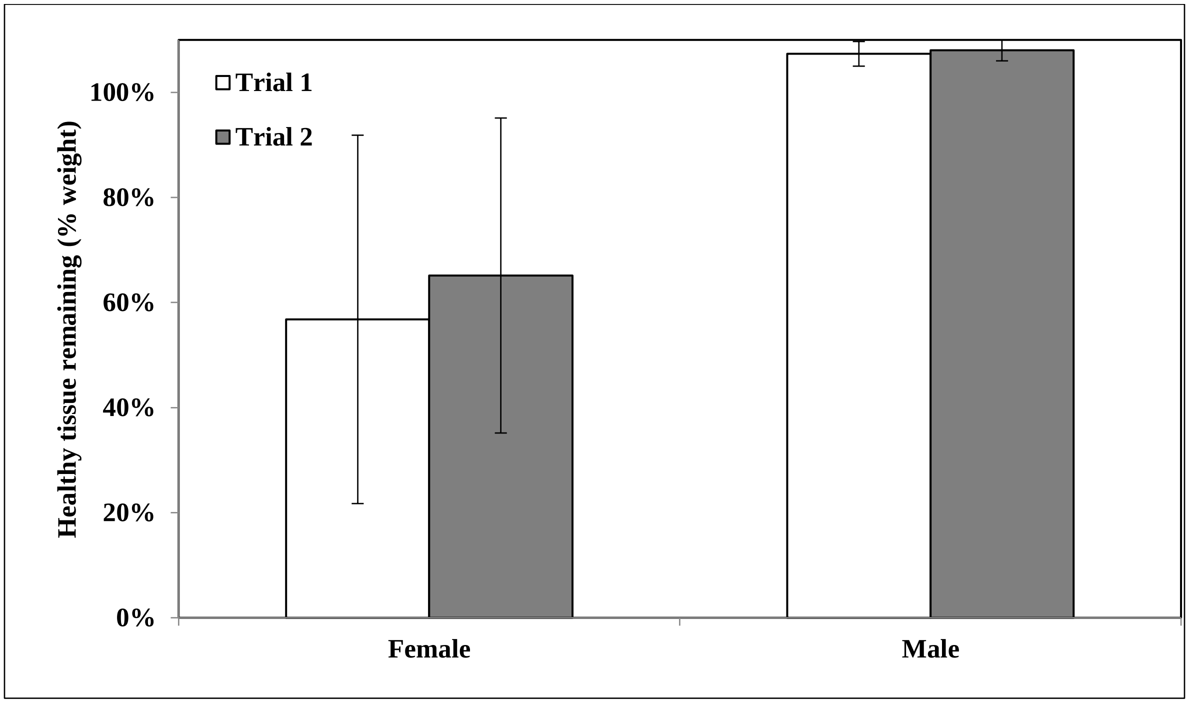

Figure 2. Percentage of healthy tissue remaining (by weight) after inoculating carrot root slices with soft rot *Pectobacterium*. Error bars indicate standard deviation values.

Evaluation of Late-Season ManKocide Applications to Reduce *Xanthomonas hortorum* pv. *carotae* on Harvested Carrot Seed

Jeremiah K.S. Dung, Jeness C. Scott, and Rich Affeldt

Abstract

Field plots were established to evaluate the efficacy of late-season applications of ManKocide for the suppression of *Xanthomonas hortorum* pv. *carotae* (*Xhc*) on harvested carrot seed. Two ManKocide applications were made in mid to late August 2014 in each of two fields, and harvested seed from the plots was assayed by plating dilutions of seed washes onto a semi-selective agar medium. Late season applications of ManKocide did not significantly reduce *Xhc* populations on harvested seed in this study.

Introduction

Bacterial blight of carrot, caused by the plant pathogenic bacterium *Xanthomonas hortorum* pv. *carotae* (*Xhc*), is a common disease of carrot wherever the crop is grown. The disease can affect carrot foliage, stems, umbels, and roots and can be seed-borne. Symptoms of bacterial blight include small, irregular, chlorotic areas on leaves that can manifest into water-soaked, necrotic lesions. Lesions can also occur on stems and petioles. Floral infections can result in blighted umbels, reduced seed yield, and reduced germination rates of harvested seed. Bacterial blight is of particular concern to carrot seed producers because *Xhc* is seedborne and seed treatments with hot water or disinfectants may not entirely eradicate the pathogen.

Carrot seed producers would like to reduce *Xhc* populations on harvested seed in order to minimize the need for hot water treatment and lessen the impact of bacterial blight on root crop producers. Copper-based bactericides such as ManKocide (mancozeb + copper hydroxide) are routinely applied multiple times each season to manage bacterial blight and increase seed quality. However, the effect of ManKocide on bacterial populations on leaves is generally short-term and it does not consistently reduce bacterial populations on seeds. The objective of this study was to evaluate the impact of late-season, pre-harvest applications of ManKocide on *Xhc* populations on harvested seed.

Materials and Methods

Twelve plots, each consisting of a single four-row set of female carrot plants, were established in two grower-cooperators' fields (#66 and #72) during the 2014 season. Ten umbels were collected from each plot in August to determine pre-treatment *Xhc* populations in both fields. Umbels from each plot were bulked according to field and subjected to an umbel wash assay on semi-selective XCS agar medium. Four 100 g subsamples of umbel tissue were soaked for 2 hours at room temperature in 1.5 L of sterilized PO_4 buffer (0.0125 M) containing Tween 20. After the soak the flasks were shaken by hand for 5 minutes. A 10-fold dilution series was prepared for each suspension ranging from 10^{-1} to 10^{-5} concentration using sterilized PO_4 buffer. A 0.1 ml aliquot of each dilution series was spread onto each of three plates of XCS agar medium for each dilution. The plates were incubated at 28ºC in the dark and monitored for the development of colonies typical of *Xhc*. The number of colonies typical of *Xhc* was counted after 6 days of incubation and suspect colonies were subcultured onto YDC agar medium to observe the development of growth typical of the pathogen.

Treatments included ManKocide (2.5 lb/acre) and a non-treated control that were replicated 6 times in a randomized complete block design. Each plot was treated with two passes in a total volume of approximately 50 gal/acre. Field 66 was treated on August 18 and August 25 and field 72 was treated on August 22 and August 29. Due to prolonged cool and wet weather, harvest of field 66 and field 72 were delayed until September 17 and October 4, respectively.

Plots were mechanically harvested according to standard grower practices and seed from each plot was cleaned by Central Oregon Seeds, Inc. before assaying. Seed from each plot was assayed for *Xhc* using a seed wash dilution plating assay similar to the umbel wash assay described above. Three 10 g subsamples were taken from each seed sample and soaked for 2 hours at room temperature in a 250 ml Erlenmeyer flask containing 100 ml of sterilized PO_4 buffer and one drop of Tween 20. After the soak the flasks were placed on a horizontal shaker set at 250 rpm for 5 minutes. A 10-fold dilution series was prepared for each suspension, plated on XCS agar, and incubated as described above. The number of colonies typical of *Xhc* was counted after 7 days of incubation.

Results and Discussion

Pre-treatment populations of *Xhc* on umbels were $>10^8$ CFU/g umbel tissue in field 66 and $>10^5$ CFU/g umbel tissue in field 72 (Table 1). *Xhc* populations on harvested seed were lower than on umbels collected earlier in the season, but significant differences were not observed between seed harvested from treated and non-treated plots (Table 1). *Xhc* levels in seed harvested from treated plots were slightly higher than *Xhc* levels recovered from seed harvested from non-treated plots but the differences were not significantly different. Cool, wet weather delayed the harvest of both fields for several weeks, so ManKocide applications were not as close to harvest as desired and it is possible that *Xhc* populations may have rebounded during the period between treatment and harvest.

Acknowledgements

The researchers would like to thank Central Oregon Seeds, Inc. for funding and the grower-cooperators for hosting this trial in their fields. We also would like to thank Hoyt Downing for performing the treatment applications.

Table 1. Amount of *Xanthomonas hortorum* pv. *carotae* detected in two fields prior to ManKocide treatments and in plots that were not treated and treated with ManKocide in mid- to late August.

Field	Pre-treatment (± std. dev.)	Non-treated (± std. dev.)	Treated (± std. dev.)
66	2.08×10^{8} ($\pm 2.43 \times 10^{8}$)	4.23×10^{7} ($\pm 9.16 \times 10^{6}$)	4.91×10^{7} ($\pm 8.80 \times 10^{6}$)
72	1.61×10^{5} ($\pm 5.13 \times 10^{4}$)	6.25×10^{2} ($\pm 7.19 \times 10^{2}$)	3.20×10^{3} ($\pm 2.84 \times 10^{3}$)

Evaluation of Copper and Quaternary Ammonium to Control Bacterial Blight in Steckling-Planted Carrot Seed Crops

Jeremiah Dung and Jeness Scott

Introduction

The Pacific Northwest, specifically central Oregon, central Washington, and Idaho's Treasure Valley, is a major global producer of hybrid carrot seed. Carrot seed crops are produced in direct-seeded (seed-to-seed) or steckling-planted (root-to-seed) fields. In the Pacific Northwest, stecklings used to produce root-to-seed crops are typically grown in California or Arizona and dug in January or February. Stecklings are stored at 1 to 2°C for 4 to 8 weeks to vernalize roots and condition them for bolting the following spring. Vernalization can be performed before or after the stecklings are shipped to seed producing regions.

Bacterial blight of carrot, caused by the plant pathogenic bacterium *Xanthomonas hortorum* pv. *carotae* (*Xhc*), is a common disease of carrot wherever the crop is grown. The disease can affect carrot foliage, stems, umbels, and roots and can be seed-borne. Symptoms of bacterial blight include small, irregular, chlorotic areas on leaves that can manifest into water-soaked, necrotic lesions. Lesions can also occur on stems and petioles. Floral infections can result in blighted umbels, reduced seed yield, and reduced germination rates of harvested seed. Although severe symptoms of bacterial blight rarely occur in the semi-arid regions of the Pacific Northwest where carrot seed is produced, significant epiphytic populations can occur on asymptomatic plants in the field, resulting in seed that is infected or infested by the pathogen. The seed-borne nature of *Xhc* makes it a major concern not only to the hybrid carrot seed industry in the Pacific Northwest but also to regions that import carrot seed for root production.

In addition to infested seed, infected carrot stecklings may be an important source of inoculum for carrot seed producers in the Pacific Northwest. A previous study detected *Xhc* in 4 of 12 steckling crops that were sampled directly from shipping crates. Although the disease is often less prevalent in root-to-seed fields, outbreaks do occur. From 1931 to 1933, Kendrick reported bacterial blight outbreaks associated with infected stecklings in the Sacramento Valley of California. Similarly, during the 2014 season disease symptoms were observed in three steckling-planted fields which were well-isolated from other root-to-seed and seed-to-seed carrot seed crops (Jeremiah Dung, *personal observation*).

The use of disease-free seed and stecklings is an important component of an integrated disease management program to reduce the impact of bacterial blight on harvested seed. When possible, stecklings should be produced in areas where bacterial blight is not endemic. In addition, potentially infected stecklings should be treated prior to transplanting. However, there is a lack of effective control options for infected stecklings. The objective of this research is to evaluate potential treatments for stecklings infected with *Xhc* to prevent bacterial blight in root-to-seed carrot seed crops.

Materials and Methods

The effect of selected treatments on epiphytic populations of *Xhc* and bacterial blight was evaluated in a greenhouse. Carrot stecklings were obtained from commercial steckling production fields and vernalized according to standard industry practices. Each experimental unit consisted of three stecklings (subsamples). Stecklings were treated with KleenGrow (7.5% didecyldimethylammonium chloride; PACE 49 Inc., Canada), OCION PT81 (20.3% copper sulfate pentahydrate; OCION Water Sciences Group, Canada), OCION FT33 (4.16% Cu, 1.64% Zn, and 4.97% S; OCION Water Sciences Group, Canada), and/or ManKocide (15% mancozeb, 46% copper hydroxide; Certis USA, Columbia, MD) (Table 1). A non-treated/non-inoculated control and a non-treated/inoculated control were also included.

Stecklings were planted in potting mix and *Xhc* inoculations were performed using a CO_2-pressurized backpack sprayer. Stecklings were inoculated with a mixture of three *Xhc* isolates that were previously shown to cause bacterial blight on carrots under greenhouse conditions. Each steckling was inoculated with a total of 10^6 CFU/steckling. The non-inoculated control was mock-inoculated with sterile phosphate buffer (0.0125 M). Plants were arranged under a greenhouse bench covered with Remay cloth for 5 days to promote environmental conditions that are conducive to *Xhc* growth and epiphytic colonization.

Bactericide treatments were applied 5 days after *Xhc* inoculations. Bactericide treatments consisting of two applications were applied at 5 and 12 days post-inoculation. Bactericide treatments were applied using a CO_2-pressurized backpack sprayer calibrated to apply the products in 50 or 100 gallons/acre at 20 psi. The experiment was designed as a randomized complete block design with four replications.

Severity of bacterial blight symptoms was evaluated weekly after inoculation using a scale of 0 to 5 where: 0 = no symptoms, 1 = a few small lesions on one leaf, 2 = 5-10 lesions on one or two leaves, 3 = at least two leaves with prevalent symptoms, 4 = three or more leaves with extensive lesions, and 5 = >50% of the leaves with symptoms. Individual plants (subsamples) were destructively sampled and assayed at approximately 3- , 6- and 11 weeks after the first bactericide treatment application. Plants were finely chopped and a subsample of tissue was placed in a sterilized flask containing 250 ml of sterilized phosphate buffer (0.0125 M). Flasks containing buffer and foliage were incubated for 2 h, shaken for 5 min at 250 rpm on a gyratory shaker, and the rinsate from each flask was diluted serially up to 10^{-5}. Two 100 µl aliquots of each dilution were spread onto semi-selective XCS agar medium. Plates were incubated at 28°C for 5 to 7 d. The number of colony forming units (CFUs) of *Xhc* from each plate was used to calculate the mean number of CFUs/ml. The chopped and rinsed foliage of each subsample was dried at 60°C for at least 4 d and weighed to calculate the mean number of CFUs/g dry foliage. Data was subjected to analyses of variance (ANOVA) and means comparisons using Fisher's protected LSD.

Results and Discussion

Although the non-treated and inoculated control treatment exhibited the highest disease rating at the conclusion of the trial, relatively low bacterial blight severity was observed among all treatments (Table 1). None of the treatments significantly reduced *Xhc* populations compared to the non-treated and inoculated control (Table 1). The largest *Xhc* populations were observed on plants treated with a single application of ManKocide (1.91×10^8). *Xhc* was not detected on plants treated with two applications of KleenGrow+Ocion PT81 or on the non-treated/non-inoculated control plants. Lower populations of *Xhc* were detected on plants treated with Ocion PT81 (6.70×10^2) and two applications of KleenGrow+Ocion FT33 (8.47×10^3), but these treatments were not significantly different than the non-treated/inoculated control. Phytotoxicity was not observed in any treatments and treatments did not prevent or delay bolting.

