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The Central Oregon Agricultural Research Center (COARC) faculty and staff are pleased to present this summary of 2017 research activities for your review. The reports included in this publication represent a snapshot of the research focus in our region by faculty stationed in central Oregon.

Our research center is part of a network of Oregon State University research locations across the state (OAES) which operate under the umbrella of the Statewide Public Service Programs. These programs include OSU Extension, OAES and the Forest Research Laboratory. Currently, we have two faculty researchers working in Plant Pathology and Soil Science at COARC who collaborate with Extension in Deschutes, Crook and Jefferson County at the local level and with other counties statewide to ensure we are addressing the most pressing and important needs today and far into the future. In addition to our research programs, we have active Extension programs in Agriculture Education, Honey Bee and Pollinator Health as well as access to a multitude of other programs and information through the OSU Extension system.

Today, our Plant Pathology program is working toward improved and sustainable management of plant diseases in central Oregon specialty crops. This includes understanding pathogen biology and disease epidemiology, developing tools for disease detection and pathogen identification, disease modeling and forecasting, and developing integrated disease management strategies. In addition, our Soil Science program is working to find ways to manage soils sustainably to ensure the future of central Oregon agriculture. This includes improving soil nutrient management to improve plant health and yields and protecting soil resources through new and improved soil conservation methods.

In the future, we look forward to these strong, active research programs moving COARC to the forefront of innovative research and finding solutions to growing problems in our area such as increased plant disease, insect and weed invasions and finding ways to support honeybees and pollinators.

If you have not had the opportunity to visit COARC in the past or to talk with one of our researchers about their work, we invite you to attend an event or visit our location. Your ideas and involvement are a key component to our success. It is the local community that allows us to continue to provide important research and educational opportunities for central Oregon that are vital to the agricultural community and local economy.

If you have questions or thoughts, you would like to share with me feel free to call (541-460-7680), email me (Carol.Tollefson@oregonstate.edu) or visit COARC in person. Your feedback and comments are appreciated and are helpful as we plan for the upcoming year.

Thank you,

Carol Tollefson, Director
Central Oregon Agricultural Research Center

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Ergot Evaluations of Kentucky Bluegrass Cultivars in Central Oregon, 2015-2017

Jeremiah Dung, Qunkang Cheng, and Kenneth Frost

Introduction

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, 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. 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

Materials and Methods

Plots of Kentucky bluegrass cultivars were established in August of 2014, 2015, and 2016 for ergot evaluations in 2015, 2016, and 2017, respectively. 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 borders of the experiment area was artificially infested in October with ergot sclerotia collected from Kentucky bluegrass seed lots produced in central Oregon.

A Burkard 7-day recording volumetric spore sampler was used to collect airborne ascospores from the experimental areas. The spore sampler was placed in the middle of the plots from April to June of each year 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. Disease incidence (number of infected seed heads) and severity (number of sclerotia) were determined from a random sample of 50 seed heads collected from each plot at harvest. An ergot disease index (EDI) value was calculated by multiplying ergot incidence by ergot severity. EDI data were analyzed using ANOVA and multiple comparisons were made using Fisher's protected LSD test.

Results and Discussion

Significant differences in EDI values were observed among Kentucky bluegrass cultivars in all three years (Table 1). Differences in ergot incidence and severity among years were also observed among cultivars and individual years (Fig. 1). In general, ergot was most severe in 2017 and least severe in 2015.

The first occurrence of ascospores was on May 20, May 1, and May 15 in 2015, 2016, and 2017, respectively. Ascospore production continued for 24 days in 2015, 51 days in 2016, and 44 days in 2017. Ergot incidence and severity was greater in 2017 than 2016 for most cultivars despite the fact that more overall spores were produced in 2016 (3,748 spores) compared to 2017 (2,390) and spore production occurred for 7 days longer. Differences in ergot incidence and severity could potentially be attributed to differences in ergot resistance and/or differences timing of spore production and flowering among the three years (Fig. 2).

Acknowledgements

Funding for this research was provided by the Oregon Seed Council, the Washington Turfgrass Seed Commission, the Columbia Basin Grass Seed Association, and the Union County Grass Seed Growers. The researchers would like to thank the following companies for providing in-kind support: Central Oregon Seeds, Inc., Jacklin Seed, Pratum Co-Op, Pure Seed, and Wilbur-Ellis. The technical support provided by Hoyt Downing, Julia Wilson, and Cara Boucher was greatly appreciated.

Tables and Graphs

Table 1. Ergot disease index values for Kentucky bluegrass cultivars grown in artificially-infested plots at COARC in 2015, 2016, and/or 2017

	Ergot Disease Index			
Cultivar	**2015**	**2016**	**2017**	**Overall**
PST-K4-7	0.5 bc	0.2 c	1.2 b	0.6
Jumpstart	0.1 c	3.5 c	7.2 b	3.6
Geronimo	NT	NT	3.9 b	3.9
Right	0.3 c	4.1 c	11.2 b	5.2
Shamrock	0.5 bc	2.6 c	13.9 b	5.7
Fielder	0.1 c	1.2 c	18.3 b	6.5
DB-1013	1.2 bc	11.7 bc	10.0 b	7.6
Merit	NT	2.1 c	22.0 b	8.8
Blue Ghost	3.8 bc	22.7 b	15.9 b	14.1
Gladstone	4.3 b	6.0 c	35.0 ab	15.1
Crest	NT	NT	17.0 b	17.0
Gateway	1.0 bc	7.1 c	69.9 ab	26.0
Midnight II	9.9 a	48.7 a	45.9 b	34.8
Nuglade	3.6 bc	NT	89.7 ab	46.6
Bluechip	2.3 bc	NT	114.4 a	58.4
Rhythm	NT	NT	166.0 a	166.0
***P*-value**	0.0005	< 0.0001	< 0.0001	NS

[1] Ergot disease index values were calculated by multiplying ergot incidence (number of panicles with ergot) by ergot severity (number of sclerotia in each panicle). A total of 50 panicles were evaluated from each plot.

[2] Means followed by the same letters are not statistically different using Fisher's protected LSD. NT = Not tested.

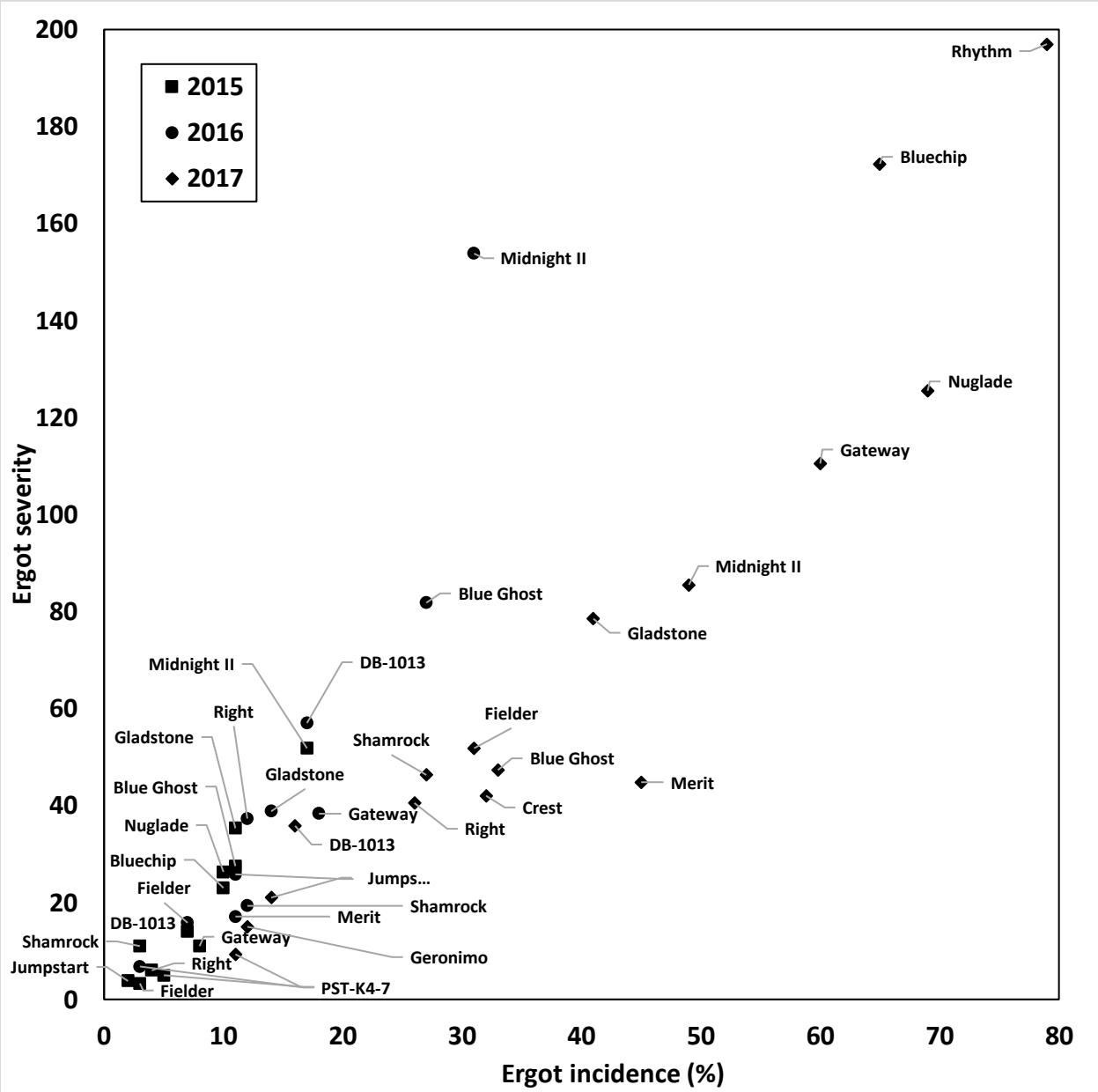

Figure 1. Dot plot of ergot incidence and severity for 16 cultivars grown in artificially infested Kentucky bluegrass plots located at COARC in 2015 (squares), 2016 (circles) and/or 2017 (diamonds).

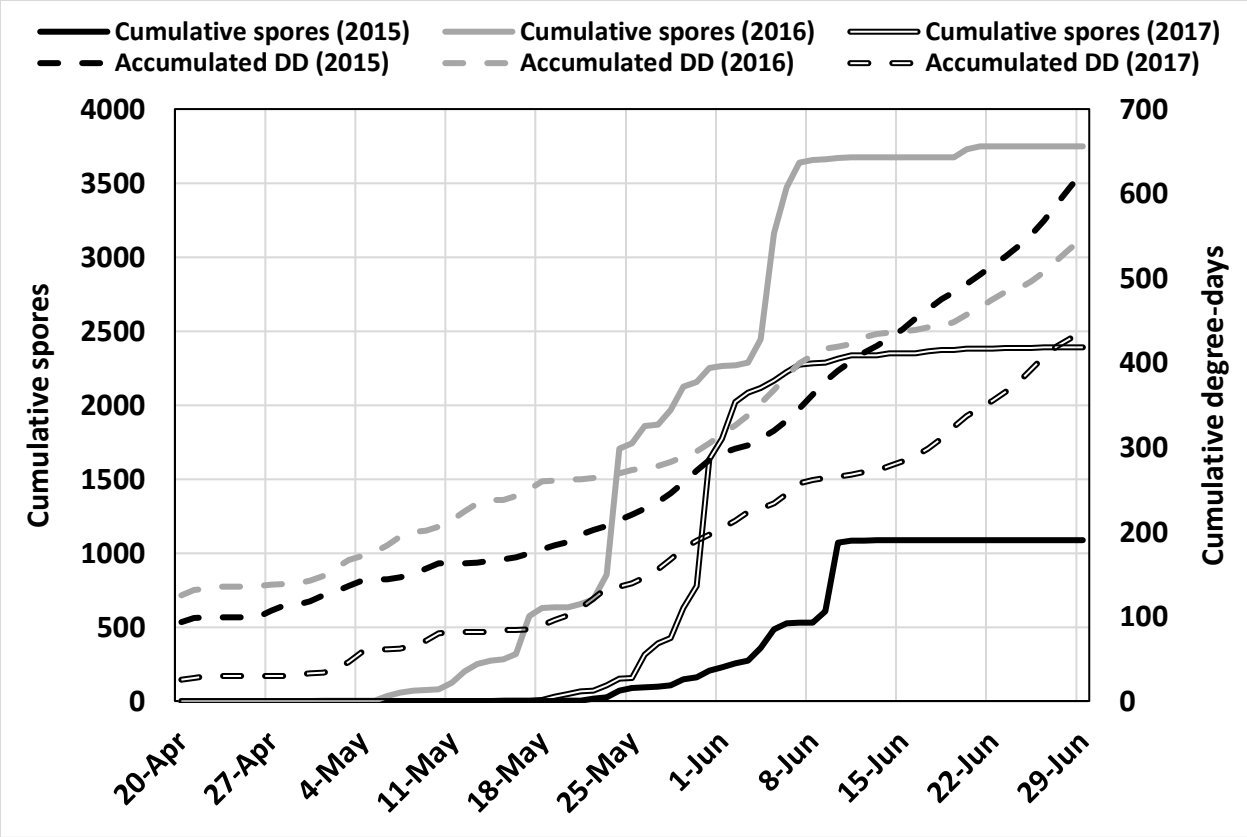

Figure 2. Cumulative ascospore captures in artificially infested Kentucky bluegrass plots located at COARC in 2015 (solid black line), 2016 (solid grey line) and 2017 (solid white line) plotted with accumulated degree-days (DD) in 2015 (dotted black line), 2016 (dotted grey line), and 2017 (dotted white line).

