Special Report 969
February 1997

Central Oregon Agricultural Research Center Annual Report, 1996

Agricultural Experiment Station
Oregon State University

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UPDATE 1996 -- http://www.orst.edu/dept/coarc/

Fred Crowe, Superintendent, COARC

For three years, we have published the hard copy of this annual report in time to be distributed to local clientele during the Central Oregon Farm Fair. This two-day event is held sometime between the 5-12th of February each year. In earlier years, our deadline was our main summer field day in June or July, when we also could expect many of those interested in the University's local efforts to be on hand at a common setting. We found, however, that farmers and field persons were too busy during the summer for our reports to be read. If available in February, there still is time for farmers to glean the latest information on variety or pesticide performance, or on management practices, prior to the spring farming activity. Even more ideal would be publication of the previous year's data during the late summer or fall, prior to fall planting decisions, but there simply is not time enough to collect, summarize and analyze data, write a report, consolidate and edit the various reports collected from numerous contributors and published prior to about February 1st. Most ideal would be a constantly updated set of reports, but more about that below. At this writing, we are not sure we will meet the 1997 Central Oregon Farm Fair deadline for publishing, but we are trying. If not, we should have these reports available by early March when the Central Oregon Vegetable Seed Production Conference meets. Fortunately, most of the audience for this gathering is the same as that which comes to the Farm Fair.

Along with the rest of the world, the University and many of our clientele are becoming highly computerized. Oregon State University and all of its component departments and branch research stations now have home pages on the internet. The World Wide Web home page address for the Central Oregon Agricultural Research Center appears as the title to this introduction. As we develop reports of research progress, and final reports, these are being entered onto our home page site so that they may be available and updated as soon as possible. Our home page is not quite as fully developed as it will be, but we hope you find it increasingly useful as it improves. Eventually, you will find the individual research reports regularly updated as soon as information can be compiled and evaluated

The internet also makes such information from many sources more widely available and more quickly than before. For example, I recently browsed the internet by searching a few key words and accessed an Australian newsletter on new crop development with information on research on coriander, garlic and peppermint, along with many other crops unlikely to be of interest here (but who knows?). Not only was I able to see what was being done in that country on these crops, but I quickly found who was funding and conducting the research in progress. In the "old days", it would have taken great time and effort to discover this information, if I found it at all. For those interested, the newsletter's internet address is: http://www.uq.oz.au/~gagkrego/newslett/nc-14.htm

Of course, with rapid and highly available information flow, if you are not actively looking you won't find it, whereas those who do look will find it. People in every profession risk not keeping up with useful information if they aren't looking. This is true for scientists as well as farmers, seed companies and field persons. The trade off is that searching for new information costs time, and forces us to acquire modern skills in information management. We in agriculture at Oregon State University remain dedicated to assisting in developing and delivering information to Oregon agricultural industries. Developing information will remain hard work. Delivering it, and accessing it should be getting easier. One of these days, perhaps sooner than we think, maybe we will no longer need a written form of our annual report.

Station Staff in 1996

State-supported staff:

Dr. Fred Crowe, Superintendent, and Associate Professor of Botany & Plant Pathology

Dr. Alan Mitchell, Assistant Professor of Crop and Soil Science (75% research and 25% extension on soil and water issues)

Mylen Bohle, Assistant Professor, Crook County Extension (75% extension and 25% research on forages)

Marvin Butler, Assistant Professor, Jefferson County Extension (75% Extension and 25% research on mint, grass seed and specialty crops)

Steve James, Senior Research Assistant (75% research and 25% extension of potatoes)

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Kelli Muskopf, Office Coordinator

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Jody Nartz, Student Technician

Christine Locke, Student Technician

Michelle Fox, Student Technician

Andrew Earnest, Student Technician

Casey Foltz, Student Technician

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Madras, Oregon
1996 Water Year
(source AgriMet)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
AIR TEMPERATURE (°F)												
AVE. MAX. TEMP.	61	54	40	42	43	52	60	62	76	88	85	72
AVE. MIN. TEMP.	36	36	28	29	25	32	37	39	44	52	51	42
MEAN TEMP.	48	45	34	35	33	42	48	50	60	71	68	57
AIR TEMPERATURE (No. of Days)												
MAX. 90°F OR ABOVE	0	0	0	0	0	0	0	0	0	17	12	0
MAX. 32°F OR BELOW	0	0	10	4	5	0	0	0	0	0	0	0
MIN. 32°F OR BELOW	9	4	23	20	16	15	9	7	0	0	0	2
MIN. 0°F OR BELOW	0	0	0	0	3	0	0	0	0	0	0	0
GROUND TEMPERATURE (°F at 4")												
AVE. MAXIMUM	52	47	41	40	40	43	49	53	60	67	65	59
AVE. MINIMUM	50	45	40	39	38	41	46	50	57	63	62	57
GROUND TEMPERATURE (°F at 8")												
AVE. MAXIMUM	53	47	42	40	40	42	48	52	59	65	65	59
AVE. MINIMUM	52	46	41	40	39	41	47	50	57	63	63	58
PRECIPATATION (inches)												
MONTHLY TOTAL	0.34	1.06	1.95	1.41	1.84	1.17	0.68	1.37	0.41	0.17	0.00	0.78
EVAPORATION (inches)												
AVE. PER DAY	0.09	0.04	0.02	0.03	0.04	0.07	0.13	0.18	0.27	0.34	0.31	0.18
WINDAGE (miles)												
AVE. PER DAY	121	151	124	146	145	126	153	120	107	116	130	109
SOLAR RADIATION (langleys)												
AVE. PER DAY	250	115	88	118	203	302	401	549	672	680	588	451
HUMIDITY (percent relative humidity)												
AVE. PER DAY	65	79	89	83	81	74	68	69	59	46	44	59

GROWING SEASON	**Last Day Before July 15**	**First Day After July 15**	**Total Number of Days Between Temp. Min.**
AIR TEMP. MIN.			
32°F or below	May 10	September 22	134
28°F or below	May 9	October 16	159
24°F or below	March 26	October 21	208

Powell Butte, Oregon
1996 Water Year
(source AgriMet)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
AIR TEMPERATURE (°F)												
AVE. MAX. TEMP.	59	53	42	42	44	52	58	59	71	83	81	69
AVE. MIN. TEMP.	33	34	26	27	24	29	33	35	39	47	46	38
MEAN TEMP.	46	44	33	35	34	40	46	48	57	67	64	54
AIR TEMPERATURE (No. of Days)												
MAX. 90°F OR ABOVE	0	0	0	0	0	0	0	0	0	6	8	0
MAX. 32°F OR BELOW	0	0	5	3	8	0	0	0	0	0	0	0
MIN. 32°F OR BELOW	14	11	24	21	22	22	16	13	3	1	0	7
MIN. 0°F OR BELOW	0	0	0	1	1	0	0	0	0	0	0	0
GROUND TEMPERATUE (°F at 4")												
AVE. MAXIMUM	52	46	39	38	38	42	48	55	61	69	68	61
AVE. MINIMUM	49	44	38	37	37	39	44	50	57	63	63	56
GROUND TEMPERATURE (°F at 8")												
AVE. MAXIMUM	49	43	37	35	38	38	44	50	51	54	60	58
AVE. MINIMUM	48	42	36	35	35	37	42	48	49	50	57	55
PRECIPATATION (inches)												
MONTHLY TOTAL	.40	0.92	2.51	1.27	0.89	0.91	0.90	1.82	3.62	0.84	0.06	0.25
EVAPORATION (inches)												
AVE. PER DAY	0.11	0.05	0.03	0.04	0.05	0.08	0.13	0.17	0.24	0.30	0.26	0.15
WINDAGE (miles)												
AVE. PER DAY	111	139	123	150	144	112	142	122	105	98	102	84
SOLAR RADIATION (langleys)												
AVE. PER DAY	257	115	107	124	205	303	375	493	541	588	498	382
HUMIDITY (percent relative humidity)												
AVE. PER DAY	63	74	84	75	76	71	65	68	60	51	50	62

GROWING SEASON	**Last Day Before July 15**	**First Day After July 15**	**Total Number of Days Between Temp. Min.**
AIR TEMP. MIN.			
32°F or below	July 5	September 6	64
28°F or below	June 19	September 21	93
24°F or below	May 9	September 23	137

FALL NITROGEN FERTILITY OF PEPPERMINT

Alan Mitchell and Charissa Yang

Abstract

Nine rates of nitrogen fertilizer were applied on an established peppermint field after harvest in August 1995, to determine whether nitrogen increases fall vigor and subsequent yield of peppermint. Stems and leaves tested in December 1995 showed no response to nitrogen, but rhizome mass was greater for the 60 and 80 lb/ac treatments. Plant nitrogen concentration and etiolated growth measurements did not differ by treatment. Subsequent dry matter and oil yield (70 lb/ac) were also unaffected by nitrogen treatment. Because of the mild winter of 1996, which permitted good survival of rhizomes, more trials are needed to substantiate whether there is a peppermint yield response to nitrogen applied after harvest.

Introduction

While the extent of nitrate leaching under peppermint is highly dependent on the soil inorganic nitrogen (N) at the end of the growing season prior to the rainy winter season, a 1992 survey of peppermint growers showed a high correlation of fall fertilization to increased yields. If fall N fertilization is shown to increase yield the following year, and more growers adopt the practice, then nitrate leaching may be increased. Thus it is important to find the rates and conditions when fall N fertilization may be profitable.

The objective of this study was to determine whether post-harvest N fertilizer application increased the vigor and yield of peppermint. Measurements were taken in the fall after fertilization, in mid-summer, and at harvest the following August.

Materials and Methods

Nine rates of nitrogen (0, 20, 40, 60, 80, 100, 120, 140, and 160 lb/ac) were applied to 27 plots (6 ft by 15 ft) in 3 replications (Fox, 1973). This experimental design was used earlier on studies of peppermint response to nitrogen in the spring (Mitchell and Farris, 1996). Nitrogen fertilizer was applied on 10 August 1995 as ammonium nitrate.

On 15 December 1995, above- and below-ground peppermint was sampled from $1ft^2$ areas within each plot. Samples were washed with water and separated into leaf, stem (above-ground), and rhizome/root (below-ground) components. Dead matter was discarded. Leaf, stem, and rhizome/root sample components were oven-dried at 130 °F. Samples were weighed, ground, and analyzed for total Kjeldahl nitrogen.

On 14 March 1996, rhizomes were sampled from the 0, 80, and 160 lb/ac treatments by taking rhizomes from section approximately 1-ft wide, 2-ft long, and 4-inches deep. Rhizomes were washed, trimmed, weighed, tagged, treated with fungicide, buried in moist vermiculite and placed in a dark room according to the procedure of Mitchell and Rechel (1997). Four to five weeks later, when growth had ceased, rhizomes were weighed again to determine the non-structural biomass (NSB) expended by the plant for regrowth.

On 31 July 1996, above-ground plant samples consisting of 10 single stems per plot were taken for stem and leaf measurements. Stem length was measured from soil surface to tip of topmost leaf. Number of leaves directly attached to the main stem and number of leaves attached to branches were counted separately. Fully-expanded leaves and terminal clusters of leaves (including three or more small leaves) were counted as single leaves. Presence of buds was noted. Numbers of branches and of leafed and non-leafed nodes were recorded. Dry weight measurements of stems and leaves were taken.

Harvest occurred 15 August 1996. Plots were cut with an experimental plot harvester. Samples from a 40-inch by 15-ft strip from the center of each plot were weighed fresh for biomass determination. One 10- to 12-lb subsample from this strip was weighed fresh and reserved in a burlap sack for oil analysis, and a second, approximately 0.5-lb subsample was weighed both fresh and dry for percent dry matter determination. To ensure accurate fresh weight measurements, fresh weights were recorded without delay after sampling. Burlap-sack samples were kept outdoors under shelter and turned periodically to allow dissipation and even distribution of moisture before distillation. Oil was distilled directly from burlap-sack samples using the mini-distillery apparatus at the Hyslop farm, Corvallis, OR.

Results

Stem and leaf mass taken 15 December 1995 did not vary significantly among treatments (Figure 1). Rhizome mass, however, appeared to increase with nitrogen application rate through 80 lb/ac and decline with application rates above that level. Rhizome mass was significantly effected ($P \leq 0.02$) by N according to Tukey's ANOVA test. The highest response was for the the 80 lb/ac N treatment which was significantly greater than five of the other treatment levels, according to Fisher's mean comparison test, $P \leq 0.05$. Stem, leaf, and rhizome nitrogen contents were not different between treatments. Etiolated growth measurements, taken in March, did not differ significantly between treatments, although higher N application was associated with higher non-structural biomass and etiolated growth (Table 1).

The July plant sampling likewise revealed little differences in plant growth. The August harvest produced no differences for N rate, with a mean of 2.32 t/ac dry matter and 70 lb/ac oil yield. The mild winter of 1996 likely had no detrimental effect on winter survival of rhizomes, and this may have produced similar yield for all treatments.

Discussion and Conclusion

More trials over several years are needed in order to make reliable conclusions. More severe winters may profoundly influence the survival rates of peppermint rhizomes with different health. If this study's finding on the fall rhizome response to moderate N is real, then there are unanswered questions. Why did the rhizomes not respond to N above the 80 lb/ac rate? Why was the N content of rhizomes not higher for the 60 and 80 lb/ac levels? And ultimately, will fall nitrogen improve winter survivability of rhizomes.

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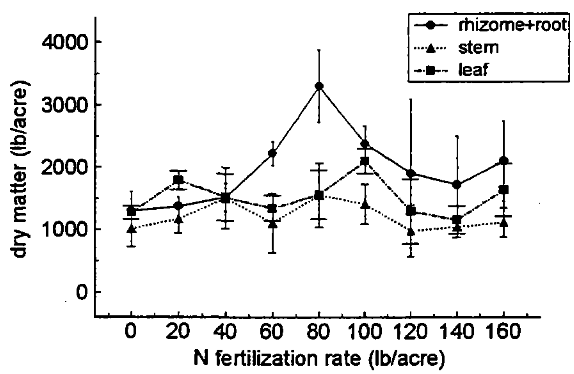

Figure 1. Leaf, stem, and rhizome-and-root dry matter taken 15 December 1995, Madras, OR.

Table 1. Etiolated growth measurements of rhizomes sampled 15 March 1996, Madras, OR.

Treatment (lb/ac fall-applied N)	Non-Structural Biomass (g/kg)	Etiolated Growth (g/kg)
0	656±210*	261±195
80	751±303	344±216
160	846±33	660±232

*arithmetic mean ± standard error

PEPPERMINT RHIZOME STUDIES

Alan Mitchell and Eric Rechel.

Abstract

*Once established, peppermint (*Mentha piperita, L*) grows anew from rhizomes each spring. Thus, it would be useful to develop methods to measure the energy stored in the peppermint rhizomes for regrowth. Etiolated growth measurements of non-structural biomass (NSB) have been shown to be effective for alfalfa taproots. Our objective was to compare NSB by this method with measurements of carbohydrate. Rhizomes were sampled monthly from four locations throughout a growing season. NSB was correlated (r=0.74) with the total nonstructural carbohydrate (TNC), and either method could be used to study energy storage, although the NSB was more sensitive to seasonal changes, and less technically demanding. Both NSB and TNC decreased in summer and increased in the fall as the plants stored carbohydrate for winter survival and regrowth.*

Introduction

Peppermint spring regrowth and subsequent yield are presumably dependent on the health of the rhizomes that survive winter, as observed previously (Mitchell, 1994). In this respect, peppermint is analogous to alfalfa (*Medicago sativa*, L), and considerable research has established the storage of non-structural carbohydrates as an important parameter in stand longevity and productivity (Heichel et al., 1988; Sheaffer et al., 1988). As in alfalfa, methods to evaluate non-structural carbohydrates of peppermint rhizomes would be useful for studying the effect of harvest timing and other agronomic practices. Because peppermint is planted from rhizomes, a test for regrowth potential would be useful for comparing rhizomes from different locations or treatments. Standard methods of sugar and total nonstructural carbohydrate (TNC) analysis may be helpful, and newer methods should be considered, such as NIR spectroscopy and etiolated growth.

Etiolated growth of alfalfa has been proposed as a simple, inexpensive way to measure the non-structural biomass of alfalfa taproots (Rechel, 1993), that may be useful for peppermint rhizomes. Burton and Jackson (1962) used etiolated growth to measure the NSB of sod, and later updated the method to take direct measurements in the field (Burton, 1995). The measurement of NSB by etiolated growth has advantages of simplicity as well as cost, because it requires only a balance, a dark room, and containers.

The objectives of this study were to develop methods for measuring etiolated growth as a means of estimating non-structural biomass of peppermint rhizomes, and to compare NSB to measurements to laboratory measurements of TNC for the growing season.

Materials and Methods

On 13 April 1995, four plots (1 m by 10 m) were chosen from an established field of 'Murray Mitcham' peppermint that had been planted in March 1994. The field had never been harvested. Plots were selected by visual inspection for uniform stand density. Sampling was repeated 25 May, 20 June, 20 July, 16 August, 14 September, and 12 October. Peppermint harvest occurred on 13 August.

Samples were dug from randomly selected areas of each replication. Each sample was dug from a 300 by 800-mm rectangle to a depth of 100 mm, and included rhizomes that were at least 200-mm long. Soil was washed from the samples, then eight rhizomes of at least 200-mm length were chosen from the sample. Fine roots and green stems were removed from all rhizomes. Four additional rhizomes (50 to 150-mm long) were also taken from the sample and freeze-dried for later analysis.

To estimate moisture content of each of the rhizomes, a 30-mm segment was removed, weighed fresh, dried in an oven at 75 °C overnight, and weighed again. The remaining rhizome was treated with fungicide by placing in a 1-L beaker of 6.0 g/L of pentachloronitrobenzene (PCNB, Terraclor 75 percent wettable powder, Uniroyal) for five minutes. Rhizomes were then planted 80 mm deep in trays of moist vermiculite, and placed in the dark at room temperature.

Etiolated rhizomes were observed periodically for an endpoint for growth, usually manifest by a blackening of the tip of the etiolated stem after four to five weeks. The plants were then separated into rhizomes or etiolated growth (comprising the newly developed shoots and roots), and the NSB (g/kg) was calculated as the difference between the initial and final dry mass divided by the initial dry mass. Etiolated growth (g/kg) was calculated as the dry mass of the

Table 1. Correlation matrix for etiolated growth, sugars, extracted sugars, TNC, nitrogen, and NSB collected at Madras, OR, in 1995. Values presented are means of all replications for a single date.

	Etiolated Growth	TNC	Soluble Sugar	Extracted Sugar	Nitrogen
NSB	0.62	0.74	0.51	0.45	0.72
Etiolated Growth	1	0.37	-0.05 (0.92)[1]	0.84	0.91
TNC	...	1	0.88	0.21	0.53
Soluble Sugar	...	...	1	-0.28	0.13
Extracted Sugar	...	...	...	1	0.79

[1]**the number in parentheses refers to correlation excluding the October data—see text.**

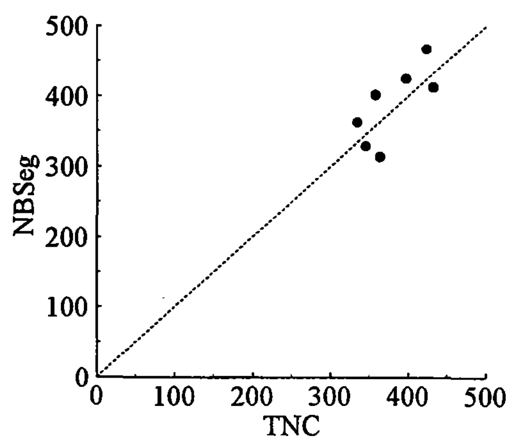

Figure 1. NSB vs. TNC.

growth divided by the initial mass. There may have been a problem in the data for the October rhizomes, which were inadvertently neglected towards the end of the growth cycle, and dried out before sampling. Some etiolated roots were difficult to remove from the vermiculite aggregates, possibly resulting in underestimates of mass etiolated growth. The associated rhizome sampling, and the NSB data which is not based on the direct measurement of mass etiolated growth, however, were not affected.

The four freeze-dried rhizomes of each replication were ground on a fine sieve prior to lab analysis. Soluble sugar content was determined by the method of Candolfi-Vasconcelos and Koblet (1990). TNC was measured after extraction with 1 M perchloric acid. The additional sugars that were detectable after extraction normally represents starch in most plants, but peppermint stores carbohydrate as fructan and in other forms. Here, this fraction will be referred to as "extracted sugars."

Correlation analysis was perfomed on Minitab (Minitab, Inc., State College, PA) according to the Pearson product moment.

Results and Discussion

Our hypothesis that NSB was related to measurements of TNC was supported by a high correlation coefficient (r=0.74) between the measurements (Table 1). Furthermore, the absolute value of NSB and TNC are very similar, as shown in the comparison in Figure 1. The NSB measurements were more sensitive than the TNC values in that they were slightly higher than TNC for the greatest values, and slightly lower for the lowest.

The correlation between other measurements provide interesting insights. The TNC values were well correlated to soluble sugar (r=0.88), which may be expected for a component of the whole. TNC was not as well correlated with extracted sugar (r=0.21), suggesting that soluble sugars provided most of the variability in TNC in this study.

The N content of the rhizomes were well correlated with parameters of NSB (r=0.72), etiolated growth (r=0.91), and extracted sugars (r=0.79). In spite of these high correlation coefficients, we should not conclude that rhizome N content was the cause of the NSB or etiolated growth; such a correlation only shows that rhizome N level and other measurements varied synchronously. However, the high correlation between N and etiolated growth suggests that more experiments of rhizome regrowth with N as a treatment variable may provide useful information.

The NSB and TNC behaved in a similar fashion throughout the season (Figure 2), with high values in the spring followed by a decline in the summer, and an increase in the fall. This pattern is similar to the carbon assimilation of alfalfa and many crops, wherein the plant directs carbohydrate toward growth in the spring and toward storage in the fall (Heichel et al., 1988). Unlike alfalfa, which responds to harvests by

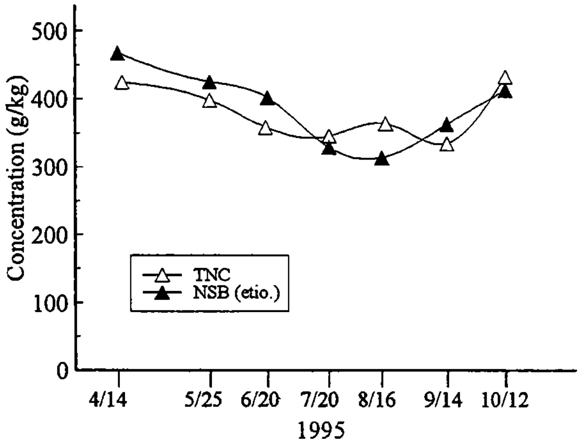

Figure 2. NSB compared to TNC throughout 1995, Madras, OR.

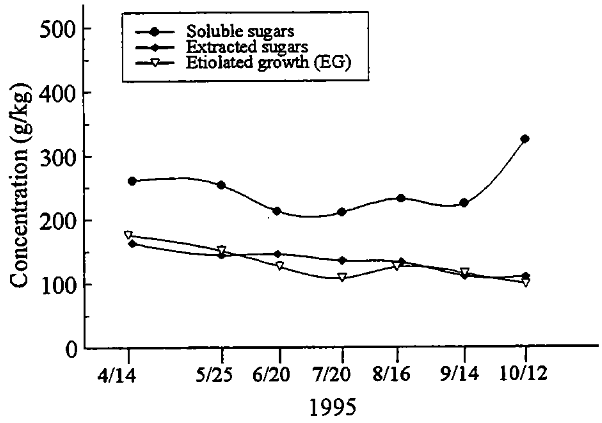

Figure 3. Soluble sugars and extracted sugars throughout 1995, Madras, OR.

initiating the storage phase of its carbohydrate cycle, peppermint NSB decreased throughout the summer even though it was not harvested until August.

The harvest that occurred just prior to sampling on 16 August produced some interesting effects on soluble sugars and etiolated growth (Figure 3). Both etiolated growth and soluble sugars increased from July to August, but then declined again in September. In contrast to soluble sugars, extracted sugars seemed unaffected by harvest and barely increased in October (Figure 3.) It is possible that the rhizome soluble sugar concentration declined in September due to the harvest that necessitated regrowth, only to increase drastically in October after the plant had grown to the point where it could replenish soluble sugar in the rhizomes. Etiolated growth also increased briefly in August, then declined in September. The measurement error in October, mentioned earlier, could have given an artificially low number for etiolated growth, which presumably would have increased drastically in a manner like the NSB data. If we delete the October data, the soluble sugar to EG correlation becomes 0.92! Evidently, both the etiolated growth and soluble sugar change similarly throughout the growing season.

In conclusion, the method of using etiolated growth was developed with some modifications from an alfalfa-NSB method. NSB of peppermint rhizomes was similar to TNC measured throughout a growing season. The measurement of NSB was technically less demanding than TNC in that it required only simple measurements and equipment (a balance, trays with vermiculite, and a dark room.)

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RELAY INTERCROPPING IN PEPPERMINT

Alan Mitchell and Charissa Yang

Abstract

Relay intercropping with peppermint may be a viable alternative to conventional monocropping practices. Potential benefits include the prevention of nitrate pollution of groundwater, and the utilization of excess, after-harvest nitrogen in the production of a secondary crop that would be interplanted into the peppermint. Earlier field trials showed some promise with a variety of crops, of which five were selected as 'companion' crops in this study. 'Belford' barley performed best, followed closely by 'Monida' oat and then 'Gwen' barley. 'Wheeler' rye was less impressive than the barley and oat, but still resulted in peppermint oil yields equivalent to those of the control (non-intercropped) peppermint. In fact, of the five intercropping treatments, only that of the 'Humus' rape resulted in any measurements inferior to that of the control. In terms of dry matter, plant stand characteristics, and oil yield, the treatments in which peppermint was intercropped with cereals were equal to or outperformed the control treatment peppermint. More studies should be performed to confirm and explain these results.

Introduction

Peppermint (*Mentha piperita*) requires high nitrogen inputs and late-season irrigation in order to be economically productive in the Pacific Northwest, USA. Because of the input-intensive demands of peppermint, and the shallow soils common to the geographical regions in which it is grown, the potential for loss of nitrogen as nitrate to groundwater is high under peppermint. In this study, various intercropping systems were implemented in order to investigate their potential as alternative, nitrogen-conserving management practices for peppermint production.

There are many types of intercropping; in each case, several crops that benefit the system in some way are planted to the same area. In our study, secondary crops were planted into peppermint stands to test their effectiveness as nitrogen "catch crops," which were intended to grow vigorously only after the primary crop, peppermint, was harvested, so that they would use excess soil nitrogen during the period between the growing seasons for the primary crop. Because the maturity and harvest dates for the primary and secondary crops are widely staggered, this type of intercropping is called relay cropping. Competition between the crops is largely avoided, and more nitrogen is conserved than would be under a typical monocropping system.

Intercropping often provides many other secondary benefits to the crops involved. Erosion may be minimized, due to less soil exposure during the "off" season for one crop in which the other crop is growing. Insect pests may be better controlled through the provision of habitats for pest predators. A taller canopy provided by one crop may protect the second, later-emerging companion crop from frost.

Methods and Materials

Fertilizer, pesticide, irrigation, and other management, excluding the experimental treatments, were applied according to standard procedures for peppermint. The herbicide 'Sinbar' (terbacil) was not applied to the peppermint in the year prior to planting of relay crops.

Five crops, 'Humus' rape (*Brassica rapa*), 'Wheeler' rye (*Secale cereal*), 'Belford' barley (*Hordeum vulgare*), 'Gwen' barley (*Hordeum vulgare*), and 'Monida' oat (*Avena sativa*), selected for their superior performance in a screening trial (Mitchell, 1995), were seeded into already-established peppermint at rates recorded below on 10 August 1995 (Table 1). These secondary crops will be generally referred to as 'companion' crops in this paper. Planting rates and row widths were those suggested by experience from the screening trials (Table 1).

Table 1. Seeding rates of companion crops interplanted into peppermint as experimental treatments on 10 August 1995 at Madras, OR.

Treatment	Companion crop	Planting rate of companion (lb/ac)
Rape	Rape 'Humus'	25
Rye	Rye 'Wheeler'	15
'Belford'	Barley 'Belford'	45
'Gwen'	Barley 'Gwen'	25
Oat	Oat 'Monida'	45
Control (peppermint only)	none	n/a

Above- and below-ground peppermint and companion crop plant samples from 1ft^2 areas of each plot were taken 25 and 26 October 1995 for N uptake measurements. Above-ground samples were dried at 150°F overnight, ground, and analyzed for total Kjedahl N. Below-ground samples were first washed with water to remove soil, separated from dead biomass, and then similarly dried, ground, and analyzed.

Above-ground companion crop samples from 3 1ft^2 areas per plot were taken 3 April 1996 for biomass measurement from the rape, rye, and 'Gwen' barley treatments, which were the only treatments in which the companion crops survived the winter. Samples were dried at 150°F to obtain dry mass.

Companion crops were harvested with a plot mower 29 May 1996 to allow peppermint to grow at its maximal rate once danger of frost was past and would no longer benefit from cold protection provided by the companion crops. Companion crop mass from the entire 10 ft by 25 ft plot areas was recorded. Two-pound subsamples of companion crop were taken from each plot, and weighed fresh and after oven-drying for percent dry matter determination. The peppermint from he control was not removed at that time.

Ten stems, including all above-ground branches and leaves attached to a single main stem, were removed from each plot 30 July 1996 for leaf, node, and branch counts; stem and leaf dry weights; and total stem length measurements. The number of leaves on the main stem, and leaves on branches only were counted separately. Only fully-expanded leaves were counted, but a terminal, immature pair was counted as a single leaf. The number of nodes total, as well as number present before the first (bottom-most) live pair of leaves was also recorded. Stems were measured from ground-level to tip of topmost leaf.

Harvest for oil occurred 15 August 1996. Plots were cut with an plot forage harvester. Peppermint was not separated from 'companion' crop biomass, if present, in order to keep oil harvest similar to routine procedures. Samples from a 40 in by 25 ft strip from the center of each plot were weighed fresh for biomass determination, one 10- to 12-lb subsample from each strip was weighed fresh and reserved in a burlap sack for oil analysis, and a second subsample was weighed both fresh and dry for percent dry matter determination. To ensure accurate fresh weight measurements, fresh weights were taken without delay after sampling. Burlap-sack samples were kept outdoors under shelter and turned periodically to allow dissipation and even distribution of moisture before distillation. Oil was distilled directly from burlap-sack samples using mini-distillery apparatus.

Results

Fall nitrogen uptake

All the experimental intercrop systems consumed more nitrogen than did the control, on average; 'Belford' barley and 'Monida' oat systems consumed significantly more (Table 2). 'Belford' barley and 'Monida' oat took up 243 and 220 lb/ac nitrogen, respectively, on average, more than twice the 95 lb/ac uptake of the non-intercropped peppermint.

The 'Wheeler' rye (companion crop only) consumed the least nitrogen (81 lb/ac) relative to the other 'companion' crops, significantly less than the 'Belford' barley. The associated peppermint within the rye treatment took up more nitrogen than did the peppermint from within the other intercropped treatments, partially compensating for the low nitrogen uptake of the rye itself (difference not significant, $p = 0.236$). The total nitrogen consumption by the combination of crops in each treatment was lowest in the rye compared to the other intercropped treatments (although it was still higher than that of the control).

Likewise, when considering only the

peppermint component of each system, significantly more nitrogen, 95 lb/ac, on average, was consumed by the peppermint when not intercropped at all, but the 'system' totals of each treatment show that the control resulted in a much lower nitrogen recovery than any other treatment.