Acknowledgements

The researchers would like to thank PACE 49 Inc., OCION Water Sciences Inc., and Seminis Vegetable Seeds for providing funding and in-kind support.

Table 1. Bacterial blight disease ratings and populations of *Xanthomonas hortorum* cv. *carotae* (*Xhc*) on carrot foliage following treatments for bacterial blight control in carrot stecklings

Treatment	Rate	Disease rating (0-5)	*Xhc* CFU/g[1]
Non-treated and non-inoculated (control)	NA	0.00	0.00E+00 a
Non-treated and inoculated (control)	NA	2.00	2.43E+06 ab
ManKocide	2.5 lb/acre	1.75	1.91E+08 c
Ocion PT81	40 oz/acre	0.50	6.70E+02 a
Ocion FT33	40 oz/acre	0.75	6.87E+05 bcd
KleenGrow	25 oz/acre	0.00	2.46E+05 ac
KleenGrow + Ocion PT81	25 oz/acre	0.00	3.30E+06 bce
KleenGrow + Ocion FT33	25 oz/acre	0.25	2.41E+05 ac
ManKocide (x2, 7 day interval)	2.5 lb/acre	0.00	5.51E+05 a
Ocion PT81 (x2, 7 day interval)	40 oz/acre	0.00	1.54E+04 ade
Ocion FT33 (x2, 7 day interval)	40 oz/acre	0.00	2.44E+06 ade
KleenGrow (x2, 7 day interval)	25 oz/acre	0.25	4.20E+06 ade
KleenGrow + Ocion PT81 (x2, 7 day interval)	25 oz/acre	1.00	0.00E+00 a
KleenGrow + Ocion FT33 (x2, 7 day interval)	25 oz/acre	0.00	8.47E+03 a
		$\boldsymbol{P = 0.06}$	$\boldsymbol{P = 0.02}$

[1] Data were combined from the three sampling periods and log-transformed for ANOVA.

Evaluate Potential Crop Injury from Herbicides Applied the Final Year of Peppermint Production when Rotating to Kentucky Bluegrass Seed or Wheat

Marvin Butler, Rich Affeldt, Jim Carroll, Jim Cloud and Mark Hagman

Abstract

There have been ongoing concerns by growers and fieldmen in about herbicides used in peppermint production carrying over when rotating into Kentucky bluegrass or winter wheat. Symptoms generally appear as Sinbar damage despite lowered rates later in production years with no Sinbar applied the final year of production. Of concern is whether alternative herbicides used in the final year or two in combination with Sinbar is creating a synergistic effect that is causing the observed damage. A research project was established to evaluate four herbicides applied alone and in various combinations to address these concerns. As of early December, no observable effect of these twenty herbicide treatments on Kentucky bluegrass or winter wheat stands has been observed.

Introduction

In central Oregon, there has been grower and fieldmen concern over the last several years about herbicide injury to Kentucky bluegrass and wheat when rotating out of peppermint. Growers typically reduce Sinbar (terbacil) use in older stands to prevent future damage as they rotate out of mint. Rates are generally 1.5 lb/acre the first year, 1 lb/acre the second year, 0.5 lb/acre the third year and no Sinbar applied the fourth or final year.

To offset reduced Sinbar use in older stands, various combinations of Spartan (sulfentrazone), Chateau (flumioxazin), and Command (clomazone) are used for weed control. However, as use of these products has increased rotational problems are becoming more evident. Most of the rotation crop research that was previously conducted with these herbicides was done with each product individually, rather than in combination, as would typically be done in production. The combination of these products is of particular importance, as there is strong local concern that potential synergism may be increasing injury when these herbicides are tank mixed.

This project focuses on soil residual herbicides applied alone and in combination to peppermint that may be causing rotational crop damage to Kentucky bluegrass grown for seed and wheat. Herbicides include Sinbar, Spartan, Chateau and Command applied late winter alone and in various combinations on the final year of mint production. Injury to rotational crops Kentucky bluegrass for seed and wheat will be evaluated.

Methods and Materials

This project is being conducted on a plot of peppermint 80 ft x 120 ft at the Central Oregon Agricultural Research Center (COARC) planted in 2014. A total of 20 treatments were applied February 18, 2015 to 10 ft x 20 ft plots, replicated four times in a randomized complete block design. Herbicides were applied with a CO_2 powered backpack sprayer with a hand-held boom commonly used for research plots. Due to an anticipated lack of precipitation, the plot area was irrigated with a half inch of water following application using a rain bird sprinkler. However, there was 0.17 inch of precipitation on February 27.

The plot area was managed similar to commercial practices for mint production in central Oregon. At harvest timing, mint was cut and removed from the plot area and Roundup was applied following a post-harvest irrigation. The plot area was rotovated to 3-4 inches and rolled to firm the seed bed prior to planting with an 8 ft Great Plains no-till drill. Kentucky bluegrass was planted August 19 and winter wheat was planted October 9. These two crops were planted perpendicular to herbicide treatments creating 10 ft x 10 ft sub-plots.

Results and Discussion

The tillage practices for removing the mint stand varied from the common commercial practice of discing or discing and ripping followed by cultimulching prior to planting. The small size of the plots is the reason for rotovating rather than discing to minimize soil movement across plots. We do not believe this variation in tillage practice changed the outcome because the tillage depth was consistent with standard commercial practice.

Through early December 2015 there has been no discernable effect on Kentucky bluegrass or winter wheat stands based on herbicide treatments. In commercial fields herbicide damage would have been observed earlier in the fall for Kentucky bluegrass, though symptoms on wheat may be delayed until early spring. This lack of results to date, on Kentucky bluegrass in particular, comes as a surprise to those involved in the project without any clear explanation. All would expect to at least see symptoms from Sinbar applied at 1 lb/acre in February of this year, either alone or in combination with Spartan, Chateau or Command.

Plots will continue to be monitored through spring for herbicide injury. If warranted, wheat stand counts will be taken and fresh biomass samples for both wheat and Kentucky bluegrass will be collected. If no injury is observed, sugar beets will be planted through the plots and used as a highly sensitive indicator crop for Sinbar or other herbicides.

Acknowledgements

The primary author would like to thank the Oregon Mint Commission for their support of this project, Rich Affeldt and Jim Carroll for their cooperation in designing and managing the project and Jim Cloud and Mark Hagman for their assistance as growers affected by herbicide carryover issues.

Electronic Mint Pest Alert Newsletter to Promote Optimal Application of Coragen® to Control Mint Root Borer, Cutworms, Armyworms and Loopers

Marvin Butler, Darrin L. Walenta, Clare Sullivan,
Nicole Anderson, and Ralph Berry

Abstract

An electronic newsletter was developed for the peppermint production regions in Oregon to assist growers and fieldmen consider control of mint root borers, cutworms, armyworms and loopers during the growing season prior to crop damage. The newsletter was designed as a two-year project to help with timing of this new insecticide application strategy, and to be used in conjunction with existing field monitoring programs. Extension Agents from the Willamette Valley and Union County were valuable cooperators and provided scouting services to confirm insect development model accuracy. A formal survey of those receiving the newsletter indicates that the newsletter was well received, provided information valuable to growers and crop consultants/scouts, and respondents would overwhelmingly like to see the newsletter continue.

Introduction

Mint root borer is one of the more serious insect pests of commercial peppermint in the Pacific Northwest based on discussions with OUS entomologist, Ralph Berry and Glenn Fisher. In some regions, cutworms are considered an equally important pest, with the variegated cutworm being the most common and damaging species of the cutworm complex. Additional pests include loopers and armyworms.

Coragen® provides a new approach to control these insect pests prior to crop damage in an environmentally friendly manner. The traditional approach for mint root borer has been to apply Lorsban Advance® in the fall, which requires irrigation to move the product into the soil for larval control. In contrast, Coragen® provides control of eggs and first instar larvae feeding on foliage prior to dropping to the ground to enter the rhizomes. The life cycles of these three pests, based on developmental models, offer a window of opportunity to provide control of more than one target pest with a single application of the new insecticide.

This new application strategy timed earlier in the growing season provides an opportunity for growers and industry representatives to control mint root borers, cutworms and loopers before the pests cause damage during the growing season. The objective of this project was to deliver region-specific insect development information in the form of an electronic Pest Alert Newsletter to assist growers, fieldmen and industry representatives in maximizing the effectiveness of Coragen® applications throughout Oregon. A secondary objective was to evaluate the Newsletter's impact on current pest management programs and knowledge of pest phenology.

Methods and Materials

Regional cooperators on the project were Darrin L. Walenta (Union Co.), Clare Sullivan (S. Willamette Valley) and Nicole Anderson (N. Willamette Valley), in addition to the involvement of Ralph Berry, Entomology Professor Emeritus. For this second year of the project, electronic templates and contact lists for the newsletter were updated for the three regions: Willamette Valley, northeastern Oregon and central Oregon. Insect pest degree-day development models (source: Integrated Pest Management on Peppermint Program) were generated using temperature data from AgriMet stations in each region: Corvallis (Willamette Valley), Imbler and Baker Valley (N.E. OR), Madras and Powell Butte (central Oregon). Links to AgriMet weather station data is available at: http://www.usbr.gov/pn/agrimet/.

Degree day development models for mint root borer and variegated cutworm were run weekly using the models in IPMP from June 12 through July 10 and August 28 through September 4, with results provided through the weekly electronic Mint Pest Alert Newsletter. OSU faculty cooperators provided onsite confirmation of model accuracy for each region. Two commercial fields from two mint production areas in each region were used for this field scouting activity. Pheromone traps were used for mint root borer adults and sweeps were used for cutworms. Soil samples were used for mint root borer larvae assessment in September. There was general consensus from data across regions that the insect development models are reliable, even during the exceptionally warm 2015 season.

A survey was developed to evaluate the newsletter value and impact to Oregon mint growers and industry representatives. An email was sent out by regional OSU cooperators in late August asking those on the mailing list for that region to participate in the online survey. The last newsletter in early September provided follow-up reminders about the survey, followed by a reminder in mid-September. This information will be helpful for OSU faculty to assess the impact of their Extension program, determine whether the newsletter has accomplished its goal, and if there is ongoing value to the Oregon mint industry of continuing the newsletter.

Results and Discussion

The newsletter was sent to 107 individuals, 67 growers, 37 crop consultant/field scout and 3 others involved in the mint industry. Twenty-eight individuals responded to the survey, which represents 26% of those who received it. Of the 28 who responded to the electronic survey, 43% were growers, 50% crop consultant/field scouts and 7% mint industry representatives (Figure 1). Respondents by region were 68% from the Willamette Valley, 14% from the Grande Ronde and Baker Valleys and 18% from central Oregon (Figure 2).

Across regions the relative importance of the following insect pests was rated 1) mint root borer, 2) cutworm, 3) looper and 4) armyworm. Level of knowledge about degree-day insect development models from reading the newsletter increased from 2.9 to 4.0 on a scale of 1 (uninformed) to 5 (fully informed). The degree to which the newsletter influenced insecticide application timing decisions was rated a 2.8, on a scale of 1 (no influence) to 5 (high influence). Confidence in degree-day insect models during this extremely warm season was rated 3.5 on a scale of 1 (no confidence) to 5 (high confidence).

Level of knowledge about the use of Coragen from reading the newsletter increased from 3.4 to 4.1 on a scale of 1 (uninformed) to 5 (fully informed). The degree to which the newsletter influenced decisions about insecticide product of choice was rated 2.8 on a scale of 1 (no influence) to 5 (high influence). Current practices for controlling larval pests were 72% use of traditional insecticides (Orthene, Lorsban, etc.), 36% applied Coragen pre-harvest and 12% applied Coragen post-harvest (Figure 3). When asked whether future plans include the use of Coragen, 63% said "Yes", 19 percent were "No" and 19 percent said "Maybe" (Figure 4). If respondents did not plan to use Coragen in the future, the major reason given was the higher cost of Coragen (57%).

Respondents rated the newsletter effectiveness in assisting grower/crop consultants in using degree-day models and specifically targeting use of Coragen for mint root borer control of eggs and first instar as 3.5 on a scale of 1 (not effective) to 5 (very effective). When asked if the Mint Pest Alert Newsletter should continue as an ongoing project 75 percent indicated "Yes", 25 percent said "Maybe" and 0 percent indicated "No" (Figure 5). Maybe respondents were asked to explain, with the explanations largely positive about the need for this area-wide information for fieldmen that the grower depends on for scouting and recommendations. In addition, four individuals provided comments at the end of the survey; all were very positive and appreciative of the newsletter.

Acknowledgements

The primary author would like to thank the Oregon Mint Commission for their support of this project, Darrin L. Walenta, Clare Sullivan and Nicole Anderson for their cooperation and active participation, and Ralph Berry for his expertise and ongoing interest in the project.

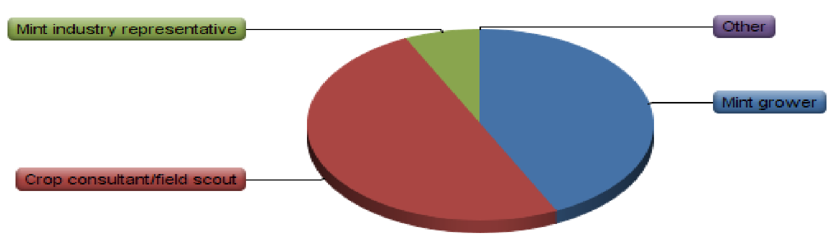

Figure 1. Survey respondents by category.

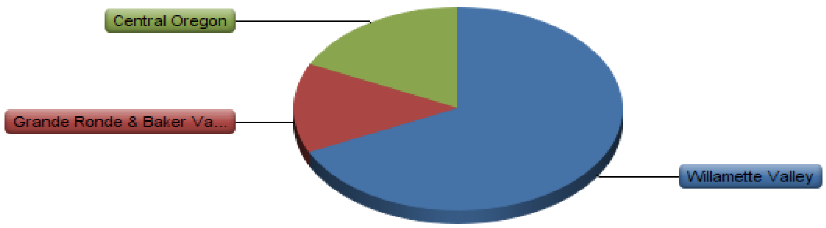

Figure 2. Survey respondents by mint production region.