Evaluation of Fungicides for Control of Ergot on Kentucky Bluegrass in Oregon, 2017

Qunkang Cheng, Kenneth Frost, and Jeremiah Dung

Introduction

Fungicides are an important component of an ergot integrated pest management program. However, in many cases multiple fungicide applications do not reduce ergot to acceptable levels at harvest. Additionally, current fungicides labeled for ergot control have similar modes of action (FRAC 3 and/or FRAC 11). Repeated applications of fungicides with similar modes of action may increase the potential for fungicide resistance to develop. The same or similar fungicides may be used for powdery mildew and/or rust in grass seed crops, further increasing the potential for fungicide resistance development in pathogens of grass seed crops. Since only two active ingredients are labeled for ergot control in grass grown for seed, novel fungicide chemistries need to be tested for their ability to protect flowers from infection during anthesis. The objective of this research is to screen novel, unlabeled fungicide chemistries for the ergot control during flowering.

Materials and Methods

A fungicide trial was established at the Central Oregon Agricultural Research Center. Plots (26-ft long by 5-ft wide with 3-ft spacing) of Kentucky bluegrass cultivar 'Shamrock' were established (5 lb seed/A) on August 12, 2016. Plots were artificially infested with *Claviceps purpurea* sclerotia on October 20, 2016. Treatments consisted of a non-treated control and nine fungicide treatments, including an industry standard (Table 1). Fungicides were applied on May 26, 2017 at the beginning of flowering (Feekes stage 10.51) using CO_2-charged spray boom. The boom was outfitted with three TP8002VS flat fan nozzles spaced 18-in. apart and delivered 20 gal/A at 15 psi. The experimental design was a randomized complete block with four replicates.

Random samples of 50 seed-heads were collected from each plot at the end of growing season (July 18, 2017), from which ergot incidence and severity were measured based on the number of seed heads containing sclerotia and the number of sclerotia present in each seed head. An ergot disease index (EDI) was calculated by multiplying incidence and severity. Data were subjected to analysis of variance and treatment means were compared using Tukey's honest significant difference test.

Results and Discussion

Ergot incidence and severity was low among all plots in the trial, limiting the ability to detect significant differences among treatments (Table 1). However, Priaxor® reduced ergot severity in Kentucky bluegrass by over 50% and significantly reduced overall disease ($P = 0.03$). Adepidyn®, Aproach®, Trivapro®, and Luna Privilege® also provided similar ergot control compared to the industry standard, Quilt Xcel® (Table 1). Data collected from field trials over three years suggest Priaxor® is effective at reducing ergot in perennial ryegrass and Kentucky bluegrass seed crops (Kaur et al. 2015).

Acknowledgements

Funding for this research was provided by the Oregon Seed Council, the Washington Turfgrass Seed Commission, the Columbia Basin Grass Seed Association, and the Union County Grass Seed Growers. The researchers would like to thank the following companies for providing in-kind support: BASF, Bayer Crop Science, Central Oregon Seeds, Inc., DuPont, and Syngenta. The technical support provided by Hoyt Downing was greatly appreciated.

References

Kaur, N., Alderman, S.C., Walenta, D.L., Frost, K.E., Dung, J.K.S., and Hamm, P.B. 2015. Evaluation of new fungicide chemistries and application strategies to reduce ergot in grass seed production systems. Pages 23-26 in: 2015 Seed Production Research at Oregon State University USDA-ARS Cooperating. N. Anderson, A. Hulting, D. Walenta, M. Flowers, and C. Sullivan, eds. Oregon State University, Ext/CrS 152.

Tables

Table. 1. Ergot incidence, ergot severity, and ergot disease index (EDI) following treatments with fungicides during anthesis

Treatment and rate (oz/A) [z]	Incidence (%)[y]	Severity[y]	EDI[y]
Control	14.0 a	11.3 a	1.60 ab
Aprovia® EC, 7.7	16.0 a	13.8 a	2.23 a
Propulse® SC, 14.0	13.0 a	9.5 a	1.28 ab
Aproach® 2.08 SC, 12.0	10.0 a	8.0 a	1.04 ab
Luna Privilege® SC 500, 6.8	11.5 a	7.5 a	0.88 ab
Quilt Xcel® SE, 14.0	10.5 a	7.8 a	0.85 ab
Aproach® 2.08 SC, 9.0	8.0 a	7.5 a	0.83 ab
Trivapro® SE, 27.4	9.0 a	5.3 a	0.67 ab
Adepidyn®, 3.8	7.0 a	7.3 a	0.60 ab
Priaxor® SC, 6.0	10.5 a	5.3 a	0.37 b
***P*-value**	**0.08**	**0.16**	**0.03**

[z] All products were applied with Induce®, a nonionic surfactant, at 0.25% v/v.
[y] Column means followed by the same letter are not significantly different at α=0.05 as determined by Tukey's honest significant difference test.

Evaluation of Herbicides for Control of Rough Bluegrass, Downy Brome, Rattail Fescue and Medusahead in Establishment Year and Second Year Kentucky Bluegrass Grown for Seed, 2016-2017

Marvin Butler, Hoyt Downing, Rich Affeldt, Jim Carroll, and Kurt Feigner

Abstract

Adequate weed control during the establishment year of Kentucky bluegrass seed production is a challenge, particularly for grassy weeds in a grass crop. This is a second-year project to evaluate innovative ways to use currently registered products to accomplish this goal, focusing on rough bluegrass, downy brome, rattail fescue and medusahead. Treatments and application timings include Callisto applied pre-emergence between planting and first irrigation, Beacon applied at 0.19 oz/acre, with and without Bronate at 1 pt/acre at the 2-3 leaf and 4-5 leaf stages, and Beacon at 0.38 oz/acre applied during an October/November timing. Visual evaluation of establishment year plots indicates significantly less injury of Kentucky bluegrass when Beacon is applied at 2-3 leaf rather than the 1-2 leaf stage as was done during 2015. Bronate appears to be an effective crop safener when added to Beacon at either 2-3 leaf or 4-5 leaf stages, with similar control of the grassy weeds. There were statistically significant differences in seed yield between Callisto applied pre-irrigation followed by Beacon applied at the 4-5 leaf stage and Oct/Nov and Beacon applied alone or with Bronate at the 2-3 leaf stage and Oct/Nov. There were no significant differences in seed yield between treatments in the second year field.

Potential new herbicides, Fierce, Alion and Sharpen were evaluated in two second-year stands for control of the same four grassy weeds and for crop safety when applied pre-emergence and during October/November.

Introduction

The greatest challenge to weed control in Kentucky bluegrass is during the establishment year. Control of grassy weeds while protecting crop safety is vital to crop establishment and is important to first year production and ongoing profitability. This project is designed to evaluate for a second season the most promising of currently available herbicides in various combinations, application timings and rates to identify a successful strategy. Although there are a variety of grassy weeds, the focus of this project is rough bluegrass (*Poa trivialis*), downy brome (*Bromus tectorum*), rattail fescue (*Vulpia myuros*) and medusahead (*Taeniatherum caput-medusae*).

Secondly, it is important to evaluate potential new herbicides that hold promise for use in Kentucky bluegrass to maintain a strong toolbox of herbicides against these four grassy weeds while providing adequate crop safety.

Methods and Materials

Establishment Year:
Kentucky bluegrass (Shamrock) was planted at 7 lbs/acre on August 22, 2016 with the COARC Great Plains drill into ground rotating out of winter wheat. This was done following open field burning, an initial irrigation and reworking the ground. Rough bluegrass, downy brome, rattail fescue and medusahead seeds were planted at a high infestation rate (rough bluegrass at 1 g/40 ft, rattail fescue at 1.5 g/40 ft, downy brome and medusahead at 3 g/40 ft) with a 5-foot cone planter at 7-inch spacings across 10 x 45 ft plots, replicated 4 times.

Herbicide treatments included Callisto (4 lb/gal of mesotrione) applied pre-emergence at 6 fl oz/acre on August 22 between planting and first irrigation on August 23. Beacon (75% primisulfuron) was applied at 0.19 oz/acre ($1/4^{th}$ label rate) on September 24 at the 2-3 leaf stage and on October 6 at the 4-5 leaf stage. At both application timings Beacon was applied with and without Bronate (2 lb/gal bromoxynil + 2 lb/gal MCPA acid) at 1 pt/acre as a potential safener. In addition, Beacon was applied at a split-application rate of 0.38 oz/acre at the October/November timing on October 24. The labeled rate for Beacon is 0.76 oz/acre, so all treatments left some Beacon in reserve for use later in the fall or spring as needed by managers of production fields.

All treatments were applied using a CO_2 powered, backpack sprayer and 20 gal/water per acre. A non-ionic surfactant at 1 qt/100 gal was added to treatments applied at the 2-3 leaf stage, while crop oil concentrate at 1 gal/100 gal was used with all other post-emergence treatments.

Crop injury and weed control at the COARC location were evaluated October 26 for Callisto applied pre-irrigation and Beacon applied at the 2-3 leaf stage. This evaluation does not account for effects from the October 24 Beacon application. Unfortunately, another weed control rating was not made in spring.

At harvest plots at the COARC location were swathed July 10 using a John Deere 2280. Harvested area was 6 ft by 27 ft. Plots were threshed on July 20 using a Wintersteiger plot combine equipped with a pickup header. Dirt weights were recorded, and bagged samples transported to the USDA seed-conditioning lab in Corvallis for cleaning. Samples were run through a laboratory brush machine, and then transferred to a Westhrup Air screen with 8/64 round top screen and 6x34 mesh bottom screen. Samples then passed through an air column to remove lightweight material prior to recording final clean weights.

2^{nd} YearProduction:
Kentucky bluegrass plots were established in second year stands at COARC (Shamrock) and K&S Farms (Gaelic) to evaluate herbicides. Treatments of Fierce at 3 oz/ac and Alion at 1.5 fl oz were applied pre-emergence on September 7 and post-emergence on November 4. At K&S Farms the plot area was inadvertently sprayed pre-emergence with Outlook at 21 fl oz plus Prowl at 2 pt per acre. Crop injury was visually evaluated on November 7 prior to dormancy and on June 7 at heading. Plots at the K&S Farms location were swathed on July 11 and combined on July 21. Harvested area was Harvest and seed cleaning at this location followed the same protocol described above.

Results and Discussion

Establishment Year:
No crop injury was observed at the COARC plots on October 26 from Callisto applied pre-emergence. An average of 8 percent crop injury was observed following Beacon applied at 0.19 oz/acre at the 2-3 leaf stage (Table 1). This compares with 35 percent injury from Beacon applied at 0.15 oz/acre at the 1-2 leaf stage during the 2015 season. Beacon applied alone caused 13 percent injury of young Kentucky bluegrass, while Beacon plus Bronate caused 5 percent injury. Sharpen, a new product registered on grass seed, was included in establishment year plots to evaluate crop safety and resulted in 8 percent injury.

A different collection of stored downy brome seed was inadvertently used for planting across herbicide plots this season, resulting in a lack of germination and no ratings for this weed species. Based on the October 26 evaluation of Beacon applied at the 2-3 leaf stage, Beacon alone provided 53 percent control of rough bluegrass, 27 percent control of rattail fescue, and 10 percent control of medusahead. The Beacon plus Bronate combination provided similar results, with an average of 54 percent control of rough bluegrass, 27 percent control of rattail fescue, and 18 percent control of medusahead. An evaluation on November 7 indicated that Sharpen provided no control of grassy weeds (data not shown). The best performing treatments for crop safety plus weed efficacy were the three Beacon plus Bronate treatments.

At harvest there were statistical differences between treatments that can be identified by treatments where there is no overlap in the letters (Table 2). Heavy weed pressure in the untreated check resulted in low seed yield. The highest yielding treatment was Callisto pre-emerge followed by 0.19 oz of Beacon at 4-5 leaf stage followed by 0.38 oz of Beacon on Oct-24 (total of 0.57 oz/acre). Waiting until the 4-5 leaf stage is beneficial when applying a total of 0.57 oz/acre of Beacon within this timeframe. However, there were no statistical difference between the traditional Callisto followed by Beacon treatment and Beacon applied at the 2-3 leaf stage and again at the Oct-24 timing for a total of 0.38 oz/acre, with or without Bronate, or with Sharpen applied at the 4-5 leaf stage. The 2-3 leaf timing for Beacon was safest when tank-mixed with Bronate. Also, when following the 2-3 leaf timing with another fall application of Beacon the 0.19 oz rate was safer than the 0.38 oz rate.