Companion Crop Spring yields

Two out of the five companion crops were winter-killed, 'Monida' oat and 'Belford' barley. The three remaining types of relay crops continued to yield, but in moderate amounts, less than 1 ton/ac dry matter in each case (Table 3). The 'Humus' rape continued to grow even after mow-down 29 May 1996, which was intended to terminate the growth of the companion crops in order to eliminate competition between them and the peppermint.

Spring peppermint

On 29 May 1996, visual inspection revealed that the young peppermint of the cereal companion crop treatments appeared greener than the mint grown with rape or alone (control) (as noted in Table 3).

Stem and leaf measurements

Peppermint measurements taken 30-31 July 1996 demonstrated some differences in plant characteristics between treatments (Table 4). The 'Belford' barley treatment ranked highest in all measurements except stem length, for which it did not differ significantly from the highest-ranked treatments. In many of the categories for which 'Belford' was ranked highest, it measured significantly higher than other treatments. None of the 'Belford' treatment measurements differed significantly from those of the 'Control' or the highest-ranking measurements for any given category.

The 'Monida' oat treatment measurements ranked similarly to those of 'Belford.' 'Monida,' in fact, had the highest mean stem weight, and though it never averaged higher than 'Belford' on other measurements, it never differed significantly from any of them, either.

'Gwen' measurements were consistently lower, and significantly less than those of 'Belford' for stem weight, leaf weight, and stem length. 'Wheeler' rye and 'Humus' rape treatments generally ranked lowest.

Final dry matter and oil yield

Final dry matter measured least in the rye treatment (2.5 ton/ac) and highest in the rape treatment (3.7 ton/ac), with these two extremes differing significantly (Table 5). 'Belford,' 'Gwen,' oat, and control treatments all had between 2.8 and 3.4 ton/ac and did not differ significantly from each other. It was very apparent at harvest that within the rape treatment, the rape crop had not been adequately suppressed by the mow-down in May, as it was still growing vigorously. The companion crops of the other treatments, in contrast, had behaved as intended, and were not at all visible within the peppermint.

Oil yields from the 'Belford,' 'Gwen,' and oat treatments averaged 73-80 lb/ac and were significantly higher than that of the rape treatment (48 lb/ac), and higher, but not significantly, than those of the rye (71 lb/ac) and control treatments (68 lb/ac), which did not differ significantly from each other.

Table 2: Fall nitrogen uptake by 'companion' crop and peppermint grown in relay-cropping system treatments, based on plant samples obtained 25 and 26 October 1995 at Madras, OR.

	'Companion' crop			Peppermint only			Both
	above-ground	below-ground	'companion' total	above-ground	below-ground	mint total	system total
	N (lb/ac)			N (lb/ac)			N (lb/ac)
Rape 'Humus'	153 a*	16 b	169 a	13 a	18 a	31 a	200 ab
Rye 'Wheeler'	71 a	10 ab	81 a	31 c	26 a	57 a	138 ab
Barley 'Belford'	201 a	6 ab	207 a	9 ac	27 a	36 a	243 b
Barley 'Gwen'	121 a	12 ab	132 a	17 abc	20 a	37 a	170 ab
Oat 'Monida'	160 a	12 ab	172 a	25 abc	22 a	48 a	220 b
Control	n/a	n/a	n/a	51 d	45 a	95 b	95 a

*Means followed by different letters within columns do not differ at the $\alpha = 0.05$ level, as determined by Fisher's LSD procedure.

Table 3. Spring dry matter yields of the companion crops, and color of peppermint noted 29 May 1996 at Madras, OR.

	3 April	29 May	Peppermint
	(dry matter, lb/ac)		(color)
Rape 'Humus'	207 a *	406 a	purplish
Rye 'Wheeler'	652 b	1394 b	green
Barley 'Belford'	0	0	green
Barley 'Gwen'	235 a	1331 b	green
Oat 'Monida'	0	0	green
Control	n/a	n/a	purplish

*Means followed by different letters within columns do not differ at the $\alpha = 0.05$ level, as determined by Fisher's LSD procedure.

Table 4. Peppermint stem-and-leaf measurements taken 30-31 July 1996 at Madras, OR. Mean values of 10 stems are presented unless otherwise noted.

	Stem Weight[1] (g)	Leaf Weight[1] (g)	Stem Length (cm)	#Leaves On Main Stem	#Nodes without Leaves	Total # Nodes	Buds present[2]	# Branches	Leaves On Branches
Rape	11.1 a*	11.2 a	71 ab	15 a	7 a	14 a	7 a	7 a	19 a
Rye	11.2 a	12.3 ab	58 a	17 ab	7 a	14 a	6 a	6 a	23 ab
Belford Barley	19.5 c	16.9 b	81 bc	18 b	9 a	17 a	8 a	11 b	37 b
Gwen Barley	11.5 ab	11.9 a	60 ab	17 ab	7 a	16 a	6 a	8 ab	27 ab
Monida oat	17.0 abc	12.5 ab	84 c	16 ab	9 a	16 a	5 a	9 ab	29 ab
control	18.3 bc	14.2 ab	82 c	17 ab	9 a	17 a	8 a	10 ab	31 ab

[1]Stem and leaf weights were composites of all the stem and leaf matter harvested from 10 stems.
[2]Buds present how many times out of ten stems.
*Means followed by different letters within columns do not differ at the $\alpha = 0.05$ level, as determined by Fisher's LSD procedure.

Table 5. Final dry matter and oil yields, taken at harvest 15 August 1996 at Madras, OR.

	Total Dry Matter (ton/ac)	Peppermint Oil Yield (lb/ac)
Rape 'Humus'*	3.7 b**	48 a
Rye 'Wheeler'	2.5 a	71 ab
Barley 'Belford'	3.2 ab	78 b
Barley 'Gwen'	2.8 ab	80 b
Oat 'Monida'	3.4 ab	73 b
Control	2.8 ab	68 ab

*The rape treatment yields included substantial amounts of rape as well as peppermint at this time.
**Means followed by different letters within columns do not differ at the $\alpha = 0.05$ level, as determined by Fisher's LSD procedure.

Discussion

In this study, the 'Belford' barley treatment consistently resulted in the best overall peppermint measurements. 'Monida' oat performed almost as well, and both of these generally performed as well - or better than - did the control. Both 'Belford' and oat were winter-killed, unlike the other treatments, suggesting that the winter-kill of these companion crops was not only convenient, eliminating the need to mow the crops down later on, but beneficial to the peppermint, perhaps by reducing competition very early. It is also evident that both 'Belford' and 'Monida' oat were efficient 'catch' crops, consuming 207 and 172 lb/ac N, respectively, between their August planting and late October sampling.

The 'Gwen' barley treatment was largely successful, as well, with the barley alone consuming 132 lb/ac nitrogen in the fall and the associated peppermint yielding 80 lb/ac oil. The 29 May dry matter yield (0.7 ton/ac) suggests that 'Gwen' may have promise as a companion crop with market potential. 'Gwen' is a feed barley that was in the early milk stage at the time of the 29 May cutting, and may have yielded and matured better had the 3 April cutting not occurred.

The rape and rye treatments were the least successful. The rape grew too vigorously, despite the May mow-down, which was effective in suppressing all other companion crops in this study. The rye did not consume as much nitrogen as did the other crops by late October, though it possibly continued to consume more throughout the winter and early spring, as it was visibly a very productive, winter hardy crop. The fact that the peppermint to which the rye was interplanted consumed more nitrogen on average than did the peppermint of other intercropped treatments also implies that nitrogen uptake in the rye may be slower and less efficient than that of the other companion crops in this study during the time in which it is most critical. The mean oil yield resulting from the rye treatment, however, did not differ from that of the control. In contrast, the oil yield resulting from the rape treatment was substantially lower, suggesting that competition with the rape throughout the growing season depressed peppermint oil yield.

All companion crops besides the rape resulted in higher oil yields than the control, a result worthy of further investigation. The peppermint intercropped with the cereals also looked greener at the time of the May cutting, suggesting that the mint plants were less stressed physiologically. Perhaps the rape is somewhat allelopathic to, or simply more competitive with peppermint compared to the cereals.

Of the cereals used in this study, our observations confirmed that rye is the most winter-hardy, followed by the 'Gwen' barley, and then the 'Belford' barley; rape is also a winter-hardy crop. That the peppermint appeared most benefited by the 'Belford' barley and least by the rye and rape suggests that the winter-hardiest crops are not optimal choices for relay cropping with peppermint.

Long-term, continued study of the intercropping of peppermint would provide useful information on the reproducibility of the results observed in this study. Clearly there is a potential for relay intercropping of peppermint in reducing nitrogen loss and maintaining high oil yields.

MINT POWDERY MILDEW CONTROL IN CENTRAL OREGON

Fred Crowe & Marvin Butler

Abstract

In 1996, under mild disease conditions prevailing after mid-June fungicide applications, sulfur, propiconazole(Tilt, Ciba-Geigy Corp.), mycobutanil (Rally, Rohm & Haas Co.), and chlorothalonil (Bravo, ISK Biosciences Co.) each controlled powdery mildew in central Oregon. Untreated plots and sulfur-treated plots were harvested in mid-August, and no hay or oil yield differences were found. Oil character was similar for the two treatments, although a trace (0.006%) of mint sulfate was detected in sulfur-treated plots, in contrast to no such detection in untreated plots.

Introduction

Powdery mildew (*Erysiphye chicoracearum*) is common on central Oregon peppermint, but is not chronically severe. The need for routine control is questioned. Sulfur is effective against powdery mildew, is relatively inexpensive, and has been regularly applied. Further, sulfur is considered to provide partial control of spider mites. Recently, however, concerns have been raised about the routine use of sulfur. First, sulfur may adversely impact predator mites. Second, concerns have been raised about high sulfur residues in mint oil, although the source of such sulfur residues is not clearly established and may not involve elemental sulfur. Our study was designed to address the impact of powdery mildew, compare several fungicides for its control, and evaluate the impact of sulfur treatments on mites. We cooperated with N. Christensen at Oregon State University and others investigating potential sources of sulfur residues in oil, such as fertilizer, soil, elemental sulfur applied to foliage, etc., and contributed samples for oil residue analyses.

Objectives

1. Determine whether unchecked powdery mildew occurrence will result in adverse peppermint performance or, alternatively, whether control of powdery mildew improves peppermint performance.
2. Determine relative efficacy of sulfur and other fungicides against powdery mildew.
3. Assess impact of sulfur on spider mites and predator mites.
4. Determine sulfur residues in oil at harvest, as per N. Christensen's study.

Methods

Mildew was rated by visually determining, under a binocular microscope, the proportional leaf area covered by mildew on a third and on a fourth mature leaves from the top of the plant for 20 randomly selected stems from each plot. Numbers of two-spotted spider mites (*Tetranychus urticae*) and predator mites (*Neoseiulus fallacis*) were estimated as the
average number of mites and/or eggs per leaf from 30 leaves on 10 stems selected at random from each plot. Plots were 20 ft x 20 ft, replicated 3 times in a randomized block design, in a grower's field north of Madras, OR, in which mildew had built up during late May and early June 1996. Pre-application evaluation of powdery mildew and mites was on June 7 and June 8, respectively. Fungicides were applied to peppermint on June 12, 1996, with 20 gpa water and 1 pt/ac Silgard using a CO2 powered backpack sprayer. Product, active ingredients, and rates per acre are shown in Table 1. Additionally, predator mites were applied 2,000 per acre over the entire trial area. Post-treatment evaluations of mildew were 1, 2, and 4 wk after application. Post-treatment mite estimates were 1, 2, 3, and 4 wk after application.

For each plot and date, verticillium wilt (*verticillium dahliae*) was rated by counting the number of wilt loci per 75 ft^2. Plant growth responses were determined by measuring several features for each date of mildew evaluation; the average stem length, the average number of nodes between the soil and the first retained leaf, average number of nodes per stem, the average number of branches per stem, the dry weight of 20 stems, and the dry weight of all leaves from 20 stems.

Based on lack of growth differences measured earlier, yield differences were not anticipated. Primarily for sulfur determinations, two 3 ft x 20 ft strips were harvested within untreated and sulfur-treated plots on August 15, 1996. Peppermint was placed into burlap bags and weighed in the field. Additional samples were taken for dry weight determinations. Hay was allowed to air dry in central Oregon. Half of the hay was distilled later in August at the OSU-Corvallis research stills, and half was distilled in research stills maintained by L. McKellip in Idaho. Oil yields from the two research stills were added together to calculate the oil yield per plot. Oil character and composition only, from the half of each plot's hay that was distilled in Idaho, was determined by Wm. Leman Co.

Results

Mean pre- and post-application mildew ratings are shown in Table 1. Prior to application, the amount of mildew was abundant and active on peppermint in all plots, as a result of prolonged high humidity prior to mid-June. At that time, some leaf damage had resulted from the effects of mildew. Immediately following application on June 12, normally arid and warmer conditions developed and persisted for two weeks, resulting in inactivation of mildew and development of new, rapid growth on the mint in all plots. During this period, untreated check plots were reduced from nearly 80 percent leaf coverage to less than 30 percent leaf coverage of active mildew on the third and fourth developed leaves. Assisted by the weather, one week after application, all fungicides controlled mildew to a greater extent than the weather alone. All plots treated with fungicides averaged 6.5 percent mildew Vs. 28.1 percent mildew in the untreated control plots ($p \leq 0.05$). Bravo initially seemed less effective than Rally, Tilt, or sulfur.

After two weeks, some ambient humidity returned and the plant canopy thickened, which further promoted humidity within the canopy. Mildew re-activated during this period, but remained less aggressive than during in early June. The untreated check maintained around 30-40 percent leaf coverage by mildew without visible plant damage. During this period of light disease pressure, residual control of mildew was achieved by the initial application of Rally, sulfur, Tilt, and Bravo.

Initially, about 10 verticillium wilt strikes were measured per 75 ft^2. Following application, the number of wilt loci did not increase in any plots ($p \leq 0.05$), suggesting that neither light mildew nor fungicides contributed to increased stress, which might translate into enhanced wilt. Further, no differences were found among any measured plant growth parameters ($p \leq 0.05$), another indicator that neither mildew nor products influenced mint growth. Spider mite numbers prior to the June 12 applications approached the damage threshold, and this level was maintained in all plots, except where populations diminished in plots treated with Comite (propargite) plus sulfur. The impact of lightly but universally-applied predator mites was not easily discerned. Plant growth measurements in plots that had received Comite were not different from those in plots that did not receive Comite ($p \leq 0.05$). A slight reduction in the numbers of mites was seen in plots treated with sulfur alone, although this was not statistically significant ($p \leq 0.05$) compared to other treatments. Impact of various products, including sulfur, on predator mite numbers, was inconclusive. No two-spotted nor predator mite data are shown.

In Table 2, harvest yields in August are shown for untreated plots and for plots treated with sulfur alone on June 12 (nearly two months earlier). Data include the dry hay per acre and the oil yield per acre, for which no differences were seen for the two treatments ($p \leq 0.05$). Partial analysis of the oil is shown in Table 2. Only a selection of the total oil composition is shown, but no statistical differences between untreated and sulfur-treated plots were seen for any component (or for the organoleptic rating) except for mint sulfide ($p \leq 0.05$). Mint sulfide was detected at a trace level in mint oil from all plots treated with sulfur, but none was detected from untreated plots.

Discussion

Mildew was intense prior to mid-June when our applications of fungicides were made, but subsided quickly as the weather became unfavorable for mildew. No sustained plant damage resulted from either mildew or applied materials (although Tilt and Bravo applications turned foliage darker than other treatments for about one week). Most fungicides provided both immediate control of mildew (except for Bravo) and residual action against mildew (including Bravo), at least under mild mildew conditions of late June and early July. Under more severe mildew pressure, this response might be different for some materials. Further testing will be required to evaluate mildew control and impact where applications can be made prior to intense buildup of mildew, and where mildew occurs abundantly at other times of the year, for example on fall re-growth.

Additional testing is required to evaluate these products for activity on spider and predator mites. Our 1996 results were inconclusive.

Plant growth measurements in late June and early July were not different ($p<0.05$) among plots treated with various mildew control treatments, nor were harvest weights and oil yield significantly different ($p<0.05$) for the two treatments that were harvested: untreated plots and plots treated with sulfur. As the only application of foliar-applied sulfur was on June 12, nearly two months prior to harvest, most treated leaves likely would have fallen from the plant by August 15. Thus, sulfur residue would not be expected to contribute much to oil character. No dimethly sulfide was found in oil for either treatment. A positive but negligible amount of mint sulfate (0.006% in all three replications) was found in untreated plots, in contrast to no detection in untreated plots.

Table 1. Percentage of 3rd and 4th leaf area covered by powdery mildew (*Erysiphye chicoracearum*) in the mildew control trial, Madras OR, following a single application of fungicides on June 12, 1996.

Product & Application Rate/Acre	Active Ingredient	AI/Ac	Mildew Rating (% leaf coverage)			
			Pre-Appl.	1 wk Post	2 wk Post	4 wk Post
Tilt 41.8EC, 6 oz	propi-conazole	2.5 oz	80.4 a[1]	2.3 a	0.3 a	2.0 a
Bravo 720, 1.5 pts	chloro-thalonil	1.13 lb	80.1 a	13.4 c	4.6 a	4.3 a
Micro-Thiol, 5 lb	sulfur	4 lb	86.3 a	2.8 ab	3.2 a	6.7 a
Micro-Thiol, 5 lb + Comite, 2 pt	sulfur + propargite	4 lb + 1.64 lb	82.1 a	9.5 abc	5.6 ab	6.3 a
Rally 40W, 5 oz	mycobutanil	2 oz	81.7 a	3.0 ab	0 a	1.9 a
Untreated	--	--	78.3 a	28.1 d	42.6 bc	30.7 b

1. Means followed by the same letter were not statistically significant, $p \leq 0.05$.

Table 2. Mean yields and oil character ratings from peppermint harvested on August 15, in untreated plots and in plots treated once with 4 lb AI/Ac sulfur on June 12, 1996[1].

	Harvested Dry Matter	Oil Yield	Dimethyl Sulfide	Mint Sulfide	Menthone	Menthol	Mentho-furan	Organo-leptic
	lb/ac	lb/ac	%	%	%	%	%	rating[2]
Untreated	7,398 a[3]	35.0 a	0[4] a	0[4] a	15.2 a	39.8 a	2.8 a	2.0 a
Sulfur 4 lb AI/Ac	7,913 a	40.4 a	0[4] a	0.006 b	16.2 a	38.8 a	3.3 a	2.3 a

1. Data shown are means of three replications from a field trial in a randomized block design. Other treatments, shown in Table 1, were not harvested.
2. Ratings of 1, 2 and 3 were acceptable, acceptable with modification, and unacceptable, respectively.
3. Means followed by the same letter were not statistically significant, $p \leq 0.05$.
4. Not detectable, which was recorded as 0 for this analysis

PEPPERMINT PERFORMANCE AND WILT INCIDENCE, AS INFLUENCED BY SELECTED CULTURAL PRACTICES AND INOCULUM DENSITY OF *VERTICILLIUM DAHLIAE* [YEAR 6][1]

Abbreviated Final Report: 1989-1996. *This is a review of 1995-96 data with reference to previous reports. Readers are encouraged to review reports from 1990 through 1995 for additional background and detail. One or more detailed manuscripts, summarizing all data, will be prepared for formal publication during 1997, and included in the 1997 annual report.*

Fred Crowe, Neysa Farris & Charissa Yang

Abstract

From plots in the long-term field trial at the COARC Powell Butte field, pre-plant inoculum densities of microsclerotia of V. dahliae (MS/g soil) from 1994 and 1995 were related to 1996 wilt disease incidence in a peppermint crop that had been replanted in the fall of 1995.

Using a complete, split-plot experimental design with five replications, soil in these plots was (a) artificially infested with various uniform levels of V. dahliae in 1989 (main plots) following 1987 fumigation with methyl bromide, (b) planted with verticillium- and nematode-free Todds rootstock in 1990, (c) and managed with either spring tillage without flaming or with post-harvest flaming without tillage (split plots) for three production seasons through 1993 until hay and oil yield declined in plots with the highest initial infestation levels. Peppermint in all plots was killed in the spring of 1994, plots were left fallow but irrigated in 1994, and plots were cropped to a combination of irrigated wheat and peas in 1995 using normal soil management, prior to planting of verticillium- and nematode-free rootstock in the fall of 1995.

Based on calculation verified by preliminary soil assay recovery, plots were initially infested near 0, 0.01, 0.1, 1.0 and 5.0 MS/g soil using lab-grown microsclerotia. Changes in inoculum density within plots between 1990 and 1994 were expected but could not be measured until a consistent soil assay was developed in 1994. Inoculum densities based on reliable assays of soil samples were determined for 1994 and 1995. Inoculum density did not change in plots between 1994 and 1995. This suggests that MS had been released into soil from herbaceous mint stems by the August 1994 sampling and that the soil population had stabilized. Prior to re-planting of peppermint in 1995, mean inoculum densities from soil in plots that had been flamed but not tilled during the 1990-93 peppermint crop were assayed to be 0.37, 0.02, 0.00, 0.12, and 0.74 MS/g soil, respectively, and a mean of 0, 0, 0.6, 2.4 and 7.2 percent of the peppermint plants, respectively, developed strong wilt symptoms in 1996. In contrast, mean inoculum densities from soil in plots that had been tilled but not flamed during the 1990-1993 peppermint crop were assayed to be 0.79, 0.07, 0.26, 5.70, and 18.60 MS/g soil, respectively, and a mean of 1.4, 1.8, 8.8, 15.7, and 62.8 percent of the peppermint plants, respectively, developed strong wilt symptoms during 1996. Among main plot treatments, inoculum densities in 1995 and wilt incidences in 1996 were significantly different ($p \leq 0.05$), irrespective of whether these plots had been flamed but not tilled or whether they had been tilled but not flamed. Sub-plot treatments (flaming with tillage vs. tilling without flaming) were significantly different ($p \leq 0.05$) with respect to both 1995 inoculum density and 1996 wilt incidence.

For several reasons, inoculum levels calculated for and recovered for 1989-90 should not be compared closely with those determined for 1994 and 1995. First, the lab-produced inoculum used in 1989 might have different size and behavior per unit inoculum than the naturally-produced inoculum most likely represented in 1994 and 1995. Second, the soil assay used to verify infestation level in 1990 was different from that used for estimating soil populations in 1994 and 1995.

The higher recovery of MS in 1994 and 1995 from initially non-infested plots in which wilt never occurred in 1990-93 or in 1996 seems anomalous and likely represents MS from a strain of V. dahliae nonpathogenic to mint.

These data constitute a general verification of earlier studies in the Willamette Valley that showed that wilt can be held static under a program of post-harvest flaming without tillage, but that wilt worsens

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under a program of tillage without flaming. For the first time, our data provide a quantitative basis with respect to soil inoculum density for these responses. The earlier Willamette Valley studies were done with highly susceptible Black Mitcham. We show a similar pattern with the moderately tolerant variety Todds. The 1990 and 1996 disease incidences resulted strictly from new root infections (at least those which become systemic) on the replanted mint. As the mint stand aged, additional new root infections undoubtedly developed. Nevertheless, the data support the concept that a substantial proportion of the wilt in subsequent years is carried over within rhizomes. This was most likely true for flamed and untilled plots since the initial infestation levels did not support the high levels of wilt eventually seen as stands aged. But this pattern of disease intensification also was likely true for tilled plots – not only were new MS incorporated into soil from infected stems, but infected rhizomes were chopped into pieces and redistributed during tillage.

It is not clear from this study what levels of inoculum are critical in various soils, or for various varieties. As in 1990 through 1993, wilt incidence in 1996 varied with soil type across the COARC Powell Butte field, associated with a statistically significant block effect ($p \leq 0.05$). For example, in plots which were tilled but not flamed from 1990-93, wilt incidence in the highest two infested treatments ranged from 2-45 percent and 25-100 percent, respectively, with the lower incidences occurring on the west end of the trial area, and the higher incidences occurring on the eastern side. In contrast, inoculum densities determined in 1994 and 1995 were not higher in the east than in the west. This suggests that soil characteristics rather than inoculum density were responsible for the consistent range in wilt development across the trial area. These data support Idaho potato data for verticillium that an inoculum density vs. disease incidence relationships vary with respect to soil type or other factors. Thus, whereas soil assays may be useful research tools, they may not provide reliable prediction of commercial disease losses among diverse field situations.

Our reports from 1990-1993 document greater weed problems in plots that were not tilled. [This likely was directly related to the soil disturbance during spring tillage, but also may have been related to weed establishment in bare areas of untilled plots.] Our earlier reports document the value of tillage for redistribution of rootstock in thin stands. Other studies indicate the value of tillage for control of invertebrate pests. A possible detrimental effect of post-harvest flaming on predatory mites has been suggested. Nevertheless, our data support the concept of reducing tillage to a bare minimum, while retaining flaming as a critical component of mint culture as long as V. dahliae remains a dominant influence. Our investigation did not determine what pattern of wilt and soil inoculum changes would develop under a program of tillage <u>plus</u> flaming, or a program of <u>no</u> tillage and <u>no</u> flaming. The earlier Willamette Valley studies suggested intermediate results with these two programs with Black Mitcham, but these variations might be worth investigating further.

Our earlier reports also documented an interaction between high soil population of V. dahliae and winter kill. In fact, in the most highly infested plots that were flamed but not tilled, yield losses in 1993 resulted from the combination of low stand and verticillium wilt, rather than wilt alone. Similar interactions might occur between V. dahliae and other stress factors. Thus, whether from a wilt response alone, or from wilt interactions with other factors, this study underscores the difficulty in retaining mint productivity in the presence of high soil inoculum density of the peppermint wilt fungus.

Introduction

On this long-term project, readers are referred to previous reports of progress from this project from 1990 through 1995 (Crowe, 1992, 1993, 1994, 1995). The initial intent was several-fold: (1) To determine the general ranges of infestation of microsclerotia (MS) of mint strains of *V. dahliae* that induce various levels of verticillium wilt, and the type of soil assay most likely to detect these ranges, (2) to determine whether reduced tillage combined with propane flaming after harvest would limit the increase of verticillium wilt in central Oregon (Horner & Dooley 1965 and 1966, McIntyre & Horner 1973), (3) to determine whether winter damage of consistently untilled mint might be more adverse to production in central Oregon than damage due to wilt aggravated by tillage, (4) to determine actual changes in soil inoculum levels of MS over time, which had only been assumed previously but not measured, and (5) to serve as a basis for evaluation of inoculum density and "wilt potential" in commercial field soils using the inoculum density vs. disease loss relationships determined from this field trial.

Plots at the COARC Powell Butte field were fumigated with methyl bromide in 1987. In

1989, the widely used Butterfield soil assay (Butterfield & DeVay 1977, Joaquim et al. 1988, Nicot & Rouse 1987) indicated that few MS of *V. dahliae* were present following fumigation. Field history suggested that any MS present likely were associated with potatoes and not with peppermint. Objectives 1, 2, and 3 above were largely assessed during 1990-1993, following uniform infestation of large field plots and planting of Todds peppermint in the spring of 1990. In general, wilt incidence increased on tilled but not flamed mint and remained static on flamed but not tilled mint for all initially calculated levels of infestation (0, 0.01, 0.1, 1.0 and 5.0 MS/g soil) except at the highest level of initial infestation (5.0 MS/g soil). At the highest initial level, oil and hay yields declined in 1993 for both tilled and flamed plots, a result of a combination of reduced stand and in-season wilt (Table 1).

Following the record cold winter of 1990-91, major stand decline occurred only in highly infested plots that had been flamed but not tilled in the fall of 1990. In this treatment combination, the mint never really recovered full stand during 1991, 1992, or 1993 (Table 1). The winter injury likely was associated with lack of winter hardiness on wilt-infected rhizomes in the fall of 1990. Lack of winter hardiness was never observed at initially lower levels of infestation. Undoubtedly, the winter kill also occurred in the highly infested plots that were tilled in the early spring of 1991, but any such winter kill was obscured by redistribution of surviving rhizomes.

The 1991-93 disease data suggested that inoculum density was not increasing greatly in flamed and untilled plots, and that it could even be dropping if much of the year to year wilt incidence was resulting from carryover of *V. dahliae* through active rhizome infections rather than new infections through roots, as suggested by Nelson (1950). The wilt data also suggested that inoculum density for tilled mint might be a "moving target," assuming inoculum was building up due to tillage along with the increase in incidence of wilt symptoms (although carryover in rhizomes also could complicate this argument).

Beginning later in 1990 and extending through 1994 (when we stopped using it altogether), we failed to recover *V. dahliae* consistently from the Powell Butte soil using the Butterfield assay, even when some variations were tried. On many sample dates, we cultured no colony forming units from any samples. Soil samples were shipped to other laboratories, and these labs also failed to recover *V. dahliae*. In our laboratory, a fusarium fungus consistently overgrew our culture plates and precluded growth of *V. dahliae*. This did not happen from most other soils from elsewhere in the region. The reasons for initial success in 1990, followed by consistent failure are not clear, but may relate to the short time in which lab-produced inoculum had been resident in the soil -- perhaps the contaminating fusarium became tightly associated with MS directly after the first several months, or perhaps the fusarium developed in the soil system more in association with the presence of mint roots. Whatever the reason, the failure to recover *V. dahliae* for several years in spite of seemingly normal disease progression created some confusion. The net result was that we were unable to document the changes in soil inoculum as the disease progressed between 1990-93

Because of the problems encountered with several standard soil assays for MS during 1990-1993, objectives 4 and 5 above could not be addressed by the end of 1993. In 1994 it was proposed that yet another assay be attempted that had proven useful in England on cooler soil where standard assays had failed (Harris et al. 1993). This Harris assay seemed to provide reasonable data on a limited series of tests in 1994.

As an alternative to dependency on soil assays, to verify that soil inoculum had changed, and to avoid confounding the inoculum density vs. disease incidence relationship with infected rhizome carryover with root infections from MS, it was proposed in 1993 that the mint in the Powell Butte trial be killed, that mint roots and rhizomes be allowed to decay for a period of time, and that the plots be replanted to mint for evaluation of wilt on the subsequent crop. For cotton, release of MS into soil from decaying cotton stems takes one to two years (Huisman & Ashworth 1976), and for potatoes it takes about two years before MS become released into soil from decaying potato stems (Davis & Huisman, personal communication). Two seasons were allotted for MS to become released into soil prior to mint replanting.

Methods

Triply-replicated soil samples from 1994 and doubly-replicated soil samples from 1995 were assayed as described in 1995 (Harris et al. 1993). Each soil sample was composed of two 20-core sub-samples that were separately assayed, and this sampling procedure was repeated. Briefly, soil in each sub-sample was air dried, ground, and soil volume was reduced by washing on 400-mesh screens. Concentrated soil residue was placed onto semi-selective medium in Petri plates, and characteristic growth of *V. dahliae* was noted after two weeks. Data were expressed as colony forming units (CFU) per gram of soil. Even though the soil sieving process and the culture medium used in the Harris assay were similar to the Butterfield assay (Butterfield & DeVay, 1977), certain variations must have been crucial to overcoming the influence of competitive organisms on the culture plates. Data from 1994 and 1995 soil sampling provide reasonable estimates of the soil population of *V. dahliae* into which mint was replanted in the fall of 1995 (Table 1).

In November of 1995, verticillium- and nematode-free Todds rhizomes were dug from the COARC Madras research farm. This rootstock planting had been established in 1992 from Oregon-certified rooted cuttings planted into land never previously irrigated nor cropped to mint. Rhizomes were separated into 6-8 in pieces by hand on the day of digging, and planted every row-foot into 5 rows per plot on the next day into open 4in-deep furrows opened into the established 10 ft x 80 ft plots in the long term COARC Powell Butte field trial. Roots were covered by machine and irrigated.