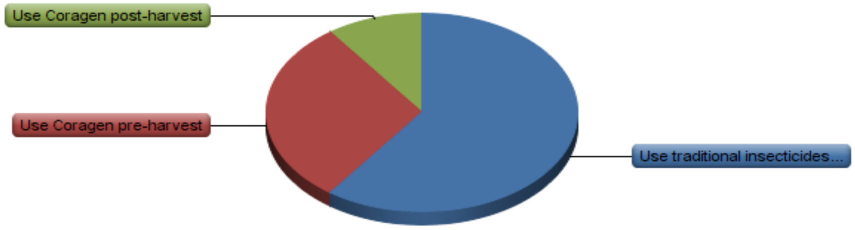

Figure 3. Insecticide product preferences and Coragen use application timing.

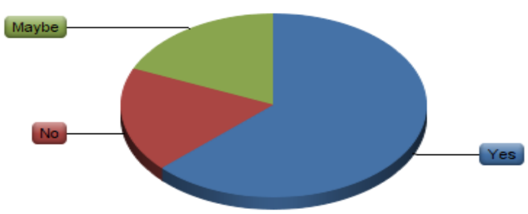

Figure 4. Whether insecticide plans for the future include the use of Coragen.

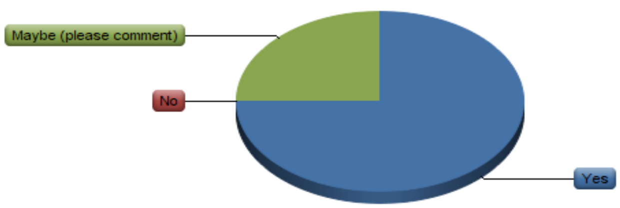

Figure 5. Response to whether the Mint Pest Alert Newsletter should continue as an ongoing project.

Discrimination of Mint Strains of *Verticillium dahliae*
Using High Resolution Melting Analysis

Jeremiah Dung, David Wheeler, and Dennis Johnson

Introduction

Verticillium wilt is the major disease impacting mint production in the Pacific Northwest. Black Mitcham peppermint and Scotch spearmint are very susceptible to Verticillium wilt while other mints, including native spearmint and some peppermint varieties exhibit varying degrees of resistance or tolerance to the disease (1, 4, 6). Verticillium wilt is caused by *Verticillium dahliae*, a soilborne fungus which has a wide host range and can survive for ten years or more as microsclerotia in field soils. Although the fungus can colonize and infect a wide range of dicot crops, a mint strain exists which belongs to vegetative compatibility group (VCG) 2B, exhibits a reduced host range, and is highly aggressive on mint (1, 3, 5). In addition, co-infection by *V. dahliae* and the root-lesion nematode *Pratylenchus penetrans* can result in increased disease incidence and severity and this interaction on mint is most synergistic when the mint strain of *V. dahliae* is involved.

Detection and quantification of microsclerotia in soils can be an important component of Verticillium wilt management. However, management options for Verticillium wilt should generally be implemented prior to planting in order to reduce disease levels. This is especially true for a perennial crop such as mint where fumigation and other control practices are difficult or impossible to perform once the field is established. Most methods to detect and quantify microsclerotia of *V. dahliae* rely on plating soils onto semi-selective medium, but these methods are time-consuming and labor-intensive and can take several weeks to obtain results. However, these tests usually do not include the identification or quantification of the mint VCG 2B strain in the assay, which can take weeks or months to complete using traditional methods.

Double-stranded DNA disassociates, or melts, into single-stranded DNA at different temperatures depending upon its length and sequence composition. High-resolution melting (HRM) analysis incorporates a fluorescent dye that disassociates from double-stranded DNA when it becomes single-stranded DNA, and this reduction in fluorescence can be used to determine the melting temperature of a particular region of DNA. The objective of this project was to determine if HRM analysis can be used to differentiate the VCG 2B mint strain of *V. dahliae* using differences in melting temperature of DNA after PCR amplification.

Materials and Methods

HRM analysis was conducted on a total of 112 *V. dahliae* isolates (49 isolates from mint, 39 isolates from potato, and 24 isolates from other hosts) using previously developed PCR primers that target the intergenic spacer (IGS) of DNA (9). The IGS region has previously been shown to exhibit sequence variation among *V. dahliae* isolates from different hosts, including mint and potato (7). A total of 86 HRM products were sequenced to identify differences in DNA sequences and IGS regions of DNA from 62 of the *V. dahliae* strains were sequenced to validate the results of HRM analysis. HRM analysis was repeated on 82 *V. dahliae* isolates (40 mint, 23 potato, and 19 other hosts) using a set of 3 representative mint strain as controls. HRM analysis was conducted using High Resolution Melt Software ver.3.0.1 (Applied Biosystems).

Results and Discussion

HRM analysis originally grouped mint isolates into three different groups based on melting temperatures of Q-PCR products. Some isolates from potato and other hosts were also grouped among some mint isolates based on melting temperatures, initially suggesting that HRM analysis would not reliably differentiate mint strains of *V. dahliae*. However, post-HRM sequencing revealed that one of the reference isolates from mint that was used as a control (isolate 111) contained a sequence that was atypical of the rest of the mint isolates. HRM analysis was repeated using control isolates that were representative of peppermint and spearmint isolate sequences. As a result, HRM analysis grouped all mint strains into a single HRM group (red), with the exception of the aforementioned mint strain with the atypical sequence (blue) (Figure 1). In addition, HRM analysis discriminated mint strains (red) from potato isolates (blue) (Figure 1) and separated mint strains from 16 of the 19 isolates from other hosts (Figure 1). The 3 isolates that grouped with mint strains contained the same sequence composition as typical mint strains (data not shown). One of these isolates was obtained from skullcap (*Scutellaria lateriflora*, Lamiaceae) and corresponded to the VCG 2B mint strain; this isolate likely originated from a mint crop that was planted in the field prior to the skullcap crop (2). Additional experiments are necessary to determine if HRM analysis can be used in environmental samples containing multiple strains.

Acknowledgements

The authors would like to thank the Mint Industry Research Council for funding this project.

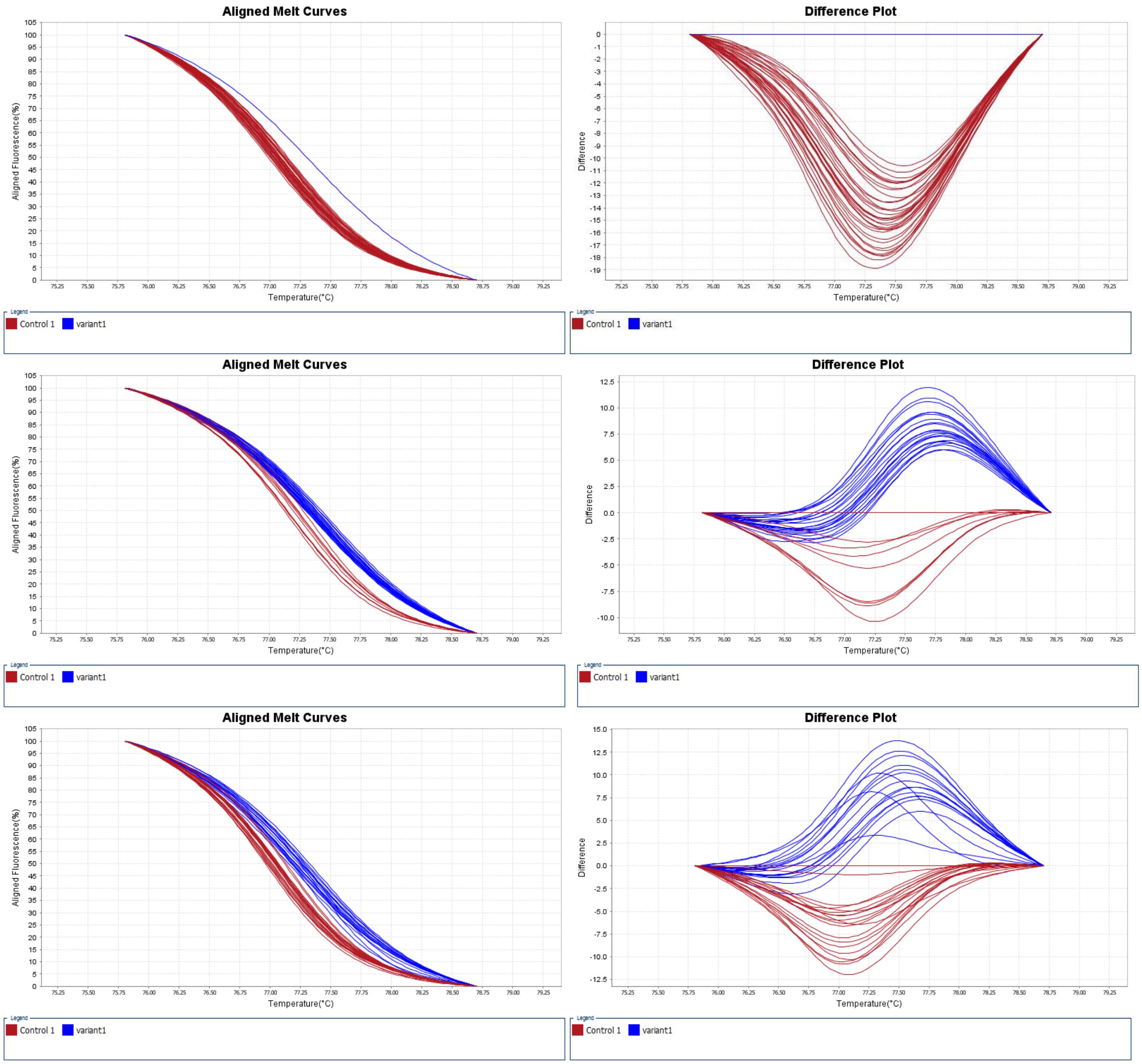

Figure 1. HRM analysis of *V. dahliae* strains from mint (top), potato (middle), and other hosts (bottom). Aligned melt curves (left) and difference plots (right) showing the differentiation of typical mint strains (red), potato strains and atypical mint strains (blue) and strains from other hosts (red or blue depending on sequence similarity).

Central Oregon Potato Extension Program

Marvin Butler, Heike Williams, Carol Tollefson

Abstract

Aphids, tuberworm moths, potato psyllids, and beet leafhoppers were collected and counted weekly in Jefferson County from June 23 to September 9, 2015. Counts were conducted to monitor pest populations and assess potential risk of disease transmission. Collection methods included fifteen water pans for aphid collection, 15 delta traps for potato tuberworm moth, and 15 yellow sticky traps each for psyllid and beet leafhopper. Weekly findings were distributed to growers, fieldmen and industry representatives through reports and website postings. Aphid numbers were low during the first week of monitoring followed by a spike for 2 weeks into a moderately high level at the end of June. Numbers then remained low until rising in August and continued at a high level until trap removal on September 9, 2015. In contrast to 2014, potato tuberworm moths were detected only sporadically and in low numbers during two weeks in August. Potato psyllids were present in increasing numbers starting the week of August 5 until vine kill. Specimens were tested for Lso (Candidatus Liberibacter solanacearum) and all tested negative. Beet leafhoppers were included in the 2015 protocol for the first time in the history of this project and were found mostly in single digit numbers. Specimens trapped after August 5th were tested for the presence of BLTVA phytoplasma and all tested negative. Early blight prediction modeling and crop water use data provided helpful information for seed potato management and weekly monitoring continues to be a significant source of information for integrated pest management in central Oregon potato fields.

Materials and Methods

Aphid, Potato Tuberworm, Psyllid, and Beet Leafhopper trapping IPM project
Aphids. Aphids are important pests in potato crops and can affect yield by removing nutrients from plants, stunting growth, or transmitting disease. Aphids are known vectors for several viruses, with the most important for our area being potato virus Y (PVY). Pan traps are used to determine when aphid populations are increasing and when field treatment becomes necessary.

Fourteen yellow water traps were used to collect winged aphids in commercial potato fields throughout Central Oregon, in addition to one at a potato test plot at the Central Oregon Agricultural Research Center (COARC). Traps were distributed on June 16, 2015 with final collection occurring on September 9, 2015. Trapped aphids were collected by straining the aphids from the water using a fish net and collecting trapped insects in 4 ounce specimen cups. Cups were transported to the COARC laboratory and kept refrigerated until examination. Aphids were separated from other insects using a microscope and identified as green peach aphids, potato aphids or other aphids. Aphids were stored in vials filled with alcohol for one week unless samples were sent to the Hermiston Agricultural Research and Extension Center (HAREC) for confirmation or research purposes. Date and location were used to identify aphid movement in area.

Potato Tuberworm. The potato tuberworm (PTW) is one of the most important pests that infest potatoes worldwide. Potato tuberworm moths appeared in the area in 2013 and have the potential to impact production due to larvae mining in tubers. In the past, the presence of potato tuberworm in central Oregon was sporadic but increased to weekly detection in 2014.

Pheromone delta traps were placed at a distance of about 5 feet from the edge of planted ground in fourteen commercial potato fields and one potato test plot at COARC from June 16 to September 9. Delta traps consist of a triangle shaped trap, removable sticky liner bottom, and a lure impregnated with the pheromone of the female potato tuberworm moth. Sticky liners were removed weekly and inspected for presence of male moths. Pheromone lures were replaced every 4 weeks.

Potato Psyllid. The Pacific Northwest potato industry has been alerted of the finding of the zebra chip (ZC) disease in 2011. The pathogen causing ZC is 'Candidatus Liberibacter solanacearum' (Lso), a type of bacterium vectored by the potato psyllid (Bactericera cockerelli Sulc).

On June 16, 2015 fifteen yellow sticky traps were distributed in commercial fields and a COARC potato test plot and left until September 9, 2015. Double sided yellow sticky traps measuring 4"x6" were placed 5 to 10 feet inside the circle of planted potatoes at canopy height and replaced weekly for potato psyllid activity monitoring.

Beet Leafhopper. Beet leafhoppers are a growing concern for the potato industry. According to information provided by the Washington State Potato Commission, beet leafhoppers transmit the disease called potato purple top disease which is caused by the beet leafhopper-transmitted virescence agent phytoplasma, or BLTVA phytoplasma. Terminal leaves of infected plants turn reddish or purplish and curl, causing infected plants to die early. In addition, nodes swell and turn purplish, internodes are shortened, and aerial tubers may form. The disease is likely transmitted mostly in early summer. This project included monitoring for this pest and testing for BLTVA of beet leafhoppers that were located.

To trap Beet Leafhoppers (BLH) yellow sticky cards were placed at the edge of fourteen commercial fields and a COARC potato test plot outside the circle of planted potatoes and out of reach of irrigation water, preferably near weeds. Yellow sticky cards were collected and changed on a weekly basis.