2nd Year Production:
At K&S, pre-emerge application of Fierce or Alion in addition to Prowl and Outlook resulted in crop injury in September (Table 3). Perhaps this injury would not have occurred had the trial not been over-sprayed with Prowl and Outlook. This injury had largely disappeared by early November, however it could still be observed as narrower rows with less regrowth. There were no statistical differences in seed yield. However, visual evaluation on June 7 at heading indicated severe injury from Fierce pre-emerge.

At COARC no crop injury was observed from application of Fierce or Alion (data not shown). A commercial standard of Beacon at 0.38 oz + Direx (80% diuron) at 2 lb + Goal 2XL (2 lb/gal oxyfluorfen) at 12 fl oz also showed no injury. However, there was some underlying problem with the stand at COARC because in the spring there was very little seed head production. Therefore, seed yield data was not collected.

Acknowledgements

The primary authors would like to thank Jefferson County Smoke Management and the Jefferson County Seed Growers for their financial support of this project, Rich Affeldt for applying treatments in my absence, Rich and Jim Carroll for their cooperation in the final design and management of the project and co-leadership for the October, 2016 plot tour, Hoyt Downing for management of the COARC plots, plot harvest and seed cleaning, Kurt Feigner for his valued advice and willingness to be grower cooperator for the yield data plots at K&S Farms, and Ryan Boyle and Curt Crossman for their insight as cooperators on the project.

Table 1. Visual evaluation of herbicide treatments on crop injury and control of rough bluegrass, rattail fescue and medusahead on October 26, 2016 and June 5, 2017.

Treatment*	Rate/Acre	Application Timing	Crop Injury/Weed Control	Oct-26	Jun-5
				(percent)	
Callisto	6.0 fl oz	Pre-irrigation	Crop injury	0	0
fb Beacon	0.19 oz	4-5 leaf	Rough bluegrass	8	
fb Beacon	0.38 oz	Oct-24	Rattail fescue	10	
			Medusahead	25	
Beacon	0.19 oz	2-3 leaf	Crop injury	13	38
fb Beacon	0.38 oz	Oct-24	Rough bluegrass	53	
			Rattail fescue	25	
			Medusahead	10	
Beacon	0.19 oz	2-3 leaf	Crop injury	5	23
+ Bronate	1.0 pt		Rough bluegrass	45	
fb Beacon	0.38 oz	Oct-24	Rattail fescue	13	
			Medusahead	20	
Beacon	0.19 oz	2-3 leaf	Crop injury	13	11
fb Beacon	0.19 oz	4-5 leaf	Rough bluegrass	53	
			Rattail fescue	28	
			Medusahead	10	
Beacon	0.19 oz	2-3 leaf	Crop injury	5	4
+ Bronate	1.0 pt		Rough bluegrass	45	
fb Beacon	0.19 oz	4-5 leaf	Rattail fescue	28	
			Medusahead	10	
Beacon	0.19 oz	2-3 leaf	Crop injury	5	9
+ Bronate	1.0 pt		Rough bluegrass	73	
fb Beacon	0.19 oz	4-5 leaf	Rattail fescue	40	
+ Bronate	1.0 pt		Medusahead	23	
Sharpen	2.0 fl oz	4-5 leaf	Crop injury	8	0
			Rough bluegrass	0	
			Rattail fescue	0	
			Medusahead	0	
UTC	-----		Crop injury	0	0
			Rough bluegrass	0	
			Rattail fescue	0	
			Medusahead	0	

* NIS at 1 qt/100 gal was included with treatments applied at the 2-3 leaf stage, while COC at 1 gal/100 gal was used with all other post-emergence treatments. Fb = followed by.

Table 2. Clean seed weight for herbicide treatments on establishment year Kentucky bluegrass at COARC, 2017.

Treatment	Rate/Acre	Application Timing	Clean Seed Yield (lbs/ac)	
Callisto	6.0 fl oz	Pre-irrigation	1653ǂ	A
fb Beacon	0.19 oz	4-5 leaf		
fb Beacon	0.38 oz	Oct-24		
Beacon	0.19 oz	2-3 leaf	743	C
fb Beacon	0.38 oz	Oct-24		
Beacon	0.19 oz	2-3 leaf	917	BC
+ Bronate	1.0 pt			
fb Beacon	0.38 oz	Oct-24		
Beacon	0.19 oz	2-3 leaf	1338	ABC
fb Beacon	0.19 oz	4-5 leaf		
Beacon	0.19 oz	2-3 leaf	1503	AB
+ Bronate	1.0 pt			
fb Beacon	0.19 oz	4-5 leaf		
Beacon	0.19 oz	2-3 leaf	1136	ABC
+ Bronate	1.0 pt			
fb Beacon	0.19 oz	4-5 leaf		
+ Bronate	1.0 pt			
Sharpen	2.0 fl oz	4-5 leaf	1090	ABC
UTC	-----		780	C

ǂThere were no statistical differences in seed yield between treatments with the same letter.

Table 3. Clean seed weight for herbicide treatments applied Fall-2016 on second year Kentucky bluegrass at K&S Farms, 2017.

Treatment*	Rate/Acre	Application Timing	Crop Injury Nov-7	Crop Injury Jun-7	Clean Seed Yield
			(percent)		(lbs/ac)
Fierce	3.0 oz	Pre-emergence	20	56	945ǂ
Fierce	3.0 oz	Nov-4	--	15	1177
Alion	1.5 fl oz	Pre-emergence	8	23	1112
Alion	1.5 fl oz	Nov-4	--	3	1286
Sharpen	2.0 fl oz	Nov-4	--	0	1261
UTC	-----		0	0	1220

*All plots were inadvertently over sprayed with Prowl at 2 pt plus Outlook 21 fl oz/ac pre-emergence.
ǂ There were no statistical differences in seed yield.

Evaluation of Copper and Boron for Control of Ergot on Kentucky Bluegrass in Oregon, 2017

Jeremiah Dung, Qunkang Cheng, Hoyt Downing, Tracy Wilson, and Kenneth Frost

Introduction

The ergot fungus can only infect the unfertilized ovaries of grasses, so factors that affect pollination efficiency can also affect ergot epidemics. Cultivars with short, uniform flowering periods and cultivars that produce copious amounts of viable pollen are less likely to be impacted by ergot than cultivars with extended flowering periods, low pollen production, and/or poor pollen viability. Deficiencies of two micronutrients in particular, copper and boron, can lead to male sterility in wheat and supplemental applications of these two micronutrients has been shown to decrease ergot and other floral diseases in wheat. The potential for micronutrients to improve pollination and reduce ergot in grass grown for seed needs to be determined. The objective of this research was to evaluate supplemental micronutrient applications during anthesis to reduce ergot.

Materials and Methods

Replicated field plots (70 ft^2) of Kentucky bluegrass (cv. 'Blue Ghost') were established at the Central Oregon Agricultural Research Center in August 2016. Plots were infested with sclerotia in October 2016. Plots were subjected to fertilization, irrigation, and cultural practices that are standard in the area.

Foliar treatments of copper sulfate (0.25 lb./A), TriPlex Boron® (0.5 lb./A), and a combination of copper sulfate (0.25 lb./A) and TriPlex Boron® (0.5 lb./A) were applied on May 19 (early Feekes 10.1) prior to flowering. A treatment consisting of ManKocide® (a premix of copper hydroxide and the fungicide mancozeb) at a rate of 1.7 lb./A was applied on May 23 (late Feekes 10.1). Plant tissue samples were taken prior to treatment application and 72 hours after application. Plant materials were dried at 60C and ground with a Wiley Mill. Ground samples were sent to OSU's Central Analytical Laboratory (Corvallis, OR) and analyzed for boron and copper concentrations using inductively coupled plasma optical emission spectrometry (ICP-OES).

The number of sclerotia were quantified from 50 plants per plot to determine ergot incidence and severity prior to swathing. An ergot disease index (EDI) was calculated by multiplying incidence and severity. Plots were harvested and seed was cleaned at the USDA ARS National Forage Seed Production Research Center prior to recording yields. Data were subjected to analysis of variance and treatment means were compared using Tukey's honest significant difference test.

Results and Discussion

Foliar treatments of copper sulfate, TriPlex Boron®, or copper sulfate + TriPlex Boron® did not significantly reduce ergot incidence ($P = 1.00$), severity ($P = 0.62$), or ergot disease index ($P = 0.80$). ManKocide®, a combination of copper hydroxide (CuOH) and the fungicide mancozeb, also did not significantly reduce ergot compared to the control ($P > 0.05$). Copper and boron

levels were not significantly different among treatments ($P > 0.59$). Significant effects on yield were also not observed ($P = 0.28$). Data is summarized in Table 1.

Acknowledgements

Funding for this research was provided by the Oregon Seed Council, the Washington Turfgrass Seed Commission, the Columbia Basin Grass Seed Association, and the Union County Grass Seed Growers. The researchers would like to thank Central Oregon Seeds, Inc., Pratum Co-Op, and Redox for providing in-kind support.

Tables

Table 1. Ergot incidence, ergot severity, and ergot disease index (EDI), and seed yield following treatments with the micronutrients boron and/or copper prior to anthesis[1]

Treatment	Micronutrient	Rate (lb./A)	Change boron (ppm)	Change Copper (ppm)	Ergot incidence	Ergot severity	EDI	Yield (lb./A)
Control	**NA**	**NA**	-1.1	-2.7	0.3	28.8	9.0	1,980
TriPlex Boron	**B (16%)**	**0.5**	-1.2	-2.3	0.3	32.3	10.2	1,588
$CuSO_4 \cdot 5H_2O$	**Cu (25%)**	**0.25**	-0.4	-3.1	0.3	39.0	12.6	1,727
TriPlex Boron + $CuSO_4 \cdot 5H_2O$	**See above**	**See above**	-1.2	-4.1	0.3	36.0	12.9	2,000
ManKocide	**Cu (30%)**	**1.7**	-1.3	-2.4	0.3	45.5	15.8	1,800
		***P*-value**	0.59	0.94	1.00	0.62	0.80	0.28

[1] Treatments were not significantly different from each other ($P > 0.05$).

Evaluation of SporeKill® for *Xanthomonas* Management in Carrot Seed Crops

Jeremiah Dung, Jeness Scott, and Mike Weber

Introduction

Bacterial blight, caused by *Xanthomonas hortorum* pv. *carotae* is an important seedborne disease of carrot. Reducing *Xanthomonas* in harvested carrot seed would benefit the carrot seed industry by minimizing the need for hot water treatment and lessening the impact of bacterial blight on carrot root crops in California, Washington, and other carrot-producing states and countries. Copper-based bactericides such as ManKocide® (mancozeb + copper hydroxide) are a primary control measure for bacterial blight in carrot seed crops and are often applied several times during carrot seed production to manage bacterial blight. However, copper-based bactericides are most effective when used as preventative treatments and have limited ability to reduce *Xanthomonas* populations once the pathogen becomes established in a seed crop (du Toit and Derie 2008). Previous research revealed that SporeKill® (12% didecyldimethyl ammonium chloride; ICA International Chemicals) was effective at reducing *Xanthomonas* in harvested carrot seed, but its ability to manage the pathogen on carrot foliage is not known. The objective of this study was to evaluate the efficacy of SporeKill® to reduce *Xanthomonas* populations on carrot plants in the greenhouse.

Materials and Methods

Commercial carrot stecklings of a proprietary female line were planted on April 7, 2017 in 1-gallon pots and grown in the greenhouse. A total of five bactericide treatments were tested: SporeKill® (1% vol/vol) applied post-inoculation; SporeKill® (0.5% vol/vol) applied post-inoculation; SporeKill® (1% vol/vol) applied before inoculation; SporeKill® (0.5% vol/vol) applied before inoculation; and ManKocide® (2.5 lbs/A) applied after inoculation. A CO_2 backpack sprayer was used to inoculate foliage of post-inoculation treatments with a suspension of *X. hortorum pv. carotae* (2 x 10^6 CFU) on June 5 and June 21. Treatments were applied on July 5 using a CO_2 backpack sprayer, after which all plants were inoculated as described above. Bactericide treatments were compared to a non-inoculated/non-treated control and an inoculated/non-treated control. The experiment was arranged as a randomized complete block design with five replications per treatment.

Bacterial blight symptoms were evaluated on a weekly basis following inoculations. Foliage was sampled 7- and 14-days after treatment and subjected to a leaf wash assay to determine foliar *Xanthomonas* populations. Phytotoxicity was evaluated using a 0-5 scale (0 = no phytotoxicity, 5 = dead plant). The impact of each treatment on bolting frequency and timing was also evaluated.