Peppermint emerged erratically in the spring of 1996, but the field pattern was unrelated to any experimental treatments. More likely, poor emergence was related to the long, cool winter that somehow similarly effected many new plantings in the entire Powell Butte region in 1996. A stand count was taken in early June.

Mint was irrigated and remained relatively weed free during 1996. Wilt symptoms developed initially in July, and worsened into September. Wilt ratings were taken at about 10 percent bloom on September 10, 1996, but plots were not harvested. Wilt ratings were the proportion of wilted plants to the number of emerged plants, expressed as a percentage (Table 1).

With the erratic stand, it was determined that future inoculum shifts and wilt disease would not occur in a consistent manner, even if the trial was replanted. In the fall of 1996, the mint was killed, and the soil in the entire trial area was fumigated to reduce the risk of spread of wilt around the COARC Powell Butte farm. Thus, this field trial was terminated.

Results & Discussion

The 1996 disease rating can be directly compared to the 1995 inoculum density rating as determined by soil sampling (Table 1). The 1990 disease rating cannot be directly compared to 1989 inoculum density because we did not attempt to recover microsclerotia from all levels uniformly infested in 1989. Early in 1990, the Butterfield assay was successfully used to confirm that the initially calculated infestation rates were reasonable estimates of recoverable MS/g soil. In the spring of 1990, an average of 1.2 and 6.3 MS/g soil were recovered from soil in which the calculated infestation was 1.0 and 5.0 MS/g soil, respectively. These recovered estimates from 1990 were reasonably similar to calculated rates of infestation. Thus, for convenience and necessity, the calculated numbers were used to generally describe the entire initial infestation range, and these calculated estimates are included in Table 1.

The relationships between 1996 disease incidence in replanted Todds peppermint and the preplant infestation rates estimated in 1994 and 1995 are striking. All plots had been uniformly infested in 1989, and populations were expected to diverge based on cultural management. Inoculum levels in plots in which mint had been tilled but not flamed in 1990-1993 were many times higher ($p \leq 0.05$) prior to the 1996 replanting than in plots that had been flamed but not tilled in 1990-93 and, accordingly, wilt incidence was at least 10-fold higher ($p \leq 0.05$) in the 1996 replanting for previously tilled vs. flamed plots (Table 1). Many plots in the previously tilled and not flamed treatments were perceived to be at "wilt-out" levels in the 1996 replanting year. In summary then, these soil inoculum density estimates provide a quantitative basis for the Horner model. Inoculum seemed to not increase with a regime of flaming without tillage, and inoculum clearly comparatively increased with a regime of tillage without flaming.

Based on the relatively low recovery of MS in 1994 and 1995 from soil sampled from previously flamed and untilled plots, much of the disease progression that occurred in those plots (especially at the highest rate of initial infestation) must have involved carryover of systemic infections from mature to developing rhizomes. Just as likely, tillage operations in tilled but unflamed plots broke new rhizomes into several infected pieces and redistributed these, enhancing wilt in tilled plots well above that which would be directly attributable to root infections from soil-borne microsclerotia. Of course, such tillage also would be incorporating senescent stems from the previous year, together with newly formed microsclerotia in those stems, into soil at the same time.

For various reasons, the inoculum density vs. disease incidence relationship for the first and second mint plantings cannot be directly compared. (a) It is not clear whether the Harris assay and the Butterfield assay would yield the same inoculum density estimates. Relative recovery efficiency for these two methods should be compared, perhaps on several different soils, with both lab and naturally-formed microsclerotia. At this time, we have not determined this. (b) The lab-produced inoculum used for artificial infestation was uniformly sized. Recovery of most such sclerotia was expected in the spring of 1990 in order to verify their placement. In contrast, by 1994 and 1995, many or most sclerotia in the soil system likely were naturally produced on wilted plant material between 1990 and 1993, and released into soil over various periods of time. Such inoculum represents a wider size range, and the smaller fraction likely is lost during assay. (c) The biological activity of lab-produced Vs natural inoculum may not be equal. (d) Disease estimates for 1990 through 1993 were based on the number of discrete wilt loci per plot, whereas disease estimates for 1996 were a proportion of the emerged rhizomes planted.

The recovery of MS from plots in 1994 that had received no added pathogenic MS in 1989 was higher than from the plots initially infested at 0.01 and 0.1 MS/g soil, even though no wilt or very little wilt occurred in "non-infested" plots. This result seems anomalous and the colonies that formed on the lab medium may represent MS from a strain of *V. dahliae* nonpathogenic to mint, one which does not appear to have been recovered from plots in which the mint strain of *V. dahliae* was added. This suggests some unanticipated relationship between populations of strains. [The Butterfield assay was used prior to 1989 infestation to determine the background level of *V. dahliae*. Any such background level likely was low, due to fumigation, but our ability to measure the background can now be questioned due to the later problems experienced with the Butterfield assay.]

Inoculum density estimates for 1994 and 1995 were very similar, suggesting that the population of MS (as measured by CFU) did not increase. This further suggests that the herbaceous mint stems had decayed and released MS following tillage operations during 1991 through 1993, and that the population had stabilized prior to August 1994 soil sampling.

For this Powell Butte field, one might integrate the pattern of disease progression during 1990-93, the mean soil inoculum density data for 1995, and the disease levels in 1996 to suggest pre-plant economic thresholds. We believe one such economic threshold might be 0.25 MS/g soil (based on the Harris assay) if the field was regularly tilled without flaming and if stand longevity was restricted to about 4 years -- at which time the field might be too highly infested to recrop successfully. In contrast, if the field was not tilled after planting and if it was regularly post-harvest flamed, the economic threshold might be elevated as high as 1.0 MS/g soil, or even higher, with the stand longevity likely to be sustained substantially longer than 4 years.

However, it remains to be determined whether assays prove to be useful predictors of wilt incidence for commercial crops, although they will be useful in research trials. Recent worldwide comparisons among several *V. dahliae* assays, using identical soil samples that were divided among 13 different laboratories, indicated that within-lab results were consistent, but between-lab results were rather variable (Termordhuizen 1995). This would suggest that different labs might communicate different levels of infestation, which would complicate interpretation with respect to disease incidence. Further, in potatoes, it seems as if even the same inoculum densities can result in a wide variation of wilt when they occur in different soil types (J. Davis, University of Idaho, personal communication), which would further complicate interpretation.

The Powell Butte trial demonstrates this same problem. In 1990-93, wilt incidence was associated with soil type on the COARC Powell Butte field [significant block effect ($p \leq 0.05$)]. Similarly, in plots that were tilled but not flamed from 1990-93, wilt incidence in 1996 in the highest two infested treatments ranged from 2-45 percent and 25-100 percent, respectively, with the lower incidences occurring on the west end of the trial area, and the higher incidences occurring on the eastern side. In contrast, however, inoculum densities determined in 1994 and 1995 were not clearly higher in the east than in the west. This suggests that soil characteristics rather than inoculum density may have been responsible for this range in wilt development across the trial area. On this basis, then, the economic threshold of inoculum density on the west side of the field might be as high as 5 MS/g soil for the flamed and not tilled scenario, whereas an economic threshold on the east side of the field might be substantially less than 1 MS/g soil.

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Table 1. Mint disease resulting from various infestation levels of microsclerotia of *Verticillium dahliae*, at Powell Butte, OR, 1989-1996[1].
Using the Fisher LSD Procedure

Inoculum Density (initial)	Seasonal Wilt Incidence in 1st Crop Per Area Covered by Mint Growth in the Spring							Inoculum Density During Crop Rotation		Wilt Incidence in 2nd Crop at Harvest	
1989 Preplant	1990 1st crop, 1st yr	1991 1st crop, 2nd yr		1992 1st crop, 3rd yr		1993 1st crop, 4th yr		1994, 1995 between mint crops		1996 2nd crop, 1st yr	
MS/g Soil [2]	Numerator = No. of Cumulative Wilt Loci at Harvest[3] Denominator = Percent Area of Plot from which Mint Emerged in the Spring (800 ft^2=100%)[4]							MS/g Soil[5]		% Wilted Plants[6]	
Calculated (Verified)	Prior to Trt	Flamed	Tilled	Flamed	Tilled	Flamed	Tilled	Flamed	Tilled	Flamed	Tilled
0 (NA)[7]	0/94	0.2/79	0.8/96	0.2/88	3/97	2/85	9/83	0.4 b[8]	0.7 b	0 a[8]	1.4 b
0.01 (NA)	0.2/96	0.2/75	0/96	0.6/89	1/98	4/83	9/92	0.2 b	0.1 ab	0 a	1.8 b
0.1 (NA)	0.3/96	0.8/79	0.8/96	0.2/87	14/97	7/84	76/90	0 a	0.3 b	0.6 b	8.8 c
1.0 (1.2)	3./82	3/82	19/97	4/87	39/96	18/82	264/91	0.1 ab	5.7 c	2.4 b	15.7 cd
5.0 (6.3)	52/97	92/29[9]	164/94[9]	88/51	401/96	**400+/54**[10]	**800+/58**[10]	0.7 b	18.8 d	7.2 c	62.8 d

1. The trial was a randomized split block design with five replications. Main plots were rates of initial infestation of *V. dahliae*, and split plots were either post-harvest flamed without spring tillage in 1990, 1991 and 1992, or were spring tilled without post-harvest in 1991, 1992 and 1993. Todds peppermint was planted in the spring of 1990 and managed through 1993. Tilled but not flamed plots were again flamed in 1993. Mint was killed in the spring of 1994, and wheat+peas were grown in 1994 and 1995 following common soil management practices. Todds peppermint was re-planted in the fall of 1995 and managed through September 1996.
2. Microsclerotia (MS) were produced in the laboratory on cellophane agar, distributed uniformly over 80'x10' plot areas and tilled 10 cm into soil in the late fall of 1989. Soil from plots with the two highest calculated rates was assayed (Butterfield & DeVay, 1977) to verify infestation level.
3. Discrete wilt infections were flagged periodically during the season until harvest. Loci nearer than 20 cm could not be distinguished. Figures above 400 wilt loci per 800 ft2 are estimates rather than exact counts. Statistical analyses for 1990-93 wilt incidence are discussed in previous reports.
4. Spring plant stands were estimated by determining the area from which mint emerged in the May of each year, and expressed as a percentage of 800 ft^2 plot area. Statistical analyses for spring stands are discussed in previous reports.
5 Inoculum as MS/g soil were estimated from soil samples which were processed as per Harris et al. 1993. Inoculum measurements in 1994-95 likely represents microsclerotia which were produced naturally in mint during previous years, and which were released into soil. Inoculum density estimates for 1989 and 1994-95 are not necessarily comparable.
6 A second crop of mint was space planted in the fall of 1995, and 1996 wilt was expressed as the percentage of emerged mint from the spring of 1996 which developed wilt symptoms during 1996. Yields were not determined for 1996 due to erratic stands unrelated to *V. dahliae*. Based on visual observations, yields would have been very low for all 5 replications of the most highly infested plots which had been tilled 1991-93, and for 2 of 5 replications in the next-most highly infested plots which had been tilled 1991-93. Yields likely would not have been reduced in all other treatments, at least for 1996.
7. NA = not applicable, the lowest calculated rates were not assayed to verify initial infestation level.
8. Within and across Flamed and Tilled columns, means followed by the same letter were not statistically significant ($p \leq 0.05$).
9. The winter of 1990-91 reached below -35 F, which resulted in winter kill but only in the most highly infested plots (as seen in a statistically significant infestation vs. spring stand interaction, $p \leq 0.05$). Spring stands were greatly reduced in plots which were flamed but not tilled, but surviving rhizomes were separated and redistributed in tilled plots such that the effect of winter kill was obscured. Mint growth compensated even for low stands, and yields were not significantly different for any treatments in 1991 (or 1992).
10. Yields are not shown, and within each year were not statistically different among infestation levels or between flaming/tillage treatments until 1993. In 1993, mint yields were reduced ($p \leq 0.05$) at the highest level of infestation for both flamed but not tilled treatment and the tilled but not flamed treatment. Boldface is used to emphasize the onset of such yield loss as described commonly as "wilt out". "Wilt out" at the highest initial levels of infestation was due to a combination of reduced stand and in-season wilt.

CONTINUED EVALUATION OF PEPPERMINT VARIETIES AND ADVANCED SELECTIONS IN CENTRAL OREGON[1]

Fred Crowe, Charissa Yang & Neysa Farris

Abstract

In 1996, the spring stand on all peppermint varieties was excellent. In 1995, the trial area was irrigated more or less as per the needs of Black Mitcham, and other varieties became water stressed and stopped growth prior to harvest. In 1996, the trial area was irrigated more than in 1995, and little or no water stress was observed. In 1996 as in 1995, Black Mitcham grew very little and remained off-color during the extended, cool spring, whereas all other varieties grew very vigorously earlier in the season. By mid- to late June, Black Mitcham began to grow vigorously, and by mid-July it was fully lodged. Other varieties eventually lodged in most plots, but later and less completely than Black Mitcham. The soil in Black Mitcham plots remained much wetter between irrigations than soil beneath other varieties. Whether Black Mitcham used water more efficiently than other varieties, or whether its early lodging prevented evaporation from the soil was not determined. Differences in soil water status is discussed with respect to growth, nitrogen usage, wilt development, and lodging -- and with respect to our ability to maintain each variety as per its optimum management and within cost-effective experimental designs. In 1995 and 1996, Black Mitcham frequently performed differently than other varieties, but it could be argued that such differences resulted from different soil moisture status through the growing season, which clearly is related to soil water management input.

Infested plots were not tilled in the fall of 1995 or the spring of 1996 due to excessive precipitation, thus inoculum of V. dahliae did not increase much in 1996 over what was present in 1995. Twice as many seasonal wilt symptoms (or more) occurred on Black Mitcham than other varieties, but this was not enough to result directly in yield losses. Once again, Black Mitcham recorded the highest powdery mildew ratings. 14 percent compared to all varieties, which averaged 0.4 percent on June 14.

Oil and dry hay yields averaged 89 lb/ac and 8,537 lb/ac, respectively, across all varieties, with no statistically significant differences among varieties, with or without the presence of the wilt fungus. As in 1995, Black Mitcham yielded the least dry hay in 1996, but, in contrast to 1995, Black Mitcham was not the highest oil yielding variety in 1996. Oil character for all varieties was not representative of the Madras area, and some significant compositional differences were measured between varieties. These are discussed at greater length below.

Introduction

A well designed field trial was established in central Oregon in 1994, to compare yield, oil character, verticillium wilt tolerance and other noteworthy responses among Mint Industry Research Council sanctioned peppermint varieties and advanced MIRC selections. Comparable field trials (including spearmint) were established in other mint production regions of the United States. Previously, no comparative efforts were conducted for varietal comparisons that could be subjected to statistical analyses.

In central Oregon and in some other locations, varieties were tested both with and without a uniform background of added inoculum of the verticillium wilt fungus, *Verticillium dahliae*. Cultural practices were applied uniformly across the trial, and were considered appropriate for commercial peppermint production in central Oregon. Results from 1995 appear in an earlier report.

Methods

In two adjacent trial areas (main plots), rooted cuttings for six peppermint varieties (sub-plots) received from Plant Technologies Inc. were established during the summer of 1994 in 8.5 ft x 20 ft plots, replicated and randomized within four blocks within each area. Mint growth

[1] This research was supported by grants of $4,000 and $4,700 in 1995 and 1996, respectively, from the Oregon Mint Commission and the Mint Industry Research Council.

thereafter was maintained within a 10 ft x 20 ft sub-plot area. All individual sub-plots in one of the areas were overseeded with microsclerotia (MS) of *Verticillium dahliae* in the fall of 1994, sufficient to provide 2 MS/g soil in the top 10 cm of each sub-plot. Both areas were rototilled in the fall of 1994, which also re-distributed rhizomes and provided for more uniform plant stand in the spring of 1995. With respect to irrigation, fertility, weed, and pest control, etc., the overall trial was uniformly maintained as per routine mint culture in central Oregon, but great care was taken to avoid cross-contaminating *V. dahliae* into the non-infested trial area. Data on plant growth and performance, oil yield and character, and disease incidence were taken since establishment. Detail of data collection methods is included in the footnotes of accompanying tables.

Results and Discussion

Plots were to be tilled in the fall of 1995 or the spring of 1996 to intensify verticillium wilt and place added disease pressure on all varieties [See companion report "Peppermint performance and wilt incidence, as influenced by selected cultural practices and inoculum density of verticillium wilt"]. However, consistently wet conditions from fall through spring precluded this operation. Following the mild winter of 1996-96, all varieties had perfect spring stands (data not shown). As in 1995, all other varieties grew very vigorously in the cool, wet spring, whereas Black Mitcham remained without much growth and was visibly stressed during this period. As the spring warmed, Black Mitcham grew vigorously and was highly lodged by the first to second week of July (Table 1). Other varieties grew well through the summer, but lodging was highly erratic for these varieties.

Because we had observed some moisture stress in 1995, the trial area was irrigated more in 1996. Nevertheless, it was determined that percent lodging was correlated with mean soil moisture (r^2=0.68). This suggested variability in soil moisture due to irrigation layout and/or soil texture around the trial area. More noteworthy, soil in Black Mitcham sub-plots was consistently wetter than soil in sub-plots of other varieties ($p \leq 0.08$). We are uncertain at this time whether Black Mitcham might utilize soil moisture more efficiently, or if its early lodging characteristic slowed the amount of evaporation from the soil surface. In 1995, we irrigated somewhat less, and all varieties except Black Mitcham became water stressed prior to harvest. In future years we are left with the difficulty in irrigating Black Mitcham vs. other varieties as per their physiological needs.

Differences in soil moisture among varieties might have several experimentally-undesirable ramifications: Excessive soil moisture early in the season when Black Mitcham is not using water much might possibly increase root infection by *V. dahliae*, whereas excessive moisture later in the season might inhibit wilt symptom development on Black Mitcham compared to other varieties (Geaudreault, Powelson, Cappaert, Christensen and Crowe, 1994). Excessive soil moisture might lead to different patterns of root behavior, nitrogen leaching, and other edaphic characters for Black Mitcham vs. other varieties, which in turn might result in different growth patterns. Excessive soil moisture might directly contribute to early lodging on Black Mitcham. If humidity within the plant canopy encourages powdery mildew activity, excessive soil moisture combined with early lodging might partially account for higher powdery mildew incidence in Black Mitcham compared to other varieties. Unfortunately, as long as the field trials are sprinkler irrigated, it would be cost prohibitive to irrigate varieties on different schedules, or to apply different amounts on the same schedule.

In response to the above observations and concerns, we evaluated data in two ways. First, including Black Mitcham in the analysis, and second, excluding Black Mitcham. In no case did the statistical relationships change among other varieties when Black Mitcham was excluded from the analysis.

Only selected and limited growth data from a few dates are shown in Table 1. By mid-June, Black Mitcham was branching more than other varieties, and its stem length was shorter ($p \leq 0.05$). Lodging proceeded early as in the previous year for Black Mitcham, and later for other varieties. Other varieties lodged more fully in 1996 than in 1995, presumably due to less water stress in 1996. Overall, lodging was not correlated with either stem height or stem weight (r^2<0.20).

Powdery mildew was not considered a problem that threatened plant growth or yield in the 1996 plots, but this disease was greater on Black Mitcham than other varieties, which experienced nearly no powdery mildew as a group (Table 1). Although the mean of Black Mitcham seems greater in Table 1, this was not determined to be statistically significant ($p \leq 0.05$).

In the heat of July, verticillium wilt symptoms became abundant. As shown in Table 1, Black Mitcham accumulated significantly more wilt loci (60 per plot) than all other varieties, but these differences were not statistically significant ($p<0.05$). By harvest, Murray had accumulated a mean of 22 wilt loci per infested plot, whereas Todds and Roberts had accumulated a mean of 39.3 and 36.7, respectively, and M-83-7 and T84-5 were intermediate. During July, a somewhat unusual rapid scorch symptom was present only in infested plots, and *V. dahliae* was cultured from most stems. Wilt was not considered to have affected yields in 1996.

Plots were harvested on August 19, 1996. Oil was distilled at the OSU-Corvallis stills. Dry hay yields and oil yields are listed in Table 1. No statistically significant differences were seen among varieties in either infested or non-infested areas of the trial with respect to yields ($p \leq 0.05$). In 1996 as in 1995, Black Mitcham yielded the least dry hay per acre.

Oil composition and character from varieties in the trial are listed in Table 2. The following discussion was abstracted from communications with Norm Rowe, Wm. Leman Co., who performed the analysis of the trial samples. In general, oil from all varieties in the trial was considered out of character for typical "Madras quality." Specifically, in the variety trial for 1996, menthofuran, menthone, esters, and pulegone averaged 8.57, 17.15, 5.63, and 2.27 percent, respectively, whereas the 1996 Madras area averages were near 1.9, 20.7, 4.5 and 1.1 percent, respectively, for these four components. Typical long-term Madras area composition would be near 2.5, 16.6, 4.5 and 1.1 percent, respectively, for these components. These compositions suggest that mint in the trial area was overmature. The excessively high menthofuran is particularly noteworthy. In contrast, the varieties averaged only 36.1 percent menthol, which is considered immature in comparison to "typical Madras oil" that would average near 41.5 percent menthol. The discrepancies in this analysis are not easily explained. In general, mint was harvested with more flower development in 1996 than in 1995, when the trial oil was considered quite immature, but in both years harvest timing was considered to be appropriate after consultation with several local oil buyer representatives. Discrepancies might be due to the nature of distillation from the research stills compared to distillation from commercial stills (Mitchell & Crowe, 1996), to delayed harvest in 1996 associated partly with delayed plant development following a very cool spring, and/or to other plant responses resulting from unspecified weather and trial management in 1996.

As indicated by N. Rowe, common problems with research stills are lower total heads (from mint oil vapor escaping the condenser), associated with excessive steam rate, inadequately sized condenser, or inadequate condenser water flow rate. However, the total heads listed among the variety trial entries was typical for Madras oil. Improper mini-still operation may be reflected in missing high boiling components, but these too were relatively normal. N. Rowe also recommended certain changes in oil handling following distillation and during shipment for analysis.

The variety trial oil compositional data can be compared with oil character for the peppermint oil recovered commercially from the non-test areas of the COARC farm (last row in Table 2), which was commercially harvested and distilled 2 days after the variety trial harvest. This oil was a composite of about 1 part Black Mitcham, 2 parts Murray and 1½ parts of the variety trial mixture of varieties, and was also analyzed by Wm. Leman Co. The mint in these areas was located very near to the variety trial (or was part of it). This mint had been managed identically and it was in comparable stages of growth and development except for the 2-day delay. This oil showed a more typical Madras-type composition of menthofuran, esters, and menthol than entrees in the variety trial. But like the variety trial entrees, it was also high in menthone and even higher in pulegone in comparison to typical Madras composition. The most noticeable distinguishable difference between the variety trial and the commercial harvest was for menthofuran: 1.6 percent for the commercial lot (which was perhaps 1/3 oil from the variety trial) vs. 8.57 percent for the variety trial average.

Odor rating was similar for all varieties. Oil compositional analysis indicated that Black Mitcham was substantially different from other varieties -- in Table 2 note differences among total ketones, menthol, and pulegone total ketones, menthol and pulegone components. All varieties seemed to vary with respect to total ketones. Varieties seemed to cluster into two groups with respect to menthofuran, Murray and Roberts were lower than Black Mitcham, Todds, M83-7, and T84-5.

In general, the field trial was managed better in 1996 than in 1995, which was partially reflected in improved yields. Without wilt as a yield-reducing factor, all varieties yielded comparably. As discussed above, we are concerned about the non-uniform soil water differences between Black Mitcham and other varieties, and we believe that Black grows differently and/or uses water differently than other varieties. This may have implications for experimental design and management when trying to compare variety performance.

In addition to seeming varietal variation with respect to irrigation and fertility management as discussed above, it seems apparent that some varieties may require different harvest dates. This may be more true with respect to oil character than yield, but might affect both measurements (White et al. 1987). Detailed data demonstrating this was not collected in 1996. Nevertheless, maturity differences suggest implications for both yield and oil character. For example, in 1996 Black Mitcham seemed to be slightly more advanced in flower development than other varieties, and was more advanced in this respect in 1995. There was probably less difference in leaf maturity (i.e. the proportion of older and younger leaves) in 1996 than in 1995. With higher irrigation in 1996 the other varieties continued to grow and produce new leaves until harvest (in contrast to 1995, in which all other varieties were water stressed and did not produce new growth near harvest), but earlier lodging on Black Mitcham vs. other varieties in 1996 still resulted in some leaf age differences – and there may have been differences among the other varieties.

With the current trial design, it is difficult (but perhaps not impossible) to harvest experimentally on different days with respect to irrigation cut-back so that test plot equipment and commercial equipment can get into each variety as needed. Harvesting on different days influences the timing of other management factors such as post-harvest flaming, irrigation resumption, etc.

We believe field trials to be of very high value in distinguishing among varieties with respect to important characteristics, but feel that further discussion is needed to review feasible, optimum, and cost-effective experimental design and management, including all pre- and post-harvest management of plots, plants, and oil.

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Table 1. Means for Disease, Yield, and Seasonal Growth Ratings for Peppermint Variety Trial, Madras, Oregon, 1996[1]
Using the Fisher LSD Procedure

	Powdery Mildew[2] (All Plots)	Branched Stems[3] (All Plots)	Main Stem Height (All Plots)	Lodging[4] (All Plots)	Lodging (All Plots)	Wilt Loci[5] (Non-Infested Plots)	Wilt Loci (Infested Plots)	Dry Hay Yield[6] (All Plots)	Oil yield[6] (All Plots)
	6/14/96	6/17/96	7/1/96	7/8/96	8/15/96	8/19/96	8/19/96	8/19/96	8/19/96
Variety	%	%	cm	%	%	per 200 sq. ft	per 200 sq. ft	lbs/Ac	lb/Ac
Murray	0.3 a[7]	11 a	62 bc	68.3 a	89 a	0 a	22.0 a	7,725 a	81 a
Todds	0.3 a	11 a	62 bc	68.8 a	86 a	0 a	39.3 a	7,965 a	89 a
Black Mitcham	14.0 b	35 b	54 a	98.3 a	100 a	0 a	60.4 a	6,823 a	87 a
Roberts	0.3 a	17 a	58 ab	72.3 a	94 a	0 a	36.7 a	7,366 a	83 a
M83-7	0.8 a	23 ab	60 ab	59.8 a	82 a	0 a	26.5 a	7,560 a	90 a
T84-5	0.5 a	12 a	67 c	79.5 a	90 a	0 a	30.0 a	8,537 a	89 a

1. Trial was as two split blocks: a single non-infested area adjacent to another single area infested with 2.0 microsclerotia/g soil of *V. dahliae*. Within infested and non-infested blocks, six varieties were included in a randomized complete block experimental design with four replications. Varieties can be compared within or across infested and non-infested areas, but infested and non-infested comparisons are statistically valid only via variety vs. +/-*V. dahliae* interaction terms.
2. Rating for each plot was determined by averaging the area covered by mildew on the third and fourth leaves from 20 stems per plot.
3. Rating for each plot was determined by averaging the height of 20 stems per plot.
4. Proportion of plot area in which plants were lodged, expressed as a percentage.
5. Wilt ratings were cumulative for each date. Wilt loci are considered a measure of the number of independent systemic infections which developed by the dates shown. Separate infections occurring close to each other (i.e. within 20 cm) could not be distinguished. so actual systemic infection prior to harvest may be underestimated, especially as frequency increases. Not all pre-harvest systemic infection may manifest as wilt symptoms prior to harvest, and systemic infection may continue on fall re-growth after harvest. Wilt infection can lead to enhanced winter damage and possibly to enhanced damage from other stress factors. Winter damage in 1995-96 did not occur, as measured by uniform 100% plant stand ratings (data not shown) for all varieties in both infested and non-infested plot in the spring of 1996 ($p<0.05$).
6. Harvest was on 8/19/96. Dry hay weights were determined from air dried samples of fresh hay harvested. Sub-samples of fresh hay from each plot (approximately 10 lbs.)
was allowed to air dry in burlap sacks, prior to distillation at the OSU-Corvallis research stills in late August.
7. Means followed by the same letter are not significantly different, $p<0.05$.

Table 2. Means for Oil Character Ratings for Peppermint Variety Trial, Madras, Oregon, 1996.[1]
Using the Fisher LSD Procedure

	Odor Rating[2] (All Plots)	Total Heads[3] (All Plots)	Total Ketones[3] (All Plots)	Total Menthol[3] (All Plots)	Mentho-furan[3] (All Plots)	Menthone[3] (All Plots)	Menthol[3] (All Plots)	Esters[3] (All Plots)	Pulegone[3] All Plots)
Variety	Grade Level	%	%	%	%	%	%	%	%
Murray	1.3 a[4]	11.4 a	23.3 b	45.0 a	7.64 ab	17.7 bc	35.3 ab	5.9 a	2.31 bc
Todds	1.3 a	11.7 a	22.5 b	45.3 a	8.53 ab	17.2 bc	35.7 ab	5.8 a	2.39 bc
Black Mitcham	1.3 a	11.5 a	19.0 a	46.8 a	9.01 b	14.4 a	38.0 c	5.3 a	1.84 a
Roberts	1.0 a	11.8 a	23.1 b	45.7 a	7.34 a	17.9 bc	36.7 bc	5.2 a	2.10 ab
M83-7	1.1 a	11.3 a	21.7 b	45.4 a	8.91 b	16.1 ab	35.8 ab	5.9 a	2.59 c
T84-5	1.4 a	11.4 a	24.1 b	44.5 a	8.98 b	18.7 bc	34.9 a	5.7 a	2.36 bc
commercial[5]	ND[6]	12.8	23.9	47.9	1.6	17.3	39.9	4.2	2.7

1. Trial was as two split blocks: a single non-infested area adjacent to another single area infested with 2.0 microsclerotia/g soil of *V. dahliae*. Within infested and non-infested blocks, six varieties were included in a randomized complete block experimental design with four replications. Varieties can be compared within or across infested and non-infested areas, but infested and non-infested comparisons are statistically valid only via variety vs. +/-*V. dahliae* interaction terms.
2. As per organoleptic analysis, Wm. Leman Co.: 1 = acceptable, 2 = acceptable with modification, 3 = unacceptable.
3. As per chromatographic analysis, Wm. Leman Co.
4. Means followed by the same letter are not significantly different, $p<0.05$. Because Black Mitcham plots were consistently wetter during the season, all data was re-analyzed excluding Black Mitcham, but no new statistical relationships arose among remaining varieties.
5. Oil composition for the commercial harvest and distillation for the parts of three trials on the COARC Madras field which were not included in small test plot harvests. This included 0.1 acre Black Mitcham, 0.2 acre Murray, and 0.15 acre of the above mixed varieties (1/6th each). This composition is included for general comparisons only, and is not included in the statistical analysis.
6. ND = not determined.

DO VARIETAL-SPECIFIC ISOLATES OF *VERTICILLIUM DAHLIAE* OCCUR ON MINT, AND DO MICROSCLEROTIA OF MINT ISOLATES FORM IN SYMPTOMLESS BUT INFECTED STEMS OF MINT AND NON-MINT PLANTS?[1]

Fred Crowe

Abstract 1996

In the spring of 1996, four out of four mint isolates of Verticillium dahliae were found pathogenic on strawberries in a field planting following inoculation. In 1995, five of six strawberry isolates were found non-pathogenic to mint; the 6th isolate rapidly killed only one of two mint varieties. Does this indicate that variety-specific strains of V. dahliae exist? Following upon field observations of greater wilt in some other crops planted after beans (considered a non-host), it was observed in California in 1996 that V. dahliae pathogenic to certain other crops systemically infected certain bean species while causing nearly unmeasurable disease on the beans – i.e. these infections would be considered symptomless to the casual observer. Nevertheless, the V. dahliae formed microsclerotia in bean stems when the stems naturally senesced, which suggests that extensive reproduction of V. dahliae may not require noticeable wilt symptoms in plants not previously considered susceptible hosts. Does this happen with mint isolate on crops and/or weeds normally associated with mint rotations -- for example red clover, which in rotation with mint has been implicated in worsening mint wilt? These and related questions are the subject of this investigation, but in 1996 the primary progress toward formally addressing these issues was to establish a broad-based collection of isolates of V. dahliae from mint and other crops.