Generate early blight prediction model and weekly water use data information.
Weekly early blight prediction models were published using June 1 and June 10 emergence dates. The model predicts the first seasonal rise in the number of spores of the early blight fungus based on the accumulation of 300 physiological days (P-days) from green row. Once 300 P-days have accumulated, the first fungicide for early blight control should be applied. This usually occurs when rows have closed. Potato is a moisture sensitive crop with a shallow active root zone compared to cereals and forages. Availability of moisture in the root zone is crucial for high yields and is influenced by soil properties such as texture and percent organic matter. Moisture demand increases as the crop begins to develop after emergence and peaks 7-9 weeks later during the tuber bulking growth stage.

Create seasonal, weekly newsletter to provide growers with insect and disease updates. A weekly newsletter was sent to potato industry participants from June 23 to September 16 that included the early blight prediction model, weekly water use, weekly aphid identification and population numbers, and notification of potato tuberworm moth, potato psyllid, and beet leafhopper presence. Location of trap sites and population numbers were identified for grower use only. Weekly reports were posted onto the OSU-COARC website and can be found at http://oregonstate.edu/dept/coarc/aphid-trap-reports, providing immediate access for our targeted audience.

Results

Aphids. Aphid populations in central Oregon ranged between 0 and 29 aphids per trap in 2015. Overall, aphid populations were low all season long with a small peak for two weeks at the end of June and another increase toward the end of the season in August, continuing through trap removal. Average green peach aphid numbers were very low ranging from a mean of 0 to 4 aphids per trap until mid-August through the end of monitoring, when the mean ranged from 5.2 to 29 per trap. Identification and reporting remains a helpful tool in controlling vectors.

Potato Tuberworm. In 2013, first identification of potato tuberworm moth occurred on August 27 and was confirmed by the OSU-HAREC Entomology Lab. In 2014, PTW moths were found each week (at least one but no greater than 3) starting July 22 until trap removal on September 17 prior to harvest. In 2015, initial detection of a tuberworm moth occurred on August 19th and was verified by the OSU-HAREC Irrigated Entomology Program Laboratory, Hermiston, OR. The following week, 2 additional fields showed presence of potato tuberworms (one specimen per field). After this date, no additional potato tuberworms were located during the 2015 growing season.

Potato Psyllid. Two psyllids were initially found in the week of August 5, 2015 (one psyllid in two separate fields). Specimens were sent to OSU-HAREC for confirmation and testing. Both tested negative for Lso. In the following weeks, the incidence of psyllids increased, both in number of fields and number of psyllids per field. In the last two weeks of the monitoring period, the weeks of September 2 and 9, the number of potato psyllids trapped on sticky cards per field ranged from 1 to 13. All specimens detected were sent to OSU-HAREC for Lso testing and all tested negative.

Beet leafhopper. Throughout the monitoring period, beet leafhoppers (BLH) were found in multiple fields with the highest number of fields testing positive (9 out of 15) during the weeks of July 7 and 14 with a steady decline of affected sites starting the week of August 19 (5 and fewer). The number of BLH per sticky card remained in the single digits with only one exception (13 specimens in one trap during the week of August 5). Starting the week of August 5, all BLH samples were sent to HAREC for BLTVA phytoplasma testing and all tested negative.

Discussion

Weekly aphid reports were sent to growers, fieldmen and industry participants by email and were made available on the Central Oregon Agricultural Research Center Website. Weekly information provides opportunity for efficient and economical control of pests and disease. Trapping continues to be an important tool for potato seed producing areas to monitor pests capable of transmitting diseases.

The yearly survey assists in the prediction of crop water use which is important to proper crop management throughout the growing season and during maturation to assist with harvest and prevent storage rot. Use of the early blight prediction model assisted growers and fieldmen as they time fungicide sprays to efficiently prevent disease outbreak.

This project identified continued incidences of potato psyllid detection in Jefferson County. Specimens were sent to OSU-HAREC for confirmation and were tested for Lso (Candidatus Liberibacter solanacearum); all tested negative. Early blight prediction modeling and crop water use data, provide helpful information for seed potato management. Weekly monitoring continues to be a significant source of information for integrated pest management in Central Oregon potato fields.

Monitoring potato pests in the area can be used to alert industry of increased populations of pests that may affect other crops as well. Virus control efforts center on reducing the source of the virus and controlling potential vectors. Insect monitoring reports are available to central Oregon growers of other crops where aphids are considered pests.

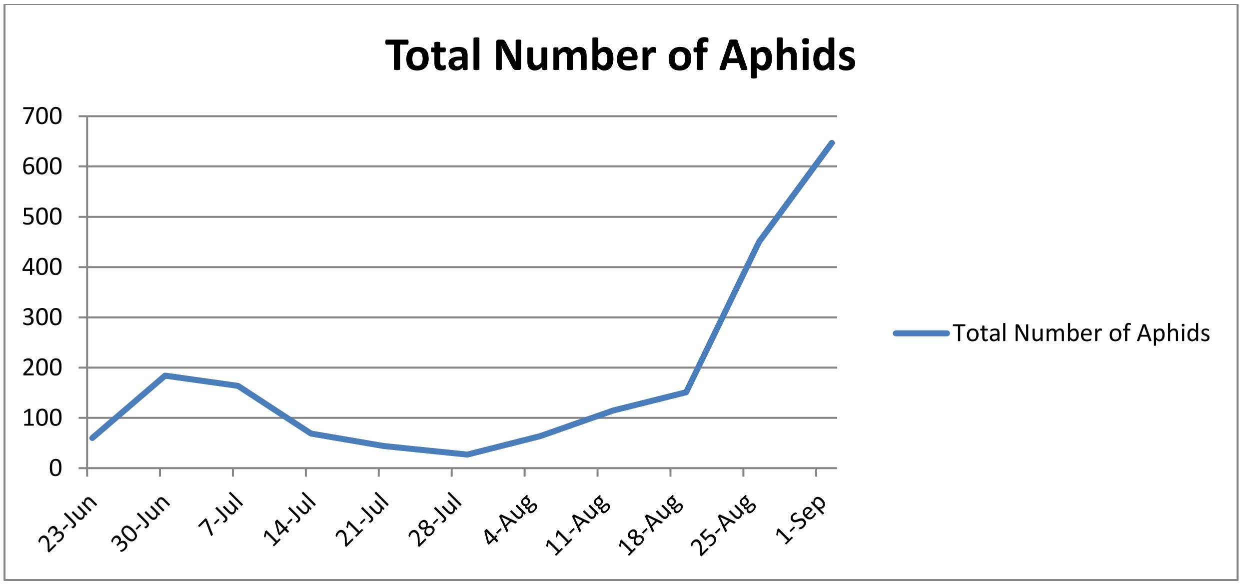

Fig. 1. Total number of aphids trapped in commercial fields in Jefferson County, Oregon 2015

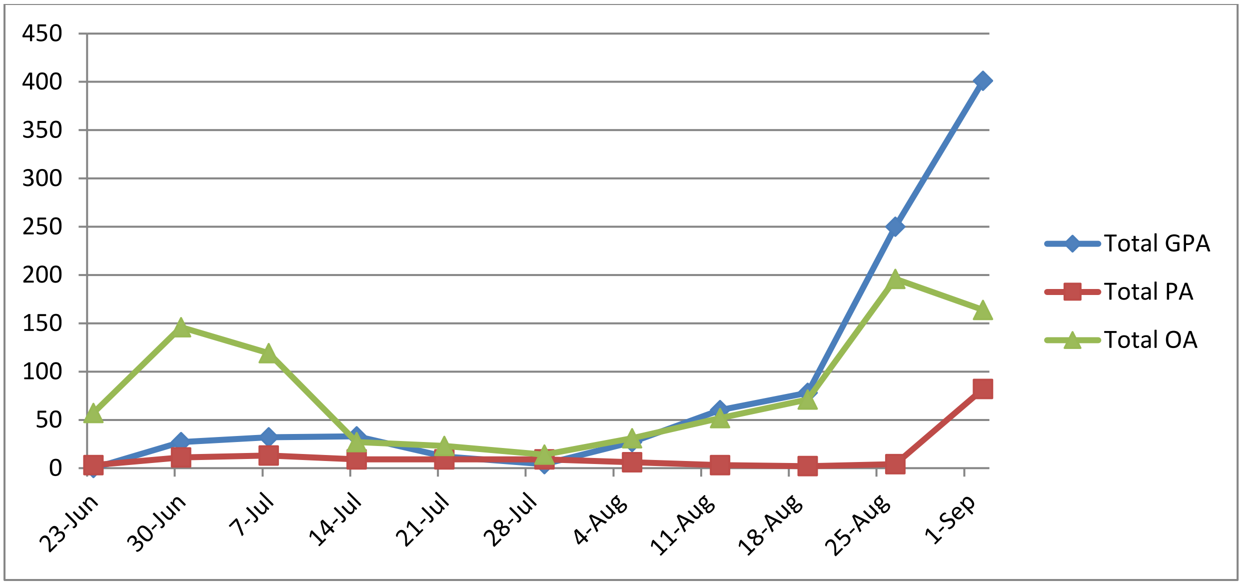

Fig. 2. Total number of aphids per type in commercial fields in Jefferson County, Oregon 2015 (GPA=Green Peach Aphids, PA=Potato Aphids, OA=Other Aphids)

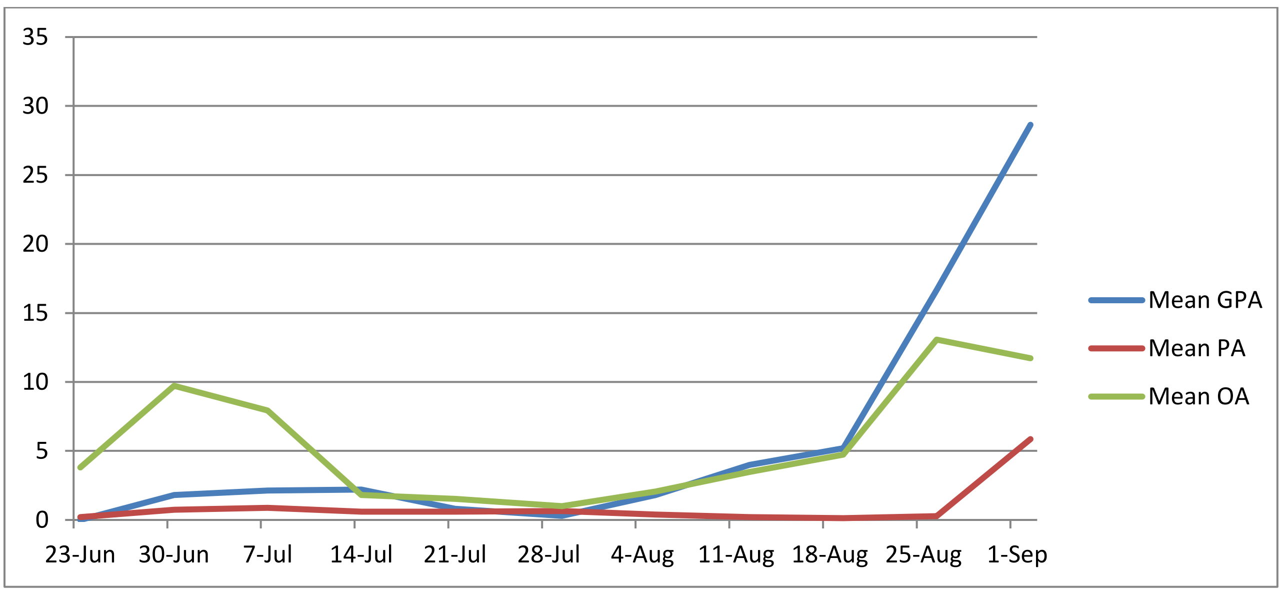

Fig. 3. Mean number of aphids per trap by type in commercial fields in Jefferson County, Oregon 2015 (GPA=Green Peach Aphids, PA=Potato Aphids, OA=Other Aphids)

Managing Straw Residue Without Burning

Tracy M. Wilson

Introduction

Managing straw residue with fire is an effective tool for growers. However, as tourism thrives and drought becomes more prevalent, increased restrictions and negative publicity surround open field burning. With so many limitations on burning, both legal and weather, it is not unlikely that there will be times when burning fields to control straw residue will not be possible. Therefore, it is imperative that growers have effective and economical alternatives to burning available for straw residue management in fields. Many products are available to producers that claim to aid in residue degradation yet no research is available to validate their efficacy for straw residue management. This project will evaluate straw residue management alternatives in comparison with burning to determine whether these microbial products or other management practices are suitable replacements for burning straw residue.

Materials and Methods

This project is currently being conducted in the greenhouse located at the Central Oregon Agricultural Research Center in Madras, Oregon. The experimental design is a randomized complete block design with three replications and the following treatments:

1. Control (no treatment)
2. Burned
3. N added (60 lb N/a as Urea), watered, not incorporated into soil
4. N added (60 lb N/a as Urea), not watered, not incorporated into soil
5. Accomplish (Loveland Products, Inc.), watered, not incorporated into soil
6. Accomplish, not watered, not incorporated into soil
7. BioDigester (Tainio Technology and Technique, Inc.), watered, not incorporated into soil
8. BioDigester, not watered, not incorporated into soil

Soil was placed into 41 x 58 cm (16 x 23 in) trays to a depth of 5 cm (2 in) and watered to 30% moisture. Trays with soil were weighed and weights of soil recorded. Each tray has grass straw residue placed on the soil surface equivalent to 1 ton of residue per acre. Initial weights of soil plus residue will be recorded so that any change in weight can be determined. Treatments will be evaluated (visual observations, weights) for 90 days for residue degradation. Visual measurements will be conducted using SamplePoint software for residue cover comparisons at the start of the experiment and at the end. At the end of the 90-day monitoring period, final tray weights and residue measurements will be recorded and the results analyzed using a mixed model and LSD for means comparisons. Due to space restrictions in the greenhouse, the wheat residue experiment will be carried out at the completion of the grass residue experiment.

Expected Results

It is anticipated that this project will provide guidance for grass seed and wheat growers for the use of microbial products or N fertilizer to aid in the breakdown of straw residue without burning. This study will help elucidate viable alternatives to burning that should be explored further in field trials to maximize the utility for growers.

Acknowledgements

I wish to thank Jim Carroll for his suggestions and comments developing this project as well as providing materials. I would also like to thank Rich Affeldt for his suggestions and providing materials.