Results and Discussion

Although bacterial blight symptoms were not observed, large populations of *Xanthomonas* (5.1 x 10^4 to 3.8 x 10^8 CFU/g leaf tissue) were recovered from inoculated plants. Pre-inoculation treatments of SporeKill® at both the 0.5X and 1X rates significantly reduced *Xanthomonas* populations compared to the non-treated/non-inoculated control at 1- and 2-weeks post-treatment

(Table 1); however, pre-inoculation treatments were only exposed to one inoculation event compared to the post-inoculation treatments, which were exposed to three inoculation events. An additional study is needed to determine if the reduced *Xanthomonas* populations observed 1- and 2-weeks after pre-inoculation treatments were due to SporeKill or lower initial inoculum levels. Regardless, post-inoculation treatments of SporeKill® (both rates) and ManKocide® did not reduce *Xanthomonas* populations. These results are consistent with previous studies showing bactericides such as ManKocide® work best when used preventatively and suggest that SporeKill® may also be most effective as a preventative treatment for bacterial blight, though this needs to be confirmed. No effect of any treatments on phytotoxicity or bolting were observed.

Acknowledgements

The authors thank Central Oregon Seeds, Inc. and ICA International Chemicals for providing funding and in-kind support.

Tables

Table 1. Effect of SporeKill® treatments on colony forming units (CFU) of *Xanthomonas hortorum* pv. *carotae* on carrot foliage[1]

		CFU/g tissue			
Treatment	**Bactericide timing**	**1 week**		**2 weeks**	
Non-inoculated/non-treated control	**NA**	1.6×10^3	a	3.0×10^2	a
SporeKill® (0.5X rate)	**Pre-inoculation**	1.0×10^6	ab	5.1×10^4	b
SporeKill® (1X rate)	**Pre-inoculation**	6.8×10^4	a	7.2×10^5	b
ManKocide®	**Post-inoculation**	7.3×10^7	c	1.8×10^8	c
SporeKill® (0.5X rate)	**Post-inoculation**	1.8×10^8	c	1.6×10^8	c
SporeKill® (1X rate)	**Post-inoculation**	1.5×10^8	bc	3.0×10^8	c
Inoculated/non-treated control	**NA**	7.5×10^7	c	3.8×10^8	c

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

Foliar Boron Fertilizer Application and Timing in Hybrid Carrot Seed Production

Tracy Wilson and Rich Affeldt

Introduction

Hybrid European Nantes carrot seed production can be challenging for growers as yields can be unreliable. Demand for boron (B) in many crops is greatly elevated during flowering and seed set even when B in the plant leaves are in the "adequate" range for that crop. Several studies have found that foliar B applications can increase fruit set and yield (Nyomora et al, 1999; Perica et al, 2001; Asad et al, 2003). Research conducted on alfalfa seed found that foliar B applications increased seed yield even though B concentrations in the plants and soil were considered adequate for alfalfa forage production (Dordas, 2006). The objective of this research project was to determine what effect foliar B application and application timing had on hybrid carrot seed production.

Materials and Methods

Year 1

Three hybrid carrot seed fields of the same variety were selected for the trial. Soil tests for the three fields selected had B levels that ranged from "low" (1.1 lb B/ac) to "medium low" (1.5 lb B/acre). Two fields were planted in a 2x4 configuration of two rows of males and four rows of females, the third field was planted in a 4x4 configuration of four rows of males and four rows of females. Four areas near the corners of each field were randomly assigned a treatment: control (no B), pre-bloom B application, during bloom B application, and split (pre- and during bloom) B application. Four plots (replicates) of each treatment were placed in one area of each field in an effort to minimize pollen carryover from other treatments while bees were in the fields. Plots were 50 feet long with two sets of males (4 rows in 2x4, 8 rows in 4x4) and one set of females in each plot. A buffer of one set of females separated the plots. Foliar B applications were made using a CO_2 powered backpack sprayer to apply Tri-Plex B (0-0-0-16, Redox, Burley, Idaho). Pre-bloom and during bloom applications of 0.5 lb Tri-Plex B/ac (0.08 lb B/ac) were applied to the males in each plot in all three fields June 13, 2016 and July 8, 2016, respectively. Split applications of 0.25 lb Tri-Plex B/ac (0.04 lb B/ac) were applied at pre-bloom (June 13, 2016) and during bloom (July 8, 2016).

Just prior to application and seven days after application, above ground samples were collected from male and female plants in each treatment by randomly selecting three plants within the plot and clipping the carrot plant at the soil surface. Plant samples were dried at 80° F and then ground. Ground plant samples were sent to the Central Analytical Laboratory at Oregon State University for analysis of B concentrations.
Just prior to each field being swathed, a 5 ft by 5 ft area of each plot was hand harvested to determine seed yield. Seed heads were clipped in the field and placed in a burlap sack to dry down. Once seed heads dried down, they were passed through a thresher and sieved to remove pieces of stem and other flower pieces. Seed was cleaned at the USDA-ARS Forage Seed and Cereal Research facility in Corvallis, OR.

Year 2

Two hybrid carrot seed fields of different varieties were selected for the trial, Field 1 (Nantes-type) and Field 2 (Kurota-type). The two fields were planted in a 2x4x4 configuration of two rows of males, four rows of females, and four rows of males in a repeating pattern. Four areas near the corners of each field were randomly assigned a treatment: control (no B), pre-bloom B application, during bloom B application, and split (pre- and during bloom) B application. Field plots were laid out as described above. Pre-bloom and during bloom applications of 0.5 lb Tri-Plex B/ac (0.08 lb B/ac) were applied to all plants in each plot in both fields on June 29 and July 18, respectively. Split applications of 0.25 lb Tri-Plex B/ac (0.04 lb B/ac) were applied at pre-bloom (June 29) and during bloom (July 18).
Plant samples and harvest were conducted in the same manner as described above.

Year 1 Results

For the 2016 growing season, the plant sample analyses indicate that foliar applications of B to the male plants at pre-bloom increased plant B concentrations one week after application (Figures 1-3). The half-rate of foliar B applied pre-bloom in split treatment did not increase plant B concentrations (Figures 1-3). However, the application during bloom did increase plant B concentrations one week after application (Figures 1-3).

The foliar B applications while the carrots were in bloom (during bloom) increased plant B concentrations and carrot seed yield. Seed yield for the during bloom treatment was numerically (but not statistically) higher than the control plots where no foliar B was applied, and seed yield in the during bloom treatment was significantly higher than both the pre-bloom and split application treatments.

Year 2 Results

Seed yields for Field 1 showed no significant treatment effects (Table 2). Field 2 did show significant differences in seed yields between the During Bloom treatment and all other treatments (Table 1). Application of foliar B during carrot bloom resulted in an increased seed yield of 28% over the control (no foliar B applied), 12% increase over the Pre Bloom application, and a 22% increase over the Split application treatment. Application of foliar B during bloom, shows promise for increasing seed yields for some varieties of hybrid carrots.

Acknowledgements

The authors wish to thank the growers for the use of their fields and for their cooperation. The authors are grateful to Central Oregon Seeds, Inc. for their generous support of this project. Thank you as well to Ekaterina Jeliazkova, Mitchell Alley, and Misty Cottingham for their hard work and invaluable assistance in hand harvesting the field plots. Also to the USDA-ARS Forage Seed and Cereal Research group in Corvallis, OR and Hoyt Downing for assisting with seed cleaning.

Tables

Table 1. Seed yield by field and treatment for 2016 season for the WY-969 variety. Check had no foliar B applied. Pre Bloom B applications were June 13. During Bloom applications were applied July 8. The Split application had the first application at pre bloom (June 13) and the second application during bloom (July 8).

	Seed Yield* (lb/ac)			
Treatment	**Field 31**	**Field 33**	**Field 36**	**Treatment Average**
Check (No B)	349	345	312	335ab
Pre Bloom	278	282	367	309c
During Bloom	373	290	481	381a
Split (Pre & During B)	285	254	291	277c

Means followed by the same letter are not significantly different (α= 0.1).
*Seed yield was calculated on gross acreage.

Table 2. Seed yield by field and treatment for 2017 season. Check had no foliar B applied. Pre Bloom B applications were June 29. During Bloom applications were applied July 18. The Split application had the first application at pre bloom (June 29) and the second application during bloom (July 18).

Variety	**Field 1**	**Field 2**
Treatment	**Seed Yield* (lb/ac)**	
Check (No B)	674a	316a
Pre Bloom	538a	388a
During Bloom	609a	440b
Split (Pre & During B)	582a	343a

Means followed by the same letter are not significantly different (α= 0.05).
*Seed yield was calculated on gross acreage.

Figures

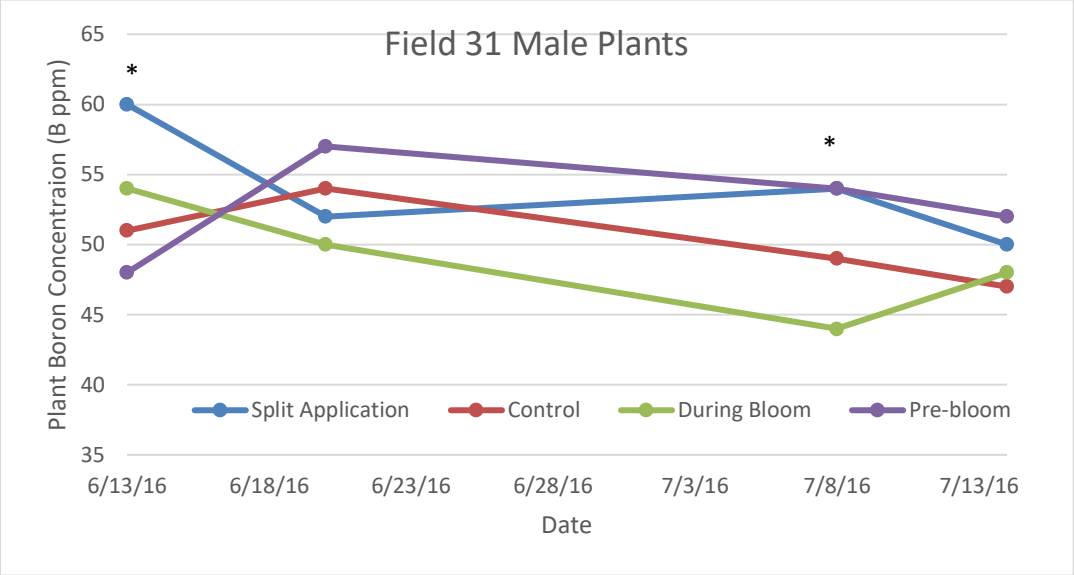

Figure 1. Plant B concentrations (ppm) for male plants collected from field 31 (4x4 planting). Application dates are noted with an *.

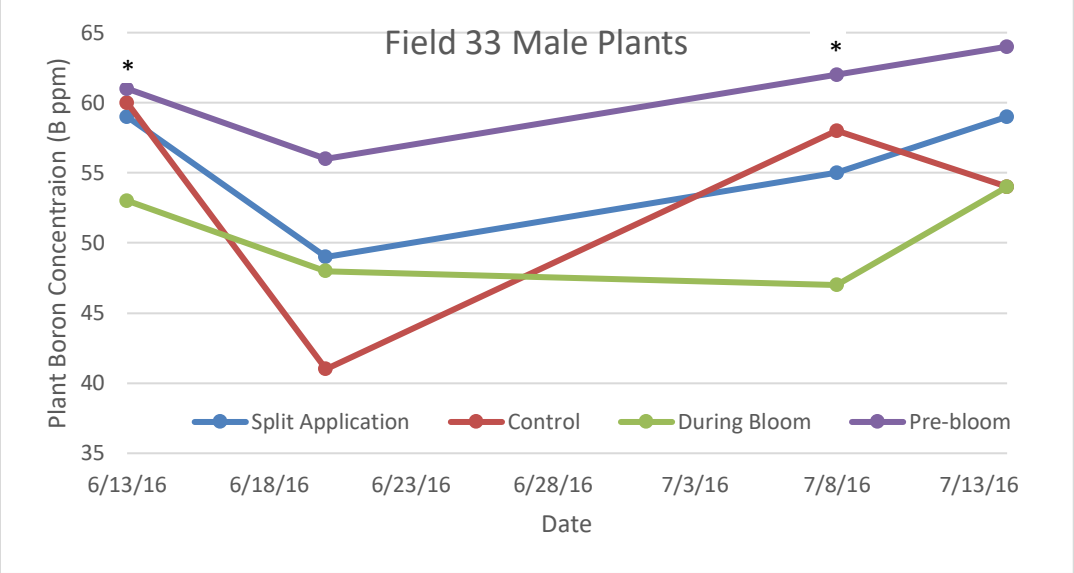

Figure 2. Plant B concentrations (ppm) for male plants collected from field 33 (2x4 planting). Application dates are noted with an *.