Introduction

Verticillium dahliae is distributed worldwide, causing a rapidly developing wilt on many different types of plants including vegetables, woody and herbaceous ornamentals, forest trees, mint, hops, etc. A related pathogen, *V. albo-atrum*, also causes a similar wilt disease on some crops, and in much of the older literature some of what is now labeled *V. dahliae* was then described as *V. albo-atrum*. [In general, unless otherwise noted, for all citations listed below in which *V. albo-atrum* is listed, *V. dahliae* would be the current nomenclature.] On potato, both fungal species cause a disease known as "early dying", a somewhat slower and less severe form of wilt on other crops. *V. dahliae* is widely distributed in the western United States, including California, Oregon, Washington, Idaho and Nevada. *V. dahliae* isolates aggressive against mint have been widespread in Oregon mint and throughout the United States. In some crops, verticillium wilt can be managed by combining chemical and cultural methods including preplant fumigation or soil solarization. For some crops in which fumigation is not economically feasible or effective, resistant or tolerant cultivars are available. Suitable crop rotations may be practiced in some cases. Methods such as fumigation and crop rotation are more effective where crops are high valued, where crops are not perennial (or at least are not grown perennially), where higher populations of *V. dahliae* are required for commercially-unacceptable disease loss (e.g. potato), and/or where at least some level of tolerance or resistance has been selected and utilized.

Microsclerotia (MS) of *V. dahliae* survive long periods of desiccation or absence of crop. Most MS seem to be produced in the stems of systemically infected plants after stem death (Gerik & Huisman 1985, Green 1980). Even if it does not cause symptoms, *V. dahliae* may invade systemically and distribute itself through the infected plant (Horner 1954, Lacy & Horner 1966). Grains such as barley, corn, sorghum, and wheat seem relatively immune to systemic invasion (Benson & Ashworth 1967), and thus may be the best rotational crops with respect to encouraging the decline in field infestation.

One of the questions addressed below is "Does the plant need to have been diseased by *V. dahliae* systemic infection in order for the fungus

[1] In 1996, this research was supported by a grant of $18,226 from the Oregon Mint Commission and the Mint Industry Research Council. These funds will support research through 1997.

to reproduce in stems?" Where the rotation crops are also susceptible to the same forms of *V. dahliae* (e.g. cotton, pistachio, olive, tomato, etc.), MS may build up on each host and these may be poor choices as rotational crops with each other. On the other hand, it is less certain whether MS increases in rotation crops that might become systemically infected but that do not become diseased. For example, neither alfalfa nor red clover seems to be affected by isolates of *V. dahliae* that incite wilt on mint. It has been observed that wilt does not worsen when mint follows alfalfa, but it does worsen where mint follows red clover (C.E. Horner, personal communication). These and other examples are not well documented, but the red clover observation suggests that numbers of MS of mint-aggressive isolates in the soil may be higher following red clover. Part of our investigation is to survey the potential for non-host crops to allow buildup of inoculum.

Strain specificity is a term used in the mint industry with respect to *V. dahliae*. For example, forms of the fungus may be recovered from mint or potatoes that prove aggressive on potatoes but that seem typically benign when they infect mint, and these are termed strains to indicate host specificity. Strains also may designated that preferentially attack certain varieties or cultivars within a species, such as in cotton or tomatoes. Whether this is true for mint is another object of this investigation. If forms of *V. dahliae* were found that differ greatly in their ability to incite disease among various mint species and varieties, evaluation of new mint varieties for crop resistance to *V. dahliae* would need to be done against the range of forms of *V. dahliae* that those mints will encounter in commercial fields. For any given naturally infested field, the set of isolates encountered may not well represent the capabilities of the total set of isolates across a region or state. When one or a narrow number of isolates is chosen for greenhouse testing or for artificial infestation of soil (so effects can be studied against a uniform background of inoculum), it is imperative that the isolates used represent the range of capabilities of the full populations of isolates.

Strain specificity may not be genetically stable, potentially shifting in plant preference (Fordyce & Green 1963, Green 1977). However, most scientists consider strains of *V. dahliae*, where they exist, relatively stable. The situation remains somewhat undecided. As per Subbarao et al 1995, "*V. dahliae* generally lacks host specificity and, thus, genetically stable races that attack only certain cultivars or varieties within a crop are not reported, with the exception of tomato (Baergen et al. 1993). From ecological, disease management, and taxonomic perspectives, the potential pathogenic specialization, or lack thereof, within *V. dahliae* is an important consideration. For example, the choice of crops for rotation is primarily dependent on the host range of the isolates in the region. The absence of information on the relative susceptibilities of crops in the region makes choice of rotation difficult" (Subbarao et al. 1995).

Objectives:

1. Determine the pathogenicity on various mint species and varieties of common local mint isolates of *V. dahliae* collected from several states.

2. Determine the pathogenicity of isolates from objective 1 on a selected range of alternate host plants, and determine whether *V. dahliae* grows symptomatically and asymptomatically in these alternate host plants. Include red clover, alfalfa, potato, strawberry, etc.

3. Evaluate MS production in both diseased and non-diseased plants from Objective 2. Evaluate living, senescent tissue and senescent tissue plus soil after burial of plant in soil.

4. Inventory the above isolates for possible further evaluation into vegetative compatibility groups (VCG) by D. Johnson at Washington State University.

5. Determine how long mint stems take to decay and release MS into the soil. (Carried over from previously funded-but-unfinished objective in wilt inoculum density vs. disease incidence vs. flame/till trial at Powell Butte).

Methods

1. Collect 40 isolates of *V. dahliae*, 10 from each of 'Black Mitcham', 'Murray' and 'Todds' and Scotch spearmint distributed among both western and mid-western states. Test the pathogenicity of each against the same set of mints using root dip inoculation from conidial spore suspensions. A cross-section of *V. dahliae* isolates pathogenic to other crop species will be included.

2. Grow plants for inoculation using several mint varieties, potato, red clover, alfalfa, strawberry, and several others to be determined. Inoculate these the same way as the mint above and assess pathogenic responses including plant height, leaf number, root dry weight, shoot dry weight, wilt severity, and root discoloration. Determine whether *V. dahliae* can be recovered from stems.

3. Observe mint and non-mint plants above for formation of MS in stems. Assess this while plants appear healthy, after symptoms (if any) develop, as plants senesce (this may need to be facilitated by withholding water or other means), after senescence is complete, and after plants have been placed into soil for several weeks or months. The soil used will be initially free of recoverable MS, and may include natural soil and/or potting media. Recover *V. dahliae* from stems and reassess pathogenicity on mint.

4. Isolates used will be placed into sterile soil in test tubes, and stored under refrigeration for use in other investigations.

5. As an extension of Objective 3, wilted stems will be placed into potted and field soil, or left on the soil surface. Stems will be periodically recovered and visually inspected under the microscope to determine when MS is released from stem tissues.

Results from 1996

Preliminary data are mentioned in the summary for strawberries, but routine infection of other plants has not been formally undertaken yet. Collection of preliminary data mentioned above on beans by T. Gordon is progressing independently of the mint investigation, but cooperative work may be structured, if possible.

In 1996, our primary accomplishment was to establish a broad collection *of V. dahliae* isolates. Wilted mint stems were collected in or received from Oregon [central Oregon, the Willamette Valley, La Grande], Washington, Idaho, Montana, and Indiana. Approximately 38 isolates have been catalogued a this time, and a few additional collections will be made during 1997. Most isolates were from peppermint, a few from spearmint. Some non-mint isolates have been received, but over the winter of 1996-97, additional isolates will be gathered from cooperators working with potato, alfalfa, strawberry, cauliflower, cotton, and perhaps other crops susceptible to *V. dahliae*. Experimentation will begin early in 1997.

Much experimentation will be conducted under light banks or in the greenhouse at COARC-Powell Butte. For certain plants such as strawberry, the normal course for wilt development only really occurs with field planting. Strawberry plants are inoculated, then placed into field plots in the fall, with wilt onset in the following spring or summer. MS may take some time to form in stems, and stems of mint and other crop plants buried in soil may also take some time to decay. This type of activity may delay completion of the entire study beyond 1997.

Discussion

Very limited preliminary data mentioned above together with common experience (e.g. with potatoes rotated with mint) suggests that strain variability exists with respect to pathogenicity of *V. dahliae* on mint and other crops. Data is suggestive that varietal specialization could exist among some *V dahliae* isolates that have the ability to wilt mint, but whether this is common and true for most isolates found in mint regions remains to be determined. Preliminary data -- that relatively non-susceptible beans allow increase in soil inoculum of *V. dahliae* in California when used in rotation with crops highly susceptible to wilt -- remains to be confirmed, but provides further impetus for following through with comparable investigations with mint.

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FIELD PERFORMANCE OF MINT PROPAGATED BY VARIOUS MEANS[1]

Fred Crowe

Abstract

For this field trial, peppermint and spearmint rooted cuttings were propagated in various ways, some of which might result in measurable shifts in field growth, development, yield, or oil character in comparison to other propagation methods. If differences were to occur, the most likely cause(s) would be clonal genetic variation (when only one or a few selected plants were used as the basis for propagation of many plants) or alteration in disease status (when plants were meristem tip cultured or otherwise treated in a manner that might eliminate viruses or other systemic infection). The several propagation treatments were not necessarily exclusive with respect to their potential genetic or disease effects – i.e. in some treatments, both clonal selection and disease freedom might occur, either of which, or both of which, might effect growth, development, yield, and oil character. In general, whether any measurable differences for various propagation methods occurred in the field were of interest. The nature of any such differences would be investigated later.

In this first year of planting, plants from all propagative techniques established well in the field. Plants were managed in ways that might prevent transmission of virus and bacteria among plots. Strong differences in vigor (peppermint and spearmint), timing and extent of flowering (peppermint and spearmint), and stolon development (peppermint) were observed ($p \leq 0.05$). Harvest weights seemed to differ, especially for peppermint, but means were not statistically separable ($p \leq 0.05$). Specific treatment differences are not discussed, as the identity of treatments remains coded at this time. Some caution is urged in interpreting this first year data, as there is the potential for field differences to have arisen from cultural effects during greenhouse production and shipping, especially for peppermint where two different propagation companies were involved, and where plants for one treatment arrived in two stages.

Introduction

Commercial propagation of rooted mint cuttings has changed in recent years. In addition, heretofore unknown micro-organisms have been identified within mint plants that might have effects on mint growth and performance. It could become routinely important to distinguish genetic variation within the plants themselves from pathogenic infection by viruses or other micro-organisms that may or may not reside in mint plants. Another issue is whether mint rootstock should routinely be passed through a meristem tip culture or tip culture phase to eliminate any risk that the common soil-borne and rhizome-borne pathogen fungus, *Verticillium dahliae*, might be carried along in propagation stock, although the risk of this is low already. There is some advantage in maintaining mint axenically (free of all micro-organisms) in a culture test tube (*in vitro* culture) as a source of stock plants, rather than keeping stock plants in greenhouse beds or collecting new stock plants from the field – although such culture in itself will not exclude viruses.

With respect to axenic or *in vitro* culture of mint in test tubes, problems typically arise when bacteria living within the plant (endogenous bacteria) eventually proliferate and contaminate test tube plant cultures (Buckley et al. 1995, Reed et al. 1995). The natural distribution of such bacteria in commercial mint production, and the possible influence by such organisms on growth and development of mint in the field has been raised. Certain endophtyic bacteria are occasionally influential in some plant systems, so at least theoretically, their exclusion from (if detrimental) or retention in (if beneficial) rootstock destined for the field could be important. It is argued here, however, that the endogenous bacteria associated with mint are far less likely to be the cause of growth differences in the field than are either virus(es) as discussed below or genetic variation in the mint plant (also addressed below). Bacteria almost certainly routinely enter mint plants through cut ends of rhizomes, through wounds of various sorts, or into leaf air spaces. The two citations above are for mint (Buckley et al. 1995, Reed et al. 1995), and resulted from work under the direction of Dr. Barbara Reed. She observed many kinds of bacteria associated with mint, none of which were common plant pathogens, but all of which were common soil inhabitants. Dr. Reed did not perceive the presence of absence of bacteria to impact mint growth in her studies, except in tissue culture. No individual mint plant harbored more than one or two bacterial

[1] In 1996, this research was supported by a grant of $12,246 from the Oregon Mint Commission and the Mint Industry Research Council.

species. No bacterial type was predominant – many types were each found in low frequency. No bacteria were found in some plants, and no bacteria were found in high population within any plants. Dr. Reed's only concern was to eradicate any bacteria that proliferated after mint plants were placed into tissue culture, under conditions that favored the growth of the bacteria such that the mint cultures were overwhelmed and unsustainable. She considers the endogenous bacteria associated with mint to be strictly a tissue culture problem in the laboratory. This may translate into a hurdle for maintaining *in vitro* propagative stock for commercial mint propagators, but bacterial status of rootstock in the field is likely unimportant (Barbara Reed, USDA-ARS, Corvallis OR, personal communication). While there are endogenous bacteria that do affect plant growth (usually adversely), these are typically quite different than the ones Dr. Reed found. Screening mint rootstock for bacteria and subsequently identifying the various types is tedious, expensive work, which we feel is an unjustified effort unless some stronger indication emerges that bacteria play a larger role in mint performance in the field.

A previously undetected Capilloviruses virus was recently detected in peppermint. This plant virus group is typically transmitted by vegetative propagation and typically only causes growth reduction rather than necroses, distortions, color changes or other debilitating symptoms often associated with many plant viruses. We suspect that this virus is routinely propagated with normal grower handling of field grown rhizomes, and likely is routinely transmitted with greenhouse grown rooted cuttings unless extreme measures (e.g. meristem tip culture) are taken to eradicate it (Crowe 1993, 1994, and Crowe & Lommel 1995). Observations by us and others (L. Welty, Montana State Univ., personal communication) indicate that this virus may in fact prove beneficial in mint. Even though hay yields were lower, oil yield was higher in non-meristemmed mint. However, some growers have reported better growth and yields with meristemmed mint.

Our virus findings have not yet been completed to the point where the virus has been reinserted into truly virus-free mint in order to verify that it actually causes the observed differences in plant growth. This is an objective of research in progress, which has been delayed by the need to establish truly virus free test plants for the transmission studies.

As an alternative hypothesis to explaining the above growth differences, it is possible that by using a single selected mother plant (meristem tip cultured or otherwise) as the base for all later propagation, genetic clonal variation inadvertently occurs. This could be true for axenic culture or *in vitro* systems, too, if most rooted cuttings were derived from only one or a few mother plants.

For the field trial reported here, and for a similar field trial in Montana, peppermint and spearmint rooted cuttings were propagated in various ways, some of which might result in measurable shifts in field growth, development, yield, or oil character in comparison to other propagation methods. If differences were to occur, the most likely cause(s) would be clonal genetic or alteration in disease status. Treatments included in central Oregon are described in detail below. The several propagation treatments were not necessarily exclusive with respect to their potential genetic or disease effects – i.e. in some treatments, both clonal selection and disease freedom might occur, either of which, or both of which, might effect growth, development, yield, and oil character. In general, whether any measurable differences for various propagation methods occurred in the field were of interest. The nature of any such differences would be investigated later.

Ideally, all material used for field testing comparisons would have come from a single propagator and materials to be compared would have been handled comparably during propagation and shipment. Indeed, in our past field study, our inability to acquire both meristemmed and non-meristemmed mint from a single propagator was cause to discount all information on size and vigor of plant materials shipped from different suppliers, and to discount all growth comparisons in the first year in which materials were planted. When the plantings grew differently in the second and later years, we were confident that such differences were not due to carryover of different greenhouse management.

In 1996, all spearmint treatments and four of five peppermint treatments were from Summit Labs, with one additional treatment from Lake Seed Co.

Objectives

1. Determine whether methods of propagation affect field performance of peppermint and spearmint.
2. Gather clues as to whether observed differences in plant growth might be due to virus infection status or to genetic alteration (stable or semi-stable) during propagation.

Methods

Treatments included in the 1996 planting were as follows, with sources of the material in parentheses. Treatments in central Oregon may vary somewhat from those included in related Montana field trials.

<u>Black Micham Peppermint Treatments</u>: The mother plant mentioned below was tested by S. Lommel to be infected with the Capillovirus mentioned above.

a. (Summit Labs) **Heat treated and meristem tip cultured from single mother plant.** Using a single, heat treated mother plant from the MIRC greenhouse beds, fully differentiated daughter plants were regenerated in test tube from meristem tip. Both heat treatment and meristem tip culture assist in the elimination of viruses from regenerated plants (Wright 1988). Regenerated daughter plants were relocated to the greenhouse. Several of these putative virus-free daughter plants were used as sources of rooted cuttings planted into shipping trays received in central Oregon. The probable virus status of the several daughter plants regenerated has not yet been established.

b. (Summit Labs) **Rooted cuttings from same single mother plant as in section a.** The same mother plant as above was the source for a step-wise increase of rooted cuttings into shipping trays. These plants are almost certainly virus infected, but this has not yet been confirmed.

c. (Summit Labs) ***In vitro* nodal propagation from same single mother plant as in section a.** The mother plant above was used to create several aseptically-maintained daughters *in vitro* in test tubes. From these daughters, nodes were rooted briefly in aseptic medium *in vitro* and, when rooted, were transferred to shipping trays. These plants likely are infected with the virus, but this has not yet been confirmed.

d. (Summit Labs) **Recent *in vitro* nodal propagation from many plants.** [Hundreds of plants originating from MIRC beds were established *in vitro* in the winter of 1995-96. Nodes were cut and rooted aseptically for a few weeks in early spring of 1996, then transferred to greenhouse flats. These were then re-established *in vitro*, from which nodes were rooted *in vitro* and then transferred to shipping trays. These plants likely are infected with the virus, but this has not yet been confirmed.

e. (Lake Seed) ***In vitro* propagation from many plants (4 yr. *in vitro*).** This propagator established Black Mitcham *in vitro* in 1992 from one or a very few plants, but did not meristem tip culture. The plants have remained in culture since then. Nodes were rooted *in vitro* prior to transferring to shipping trays. The plants have not yet been tested for virus infection status.

Scotch Spearmint Treatments: The mother plant used by Summit Labs was tested by S. Lommel to be infected with the Capillovirus mentioned above. Treatments were identical as for a, b, c, and d above, but no plants were available from Lake Seed or other propagators.

In 1996, plants were rooted in potting medium in individual plastic flat cells at Summit Labs and Lake Seed Co., shipped on June 17 from Colorado and Montana, and received June 18 in Madras. Prior greenhouse management is not listed here, but slight variations would be expected among propagators, and slighter variation for each propagator with respect to length of time within rooting cells, light incidence, fertility, potting mix, etc. All plants were in excellent condition upon arrival in Madras.

The experimental design was a randomized, complete block with four replications. Within plots, plants were placed 15 inches apart into 20 ft open furrows and covered with soil 2.5-3 inches deep on June 18. Irrespective of length of root ball and stems, plants were laid along the furrow, with only the top-most foliage protruding above the soil surface. This allowed for greater rooting area along stems. There were five furrows per plot spaced 20 inches apart. As mint grew, plots were considered to be 9 ft wide x 20 ft long. There were 5 ft separations between plots within replications, and 10 ft separations between replications. Due to an under-supply of Summit meristem tip cultured peppermint, plants were received in two shipments. Sicty-four percent of the meristem tip cultured peppermint plants were planted on June 18 leaving alternate gaps; gaps were planted on August 7 with additional meristemmed plants.

Within 3 weeks of planting, a half-rate of Sinbar (terbacil, DuPont) herbicide (¾ lb ai/ac) was applied to peppermint, but not spearmint. All plots were hand-weeded as necessary during the season. After harvest, another ¾ lb ai/ac of Sinbar was applied to both spearmint and peppermint. Plots were aerially sprayed once with Comite (propargite) at mid-season.

For all plant sampling, and for harvest, care was taken to avoid transmission of virus and other micro-organisms between plots. For flower stem collection, stems were snipped with scissors that were sterilized between plots with disinfectant. At harvest, swather cutter bars and related pieces involved with cutting and bringing hay into the swath were sprayed with 0.05 percent NaOCL between each plot. No viral or bacterial analysis was attempted from field grown material in 1996, although in retrospect this probably should have been done.

The total plot width and length was harvested on September 9, for both peppermint and spearmint.

To date, treatments remain coded, such that the field investigator in central Oregon (F. Crowe) is not aware of the type of propagation (except for Summit's meristem tip cultured plants which were in short supply, and plants from Lake Seed Co., which arrived by separate shipment).

Results

As indicated above, the virus infection status of plants in various treatments has not yet been determined.

Peppermint: Treatments are coded P1 through P5. Ignoring the fewer plants placed into the one treatment, a perfect stand was achieved in all treatments – 100 percent of those planted on June 18 were present and growing on July 29. Evidence for differing field performance among treatments is seen in Table 1. No buds were observed on July 22, but by July 29, buds were seen in treatment P1 but in no other treatments ($p \leq 0.05$). Vigor rating for July 22 (not shown) was similar to July 29 for which there were strong differences ($p \leq 0.05$). Above ground stolon development showed some differences on July 29 ($p \leq 0.05$). Careful excavation suggested that underground rhizome development somewhat matched ground surface development of stolons for each treatment, although data were not specifically collected. In general, plants within plots seemed quite uniform in growth and development.

Harvest results are shown in Table 1 as the mean dry weight (lb/ac) per treatment. The peppermint was not distilled. In the meristem tip cultured treatment, the plants received late were well-established by harvest, but did not have sufficient top growth to contribute to harvest yield. Further, there was no top growth on plants in any treatment that intersected the top growth of adjacent plants, which might have resulted in competition for sunlight and reduced growth per plant. Thus, each plant in each treatment was considered to have contributed equally toward harvest yield in 1996, irrespective of stand. For presentation in this table, harvest yield for the meristem tip cultured treatment was corrected by the stand proportion for the first planting date, so the harvest data reflect yield for a 100 percent stand as for other treatments. When the data were analyzed either with or without such correction, no statistically significant differences were found in either case ($p \leq 0.05$).

Spearmint: Treatments are coded S1through S4. Survival averaged 95 percent, with no statistical differences among treatments ($p \leq 0.05$). Evidence for differing field performance among treatments is shown in Table 2. Well-developed lower buds were present on plants in two of the four treatments on July 22 ($p \leq 0.05$). Also on July 22, vigor in one treatment was substantially less than in other treatments ($p \leq 0.05$). It was felt that excessive early flower development might be to the detriment of root and rhizome growth. To redirect growth from flowers to vegetative growth flowers were removed, and in addition were counted and weighed (Table 2). By July 29, uniform but very early development of bud initials were present on plants in all treatments. Extensive foliar growth had occurred during the previous week, and no flowers were removed at this point. In contrast to peppermint above, no rhizome/stolon development was seen at ground surface level on July 22 or July 29, but this was irregularly present on August 7, 1996. Careful excavation suggested that underground rhizome development was comparable to surface development of surface stolons. In general, plants within treatments seem quite uniform in growth and development.

Harvest results are shown in Table 2 as the mean dry weight (lb/ac) per treatment. No statistically significant differences were found among harvest weights ($p<0.05$). The spearmint was not distilled.

Discussion

All rooted cuttings from all treatments established well in 1996. Spearmint and peppermint derived by different propagation means show some marked early and mid-season variability in vigor, growth, development and yield following planting in field plots in central Oregon. The various treatments remain coded at this time and are not identified. Caution should be used in inferring that all field variation is due to propagative technique and/or pathogenic status, as some or all variation could be due to greenhouse management/shipping variables, especially between the two propagation companies in the peppermint trial. Further, in the case of the meristem tip cultured peppermint, we may not have been correct to adjust the data as we did for stand differences, although we believe this was the appropriate way to consider the data. As any theoretical greenhouse or establishment effects should be gone by 1997, future differences may be more meaningful than those seen this establishment year.

Final comment on previous meristem tip culture trial, 1992-1996

The previous field trial, in which Black Mitcham that had been meristem tip cultured was compared with Black Mitcham that had not been meristem tip cultured, was retained in 1996 with minimal attention. No differences were seen with respect to several growth or harvest parameters, although originally meristem tip cultured plants were substantially greener in early to mid June than originally non-meristemmed plants. It may be recalled that growth in originally meristemmed plants was greater, and oil yields were lower than in non-meristemmed plants. However, these differences subsided over several years while at the same time virus began to appear in originally meristemmed plants that had not been present in the earliest years of the trial.

We initially thought that the meristem tip culture process might not have been efficient, and that a trace of virus particles might have been left in the meristemmed plants, resulting in eventual reappearance of the slow-growing virus over several years. We now suspect that our harvest processes, especially swathing, may have spread this virus between and among mint plants and across plots. We made no attempt to disinfect the swather cutter bars or other surfaces exposed to plant sap during harvest or other field operations during 1992-1995. Our new trial reported above is being handled substantially differently in this respect.

Growers of commercially available meristemmed mint may note a similar slow reversion of meristemmed mint to the non-meristemmed type of growth if they move swathers, tubs/choppers or other equipment that might spread expressed plant sap between fields of meristemmed and non-meristemmed mint.

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Table 1. Means for ratings of peppermint development and yield in the propagation trial in Central Oregon, following planting of rooted cuttings on June 18, 1996, using the Fisher LSD Procedure

Treatment	No. Plants with Buds Present per Plot[1] 7/29/96	Stolon Development[2] 7/29/96	Vigor of Top Growth[3] 7/29/96	Dry Hay Yield at Harvest[4] (lb/ac) 9/9/96
P1	26.5 b[5]	6.0 a	6.6 a	1,768 a
P2	0 a	8.4 b	7.7 ab	1,961 a
P3	0 a	8.7 b	9.3 bc	2,098 a
P4	0 a	8.3 b	8.4 abc	1,642 a
P5	0 a	9.0 b	10.0 c	2,088 a

1. The number of plants (of 80 per plot) on which at least a single bud was seen to be developing.
2. Rhizome/stolon development at ground surface on a scale of 1 (none) to 10 (abundant and aggressive).
3. Vigor (visual rating, considering number and length of branches, of stems and foliage) on a scale of 1 (very little) to 10 (abundant and aggressive).
4. Entire plot was harvested with a forage swather, weighed, with sub-samples weighed and dried to determine the proportion of dry to fresh weight.
5. Means followed by the same letter are not significantly different ($p \leq 0.05$).

Table 2. Means of ratings for spearmint development and yield in the propagation trial in Central Oregon, following planting of rooted cuttings on June 18, 1996, using the Fisher LSD Procedure

Treatment	Buds Present per Plot[1] 7/22/96	Dry Wt of Flower Stems + Buds[2] 7/22/96	Vigor of Top Growth[3] 7/22/96	Vigor of Top Growth[3] 7/29/96	Dry Hay Yield at Harvest[4] 9/9/96
S1	2.8 a[5]	4.8 a	8.5 b	9.8 b	2,091 a
S2	52.3 b	105.0 b	8.5 b	9.3 ab	2,323 a
S3	4.8 a	7.6 ab	9.3 b	9.8 b	2,344 a
S4	41.0 ab	75.3 ab	4.8 a	7.8 a	2,163 a

1. The total number of stems with buds seen within a plot. Some plants had more than one stem in bud.
2. Oven dry wt (grams) of buds and stems removed.
3. Vigor, including number and length of branches, of stems and foliage on a scale of 1 (very little) to 10 (abundant and aggressive).
4. Entire plot was harvested with a forage swather, weighed, with sub-samples weighed and dried to determine the proportion of dry to fresh weight.
5. Means followed by the same letter are not significantly different ($p \leq 0.05$).

WATER USE OF KENTUCKY BLUEGRASS GROWN FOR SEED

A.R. Mitchell, S.M. Griffith, and C.L. Yang.

Abstract

*Kentucky bluegrass (*Poa pratensis*) grown for seed in the Northwest is irrigated until late spring and harvested in earlier summer. Daily crop water use was measured for both aggressive ('Glade') and nonaggressive ('South Dakota') bluegrass by the changes in soil water content from soil sensors. There was no significant difference in crop water use between cultivars that had differing seed and dry matter yield. Cumulative water use to harvest was 365 and 257 mm in 1994 and 1996, respectively. The crop coefficient (Kc) for bluegrass had a midseason stage that began very early in the season, followed by a decline after anthesis. A system of multiplexing soil moisture sensors was used to measure water use by changes in soil water content, and compared favorably to estimates of seasonal water use in 1994. In 1996, the sensors measured less water use, possibly due to the cool spring and ample irrigation that keep the soil wet.*

Introduction

Kentucky bluegrass (*Poa pratensis*) is grown for seed in many areas of the Pacific Northwest in both irrigated and non-irrigated regions. The water requirements for Kentucky bluegrass seed have not been directly studied as far as we know. Published estimates of crop water use, or evapotranspiration (ET), do not agree. Using three sources of data for central Oregon as examples, bluegrass seed yearly water use was listed as 912 mm (35.9 inches) by Cuenca et al. (1992), while the Bureau of Reclamation's AgriMet system calculated a five-year average as 371 mm (14.6 inches) (Bureau of Reclamation, 1995), and Watts et al. (1968) listed 151 mm 5.95 inches. The discrepancy makes it imperative that field measurements substantiate water use of Kentucky bluegrass seed.

Cultivars of Kentucky bluegrass have been classified as aggressive and non-aggressive according to their tillering characteristics. Aggressive cultivars have more active rhizomes, and typically produce more seed at an earlier date, than the nonaggressive cultivars. Because this growth characteristic may influence ET, it should be measured for both aggressive and non-aggressive types.

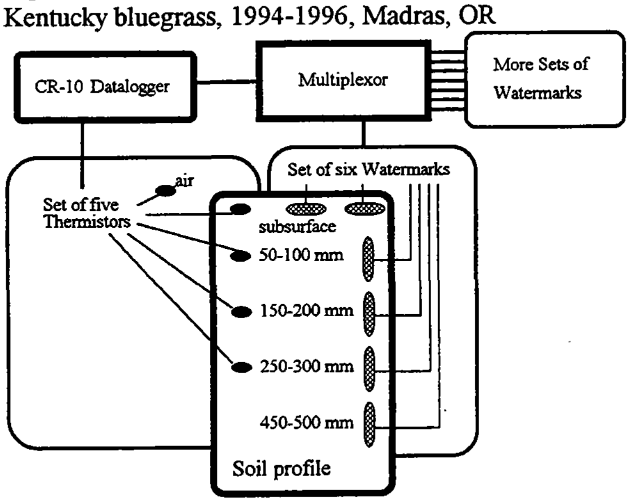
The objectives of this study were to determine the crop water use of Kentucky bluegrass seed for aggressive and nonaggressive cultivars. Indexing ET to potential evaporation is a valuable means of transferring crop ET to other locales and years. A secondary objective is to develop a crop coefficient (Kc) relationship for Kentucky bluegrass seed.

Materials And Methods

Water use was measured on Kentucky bluegrass seed experiments located at the Central Oregon Agricultural Research Center, Madras, Oregon. The two cultivar treatments used here were part of a larger nitrogen-source experiment, consisting of eight cultivars and two nitrogen fertilizer types, that will be reported elsewhere. Two cultivars were selected based on their aggressivity; 'Glade' the most aggressive, and 'South Dakota' the least. The soil was a Madras loam (fine-loamy, mixed, mesic, Xerollic Duragid).