Evaluation of N Fertilizer Rate and Timing on Wheat Yield

Researchers

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Neil Christensen, Professor Emeritus, Soil Science, OSU

Abstract

This project sought to evaluate the effects of N rate and timing on yield and grain protein content in irrigated winter wheat grown in central Oregon. Currently, many wheat producers in the area apply N fertilizer in the fall, rather than in the spring, due to logistical concerns of weather, soil moisture, and workload. By evaluating the effect of fall and spring applications of N, we aim to provide guidance for growers on when to apply N fertilization in an effort to maximize grain yield. Large-scale plots were used to assess N rate and timing effects on grain yield, test weight and protein percentage. To trace the fate of fertilizer N, ^{15}N labeled urea was applied to micro-plots in fall and spring, and soil and biomass samples were collected and analyzed to track recovery of the ^{15}N labeled urea. Winter wheat grain yield for 2013-14 and 2014-15 where soil test N was high was largely unresponsive to N fertilization. The labeled ^{15}N urea was recovered primarily from the top six inches of soil and losses ranged from 0 to 30% in 2013-14. Winter wheat response to N fertilization in central Oregon is highly variable likely due to variation in soil depths and textures as well as soil N supply related to crop rotation.

Introduction

The 4R concept of nutrient management means using the:

- Right fertilizer rate at the
- Right time with the
- Right fertilizer source in the
- Right place.

The researchers at COARC in Madras wanted to address the first two R's (rate and timing) for winter wheat in central Oregon. In addition to measuring N fertilizer rate and timing effects on grain yield and protein, we also measured the fate of applied N applied using ^{15}N labeled urea. Conventional wisdom states that applying all of the nitrogen required for winter wheat in the fall is not the best management practice because the N could be immobilized in the soil, leach below the root zone, or be lost as volatilized NH_3 where urea is topdressed on high pH soils.

However, there are many factors that play into management decisions and can take priority over what research suggests as best management practices. Factors such as spring rainfall and field conditions can prevent timely spring application of nitrogen to winter wheat. Some growers choose to apply all of the crop's nitrogen in the fall when field conditions are good which may limit the effectiveness of applied N fertilizer rather than risk not being able to apply nitrogen in the spring. To determine the impacts of nitrogen rate and timing, as well as the fate of N applied, large plots (70 ft by 300 ft) were placed in three commercial fields for the 2013-14 and the 2014-15 crop years.

Materials and Methods

N Rate and Timing

Three locations were used for the 2013-14 crop year: Madras (previous crop wheat), Culver (previous crop potatoes), and Lower Bridge (previous crop garbanzo beans). Soil tests at the three locations were performed prior to nitrogen fertilizer application. Soil test nitrate (NO_3) values were 58 (Madras), 114 (Culver), and 60 (Lower Bridge) lb NO_3/a. Nitrogen rates used were 0, 60, 120, and 180 lb N/a for either fall or spring application.

Three locations were used for the 2014-15 crop year: Madras (previous crop carrot seed), Culver (previous crop wheat), and Lower Bridge (previous crop garbanzo beans). Soil tests at the three locations were performed prior to application of fertilizer nitrogen. Soil test NO_3 values were 159, 19, and 54 lb NO_3/a at Madras, Culver, and Lower Bridge, respectively. Plots were then fertilized in either the fall or spring at nitrogen rates from 0 lb/a to 280 lb/a in 70 lb increments (Table 1.).

^{15}N Fate and Recovery

To measure trace the fate of applied in fall or spring, we applied 150 lb N/a of ^{15}N labeled urea to micro-plots within the check plot. These micro-plots with the ^{15}N labeled fertilizer were used to determine the fate of fall and spring applied N fertilizer by quantifying the amount of applied N taken up by the wheat crop, the amount of applied N remaining in the soil as organic N, and residual inorganic N in soil. The results allow us to determine the percentage of applied N that can be accounted for in the wheat crop and in the soil, as well as the percentage of applied N lost to NH_3 volatilization, NO_3 leaching, and/or denitrification. The entire wheat plant was harvested from the micro-plots when wheat was at milky to mealy ripe growth stage (Feekes 11.1-11.2). Samples were dried, weighed, and ground and were analyzed at the Stable Isotope Research Unit at Oregon State University. After the plants were removed soil cores were collected to a depth of up to 36 inches to determine where in the soil profile the ^{15}N labeled N was at the end of the season.

Results and Discussion

^{15}N Fate (2013-2014)

Data from this year (2014-15) is currently being analyzed therefore the results discussed are from the previous year's project (2013-14). The soil distribution of the ^{15}N labeled urea at all locations found the majority of the recovered ^{15}N in the surface six inches (Table 2). Table 3 shows the amount of the labeled urea found in the plant and in the soil and what percentage of the labeled urea was recovered. If less than 100% was recovered that indicates that there was a net loss of the labeled urea from the system. Looking at the soil distribution of the labeled urea recovered, leaching of N with fall application on sandy soils could be problematic during wet years.

Overall, N loss for the 2013-14 crop year ranged from no loss to almost 30%. The Culver site in the first year started with a high soil nitrate concentration (114 lb N/a) and the low recovery of the labeled urea could be due to dilution in both the soil and plant. In general, spring N application resulted in more N left in the soil than fall application, meaning that less N made it into the wheat and lowering the efficiency of the N applied.

Yield 2013-14

At the Madras location, fall applied N yielded better than spring applications. The grower application of 225 lb N/a in the fall outperformed all treatments prompting us to increase N rates for the second year of the trial. The Culver location (following potatoes) was unresponsive to N fertilizer due to high soil N availability prior to N applications. Lower Bridge saw higher yields from spring N applications than fall N.

Yield 2014-15

Yield results varied by location. At the Madras location where soil test nitrate was high before application of the nitrogen fertilizer and the previous crop was carrot seed, there was no response to the fertilizer (Figure 1). At the Madras location, significant lodging was observed in the high nitrogen rates (>140 lb/a) for both fall and spring application. Additionally, N application >70 lb/a reduced yields, particularly in the spring. Both Culver and Lower Bridge were responsive to N fertilization. Spring application of N at the Culver location was more effective than the fall application of N. It is likely that the residue carryover from the previous year's wheat immobilized the fall applied N, particularly at lower application rates resulting in poor crop uptake. At Lower Bridge yields with fall or spring applied N were comparable up to a rate of 140 lb N/a. At N rates above 140 lb N/a spring N reduced yield; a common response observed when the N supplied to plants is excessive. The field at Lower Bridge came out of garbanzo beans and N release from the garbanzo residue

The yield data from the 2013-14 crop year at Lower Bridge indicated that spring application of N performed better than fall application. The difference between the two years lies in the winter conditions for the fields. The winter of 2013-14 was colder with more winter precipitation, whereas the winter of 2014-15 was warm with little to no precipitation. The soil at Lower Bridge is a sandy loam so the increased winter precipitation in 2013-14 potentially leached as much as 10% of the N applied in the fall resulting in depressed yields in the fall N application plots.

Grain Protein and Test Weight

The results from this year's (2014-15) grain protein and test weight analysis are not yet available.

Conclusions

The yield results of this trial indicate a strong influence of crop rotation on the effect of spring or fall N application. Response to N fertilizer can range from a negative response from over application of N fertilizer (2015 Madras >140 lb/a & Lower Bridge Spring N) to highly significant responses (2015 Culver). We can gain some guidance from the results of the two years of data. This data clearly highlights how critical preplant soil tests can be when determining fertilizer application rates. Failure to account for soil N supply capacity before making fertilizer N rate/timing decisions increases the probability of making unprofitable N fertilizer applications. The data from the Culver location in 2013-14 (following potatoes) and the Madras location in 2014-15 (following carrot seed) showed no response to N fertilization with soil test N at 137 lb N/a and 159 lb N/a, respectively. These locations followed low residue crops, which prevented immobilization of N in the soil and thus needed no additional N fertilization.

The Lower Bridge results (following garbanzo beans) from 2013-14 indicated that spring application of N performed better than the fall applications. This is likely due to a cold, wet winter where the fall applied N on a LaFollette sandy loam had more opportunity to be leached below the root zone. However, the 2014-15 data showed the reverse; fall application of N out yielded the spring applications.

The wheat after wheat rotations showed similar results to the Lower Bridge, where the first year indicated fall applications were more effective but the second year indicated spring applications. This is likely the result of the growing conditions for the two years. Again, 2013-14 was a cold, wet winter and 2014-15 was a warm, dry winter. The cold, wet winter prevented the wheat residue from the previous year's crop from breaking down rapidly leading to prolonged immobilization of N in the residue. The capacity of the soil to supply N to the crop was so low that without fall N the yield potential could not be met by spring N alone. The warm, dry winter in 2014-15 allowed for more rapid breakdown of the wheat residue and thus making the N in the soil more available to the crop in the fall so that the spring application of N went to the growing wheat rather than being tied up in the residue.

Data from 2013-14 and 2014-15 indicate that spring N application is superior to, or at least as good as, fall N application with respect to getting applied N into the plant rather than having it immobilized in the soil or lost from the soil/plant system. This is confirmed by the ^{15}N data from 2013-14 and yield response data in 2013-14 and 2014-15. The apparent exception was the yield response at Madras in 2013-14, which was the result of insufficient soil N in the fall, which limited yield potential.

Table 1. Distribution of ^{15}N labeled urea in soil at each location (2013-14 crop year).

	Madras		Culver		L. Bridge	
Soil depth	Fall	Spring	Fall	Spring	Fall	Spring
inches	lb N/a	lb N/a	lb N/a	lb N/a	lb N/a	lb N/a
0 to 6	31.2	42.5	42.8	37.7	47.9	51.9
6 to 12	2.8	5.1	5.9	12.2	6.2	12.6
12 - 24	-*	2.2	4.0	10.9	14.7	10.9
24 to 36	-	1.9	4.3	-	8.6	6.8

*Missing values for soil depths indicate that samples were unable to be collected at that depth.

Table 2. Recovery of 150 lb N/a as ^{15}N-labeled urea from plant and soil at each location for 2013-14.

Location	Time	Plant		Soil		Total		
		lb N/a		lb N/a		lb N/a		%
Madras	Fall	87	a*	34	d	121	b	80
	Spring	85	a	51	cd	136	ab	89
Culver	Fall	51	b	57	bcd	108	b	72
	Spring	54	b	61	abc	114	b	76
L. Bridge	Fall	57	b	77	ab	134	ab	90
	Spring	81	a	82	a	163	a	109

*Means followed by different letters indicates significant differences.

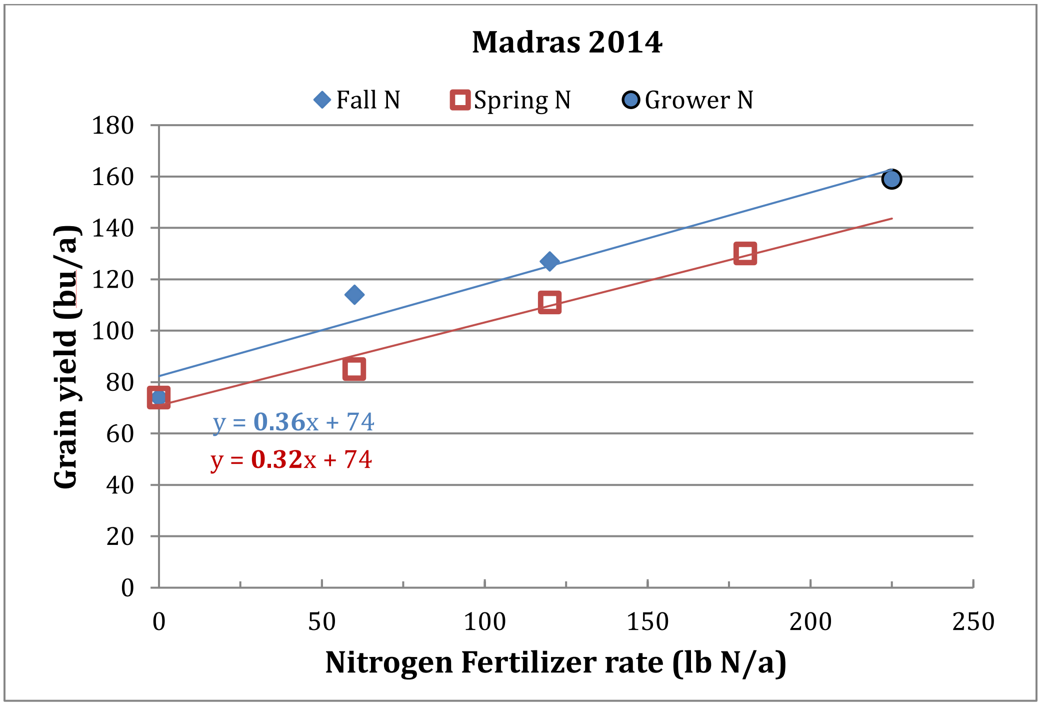

Figure 1. Response to N rate and application time (spring or fall) at the Madras location for 2013-14.

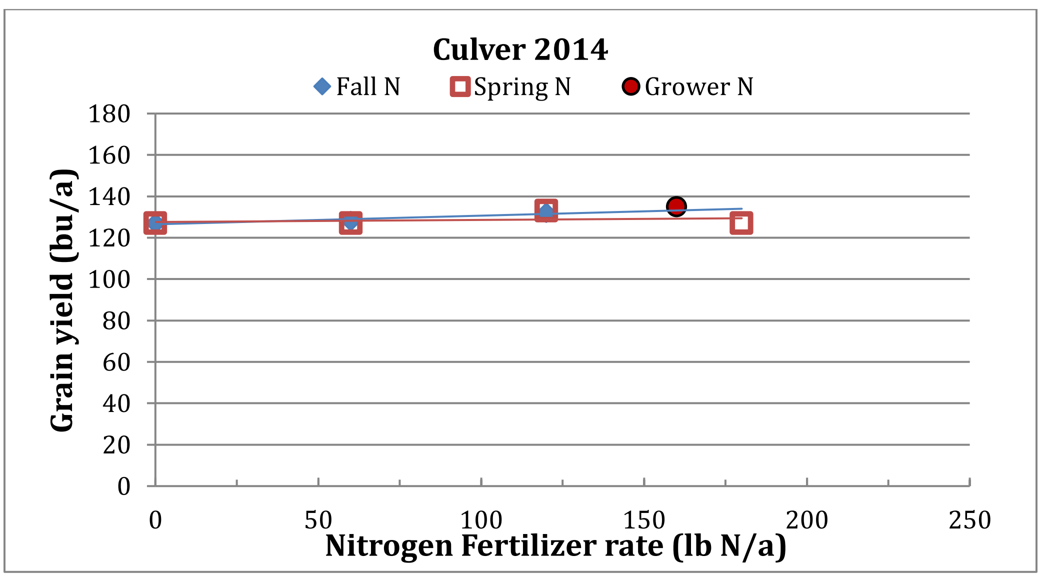

Figure 2. Response to N rate and application time (spring or fall) at the Culver location for 2013-14.