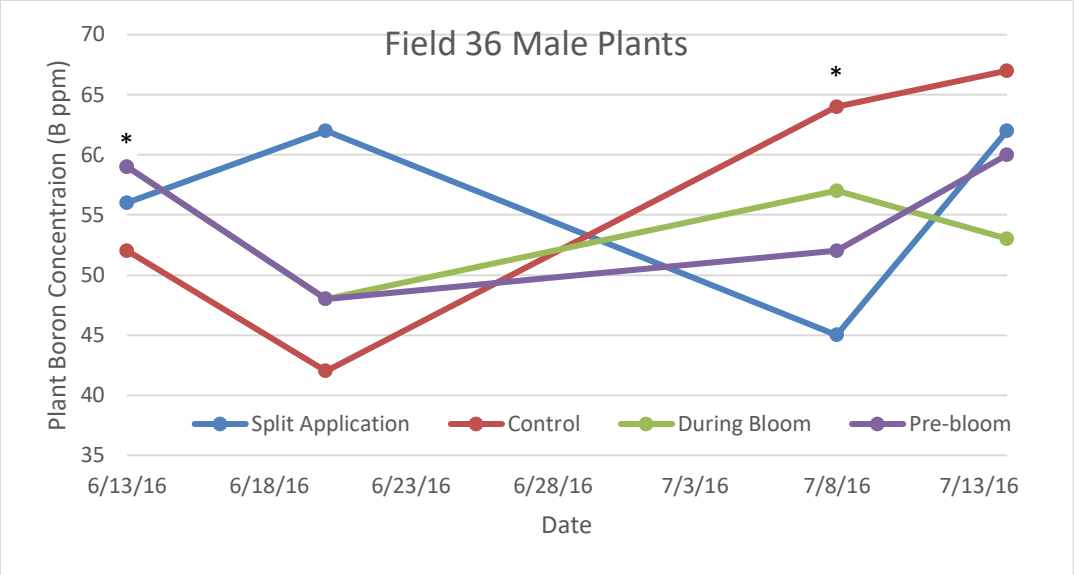

Figure 3. Plant B concentrations (ppm) for male plants collected from field 36 (2x4 planting). Application dates are noted with an *.

Nitrogen Release from Cover Crops

Tracy Wilson and Joshua Neuman

Introduction

Cover crops are a tool for growers in central Oregon to conserve moisture, protect the soil, reduce weeds, and improve soil health in the fields during the fallow year (Blanco-Canqui and Lal, 2008). Fall planting of cover crops takes advantage of winter precipitation to grow the cover crops and allows the cover crops to "scavenge" nitrogen from the soil and protect it from being leached below the rooting depth of the next crop (Clark, 2008).

Some growers in central Oregon are already experimenting with cover crops in their own crop rotations and have seen some positive results. However, as the predominant source of information regarding using cover crops comes from the Midwest, the growers need guidance as to which cover crop species or mixes are best suited to central Oregon's growing conditions. Some cool season cover crops to consider for central Oregon include brassicas (i.e. mustards, radish), legumes such as Austrian winter peas and hairy vetch, and cereals such as oats. Each of these cover crops provides a benefit when planted as an individual cover crop. For example, brassicas can reduce pest pressures, legumes fix nitrogen from the atmosphere, and cereals provide biomass to protect the soil surface and can also catch nitrogen left in the soil and prevent it from being leached deeper into the profile. Combinations of different cover crop species aims to combine these benefits. By pairing cereals with legumes, when the legumes completely breakdown and the nitrogen they contain is subject to loss if not immediately taken up by plants, the cereals with their higher carbon to nitrogen (C:N) ratio are able to minimize nitrogen losses and can provide a sort of "slow-release" nitrogen for the cash crop (Sullivan et al., 2011).
In addition to needing guidance on how to select a cover crop, there is a need for information about what happens to the nutrients, nitrogen in particular, in those cover crops when they begin to break down. Equally important to growers is the need to know when and how much nitrogen is being released from the cover crops. By being able to predict how much nitrogen is released, and when, growers can fine tune production practices such as fertilizer rates and timings for the subsequent crop. Being able to better predict nitrogen release from cover crops allows for potential reduction of fertilizer inputs without sacrificing yields in the cash crop.

Objectives

The three objectives of this research are: 1. Determine the uptake and retention of N from fertilizer by three commonly-planted winter cover crops in Central Oregon 2. Determine the mineralization rate of N from decomposing residues of these cover crops when incorporated immediately prior to planting of soft white spring wheat. 3. Determine the synchrony between N mineralization and the physiological need by wheat for the mineralized N. This is expressed by comparing the N content of the growing wheat at two critical stages in its physiological development—stem jointing and seed head development ("booting"), to the amount of mineral N in the soil at these same stages, and by comparing this concentration to critical N uptake levels at these times as published in the Oregon State University Extension publication *Irrigated Soft White Wheat (Eastern Oregon)*.

Materials and Methods

A preliminary soil mineral N test was collected on August 28th, 2017 prior to planting the cover crops for the 0-6 and 6-12 inch depths to determine initial soil levels of nitrate (NO_3) and ammonium (NH_4).

Cover crops were planted September 7th in 12x30 ft plots at rates published in *Using Cover Crops in Oregon* (EM 8704) and then fertilized with granular urea (46-0-0) at four different rates to determine optimal response to N fertilization. The N rates are 0, 40, 80, and 120 lb N/ac. In addition to the cover crop plots, there are bare soil plots which are also fertilized at the aforementioned rates. There are four treatments that are primary effects, the three cover crops: forage radish, mustard, oats, and the bare soil. In addition to these treatments, there is the secondary effect of the fertilizer rates. This gives a total of 16 treatments, each with four replications, for a total of 64 plots arranged in a randomized complete block.

The cover crops were established by wheel line irrigation until the end of the irrigation season in mid-October. Cover crops will be chemically terminated in the spring (if they do not winter kill prior to chemical termination) and three $1m^2$ squares of above ground biomass will be collected from each cover crop plot, weighed and tested for N content following standard procedures as determined in the CAL soil analysis handbook. Soil samples will also be taken at termination to determine inorganic N content. The soil inorganic N content at cover crop termination is used as the baseline for soil N content prior to the start of N mineralization from cover crop residues. The remaining cover crop residues are then tilled into the soil and then wheat is planted.

Wheat will then be planted in all plots, including the bare soil treatments. Soil samples will be taken, along with plant tissue samples, at the phenological stages when wheat has the highest N requirement. This is the period from jointing to grain head initiation (i.e. “booting”) and falls between Feekes stages 6-10. One soil sample will be taken from each plot each week during this period and analyzed for mineral N content. Ten random samples of wheat main stems will be taken from each subplot, composited and then the composite sample will be analyzed for total plant N concentration.

At harvest, a final soil sample for mineral N will be taken from each subplot and instead of ten samples of main stems from each plot, ten grain heads will be taken from each plot and tested for both total composite N concentration and protein content.

In addition to the in-field N mineralization study, there will also be an in-lab incubation study of the different incorporated in field soil cover crop residues and bare soil fertilizer for N mineralization rate assessment. This will serve as an additional index for N mineralization rate from these cover crops as opposed to non-cover-cropped soils with the same applied N fertilizer rates.

Literature Cited

Blanco-Canqui, H., and R. Lal. 2008. Principles of Soil Conservation and Management. Springer Netherlands.

Clark, A. 2008. Managing Cover Crops Profitably (3rd Ed.). DIANE Publishing Company.

Sullivan, D.M., R. Datta, N. Andrews, and K.E. Pool. 2011. Predicting plant-available nitrogen release from cover crop residues. p. 55–60. *In* Proceedings of the Western Nutrient Management Conference.

Acknowledgements

The authors wish to thank Hoyt Downing and Mitchell Alley for all of their assistance in planting the cover crops and also for their help hand fertilizing all of the plots. The authors also wish to thank Kurt Feigner and Ryan Boyle for their questions regarding cover crops which helped form this project.

Evaluation of Bacteria for Potential Biocontrol of *Xanthomonas* in Carrot Seed Crops

Jeremiah Dung, Jeness Scott, and Ekaterina Jeliazkova

Introduction

Biological control, also known as biocontrol, involves the use of living organisms to reduce pest populations. In plant pathology, microbial antagonists can be used to suppress plant diseases through hyperparasitism, the production of antagonistic antibiotics or enzymes, competition for resources or physical niches, or the induction of host resistance. Bacteria that can survive and reproduce on carrot foliage and/or seeds may be able to reduce *Xanthomonas hortorum* pv. *carotae* levels in fields and seed lots. During the course of field and seed sampling, it was observed that some bacteria appeared to inhibit the growth of *X. hortorum* pv. *carotae*. The objective of this study was to evaluate potential biocontrol activity of bacteria collected from carrot plants and seeds against bacterial blight under laboratory conditions.

Materials and Methods

A collection of 93 bacteria were collected from leaves, umbels, and seed lots of carrot seed crops grown in central OR. Bacteria were selected for biocontrol potential if: 1) they were present in high numbers on carrot leaves or seed lots and *X. hortorum* pv. *carotae* was either not detected or detected at low levels in the same assay; and/or 2) the bacteria exhibited antagonistic activity against *X. hortorum* pv. *carotae* as indicated by zones of inhibition (lack of growth) on petri plates. A subset of eight isolates representing the range of colony morphologies were selected for evaluation of biocontrol potential against *X. hortorum* pv. *carotae* using an overlay assay.

An isolate of *X. hortorum* pv. *carotae* was grown in liquid culture and inoculated into 0.7% Wilbrinks agar. Five ml of the *X. hortorum* pv. *carotae* -inoculated agar was poured into petri plates and allowed to incubate for 24 hours at 4°C. Biocontrol isolate treatments were stab-inoculated onto the center of each *X. hortorum* pv. *carotae* plate using a 10 µl pipette tip containing 10 µl of bacterial suspension. Several controls were included in this study: a non-inoculated control, a phosphate buffer stab-inoculated control, a *X. hortorum* pv. *carotae* stab-inoculated control, and a *Pseudomonas syringae* pv. *syringae* stab-inoculated control. All treatments were replicated 10 times and arranged in a randomized complete block design. After 48 hours of incubation at 28°C, the zone of inhibition was measured from digital images using ImageJ software (Schneider et al. 2012). Treatments were analyzed using analysis of variance. Isolates that exhibited inhibition against *X. hortorum* pv. *carotae* were identified using DNA sequences.

Results and Discussion

Several bacterial isolates exhibited potential biocontrol activity in the petri plate assay used in this study (Table 1). Among the eight isolates tested, six exhibited zones of inhibition that were 5 to 15 times larger than the phosphate buffer control. Two isolates and the *X. hortorum* pv. *carotae* control exhibited inhibition less than the *P. syringae* pv. *syringae* control and similar to the phosphate buffer control.

Five of the six isolates that exhibited inhibitory effects against *X. hortorum* pv. *carotae* were identified using 16S rRNA sequences. Four isolates were identified as *Pantoea* species, including two isolates identified as *P. agglomerans*. One isolate was identified as a species of *Enterobacter*. *Pantoea* and *Enterobacter* are ubiquitous bacteria and are often found associated with plants and insects as pathogens and commensals. Certain strains of *P. agglomerans* are also used in commercially available biocontrol products for plant diseases.

Since the bacterial isolates screened in this study were isolated from carrot foliage or seeds grown in central Oregon, it would be expected that they can colonize and reproduce in central Oregon carrot seed fields; however, further testing would be required to determine their biocontrol potential under field conditions.

Acknowledgements

Funding for this research was provided by Central Oregon Seeds, Inc. and the Oregon State University Foundation. The technical support provided by Hoyt Downing was greatly appreciated.

References

Schneider, C.A., Rasband, W.S., Eliceiri, K.W. 2012. NIH Image to ImageJ: 25 years of image analysis. Nature Methods 9:671-675.

Tables

Table 1. Inhibition of *Xanthomonas hortorum* pv. *carotae* (*Xhc*) by various carrot-associated bacteria as determined in a petri plate stab-inoculation assay

Isolate	Bacteria identification	*Xhc* inhibition (diameter mm)[z]
14-022-B	*Enterobacter* sp.	33.2 a
16-354-B	*Pantoea agglomerans*	21.0 b
16-317-B	*Pantoea* sp.	16.0 c
16-297-B	Not identified	16.0 c
16-347-B	*Pantoea* sp.	14.0 cd
14-020-B	*Pantoea agglomerans*	11.9 d
15-069-B Pss	*Pseudomonas syringae* pv. *syringae*	4.1 e
16-135-B	Not identified	2.8 f
16-024-B	Not identified	2.8 f
***Xanthomonas* control**	*Xanthomonas hortorum* pv. *carotae*	2.3 f
Phosphate buffer control	Not applicable	2.2 f
No bacteria control	Not applicable	0.0 g
	***P*-value**	< 0.0001

[z] Column means followed by the same letter are not significantly different at α=0.05 as determined by Tukey's honest significant difference test.