The trial was conducted according to standard practices for planting, weed control, pest control, irrigation, and fertilizer application. Irrigation is typically halted in mid-June to dry the crop preparatory to harvest. Harvest occurred on 5 July 1994 and 2 and 10 July 1996 for 'South Dakota' and 'Glade', respectively. Harvest was accomplished by taking 1 m^2 sections of each plot. Samples were weighed for dry matter, and stored for later threshing of the seed. Seed threshing was done at the USDA-ARS National Forage Seed Production Research Laboratory, Corvallis, Oregon.

Figure 1. Automated Watermark ET system for Kentucky bluegrass, 1994-1996, Madras, OR



An automated weather station located within 30 m of the experimental plots provided hourly weather data for precipitation and potential ET calculation. The Kimberly-modified Penman equation was used to calculate potential ET (Epenman) according to Dockter (1994). The weather station was managed by the US Bureau of Reclamation as part of their AgriMet network of weather stations.

The ET measured by the sensors (ETsensors), was calculated according to the method outlined in Mitchell et al. (1994) and Mitchell and Shock (1996). Watermark Model 200SS sensors (Irrometer, Inc., Riverside, CA) were buried at several soil depths and multiplexed to a CR-10 datalogger (Campbell Scientific, Inc., Logan, UT) as shown in Figure 1. A set of eight sensors were placed in three locations within replications of the 'Glade' and 'South Dakota' treatments. Readings were taken at 6:00 am daily. The surface sensors were installed horizontally 1 cm below the surface to monitor changes in evaporation after irrigation. Surface soil water changes would not be easily detected if the sensor were placed vertically, which is the practice for installation at greater depths. When integrating water content changes for the whole profile, each sensor was assigned a weight corresponding to the relative volume of soil that it represented.

The data from the CR-10 was transformed to water content according to equations outlined in Mitchell and Shock (1996). Although the Watermark sensors measure the soil matric potential (Eldredge et al. 1993), they can be calibrated to soil water content directly for a specific soil, or alternately calibrated using the soil water characteristic to transform matric potential to water content (Mitchell and Shock, 1996). Precipitation events and sprinkler irrigation upset the calculation of ET by the sensors because they measure soil water changes that do not represent the evaporation of water on the leaf surface following irrigation. For this reason, we decided that it would be impossible to construct the ET on days with significant precipitation or irrigation. Instead, we assumed the magnitude of ET on those days to be equal to that of the previous day.

Total seasonal ET was estimated using water balance equation (ETwb) from early March to July 1 according to

$$ETwb = I + P + \Delta S - D - R$$

where I is irrigation, P is precipitation, and ΔS is the difference in soil water storage between the initial and final measurement dates in March and July. Drainage from the profile, D, and runoff, R, were assumed to be negligible.

The crop coefficient (Kc) was calculated as the ratio of ETsensor to Epenman. We estimated Kc by fitting polynomial equations to the Kc data from five-day periods throughout the season.

Table 1. Total ET until July 1 as measured by sensors, water balance, AgriMet, and Epenman, and seed yield and dry matter for 1994 and 1995, Madras, OR.

	ETsensors (mm)	Etwb (mm)	ET AgriMet (mm)	Epenman (mm)	Seed Yield (kg ha^{-1})	Dry Matter (kg ha^{-1})
1994						
Glade	367	367			94*	9,919
South Dakota	364	368			376	11,610
Average	365	367	376	553		
1996						
Glade	246	302			591	6,980
South Dakota	269	305			563	9,819
Average	257	303	363	485		

*=significant at the 0.05 level

Results

In 1994, the seasonal ETsensor values for the two cultivars did not differ significantly and were virtually identical to each other and to the ETwb calculation (Table 1) . In 1996, the mean ETsensor was 257 mm and the ET between treatments differed by 23 mm, which is only 9 percent of the total. The ETwb was higher than ETsensor in 1996, possibly from drainage that occurred in the abnormally wet spring months but was not accounted for in the ETwb calculations.

Plant above-ground dry matter between 'Glade' and 'South Dakota' was not significantly different in 1994 or 1996, whereas the first-year seed yield (1994) was greater in 'South Dakota' compared to 'Glade'. In contrast, third-year (1996) seed yield was not significantly different between cultivars.

Figure 2. Cumulative Kentucky bluegrass seed ETsensor and Epenman, Madras, OR, 1994.

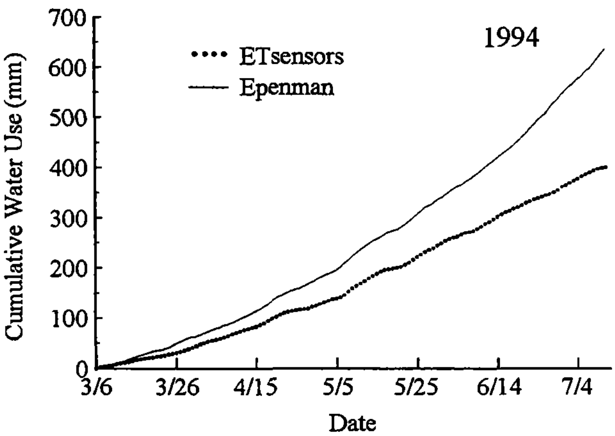
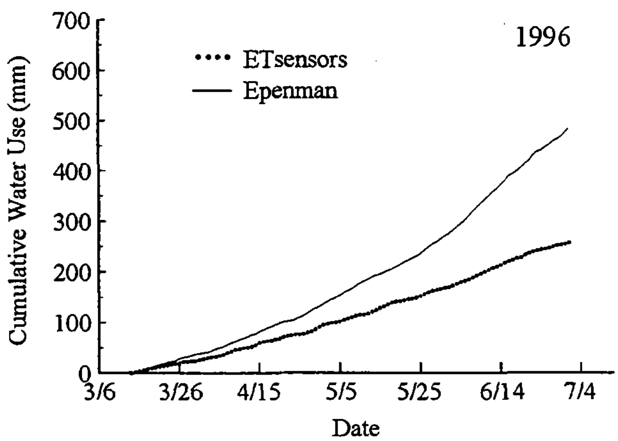


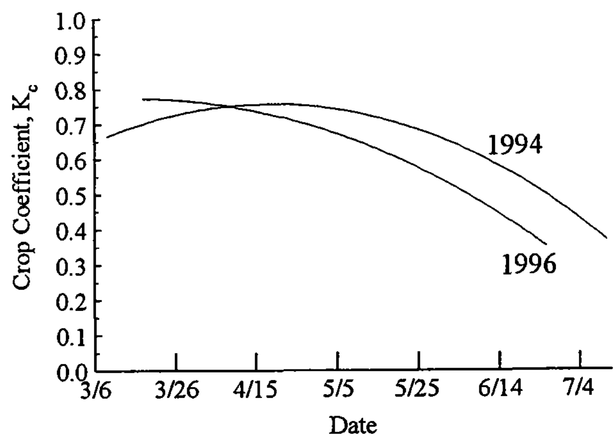
Figure 3. Cumulative Kentucky bluegrass seed ETsensor and Epenman, Madras, OR, 1996.



The total (through July 1) ETsensor value is compared against the Penman evaporation of both years in Figures 2 and 3. In 1994 and 1996, the ETsensor was 66 and 53 percent of Epenman. The lower 1996 ETsensor value may have occurred because of the cool spring, and ample irrigation that kept the soil in the wet range of soil water content, where sensors are not a sensitive to water content changes. Another possibility is the powdery mildew that infested the bluegrass in 1996 and likely reduced growth and plant transpiration in late May and early June. This reduction can be observed in the Kc curve of 1996 (Figure 4).

The general form of Kc curves consists of initial, crop development, mid-season, and at-harvest stages (Doorenbos and Pruitt, 1977). As Figure 4 shows, The Kc values for both years started relatively high (0.7), meaning that the grass did not experience the low value of the initial growth stage as do most field crops (Doorenbos and Pruitt, 1977). This is not surprising since bluegrass was already established when it began growth in late winter. The midseason Kc remained at 0.8 until late May in both years, then began declining during the second week of June in both years, which corresponds precisely with the anthesis of the bluegrass, and its reproductive stage. After that, Kc declined as irrigation ceased two weeks prior to harvest in early July (Figure 4).

Figure 4. Kentucky bluegrass Kc values for 1994 and 1996, Madras, OR.



Discussion

The various estimates of Kentucky bluegrass seed water use in the literature differ from our field measurements due to disagreement about the Kc during different cropping periods. Watts et al. (1968) used the Blaney-Criddle monthly ET estimates with an equation-specific Kc. They assumed the growing period to be from mid April to mid June, which has been shown to start earlier (Figures 2 and 3 above.) Cuenca et al. (1993) used the modified Blaney-Criddle method (Doorenbos and Pruitt, 1977) and assumed the growing season was the entire year, which also is not accurate. The 12-month growing season and the high grass seed Kc combine to give high estimates of ET. All of the above crop water estimates appear to be based on Kc values of turfgrass, for which considerable research has been done (Carrow et al. 1990). Unlike grass seed, turfgrass is regularly cut and is at full cover, which gives it a high Kc near 1.0. However, grass seed followed the water-use pattern of grain, in which Kc decreases late in the season as the plant shifts from vegetative growth to reproductive growth and relocation of assimilates.

The Bureau of Reclamation's AgriMet ET estimates out-performed the above in approximating ET. These estimates were from daily calculated Etpenman based on the weather station data, in conjunction with Kc values that started in early March and ended in mid June (Bureau of Reclamation, 1995). The largest discrepancy between the AgriMet estimates and our data is the rate at which the Kc increases in earlier spring.

Late season irrigation in September and October is necessary to produce fertile tillers in the dry autumn climate of the Northwest, although it was not included in our analysis, nor those of the Bureau (1995) and Watts et al. (1968). Like the spring season analysis here, there is a need for actual measurements of late season crop water use and irrigation requirements.

The good agreement between ETsensor and ETwb in 1994, indicates that the mulitplexed Watermark sensors can be an accurate method for estimating water use. We believe the discrepancy between the estimates in 1996 can be explained by drainage not included in the ETwb. The Watermark system has additional advantages of being inexpensive and somewhat portable from year to year (Mitchell and Shock, 1996).

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IRRIGATION CUTOFF EFFECTS ON KENTUCKY BLUEGRASS SEED YIELD

A.R. Mitchell, Grace Armah-Agyeman, C.L. Yang, and S.M. Griffith.

Abstract

*An experiment on two Kentucky bluegrass (*Poa pratensis*) cultivars was initiated to test the hypothesis that later irrigation cutoff would lead to more bluegrass seed yield. The cultivars 'Abbey' and 'Bristol' were selected for their nonaggressive and aggressive characteristics, respectively. Three irrigation treatments were imposed by cutting irrigation at weekly intervals in June. There was no difference in dry matter between irrigation treatments or cultivars. Seed yield was higher for 'Abbey' than 'Bristol'. Later irrigation cutoff did not significantly increase seed yield; hence, our hypothesis was not proven this first year. Although not significant, the lowest yield occurred at the earliest cutoff date. Because of the inconsistency of first year yield data, more tests are necessary to determine the optimum time to discontinue irrigation.*

Introduction

Preliminary results from a 1995 study on the irrigation of Kentucky bluegrass seed suggested that seed yield may be affected by irrigation during the weeks prior to harvest (Mitchell and Griffith, 1996). Specifically, higher soil moisture after June 10 was associated with increases in seed yield of several hundred pounds per acre. The 1996 experiment, reported here, was initiated to specifically examine the effect of late-season irrigation on Kentucky bluegrass seed yield of different cultivars.

Cultivars of Kentucky bluegrass seed have been classified as aggressive and non-aggressive bluegrass according to their tillering characteristics. Aggressive cultivars have more active rhizomes, and typically produce less seed at an earlier date, than the nonaggressive cultivars. Because this growth characteristic may influence water use, both aggressive and non-aggressive types were included in this experiment, and the water use measured for each.

The objectives of this study were to determine effect of timing of irrigation cutoff on the yield and growth parameters of bluegrass seed for aggressive and nonaggressive cultivars. Our hypothesis was that later irrigation cutoff dates would increase seed yield.

Materials and Methods

The experiment was conducted at the Central Oregon Agricultural Research Center, Madras, Oregon. Two cultivars were selected based on their contrasting aggressivity: 'Bristol' was the most aggressive (highly rhizomatous), and 'Abbey' was the least aggressive (less rhizomatous). The soil was a Madras loam (fine-loamy, mixed, mesic, Xerollic Duragid). The experimental design was a split-plot design with four replications, the two cultivars planted to main plots, and three irrigation treatments applied within subplots. As such, it was similar to the double-line-source sprinkler design describe by Frenkel et al. (1990). Each plot was 60-feet long and 15-feet wide, as shown in Figure 1. The 3-acre field was seeded on 23 August 1995 in rows 1-ft apart.

The trial was conducted according to standard practices for planting, weed control, pest control, irrigation, and fertilizer application. On 14 March 1996, fertilizer was applied at the rate of 140 lb N/A. A mixture of Gramoxone (paraquat dichloride, Zenena), and Round-up (glyphosate, Monsanto) was sprayed on 2 September to control weeds that had emerged prior to the seedlings. Buctril (bromoxynil, Rhone-Poulenc) was applied on 29 September to control broadleaf weeds. Round-up was applied with a wiping machine in two directions on 20 March 1996 to control volunteer wheat and barley. A mixture of Bronate (Rhone-Poulenc) and Banvel (dicamba, Sandoz) was applied 18 April 1996. To control rust, Tilt (propiconazole, Ciba) and elemental sulfur were applied on 31 May 1996.

Water was applied by sprinkler lines spaced 40 ft apart, with impact sprinklers at 30-ft intervals. The sprinklers were mounted on 18-inch risers and had nozzles with 9/64-inch diameters. Irrigation was carried out in the morning when the wind speed was low, in order to minimize non-uniform water distribution and to reduce evaporation. The quantity of applied water was measured after each irrigation as the amount captured in glass jars placed in the middle of each plot. To determine the time and quantity to irrigate, soil water tension readings were taken with sets of Watermark soil sensors (Eldredge et al. 1993) at two locations ('Abbey' and 'Bristol') and at two depths (6 inches and 18 inches).

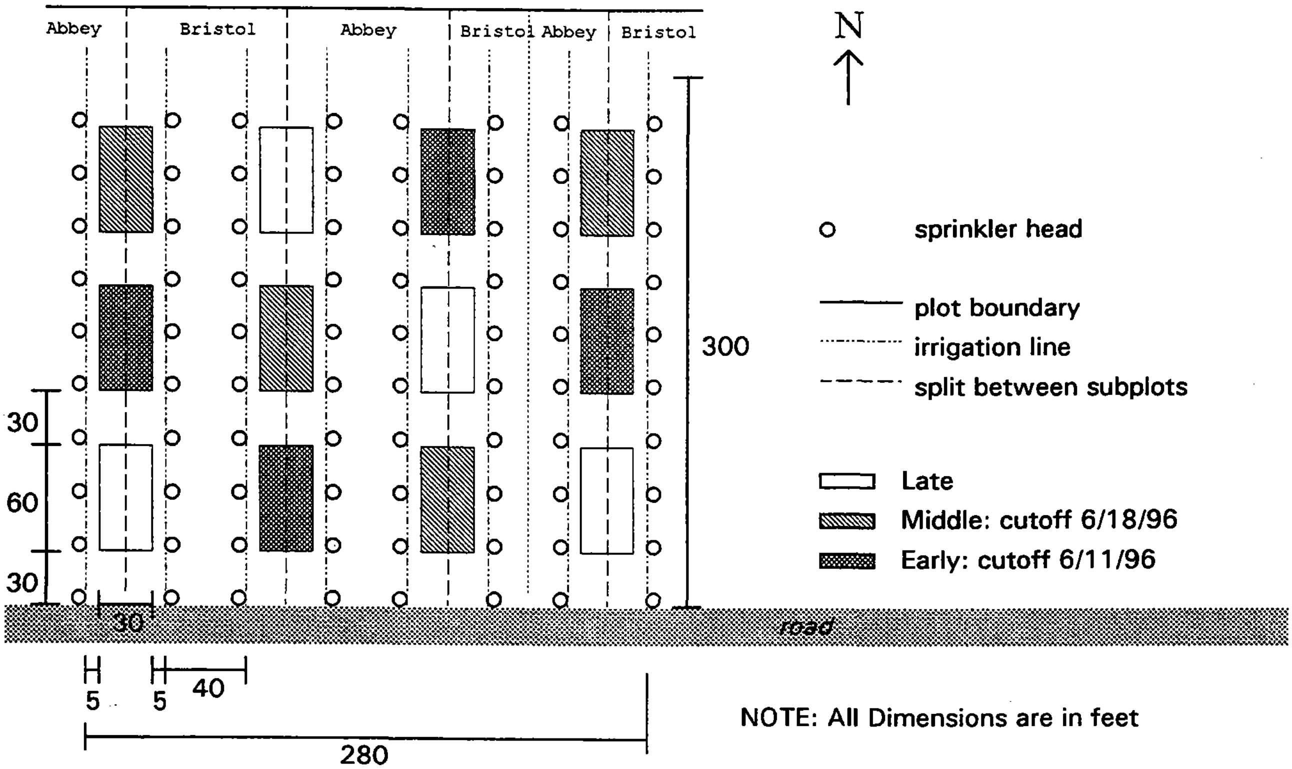

Figure 1. Plot map for 1996 irrigation experiment, Madras, Oregon.

Irrigation is typically halted in mid-June to dry the crop preparatory to harvest. The irrigation treatments of the experiment were the dates of last irrigation: 10 June, 17 June, and 24 June, here referred to as 'early', 'middle', and 'late'. Irrigation was applied to all treatments on 30 April, 13 May, 16 May, 23 May, 29 May, 6 June, and 10 June. At this point, the 'early' irrigation treatment received no additional irrigation. This was accomplished by plugging the sprinkler nozzles with wooden golf tees. The 'middle' and 'late' irrigation treatments were irrigated on 11 June, 13 June, and 17 June, and the 'late' treatment was irrigated one last time on 20 June. On 24 June, it rained 0.30 inches, thus we considered that to be the final irrigation for the 'late' treatment.

Soil volumetric water content was measured in each plot by the neutron probe method. Access tubes were installed within each plot. Neutron probe readings were taken at 6-inch increments until limited by the underlying rock or duripan, which varied in depth from 18 to 30 inches.

Evapotranspiration (ET) was estimated using water balance equation

$$ET = I + P + \Delta S - D - R \quad [1]$$

where I is irrigation, P is precipitation, and ΔS is the difference in soil water storage between the initial and final measurement dates in March and July. Drainage from the profile, D, and runoff, R, were assumed to be negligible.

Beginning 18 June, the seed head moisture content of the grass was measured at least every other day in order to determine the time of swathing. This was done by taking samples of seed heads at random from each plot, weighing fresh, oven-drying at 105 °C for 3 hours until constant weight was achieved, and weighing again. Harvest occurred on 3 July for 'Abbey', when seed moisture content was 39 percent, and on 10 July for 'Bristol', when seed moisture content was 28 percent. The number of fertile tillers and the above-ground biomass were determined by hand-harvesting a 30-cm section of a row at three locations approximately 15 feet apart in adjacent rows along a diagonal, where the first location was selected at random. The three samples were bagged separately, and counted later, then dried and weighed to determine dry mass. Separate samples were collected for seed yield in the same fashion for three 1-m^2 samples at locations within the plot that were selected similar to the above description. Samples were threshed at the USDA-ARS National Forage Seed Production Research Laboratory, Corvallis, Oregon.

Results

The irrigation treatments were effective in creating different soil moisture regimes, as shown in Figure 2 for the top six inches of soil. The soil moisture differences between cultivars were small and insignificant; thus, data were grouped by irrigation treatment in Figure 2. Other depth increments of the soil behaved in similar manner (data not shown). The 'late' treatment exhibited a sharp increase in soil water content at the end of June that was due to the magnitude of the late irrigation and rain on June 24. By the time 'Abbey' and 'Bristol' were harvested on July 3 and 10, respectively, the treatments had different soil moisture regimes based on irrigation treatment.

The 'Abbey' cultivar had significantly (P 01) higher seed yield than 'Bristol' (592 to 154 lb/ac, respectively). These cultivars are known to differ considerably in seed yield under central Oregon conditions (Crowe et al. 1996). Overall, 'Abbey' also had significantly (P≤01) more fertile tillers than 'Bristol', with the differences varying by irrigation treatment (Figure 3). The dry matter (above ground biomass) was not significantly different between the cultivars with a mean of 3.62 t/ac.

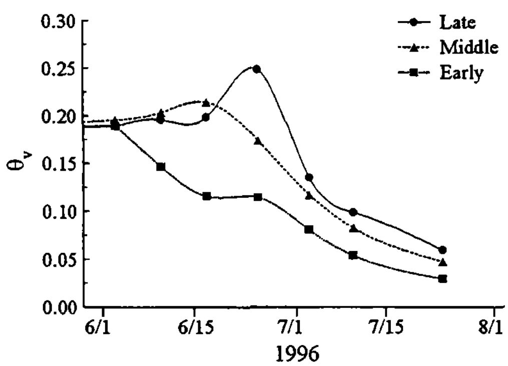

Figure 2. Volumetric water content in the top 6-inch layer of soil for three irrigation-cutoff treatments, Madras, Oregon, 1996.

The 'late' irrigation treatment did not produced the anticipated seed yield increase. 'Bristol' increased slightly with later irrigation, but not significantly. 'Abbey' was highest at the 'middle' irrigation cutoff, but any potentially significant differences were masked by the high variability in seed yield. High variability in plant stand and yield is not uncommon for first year Kentucky bluegrass plantings. The fertile tillers did not increase with later irrigation cutoff date—quite the contrary, they decreased. But, again, the lack of significance does not permit us to draw conclusions about the effect of irrigation cutoff timing.

Discussion

The results from the first year data did not show significant differences in seed yield due to irrigation cutoff dates two weeks apart. There may have been a trend toward lesser yield at the earliest irrigation cutoff date of June 10, but the high variability in first-year bluegrass seed yield limited the interpretation of the study. Although equal yield for irrigation treatments was not an anticipated result, it would nonetheless be important if supported by additional years' data, because it would mean that irrigation cutoff is not critical. The experiment needs to repeated for more seasons.

A seed germination test on the different treatments has yet to be conducted, but may provide information on the effects of the timing of irrigation cutoff.

Additionally, thermal and nonthermal treatment were imposed in early August 1996. Next year, we will have information on how the timing of the last irrigation interacts with thermal and nonthermal management.

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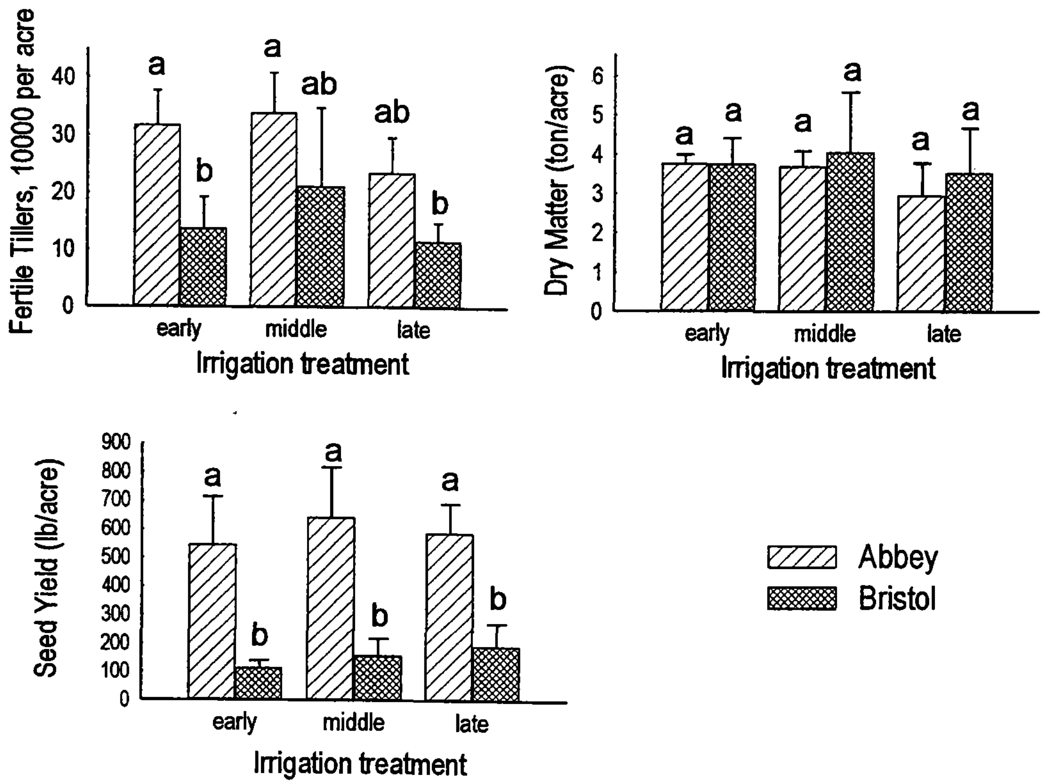

Figure 3. Fertile tillers, dry matter, and seed yield by cultivar and irrigation treatment, Madras, Oregon, 1996. Like letters indicate no significant differences (P≤05) based on Fisher's mean comparison test.

EVALUATION OF PREEMERGENCE HERBICIDES ON CARBON-BANDED ROUGHSTALK BLUEGRASS, 1995-1996

Marvin Butler and Les Gilmore

Abstract

Herbicides diuron (Karmex, Du Pont), metribuzin (Lexone, Du Pont), and terbacil (Sinbar, Du Pont) were applied preemergence to carbon-banded roughstalk bluegrass at three locations near Madras and Culver, Oregon. The greatest total weed control was 95 percent, with Karmex at 2.5 lb/a plus Lexone at 0.3 lb/a, followed by 89 percent with Sinbar at 1.2 lb/a, and 88 percent with Karmex at 0.6 lb/a plus Sinbar at 0.6 lb/a. Unacceptable crop injury resulted from Sinbar at 1.2 lb/a, followed by Lexone at 0.7 lb/a, Karmex at 0.6 lb/a plus Sinbar at 0.6 lb/a, and Sinbar at 0.6 lb/a.

Introduction

Carbon-banding grass seed at planting to protect emerging seedlings from herbicide damage is gaining popularity in central Oregon. Experimentation has focused particularly on roughstalk bluegrass. The objective of this project was to evaluate Karmex, Lexone, and Sinbar applied preemergence alone, and in combination, on carbon-banded roughstalk bluegrass in three commercial fields near Madras and Culver, Oregon.

Methods and Materials

Commercial equipment was used to place a 1.5 inch-wide band of carbon over the seed row at the rate of 35 lb/treated acre in combination with Solution 32 at 45 gal/a. Treatments included Karmex at 2.5 and 5 lb/a, Lexone at 0.3 and 0.7 lb/a, Sinbar at 0.6 and 1.2 lb/a, Karmex at 2.5 lb/a plus Lexone at 0.3 lb/a, and Karmex plus Sinbar each at 0.6 lb/a. Treatments were applied preemergence with a CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gal/a water at the Roff location September 7, at the DuRette location September 8, and at the Grote location October 4. Plots 10 ft x 30 ft were replicated three times in a randomized complete block design.

Treatments were evaluated for crop injury, stand reduction, and percent control of common groundsel, China lettuce, buttonweed, henbit, cheatgrass, volunteer wheat, and volunteer barley. Evaluations were conducted January 18 at the DuRette location, and February 16, 1996 at the Roff and Grote locations.

Results and Discussion

Karmex at 2.5 lb/a plus Lexone at 0.3 lb/a provided overall weed control of 95 percent. Sinbar at 1.2 lb/a provided 96 percent weed control or better for all weeds except common groundsel at 33 percent. Karmex at 0.6 lb/a plus Sinbar at 0.6 lb/a provided 94 percent control or better for all weeds except common groundsel at 40 percent. Karmex at 2.5 lb/a provided inadequate control of all weed species evaluated, except 87 percent control of common groundsel and volunteer wheat. The greatest crop injury and stand reduction resulted from Sinbar at 1.2 lb/a, followed by Lexone at 0.7 lb/a, Karmex at 0.6 lb/a plus Sinbar at 0.6 lb/a, and Sinbar at 0.6 lb/a. The least amount of crop injury and stand reduction in roughstalk bluegrass resulted from Karmex at 2.5 lb/a, followed by Karmex at 5 lb/a and Lexone at 0.3 lb/a.

Table 1. Effect of preemergence herbicide applications September 8, 1995 on carbon-banded roughstalk bluegrass near Madras and Culver, Oregon.

		Weed control[1]						
		DuRette location					Roff location	Grote location
Treatments[2]	Rate	Common groundsel	China lettuce	Buttonweed	Henbit	Cheatgrass	Volunteer wheat	Volunteer barley
	(product/a)	(percent)						
Karmex	2.5 lb	87 ab[3]	20 c	63 a	0 b	20 b	87 a	23 bc
Karmex	5.0 lb	93 a	100 a	100 a	100 a	65 a	83 a	53 ab
Lexone	0.3 lb	93 a	0 c	92 a	100 a	67 a	90 a	67 ab
Lexone	0.7 lb	97 a	83 ab	97 a	100 a	94 a	81 a	69 ab
Sinbar	0.6 lb	0 c	43 bc	100 a	100 a	90 a	95 a	96 a
Sinbar	1.2 lb	33 bc	97 ab	100 a	100 a	99 a	96 a	99 a
Karmex	2.5 lb							
+ Lexone	0.3 lb	92 a	97 ab	100 a	100 a	91 a	97 a	85 a
Karmex	0.6 lb							
+ Sinbar	0.6 lb	40 abc	100 a	100 a	100 a	94 a	90 a	95 a
Untreated	---	0 c	0 c	0 b	0 b	0 b	0 b	0 c

[1] Visual evaluations were conducted January 18, 1996.
[2] Treatments were applied September 8, 1995.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

Table 2. Effect of preemergence applications treatments September 8, 1995 on carbon-banded roughstalk bluegrass near Madras and Culver, Oregon.

		Crop injury[1]			Stand reduction[1]		
Treatments[2]	Rate	DuRette location	Roff location	Grote location	DuRette location	Roff location	Grote location
	(product/a)	---(%)---					
Karmex	2.5 lb	0 c[3]	0 c	8 b	0 b	0 b	7 b
Karmex	5.0 lb	0 c	15 abc	8 b	2 b	12 b	5 b
Lexone	0.3 lb	0 c	13 abc	20 b	0 b	8 b	12 b
Lexone	0.7 lb	17 bc	32 ab	17 b	8 b	32 ab	7 b
Sinbar	0.6 lb	20 bc	23 abc	18 b	12 b	22 b	10 b
Sinbar	1.2 lb	92 a	38 a	75 a	92 a	60 a	85 a
Karmex + Lexone	2.5 lb + 0.3 lb	7 bc	10 bc	17 b	0 b	7 b	8 b
Karmex + Sinbar	0.6 lb + 0.6 lb	30 b	30 ab	17 b	10 b	32 ab	11 b
Untreated	---	0 c	0 c	0 b	0 b	0 b	0 b

[1] Visual evaluations were conducted January 18, 1996.
[2] Treatments were applied September 8, 1995.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

DEVELOPMENT OF CONTROL PROGRAM FOR ERGOT IN KENTUCKY BLUEGRASS SEED PRODUCTION, 1995

Marvin Butler, Fred Crowe, and Steve Alderman

Abstract

Fungicides, fusilazole (Punch, Du Pont), propiconazole (Tilt, Ciba), tebuconazole (Folicur, Miles) and Orthorix (Best Sulfur Products) were evaluated for control of ergot in Kentucky bluegrass seed production at two locations in central Oregon during the 1995. Incidence of ergot at the Central Oregon Agricultural Research Center (COARC), Powell Butte location, was much higher in the commercial production field near Trail Crossing. A single application of Punch provided the greatest ergot control, followed by a double application of Tilt at 8 fl oz/a, a single application of Tilt at 8 fl oz/a, and a double application of Tilt at 4 fl oz/a plus Orthorix at 64 fl oz/a.