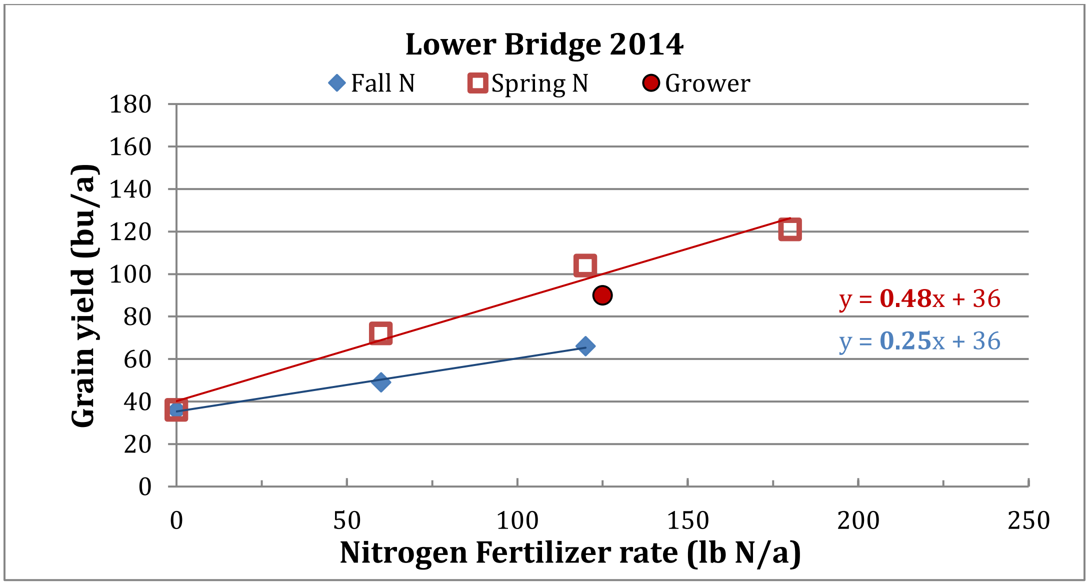

Figure 3. Response to N rate and application time (spring or fall) at the Lower Bridge location for 2013-14.

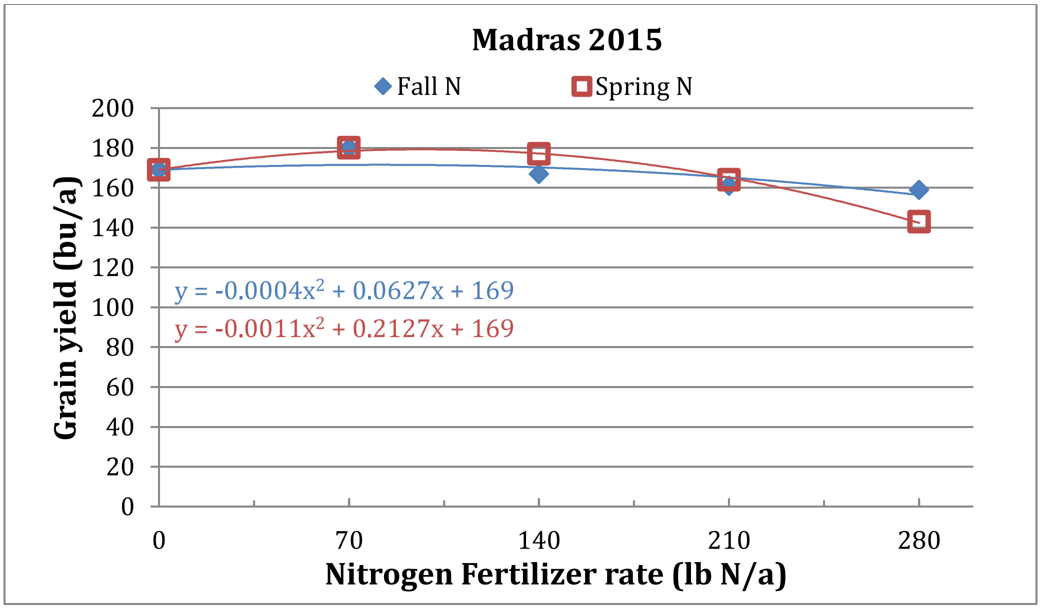

Figure 4. Response to N rate and application time (spring or fall) at the Madras location for 2014-15.

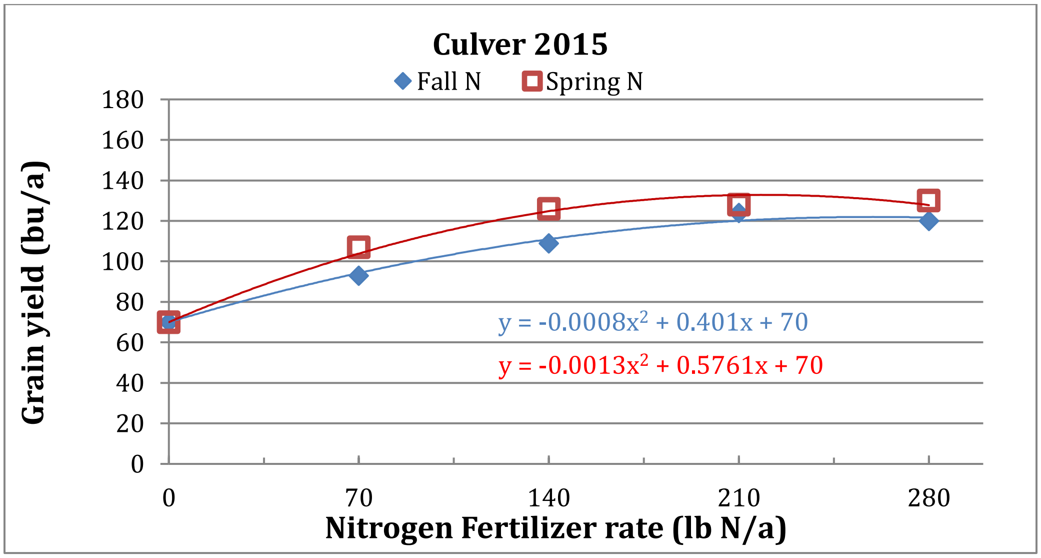

Figure 5. Response to N rate and application time (spring or fall) at the Culver location for 2014-15.

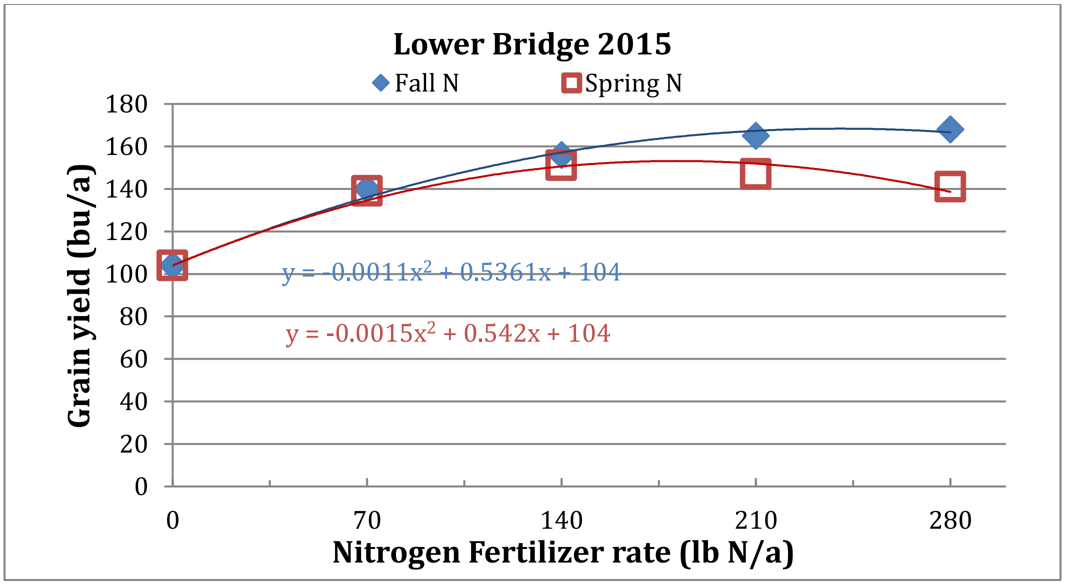

Figure 6. Response to N rate and application time (spring or fall) at the Lower Bridge location for 2014-15.

Summary Report of Conventional and Roundup Ready Alfalfa Variety Yield and Quality over Four Production Years in Central Oregon, 2011-2015

Marvin Butler, Rod Fessler, Mike Knepp, Jay McCabe,
Scott Minor, Scott Simmons, Britt Spaulding and Hoyt Downing

Abstract

An alfalfa variety trial was established in August, 2011 at the Central Oregon Agricultural Research Center in Madras, Oregon. The trial includes ten conventional varieties and seven Roundup Ready varieties. Yield and quality data were collected under a 4-cut management system over four production seasons from 2012 to 2015. Results indicate average annual hay yields of 8.5 to 11 tons/acre and average Relative Feed Value (RFV) ranging from 145 to 160, largely in the Premium quality rating. Initial stand establishment and stand longevity were 90 percent or better across all varieties.

Introduction

Alfalfa is an important crop for central Oregon, with hay produced in the three counties used for feed on local ranches and marketed to livestock producers and dairies in Oregon, the Pacific Northwest and Canada, and exported to Pacific Rim countries. Alfalfa is important as a rotational crop to break disease and insect cycles, with the added benefit of being able to fix nitrogen for its own use and subsequent crops.

Yield, protein and relative feed value data are important components to provide a thorough varietal performance evaluation under central Oregon conditions. Neutral Detergent Fiber (NDF) is used to predict intake because it's slowly digested and part of the diet that fills the rumen and signals the animal to quit feeding. Acid Detergent Fiber (ADF) predicts digestibility, as it represents the very slowly digested fiber that is tolerant to strong acids. Total Digestible Nutrients (TDN) is calculated using ADF and represents feed energy. Relative Feed Value (RFV) provides a single value to describe forage quality, and has become a common tool for determining overall hay quality (intake and energy value). Forage grade alfalfa hay can be categorized into 5 major grades: Supreme, Premium, Good, Fair, and Poor. Addendum 1 provides quality standards for RFV, with the higher the RFV the more digestible and palatable the feed.

The objective of this research project was to generate yield and quality data for pre-release and recently released alfalfa varieties under central Oregon and conditions. Two industry standard varieties, Vernal and Plumas, were included with the conventional varieties for comparison. This timely information provides alfalfa seed companies, field consultants, hay growers and the agricultural community-at-large with data important to decision-making in central Oregon and eastern Oregon.

Materials & Methods

2011-2012 Season:
This alfalfa variety evaluation was established at Central Oregon Agricultural Research Center (COARC) near Madras, Oregon. Based on soil samples prior to planting, lime was applied at 1 ton/acre on August 23 followed by tilling. Fertilizer was applied at 150 lbs/acre of Mesz (or hydropyl) 12-40-0-10 with 1% zinc on August 25, 2011.

Ten conventional and seven Roundup Ready® alfalfa cultivars were planted August 31, 2011. Conventional and Roundup Ready® cultivars were placed in separate side-by side trials, with a 60-ft border between. The entries were planted in 5 ft by 20 ft plots in a randomized block design, replicated 4 times. Planting rate was 25 lbs/acre of pure live seed, with an Oyjord plot drill on 8-inch row spacing. All seed was inoculated with Nitragin AB® prior to planting. No fungicides treatments were added to seed, although some varieties were coated by the provider.

Due to light weed pressure following planting, no herbicides were applied to the conventional trial. The Roundup Ready® trial was sprayed with Roundup PowerMAX® at 44oz/acre with a non-ionic surfactant at 4 pts/100gal on October 12, 2011 per label recommendation.

2013 Season:
The conventional trial was sprayed with Velpar® Alfamax™ at 1.75 lbs/acre, Firestorm® at 1.25 pts/acre, Hellfire® at 10 oz/acre, and non-ionic surfactant at 2 pts/100 gal on February 18, 2013 The Roundup Ready® trial was sprayed with Roundup PowerMAX® at 44oz/acre plus Quest® at 2 pts/100 gal on April 3, 2013 per label recommendation.

2014 Season:
The conventional trial was sprayed on February 26 and the Roundup Ready® trial was sprayed on April 7 with the same products used in 2013. Based on a soil sample during the fall of 2013, fertilizer was applied to the plot area on March 24, 2014 at the rate of 100 lbs of 11-52 for N and P and 150 lbs potash for K, 300 lbs gypsum, 0.5 lb boron and 0.5 lb zinc per acre.

2015 Season:
In this final year both the conventional and Roundup Ready® portions of the trial was sprayed on February 11 with the conventional herbicide treatment used previous years across both the conventional and Roundup Ready® portions of the trial to clean up the entire plot area in the final year of production.

Irrigation:
The plot area is irrigated using solid-set sprinklers (9/64-inch Rainbird nozzles) on a 30-ft by 40-ft spacing. Configuration of the sprinklers included every other line being off-set to provide a more uniform application. The off-sets were rotated following each cutting, with the initial half-length of pipe on every other line moving to the adjacent line that had been a full-length pipe.

Harvest:
Plots were harvested four times throughout the growing season during early June, early to mid-July, early to mid-August and early to mid-October. Seventeen foot plots, after cutting 3 ft

alleyways, were harvested using a small-plot, forage harvester. After each of the four harvests, the trial area was swathed, dried for 4 days, baled and hay removed to simulate grower practice.

Sample Processing:
Total fresh weight was taken in the field, with subsamples placed into a paper bag, weighed, and dried at 145°F until no further change in weight occurred. Fresh weight yields were adjusted to represent oven-dry weights based on sub-sample weight change due to drying. Dried samples were ground using a Wiley mill, and sub-samples from all four replications combined for analysis by Dairy One Forage Testing Laboratory in Ithaca, New York.

Initial Stand Establishment and Stand Longevity:
Percent stand establishment was visually rated as percent green in the rows on September 15, 2011, 15 days after planting and 10 days after emergence. After the final harvest on October 19, 2015 the number of plants present compared to a full stand with no skips was visually rated as percent stand.

Results and Discussion

Yield Data: Yearly total yields averaged across varieties increased each of the four years for both conventional and Roundup Ready® varieties (Table 1). Yield increases in the third and fourth years are likely the result of a warmer than normal third production year followed by an unusually warm fourth production year. Across seasons, first cutting yields were highest followed by the second cutting, with third and fourth cutting providing similar, lower yields. Specific varietal performances averaged across the four years range from 8.5 to 11.0 ton/acre for conventional varieties and 9.7 to 10.6 tons/acre for Roundup Ready® varieties (Table 2).

Quality Data: Average Relative Feed Value (RFV), an indicator of feed quality, averaged across varieties for each cutting across the four years saw increasing quality over the growing season for both conventional and Roundup Ready® varieties (Table 3). Varietal average RFV ratings by year across the four-cut season ranged from 145 to 155 for conventional varieties and 151 to 160 for Roundup Ready® varieties. These ratings are largely within the Premium quality rating (Addendum 1).