Sulfentrazone and Metribuzin Crop Safety on Carrot for Seed, 2017

Rich Affeldt, Central Oregon Seeds, Inc. and Clare Sullivan, Oregon State Univ. Extension

Introduction

Adequate weed control in hybrid carrot grown for seed is a major challenge. Carrot seed is a relatively long-season crop (typically 13 to 14 months), which creates a long window of time for weeds to develop. It is planted in wide rows at low density to allow room for branching, flowering, and seed set. This arrangement also allows room for weeds to establish and develop. Most importantly there are low and strict tolerances for weed seed contamination in the finished carrot seed product.

Currently Lorox (50% linuron) plays a critical role for weed control in carrot seed production. Additional herbicides such as Galigan (2 lb/gal oxyfluorfen), Caparol (4 lb/gal prometryn), Prowl H2O (3.8 lb/gal pendimethalin) and Aim (2 lb/gal carfentrazone) are usually necessary but still inadequate to achieve acceptable weed control on problem weeds like pigweed, nightshade, Russian thistle, and kochia.

In 2016 Marvin Butler evaluated Spartan (4 lb/gal sulfentrazone), Sharpen (2.85 lb/gal saflufenacil), and Sencor/Tricor (75% metribuzin) in a directed spray application at layby on carrot seed in central Oregon. Sulfentrazone and metribuzin caused minimal crop injury and improved control of pigweed.

Our objective for 2017 was to develop additional crop safety data for sulfentrazone and metribuzin on carrot seed.

Methods and Materials

Plots were established in the male rows of a commercial hybrid carrot seed field near Culver, Oregon. Plots were 9 ft by 20 ft with 3 replications arranged in randomized complete blocks. Herbicides were applied as a directed spray at the bottom 4 to 6 inches of the carrot plants on June 26, 2017 using a CO2 powered backpack sprayer, hand-held boom, two 8002 nozzles that were 18 inches apart, at 40 psi, and 20 gal of water per acre. Carrots were 2.5 ft tall at the time of application and were beginning to head, but not yet blooming. Plots were visually evaluated on July 5 and July 12, 2017.

Statistical analysis was conducted with Statistix 9.0 using Tukey HSD

Results and Discussion

Unfortunately, there were insufficient weed populations to evaluate control. Crop injury of 25% or greater was deemed unacceptable during visual evaluation. Aim was included as a standard to compare against for crop injury because it can be injurious to carrots when applied as a drop nozzle/directed spray. Tricor alone caused no visible crop injury. Spartan cause slight crop injury, but much less than Aim. It seems likely that Spartan and Tricor can be used safely on carrot grown for seed as a directed spray at this timing.

Tables

Table 1. Percent crop injury from herbicides applied as a directed spray to seed carrots near Culver, OR on June 26, 2017.

		Crop inury (%)[2]			
Treatment[1]	Rate/acre	July 5, 2017		July 12, 2017	
Check	---	0	B	0	D
Spartan 4F	6 fl oz	6.7	B	7.5	BC
Aim 2EC	1.5 fl oz	16.7	A	20.8	A
Tricor DF	4 oz	0	B	0	D
Spartan 4F + TriCor DF	6 fl oz + 4 oz	3.3	B	5	CD
Aim 2EC + TriCor DF	1.5 fl oz + 4 oz	18.3	A	11.7	B

1 All treatments included crop oil concentrate at 1% vol/vol.
2 Means followed by the same letter in the same column are not significantly different at p=0.05.

Re-evaluating Seed Contamination and Seed Transmission Thresholds for Carrot Bacterial Blight

Jeremiah Dung, Jeness Scott, and Mike Weber

Introduction

Existing seed contamination thresholds for *Xanthomonas* used by the carrot seed industry were developed using artificially-infested seed inoculated at a uniform rate and blended with healthy seed (Umesh et al. 1998). However, previous research revealed that the incidence and severity of *Xanthomonas*-contaminated seed can vary drastically within and among naturally-infested commercial carrot seed lots and, in most cases, a small proportion of seed is infested (Dung et al. 2016). Additionally, a relatively few number of seeds can harbor high populations of the pathogen ($>10^5$ CFU/seed). A re-evaluation of seed contamination and seed transmission thresholds is needed to better understand the epidemiological and market implications of these new findings. This project used naturally-infested seed to help determine: 1) the incidence of infested seed required for seed-borne transmission of bacterial blight; and 2) the level of *Xanthomonas* required on an individual seed to transmit the pathogen to carrot seedlings.

Materials and Methods

Objective 1. Five commercial carrot seed lots containing similar levels of overall *Xanthomonas* contamination (ranging from 1.3 to 4.9 x 10^8 CFU/g seed as determined in bulk seed wash assays) but different incidences of infested seed (27, 43, 56, 92, and 98% as determined in single-seed assays) were used in this study. The five seed lots represented two different proprietary hybrid carrot lines. Between 74 and 97 seeds from each lot were planted in flats containing peat-based greenhouse mix and placed in a growth chamber under conditions conducive for bacterial blight development (82/64° F day/night and 90-100% relative humidity). Flats were covered with clear plastic domes to maintain high relative humidity and reduce flat-to-flat contamination. Seedlings were harvested at the 2-3 leaf stage, bulked, and subjected to a leaf wash assay to determine the level of *Xanthomonas* on all seedlings in each flat. A total of 10 flat assays were performed among the five seed lots. *Xanthomonas* levels (CFU/100 seedlings) for each flat were log-transformed and subjected to correlation analysis.

Objective 2. Seeds from four commercial carrot seed lots representing three proprietary hybrid carrot lines were obtained. Carrot seeds were individually assayed to identify seeds with varying levels of natural infestation (ranging from 0 to 3.6 x 10^7 CFU/seed). The same seeds were then planted in 6-cell trays containing greenhouse potting mix and placed in a growth chamber (82/64° F day/night and 90-100% relative humidity). Flats were covered with clear plastic domes until germination. Seedlings were harvested at the 2-3 leaf stage and individually assayed to determine the level of *Xanthomonas* on each seedling. *Xanthomonas* counts (CFU/seedling) for each individual seeding were log-transformed and subjected to correlation analysis.

Results and Discussion

Objective 1. Five highly infested (10^8 CFU/g) seed lots with varying amounts of infested seed (27-98% incidence) were planted in bulk under conditions highly conducive to bacterial blight. Although symptoms were not observed, *Xanthomonas* was recovered from 9 out of 10 plantings at relatively high levels (6.7×10^5 to 4.3×10^8). While not significant, stronger correlation with seedling infestation was observed for the incidence of infested seed ($r = 0.62$; $P = 0.07$) than the overall level of *Xanthomonas* in the seed lot as determined by bulk seed wash assays ($r = 0.33$; $P = 0.39$).

Objective 2. Previous studies have shown that, on average, 94% of carrot seeds from commercial seed lots contain < 100 CFUs per individual seed (Dung et al. 2016). Pathogen transmission from seed to seedling was not observed for individual seeds that harbored ≤ 10 CFU, and the pathogen was only detected on 9% of seedlings grown from individual seed with 11 to 100 CFU. Transmission of *Xanthomonas* from seed to seedling was greater in seed harboring larger pathogen populations, with pathogen transmission rates ranging between 20% (for seed containing 10^2 to 10^3 CFU/seed) to 67% (for seed containing 10^4 to 10^5 CFU/seed). These results suggest that seed with < 100 CFUs of *Xanthomonas* may not be as important for seedborne transmission as seed with greater levels (>10^2 CFU) of *Xanthomonas*.

Overall germination was lower, which may have been due to the seed wash assay that each seed was subjected to prior to planting. Regardless, germination appeared to be negatively impacted by greater levels of seed infestation. Germination rates for seed harboring between 10^2 and 10^6 CFU ranged from 50 to 71% compared to seed with lower levels of the pathogen (Table 1).

Highly infested individual seeds were less frequent in commercial seed lots, so additional data points are needed to better characterize seedborne transmission from seeds with higher levels (>10^3 CFUs) of the pathogen. The effect of *Xanthomonas* contamination on seed germination may also warrant further investigation. It should be noted that these initial studies were performed under conditions highly conducive for bacterial blight development and additional studies should be conducted to determine the effect of environment on seed-borne transmission of bacterial blight.

Acknowledgements

Funding for this research was provided by Central Oregon Seeds, Inc. and the Oregon State University Foundation.

References

Dung, J., Scott, J., and Weber, M. 2016. Characterizing the incidence and distribution of bacterial blight infestations in individual carrot seeds: Can one bad seed spoil the whole lot? Central Oregon Agricultural Research Center 2016 Annual Report: 22-26.

Umesh, K. C., Davis, R. M., and Gilbertson, R. L. 1998. Seed contamination thresholds for development of carrot bacterial blight caused by *Xanthomonas campestris* pv. *carotae*. Plant Disease 82(11):1271-1275.

Tables and Figures

Fig. 1. Correlation between *Xanthomonas hortorum* pv. *carotae* (*Xhc*) levels in 10 g seed lot samples and pathogen populations on seedlings grown from the same seed lots.

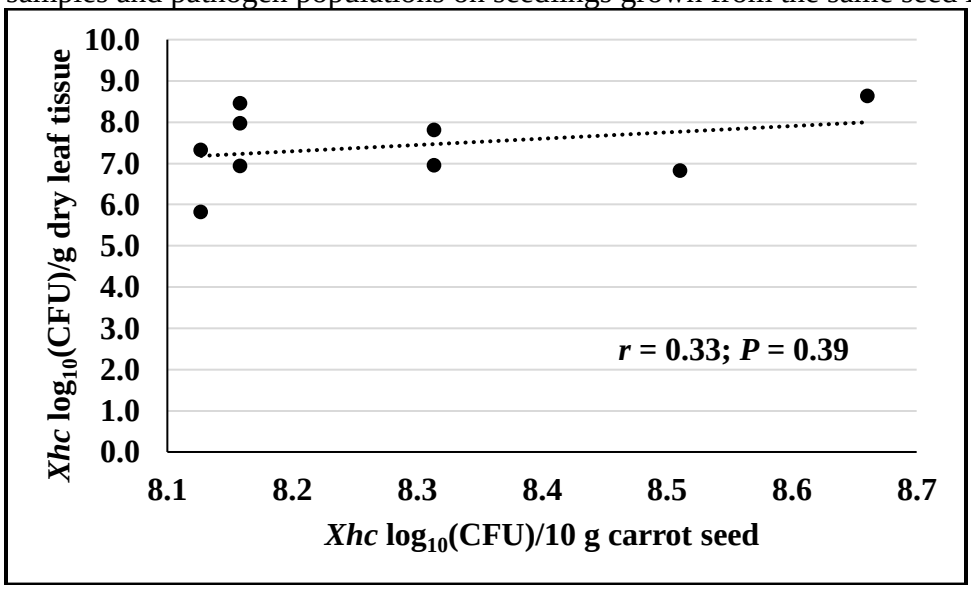

Fig. 2. Correlation between the incidence of seed infested with *Xanthomonas hortorum* pv. *carotae* (*Xhc*) and pathogen populations on seedlings grown from the same seed lots.

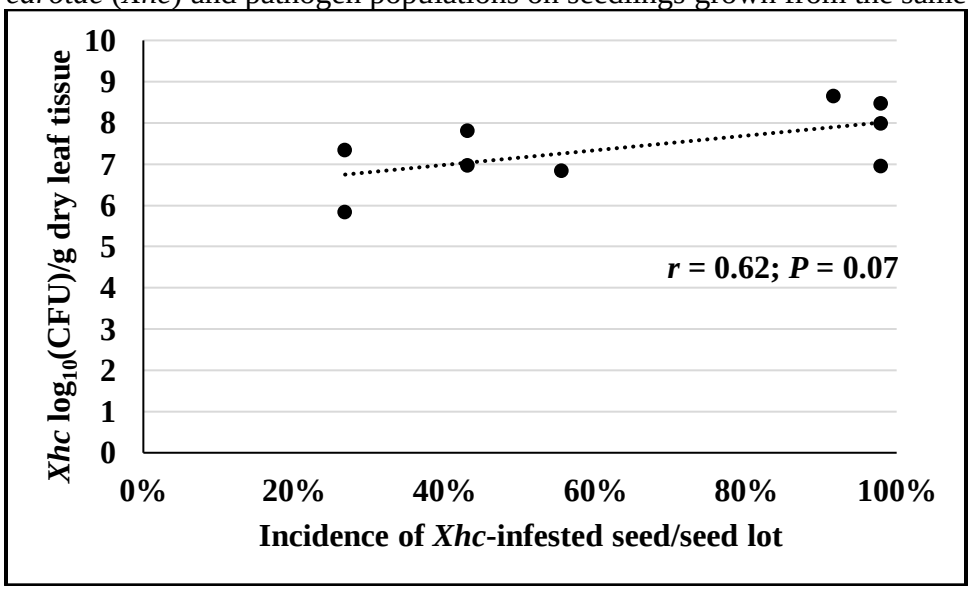

Table 1. Percent germination, percent pathogen transmission, and mean colony forming units (CFU) on seedlings grown from individual carrot seeds with varying levels of *Xanthomonas hortorum* pv. *carotae* infestation.