Introduction

Ergot, caused by the fungus *Claviceps purpurea*, is an important flower-infecting pathogen in Kentucky bluegrass seed production in central Oregon. Research has been conducted locally since 1992 to evaluate fungicides, rates, and timings for development of a control program for ergot. The objective of this project was to focus on combinations which included Tilt, the only fungicide with a label for use on grass seed for ergot control.

Methods and Materials

During the 1995 season fungicides were evaluated for control of ergot in a 'Coventry' Kentucky bluegrass seed field at Trail Crossing near Culver, Oregon. Fungicide evaluations were conducted at a second field of 'Coventry' located at the COARC, Powell Butte site, which was infected with ergot at 1 sclerotia/ft^2 in 1993 and 1994. Punch, Tilt, Folicur, and Orthorix were evaluated during 1995. Surfactants Sylgard 309 and Penaturf were evaluated as the second of two applications following Tilt.

Materials were applied to 10 ft x 20 ft plots, replicated four times in a randomized complete block design, with 8003 TwinJet nozzles on a 9 foot CO_2 pressurized, hand-held boom sprayer at 40 psi and 30 gal/a water. Sylgard 309 at 16 fl oz/100 gal and R-56 at 1 pt/100 gal were applied in combination with all fungicides except Orthorix, and one 4 fl oz Tilt treatment. Treatments were applied at the Trail Crossing location on June 3 and June 16, and at the Powell Butte site on June 3 and June 13. The first treatments were applied at the initiation of anthesis at both locations.

One hundred panicles were collected from each plot on June 30 at the Trail Crossing location, and July 6 at the Powell Butte site. Number of panicles with sclerotia and total sclerotia per sample were determined for each plot. Seed weight per sample and weight per 1,000 seed was determined following standard separation procedures. Percent germination followed the Association of official Seed Analysts (AOSA) rules for testing seed.

Results and Discussion

Incidence of ergot at the Powell Butte site was quite high, while the infection level at Trail Crossing was relatively low. Comparison of the number of panicles with sclerotia and the total number of sclerotia per sample at the Powell Butte site (Table 1) indicates a single application of Punch provides the most effective control of ergot. A single Punch application, both a single and double application of Tilt at 8 oz/a, and a double application of Tilt plus Orthorix statistically out-performed both single and double applications of Orthorix and the nontreated plots. At the Trail Crossing location, there were no significant differences between treatments (Table 2) when comparing either panicles with sclerotia or total sclerotia per 100 panicle sample.

Seed weight per sample or weight per 1,000 seed was not significantly different at either location, indicating no detrimental effect from fungicide applications on seed size. There were no differences in percent seed germination between treatments.

Table 1. Evaluation of fungicides applied for ergot control to 'Coventry' Kentucky bluegrass at the COARC Powell Butte site in central Oregon on June 3 and June 13, 1995.

Fungicide Treatment	Rate June 3	Rate June 13	Panicles with sclerotia		Total sclerotia per sample		Weight per sample	1000 seed weight	Seed Germination
	(fl oz/a)		(%)		(no.)		(g)	(mg)	(%)
Punch 25E	28		13	f	23	d	4.47	334	92
Tilt 3.6E/Orthorix + Tilt 3.6E/Orthorix	4/64	4/64	34	cdef	89	cd	4.75	335	90
Tilt 3.6E	4		50	abcde	194	bcd	4.63	350	94
Tilt 3.6E	4[1]		57	abc	221	abcd	4.63	344	92
Tilt 3.6E + Tilt 3.6E	4	4	43	bcde	152	bcd	4.37	345	92
Tilt 3.6E + Orthorix	4	64	45	bcde	145	bcd	4.71	337	93
Tilt 3.6E + Sylgard 309	4	32[2]	66	ab	282	abc	4.23	335	94
Tilt 3.6E + Penaturf	4	42	56	abcd	262	abc	4.40	324	94
Tilt 3.6E	8		33	def	89	cd	4.76	340	94
Tilt 3.6E + Tilt 3.6E	8	8	27	ef	72	cd	4.44	329	92
Folicur 3.6F	4		49	abcde	172	bcd	4.67	338	93
Folicur 3.6F	8		51	abcde	177	bcd	4.59	346	93
Orthorix	64		65	ab	348	ab	4.86	327	92
Orthorix + Orthorix	64	64	61	ab	325	ab	4.59	340	91
Untreated			71	a	415	a	4.85	327	90
							n.s.	n.s.	n.s.

[1] Application with Penaturf at 42 fl oz rather than standard surfactants
[2] Sylgard 309 applied at 32 fl oz per 100 gals
Mean separation with T-method at $P \leq 0.05$

Table 2. Evaluation of fungicides applied for ergot control to 'Coventry' Kentucky bluegrass in the Trail Crossing area near Culver, Oregon on June 3 and June 16, 1995.

Fungicide Treatments	Rate June 3	Rate June 16	Panicles with sclerotia	Total sclerotia per sample	Weight per sample	1000 seed weight	Seed Germination
	(fl oz/a)		(%)	(no.)	(g)	(mg)	(%)
Punch 25E	28		1.3	1.3	3.03	291	92
Tilt 3.6E/Orthorix + Tilt 3.6E/Orthorix	4/64	4/64	1.0	1.3	3.03	273	91
Tilt 3.6E	4		1.8	3.3	3.44	291	88
Tilt 3.6E	4[1]		4.0	8.5	3.38	306	90
Tilt 3.6E + Tilt 3.6E	4	4	1.8	2.0	3.01	296	89
Tilt 3.6E + Orthorix	4	64	2.3	3.8	2.96	295	90
Tilt 3.6E + Sylgard 309	4	32[2]	2.5	5.5	3.23	297	89
Tilt 3.6E + Penaturf	4	42	3.0	6.0	3.34	280	88
Tilt 3.6E	8		1.0	1.5	3.16	285	89
Tilt 3.6E + Tilt 3.6E	8	8	0.3	0.3	3.59	275	87
Folicur 3.6F	4		1.0	2.8	3.53	285	90
Folicur 3.6F	8		0.3	0.3	3.24	280	88
Orthorix	64		6.8	36	3.53	292	90
Orthorix + Orthorix	64	64	3.0	5.8	3.28	302	93
Untreated			5.0	10	3.48	296	91
			n.s.	n.s.	n.s.	n.s.	n.s.

[1] Application with Penaturf at 42 fl oz rather than standard surfactants
[2] Sylgard 309 applied at 32 fl oz per 100 gals
Mean separation with T-method at $P \leq 0.05$

EVALUATION OF HERBICIDES FOR CONTROL OF ROUGHSTALK BLUEGRASS AND INJURY TO KENTUCKY BLUEGRASS, 1995-1996

Marvin Butler, Jim Carroll, Mark Morlan, and Al Short

Abstract

Herbicides terbacil (Sinbar, Du Pont), diuron (Karmex, Du Pont), primisulfuron (Beacon, Ciba), oxyfluorfen (Goal, Rohm and Haas), metribuzin (Lexone, Du Pont), and imazamethabenz (Assert, Cyanamid) were applied in combination to commercial fields of roughstalk bluegrass and Kentucky bluegrass.

Introduction

Research to evaluate herbicides for control of roughstalk bluegrass in Kentucky bluegrass was initiated in 1993. A wide variety of herbicide combinations were screened during the 1994-1995 season. The objective of this project was to evaluate in replicated plots the most promising fall and spring-applied herbicides from 1994-1995. Herbicides evaluated in combination included Sinbar, Karmex, Beacon, Goal, Lexone, and Assert.

Methods and Materials

Combinations of Sinbar at 0.25 and 0.5 lb/a, Karmex at 2 lb/a, Beacon at 0.38 and 0.75 oz/a, Lexone at 2.7 and 5.3 oz/a, Goal at 15 fl oz/a, and Assert at 0.75 pt/a were applied October 14 to two roughstalk bluegrass fields to evaluate control of established and seedling plants, and to two Kentucky bluegrass fields to determine crop injury. Spring applications were made April 3 and April 26. Treatments included a spring application of Sinbar at 0.25 lb/a plus Karmex at 2 lb/a following a fall application of Lexone at 2.7 oz/a plus Goal at 15 fl oz/a, a split application of Beacon at 0.38 oz/a, and split application of Beacon at 0.38 oz/a plus Karmex at 0.5 lb/a followed by Beacon at 0.38 oz/a. Treatments were applied with a CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gal/a water. Plots 10 ft x 20 ft were replicated three times in a randomized complete block design. A nonionic surfactant was applied at 1 qt/100 gal in combination with all herbicides. Visual evaluation for control of established and seedling roughstalk bluegrass, and crop injury based on reduction in plant biomass to Kentucky bluegrass was conducted January 5, 1996. Pre-harvest evaluation of percent reduction in seed set was conducted for roughstalk bluegrass June 23, and for Kentucky bluegrass June 26, 1996.

Results and Discussion

Seedling roughstalk bluegrass was more easily controlled than established plants. Of the fall-applied herbicides Sinbar at 0.5 lb/a plus Karmex at 2 lb/a provided the greatest control of roughstalk seedling and established plants at 89 percent and 39 percent control, respectively. Beacon at 0.38 oz/a plus Karmex at 2 lb/a provided 86 percent control of roughstalk seedling plants but only 9 percent control of established plants. Treatments that included Goal produced 20 percent injury to Kentucky bluegrass, more than any other treatment. Spring split-applications of Beacon at 0.38 oz/a provided 81 percent control while Beacon at 0.38 oz/a plus Karmex at 0.5 lb/a provided 84 percent control of seedling and established roughstalk bluegrass.

No difference among treatments could be detected in seed set prior to harvest for either roughstalk bluegrass or Kentucky bluegrass, except for the two spring split-applications. Despite the serious damage, what plants remained did establish seed heads. Presumably they were late enough that they did not produce viable seed.

Table 1. Effect of fall-applied herbicide applications October 14, 1996 on established and seedling roughstalk bluegrass at two locations, and crop injury to Kentucky bluegrass at two locations near Madras and Culver, Oregon.

Treatments[2]	Rate	Roughstalk bluegrass control[1] Seedling plants		Established plants		Injury to Kentucky bluegrass
	(product/a)	(percent)				
Sinbar	0.5 lb					
+ Karmex	2.0 lb	89	a[3]	39	a	9
Sinbar	0.5 lb					
+ Beacon	0.38 oz	83	a	3	b	12
Sinbar	0.5 lb					
+ Goal	15 oz	80	a	8	b	20
Sinbar	0.5 lb					
+ Lexone	5.3 oz	80	a	17	ab	7
Sinbar	0.5 lb					
+ Assert	0.75 lb	70	a	15	ab	15
Sinbar	0.25 lb					
+ Karmex	2.0 lb	80	a	20	ab	9
Lexone	2.7 oz					
+ Goal	15 oz	74	a	1	b	20
Beacon	0.38 oz					
+ Karmex	2.0 lb	86	a	9	b	10
Untreated	----	0	b	0	b	0
						n.s.

[1] Visual evaluations were conducted January 5, 1996.
[2] Treatments were applied October 14, 1995.
[3] Mean separation with Honesty Significant Difference at $P \leq 0.05$.

STATE-WIDE CEREAL VARIETY TESTING PROGRAM TRIALS IN CENTRAL OREGON

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Abstract

Winter and spring barley, triticale and wheat trials were conducted at Madras in 1995-96 as part of a state-wide variety testing program. This was the fourth year of coordinated trials. These trials are sponsored by the Oregon State University Extension Service, OSU Agricultural Experiment Station, Oregon Wheat Commission, and Oregon Grains Commission. As groups, winter wheats and triticales had the highest average yield (7,272 lb/a) followed by spring barleys (4,256 lb/a), winter barleys (4,167 lb/a), and spring wheats and triticales (3,858 lb/a). Spring wheat and triticale yields are about two-thirds those obtained in previous years. There are significant differences, as great as two-fold, among varieties within each grouping. Trial results for 1996 and a four-year summary for winter grains are presented in tabular format. Growers are encouraged to carefully review prospective varieties for both yield and other desirable characteristics. Trial results from across the state will be summarized in winter and spring grain publications. These publications will be available at local county Extension offices in early 1997.

Introduction

New cereal varieties are being released by public and private Pacific Northwest plant breeders each year. In order to provide growers with accurate, up-to-date information on variety performance, a state-wide variety testing program was initiated in 1993 with funding provided by the OSU Extension Service, OSU Agricultural Experiment Station, Oregon Wheat Commission, and Oregon Grains Commission. The program is centrally coordinated by Russ Karow, OSU Extension Specialist, Dept. of Crop and Soil Science, and Ernie Marx, Crop and Soil Science Research Assistant. The central team packages and distributes seed to cooperators across the state. Cooperators, such as Steve James and Mylen Bohle in central Oregon, plant, manage, and harvest the trials. The central team processes harvested grain, analyzes results, and provides summary data to interested parties across the state and region.

Eleven sites are included in the testing network. More than 50 varieties are tested each year at each site. Height, lodging, yield, test weight and protein data are determined for all plots. Other information is collected as time and labor allows. Collected data are summarized in extension publications and county Extension newsletters as well as in *Oregon Wheat Magazine* and other popular press media.

Materials and Methods

Plots (5 x 20 feet) were seeded at a rate of 30 seeds per square foot using an Oyjord plot drill. Winter trials were seeded on October 13, 1995, spring barleys on April 15, 1996, and spring wheats on April 29, 1996. The nitrogen supply goal for winter wheats and triticales was 200 lb N/a. These grains were fertilized on April 10, 1996, with 141 lb/a of nitrogen (as 34-0-0-0 - the type of nitrogen fertilizer used on all trials) and 40 lb/a sulfur (as 0-0-0-16 - the type of sulfur fertilizer used on all trials). The nitrogen target for winter barleys was 120 lb N/a. Winter barleys were fertilized on April 10, 1996 with 50 lb N/a and 46 lb S/a. The soil reserve nitrate nitrogen level was 45 lb N/a and plant nitrogen content at fertilization was estimated to be 25 lb N/a for winter grains. The nitrogen supply target for spring wheat and triticales was 160 lb N/a. These grains were pre-plant fertilized with 81 lb N/a and 46 lb S/a. Spring barleys had a nitrogen supply target of 100 lb N/a and were pre-plant fertilized with 46 lb S/a on April 11 and top dressed with 29 lb N/a on April 19. Soil nitrate reserve was 70 lb N/a in spring trials. Herbicide and irrigation programs were typical for central Oregon production. Winter barley plots were ravaged by birds. Loss was visually rated as uniform, ranging from 30-40 percent. Plots were harvested August 22-29 with a Wintersteiger plot combine then cleaned on a Peltz rub-bar cleaner. Plot yield, test weight, protein, moisture, and seed size were all determined on cleaned grain samples. Wheat and triticale yields are reported on a 10 percent moisture, 60 lb bushel basis. Barley yields are in pounds per acre at 10 percent moisture. Protein and moisture levels were determined using a whole-grain, near infrared protein analyzer. Proteins are reported on a 12 percent moisture basis.

Results and Discussion

Winter Wheats and Triticales

Winter wheat and triticale data are presented in Table 1. Unlike past years, lodging was a problem for only some varieties. Closer attention to residual soil nitrogen levels in the plot site and the 200 lb/a nitrogen supply goal may account for this difference. Only the club wheats and other known lodging susceptible varieties did lodge. Note that increased height does not directly equate with increased lodging. Varieties do differ in straw strength per se. The trial average yield was 121 bu/a with a range of 92 to 144 bu/a. Stephens and Daws and the more recently released varieties Gene, MacVicar, and W301 were among the highest yielding entries in the trial (yields >129 bu/a). All club wheat entries showed more than 50 percent lodging and had yields less than 112 bu/a. None appear to have merit for commercial production in the area. Celia, the sole triticale in the trial, had a below average yield and the lowest grain protein level of all entries. Wheats produced in optimally fertilized Oregon dryland and high rainfall areas have a protein content near 9.5 percent. Research with irrigated wheat in Idaho found protein levels of optimally fertilized wheat to be near 11 percent. The average protein level for this trial was 10.4 percent suggesting that fertility was adequate. Several seed treatments were evaluated on Stephens wheat. The highest yielding entry in the trial was Stephens treated with RTU-Vitavax-Thiram and Gaucho. Gaucho is a new seed applied insecticide that shows excellent early season control of aphids and other grain insects.

Spring Wheats and Triticales

Spring wheat and triticale data are presented in Table 2. Spring grains showed no significant lodging. Average yield level (64 bu/a) was just over half that of the winter grains. ID377S, a hard white spring wheat that was commercially produced for the first time this past year under "identity preserved" contracts with the Idaho Wheat Commission, was the highest yielding entry in the trial at 86 bu/a. The highest yielding soft white wheat was Centennial, another Idaho spring wheat. Centennial has yielded well in trials across Oregon but can be difficult to thresh and has exhibited high dockage levels in some production environments. The highest yielding soft white entry in this trial was Alpowa (a newer WSU release) treated with Gaucho seed treatment. The hard red spring wheats Yecora Rojo and WB936R had yield levels similar to the soft white wheats, but proteins were one to two percent higher, as expected. However, the 13.0 to 13.7 percent protein levels observed in the hard reds would not be adequate to assure easy marketability. TRICAL2700 and RSI310 triticales had below average yields.

Winter and Spring Barleys

Barley data are shown in tables 3 and 4. Winter barleys showed severe lodging despite receiving less nitrogen than the winter wheats. Winter barley yields were significantly lower than those of the winter wheats and triticales, but were surprisingly high given the severe amount of bird damage observed. If the 30-40 percent visual damage assessments were correct, then the better yielding winter barley varieties (SDM204, Gwen, and Kold) had yields better than or similar to those of the best wheats. As in 1995, SDM204 was the highest yielding winter barley. This is an experimental line released by Don Sunderman, retired University of Idaho spring grain breeder. Traces of barley stripe rust were found in this trial but had no effect on yield. In western Oregon locations where barley stripe rust was more severe, the variety Gwen was devastated by the disease. Kold and Strider are barley stripe rust resistant varieties.

The spring barley yield average was higher than that for the spring wheats and triticales (4,256 versus 3,528 lb/a). Those varieties exhibiting the least amount of lodging tended to have the highest yield levels. Maranna, the highest yielding entry in the trial, is an OSU release. Idagold, the next highest entry, is a variety released by the Coors Brewing Company breeding program, as is Galena. Galena is a 2-row malt variety while Idagold is a 2-row feed type. Galena had the highest test weight of the hulled barleys in the trial. Three hull-less entries were tested. Hull-less barleys have greater feed value than hulled types and superior test weight due to the lack of hull. Assuming that the hull accounts for 15 percent of the weight of a typical hulled variety, hull-less types must yield at least 85 percent of hulled types to have equivalent yields. The Western Plant Breeders experimental line BZ489-74 had a yield that was 65 percent of the yield produced by Maranna, the high yield entry. Traces of barley stripe rust were also found in this trial.

Over-years Winter Grain Summary

Table 5 is a summarization of yield data for winter grains over the period 1993-96. The ability to analyze variety performance over time is one of the benefits of coordinated, long-term trials. Data is presented in two different formats in Table 5. Actual yields (bu/a) for each year are presented in one set of columns. Yields expressed as a percent of the trial average yield are presented in a second set of columns. The percent of average figures are easiest to visually assess. The data show that from a statistical point of view (5 percent probability level) there are no differences among commonly grown varieties. What the data suggests is that you not be concerned about yield performance when selecting a newer variety to grow, but rather that you should consider other desired characteristics.

Data from the Madras site will be combined with that from the other 10 locations in the state-wide variety testing network and published in Extension bulletins. Contact your local OSU county Extension office in early 1997 for a copy of the summary bulletins for both winter and spring grains.

Table 1. 1996 state-wide variety testing program winter wheats and triticales at Madras, OR.

Variety or line	Market class	Julian heading date	Height (in)	Lodging percent	Yield (bu/a)	Test weight (lb/bu)	Protein percent
Celia	Triticale	161	38	0	113.6	57.0	9.2
Daws	SW	167	42	10	136.4	60.5	10.5
Gene	SW	162	34	0	137.0	58.8	11.5
Hill 81	SW	169	43	7	119.0	60.4	10.5
Hiller	Club	164	39	93	90.2	59.6	10.9
Hyak	Club	166	42	83	104.9	57.0	11.2
ID467	HR	165	39	73	96.7	60.8	10.3
ID8614502b	SW	157	36	10	141.6	62.7	9.8
Lewjain	SW	174	41	83	98.4	59.0	10.8
MacVicar	SW	165	40	7	128.7	58.8	10.5
Madsen	SW	168	37	0	120.9	60.5	10.7
Madsen+Stephens	SW	163	37	3	132.0	59.9	10.2
Malcolm	SW	164	40	10	115.1	59.7	9.4
Rely	Club	169	44	53	111.9	58.3	9.6
Rod	SW	167	40	53	123.8	58.6	9.8
Rohde	Club	165	40	73	111.0	60.3	10.6
Stephens+Vitavax	SW	161	40	0	142.7	59.9	10.3
Stephens+Baytan	SW	162	38	0	138.1	59.7	10.6
Stephens+Dividend	SW	161	37	3	135.0	59.4	10.3
Stephens+Vitavax+Gaucho	SW	162	39	0	144.3	59.8	10.8
W301	SW	163	40	0	132.9	59.9	10.2
Yamhill	SW	168	47	30	91.6	57.8	10.8
Average		165	40	27	121.2	59.5	10.4
PLSD (5%)		2	2	25	25.8	1.6	1.1
PLSD (10%)		2	2	21	21.5	1.3	0.9
CV		1	4	57	13	2	6
P-value		0.00	0.00	0.00	0.00	0.00	0.01

Analysis by ANOVA mean separation with protected least difference.

1996 state-wide variety testing program spring wheats and triticales at Madras, OR

Variety/ line	Market class	Julian heading date	Height (in.)	Lodging percent	Yield (bu/a)	Test weight (lb/bu)	Protein percent
Alpowa	SW	190	34	0	64.2	58.9	11.5
Alpowa+Gaucho	SW	190	34	7	74.6	59.3	11.7
Centennial	SW	184	33	0	85.1	58.5	11.6
Dirkwin	SW	189	35	10	73.5	55.6	12.8
ID377S	HW	184	37	5	86.3	60.3	12.1
ID462	HR	186	34	0	64.1	61.3	13.8
ID488	SW	184	34	0	76.6	60.3	10.6
Klasic	HW	180	26	0	73.0	60.2	13.5
OR4895181	HW	191	31	0	62.3	56.5	12.5
Penawawa	SW	187	31	0	62.6	59.7	11.3
Pomerelle	SW	188	29	0	62.7	60.3	11.1
RSI310	Triticale	187	36	0	58.1	53.8	10.4
SDM405S	SW	183	34	0	59.7	59.1	11.8
Sunstar Promise	SW	183	33	0	53.2	60.2	11.0
TRICAL 2700	Triticale	190	46	0	51.6	52.0	10.3
Treasure	SW	190	31	0	69.9	60.4	11.7
WPB926R	HR	181	30	0	46.9	60.1	13.4
WPB936R	HR	180	30	0	61.9	59.3	13.7
Wawawai	SW	183	34	0	42.5	58.2	11.7
Whitebird	SW	189	33	0	59.0	59.9	11.5
Yecora Rojo	HR	180	25	0	62.7	60.5	13.0
Average		186	33	1	64.3	58.8	12.0
PLSD (5%)		4	4	NS	NS	3.1	1.4
PLSD (10%)		3	4	NS	NS	2.6	1.2
CV		1	8	471	28	3	7
P-value		0.00	0.00	0.48	0.41	0.00	0.00

Analysis by ANOVA mean separation with protected least difference.

Table 3. 1996 state-wide variety testing program winter barleys at Madras, OR

Variety/ line	Market Class	Julian heading date	Height (in)	Lodging percent	Yield (lb/a)	Test weight (lb/bu)	Protein percent
Gwen	6RF	143	43	77	4953	48.7	10.5
Hesk	6RF	156	42	100	3804.7	43.7	11.0
Hesk+Baytan	6RF	155	44	100	4173.7	43.6	11.2
Hundred	6RF	156	43	90	3699	44.3	11.4
Kold	6RF	155	41	97	4686	46.6	11.2
SDM204	6RF	160	43	28	5618.7	49.1	7.6
Scio	6RF	152	44	68	4308	46.1	11.1
Steptoe	6RF	152	43	42	2242.3	47.4	9.3
Strider	6RF	149	42	98	4020	44.5	10.4
Average		153	43	78	4167	45.0	10.4
PLSD (5%)		3	NS	40	1496	3.1	2.1
PLSD (10%)		3	NS	33	1232	2.5	1.8
CV		1	5	30	21	4	12
P-value		0.00	0.65	0.01	0.01	0.01	0.03

Table 4. 1996 state-wide variety testing program spring barleys at Madras, OR

Variety/ line	Market class	Julian heading date	Height (in)	Lodging percent	Yield (lb/a)	Test weight (lb/bu)	Protein percent
Baronesse	2RF	181	30	33	4773	52.3	9.7
Colter	6RF	174	35	3	4671	51.0	8.4
Crest	2RM	180	30	27	3333	52.0	10.2
Galena	2RM	186	27	0	5026	53.2	9.8
Icaro	2RF	176	33	33	3793	50.9	10.9
Idagold	2RF	194	24	0	5508	51.5	10.3
Maranna	6RF	183	26	3	5714	51.8	9.6
Payette	6RF	182	27	0	4827	52.1	9.7
Russell	6RM	172	32	3	3880	51.9	9.4
Steptoe	6RF	176	33	40	3941	49.8	9.9
Steptoe+Baytan	6RF	176	32	60	4264	49.0	9.8
WA11045-87	Hulless	181	32	40	3145	57.7	10.5
WPB-BZ489-74	Hulless	185	27	3	3695	59.1	11.7
WPB-Waxbar	Hulless	185	34	100	3009	55.1	10.7
Average		181	30	25	4256	52.7	10.0
PLSD (5%)		2	4	42	927	2.1	1.3
PLSD (10%)		2	3	35	769	1.7	1.1
CV		1	7	102	13	2	8
P-value		0.00	0.00	0.00	0.00	0.00	0.01

Analysis by ANOVA mean separation with protected least difference.

Table 5. 1993-96 yields for winter wheats, triticales and barleys at Madras, OR

	Market class	1993	1994	1995	1996	Average		1993	1994	1995	1996	Average
				bu/a						Percent of average		
Winter wheats and triticales												
Celia	Triticale	111	117	99	114	110	Celia	1.04	1.05	0.98	0.94	1.00
Daws	SWW	107	93	114	136	112	Daws	1.00	0.84	1.12	1.12	1.02
Gene	SWW	114	107	89	137	112	Gene	1.07	0.96	0.88	1.13	1.01
Hill 81	SWW	98	112	113	119	110	Hill 81	0.92	1.01	1.12	0.98	1.01
Lewjain	SWW	101	106	93	98	100	Lewjain	0.94	0.96	0.92	0.81	0.91
MacVicar	SWW	120	118	104	129	118	MacVicar	1.12	1.06	1.03	1.07	1.07
Madsen	SWW	121	101	98	121	110	Madsen	1.13	0.91	0.97	1.00	1.00
Malcolm	SWW	99	123	113	115	112	Malcolm	0.92	1.10	1.11	0.95	1.02
Rod	SWW	110	108	115	124	114	Rod	1.03	0.97	1.14	1.02	1.04
Rohde	Club	101	112	105	111	107	Rohde	0.94	1.01	1.03	0.92	0.97
Stephens	SWW	109	120	105	143	119	Stephens	1.02	1.08	1.04	1.18	1.08
W301	SWW	119	119	97	133	117	W301	1.11	1.07	0.96	1.10	1.06
Yamhill	SWW	84	107	74	92	89	Yamhill	0.79	0.96	0.73	0.76	0.81
Average		107	111	101	121	110						1.00
PLSD (5%)		17	13	21	26	14						0.12
CV		9	7	13	13	10						9
P-VALUE		0.02	0.00	0.00	0.00	0.01						0.01
				lb/a						Percent of average		
Winter barleys												
Gwen	6RF	6061	4266	2889	4953	4542	Gwen	1.16	0.98	0.76	1.28	1.05
Hesk	6RF	5196	4408	4078	3805	4372	Hesk	1.00	1.01	1.07	0.98	1.02
Hundred	6RF	4972	5044	3860	3699	4394	Hundred	0.96	1.16	1.02	0.95	1.02
Kold	6RF	5620	4289	4215	4686	4703	Kold	1.08	0.98	1.11	1.21	1.10
Steptoe	6RF	4170	3796	3932	2242	3535	Steptoe	0.80	0.87	1.04	0.58	0.82
Average		5204	4361	3795	3877	4309						1.00
PLSD (5%)		NS	622	1534	1496	NS						NS
CV		17	9	22	21	15						16
P-VALUE		0.12	0.00	0.00	0.01	0.18						0.23

NS = non-significant

Analysis by ANOVA mean separation with protected least difference.

FUNGICIDES TO CONTROL EARLY AND LATE BLIGHT ON RUSSET NORKOTAH POTATOES

Steven R. James and Frederick J. Crowe

Abstract

An experiment to evaluate the efficacy of selected fungicides on early and late blight control on Russet Norkotah potatoes was planted at the Madras site of Central Oregon Agricultural Research Center in 1996. No late blight was observed during the growing season because of weather conditions. All of the fungicide treatments tested reduced the level of early blight as compared with the untreated check. There were no statistically significant differences in yield, specific gravity, or tuber weight among the fungicide treatments.

Introduction

Late blight (*Phytophthora infestans*) is perhaps the most economically devastating disease infecting potatoes worldwide (4,5). It had rarely been observed in central Oregon potato fields until the 1995 growing season, when it infected nearly every potato field in the region (3). Growers and crop advisers were largely unprepared for late blight epidemic, because outbreaks normally occur in cool, wet growing regions rather than in locations like central Oregon where the summer climate is hot and dry. Fungicide supplies were concentrated in the eastern and midwestern United States and were initially difficult to obtain in the western United States Growers and crop advisors also had little experience dealing with late blight and information regarding fungicide efficacy was difficult to obtain.

Early blight (*Alternaria solani*) is the most common annually occurring foliar disease of potatoes in central Oregon. Early blight is most severe under alternately wet and dry conditions, consequently the problem is frequently observed in sprinkler irrigated potato growing regions. If not controlled it can reduce both tuber yield and quality in some cultivars (1,2).

New fungicide formulations and chemistry are continually being developed for the control of various foliar diseases on potatoes. This study was designed to evaluate the efficacy of several newly developed fungicides on early and late blight.

Materials and Methods

An experiment to evaluate the efficacy of selected fungicides on potato early and late blight was planted at the Madras site of Central Oregon Agricultural Research Center on May 20, 1996. The experiment was planted with the cultivar Russet Norkotah and arranged in a randomized complete block design with four replications. Individual plots were 25 feet long by four rows wide (12 feet) and were bordered on each end with 6 feet of bare ground. One hundred thirty-two seed pieces were planted nine inches apart in each plot, at a rate of 33 seed pieces in each row of the plot. Late blight was observed during the 1995 growing season in the seed lot that was used to plant the 1996 trial. Also, the trial location was previously planted to potatoes in 1995 and was heavily infected with late blight. Volunteer potato plants were observed growing in the trial area during the 1996 growing season. The experiment was fertilized, cultivated, sprinkler irrigated, and managed according to practices commonly used in central Oregon.