Stand Establishment and Longevity: Initial stand establishment ranged from 86% to 100% for both conventional and Roundup Ready® varieties. Stand counts at the end of the trial ranged from 84% to 95% for conventional varieties and 89% to 95% for Roundup Ready® varieties.

Summary Information: Alfalfa varietal yield and quality data provided by this research project conducted at the Central Oregon Agricultural Research Center in Madras provides valuable information to assist, seed companies, fieldmen and growers in making decisions related to optimizing alfalfa production and enhancing the economic benefit throughout the region. Our thanks to alfalfa seed companies and industry representatives directly involved in this project.

Information related to fall dormancy, winter survival index, pest resistance, and other agronomic ratings for conventional and Roundup Ready® alfalfa varieties included in this performance evaluation is provided in Addendums 2 and 3.

Table 1. Average yields for conventional and Roundup Ready® varieties by cutting across four years of hay production, Madras, OR, 2012-2015.

Variety	1st Cutting Yield	2nd Cutting Yield	3rd Cutting Yield	4th Cutting Yield	Yearly Total Yield
	- - - - - - - - - -	- - - - - - - - - -	(tons/acre)	- - - - - - - - - -	- - - - - - - - - -
Conventional					
2012	3.1	1.8	1.7	1.7	8.5
2013	3.2	2.0	2.0	1.4	8.6
2014	3.8	2.6	2.4	1.8	10.6
2015	4.1	3.2	2.3	3.2	12.8
Average	*3.6*	*2.4*	*2.1*	*2.0*	*10.1*
Roundup Ready®					
2012	3.1	1.8	1.7	1.8	8.4
2013	3.5	2.5	1.8	1.5	9.4
2014	3.4	2.8	2.3	1.8	10.3
2015	3.9	3.2	2.3	3.2	12.6
Average	*3.5*	*2.6*	*2.0*	*2.1*	*10.2*

Table 2. Annual total yield by alfalfa variety across four years of hay production, Madras, OR, 2012-2015.

Variety	2012	2013	2014	2015	4 Year Aver.
Conventional	- - - - - - - - - -	- - - - - - - - - -	(ton/acre)	- - - - - - - - - -	- - - - - - - - - -
WL 354HQ	9.0	8.8	11.8	14.4	11.0
6422Q	8.4	8.8	11.6	13.1	10.5
Pioneer 54V09	8.9	9.3	11.3	12.3	10.5
Mountaineer 2.0	8.8	8.7	11.3	12.6	10.4
Pioneer 54Q25	8.1	8.7	10.9	14.0	10.4
445NT	8.8	8.8	11.0	12.5	10.3
WL 363HQ	8.6	8.5	11.1	12.6	10.2
Plumas	8.4	8.4	10.6	12.8	10.1
Integra 8420	7.9	8.3	10.7	12.7	9.9
Vernal	7.6	7.2	8.5	10.5	8.5
Average	*8.5*	*8.6*	*10.9*	*12.8*	*10.2*
Roundup Ready®					
Ameristand 415NT-RR	8.5	9.3	11.7	13.0	10.6
DKA 43-22RR	8.3	9.3	11.0	13.4	10.5
Pioneer 54R014	8.4	9.5	10.6	12.4	10.2
4R200	8.4	9.1	10.4	12.6	10.1
RR Nemastar	8.5	9.6	9.9	12.4	10.1
433TRR	8.4	9.4	9.7	12.2	9.9
Integra 8444 RR	8.0	9.2	9.7	11.9	9.7
Average	*8.4*	*9.3*	*10.4*	*12.6*	*10.2*

Table 3. Average Relative Feed Value (RFV) ratings for conventional and Roundup Ready® varieties by cutting across four years of hay production, Madras, OR, 2012-2015.

Variety	1st Cutting Yield	2nd Cutting Yield	3rd Cutting Yield	4th Cutting Yield	Yearly Aver.
	- - - - - - - - - - -	- - - - - - - - - - -	(% dry matter)	- - - - - - - - - - -	- - - - - - - - - - -
Conventional					
2012	135	137	155	184	153
2013	138	140	149	173	150
2014	140	143	142	179	151
2015	146	139	156	174	154
Average	*140*	*140*	*151*	*178*	*152*
Roundup Ready®					
2012	139	150	162	188	160
2013	135	143	153	180	153
2014	145	141	137	182	151
2015	159	144	157	165	156
Average	145	145	152	179	155

Table 4. Annual average Relative Feed Value (RFV) ratings by alfalfa variety across four years of hay production, Madras, OR, 2012-2015.

Variety	2012	2013	2014	2015	4 Year Aver.
Conventional	- - - - - - - - - - -	- - - - - - - - - - -	(% dry matter)	- - - - - - - - - - -	- - - - - - - - - - -
WL 354HQ	153	151	153	161	155
6422Q	156	148	154	157	154
Integra 8420	158	149	150	158	154
Plumas	155	154	151	152	153
WL 363HQ	156	149	156	152	153
Pioneer 54Q25	152	152	145	157	152
445NT	150	148	160	147	151
Vernal	148	155	149	151	151
Pioneer 54V09	151	145	148	156	150
Mountaineer 2.0	145	149	144	140	145
Average	*152*	*150*	*151*	*153*	*152*
Roundup Ready®					
433TRR	165	158	155	162	160
Integra 8444 RR	163	156	153	158	158
Pioneer 54R014	160	151	152	160	156
4R200	159	151	154	156	155
RR Nemastar	164	154	151	148	154
DKA 43-22RR	156	150	150	154	153
Ameristand 415NT-RR	151	152	145	154	151
Average	*160*	*153*	*151*	*156*	*155*

Table 5. Initial stand establishment on September 15, 2011 and stand longevity ratings on October 19, 2015 based on a visual evaluation of percent stand.

Variety	Stand Count Following Planting	Stand Count at Final Harvest	Change in Stand Count
Conventional	- - - - - - - - - - - - - - - -	(%) - - - - - - - - - - - - - - - -	
Pioneer 54V09	100	95	-5
Plumas	100	94	-6
Pioneer 54Q25	100	93	-7
WL 354HQ	95	91	-4
Mountaineer 2.0	89	90	+1
Integra 8420	86	89	+3
WL 363HQ	93	89	-4
6422Q	89	88	-1
Vernal	90	86	-4
445NT	92	84	-8
Average	*93*	*90*	*-3*
Roundup Ready®			
DKA 43-22RR	86	95	+9
Pioneer 54R014	89	94	+5
4R200	100	93	-7
Integra 8444 RR	95	91	-4
RR Nemastar	92	91	-1
433TRR	93	89	-4
Ameristand 415NT-RR	89	89	0
Average	*92*	*92*	*0*

Acknowledgements

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Addendum 1. Relative Feed Value (RFV) grading criteria used for determining forage quality.

Forage Grade and Description	If the ADF is:	If the NDF is:	Then the Relative Feed Value is:
1 Supreme	Under 30	Under 40	Over 180
2 Premium	31-35	41-45	151-180
3 Good	36-40	47-53	126-150
4 Fair	41-42	54-60	101-125
5 Poor	43-45	61-65	Under 100

Addendum 2. Fall dormancy, winter survival index, pest resistance, and other agronomic ratings for the conventional alfalfa varieties.

Variety	FD[1]	WSI[2]	BW[3]	VW	FW	Anth1	PRR	SAA	PA	SN	APH1	APH2	NRKN	MFE	Tech
6422Q	4	1	HR	HR	HR	HR	HR		R	R	HR			H	C
WL 363HQ	5	1	HR	HR	HR	HR	HR		HR	HR	HR		HR	H	C
WL 354HQ	4	1	HR	HR	HR	HR	HR	HR	HR	R	HR	HR		H	C
445NT	4		HR	R	HR	HR	HR	HR	R	HR	R		HR	M	C
Integra 8420															
Mountaineer 2.0	5	2	HR	R	HR	HR	HR	R	HR	HR	R		R	H	C
Pioneer 54V09	4		HR	HR	R	HR	HR	R	HR	HR	R	MR	HR		C
Pioneer 54Q25	4		HR	HR	HR	HR	HR	R	R	HR	R		HR		C
Vernal	2		R		MR								MR		C
Plumas	4	2	HR	R	HR	HR	HR	R	R	HR	HR		R	H	C

Addendum 3. Fall dormancy, winter survival index, pest resistance, and other ratings for the Roundup Ready alfalfa varieties.

Variety	FD[1]	WSI[2]	BW[3]	VW	FW	Anth1	PRR	SAA	PA	BAA	SN	APH1	NRKN	MFE	Tech
Ameristand 415NT-RR															R
433TRR	3	2.5	HR	R	R	HR	HR		R			HR			R
Integra 8444 RR															R
RR Nemastar															R
DKA 43-22RR	4	2	HR	HR	HR	HR	HR				HR	HR	R	H	R
Pioneer 54R01	4	2	HR	HR	HR	HR	HR	R	R		R	HR	R	H	R
4R200	4	2	HR	HR	HR	HR	HR	MR	R	MR	HR	HR	R	H	R

FD = Fall Dormancy[1], WSI = Winter Survival Index[2], BW = Bacterial Wilt, VW = Verticillium Wilt, FW = Fusarium Wilt, Anth1 = Anthracnose Race 1,
PRR = Phytopthora Root Rot, SAA = Spotted Alfalfa Aphid, PA = Pea Aphid, BAA = Blue Alfalfa Aphid, SN = Stem Nematode, APH1 = Aphanomycese Race 1, APH2 = Aphanomycese Race 2, NRKN = Northern Root Knot Nematode, MFE = Multi-Foliate Expression
CGT = Continuous Grazing Tolerance, SE = Standability Expression, ST = Salt Tolerance (G – germination, F – forage), Tech = Technology (C – conventional, H – Hyrbrid, R – Roundup Ready)
[1]Fall Dormancy Rating: 1 = most dormant to 11 = least dormant
[2]Winter Survival Index: 1 = Superior, 2 = Very Good, 3 = Good, 4 = Moderate, 5 = Low, and 6 = Non-Winter Hardy
[3]Resistance Ratings: S = susceptible, LR = low resistance, MR = moderate resistance, R = resistance, HR = high resistance , MR = moderate resistance, R = resistance, HR = high resistance

Evaluation of New Fungicide Seed Treatment Pre-Mixes for Penicillium Dry Rot Control in Soft White Winter Wheat

Jeremiah Dung, Jeness Scott, and Joshua Adkins

Introduction

Penicillium dry rot of wheat (also known as Penicillium dry seed decay) occurs when wheat seed is planted into soils that are too dry to allow for timely germination of the seed. This is often done in semi-arid production regions with the expectation that precipitation will follow planting and stimulate seed germination. However, if precipitation does not occur in a timely manner the wheat seed may remain in dry soils for extended periods prior to germination and, as a result, *Penicillium* spp. can infect the seed and prevent it from germinating. The objectives of this study were to: i) determine the efficacy of experimental seed treatment EXP102 alone and in combinations with other Penicillium dry rot-effective products; and ii) evaluate each seed treatment product for negative effects on wheat germination and growth.

Materials and Methods

Greenhouse Trial

The *Penicillium* isolate (Pen-5) used in this study was obtained by incubating seed of soft white winter wheat cv. 'Stephens' in petri plates filled with autoclaved soil under conditions conducive for Penicillium dry rot (~8% soil moisture at 70°F in the dark). Pathogenicity of isolate Pen-5 was tested in a preliminary petri plate assay and it was observed to cause more dry rot on 'Stephens' than the other isolates tested.

Seed germination flats (length: 21 in; width: 15 in; depth: 2.5 in) were filled with dry, pasteurized field soil. Each treatment consisted of 20 seeds of soft white winter wheat cv. 'SY Ovation' that were treated with experimental seed treatments by Syngenta prior to planting (Table 1). Seeds were covered with 35 g of *Penicillium*-infested soil (equal to approximately 2 g of *Penicillium* spores/treatment). A non-treated, non-infested control and a non-treated, infested control were also included. The non-treated, non-infested control treatment was covered with 35 g of pasteurized soil. All seeds were covered with an additional 2 cm of pasteurized soil and moistened with water to a depth of approximately 1 in. After 14 days the flats were thoroughly watered to promote seed germination. Each treatment was replicated 4 times and the experiment was arranged as a randomized complete block design.

Treatments were assessed 7 days after germination (DAG) for stand count, crop growth stage (Feekes scale), plant height, number of leaves, % crop phytotoxicity (0% = no injury; 100% = dead plants), and % pre-emergence damping off (% of non-germinated seeds exhibiting Penicillium dry rot). At 21 DAG, treatments were assessed for stand count, crop growth stage, plant height, number of leaves, % crop phytotoxicity, fresh weight, and % post-emergence seed decay (% of plants with *Penicillium* sporulation on the germinated seed).

Petri Plate Assay
A petri plate assay was also performed to test the same seed treatments for Penicillium dry rot control under controlled conditions in the laboratory. Each experimental unit consisted of a petri plate with 20 treated seeds and each treatment was replicated 4 times. A non-treated, non-infested control and a non-treated, infested control were also included as described above. Approximately 25 g of autoclaved soil was added to each petri plate and 20 seeds/treatment were placed on the soil with the crease side facing up. Two grams of *Penicillium*-infested soil (isolate Pen-5) was sprinkled over the seeds (~125 mg of spores/plate) and an additional 10 g of autoclaved soil was added to cover the seed completely. Sterile water was sprayed onto each plate using a hand sprayer to achieve a soil moisture level of 8.1% (v/w). Plates were placed in a 68° F incubator and the experiment was arranged as a randomized complete block design. After 18 days of incubation the seeds were assessed for % pre-emergence damping off (% of seeds exhibiting Penicillium dry rot). All seed was then placed in a petri plate lined with sterile Whatman filter paper, moistened with sterile water, and assessed for % germination.

Data analysis
Data from both trials were analyzed as randomized complete block designs. Analysis of variance (ANOVA) was performed using PROC MIXED in SAS version 9.4 and multiple pairwise comparisons were made using Tukey's test.

Results and Discussion

Greenhouse Trial
All treatments exhibited germination rates of 85% or more and pre-emergence damping-off was not observed at 7 DAG (Table 1). A significant effect on plant height ($P = 0.0006$) and leaf number ($P = 0.002$) was observed, with treatment EXP108+EXP109 exhibiting reduced plant height and leaf number. Significant effects on stand count or growth stage were not observed ($P > 0.05$). The high germination rates and lack of pre-emergence damping off at 7 DAG may have been a result of sufficient moisture content in the flats that promoted seed germination and prevented dry seed decay.