***Xanthomonas* CFU/individual seed**	***n***	**Germination**	**Pathogen transmission to seedlings**	**Mean CFU/ seedling**
0	**51**	80%	0%	0
1-10	**45**	78%	0%	0
11-100	**68**	82%	9%	4.7×10^4
101-1,000	**23**	74%	20%	9.5×10^5
1,001-10,000	**8**	63%	40%	9.4×10^6
10,001-100,000	**4**	50%	67%	1.9×10^7
100,001-1,000,000	**7**	71%	60%	1.5×10^7
> 1,000,000	**8**	50%	25%	1.2×10^4

Updating Oregon State University Nitrogen Fertilizer Recommendations for Carrot Seed Production Through Field Trials

Tracy Wilson and Amber Moore

Introduction

Central Oregon produces 85% of the hybrid carrot seed grown in the US for domestic fresh markets and some seed is exported for European and Japanese markets. Carrot seed yields for hybrid varieties are typically less than 500 lb/acre. While carrot seed yields are relatively low, they are an economically important crop for Oregon bringing in $8-$15/ 100 lb seed, depending on variety, therefore even seemingly small fluctuations in yield can have large impacts on a grower's income. Some hybrid European Nantes type carrots have become popular with consumers yet unpopular with seed growers due to unreliable seed yields.

Very little research is available regarding nitrogen response of carrot grown for seed. The current OSU Nutrient Management Guide for hybrid carrot seed has multiple years of data tracking nutrient uptake yet has limited guidance for nitrogen response as there was only one year of field data available.

Therefore, in an effort to identify what factors could be influencing seed yield in European Nantes type carrots, an N rate field trial was conducted to access the impact of N rate on carrot seed yield in 2015. Additionally, nutrient uptake and accumulation of macro- and micronutrients will be tracked to determine if there is any interaction between N and other nutrients in the above- and/or belowground biomass. This project proposes to continue this N response and nutrient uptake experiment for another year in an effort to clarify seed yield responses seen in 2015.

Results from the N rate experiment in 2015 were mixed. One location showed decreased seed yield as N rate increased, the other location showed no clear trend in response to N rate. The location that showed no response to N rate had a history of compost and manure applications to the field and the previous crop was Timothy grass grown for hay. Most likely, the lack of response in that field was due to warm temperatures and irrigation aiding in the mineralization of large quantities of NO_3 in the soil.

The impacts of this research are not limited to carrot seed producers in central Oregon. As vegetable producers in the South Willamette Groundwater Management Area (GWMA) begin to shift their operations from producing vegetables for canning/processing to producing vegetable seeds, a broad base of knowledge will be required for nitrogen management for vegetable seed production to avoid detrimental environmental impacts in the South Willamette GWMA, such as nitrate leaching due to excessive N fertilization.

Objectives

The hypothesis of this research project is that the presence of excess N in the soil promotes greater biomass production that does not translate into an increase in seed production. Therefore,

the objectives of this research project are 1) to evaluate the response of hybrid carrot seed production to N rate applied at bolting, and 2) to track and measure the rate and timing of nutrient uptake in the above and belowground biomass of hybrid carrot plants grown for seed.

Materials and Methods

Two locations in central Oregon were selected for the trial based on summer soil tests (low soil N). Hybrid carrot variety are the same for both locations. Two irrigation methods were selected, one drip irrigated and the other furrow irrigated. Large scale plots were arranged in carrot fields in a randomized complete block design with 4 replications. Nitrogen rates will be applied at bolting: 0 lb N/a (check), 40 lb N/a, 75 lb N/a (current practice), and 110 lb N/a. Nitrogen will be applied in a furrow next to the carrot plants. Prior to plot fertilization and after harvest, deep soil cores (4ft or to bedrock) will be collected using a Giddings hydraulic probe and divided into 6 inch segments. Soil samples from 0 to 6 inches will be collected from each plot each month from fertilization until harvest, including samples collected post-harvest. The 0-6 inch soil samples will be sent to Oregon State University's Central Analytical Lab (CAL) for analysis of macro- and micronutrients. Whole plant samples (root and aboveground biomass) will be collected twice a month from all plots, randomly selecting one three-foot of row sections for female rows within each plot. Plant samples will be separated into 2 sections, roots and tops+seeds, placed into brown paper bags, and dried at 80F. Plant samples will be ground and analyzed at CAL for macro- and micronutrients. Seed will be swathed and harvested with commercial equipment and then cleaned at Central Oregon Seeds, Inc (Madras, OR).

In addition to the soil samples, data collection will include in-season plant tissue samples of carrot roots and tops from one "typical" N fertilizer rate treatment at 2-6 week intervals (adjusted for seasonal changes in growth rate) from both locations, and tested for biomass weight, dry matter content, and tissue concentrations of nitrogen, phosphorus, potassium, sulfur, magnesium, calcium, sodium, manganese, iron, zinc, copper, and boron. This information will be shared with the International Plant Nutrition Institution (IPNI) to update nutrient uptake databases on the IPNI nutrient management website, which is accessed frequently by NRCS groups throughout the US who update their own state-focused nutrient uptake databases. This information will also be available to Oregon government agencies, growers, crop consultants, etc., who have interest in accounting for seasonal flux in nutrient uptake in the determination of preplant and in-season fertilizer applications. Partitioning the plant between roots and tops will also provide new information on nutrient removal (as harvested carrot roots) and nutrient cycling (as tops remaining in the field post-harvest) from carrot production.

Literature Cited

Hart, J. and M. Butler. 2004. Hybrid Seed Carrot Nutrient Management Guide (Central Oregon). EM 8879-E. Oregon State University Extension Service.

Kumar, J.C. and K.S. Nandpuri. 1978. Effect of nitrogen and plant spacings on the seed crop of carrot (Daucus carota L.). Journal of Research 15:38–42.

Malik, B.S. and J.S. Kanwar. 1969. Spacing-cum-fertilizer studies on carrot stecklings in relation to seed production. Indian J. Horticulture 26:165–171.

Sharma, S.K. and I.J. Singh. 1981. Effect of level of nitrogen and spacing of plants on the yield of carrot seed. Prog. Hort. 13:97–100.

Acknowledgements

The authors wish to thank the Oregon Department of Agriculture and the International Plant Nutrition Institute for funding this project, Central Oregon Seeds, Inc for all of their assistance with this project, and Ekaterina Jeliazkova and Mitchell Alley for their hard work and assistance with all of the samples.

Utilizing Cover Crops in Carrot Seed Production

Tracy Wilson and Ekaterina Jeliazkova

Introduction

Carrot seed production in central Oregon generally utilizes wide rows (30 inches) and full width tillage. Full width tillage exposes the entire soil surface thereby increasing the risk of soil crusting that can adversely affect the crop (Blanco-Canqui and Lal, 2008). Soil crusting effectively creates a wall at the soil surface that can prevent seedling emergence and reduce water infiltration. One potential solution to reducing soil crusting is to plant cover crops that would protect the soil surface. Cover crops can decrease crusting by protecting the soil surface from the impact of water droplets hitting the soil surface during irrigation and rainfall events (Clark, 2008). Improving water infiltration ensures that water penetrates into the soil where it is accessible to plant roots and prevents generating excess runoff.
Another benefit of incorporating cover crop systems is the conservation of soil moisture. Since the soil surface is covered by either actively growing vegetation or by cover crop residue, this cover slows the evaporation of water from the soil. Conserving soil moisture is critical in central Oregon as drought conditions persist and snow pack is at record lows thus limiting water availability for irrigation. Despite the successful demonstration of the benefits of cover crops in other regions, adoption of cover crops into carrot seed crops in central Oregon has been slow. One major obstacle cited by growers in the region, is the lack of information regarding use of cover crops in Central Oregon. There is no information available to guide growers in selecting which cover crops work well in carrot production, or even when to plant the cover crop. The selection of cover crop species is vast and can quickly become overwhelming when trying to find which cover crop to plant. Another, equally important, concern for growers is the potential for the cover crop to produce seed that would contaminate the grower's seed crop and thereby decrease the value of the seed crop. These factors, and others, have combined to create a barrier to using cover crops that many growers simply are not willing to cross.

Materials and Methods

Experimental plots were established at the Central Oregon Agricultural Research Center in Madras, OR in July 2017. To account for any variation in the field the experiment was arranged as a randomized complete block. The cover crops and corresponding termination times tested in this experiment are listed in Table 1. Each set of treatments was replicated four times in three soil management types, no-till, strip-till, and conventional tillage. Cover crops were planted on August 7th and carrots were planted on August 16th. Soil samples were taken from the plot area prior to planting and the plot area was fertilized as needed.

Cover crop biomass samples were collected from all plots containing cover crops to measure total biomass produced just prior to the herbicide application (October 2nd) to terminate the cover crops in the designated plots. Soil moisture and temperature are being monitored throughout the study period. Winter survival of the carrots, carrot biomass, and weed pressure will be evaluated in the spring of 2018.

Table 1. Treatment descriptions.

Treatment	Termination
Mustard	Chemically terminated at flowering
Mustard	Allowed to winter-kill/Chemically Terminated in Spring
Spring Wheat	Chemically terminated at mustard flowering
Spring Wheat	Allowed to winter-kill/Chemically Terminated in Spring
No Cover	N/A

Impacts

Short-term impacts of this research include providing: proof of concept for the use of cover crops in carrot seed production and guidance for the research into how cover cropping can be refined and better adapted to the cropping systems in central Oregon.
Long-term impacts will be to provide needed guidance for growers that would like to adopt cover cropping into their carrot seed crops, and also how soil health is affected by implementing cover crops into central Oregon agriculture. This research has the potential to aid growers in making the decision to implement cover cropping and thereby reducing soil erosion, improving water infiltration into the soil, and improving soil health.

Acknowledgements

The authors wish to thank Hoyt Downing for all of his assistance in planting and maintaining the study area, Kurt Feigner for his advice regarding this project, and Central Oregon Seeds, Inc. for providing in-kind support.

References Cited

Blanco-Canqui, H, and R Lal. 2008. *Principles of Soil Conservation and Management*. Springer Netherlands. https://books.google.com/books?id=Wj3690PbDY0C.

Clark, A. 2008. *Managing Cover Crops Profitably (3rd Ed.)*. DIANE Publishing Company. https://books.google.com/books?id=ahxLEpn6WYwC.

Central Oregon Potato Extension Program, 2017

Heike Williams, Carol Tollefson, Jeremiah Dung

Abstract

Aphids, potato psyllids, and beet leafhoppers were collected and counted weekly in Jefferson County from June 19 to September 5, 2017, and tuberworm moths from June 19 to September 19, 2017. Counts were conducted to monitor pest populations and assess potential risk of disease transmission. 2017 is the second season of including beet leafhoppers in the monitoring program. Collection methods included fifteen water buckets 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 over the entire 2017 monitoring season were at a similar level as 2015 not repeating the high detection level of 2016. Numbers for green peach aphids (GPA) peaked in the week ending July 14 and July 26 with a mean of 20 GPA per trap and then dropped sharply for the remainder of the season to levels below a mean of 4 GPA per trap. Potato aphid (PA) detection increased from the beginning of the monitoring season to a mean of 7 specimens per trap in the second half of July followed by low weekly levels of less than 10 total PA in all traps (mean of less than 1 specimen per trap) until vine kill.

Potato tuberworm moth (PTW) detection was low. Single PTW were identified twice during the length of the monitoring period. Counts of potato psyllids and beet leafhoppers also remained low. All specimens of both potato psyllids and beet leafhoppers tested negative for pathogens. Early blight prediction modeling and crop water use data provided helpful information for seed potato management.

Methods and Materials

1. 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). Weekly monitoring of aphid traps serves as tool to determine when aphid populations are increasing and when field treatment becomes necessary.

Fifteen yellow buckets filled with water were used as traps to collect winged aphids in commercial potato fields throughout Central Oregon. Traps were distributed on June 19 and 20, 2017 with final collection occurring on September 5, 2017 at the end of the week 11 of the monitoring period. 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 and identified as green peach aphids, potato aphids or other aphids using a microscope. Aphids were stored in vials filled with alcohol, if necessary. On occasion, samples were sent to the Hermiston Agricultural Research and Extension Center (HAREC) for confirmation purposes. Date and location were used to identify aphid movement in the 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 the edge of planted ground in fifteen commercial potato fields from June 19 to September 19. 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.

Unlike traps for other pests, delta traps stayed in place throughout the vine kill until harvest which occurred in weeks 12 and 13 of the monitoring period (September 5 to 19).

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 19 and 20, 2017 fifteen yellow sticky traps were distributed in commercial fields and left until the vines were killed. 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. Vine kill and subsequent sticky card removal started August 22 and ended September 5.