Fungicide treatments and application dates are shown in Table 1. Applications were made using a carbon dioxide powered backpack sprayer delivering 31 gallons per acre at 32 psi with Teejet 8003 flat fan nozzles. The first treatments were applied on July 3 when plants were 6-8 inches tall and rows were 30 percent closed. Rows were 70, 80, and 100 percent closed on July 12, July 23, and August 2 respectively. Tubers were present by mid July. The largest tubers were 2-3 ounces by early August, 4-6 ounces by mid August, and over 8 ounces by early September. Plots were visually rated for the presence of early and late blight each week beginning August 2. Disease severity was rated as the percent of plants in the two middle rows of the plot with any symptoms of the respective disease.

Vines were flailed on September 18 and a 15 foot section from the two middle rows of each plot was harvested September 30, 1996. Plots were weighed and graded into three grade and four size categories. The total number of tubers per plot was determined and used to calculate the average tuber size. Specific gravity was obtained by using the air/water method.

Results

Late blight failed to develop in the trial area. In fact, no late blight was observed anywhere in central Oregon during the 1996 growing season. The weather during the growing season was generally hot and dry with no extended periods when moisture remained on the plants. The plots were not inoculated with the late blight fungus because of certified seed potato fields growing in the vicinity of the trial.

Early blight was first observed in the plots in early August. Early blight symptom development is summarized in Table 2. Significantly more infected plants were observed in the untreated check plots than fungicide treated plots each week that early blight was present. There were no significant differences ($p<5\%$) among the fungicide treatments except for the week of August 30 when more early blight infected plants were observed in the Dithane/Bravo (mancozeb/chlorothalonil) treatment than the Quadris (azoxystrobin) and IB11925 treatments. All tested fungicides significantly reduced early blight infection as compared with the untreated check.

Fungicide treatment effects on yield, specific gravity, and tuber weight of Russet Norkotah potatoes are summarized in Table 3. There were no statistically significant differences in yield, specific gravity, or tuber weight among the check and fungicide treatments.

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Acknowledgements

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Table 1. Fungicide treatment and application dates, Madras, Oregon, 1996.

Fungicide Treatment	Rate Product/A	Application Date									
		7/3	7/12	7/23	7/26	8/7	8/9	8/17	8/23	8/28	9/6
Untreated											
Dithane	3.20 pt/a	X			X				X		
Bravo WS	1.50 pt/a		X				X				X
Quadris	0.125 lb/a		X		X		X		X		
Bond	0.125% v/v		X		X		X		X		
Bravo WS	1.50 pt/a										X
Quadris	0.1875 lb/a		X		X		X		X		
Bond	0.125% v/v		X		X		X		X		
Bravo WS	1.50 pt/a										X
Quadris	0.250 lb/a		X		X		X		X		
Bond	0.125% v/v		X		X		X		X		
Bravo WS	1.50 pt/a										X
Quadris	0.3125 lb/a		X		X		X		X		
Bond	0.125% v/v		X		X		X		X		
Bravo WS	1.50 pt/a										X
Quadris	0.3125 lb/a		X		X		X		X		X
Bond	0.125% v/v		X		X		X		X		X
Bravo WS	0.75 pt/a	X									
Bravo WS	1.00 pt/a		X								
Bravo WS	1.50 pt/a			X		X		X		X	X
Bravo Zn	2.20 pt/a		X	X		X		X		X	X
IB11925	1.75 pt/a		X	X		X		X		X	X
IB11925	1.00 pt/a	X									
IB11925	1.50 pt/a		X								
IB11925	1.75 pt/a			X		X		X		X	X
IB11522	1.50 pt/a		X	X		X		X		X	X
Bravo Zn	2.00 pt/a		X	X		X		X		X	X
SuperTin	2.50 oz/a					X		X		X	X
IB14121	2.00 pt/a		X	X		X		X		X	X

Table 2. Fungicide treatment effects on early blight of Russet Norkotah potatoes, Madras, Oregon 1996

Treatment	Rate Product/A	Early Blight Symptom Development Aug 2	Aug 9	Aug 17	Aug 23	Aug 30	Sep 6
		%	%	%	%	%	%
Untreated Check		0	6	14	18	19	37
Dithane/Bravo	3.2 pt/a	0	3	4	4	10	12
Quadris/Bravo	0.125 lb/a	0	2	4	4	6	11
Quadris/Bravo	0.1875 lb/a	0	2	2	6	6	7
Quadris/Bravo	0.250 lb/a	0	1	3	6	7	7
Quadris/Bravo	0.3125 lb/a	0	2	3	3	6	8
Quadris	0.3125 lb/a	0	1	2	2	4	8
Bravo W/S	Various	0	2	3	3	5	10
Bravo Zn	2.2 pt/a	0	3	4	4	5	10
IB11925	1.75 pt/a	0	2	4	5	6	7
IB11925	Various	0	1	2	4	4	7
IB11522	1.5 pt/a	0	2	3	6	5	8
Bravo Zn/Tin	2.0 pt/a	0	1	4	7	5	10
IB14121	2.0 pt/a	0	3	4	5	7	9
LSD 5%		NS	2	4	4	5	7

Table 3. Fungicide treatment effects on yield, specific gravity, and tuber weight of Russet Norkotah potatoes, Madras, Oregon, 1996.

Treatment	Rate Product/A	Total Yield	No. 1 Yield	Specific Gravity	Tuber Weight
		cwt/a	cwt/a		oz/tuber
Untreated Check		294	233	1.082	7.21
Dithane/Bravo	3.2 pt/a	362	273	1.079	7.47
Quadris/Bravo	0.125 lb/a	358	282	1.082	7.43
Quadris/Bravo	0.1875 lb/a	335	262	1.079	8.16
Quadris/Bravo	0.250 lb/a	378	295	1.081	7.61
Quadris/Bravo	0.3125 lb/a	367	279	1.079	7.59
Quadris	0.3125 lb/a	378	300	1.081	7.46
Bravo W/S	Various	342	283	1.082	6.91
Bravo Zn	2.2 pt/a	373	287	1.080	8.04
IB11925	1.75 pt/a	353	263	1.083	7.07
IB11925	Various	359	280	1.081	7.38
IB11522	1.5 pt/a	402	322	1.078	8.30
Bravo Zn/Tin	2.0 pt/a	390	323	1.080	8.42
IB14121	2.0 pt/a	328	251	1.081	7.10
LSD 5%		NS	NS	NS	NS

SEED POTATO WINTER TEST COMPARISON STUDY

Steven R. James and Central Oregon Potato Grower's Association

Introduction

Seed potato certification agencies require seed lots to be inspected during the growing season for various pathogens, chemical injury, and other varieties. In addition, many agencies require all seed lots passing growing season inspections to be winter tested prior to sale as certified seed potatoes. Some certifying agencies winter test outdoors in southern sites such as Oceanside, California or Homestead, Florida. Other agencies winter test seedlots in greenhouses in more northern climates. Seed growers in Oregon (and perhaps other states) have wondered if the two winter testing methods are equivalent. This study was designed to evaluate samples from the same potato seedlot under two winter testing schemes.

Materials and Methods

Russet Burbank, Ranger Russet, and Shepody tubers used for the study were collected from a variety by irrigation by Verticillium study planted at Madras in 1995 by Mary Powelson and Meghan Arbogast, Oregon State University Plant Pathology Department. The Katahdin seedlot used for that study was 40-50 percent infected with Potato Virus Y (PVY). The other seedlots used in that study (Russet Burbank, Ranger Russet, Shepody, Viking, and Red Lasoda) were not initially infected with PVY but became infected with PVY during the growing season. Late blight was also present in that study during the later part of the growing season.

Tubers from each lot were collected and sorted into three groups: 1) single drop seed weighing 2-3 ounces, 2) small tubers weighing 4-6 ounces, and 3) tubers weighing over 6 ounces. The single drop seed was packaged and sent to the Idaho Crop Improvement Association for planting and evaluation in Oceanside, California. The Russet Burbank, Ranger Russet, and Shepody lots were subjected to the same winter testing protocol as seedlots submitted from other seed growers except that the samples arrived too late to receive the normal dormancy breaking treatment. The 4-6 ounce tubers were submitted to the Oregon State University Seed Certification Service and tubers were subjected to the same winter testing protocol as seedlots submitted from other seed growers. The tubers weighing over 6 ounces were discarded.

A Norkotah seedlot was obtained from a local grower, but the lot was not submitted because of excessive tuber size. The Norkotah seedlot was not resampled due to submission time constraints.

An Oregon seed grower also submitted samples from the same Russet Burbank NewLeaf seedlot for winter testing to both the Idaho Crop Improvement Association and the Oregon State University Seed Certification Service. The NewLeaf seedlot was handled by existing testing protocol at each location.

Results and Discussion

A summary of the winter test results from the Oceanside and Corvallis plantings is shown in Table 1. The percent leafroll, PVY, and other varieties observed at each location were nearly identical for each of the varieties tested except Shepody. Fewer PVY infected Shepody plants were reported for Oceanside because the Shepody lot was observed only one time on January 23, 1996. Dr. Richard G. Clarke reported concerning the Shepody lot planted at Oceanside: "I'm sure that I would have scored more visually positive plants if I had read it again on the second inspection. Virtually every plant was probably PVY-infected." ELISA tests performed on 100 Shepody leaves at Oceanside showed 99 percent were PVY-positive.

The percentage of plants that emerged and were observed at Corvallis was greater than that observed at Oceanside. The Oceanside samples were not submitted in time to receive the customary dormancy breaking treatment. They were also planted about six weeks earlier than the Corvallis samples and this likely resulted in a greater number of dormant seed pieces.

The data collected from this one-year study suggest that PVY, potato leafroll virus (PLRV), or other varieties (OV) that are present in seedlots can be detected similarly at either Oceanside or Corvallis.

Table 1. Summary of winter test results for five potato cultivars grown at Oceanside, California and Corvallis, Oregon, 1995-96.

	Plant Count*		Percent Leafroll**		Percent PVY**		Percent OV**	
Variety	Ocean	Corvallis	Ocean	Corvallis	Ocean	Corvallis	Ocean	Corvallis
R. Burbank	305/370	361/400	0.33	0.00	42.30	44.60	0.00	0.00
Ranger	315/427	430/450	0.00	0.00	41.00	38.37	0.32	0.47
Shepody	247/400	398/450	0.00	0.00	89.07	98.99	1.21	0.75
NewLeaf®	390/400	428/?	0.00	0.00	1.00	0.00	0.00	0.00
Norkotah		No data—submitted tubers were too large for the Oceanside planting						

* Number of plants observed/number tubers submitted

** Percent based on number of plants observed

RESPONSE OF SIX POTATO CULTIVARS TO DROUGHT AND POTATO EARLY DYING: AN UPDATE

Meghan Arbogast and Mary Powelson, OSU
Lidia Watrud, USEPA

Potato early dying (PED) is a disease complex primarily caused by the soilborne fungus *Verticillium dahliae*. It is a major constraint to potato production world wide, including the irrigated fields of the Pacific Northwest. Traditionally, this disease is controlled with soil fumigation and/or long crop rotations. Recently, cultivars with resistance to this disease have been released. Additionally, modification of irrigation practices early in the season has resulted in significant disease suppression. Our studies on cv Russet Burbank have shown that disease suppression has been brought about by maintaining a mild drought stress between emergence and tuber initiation. The mild drought stress during the time frame when most root infections by *Verticillium* occur may enhance host resistance to this disease.

Drought is defined as a shortage of water sufficient to adversely affect crop production. It can be caused by either lack of soil water or blockage of its transport by a pathogen. Infection of potato with *Verticillium* results in a water deficit stress (drought) within the plant that is not caused by a soil water deficit. Water becomes deficient as a result of a number internal events within the water conducting tissue of the potato. Whether drought results from limited soil moisture or from infection by *Verticillium,* the plant responds to a limitation in water in a variety of ways. The end result is reduced plant growth and lower tuber yields.

We are exploring the relationship between drought tolerance and resistance to PED for several reasons. First, we are interested in determining if cultivars that are drought tolerant are also tolerant to PED. Second, if resistance to PED and tolerance to drought are related, then screening for drought tolerance may provide a tool for identifying germplasm with resistance to PED. Finally, water management guidelines for suppression of PED in a diversity of potato cultivars could be developed as have been for Russet Burbank.

Field plots were established at the Central Oregon Agricultural Research Center, Madras, Oregon, in May 1995, and 1996. In 1995, treatments included six potato cultivars (Katahdin, Red La Soda, Ranger Russet, Russet Burbank, Shepody, and Viking) and three irrigation levels that were established using line source irrigation. In 1996, *Verticillium dahliae* was included as the disease variable.

Preliminary Results

Foliar Senescence

• The effect of *Verticillium* on senescence was cultivar dependent. Katahdin was very resistant, Ranger Russet and Viking were moderately resistant, and Russet Burbank, Red La Soda, and Shepody were susceptible.

• For all cultivars, a decrease in soil moisture resulted in an increase in rate of senescence. However, the percent increase in severity of senescence was cultivar dependent. Ranger Russet was the most tolerant to moisture stress whereas Red La Soda and Shepody were the most susceptible.

• *Verticillium*-included foliar senescence was mediated by amount of soil water. The severity of foliar senescence increased with an increase in soil moisture; e.g. the increase in the amount of senescence in the presence of *Verticillium* was less under drought than under wet soil conditions.

Yield

• Katahdin and Red La Soda out performed Shepody, Russet Burbank, Viking, and Ranger Russet in marketable tuber yield when grown under a mild moisture stress (65 percent estimated consumptive use).

• *Verticillium* had no effect on marketable yield.

We wish to thank Steve James and his crew for his valuable input, cooperation and labor into this study. His efforts were paramount to the success of this experiment.

CELIA WINTER TRITICALE AND STEPHENS SOFT WHITE WINTER WHEAT RESPONSE TO NITROGEN FERTILIZER IN 1996

Mylen Bohle, Russ Karow, Helle Ruddenklau, Ernie Marx and Steve James

Abstract

Celia winter triticale and Stephens soft white winter wheat responses to nitrogen fertilizer rates were tested at the Central Oregon Agricultural Research Center (COARC) at Madras, Oregon in the 1995-96 crop year. Stephens and Celia yield and protein content increased with nitrogen additions up to 120 lb/a. Stephens and Celia yielded 137.8 and 119.5 bu/a at the 120 lb/a N rate, respectively. Protein contents increased significantly up to the 120 lb N rate though there was a trend to increase up to 160 lb/a. Celia did not lodge, while Stephens lodged at the higher N rates of 120 and 160 lb/a.

Introduction

More acreage is devoted to soft white winter wheat in central Oregon than any other cereal grain crop. Winter triticale is a "new" feed grain crop with high yield potential. Interest in triticale is growing for both grain and forage purposes. The grain is excellent for livestock feed, especially in swine and poultry rations. Celia winter triticale does have the ability to outyield barley and has less lodging and disease problems. It also has superior test weight in comparison to other triticale varieties. A nitrogen fertilizer rate trial was initiated in crop year 1994/1995 to compare yield, quality, and agronomic response by Celia and Stephens. This is the second year of a three year study. Information gathered will allow better production practice decision making.

Materials and Methods

Celia winter triticale and Stephens soft white winter wheat were planted on October 13, 1995, at 30 seeds per square foot with a plot cone-type planter. The design was a randomized complete block, two factorial design with three replications. Only replication one and two were used for statistical analysis as replication 3 showed extreme variation due to higher soil nitrogen fertility. Row spacing was 8 inches and plot size was 5 feet x 20 feet. A soil sample was taken to bedrock in early March of 1996. The soil analysis was performed by Agri-Check laboratory. Soil test results are in Table 1. The previous crop was summer fallow. It was assumed that 20 pounds of nitrogen had been taken up by the plants at the time of sampling. The plots were individually fertilized by hand with 40 pounds of sulfur (gypsum source), and 0, 40, 80, 120, and 160 pounds of nitrogen per acre (ammonium nitrate nitrogen fertilizer) on March 18, 1996. Irrigation was with solid set sprinkler lines and applied as needed. Weeds were controlled with an application of Bronate (2 pints/a) and surfactant (1 pint/a) on March 27, 1996. Heading dates were not taken and a general heading date was used from a nearby variety trial, planted the same day. Plant height and lodging scores were recorded prior to harvest. Seventy-five square feet were harvested on August 27, 1996. Grain was cleaned, test weights and 1,000 kernel weights measured, and protein contents determined with a whole grain infra-red analyzer by the state-wide cereal variety testing team in Corvallis. Grain nitrogen uptake (recovery), grain protein yield, seeds per pound, and future seeding rates were calculated. The MSTAT statistical program was used to analyze the data. Protected least significant differences (PLSD's) are used in the mean separations. The grain yield, test weight, protein content, grain nitrogen uptake, and grain protein yield data are presented on a 10, 10, 12, 11 and 11 percent moisture basis, respectively. Grain yield is presented on a 60 pound bushel basis.

Results and Discussion

The results for grain yield, protein content, test weight, height, lodging, and Julian heading date are presented in Table 2. Results for grain nitrogen uptake, grain protein yield, 1,000 kernel weight, seeds per pound, and future seeding rates are presented in Table 3.

Stephens soft white winter wheat was significantly different from Celia winter triticale in all parameters measured. Stephens yield increased 13.8 bu/a with 40 lb/a N, and another 20.7 bu/a with the next 40 lb/a N increment (80 lb/a N). Increasing from 80 to 120 lb/a N increased yield only 5.8 bu/a and the high rate decreased yield. Lodging at the two high N rates was probably responsible for the yield plateau and yield decrease. Celia responded similarly, but the only statistical yield increases, was the 120 lb/a N rate compared to the 0 lb/a N rate. Celia yield also decreased with the 160 lb N/a rate, although no lodging occurred at the high N rates. The 120 lb N rate increased yield by 14.7 bu/a over the check. For some reason, it was not a "triticale year", as the triticales did not yield well across the state in other trials. Soil nitrogen mineralization rates were not measured, but must have been high as the Celia and Stephens 0 lb/a N rate yielded 104.8 and 97.5 bu/a, respectively.

Protein content increased significantly with increasing rates of N up to 120 lb N/a. The 160 lb rate increased protein content, but not significantly. Though Stephens and Celia responded similarly, Stephens always had a higher protein content than Celia at the same nitrogen rate. Previous research has shown that soft white wheat with protein contents over 9.5 to 10 percent were optimally fertilized. Using this rule of thumb, nitrogen rates slightly above 80 pounds per acre would have been adequate for Stephens. A similar rule for triticale has yet to be established. Celia and Stephens both increased grain nitrogen uptake to the 120 lb N/a rate and then both decreased with the high rate of N applied (table 3). Grain protein yield responded similarly.

Stephens test weight increased (4.3 lb/bu and 1.7 lb/bu) with the first two nitrogen rate increases up to 60.2 lb/bu. Additional nitrogen decreased test weight significantly for Stephens. In contrast, the test weight of Celia decreased with each additional rate of nitrogen up to the 120 lb N/a rate, and then increased significantly with the 160 lb/a N rate.

Stephens 1,000 kernel weight decreased with each additional 40 lb/a rate of N applied. The largest decrease was with the 120 lb/a N rate. Celia kernel weight was steady compared to Stephens. Though Celia kernel weight did not change as much, there was a significant decrease with the 80 lb N/a rate. The 120 and 160 lb N/a rate kernel weights were no different than the two lowest N rates. Seeds per pound, a calculated number, with an inverse relationship to 1000 kernel weight, was different between Celia and Stephens. Celia's future seeding rate (30 seeds per square foot under irrigated conditions) was rather static with only a 7.2 lb/a difference between all of the N rates, while Stephens had a 21.6 lb/a difference between rates.

In a variety trial (three replicates) planted next to this trial, Celia and Stephens yielded 113.6 and 142.7 bu/a, respectively. The variety trial was fertilized with 141 pounds of nitrogen per acre. Protein content and test weight were 9.2, 57.0, and 10.3, and 59.9 lb/bu, for Celia and Stephens, respectively. Celia and Stephens did not lodge.

The nitrogen rate trial will be repeated in the 1996-97 crop year.

Table 1. Soil test results taken at the COARC, Madras, Oregon in March of 1996.

Soil Depth inches	pH	P_2O_5 ppm	K_2O ppm	NO_3 lb/a	NH_4 lb/a
0 -12	6.9	20	548	17	19
12-24	8.1	8	286	28	15

Table 2. Celia winter triticale and Stephens soft white winter wheat yield, protein content, test weight, height, lodging, (and Julian heading date*) response to nitrogen fertilizer at COARC, Madras, Oregon in 1996.

Treatment	Yield bu/a	Protein %	Test Weight lb/bu	Height in.	Lodging %	Julian Heading Date* 1/1=1
Variety						
Stephens	118.5	9.2	58.0	38.6	24	161
N Rate lb/a						
0	101.2	7.5	56.0	39.0	0	—
40	111.7	8.1	58.0	40.3	0	—
80	123.2	9.0	58.6	40.0	0	—
120	128.6	10.0	57.3	39.5	23	—
160	111.6	10.2	57.8	38.0	38	—
Variety x N Rate						
Stephens						
0	97.5	7.8	54.2	38.0	0	—
40	111.3	8.2	58.5	40.5	0	—
80	132.0	9.2	60.2	39.5	0	—
120	137.8	10.5	58.5	38.5	45	—
160	114.1	10.6	58.4	36.5	75	—
Celia						
0	104.8	7.3	57.9	40.0	0	—
40	112.2	8.0	57.5	40.0	0	—
80	114.5	8.9	57.0	40.5	0	—
120	119.5	9.6	56.2	40.5	0	—
160	109.2	9.7	57.2	39.5	0	—
Mean	115.3	8.9	57.5	39.4	12	161
Variety						
PLSD .10	S	S	S	S	S	—
PLSD .05	S	S	S	S	S	—
N Rate						
PLSD .10	14.6	0.7	0.7	NS	9	—
PLSD .05	18.0	0.8	0.8	NS	12	—
Variety x N Rate						
PLSD .10	20.7	NS	0.9	NS	13	—
PLSD .05	25.5	NS	1.2	NS	17	—
CV%	4.1	0.9	5.9	3.9	60.9	—

* These heading dates are taken from the variety trial planted next to this trial.

Table 3. Celia winter triticale and Stephens soft white winter wheat grain N uptake, grain protein yield, 1,000 kernel weight, seeds per pound, and future seeding rate (based on 30 seeds per square foot) response to nitrogen fertilizer at COARC, Madras Oregon in 1996.

Treatment	Grain N Uptake lb/a	Grain Protein Yield lb/a	1000 Kernel Weight g	Seeds Per Pound	Future Seeding Rate lb/a
Variety					
Stephens	116.0	724.9	46.7	9,771	134.5
Celia	102.7	642.1	42.0	10,815	121.0
N Rate lb/a					
0	79.9	499.1	46.3	9,875	133.3
40	94.9	593.2	46.5	9,802	134.0
80	116.6	728.4	44.3	10,350	127.5
120	136.0	850.1	42.5	10,678	122.5
160	119.5	746.8	42.3	10,758	121.7
Variety x N Rate					
Stephens					
0	79.8	498.8	50.0	9,076	144.1
40	95.7	597.9	49.5	9,165	142.6
80	126.1	789.5	48.5	9,354	139.8
120	151.0	943.8	43.0	10,549	123.9
160	127.2	794.7	42.5	10,710	122.4
Celia					
0	79.9	499.4	42.5	10,675	122.5
40	94.2	588.6	43.5	10,440	125.3
80	106.8	667.4	40.0	11,347	115.3
120	121.0	756.5	42.1	10,806	121.0
160	111.8	699.0	42.0	10,806	121.0
Mean109.4	683.5	44.4	10,293	127.8	
Variety					
PLSD .10	S	S	S	S	S
PLSD .05	S	S	S	S	S
N Rate					
PLSD .10	12.2	76.2	2.0	502	5.9
PLSD .05	15.1	94.0	2.5	620	7.3
Variety x N Rate					
PLSD .10	NS	NS	2.9	710	8.3
PLSD .05	NS	NS	3.6	877	10.3
CV%8.6	8.6	3.6	3.8	3.6	

EVALUATION OF SUGAR BEET VARIETIES IN CENTRAL OREGON, 1996

Marvin Butler

Abstract

Evaluation of sugar beet varieties in central Oregon was abandon in the Prineville area due to freeze damage, but was conducted at the second location in Culver where a strong stand was established. Sub-samples of the 18 varieties were sent to the Beet Sugar Development Foundation to be evaluated for curly top resistance. The 2-row x 20 ft plots were rated for stand establishment and plants hand thinned to 7 inches apart May 31. A single row per plot was harvested September 26, and samples transported to Spreckles Sugar, Woodland, California for determination of weight, percent sugar, and ppm nitrate. Comparison of varietal performance is provided in Table 1.

Introduction

The seed evaluation committee of the Central Oregon Beet Growers Association determines what varieties may be grown in central Oregon based on yield, sugar, and resistance to beet curly top virus. The objective of this project was to evaluate sugar beet varieties submitted by seed companies at two locations, in the Prineville and Culver areas. This information, along with local large plot and field data, will assist the seed evaluation committee in their decision concerning variety selection.

Methods and Materials

Eighteen varieties submitted by five sugar beet seed companies were planted in commercial fields near Prineville April 16 and near Culver April 23. An Earthway push planter was used for the 2-row x 25 ft plots, replicated four times in a randomized complete block design. Sub-samples of each variety were sent to the Beet Sugar Development Foundation to be evaluated for curly top resistance at Kimberly, Idaho.

Freeze damage occurred at both locations, with replanting of the commercial production outside of the plots. Plant emergence in the plots was earlier due to a slightly shallower planting depth, and greater due to a higher seeding rate to insure an adequate stand. With less freeze damage than the field, plots were not replanted at either location. An excellent stand emerged at the Culver location, but lack of continued emergence at the Prineville location forced abandonment of the trial.

Plots were evaluated for stand establishment May 31 using a rating scale of 1 (poor) to 5 (excellent), prior to hand-thinning to 7 inches between plants. Remaining skips and doubles were removed June 14. A single row of the double-row plots was harvested September 26, and samples transported to Spreckles Sugar for determination of weight, percent sugar, and ppm nitrate.

Results and Discussion

Results of the Culver location are provided in Table 1. Although percent germination was rated low for some varieties, after hand thinning to 7 inches between plants, all plots had equal, full stands. As a result, germination ratings had no influence on yield, sugar, or total sugar per acre Since plots were harvested early in the season, yield and sugar levels may not be comparable with specific field results. The evaluations should be used to compare differences between varietal performance within the same trial where they were grown under the same conditions, rather than making a comparison with other field harvest data. Variety performance in commercial fields in central Oregon is available, and should be consulted in addition to this evaluation prior to future management decisions.

During the February 27, 1996 meeting of the Central Oregon Beet Growers Association seed evaluation committee a decision was made to not allow varieties that were rated with symptoms greater than 125 percent of the standard curly top resistant variety. This will be based on an average of three years of trials, so ratings could vary from those listed in Table 1.

Table 1. Sugar beet varieties planted April 23 and harvested September 26, 1996 in a commercial field near Culver, Oregon.

Variety	Seed company	Stand[1]		Yield		Sugar	Total Sugar	Nitrate	Curly Top Virus: Visual rating	Curly Top Virus: Percent of standard
				(tons/a)		(percent)	(lb/a)	(ppm)	(0-9)	(percent)
5CG7004	Betaseed	2	de[2]	37.62	a	17.4	13,092	14.8	5.3	118
5CG7010	Betaseed	3.8	abc	34.65	ab	17.3	11,989	19.2	4.8	107
4CG6245	Betaseed	3.3	cd	33.66	ab	17.6	11,848	14.4	5.7	127
3BG6360	Betaseed	1	e	33.17	ab	17.6	11,676	18.3	5.9	131
Beta 8450	Betaseed	4	abc	33.66	ab	17.3	11,646	18.9	5.4	120
Beta 8256	Betaseed	3.8	abc	32.67	ab	17.8	11,631	15.9	6.4	142
WS 62	Hilleshog	4.3	abc	34.16	ab	17.0	11,614	17.4	4.3	96
Ranger	Seedex	3.8	abc	33.17	ab	17.3	11,477	11.8	5.2	116
ACH 203	American Crystal	4.3	abc	33.17	ab	17.2	11,410	15.8	6.0	133
Chinook	Seedex	4	abc	33.17	ab	17.0	11,278	19.3	5.4	120
Beta 8422	Betaseed	3.7	abc	31.68	ab	17.7	11,215	13.9	4.9	109
Canyon	Hilleshog	4.3	abc	32.67	ab	17.0	11,108	17.0	4.4	98
HH 50	Holly	5	a	32.67	ab	16.9	11,042	17.9	5.7	126
HM 5892	Hilleshog	4.5	abc	32.67	ab	16.9	11,042	17.6	5.3	118
Beta 4885	Betaseed	4.3	abc	31.19	ab	17.7	11,041	15.9	5.5	122
ACH 211	American Crystal	3.8	abc	31.19	ab	17.3	10,792	15.9	5.8	129
WS 91	Hilleshog	4.8	ab	30.69	ab	17.3	10,619	17.3	4.9	109
HH 86	Holly	3.5	bc	27.72	b	17.5	9,702	22.8	5.6	124

[1] Plots were evaluated for stand establishment on May 31, 1996 using a rating scale of 1 (poor) to 5 (excellent).
[2] Varieties followed by the same letter(s) are not statistically different from one another.

EVALUATION OF PREEMERGENCE AND POSTEMERGENCE HERBICIDE APPLICATIONS ON SUGAR BEETS, 1996

Marvin Butler

Abstract

Evaluation of preemergence and postemergence herbicide applications on sugar beets was conducted in two commercial fields near Prineville and Culver, Oregon. Herbicides applied preemergence included ethofumesate (Nortron, AgrEvo), pyrazon (Pyramin, BASF), and cycloate (Ro-Neet, Zeneca). Herbicides applied postemergence were triflusulfuron (Upbeet, Du Pont), phenmedipham plus desmedipham (Betamix, AgrEvo), phenmedipham plus desmedipham plus ethofumesate (Betamix Progress, AgrEvo), and clopyralid (Stinger, DowElanco). At the Prineville location, 100 percent weed control was provided by preemergence application of Pyramin alone or with Nortron, followed by postemergence application of Betamix Progress and Upbeet. Preemergence application of Nortron, followed by postemergence application of Betamix and Upbeet provided 99 percent control. Plots treated with a combination of preemergence and postemergence applications had less weeds than those receiving only postemergence applications. Betamix plus Upbeet performed better than Betamix Progress plus Upbeet. Yields were not affected by slight stunting from Nortron or moderate stunting from Pyramin applied preemergence. Percent sugar and parts per million nitrate in sugar beets was unaffected by treatments.

Introduction

Herbicide trials were conducted at three locations during the 1995 season, the first year sugar beets were grown commercially in central Oregon. The objective of this project was to evaluate Nortron, Pyramin, and Ro-Neet applied preemergence, and Betamix, Betamix Progress, Upbeet, and Stinger applied postemergence to commercially grown sugar beets near Prineville and Culver, Oregon.

Methods and Materials

Treatments were applied with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water. Plots 10 ft x 25 ft were replicated four times in a randomized complete block design. Crop oil concentrate was added to Upbeet treatments at 1 percent of spray volume.

Treatments applied preemergence at Prineville were made April 15 except Ro-Neet, which was applied April 22 between rain showers. Treatments applied postemergence were made at the cotyledon stage May 28, the four-leaf stage June 3, and the six-leaf stage June 10. Treatments were evaluated for crop injury and percent control of lambsquarters, pigweed, nightshade, filaree, buttonweed, and mustard species June 27. The center 25-foot row of each plot was harvested October 9. Samples were weighed and 10 beet sub-samples evaluated for percent sugar and parts per million nitrate by Spreckles Sugar, Woodland, California.

Preemergence treatments at Culver were applied April 25, except Ro-Neet applied May 2 just prior to irrigation. Postemergence treatments were applied May 16, May 23, and May 30. Treatments were evaluated for crop injury and percent control of pigweed, kochia, nightshade, groundsel, lambsquarters and bindweed June 27.