At 21 DAG, phytotoxicity was observed in two plants grown from seed treated with EXP112; the phytotoxicity symptoms consisted of chlorotic, twisting leaves. Treatment EXP108+EXP109 exhibited significantly lower plant height ($P = 0.04$) than the non-treated, non-infested control treatment (Table 2). Significant effects on stand count, growth stage, leaf number, or fresh weight were not observed ($P > 0.05$) at 21 DAG. However, *Penicillium* was observed sporulating on some of the germinated seed (post-emergence seed rot) when plants were removed from the soil. All treatments exhibited significantly ($P < 0.05$) lower levels of post-emergence seed rot than the non-treated, infested control and several treatments, including EXP101, EXP102, EXP102+EXP103, EXP102+EXP104, EXP101+EXP104, EXP110, and EXP102+EXP111, were not significantly different ($P > 0.05$) than the non-treated, non-infested control (Table 2).

Petri Plate Assay
A significant treatment effect ($P < 0.0001$) was observed on pre-emergence damping off and germination in the petri plate assay. All treatments significantly reduced pre-emergence damping off compared to the non-treated, infested control (Table 3). Treatments EXP102,

EXP102+EXP103, EXP102+EXP104, EXP101+EXP104, EXP106, and EXP102+EXP111 exhibited dry rot at levels that were equal to or less than the non-infested control. Treatments EXP102+EXP103, EXP102+EXP104, EXP101+EXP104 completely prevented pre-emergence damping off. The highest germination rates were observed in treatments EXP101+EXP104 (95.0%), EXP102+EXP104 (93.8%), EXP106 (88.8%), and EXP102+EXP111 (81.3%) (Table 3).

Conclusions

All of the seed treatments, including experimental seed treatment EXP102 alone and in combination with other seed treatments, significantly reduced post-emergence seed rot in the greenhouse assay and significantly reduced pre-emergence dry rot in the petri plate assay. Treatments that combined EXP102 with other seed treatments were the most effective. Relatively few negative effects (e.g. phytotoxicity, reduced germination or stand count, reduced plant height or fresh biomass) were observed in both studies. The results from this study indicate that seed treatments can be very effective at controlling Penicillium dry rot in soft white winter wheat.

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Table 1. Phytotoxicity, stand count, Feekes growth stage, plant height, number of leaves, and pre-emergence damping off of winter wheat cv. 'Ovation SY' seed that was treated with fungicides to prevent Penicillium dry rot (7 days after germination)[1]

	7 days after germination					
Treatment	**Phytotoxicity (%)**	**Stand count**	**Feekes growth stage**	**Height (cm)**	**No. leaves**	**Pre-emergence damping-off (%)**
Non-infested control	0	19.0	1	9.0 a	2.0 a	0
Infested control	0	18.0	1	7.7 ab	1.7 ab	0
EXP101	0	17.8	1	8.2 a	2.0 ab	0
EXP102	0	18.0	1	8.5 a	1.9 ab	0
EXP102+EXP103	0	19.0	1	8.0 a	1.9 ab	0
EXP102+EXP104	0	17.0	1	8.2 a	1.9 ab	0
EXP101+EXP104	0	18.8	1	7.9 a	2.0 a	0
EXP106	0	18.8	1	7.3 ab	2.0 ab	0
EXP107	0	19.5	1	9.3 a	2.0 ab	0
EXP108+EXP109	0	17.0	1	5.3 b	1.6 b	0
EXP110	0	18.3	1	7.2 ab	1.7 ab	0
EXP102+EXP111	0	18.3	1	7.8 a	1.9 ab	0
EXP112	0	17.5	1	7.4 ab	1.7 ab	0
***P*-value**	1.00	0.49	1.00	0.0006	0.002	1.00

[1] Treatments followed by the same letter are not significantly different from each other using Tukey's test at $P = 0.05$.

Table 2. Phytotoxicity, stand count, Feekes growth stage, plant height, number of leaves, fresh weight and post-emergence seed rot of winter wheat cv. 'Ovation SY' seed that was treated with fungicides to prevent Penicillium dry rot (21 days after germination)[1]

	21 days after germination						
Treatment	**Phytotoxicity (%)**	**Stand count**	**Feekes growth stage**	**Height (cm)**	**No. leaves**	**Fresh weight (g)**	**Post-emergence seed rot (%)**
Non-infested control	0	19.0	2.1	23.0 a	5.5	0.72	0.0 e
Infested control	0	18.5	1.6	21.6 ab	4.0	0.51	74.4 a
EXP101	0	18.5	1.8	21.0 ab	4.5	0.56	18.9 bcde
EXP102	0	18.0	1.5	20.4 ab	4.0	0.51	9.4 bcde
EXP102+EXP103	0	19.3	1.6	20.1 ab	4.0	0.48	5.3 cde
EXP102+EXP104	0	18.0	1.9	20.1 ab	4.5	0.53	1.6 e
EXP101+EXP104	0	19.5	1.8	19.6 ab	4.3	0.49	2.6 de
EXP106	0	19.5	2.4	19.1 ab	5.5	0.59	25.6 bcd
EXP107	0	19.5	1.6	20.0 ab	4.5	0.51	31.5 b
EXP108+EXP109	0	17.8	1.6	15.8 b	4.8	0.51	28.5 bc
EXP110	0	18.8	1.6	17.0 ab	4.5	0.48	10.7 bcde
EXP102+EXP111	0	18.3	1.6	20.6 ab	4.5	0.56	6.9 cde
EXP112	2.5[2]	17.8	1.8	20.5 ab	4.5	0.46	26.3 bc
***P*-value**	0.47	0.27	0.64	0.04	0.30	0.56	<0.0001

[1] Treatments followed by the same letter are not significantly different from each other using Tukey's test at $P = 0.05$.
[2] Chlorosis and twisting of leaves observed in two plants.

Table 3. Pre-emergence damping off and germination of winter wheat cv. ‘Ovation SY’ seed that was treated with fungicides to prevent Penicillium dry rot[1]

Treatment	Dry rot (%)	Germination (%)
Non-infested control	8.8 d	66.3 abc
Infested control	82.5 a	5.0 f
EXP101	21.3 cd	53.8 bcd
EXP102	8.8 d	62.5 abc
EXP102+EXP103	0.0 d	75.0 ab
EXP102+EXP104	0.0 d	93.8 a
EXP101+EXP104	0.0 d	95.0 a
EXP106	1.3 d	88.8 a
EXP107	40.0 c	21.3 def
EXP108+EXP109	45.0 bc	15.0 ef
EXP110	28.8 cd	45.0 cde
EXP102+EXP111	1.3 d	81.3 ab
EXP112	23.8 cd	50.0 bcd
***P*-value**	<0.0001	<0.0001

[1] Treatments followed by the same letter are not significantly different from each other using Tukey’s test at $P = 0.05$.

Pilot Balloon Observations, 2015
Jefferson County Smoke Management

Linda Samsel and Carol Tollefson

Abstract

Pilot Balloon (PIBAL) observations are a major component of the daily decision-making process used in managing open field burning of grass seed and wheat fields in Jefferson County. PIBALs are used to track upper level wind direction and speed and are released daily during burning season at the Central Oregon Agricultural Research Center between 10:30 am and 3:30 pm. In addition, releases at potential burn sites also occur to allow more accurate decision making under marginal conditions. The PIBAL is essential to minimizing adverse smoke impacts on local communities.

Introduction

The PIBAL program began in 1998, and incorporates weather balloon data with information received from the Oregon Department of Agriculture (ODA) Weather Center. PIBAL data compiled with Real-Time Weather Data, courtesy of the US Bureau of Reclamation AgriMet Network, can be found on the Jefferson County Smoke Management website. The objective is to provide the Jefferson County Smoke Management Coordinator with real time wind patterns, wind speed and wind direction information to ensure decisions are being made with the most complete and accurate information available.

Materials and Methods

The 2015 nine-week field burning season began July 27th and continued through September 25th. Daily balloon releases occurred on demand throughout the day during this period. The release times and locations were requested by the Smoke Management Coordinator. Air temperature, relative humidity, and surface wind direction and speed are documented at the time of the PIBAL release using the AgriMet weather station at the Central Oregon Agricultural Research Center. Wind directions and speeds are determined at one-minute intervals for a period of ten-minutes using an observation Theodolite System and a twenty-six inch diameter helium filled balloon (PIBAL). The PIBAL is used to verify the forecast for the upper level wind direction, speed and mixing height. PIBAL Analyzer, a software program developed by the Oregon Department of Agriculture (ODA), analyzes PIBAL information which includes three components. 1) The PIBAL Sounding, a spreadsheet translating the azimuth (azimuth are angles used to define the apparent position of an object in the sky, relative to a specific observation point) and elevation readings from the wind direction and average wind speed; 2) the Hodograph, which charts the wind direction; 3) the Profile page, graphs the wind speed. PIBAL soundings are entered into the PIBAL Analyzer and transmitted to the Jefferson County Smoke Management website for use by the Smoke Management Program Coordinator. The Coordinator then uses this data in conjunction with the daily aircraft soundings and the ODA Weather Center forecast to determine field burning status for the day.

Results and Discussion

During the open field-burning season farmers burned a total of 7,680 acres, this included 5,135 acres of grass and 2,545 acres of wheat. There were 1,880 less acres burned than in 2014. This variance included an increase of 235 acres of grass burned and a decrease of 2,115 acres of wheat burned than in 2014. The 2015 burn season was unusual in that wheat fields were harvested slightly earlier than average causing more acres to be ready to burn during the first two weeks of the season.

Daily balloon releases in late morning and throughout the day were used to refine weather forecasts. The PIBAL provided the only method to detect the stable air layers and was a valuable tool for determining the mixing height for smoke during the optimal burn times. It was also particularly helpful on marginal burn days to assist the Smoke Management Coordinator in making decisions when conditions were either changing or hard to discern. It is on marginal days when conditions are unclear; the most exists for smoke intrusion into populated areas. In addition, using the PIBAL at the site of the potential burn prior to making the final decision has proved to be a valuable tool again during the 2015 season.

COARC Research Garden & Learning Center and Agricultural Education Outreach, 2015

Carol Tollefson, Linda Samsel, Katie Ralls

Abstract

The Central Oregon Agricultural Research and Learning Center is an ongoing project in its 9th year of activity. The garden provides a hands-on teaching location for local outreach, community programs, and K-12 science field trips. In addition to local programming, the garden provides an opportunity for local OSU Master Gardeners to work and provide services to the local community.

Introduction

The Central Oregon Agricultural Research Garden and Learning Center was established in 2008 on a half-acre parcel of land located at the entrance to the Central Oregon Agricultural Research Center (COARC). The garden provides an opportunity for COARC and Central Oregon Extension programming to extend services and opportunities to the local community in addition to the agricultural community. The garden includes woody ornamental, herbaceous perennials, ornamental grasses, fruit trees and raised garden beds. Garden signs throughout the garden display specific plant species and other information, including: common name, botanical name, plant height, width, water usage and sun/shade needs.

Events and Activities

Seeds of Science
As part of an ongoing partnership with the Jefferson County School District and Oregon Open Campus, COARC hosted over 400 fifth-grade students from the Jefferson County 509J and Culver School Districts, as well as a large Central Oregon Homeschool Group. Students were provided opportunities to learn about Honey Bees and the importance of pollinators in agriculture, Soil and Nutrients, Plant Pathology, Animal Science and Forests and Ecosystems, at individual teaching stations located in the garden. In addition, students participated in planting a vegetable garden. Staff at COARC maintained and harvested the vegetable garden, donating over 400 pounds of vegetables grown to local charities.

Pruning Class
During spring of 2015, COARC hosted a two and a half hour pruning class. The class consisted of one hour of classroom instruction and one and a half hours of hands instruction in the garden. In the classroom section, participants learned why and when they should prune along with basic pruning principles. During the hands on section, participants split into small groups and actively pruned and observed pruning techniques for ornamental trees and fruit trees along with berries, shrubs and low growing plants under the guidance of Master Gardeners and COARC staff.

Corn & Pumpkin Patch
COARC staff planted a half-acre pumpkin and corn patch to enhance community learning and outreach opportunities. In the fall of 2015, Jefferson County 4-H held their first annual kick-off party at COARC in the learning garden and all youth attending had the opportunity to choose a Halloween pumpkin to take home. In addition to 4-H, multiple groups of youth, including the Little Red Schoolhouse Preschool, had the opportunity to visit COARC for learning opportunities and to pick a pumpkin. Leftover pumpkins were donated to local food bank groups.

Kids Club
COARC hosted Jefferson County Kids Club summer agricultural camp participants for a field trip. During the fieldtrip, COARC staff presented information about the research center, agriculture equipment, worms and composting, the on-site weather station and honeybees. In addition to the summer camp, COARC faculty offered a garden club on-site at Kids Club to present children hand-on learning opportunities with an agricultural basis.

COARC Summer Science Academy
In 2015, COARC hosted their first annual Summer Science Academy. The academy was open to youth entering grades 6-8 from across central Oregon. Youth applied to the academy by completing an application and essay. Faculty from OSU Extension and the Research Center lead daily activities each day covering different topic areas including: plant pathology, soil science, local farms and bees, animals and rangeland and local agribusinesses. The 2015 academy hosted six students.

Master Gardeners
The Central Oregon Master Gardener program serves Crook, Deschutes and Jefferson Counties. This gives Jefferson County the benefits associated with a tri-county Master Gardener Program, including increased participation from Master Gardeners from outside Jefferson County. The Master Gardener Program is a voluntary, educational program which trains volunteers in the basics of designed botany and entomology; integrated pest management and pesticide safety; soils, fertilizers and composting; ornamental, herbaceous plants and woody plants; vegetable, indoor and container gardening; sustainable landscaping; and plant pathology.

Master Gardeners are available at the Central Oregon Agricultural Research Center weekly throughout the spring and summer months. Volunteers are available to provide informational and technical assistance and to answer questions from the local community in gardening and horticulture. Additionally, volunteers identify insects and diseases based upon sample submissions from the community. For those interested in volunteering or for more information about the Master Gardener program, more information is available at:
http://extension.oregonstate.edu/deschutes/horticulture/mg

Future Plans

Goals

During 2016, COARC will continue to develop the Central Oregon Agricultural Research Garden and Learning Center as an outdoor laboratory to engage in teaching, research and conservation. COARC plans to offer two gardening classes and will host two field trips during 2016, including the Seeds of Science field trip which is planned for expansion to Metolius and Warm Springs schools and to additional home-school groups. In addition, during 2016 COARC will continue to partner with the Jefferson County Kids Club to continue educational offerings on-site and at the Jefferson County Fairgrounds Garden. This will allow youth to learn about local and regional agriculture along with gardening and the inputs that go into both. The garden will continue to provide educational opportunities for the public through hands on learning, exhibits and classes in addition to other agriculture and gardening experiences.