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 measuring 4"x6" were placed at the edge of fifteen commercial fields 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. Sticky card placement and removal followed the same schedule as for aphid and psyllid traps (June 19 to September 5).

2. **Generate early blight prediction model and weekly water use data information.**
   Weekly early blight prediction models were published using observed 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.
   Water use data information was included in the weekly newsletter using daily evapotranspiration data published by the Bureau of Reclamation https://www.usbr.gov/pn/agrimet/. The information is intended to assist growers in irrigation management decisions. 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.

3. **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 21 that included the early blight prediction model, weekly water use data, weekly aphid identification, as well as of potato tuberworm moth, potato psyllid, and beet leafhopper, and population numbers. 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.

Accomplishments

Aphids. Aphid population in central Oregon ranged from to zero to 168 total aphids per trap compared to a maximum of about 490 total aphids in 2016. The number of all aphids identified throughout the monitoring period (1996) returned to the level in 2015 (2052), therefore not repeating the high numbers of the previous year (total of 6958 aphids in 2017).

Looking at weekly population levels, total numbers of aphids increased during the month of July from 117 aphids (mean of 8 aphids per trap) to a peak of 546 aphids in the week ending July 24 (mean of 36 aphids per trap). Starting in the week of July 31 total numbers dropped below 100 and continued to drop throughout August with a slight but not significant rise at the end of August/beginning of September (Fig 1).
The population curve of green peach aphids (GPA) and potato aphids (PA) paralleled in most parts the curve of total aphids with green peach aphid numbers being 28% and potato aphids 15% of total aphids (Fig.2). Both population numbers of GPA and PA were highest in week 5 (July 17 to 24) with numbers of 294 and 111, respectively, and a mean of 20 and 7 aphids per trap (Fig.3). Detection of GPA dropped sharply starting week 6 (week ending July 31), with the drop of the PA population following a week later. The population of Other aphids (OA) peaked

slightly earlier with numbers of just below 200 in all traps in weeks 3 and 4 (July 3 to 17) and a mean of 13 aphids per trap. Following those weeks, OA numbers steadily dropped to very low levels (mean of 1 aphid per trap in the week ending August 22). At the end of August and the beginning of September vines of the later varieties had not been killed yet. Of those locations a few had higher OA numbers (3 of 5 fields in week 10 and one of three fields in week 11) which explains the rise in the graph of mean numbers of aphids (Fig. 3).

Potato Tuberworm. First identification of potato tuberworm moth (PTW) in Central Oregon occurred in August 2013 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 2017 the presence of PTW was so low that most weeks no moths were caught in the traps. Single PTW were only found twice, in the middle of August (week 8-7 to 14) and the beginning of September (week 8-29 to 9-5). This means a return to the level of 2015 and a decrease from the previous year where PTW numbers had reached a high of 28 specimens in all traps at the end of August and levels of 7 to 10 in September.

Potato Psyllid. In 2017, potato psyllids were found at a much lower level compared to the previous year. Most weeks starting in mid-July, a single psyllid was trapped in only one of fifteen fields, the exception being the week of August 15 to 22 where single psyllids were identified in three fields. This is a fortunate contrast to 2016, where in the period of July 26 to the time of vine kill total numbers of psyllids averaged 66 insects per week with a mean of 4.4 specimens per trap. All psyllids detected in 2017 were sent to OSU-HAREC for Lso testing. All tested negative.

Beet leafhopper. In 2017, similar to 2016, beet leafhoppers were found in multiple fields throughout the monitoring period at low infestation levels (1 to 10 BLH per trap). The numbers of fields where BLHs were identified each week ranged from 1in 15 to 7 in 15. Most yellow sticky card trapped one, occasionally two beet leafhoppers. The highest number of specimens found on a single sticky card was four. All BLH specimens were sent to HAREC for BLTVA phytoplasma testing. All tested negative.

Early blight prediction model. May 29 and June 7 were the dates used as emergence dates. 2017 emergence dates were 4 days later compared to 2016 and 3 days earlier compared to 2015 and prior years. Fields emerging May 29 and June 7 accumulated 300 P-days by July 18 and July 31, respectively. The newsletter alerted farmers to the recommendation of fungicide application for varieties susceptible to Early Blight.

Impacts:

Weekly aphid reports were sent to growers, fieldmen and industry participants by email and were made available at 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 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 assists 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. For a second year, compound samples of beet leafhoppers were tested for BLTVA phytoplasma by OSU-HAREC. 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.

Relation to Other Research:

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.

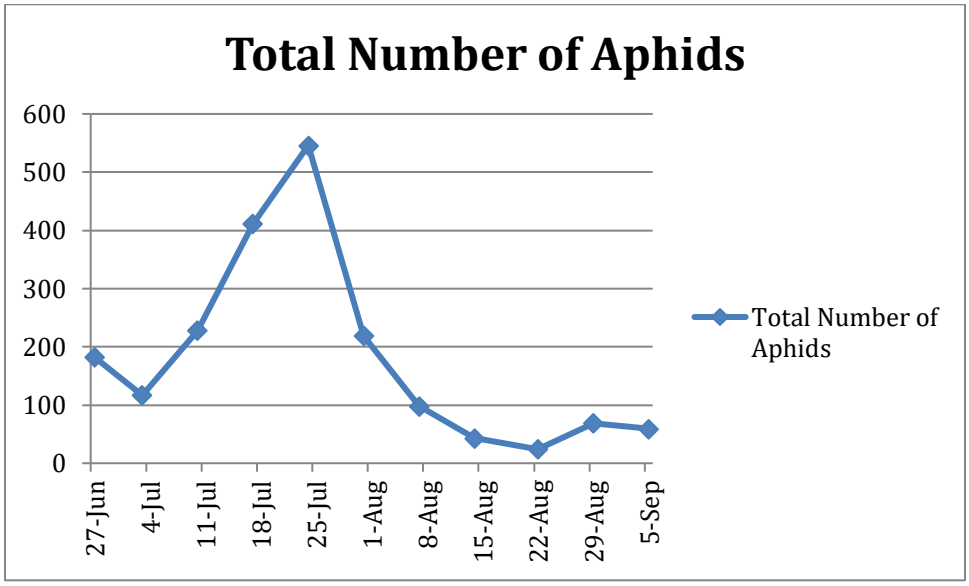

Fig. 1. Total number of aphids trapped in commercial fields in Jefferson County, Oregon 2017

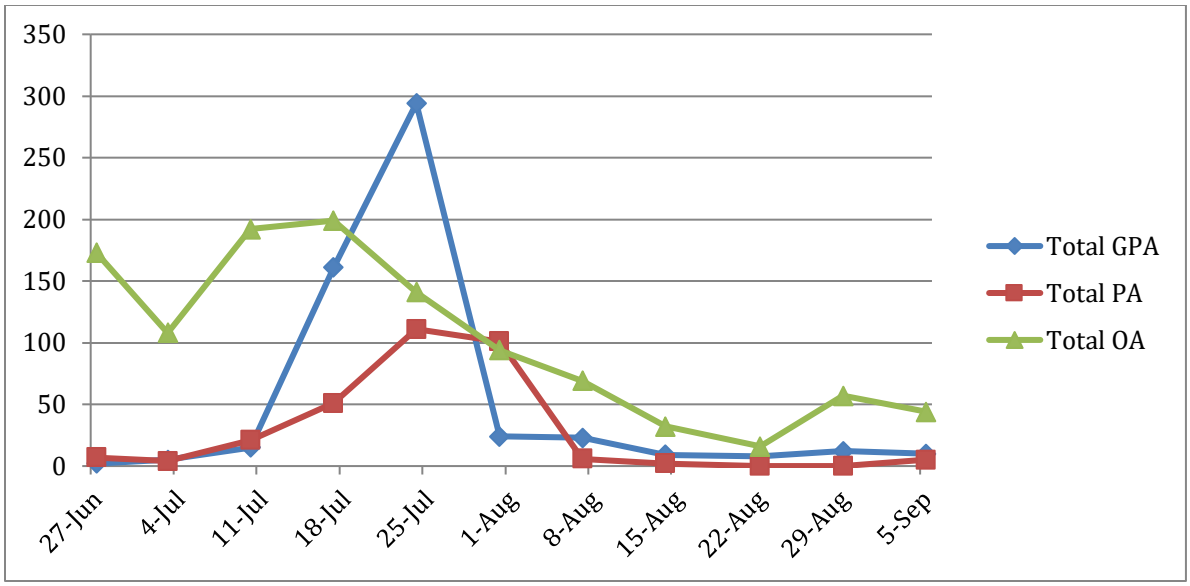

Fig. 2. Total number of aphids per type in commercial fields in Jefferson County, Oregon 2016 (GPA=Green Peach Aphids, PA=Potato Aphids, OA=Other Aphids)

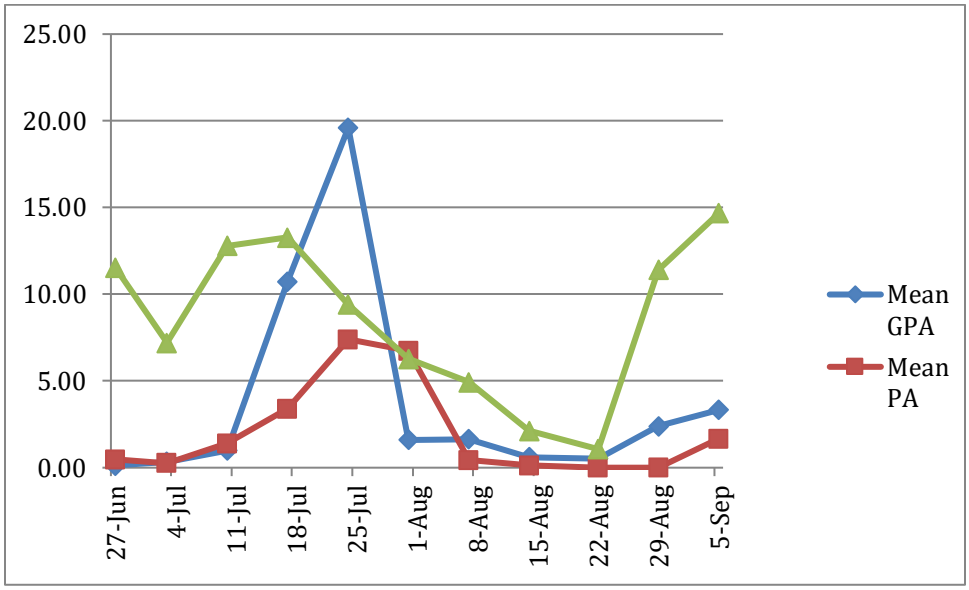

Fig. 3. Mean number of aphids per trap by type in commercial fields in Jefferson County, Oregon 2016 (GPA=Green Peach Aphids, PA=Potato Aphids, OA=Other Aphids)

Pilot Balloon Observations, 2017
Jefferson County Smoke Management

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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. They are released daily from the Central Oregon Agricultural Research Center between 10:30 am and 3:30 pm. Releases at potential burn sites allow for more accurate decision-making under marginal conditions. The PIBAL is essential in minimizing adverse smoke impacts on local communities.

Introduction

The PIBAL program began in 1998, and incorporates the weather balloon data into information the Jefferson County Smoke Management Coordinator receives 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 real time wind patterns, wind speed and wind direction information for the Smoke Management Coordinator to determine whether burning will be allowed.

Materials and Methods

Daily balloon releases occurred on demand throughout the day. 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. The software program, PIBAL Analyzer, developed by the Oregon Department of Agriculture (ODA) analyzes PIBAL information, which includes three components. The first is 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. The second is the Hodograph, which charts the wind direction. The Profile page, the third component, graphs the wind speed. The PIBAL soundings are entered into the PIBAL Analyzer and transmitted to the Jefferson County Smoke Management website for the Smoke Management Program Coordinator. The Coordinator then uses this data in conjunction with the daily aircraft soundings and the ODA Weather Center forecast as well as the ODA's Air Quality Monitor to determine the field burning status for the day.

Results and Discussion

During the open field-burning season, which began Monday, July 24th and ran through Friday, September 22rd. Farmers burned a total of 8,300 acres, which included 6,850 acres of grass and 1,450 acres of wheat. This was 1,400 acres more than the previous year. There were 1,360 more acres of grass burned this year. There was 40 less acres of wheat burned than the year before. In the 2017 burn season smoke from wildfires made field burning very difficult.

Daily balloon releases in the late morning and throughout the day were used to refine the weather forecast; it was a valuable tool for determining the mixing height for smoke during the optimal burn times. Though, the wildfire smoke was so thick for weeks we had a hard time following the PIBALL. The PIBAL provided the only method to detect the stable air layers. The PIBAL is particularly helpful on marginal burn days to assist the Smoke Management Coordinator in making the decision whether to allow burning when conditions were either changing or hard to discern. It is on these marginal days, when the conditions are unclear, that the most risk for smoke intrusion into populated areas exists.