Results and Discussion

At the Prineville location, plots treated preemergence with Pyramin alone, or in combination with Nortron, followed by postemergence treatments of Betamix Progress plus Upbeet provided the best weed control, with 100 percent control of lambsquarters, pigweed, nightshade, filaree, buttonweed, and mustard species. Plots treated with a combination of preemergence and postemergence herbicides recorded at least 93 to 100 percent total weed control, compared to 83 percent total weed control with postemergence applications only. Preemergence application of Nortron followed by postemergence applications of Betamix plus Upbeet provided 99 percent total weed control compared to 93 percent for Betamix Progress plus Upbeet.

At the Culver location there was greater variability and less weed control, which may have been caused by the stage of development during the spring freezing events. Because of the inability to insure adequate, timely incorporation of Ro-Neet, judgment concerning its performance should be reserved.

There was no reduction in yields following slight stunting in plots treated preemergence with Nortron, or moderate stunting in plots treatment with Pyramin or Pyramin plus Nortron. In general, the better the weed control, the higher the yield. Treated plots had yields ranging from 25.2 to 28.1 tons/a compared to 13.0 tons/a for untreated plots. There were no significant differences among treatments when evaluated for sugar content, which ranged from 18.3 to 18.8 percent, and nitrate, which ranged from 14 to 31 parts per million.

Table 1. Effect of herbicides applied to sugar beets near Prineville, Oregon, evaluated June 27, 1996.

					Percent Weed Control[1]						Yield
Treatments[2]	Preemergence	Cotyledon	Four-leaf	Six-leaf	Lambsquarters	Pigweed	Nightshade	Filaree	Buttonweed	Mustards	Tons/ acre
1. Nortron	3 pt				96	99	83	99	63	96	25.7
Betamix Progress		1.2 pt	1.7 pt								
2. Nortron	3 pt				98	100	71	96	95	100	25.2
Betamix Progress		1.2 pt	1.7 pt								
Upbeet		0.5 oz	0.5 oz								
3. Nortron	3 pt				97	100	73	71	96	96	25.2
Betamix Progress		1.2 pt	1.7 pt								
Stinger			4 fl oz								
4. Nortron	3 pt				100	100	96	100	83	99	26.4
Betamix Progress		1.2 pt	1.7 pt	2.25 pt							
5. Nortron	3 pt				99	100	99	99	98	98	25.2
Betamix		1.5 pt	2.0 pt								
Upbeet		0.5 oz	0.5 oz								
6. Nortron	3 pt				100	100	100	100	100	100	26.6
Pyramin	4 lb										
Betamix Progress		1.2 pt	1.7 pt								
Upbeet		0.5 oz	0.5 oz								
7. Pyramin	4.6 lb				100	100	100	100	100	100	28.1
Betamix Progress		1.2 pt	1.7 pt								
Upbeet		0.5 oz	0.5 oz								
8. Ro-Neet	0.5 gal				96	95	70	30	100	85	26.0
Betamix Progress		1.2 pt	1.7 pt								
Upbeet		0.5 oz	0.5 oz								
9. Betamix Progress		1.2 pt	1.7 pt	2.2 pt	95	95	88	58	65	96	25.2
Upbeet		0.5 oz	0.5 oz	0.5 oz							
10. Untreated		-----	-----	-----	0	0	0	0	0	0	13.0

[1] Visual evaluation was conducted June 27, 1996.

[2] Treatments were applied April 15, May 28, June 3, and June 10, 1996.

Table 2. Effect of herbicide applications on sugar beets near Culver, Oregon, evaluated June 27, 1996.

Treatments[2]	Preemergence	Cotyledon	Four-leaf	Six-leaf	Percent Weed Control[1] Pigweed	Kochia	Nightshade	Groundsel	Lambsquarters	Bindweed
1. Nortron	3 pt				91	23	75	97	100	43
Betamix Progress		1.2 pt	1.7 pt							
2. Nortron	3 pt				92	79	75	75	65	15
Betamix Progress		1.2 pt	1.7 pt							
Upbeet		0.5 oz	0.5 oz							
3. Nortron	3 pt				96	23	100	100	100	25
Betamix Progress		1.2 pt	1.7 pt							
Stinger			4 fl oz							
4. Nortron	3 pt				97	63	100	75	100	25
Betamix Progress		1.2 pt	1.7 pt	2.25 pt						
5. Nortron	3 pt				96	68	75	75	75	30
Betamix		1.5 pt	2.0 pt							
Upbeet		0.5 oz	0.5 oz							
6. Nortron	3 pt				97	65	100	100	100	74
Pyramin	4 lb									
Betamix Progress		1.2 pt	1.7 pt							
Upbeet		0.5 oz	0.5 oz							
7. Pyramin	4.6 lb				99	35	100	100	100	43
Betamix Progress		1.2 pt	1.7 pt							
Upbeet		0.5 oz	0.5 oz							
8. Ro-Neet	0.5 gal				98	55	100	100	93	43
Betamix Progress		1.2 pt	1.7 pt							
Upbeet		0.5 oz	0.5 oz							
9. Betamix Progress		1.2 pt	1.7 pt	2.2 pt	95	25	95	100	100	28
Upbeet		0.5 oz	0.5 oz	0.5 oz						
10. Untreated		-----	-----	-----	0	0	0	0	0	0

[1] Visual evaluation was conducted June 27, 1996.
[2] Treatments were applied April 25, May 16, May 23, and May 30, 1996.

EVALUATION OF PREEMERGENCE HERBICIDE APPLICATIONS ON SEED ONION AND RADISH, 1996

Marvin Butler and Brad Holliday

Abstract

Herbicides pendimethalin (Prowl, Cyanamid), propachlor (Ramrod, Monsanto), and alachlor (Lasso, Monsanto) were applied post-plant, preemergence to seed radish and at partial emergence to seed onion near Madras, Oregon. Prowl provided 100 percent control of common lambsquarters and 99 percent control of redroot pigweed, but caused injury to radishes. Ramrod provided 90 percent control of redroot pigweed, and inadequate control of common lambsquarters and grasses. Lasso provided 98 percent control of redroot pigweed and 96 percent control of grasses, with lower levels of crop injury.

Introduction

Research in Europe has indicated the potential for use of Lasso in seed radish. Prowl is currently registered for postemergence application to seed onions and radish, and Ramrod for preemergence application to seed onions. There has been industry interest in the potential for use of Prowl preemergence on these two crops. The objective of this project was to evaluate post-plant, preemergence application of Prowl, Ramrod, and Lasso to seed onions and radishes grown commercially near Madras, Oregon.

Methods and Materials

Prowl at 2 pt/a, Ramrod at 5 qt/a, and Lasso at 2.5 pt/a were applied to seed onions and radishes July 27 with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water. At the time of application radish plants had not emerged, but onions and weeds were partially emerged. Plots 18 ft x 25 ft were replicated three times in a randomized complete block design. Treatments were evaluated August 14 for control of redroot pigweed, common lambsquarters, and grass species. Reduction in stand and crop injury were rated visually.

Results and Discussion

Prowl provided 100 percent control of common lambsquarters, 99 percent control of redroot pigweed, was ineffective on grass species, and reduced the radish stand by 53 percent and radish growth by 67 percent. Ramrod provided 90 percent control of redroot pigweed, did not provide adequate control of common lambsquarters at 63 percent or grass species at 70 percent, and reduced the onion stand by 47 percent and onion growth by 30 percent. Onion injury from Ramrod is likely the result of seedling emergence at the time of application. Lasso provided 98 percent control of redroot pigweed, 96 percent control of grass species, and 83 percent reduction or less in onion or radish stands and plant growth.

Table 1. Effect of post-plant, preemergence herbicide applications July 27, 1996 on commercial seed onion and radish near Madras, Oregon.

		Weed control[1]			Onion		Radish	
Treatments[2]	Rate	Redroot pigweed	Common lambsquarters	Grass species	Reduced stand	Reduced growth	Reduced stand	Reduced growth
	(product/a)	-----------	-----------	-----------	(percent)	-----------	-----------	-----------
Prowl	2 pt	99 a[3]	100 a	20 b	17 b	13 ab	53 a	67 a
Ramrod	5 qt	90 a	63 b	70 a	47 a	30 a	0 b	13 b
Lasso	2.5 pt	98 b	83 ab	96 a	13 b	13 ab	0 b	13 b
Untreated	---	0 c	0 c	0 b	0 b	0 b	0 b	0 b

[1] Visual evaluation was conducted August 14, 1996.
[2] Treatments applied July 27, 1996.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

EVALUATION OF FUNGICIDES FOR CONTROL OF BOTRYTIS IN SEED ONIONS, 1996

Marvin Butler, Fred Crowe and Brad Holliday

Abstract

Fungicides benomyl (Benlate, Du Pont), thiophanate methyl (Topsin M, Elf Atochem), iprodione (Rovral, Rhone-Poulenc), vinclozolin (Ronilan, BASF), mancozeb (Manzate Du Pont) were applied for control of botrytis in seed onions grown commercially near Madras, Oregon. Scape blight was significantly reduced in plots treated with Benlate and Topsin M when compared to untreated plots. Control provided by Rovral, Ronilan, and Manzate was inadequate. As in previous years there was less soil-line rot in plots treated with Topsin M. There were no statistical differences between treatments when comparing percent seed set or weight per umbel.

Introduction

Botrytis, which attacks onions on the bulb near the soil surface and on the scape, can damage florets and seed in the umbel, and can infect seed. Onions with Spanish heritage appear to be more susceptible to botrytis. The objective of this project was to evaluate Benlate, Topsin M, Rovral, Ronilan, and Manzate for control of botrytis in seed onions grown commercially near Madras, Oregon.

Methods and Materials

Benlate at 1 lb/a, Topsin M at 1 lb/a, Rovral at 2 lb/a, Ronilan at 2 lb/a, and Manzate at 3 lb/a were applied to commercially grown seed onions with females that were half Spanish descent and males that were a storage type. Plots 10 ft x 25 ft were replicated four times in a randomized complete block design. Fungicides were applied on April 10 and May 2 with a CO_2 pressurized, hand-held, boom sprayer with TwinJet 8004 nozzles at 40 psi with 40 gal/a of water. The surfactant, Sylgard 309 at 1 pt/100 gal and the sticker, R-56, at 1 pt/100 gal were added to all treatments.

Evaluation of scape blight was conducted August 12 by counting the number of scapes per plot with symptomatic whitish, necrotic, shriveled tissue with sporulation. Thirty plants per plot were harvested and evaluated August 13 to 15 for the presence of soil-line rot on the bulb and determination was made as to whether the infection was active in the neck or bulb. Botrytis was considered present if lesions plus sporulation were observed on the bulb at the time of sampling, or after incubation at room temperature for three days. Samples were evaluated for percent seed set and weight per umbel.

Results and Discussion

There was significantly less scape blight in plots treated with Benlate and Topsin M compared to untreated plots. While less disease occurred in plots treated with Rovral, Ronilan, and Manzate compared to untreated plots, the difference was not significant and these products provided inadequate control of scape blight. There were no significant differences between treatments when evaluating soil-line rot. However, the trend suggests that Benlate and Topsin M reduced incidence of the disease. These data support results from the last two seasons indicating significant control of botrytis with Topsin M. Based on 1996 data, Benlâte should provide at least as much control of botrytis as Topsin M. There were no significant differences between treatments in percent seed set and weight per umbel. Benlate and Topsin M do not contain the same active ingredient, but both break down to the same active compound.

Table 1. Effect of fungicide applications on botrytis in seed onions on the Agency Plains near Madras, Oregon following double spring fungicide applications on April 10 and May 2, 1996.

Treatments[1]	Rate	Scape blight	Soil-line rot Present	Soil-line rot Active	Seed set	Weight per umbel
	(product/a)	(percent)				(g)
Benlate	1 lb	7.0 a[2]	43	19	78	39
Topsin M	1 lb	7.8 a	58	25	77	36
Rovral	2 lb	18.3 ab	59	42	82	35
Ronilan	2 lb	15.5 ab	59	33	75	38
Manzate	3 lb	14.8 ab	68	32	78	34
Untreated	----	24.3 b	69	41	78	42
			n.s.	n.s.	n.s.	n.s.

[1] Treatments applied April 10 and May 2, 1996.
[2] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

EVALUATION OF PREEMERGENCE HERBICIDE APPLICATION ON SEED RADISH, 1996

Marvin D. Butler and Brad Holliday

Abstract

Herbicides metolachlor (Dual, Ciba) and trifluralin (Treflan, DowElanco) were applied pre-plant, preemergence to seed radish near Madras, Oregon. Treflan at 1 pt/a provided 100 percent control of hairy nightshade and better control of redroot pigweed, China lettuce, and common groundsel than Dual at either 1 or 2 pt/a. Common groundsel was best controlled with Dual at 2 pt/a. There was no reduction in radish stand and no visible crop injury.

Introduction

Treflan applied pre-plant, preemergence has been historically used for early weed control on seed radish. Dual recently received a 24(c) registration for use on seed radish grown in central Oregon. Dual was expected to complement Treflan, providing increased control of hairy nightshade. The objective of this project was to evaluate pre-plant, preemergence applications of Dual, Treflan, and Dual plus Treflan on seed radish grown commercially near Madras, Oregon.

Methods and Materials

Dual at 1 and 2 pt/a, Treflan at 1.5 pt/a, and Dual at 1 pt/a plus Treflan at 1 pt/a were applied April 25 with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water. Plots 20 ft x 30 ft were replicated three times in a randomized complete block design. Herbicides were mechanically incorporated into the top 2 to 3 inches of soil with a commercial discing operation shortly after application. Treatments were evaluated June 10 for control of redroot pigweed, China lettuce, hairy nightshade, common groundsel, and common lambsquarters. Reduction in stand and crop injury were rated visually.

Results and Discussion

Treatments with Treflan at 1.5 pt/a provided 100 percent control of hairy nightshade, and better control than Dual alone at 1 or 2 pt/a for redroot pigweed, China lettuce, and common lambsquarters. Dual at 2 pt/a provided the best control of common groundsel at 95 percent. There was no reduction in radish stand and no visible crop injury.

The weed spectrum in the nontreated plots was composed of 58 percent redroot pigweed, 27 percent China lettuce, 5 percent hairy nightshade, 4 percent common groundsel, and 3 percent common lambsquarters. The low presence of hairy nightshade and variability between plots may account for the unexpectedly low control provided by Dual.

Table 1. Effect of pre-plant, preemergence herbicide applications April 25, 1996 on commercial seed radish near Madras, Oregon.

Treatments[2]	Rate	Weed control[1] Redroot pigweed	China lettuce	Hairy nightshade	Common groundsel	Common lambsquarters
	(product/a)	--------(percent)--------				
Dual	1 pt	30 d[3]	0 d	85 a	45	0
Dual	2 pt	40 c	20 c	95 a	95	0
Dual	1 pt					
+ Treflan	1 pt	60 b	60 a	100 a	85	55
Treflan	1.5 pt	90 a	40 b	100 a	90	70
Untreated	---	0 e	0 d	0 b	0	0
					n.s.	n.s.

[1] Visual evaluation was conducted June 10, 1996.
[2] Treatments applied April 25, 1996.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

EVALUATION OF PREEMERGENCE HERBICIDE APPLICATION TO SEED CARROTS, 1996

Marvin Butler, Bruce Martens, Les Gilmore and Al Short

Abstract

Two herbicides, linuron (Lorox, Du Pont) and pendimethalin (Prowl, Cyanamid), were applied preemergence alone, and in combination, to seed carrots at two locations near Madras, Oregon. Lorox at 2 lb/a provided 100 percent control of common groundsel, China lettuce, redroot pigweed,, and hairy nightshade at the Harris location and China lettuce, redroot pigweed, and buttonweed at the Boyle location. Prowl provided inadequate control of common groundsel, and less overall control than either rate of Lorox. There was no reduction in carrot stand and no visible crop injury.

Introduction

Seed carrot producers in central Oregon have depended on Treflan applied preplant for preemergence weed control. Research was conducted during the 1995 season to evaluate Lorox, Eptam, and Prowl when applied preemergence. The objective of this project was to evaluate preemergence application of Lorox and Prowl alone, and in combination, to seed carrots.

Methods and Materials

Lorox at 1 and 2 lb/a, Prowl at 2 pt/a, and Lorox at 1 lb/a plus Prowl at 2 pt/a were applied to seed carrots grown commercially at two locations near Madras, Oregon. Treatments were applied preemergence on August 16, 1996 with a CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gal/a water. Plots 10 ft x 20 ft were replicated three times in a randomized complete block design. Treatments were evaluated September 20, 1996 by counting the number of weeds per plot for common groundsel, China lettuce, redroot pigweed, and hairy nightshade at the Harris location, and common groundsel, China lettuce, redroot pigweed, and buttonweed at the Boyle location. Reduction in stand and crop were rated visually.

Results and Discussion

Lorox at 2 lb/a provided 100 percent control of all four weed species evaluated at the Harris location, and 93 percent control of weeds evaluated at the Boyle location. Lorox at 1 lb/a provided 100 percent control of redroot pigweed at both locations, but was weak on common groundsel. Prowl provided less weed control than Lorox, with inadequate control of common groundsel. There was no reduction in carrot stand and no visible crop injury.

Table 1. Effect of preemergence herbicide application on seed carrots at the Harris location near Madras, Oregon, 1996.

Treatments[2]	Rate	Common groundsel	China lettuce	Redroot pigweed	Hairy nightshade	Total weeds
		Non-controlled Weeds[1]				
	(product/acre)	(plants per plot)				
Lorox	1 lb	1.7 ab[3]	0.3 a	0	0	2 a
Lorox	2 lb	0 a	0 a	0	0	0 a
Prowl	2 pt	4 b	1.7 a	2	0	7.7 a
Lorox	1 lb					
+ Prowl	2 pt	0.3 a	0.3 a	0	0	0.7 a
Untreated	----	4 b	5 b	8.3	0.7	18 b
				n.s.	n.s.	

[1] Visual evaluation was conducted September 20, 1996.
[2] Treatments applied August 16, 1996.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

Table 2. Effect of preemergence herbicide application on seed carrots at the Boyle location near Madras, Oregon, 1996.

Treatments[2]	Rate	Common groundsel	China lettuce	Buttonweed	Redroot pigweed	Total weeds
		Non-controlled Weeds[1]				
	(product/a)	(plants per plot)				
Lorox	1 lb	1.8	1	0 a[3]	0 a	2.8 a
Lorox	2 lb	0.8	0	0 a	0 a	0.8 a
Prowl	2 pt	3	1	0 a	0 a	4 a
Lorox	1 lb					
+ Prowl	2 pt	3.3	0	0 a	0 a	3.3 a
Untreated	----	3.5	1.8	1.3 b	5.5 b	12 b
		n.s.	n.s.			

[1] Visual evaluation was conducted September 20, 1996.
[2] Treatments applied August 16, 1996.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

EVALUATION OF LAYBY HERBICIDE APPLICATIONS ON SEED CARROTS, 1996

Marvin Butler, Bruce Martens, Les Gilmore, and Al Short

Abstract

Herbicides prometryn (Caparol, Ciba), linuron (Lorox, Du Pont), metribuzin (Sencor, Bayer), bromoxynil (Buctril, Rhone-Poulenc), and pendimethalin (Prowl, Cyanamid) were applied alone, and/or in combination, as a directed spray at layby to seed carrots near Culver, Oregon. Buctril at 1 pt/a plus Sencor at 0.3 lb/a, and Caparol at 1 pt/a plus Lorox at 2 lb/a plus Sencor at 0.3 lb/a provided 99 and 98 percent control of common groundsel, and 97 percent control of hairy nightshade. Treatments that included Sencor at 0.3 lb/a provided the greatest weed control. Burning of lower leaves resulted from treatment with Buctril at 1 pt/a plus Sencor at 0.3 lb/a.

Introduction
This is the second year for evaluation of herbicides applied at layby to seed carrots in central Oregon. The objective of this project was to evaluate Caparol, Lorox, Sencor, Buctril, and Prowl applied at layby for control of broadleaf weeds in seed carrots grown commercially near Culver, Oregon.

Methods and Materials
Herbicides Caparol at 2 and 4 pt/a, Caparol at 1 and 2 pt/a plus Lorox at 2 lb/a, Caparol at 1 pt/a plus Sencor at 0.3 lb/a, Caparol at 1 pt/a plus Prowl at 2 pt/a, Caparol at 1 pt/a plus Lorox at 2 lb/a plus Sencor at 0.3 lb/a, and Buctril at 1 pt/a plus Sencor at 0.3 lb/a were applied June 19 with a CO_2 pressurized, hand-held, sprayer with a 15004 TeeJet nozzle at 35 psi and 20 gal/a water.
The treatments applied layby were directed at the furrow and base of the plants. A nonionic surfactant was applied at 1 pt/100 gal in combination with all treatments. Plots 10 ft x 20 ft were replicated three times in a randomized complete block design. Treatments were evaluated July 2 for control of common groundsel and hairy nightshade. Reduction in stand and crop injury were rated visually.

Results and Discussion
Buctril at 1 pt/a plus Sencor at 0.3 lb/a provided 99 percent control of common groundsel and 97 percent control of hairy nightshade. Similar control was provided by Caparol at 1 pt/a plus Lorox at 2 lb/a plus Sencor at 0.3 lb/a, with 98 percent control of common groundsel and 97 percent control of hairy nightshade. With somewhat less control was Caparol at 1 pt/a plus Sencor at 0.3 lb/a providing 94 percent control of groundsel and 88 percent control of hairy nightshade. All three of these treatments, which provided the highest level of weed control, included Sencor at 0.3 lb/a. Caparol at 4 pt/a provided a total of 88 percent weed control compared to 66 percent at 2 pt/a. Inadequate weed control was provided by Caparol at 1 pt/a in combination with either Lorox at 2 lb/a or Prowl at 2 pt/a. There was no reduction in carrot stand, but burning was observed on the lower leaves of plants treated with Buctril at 1 pt/a plus Sencor at 0.3 lb/a.

Table 1. Effect of layby herbicide applications on commercial seed carrots near Culver, Oregon on June 19, 1996.

		Weed Control[1]		
Treatments[2]	Rate	Common groundsel	Hairy nightshade	Total weeds
	(product/a)	-------------------	(percent)	-------------------
Caparol	2 pt	62 ab[3]	70 a	66
Caparol	4 pt	83 ab	93 a	88
Caparol + Lorox	1 pt 2 lb	60 ab	53 a	57
Caparol + Lorox	2 pt 2 lb	65 ab	90 a	78
Caparol + Sencor	1 pt 0.3 lb	94 a	88 a	91
Caparol + Prowl	1 pt 2 pt	47 b	67 a	57
Caparol + Lorox + Sencor	1 pt 2 lb 0.3 lb	98 a	97 a	98
Buctril + Sencor	1 pt 0.3 lb	99 a	97 a	98
Untreated	-----	0 c	0 b	0

[1] Visual evaluation was conducted August 14, 1996.
[2] Treatments applied July 27, 1996.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

EVALUATION OF PREEMERGENCE HERBICIDE APPLICATIONS TO CARBON-BANDED SEED CARROTS, 1996

Marvin Butler, Bruce Martens, and Les Gilmore

Abstract

Three herbicides linuron (Lorox, Du Pont), metribuzin (Lexone, Du Pont), and diuron (Karmex, Du Pont) were applied preemergence to carbon-banded seed carrots near Culver, Oregon. Lorox at 5 lb/a provided 100 percent control of hairy nightshade, netseed lambsquarters, common groundsel, and China lettuce. Lorox at 2 lb/a provided 95 percent control, and Karmex provided 94 percent control across weed species evaluated. Lorox at 1 lb/a and Lexone at 0.25 lb/a provided inadequate control. There was no reduction in carrot stand and no visible crop injury.

Introduction

Carbon-banding of grass seed at planting to protect the emerging plants from herbicide damage is gaining popularity among grass seed growers in central Oregon. The success of this approach for weed control in seedling grass fields has generated interest in experimentation with seed carrots. The objective of this project was to evaluate preemergence application of Lorox, Karmex, and Lexone on carbon-banded seed carrots.

Methods and Materials

Commercial equipment was used to place a 2 inch-wide carbon band over the seed row following planting in a commercial seed carrot field near Culver, Oregon. Carbon at 17 lb/a and a dilute 10-34 fertilizer mixture were applied in a carrier rate of 45 gal/a. Following carbon-banding, Lorox at 1, 2, and 5 lb/a, Karmex at 2 lb/a, and Lexone at 0.25 lb/a were applied preemergence August 15, 1996 with a CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gal/a. Plots 10 ft x 20 ft were replicated three times in a randomized complete block design. Treatments were evaluated September 19, 1996 by counting the number of weeds per plot for hairy nightshade, common lambsquarters, common groundsel, and China lettuce. Reduction in stand and crop were rated visually.

Results and Discussion

Lorox at 5 lb/a provided 100 percent control of all four weed species evaluated. Lorox at 2 lb/a provided 95 percent control of weeds evaluated, with 100 percent control of hairy nightshade and China lettuce. Karmex provided 100 percent control of common groundsel and China lettuce, with 94 percent control of other weeds evaluated. Lorox at 1 lb/a provided inadequate control of common lambsquarters, and Lexone at 0.25 lb/a provide inadequate control of hairy nightshade. There was no reduction in carrot stand and no visible crop injury.

Table 1. Effect of preemergence herbicide application to carbon-banded seed carrots near Culver, Oregon, 1996.

Treatments[2]	Rate	Hairy nightshade		Common lambsquarters		Common groundsel		China lettuce		Total weeds	
		Non-controlled Weeds[1]									
	(product/a)	----------------------(plants per plot)----------------------									
Lorox	1 lb	2	abc[3]	5.3	b	1.7	ab	2	b	11	b
Lorox	2 lb	0	c	0.3	c	0.7	b	0	b	1	d
Lorox	5 lb	0	c	0	c	0	b	0	b	0	d
Karmex	2 lb	1	bc	0.3	c	0	b	0	b	1.3	d
Lexone	0.25 lb	5.3	ab	0.7	c	0	b	0.7	b	6.7	c
Untreated	----	6	a	7.3	a	3	a	4.7	a	21	a

[1] Visual evaluation was conducted September 20, 1996

[2] Treatments applied August 16, 1996

[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

EVALUATION OF LAYBY HERBICIDE APPLICATIONS ON SEED CORIANDER AND DILL, 1996

Marvin Butler and Brett Dunn

Abstract

Herbicides prometryn (Caparol, Ciba) and linuron (Lorox, Du Pont) were applied layby to seed coriander and dill near Madras, Oregon. Caparol at 4 pt/a provided 90 to 97 percent control for redroot pigweed, common purslane, and grass species. Total weed control for Caparol at 2 pt/a was 68 percent compared to 93 percent for Caparol at 4 pt/a. Caparol at 2 pt/a plus Lorox at 1 lb/a did not increase efficacy over Caparol alone at 4 pt/a. There was no reduction in either coriander or dill stands and no visible injury to either crop.

Introduction

Caparol received registration for postemergence broadleaf and grass control in seed carrots, parsley, dill, and parsnips in Washington during 1996. To receive registration in Oregon, data needed to be generated for the seed crops of interest in central Oregon, which are carrots, parsley, coriander, and dill. The objective of this project was to provide efficacy and phytotoxicity data by evaluating layby applications of Caparol alone and in combination with Lorox to coriander and dill grown commercially for seed near Madras and Culver, Oregon.

Methods and Materials

Caparol at 2 and 4 pt/a, and Caparol at 2 pt/a plus Lorox at 1 lb/a were applied July 11 to seed coriader and seed dill with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water. Crop oil concentrate at 1 percent of the spray volume was added to all treatments. Plots 10 ft x 20 ft were replicated three times in a randomized complete block design. Treatments to seed coriander were evaluated July 30 for control of redroot pigweed, common purslane, and grass species. Reduction in stand and crop injury were rated visually at both the coriader and dill locations July 30.

Results and Discussion

Caparol at 4 pt/a provided 97 percent control of common purslane, 92 percent control of redroot pigweed, and 90 percent control of grass species. Caparol at 2 pt/a ranged from 88 percent control of common purslane, 77 percent control of redroot pigweed, to 40 percent control of grass species. Total weed control for Caparol at 2 pt/a was 68 percent compared to 93 percent for Caparol at 4 pt/a. At 87 percent total weed control, Caparol at 2 pt/a plus Lorox at 1 lb/a provided somewhat less control than Caparol alone at 4 pt/a. There was no reduction in either coriander or dill stands and no visible injury to either crop.

Table 1. Effect of herbicides applied July 11, 1996 to coriander grown for seed near Madras, Oregon.

Treatments[2]	Rate	Weed control[1] Redroot pigweed	Common purslane	Grass species	Total weeds
	(product/a)	(percent)			
Caparol	2 pt	77 a[3]	88 b	40 b	68 a
Caparol	4 pt	92 a	97 a	90 a	93 a
Caparol + Lorox	2 pt + 1 lb	90 a	92 ab	80 a	87 a
Untreated	---	0 b	0 c	0 c	0 b

[1] Visual evaluation was conducted July 30, 1996.
[2] Treatments applied July 11, 1996.
[3] Mean separation with Honestly Significant Difference at $P \leq 0.05$.

1996 COARC FORAGE RESEARCH SUMMARY

Mylen Bohle

Alfalfa Variety Trial

The alfalfa variety trial was planted in August of 1995. Three cuttings were harvested in 1996. There are 25 varieties that range in fall dormancy from 2 to 4. Yield is being measured, and will be correlated to pest resistance ratings and fall dormancies. Stand establishment and vigor were rated subjectively by visual observation in the fall of 1995.

Alfalfa Variety x Fall Dormancy x MSC Trial

This trial has 8 varieties that have a fall dormancy range of 1 to 5 and was planted in August of 1995. Yield (3 cuts) and quality (Cut 1 & 2) will be correlated to mean stage count (MSC), pest ratings, and fall dormancy. Stand establishment and vigor were rated subjectively by visual observation in the fall of 1995.

Irrigated Agro/Eco-Zone Grass Species Trial

Twenty six species and varieties of grass were planted in August of 1994. Three cuttings were harvested in the second year of this trial. The objective of this trial is determine the adaptation of species, and compare yield for each cutting, as well as seasonal yield for hay. Height, lodging, and maturity data have been recorded.

Alfalfa Response to Vitazyme

Vitazyme, a product manufactured by Vital Earth Company in Texas, was applied at the rate of 13 oz./a to individual cuttings (three cut trial) of alfalfa. Yield and quality response to Vitazyme was tested at the COARC, Powell Butte site.

Dryland Agro/Eco-Zone Grass and Legume Demonstration (Tim Deboodt, Co-leader)

Up to 82 different species and varieties of grasses, legumes, and forbes were planted at the COARC, Powell Butte and Madras, Bob Hagerty farm, Redmond, and two sites at the Dick Bedortha Ranch at Paulina. Single plots of 5 x 20 feet, with 5 rows, were planted either in the fall of 1994 (COARC - Madras and Powell Butte and irrigated to establish only) or February (totally dependent upon rainfed conditions) of 1995. Hycrest Crested wheatgrass was planted as borders to use as a comparison within the demonstration plot and from site to site. Adaptation to these different areas of Central Oregon and "what do they look like" are the main objectives of this demonstration, so better recommendations can be made in the future.

Long Term Weed Control Effects on Alfalfa Production

The sixth year was completed in 1996. Five weed management strategies were applied to a late summer (1990) and early summer (1991) planting of alfalfa. Yield, quality, plant stand, stems per square foot, and percent weed (broadleaf and grass) invasion on each cutting are the data being collected. Dependent upon funding, the trial may be run for one to three more years. When the trial is completed, an economic analysis will be done. A sister trial at the Klamath Experiment Station, under the direction of Dr. Randy Dovel, was completed after five years.